



Depression screening outcomes among adolescents, young adults, and adults reporting past 30-day tobacco and cannabis use

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ABSTRACT

Background: Few studies examine the relationship between depression and use of specific tobacco and/or cannabis products among adolescents, young adults, and adults. We determined whether the odds of depression are greater among those who used specific tobacco and/or cannabis products and among co-users of tobacco and cannabis.

Method: Cross-sectional online survey of a national convenience sample of 13–40-year-olds (N = 6,038). The survey included depression screening and past 30-day use of specific tobacco and cannabis products (cigarettes; e-cigarettes, vaped cannabis, little cigars, cigarillos, cigars, hookah, chewing tobacco, smoked cannabis, edible cannabis, blunts). Analyses correspond to the total sample, and 13–17-, 18–24-, and 25–40-year-olds.

Results: Among 5,281 individuals who responded to the depression screener and nine product use questions, 1,803 (34.1 %) reported co-use of at least one tobacco product and one cannabis product in the past 30 days. Past 30-day co-use was associated with higher likelihood of screening positive for depression compared to past 30-day use of tobacco-only (aOR = 1.32, 1.06–1.65; 0.006) or cannabis-only (aOR = 1.94, 1.28–2.94; <0.001). Screening positive for depression was more likely among those who reported past 30-day use of e-cigarettes (aOR = 1.56; 1.35–1.80; <0.001), cigarettes (aOR = 1.24, 1.04–1.48; 0.016), chewed tobacco (aOR = 1.91, 1.51–2.42; <0.001), and blunts (aOR = 1.22, 1.00–1.48; 0.053) compared to those who did not report past 30-day use of these products. Among the 2,223 individuals who screened positive for depression, the most used two-product combination was nicotine e-cigarettes and smoked cannabis (614 individuals, 27.6 %).

Conclusions: Screening positive for depression was more likely among past 30-day co-users versus past 30-day users of tobacco-only or cannabis-only. Findings suggest that prevention programs for depression and substance use address tobacco and cannabis co-use.

1. Introduction

Depression is a major cause of morbidity and mortality across the age spectrum, with nearly 1 in 5 adolescents (12–17 years) and 1 in 11 adults (18+ years) suffering from clinical depression every year (Substance Abuse and Mental Health Services Administration (SAMHSA), 2023). The onset of both depression and substance use often initiate during adolescence and young adulthood (Maughan, Collishaw, & Stringaris, 2013). There is a bidirectional association between substance use and depression, such that reducing early substance use may help reduce later depressive symptoms (Brook, Brook, Zhang, Cohen, & Whiteman, 2002), and preventing and managing depression may reduce co-occurring or

later substance use (Quello, Brady, & Sonne, 2005; Teesson et al., 2020). Moreover, recent data underscore evolving substance use patterns wherein adolescents and young adults (AYAs) report using multiple tobacco and cannabis products in the past 30 days (Cho et al., 2021; Gaiha, Lin, Lempert, & Halpern-Felsher, 2022; Gilbert, Kava, & Afifi, 2021; Gonzalez & Sanders-Jackson, 2021; Lanza et al., 2021; Mattingly, Elliott, & Fleischer, 2023). Understanding the relationship between substance use patterns and depression across the age spectrum can support prevention efforts for both depression and substance use.

Studies report a bidirectional or reciprocal causal relationship between depression and use of different types of tobacco and cannabis (Ranjit et al., 2019; Wang et al., 2022). The evidence is mixed on

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whether co-use of tobacco and cannabis versus single use of either is linked to depressive symptoms, and the direction of influence. A systematic review among adolescents and young adults found that co-use of tobacco and cannabis is associated with experiencing depressive symptoms (Ramo, Liu, & Prochaska, 2012), and a longitudinal study found that depression was a risk factor for poly-substance use (including cigarettes and cannabis) for young adults (Crane, Langenecker, & Mermelstein, 2021). In contrast, a study showed that users of just tobacco or cannabis were more likely to have experienced depressive symptoms compared to those who used three or more substances (Martinotti et al., 2009). Nevertheless, several studies theorize that the behavioral risk profile of those co-using tobacco and cannabis may be “additive or interactive” compared to using either product alone (Tucker et al., 2019), since rates of using both tobacco and cannabis are higher among co-users than those using tobacco only or cannabis only (Ramo et al., 2012), and associated physical health problems, psychiatric disorders, and psychosocial problems are greater among co-users (Peters, Schwartz, Wang, O’Grady, & Blanco, 2014; Ramo et al., 2012; Tucker et al., 2019).

There is a lack of evidence on whether tobacco and/or cannabis use is differentially associated with depression across adolescence, young adulthood, and adulthood. Some studies show that adults using substances are more vulnerable to depression (Grant, 1995), and others found that the association between depression and substance use was constant across adolescence, young adulthood, and adults (Schuler, Vasilenko, & Lanza, 2015). Adolescents are more likely to experience depressive symptoms because they are at a physiological and social developmental stage whereby their brains are still developing and their executive functioning is still being established (Halpern-Felsher et al., 2023; Steinberg, 2005). At the same time, with depressive symptoms and substance use peaking during adolescence and very young adulthood (Maughan et al., 2013; Solmi et al., 2022), studies suggest that adolescents use substances to self-medicate for depressive symptoms as do adults (Wilkinson, Halpern, & Herring, 2016; Nkansah-Amankra & Minelli, 2016). However, there are virtually no studies focused on understanding the relationship between substance use and depressive symptoms from adolescence through young adulthood through adulthood. Further, there is a need to examine the relationship between depression and both individual and co-use of tobacco and cannabis products among adolescents, young adults, and adults.

