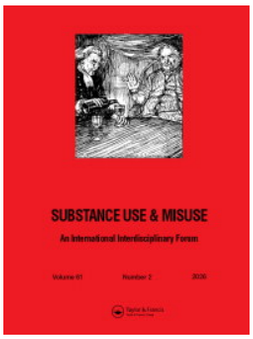

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ORIGINAL ARTICLE

The Association Between Adolescent Mental Health Symptoms and Characteristics of Cigarette and E-Cigarette Use

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ABSTRACT

Introduction: While there is a bi-directional relationship between internalizing mental health (IMH) symptoms (i.e., symptoms of depression, symptoms of anxiety) and nicotine use, it is unclear how IMH relates to patterns of use. The purpose of this study is to quantitatively examine the relationship between IMH symptoms and indicators of nicotine dependence, quit intentions, and quit attempts among adolescents who use cigarettes and/or e-cigarettes.

Methods: Data come from the 2020–2023 waves of the International Tobacco Control (ITC) Adolescents Tobacco and Vaping Survey. The analytic sample for this study includes those reporting past 30-day use of cigarettes and/or e-cigarettes ($n = 18{,}800$). We measured indicators of nicotine dependence (i.e., frequency of use, time to first use, and perceived addiction), quit intention, and quit attempt history separately for cigarettes and e-cigarettes. Respondents reported current IMH symptoms (any vs. none). We examined associations between IMH symptoms and all outcomes using regression models, adjusting for dual use, and examining moderation by dual use.

Results: IMH symptoms were positively associated with e-cigarette nicotine dependence indicators and intention to quit e-cigarettes. IMH symptoms were positively associated with cigarette nicotine dependence indicators and intention to quit for those reporting dual use of e-cigarettes and cigarettes, but not exclusive cigarette use. IMH symptoms were positively associated with ever having a quit attempt for both products.

Conclusions: Findings indicate that IMH symptoms were comorbid with greater dependence on nicotine products, particularly e-cigarettes. Smoking and e-cigarette cessation interventions should consider mental health, though research is needed to understand the directionality of the relationship between IMH symptoms and e-cigarette use.

KEYWORDS
e-Cigarette; cigarette; mental health; nicotine; dependence

Introduction

Nicotine use remains a public health concern, despite declines in cigarette use among adolescents in recent years. E-cigarette use has increased among this population globally since its introduction to the tobacco marketplace, as has dual use of these products. E-cigarette use is associated with adverse cardiovascular and respiratory effects (Gotts et al., 2019), with additional evidence that nicotine adversely affects brain development (Tobore, 2019) and that mental health can be worsened by both e-cigarette (Becker et al., 2021) and cigarette use (Prochaska et al., 2017). There is limited evidence that heavier patterns of use of cigarettes and/or e-cigarettes and cessation behaviors are positively associated with mental health symptoms (Fergusson et al., 1996; Grunau et al., 2010; Kubik et al., 2003; Lam et al., 2005; Miller et al., 2011; Smith et al., 2014; Sonntag et al., 2000). However, this limited evidence focuses largely on cigarette use and data from the period before e-cigarette use became popular among adolescents (e.g., 2017). Consequentially, these studies do not evaluate dual use of both products, which is increasingly common among adolescents (Sreeramareddy et al., 2022) and was found to be more strongly associated with poor mental health than exclusive use of either product (Dunbar et al., 2017; Leventhal et al., 2016; Wills et al., 2015). Furthermore, the COVID-19 pandemic impacted both adolescent mental health (Bosch et al., 2022; De France et al., 2022; Houghton et al., 2022; Meherali et al., 2021; Ravens-Sieberer et al., 2022) and tobacco/nicotine use (Layman et al., 2022; FDA, 2023). This study aimed to better understand how mental health is related to characteristics of cigarette, e-cigarette, and dual use among adolescents.

Adolescents with untreated internalizing mental health (IMH) conditions (e.g., depression, anxiety) are at risk for a number of adverse outcomes, including substance use

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disorders and suicide (Pompili et al., 2012). Individuals suffering from untreated IMH conditions have a significantly shorter life expectancy than the general population (DeHay et al., 2012; Parks et al., 2006). Studies have found that nicotine dependence, defined as encompassing the physical and psychological factors that make it difficult for a person who uses tobacco/nicotine products to stop (CAMH, 2023), is positively associated with IMH problems among adolescents (Fergusson et al., 1996; Miller et al., 2011; Sonntag et al., 2000). However, these studies use a variety of measures of nicotine dependence that focus only on cigarette use.