Prior research examining the relationship between depression and tobacco and cannabis use has notable limitations. First, very few studies directly explore the association between depression and co-use of both tobacco and cannabis, with the exception of one study which excluded adolescents (Nguyen et al., 2023) and another that excluded adults (Tucker et al., 2019). Second, none of the studies examining correlates of tobacco and/or cannabis use included adolescents, young adults, and adults all in one study (Jacobs, Orozco, Villanueva, & Merianos, 2023; Liu, Tan, Winickoff, & Rees, 2023; Seaman, Green, Wang, Quinn, & Fryer, 2019). Third, studies on tobacco and cannabis co-use and its relationship to depression have varied by which cannabis and tobacco products were included and how they were measured. For example, a study excluded e-cigarettes (Seaman et al., 2019), another included only measures focused on tobacco with and without cannabis but not cannabis alone (Sumbe et al., 2022), and another did not include chewing tobacco, hookah, edible cannabis, and blunts (Nguyen et al., 2023). Other studies did not include analysis of associations between depression and a wide range of individual tobacco and cannabis products or did not report commonly co-used product combinations (Nguyen et al., 2023; Tucker et al., 2019).

The purpose of this study is to determine whether the odds of screening positive for depression are greater among a national convenience sample of adolescents, young adults, and adults who use specific tobacco and/or cannabis products. Specific aims of this study were to: (1) characterize tobacco and cannabis product use combinations among those who screen positive for depression and those who do not, (2)

assess whether past 30-day use of nine tobacco and cannabis products is individually associated with screening positive for depression, and (3) examine the relationship between screening positive for depression and past 30-day co-use of both tobacco and cannabis products compared to tobacco-only use or cannabis-only use across each of the three age subgroups (adolescents, young adults, and adults). Based on separate studies assessing depressive symptoms with specific tobacco or cannabis products (M. Chaiton et al., 2024; M. O. Chaiton, Cohen, O’Loughlin, & Rehm, 2009), we hypothesize that screening positive for depressive symptoms may be more likely among users of e-cigarettes and cigarettes. We also hypothesize that tobacco and cannabis co-use is associated with screening positive for depression to a greater extent than use of tobacco-only or cannabis-only or use of neither tobacco nor cannabis in the past 30 days.

2. Methods

Using a national convenience sample, we conducted a cross-sectional online survey of 13–40-year-olds in Nov–Dec 2021 ($n = 6,131$). Data were collected from 17 November to 15 December 2021 by Qualtrics using online research panels (Czeisler et al., 2021; Qualtrics, 2014). In our sample, we recruited adolescents (ages 13 to 17 years), young adults (18 to 24 years; a time during which brains are still developing), and adults (25 to 40 years). Using quota sampling, our sample was purposefully composed such that the number of participants corresponding to each demographic characteristic of self-reported sex and race/ethnicity matched national proportions in the latest US Census. After meeting a quota, new participants representing that demographic profile would not be allowed to take the survey. Additionally, we conducted quality checks, including attention-checks and speeding checks to filter out bots and participants who were taking the survey in less than half the median time. More information about the sample and participants are described in detail elsewhere (Gaiha et al., 2022). This study was approved by the Institutional Review Board at Stanford University.

Measures.

Participants reported sociodemographic information on age, sex, and race/ethnicity.

Screening for a depressive disorder.

The Patient Health Questionnaire-2 (PHQ-2) (Kroenke, Spitzer, & Williams, 2003) inquires about the frequency of depressed mood and anhedonia over the past two weeks. The PHQ-2 screens for depression in a “first-step” approach, and participants who screen positive should be further evaluated with the PHQ-9 to determine whether they meet criteria for a depressive disorder. We asked participants, “Over the last TWO WEEKS, how often have you been bothered by any of these problems? 1) Little interest or pleasure in doing things and 2) Feeling down, depressed and hopeless.” Likert scale responses corresponding to each item (Not at all, Several days, More than half the days, Nearly every day) are scored from 0 to 3. A total PHQ-2 score is obtained by adding the score for each item (total points) on a scale from 0 to 6. A score of 3 or higher is considered a positive screen and suggests that a depressive disorder is likely. A PHQ-2 cut score of 3 had a sensitivity and specificity of 73.7% and 75.2%, respectively, of detecting youth who met criteria for major depression per the Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders on the Diagnostic Interview Schedule for Children in primary care settings (Richardson et al., 2010). Additionally, the PHQ-2 cut score of 3 had a sensitivity of 96% and specificity of 82% for detecting youth who met criteria for probable major depression on the PHQ-9 (Richardson et al., 2010).

Past 30-day use of tobacco and cannabis products.

We asked participants, “Have you EVER USED any of these products in your entire life? (Yes/No)” for the categories of: E-cigarettes (nicotine-only), Cigarettes, Cigars/ cigarillos and little cigars, Chewing tobacco, Hookah, Smoked cannabis, Vaping THC (wax or oil) or cannabis, Edible cannabis, and Blunts.” Among all those who indicated having ever used any of the products above, we asked, “During the last 30 days,

Table 1Participant characteristics by PHQ-2 screener for depression (Score ≥ 3 indicates a positive screen for depression).

	Number of participants (n, %)	Mean PHQ-2 score from 0 to 6 (S.D.)	PHQ-2 score ≥ 3 (n, %)
Total sample	6038 (100 %)	2.30 (1.92)	2583 (42.8)
<i>Age (in years)</i>			
13–17	1610 (26.7)	2.05 (1.96)	582 (36.1)
18–24	3030 (50.2)	2.44 (1.86)	1403 (46.3)
25–40	1398 (23.1)	2.29 (1.97)	598 (42.8)
<i>Gender</i>			
Female	3397 (56.3)	2.38 (1.89)	1497 (44.1)
Male	2300 (38.1)	2.09 (1.92)	907 (39.4)
Non-Binary/Other	284 (4.7)	3.11 (1.96)	156 (54.9)
Prefer not to say	57 (0.9)	1.95 (2.17)	23 (40.4)
<i>LGBTQ+</i>			
Yes	1548 (25.7)	2.94 (1.88)	855 (55.2)
No	4198 (69.5)	2.08 (1.87)	1608 (38.3)
Not listed	48 (0.8)	2.23 (2.19)	19 (39.6)
Prefer not to say	244 (4.0)	2.05 (1.97)	101 (41.4)
<i>Race/ethnicity</i>			
White, non-Hispanic	3127 (51.8)	2.24 (1.95)	1258 (40.2)
Black/ African American, non-Hispanic (NH)	825 (13.7)	2.34 (1.84)	384 (46.5)
Asian or Pacific Islander NH	315 (5.2)	2.12 (1.78)	118 (37.5)
Hispanic or Latino	1122 (18.6)	2.48 (1.89)	537 (47.9)
Other/multi-race NH	220 (3.6)	2.31 (1.94)	95 (43.2)
American Indian/Alaska Native NH	22 (0.4)	2.82 (1.40)	14 (63.6)
Prefer not to say	407 (6.7)	2.28 (2.04)	177 (43.5)
<i>Past 30-day user of E-cigarettes</i>			
Yes	2225 (36.8)	2.79 (1.77)	1232 (55.4)
No	3652 (60.5)	2.01 (1.95)	1286 (35.2)
Missing	161 (2.7)	2.12 (1.97)	65 (40.4)
<i>Past 30-day user of Cigarettes</i>			
Yes	1458 (24.2)	2.80 (1.86)	800 (54.9)
No	4427 (73.3)	2.13 (1.92)	1709 (38.6)
Missing	153 (2.5)	2.48 (1.84)	74 (48.4)
<i>Past 30-day user of Cigars, cigarillos, and little cigars</i>			
Yes	1116 (18.5)	2.81 (1.80)	632 (56.6)
No	4774 (79.1)	2.17 (1.93)	1884 (39.5)
Missing	148 (2.4)	2.49 (1.84)	67 (45.3)
<i>Past 30-day user of Chewed Tobacco</i>			
Yes	585 (9.7)	3.09 (1.65)	395 (67.5)
No	5330 (88.3)	2.21 (1.93)	2139 (40.1)
Missing	123 (2.0)	2.28 (2.01)	49 (39.8)
<i>Past 30-day user of Hookah</i>			
Yes	815 (13.5)	2.92 (1.68)	482 (59.1)
No	5118 (84.8)	2.19 (1.94)	2040 (39.9)
Missing	105 (1.7)	2.80 (1.81)	61 (58.1)
<i>Past 30-day user of Smoked cannabis</i>			
Yes	1872 (31.0)	2.69 (1.86)	960 (51.3)
No	4026 (66.7)	2.11 (1.92)	1557 (38.7)
Missing	140 (2.3)	2.40 (1.82)	66 (47.1)
<i>Past 30-day user of Edible cannabis</i>			
Yes	1360 (22.5)	2.78 (1.82)	730 (53.7)
No	4537 (75.2)	2.14 (1.93)	1771 (39.0)
Missing	141 (2.3)	2.88 (1.77)	82 (58.2)
<i>Past 30-day user of Blunts</i>			
Yes	1506 (25.0)	2.76 (1.83)	817 (54.2)
No	4385 (72.6)	2.12 (1.92)	1687 (38.5)
Missing	147 (2.4)	2.88 (1.87)	79 (53.7)
<i>Past 30-day user of Vaping Cannabis</i>			
Yes	1533 (25.4)	2.78 (1.80)	830 (54.1)
No	4386 (72.6)	2.13 (1.94)	1694 (38.6)
Missing	119 (2.0)	2.45 (1.82)	59 (49.6)

Out of 6,131 participants, 93 (1.5%) were excluded from this table due to missing PHQ-2, yielding a total sample of 6,038. PHQ-2 percentages were computed row-wise, with respect to the value in the “Number of participants” column.

on about how many days did you use each of the following products? (Put zero if you did not use the product in the last 30 days),” followed by a list of products they used to indicate past 30-day use. For simplicity of interpretation, we created a binary indicator variable for past 30-day use of each of the nine products, where “0” corresponded to no use of the product in the past 30 days and “1” corresponded to using the product at least once in the past 30 days.