Frequency of use, another indicator of nicotine dependence, is also associated with IMH symptoms and conditions among adolescents (Ferreira et al., 2019; Goodwin et al., 2005; Grunau et al., 2010; Johnson et al., 2000; Kubik et al., 2003). Studies of cigarette smoking have found consistent, positive associations with IMH and smoking frequency. The few studies to examine IMH and e-cigarette use have found that IMH symptoms were positively associated with frequency of e-cigarette use (Lechner et al., 2017), while another found no association (Dunbar et al., 2017). No studies have considered dual use of cigarettes and e-cigarettes to our knowledge.

IMH symptoms are also associated with quit intentions and quit attempts. While evidence among adults suggests that a lack of quit attempt or intention to quit are positively associated with IMH problems (e.g., Taylor et al., 2014, 2021), only two studies have examined this among adolescents and both focus only on cigarette smoking (Lam et al., 2005; Smith et al., 2014). One study found that adolescents who did not intend to quit at baseline had more IMH symptoms at follow up than adolescents who did intend to quit at baseline (Lam et al., 2005). Similarly, another study found that adolescents with IMH conditions at baseline were less likely to attempt to quit than those without IMH conditions (Smith et al., 2014). While limited, these studies suggest that making a quit attempt or intending to quit may be related to better mental health among adolescents. More research is needed to better understand how quit attempts and quit intention are related to IMH symptoms among adolescents, particularly for e-cigarette use, for which there is no evidence to date.

The purpose of this study is to examine IMH symptoms and indicators of dependence, quit intentions, and quit attempts among adolescents who use cigarettes and/or e-cigarettes, and the potential moderation of dual use status. We hypothesized that the presence of IMH symptoms would be positively associated with dependence and negatively associated with quit attempt and quit intention, for both cigarette and e-cigarette use. We also hypothesized that dual use would moderate this relationship for all outcomes, where associations would be stronger for dual use compared to exclusive use.

Methods

Data source

The data for this study come from the International Tobacco Control (ITC) Adolescents Tobacco and Vaping Survey. This national repeat cross-sectional survey is conducted in England, Canada, and the United States (USA). Participants answer questions about their experience with and beliefs about tobacco products, sociodemographic characteristics, and their mental health symptoms (Hammond & Reid, 2023). The current study uses six waves of the ITC Adolescents Tobacco and Vaping Survey conducted between 2020 and 2023: February 2020, August 2020, February 2021, August 2021, August 2022, and August 2023.

Participants were recruited from the Nielsen Consumer Insights Global Panel, which is a non-probability-based sample. A random selection of panelists, parents of panelists (for participants under 18), or panelists with children ages 16–19 received email invitations with a unique survey link to screen for eligibility. Eligible participants were aged 16–19 years. Participants received renumeration in accordance with the panel incentive structure, which included point-based rewards, monetary rewards, and/or chances to win monthly prizes.

The two analytic samples for this study were comprised of those who reported current cigarette use ($n = 9822$) and current e-cigarette use ($n = 14{,}692$). Participants reporting dual use of both products were included in both samples. Participants indicating no current use of either product were excluded ($n = 62{,}645$). Participants who responded 'don't know' or 'refused' for mental health variables were excluded ($n = 232$), resulting in a total analytic sample of 18,800.

Measures

Dependent variables: nicotine dependence indicators

Current tobacco/nicotine use measures were adapted from the PATH study surveys (United States Department of Health & Human Services. National Institutes of Health. National Institute on Drug Abuse, 2016), with questions about cigarette use and e-cigarette use asked separately but otherwise using the same wording. Participants were asked separately, "In the past 30 days, on how many days did you (smoke/vape)" and could enter 0–30 days to indicate frequency of use. Responses of 'don't know' or 'refused' were recoded as missing and were excluded from analyses ($n = 1305$ for cigarettes, $n = 2624$ for e-cigarettes).

Time to first use was measured by asking participants, "How soon after waking do you (smoke/vape)?" with response options 'within 5 min,' '6–30 min,' '31–60 min,' and '60+ minutes'. Responses of 'don't know' or 'refused' were recoded as missing and were excluded from analyses ($n = 942$ for cigarettes, $n = 1303$ for e-cigarettes).