2.1. Data analysis

We first performed a descriptive summary of tobacco and cannabis products used by participants in the past 30 days stratified by depression status. We identified the most commonly used two-product combination (the two products with concurrent past 30-day use reported by the greatest number of participants), the most common three-product combination, and the most common four-product combination. Second, we used a logistic regression model to examine whether a positive

Table 2

Past 30-day tobacco and cannabis use, n (%).

Past 30-day use of...	Total sample~ (n = 5281)		Ages 13–17 (n = 1431)		Ages 18–24 (n = 2667)		Ages 25–40 (n = 1183)	
	Total	PHQ-2 $\geq$ 3	Total	PHQ-2 $\geq$ 3	Total	PHQ-2 $\geq$ 3	Total	PHQ-2 $\geq$ 3
Tobacco and cannabis* (co-use)	1803 (34.1)	969 (53.7)	227 (15.9)	111 (48.9)	1057 (39.6)	582 (55.1)	519 (43.9)	276 (53.2)
Tobacco-only [^]	796 (15.1)	361 (45.4)	125 (8.7)	54 (43.2)	394 (14.8)	197 (50.0)	277 (23.4)	110 (39.7)
Cannabis-only [#]	174 (3.3)	69 (39.7)	33 (2.3)	13 (39.4)	113 (4.2)	51 (45.1)	28 (2.4)	5 (17.9)
Neither tobacco or cannabis	2508 (47.5)	824 (32.9)	1046 (73.1)	333 (31.8)	1103 (41.4)	394 (35.7)	359 (30.3)	97 (27.0)

~Out of 6,131 participants, 93 (1.5 %) were excluded due to missing PHQ-2 and 850 subjects (13.9 %) were excluded from the analysis due to missing a recorded response in at least one of the nine product use questions, yielding an analytical sample of 5,281 participants.

*Past 30-day use of tobacco and cannabis is defined as past 30-day use of at least one tobacco product and at least one cannabis product.

[^]Past 30-day use of tobacco-only is defined as any use of E-cigarettes, Cigarettes, Cigars/ cigarillos and little cigars, and Chewing tobacco and no use of any cannabis product.

[#]Past 30-day use of cannabis-only is defined as any use of Hookah, Smoked cannabis, Edible cannabis, Vaping Cannabis, and Blunts and no use of any tobacco product.

depression screen (PHQ $\geq$ 3, primary outcome) was associated with past 30-day product use across all nine products, adjusting for age, sex, identifying as LGBTQ+, and race/ethnicity. Third, we assessed whether the odds of a positive depression screen varied across broad categories of tobacco and cannabis use patterns adjusting for age, sex, identifying as

LGBTQ+, and race/ethnicity. We defined four such categories: (1) past 30-day use of only tobacco products (E-cigarettes, Cigarettes, Cigars/ cigarillos and little cigars, Chewing tobacco), (2) past 30-day use of only cannabis products (Hookah, Smoked cannabis, Edible cannabis, Vaping cannabis, and Blunts), (3) past 30-day use of at least one tobacco product

Table 3

Most used two-product, three-product, and four-product combinations.

	Product combination	Number of participants (n, %)	Product combination	Number of participants (n, %)	Product combination	Number of participants (n, %)
All ages	Total (n = 5281)		PHQ-2 < 3 (n = 3058)		PHQ-2 $\geq$ 3 (n = 2223)	
	scann + blunts	1152 (21.8)	scann + blunts	551 (18.0)	scann + blunts	614 (27.6)
	scann + blunts + ecig	815 (15.4)	scann + blunts + vcann	380 (12.4)	scann + blunts + ecig	464 (20.9)
	scann + blunts + vcann + ecig	638 (12.1)	scann + ecann + blunts + vcann	286 (9.4)	scann + blunts + vcann + ecig	363 (16.3)
Ages 13–17	Total (n = 1431)		PHQ-2 < 3 (n = 920)		PHQ-2 $\geq$ 3 (n = 511)	
	scann + blunts	156 (2.7)	scann + blunts	79 (8.6)	scann + blunts	77 (15.1)
	scann + blunts + vcann	113 (2.0)	scann + blunts + vcann	57 (6.2)	scann + blunts + ecig	57 (11.2)
	scann + blunts + vcann + ecig	87 (1.5)	scann + blunts + vcann + ecig	42 (4.6)	scann + blunts + vcann + ecig	45 (8.8)
Ages 18–24	Total (n = 2667)		PHQ-2 < 3 (n = 1443)		PHQ-2 $\geq$ 3 (n = 1224)	
	scann + blunts	684 (6.4)	scann + blunts	329 (22.8)	scann + blunts	371 (30.3)
	scann + blunts + vcann	492 (4.6)	scann + blunts + vcann	236 (16.4)	scann + blunts + ecig	271 (22.1)
	scann + blunts + vcann + ecig	380 (3.6)	scann + ecann + blunts + vcann + ecig	173 (12.0)	scann + blunts + vcann + ecig	211 (17.2)
Age 25–40	Total (n = 1183)		PHQ-2 < 3 (n = 695)		PHQ-2 $\geq$ 3 (n = 488)	
	cig + ecig	355 (7.5)	cig + ecig	162 (23.3)	cig + ecig	193 (39.5)
	cig + lcig + ecig	253 (5.3)	scann + ecann + blunts	106 (15.3)	cig + lcig + ecig	153 (31.4)
	cig + lcig + ecig	198 (4.2)	cig + lcig + blunts	80 (11.5)	cig + lcig + ecig	118 (24.2)
	scann + blunts		blunts		blunts	

Abbreviations key: Ecig = E-cigarettes, Cig = Cigarettes, Lcig = Cigars, cigarillos, and little cigars, Scann = Smoked cannabis, Ecann = Edible cannabis, Vcann = Vaping cannabis.

Table 4

Association between screening positive for a depressive disorder and past 30-day substance use in addition to socio-demographic factors (N = 5,324) (Adjusted Odds Ratio (95 % Confidence Interval); p-value).

	Total Sample (n = 5281)	Ages 13–17 (n = 1431)	Ages 18–24 (n = 2667)	Ages 25–40 (n = 1183)
<i>Past 30-day user of E-cigarettes</i>				
Yes	1.56 (1.35–1.80); <0.001	1.14 (0.80–1.64); 0.469	1.59 (1.31–1.93); <0.001	1.82 (1.35–2.46); <0.001
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Cigarettes</i>				
Yes	1.24 (1.04–1.48); 0.016	1.53 (0.91–2.57); 0.112	1.46 (1.14–1.85); 0.002	0.95 (0.70–1.29); 0.739
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Cigars, cigarillos, and little cigars</i>				
Yes	1.14 (0.94–1.38); 0.197	0.96 (0.53–1.72); 0.886	1.10 (0.84–1.44); 0.486	1.23 (0.88–1.73); 0.232
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Chewed tobacco</i>				
Yes	1.91 (1.51–2.42); <0.001	2.15 (0.99–4.71); 0.055	1.54 (1.12–2.12); 0.008	2.30 (1.54–3.45); <0.001
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Hookah</i>				
Yes	1.12 (0.91–1.38); 0.301	0.72 (0.37–1.42); 0.348	1.18 (0.89–1.56); 0.244	1.11 (0.76–1.61); 0.600
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Smoked cannabis</i>				
Yes	0.88 (0.73–1.06); 0.173	0.85 (0.50–1.44); 0.545	0.95 (0.75–1.22); 0.702	0.76 (0.53–1.11); 0.156
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Edible cannabis</i>				
Yes	0.99 (0.82–1.18); 0.884	0.89 (0.53–1.51); 0.670	0.97 (0.77–1.23); 0.833	1.04 (0.72–1.49); 0.849
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Blunts</i>				
Yes	1.22 (1.00–1.48); 0.053	1.71 (0.98–3.01); 0.061	1.06 (0.82–1.37); 0.647	1.40 (0.95–2.08); 0.092
No	Ref	Ref	Ref	Ref
<i>Past 30-day user of Vaped cannabis</i>				
Yes	1.03 (0.87–1.23); 0.724	1.15 (0.71–1.86); 0.580	0.92 (0.73–1.16); 0.475	1.29 (0.91–1.81); 0.148
No	Ref	Ref	Ref	Ref
<i>Age (in years)</i>				
13–17	0.99 (0.83, 1.19); 0.948			
18–24	1.21 (1.04–1.41); 0.014			
25–40	Ref			
<i>Gender</i>				
Female	1.16 (1.02–1.31); 0.019	1.02 (0.80–1.31); 0.850	1.22 (1.02–1.45); 0.026	1.25 (0.96–1.63); 0.098
Other [#]	1.33 (1.01–1.75); 0.039	1.23 (0.80–1.90); 0.341	1.27 (0.87–1.86); 0.221	1.89 (0.55–6.57); 0.314
Male	Ref	Ref	Ref	Ref
<i>Identifying as LGBTQ+</i>				
Yes	1.93 (1.68–2.23); <0.001	2.39 (1.82–3.15); <0.001	1.85 (1.53–2.23); <0.001	1.61 (1.13–2.30); 0.008
Not listed/prefer not to say	1.16 (0.87–1.54); 0.316	1.10 (0.69–1.76); 0.695	1.03 (0.68–1.57); 0.889	2.20 (1.05–4.64); 0.038
No	Ref	Ref	Ref	Ref
<i>Race/ ethnicity</i>				
Black/ African American, non-Hispanic	1.26 (1.06–1.50); 0.009	1.28 (0.86–1.91); 0.224	1.39 (1.10–1.76); 0.006	1.04 (0.72–1.50); 0.836
Asian or Pacific Islander, non-Hispanic	1.06 (0.81–1.37); 0.679	1.21 (0.80–1.83); 0.376	0.97 (0.65–1.46); 0.894	0.94 (0.52–1.71); 0.847
Hispanic or Latino	1.24 (1.06–1.45); 0.007	1.23 (0.90–1.70); 0.195	1.27 (1.03–1.56); 0.027	1.20 (0.82–1.75); 0.357
Other/multi-race, non-Hispanic [*]	1.08 (0.80–1.44); 0.621	1.12 (0.67–1.87); 0.661	1.10 (0.71–1.70); 0.665	1.02 (0.53–1.97); 0.945
Prefer not to say	1.04 (0.81–1.33) 0.756	1.23 (0.80–1.89); 0.345	1.06 (0.76–1.49); 0.719	0.65 (0.32–1.34); 0.242
White, non-Hispanic	Ref	Ref	Ref	Ref

Bolded cells indicate p-values less than 0.05.

^{*}Includes American Indian/Alaska Native, non-Hispanic due to low cell count.

[#] Other includes both “Non-binary/other” and “Prefer not to say” as low cell counts.

and at least one cannabis product, (4) no past 30-day use of either tobacco or cannabis. We performed a post-hoc multiple comparisons test with adjustment for simultaneous hypothesis testing by calculating adjusted odds ratios across all pairwise comparisons between the four tobacco and cannabis use categories. Next, we repeated the above analyses among sub-samples by age group (13–17 years, 18–24 years, and 25–40 years). In our primary analysis, we performed the association analyses and product combination analysis on complete case data, which excluded subjects who were missing a PHQ-2 score and/or a value for past 30-day use for at least one of the nine products. As a sensitivity analysis, we repeated the association analyses on data with missing values imputed using multiple imputation.

All analyses were performed in R 4.2.1. The glm package was used to fit logistic regression models and to determine p-values and confidence intervals for odds ratios. The glht and multcomp packages were used for the post-hoc test of pairwise odds ratios. The mice package was used to perform multiple imputation.

3. Results

Of the 6,131 individuals surveyed, 6,038 (98.5 %) individuals had a recorded PHQ-2 score in the dataset. Amongst those with a recorded PHQ-2 score, 2,583 (42.8 %) screened positive for depression (PHQ-2 ≥ 3), including 582 (36.1 %) of the 13–17-year-olds, 1403 (46.3 %) of the 18–24-year-olds, and 598 (42.8 %) of the 25–40-year-olds (see Table 1). Among the sample, 1497 (44.1 %) of the females and 855 (55.2 %) of the participants identifying as LGBTQ+ (see Table 1) screened positive for depression. Overall, 1,803 (34.1 %) individuals reported past 30-day co-use (i.e., use of at least one tobacco product and at least one cannabis product), 796 (15.1 %) individuals reported past 30-day use of tobacco-only, 174 (3.3 %) individuals reported past 30-day use of cannabis-only, and 2508 (47.5 %) individuals reported no past 30-day use of either tobacco or cannabis (see Table 2). Individuals who had a response to the PHQ-2 screener and a response to the product use question across all nine products were included in the product combination analysis and association analyses, resulting in a complete

Table 5

Odds Ratios for a Positive Depression Screen Across Pairwise Comparisons Between Tobacco and Cannabis Use Categories.

Comparison	Adjusted odds ratio, Total sample (n = 5281)	Adjusted odds ratio, Ages 13–17 (n = 1431)	Adjusted odds ratio, Ages 18–24 (n = 2667)	Adjusted odds ratio, Ages 25–40 (n = 1183)
Past 30-day co-use vs. Past 30-day use of tobacco-only	1.32 (1.06–1.65); 0.006	1.19 (0.67–2.14); 0.857	1.17 (0.86–1.59); 0.545	1.66 (1.13–2.45); 0.004
Past 30-day co-use vs. Past 30-day use of cannabis-only	1.94 (1.28–2.94); <0.001	1.60 (0.59–4.31); 0.608	1.53 (0.92–2.56); 0.139	6.07 (1.68–21.9); 0.002
Past 30-day co-use vs. No past 30-day use of either tobacco or cannabis	2.21 (1.86–2.63); <0.001	1.86 (1.26–2.74); <0.001	2.08 (1.66–2.62); <0.001	3.00 (2.05–4.39); <0.001
Past 30-day use of tobacco-only vs. Past 30-day use of cannabis-only	1.46 (0.94–2.27); 0.114	1.34 (0.47–3.78); 0.885	1.31 (0.75–2.28); 0.583	3.65 (0.99–13.4); 0.052
Past 30-day use of tobacco-only vs. No past 30-day use of either tobacco or cannabis	1.67 (1.35–2.08); <0.001	1.55 (0.94–2.57); 0.106	1.78 (1.31–2.42); <0.001	1.81 (1.17–2.79); 0.003
Past 30-day use of cannabis-only vs. No past 30-day use of either tobacco or cannabis	1.14 (0.75–1.73); 0.839	1.16 (0.45–2.99); 0.976	1.36 (0.81–2.27); 0.412	0.49 (0.13–1.81); 0.496

case analytic sample of 5,281 (86.1 %).

Tobacco and cannabis product combinations used.

Among the 2,223 individuals in the analytic sample who screened positive for depression, the most used two-product combination was smoked cannabis and e-cigarettes (614 individuals, 27.6 %); the most used three-product combination was smoked cannabis, blunts, and e-cigarettes (464 individuals, 20.9 %); and the most used four-product combination was smoked cannabis, blunts, vaping cannabis, and e-cigarettes (363 individuals, 16.3 %). Among the 3,058 individuals who screened negative for depression, the most used two-product combination was smoked cannabis and blunts (551 individuals, 18.0 %); the most used three-product combination was smoked cannabis, blunts, and vaping cannabis (380 individuals, 12.4 %); and the most used four-product combination was smoked cannabis, edible cannabis, blunts, and vaping cannabis (286 individuals, 9.4 %). In our age subgroup analysis, cigarettes and cigars/cigarillos/little cigars appeared in the most common product combinations only amongst 25- to 40-year-olds (see Table 3).

Association of past 30-day product use with screening positive for depression.

Screening positive for depression was more likely among those who reported past 30-day use of e-cigarettes (aOR = 1.56; 1.35–1.80; <0.001), cigarettes (aOR = 1.24, 1.04–1.48; 0.016), chewed tobacco (aOR = 1.91, 1.51–2.42; <0.001), and blunts (aOR = 1.22, 1.00–1.48; 0.053) compared to those who did not report past 30-day use of these products (see Table 4). In addition, screening positive for depression was more likely among participants who self-identified as 18–24 years old compared to 25–40 years (aOR = 1.21, 1.04–1.41; 0.014), as LGBTQ+ (aOR = 1.93, 1.68–2.23; <0.001) compared to not LGBTQ+, as female (aOR = 1.16, 1.02–1.31; 0.019) compared to male, and as Black/ African American Non-Hispanic (aOR = 1.26, 1.06–1.50; 0.009) and Hispanic or Latino (aOR = 1.24, 1.06–1.45; 0.007) compared to White Non-Hispanic participants.

In our age subgroup analysis, past 30-day use of e-cigarettes was significantly associated with screening positive for depression in 18–24-year-olds (aOR = 1.59, 1.31–1.91; <0.001) and in 25–40-year-olds (aOR = 1.82, 1.35–2.46; <0.001). In 18–24-year-olds, past 30-day cigarette use was significantly associated with screening positive for depression (aOR = 1.46, 1.14–1.85; <0.002). In 18–24-year-olds and 25–40-year-olds, past 30-day chewed tobacco use was significantly associated with depression (18–24: aOR = 1.54, 1.12–2.12; 0.008; 25–40: aOR = 2.30, 1.54–3.45; <0.001). Identifying as Black/ African American Non-Hispanic or as Hispanic or Latino was significantly associated with screening positive for depression in 18–24-year-olds (aOR = 1.39, 1.10–1.76; 0.006; aOR = 1.27, 1.03–1.56; 0.027). In all age subgroups, screening positive for depression was more likely in participants identifying as LGBTQ+ (13–17: aOR = 2.39, 1.82–3.15; <0.001; 18–24: aOR = 1.85, 1.53–2.23; <0.001; 25–40: aOR = 1.61, 1.13–2.30; 0.008).

In the sensitivity analysis performed on data with missing data imputation, the odds of screening positive for depression were not significantly higher in females compared to males and in past 30-day users of blunts compared to those without past 30-day blunt use (see Supplemental Table 1). While these adjusted odds were not significant, their directionality was the same as in the complete case analysis (i.e., was greater than 1). All of the other significant associations from the complete case analysis noted above were also significant in the sensitivity analysis.

Association of past 30-day use of both tobacco and cannabis with screening positive for depression.

Past 30-day use of both cannabis and tobacco products (i.e., co-use) was associated with higher likelihood of screening positive for depression compared to past 30-day use of tobacco-only (aOR = 1.32, 1.06–1.65; 0.006) or cannabis-only (aOR = 1.94, 1.28–2.94; <0.001) (see Table 5). We found a similar result in our age subgroup analysis for 25- to 40-year-olds, where past 30-day co-use was associated with a significantly higher likelihood of screening positive for depression compared to using tobacco-only (aOR = 1.66, 1.13–2.45; 0.004) or cannabis-only (aOR = 6.07, 1.68–21.9; 0.002).

The above significant results from the complete case analysis were also significant in the sensitivity analysis performed on data with missing values imputed (see Supplemental Table 2). In the sensitivity analysis but not the complete case analysis, screening positive for depression was significantly more likely in 18–24 year-olds who reported past 30-day co-use compared to past 30-day use of cannabis-only (aOR = 1.64, 1.00–2.62; 0.048). We note however, that the point estimate of the adjusted odds and the confidence interval bounds are similar to that of the complete case analysis (aOR = 1.53, 0.92–2.56; 0.139).

4. Discussion

Using national data across a wide age spectrum from adolescence through adulthood, this study provides evidence that screening positive for depression is associated with past 30-day tobacco and cannabis co-use to a larger extent compared to tobacco-only or cannabis-only use. These findings are supported by other studies on co-use, where co-use, cannabis-only use, and tobacco-only use were all associated with higher odds of depression compared to no use (Nguyen et al., 2023; Tucker et al., 2019). Our findings contrast with a study showing that co-use was not associated with higher odds of screening positive for depression compared to tobacco-only use, which did not include an adolescent population (Nguyen et al., 2023). Our findings also show that screening positive for depression was more likely among those who reported past 30-day use of e-cigarettes, chewed tobacco, and blunts compared to those who did not use these products in the past 30 days. Smoked cannabis and e-cigarettes were the most common product combination used by those who screened positive for depression. Cigarettes and cigars/cigarillos/little cigars appeared in the most common

product combinations only amongst 25- to 40-year-olds and not among 13–17- or 18–24 –year-olds.

Current trends show that co-use is of growing significance among adolescents and young adults (Seaman et al., 2019; Tucker et al., 2019), and our finding that depression is associated with co-use is important and timely. Our subgroup analysis for 25- to 40-year-olds, where past 30-day co-use was associated with a significantly higher likelihood of depression compared to using tobacco only, is supported by a study among adults in Texas. The authors found that past 30-day use of tobacco and cannabis was more common than tobacco-only or cannabis-only use, and the odds of multi-product use compared to single-product use increased among those with depressive symptoms (Chido-Amajuoyi, Mantey, Omega-Njemnobi, Yu, & Shete, 2021). Future research on depressive symptoms should include co-users of tobacco and cannabis as an important sub-group, since such users appear to display particular associations with depressive symptoms.

Physicians, educators, parents, and tobacco and addiction experts are often counseling people who are dealing with depressive symptoms or self-medicating through tobacco and cannabis use (Lu, Muñoz-Laboy, Sohler, & Goodwin, 2021; McRobbie, Boland, & Courtney, 2021; Nguyen et al., 2019). Yet, they are likely to inquire about single-product use rather than co-use of cannabis and tobacco products (Lu et al., 2021; McRobbie et al., 2021; Nguyen et al., 2019). Our study suggests a need to ask about and integrate information on co-occurring product use when discussing depressive symptoms, in order to provide additional behavioral support and coping mechanisms. Since co-use could be driven by a user's withdrawal symptoms from trying to quit either tobacco or cannabis (Levin et al., 2010; McClure et al., 2019), counseling including mood management is a potential solution for successful cessation (Connor, Stjepanović, Budney, Le Foll, & Hall, 2022; Taylor et al., 2014). Prevention education programs may also be developed and evaluated for their effectiveness in addressing perceptions around tobacco and cannabis product use, such as adolescents' misperceptions about the health risks of e-cigarettes versus cigarettes (Gorukanti, Delucchi, Ling, Fisher-Travis, & Halpern-Felsher, 2017) or perceiving low(er) addictive potential for cannabis e-cigarettes compared to smoked cannabis (Nguyen, Wong, Delucchi, & Halpern-Felsher, 2022). Further, given our finding that AYAs and adults who screened positive for depression commonly report 2-, 3-, and 4-product combinations of tobacco and cannabis products and that those who screened positive for depression were associated with co-occurring past 30-day use of tobacco and cannabis, there is a strong potential for intersectoral and integrated mental health, tobacco control, and cannabis awareness programs to simultaneously target reducing substance use and depressive symptoms.

In our sample, fewer adolescents screened positive for depression compared to the young adult and adult population. Regarding depression among young adults, our findings are consistent with a large nationally-representative study suggesting that economic uncertainty was associated with depression among younger adults when compared with older adults in the US (Collier Villaume, Chen, & Adam, 2023). As our data were collected prior to the spread of the Omicron variant of SARS-CoV-2 virus, school and college closures associated with COVID-19 pandemic were not in place during this time and AYA may have experienced a brief restoration of routine. It is also plausible that similar to adolescent cigarette smoking, other behavioral or physical symptoms (e.g., stress, appetite, mouth sores, and weight) may serve as additional proxies for depressive outcomes related to adolescent use of other tobacco and cannabis products (O'Loughlin et al., 2002).

There are several study limitations to consider. Findings in this study are not generalizable as they are based on a convenience sample. As this is a cross-sectional study, with no causal identification strategy, no causal conclusions should be drawn from these reported associations. Next, although the self-administered PHQ-2 is commonly applied as a screening tool for depression, it cannot be used as a tool to diagnose depression or assess its severity. Regarding analyses of product combinations used in the past 30 days, we encountered relatively small counts

for some product-combinations which implied that only descriptive analyses were feasible. Small sample sizes also need to be taken into consideration when interpreting results from the age subgroup analyses. For example, although depression was overall more likely among those with past 30-day blunt use, past 30-day blunt use was not significantly associated with depression in any of the age subgroups individually. This could be explained by the smaller samples in each individual age subgroup and therefore reduced power in the test for significant associations. In addition, we used a complete-case analysis (i.e., observations with missing values were removed from analyses). We note, however, that this only resulted in the removal of a small portion (13.9 %) of the total observations. Furthermore, in the sensitivity analyses performed on data with imputed missing values, we found minimal differences in statistically significant results and no changes to the key conclusions of this study. Finally, in survey product descriptions we did not clarify the distinction between blunts and smoked cannabis or whether hookah was used with tobacco or cannabis.

5. Conclusion

Past 30-day use of e-cigarettes, cigarettes, chewing tobacco, and blunts were each positively associated with screening positive for depression. Additionally, screening positive for depression was more likely among tobacco and cannabis co-users versus tobacco-only or cannabis-only users. Positive depression screens may potentially be associated with different product use patterns across different age ranges. Our findings suggest that clinicians should screen for both depression and substance use and that depression- and substance-use-prevention education programs should address use and co-use patterns.

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CRediT authorship contribution statement

Shivani Mathur Gaiha: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Maggie Wang:** Writing – review & editing, Formal analysis. **Mike Baiocchi:** Writing – review & editing, Formal analysis, Conceptualization. **Bonnie Halpern-Felsher:** Writing – review & editing, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Bonnie Halpern-Felsher is a paid expert scientist in some litigation against the e-cigarette industry and an unpaid scientific advisor and expert regarding some tobacco-related policies. No other authors have

any conflicts of interest to disclose.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2024.108076>.

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