Perceived addiction was measured by asking respondents, "Do you believe you are addicted to (smoking cigarettes/e-cigarettes/vaping?" with response options 'Yes, very much,' 'Yes, a little,' or 'Not at all' (Hammond et al., 2021). Responses of 'don't know' or 'refused' were recoded as missing and were excluded from analyses ($n = 161$ for cigarettes, $n = 590$ for e-cigarettes).

Dependent variables: cessation variables

For intention to quit, participants who reported any use of the specific product in the prior month were asked, "Are you planning on quitting (smoking/vaping)…" with response

options 'within the next month,' 'between 1 and 6 months from now,' recoded as 'intending to quit' and response options 'sometime in the future, beyond 6 months,' 'not planning to quit,' and 'I don't know' coded as 'not intending to quit.' Responses of 'I don't currently smoke/vape' were recoded as missing and excluded ($n = 1{,}370$ for cigarettes, $n = 1{,}780$ for e-cigarettes), as were responses of 'refused' ($n = 29$ for cigarettes, $n = 76$ for e-cigarettes).

For ever having a quit attempt, participants were asked, "Have you ever tried quitting (smoking/vaping)?" with response options 'yes' and 'no.' Responses of 'don't know' or 'refused' were recoded as missing and were excluded from analyses ($n = 75$ for cigarettes, $n = 476$ for e-cigarettes). For this outcome for cigarettes in the February 2020 wave, measurement differed from subsequent waves; therefore, respondents from that wave reporting current cigarette use have been dropped from models for this outcome ($n = 2173$).

Mental health symptoms

Mental health symptoms were measured using two items from the Screening Tool for Psychological Distress (STOP-D), which was validated among adults (Young et al., 2015). Symptoms of depression were measured by asking participants, "In the last month, how much have you been bothered by feeling sad, down, or uninterested in life?" Symptoms of anxiety were measured by asking participants, "In the last month, how much have you been bothered by feeling anxious or nervous?" For both items, response options ranged from 0 to 9 (0='not at all,' 3='a little', 6='moderately', and 9='severely'). We assessed these as both continuous and binary variables (i.e., validated cut-points of 4 for depression symptoms and 5 for anxiety symptoms (Young et al., 2015)), and as both separate indicators and combined indicators. Items were combined to create a dichotomous IMH symptoms variable, where participants who met the cut-points for either depression or anxiety were coded as '1′ and participants who did not meet the cut-points for either were coded as '0′.

Covariates

Participants were asked if they used any of the following in the past month: little cigars or cigarillos, cigars, bidis, smokeless tobacco, hookah, and nicotine pouches. A variable 'other tobacco product use' was generated (yes vs. no). A dual use of cigarettes and e-cigarettes variable was also generated, differentiating between participants who reported current use of both products and exclusive use (yes vs. no).

Participants indicated their age: 16, 17, 18, or 19 and their sex at birth: 'male' or 'female.' Participants were asked, "What is your current gender identity?" with response options 'Man', 'Woman', 'Trans male/trans man', 'Trans female/trans woman', 'Gender queer/Gender non-conforming', or 'Different identity,' where an open response was provided. These categories were recoded to a binary gender minority variable where responses of 'man' or 'woman' were coded as 0 'non-gender minority' [reference] and other responses (e.g., transgender, gender non-conforming) were coded as 1 'gender minority'. Invalid responses were coded as missing but remained in analyses. We derived a binary race variable (white only vs. other races or mixed race), due to the varying types of racial and ethnic groups between the three countries. Socioeconomic status (SES) was collected using a measure of perceived income adequacy, where participants were asked, "How would you describe your family's financial situation?" with response options 'not meeting basic expenses', 'just meeting basic expenses,' 'meeting needs with a little left over,' 'living comfortably', and 'don't know/refuse' (ITC Youth Tobacco and Vaping Survey, 2023). Participants were asked in which country they live: Canada, England, or USA. A wave indicator was generated for each data collection effort.

Analyses

For each outcome (i.e., frequency of cigarette use/e-cigarette use; time to first cigarette/e-cigarette; perceived addiction to cigarettes/e-cigarettes; quit attempt of cigarettes/e-cigarettes; intention to quit smoking/e-cigarette use), a model was estimated using all respondents reporting use of the product (cigarettes or e-cigarettes), resulting in 10 total models. The primary independent variable for all models was the presence of IMH symptoms (any vs. none). For a sensitivity analysis to ensure the dichotomous version of the IMH symptom was consistent with the continuous version of that variable, we re-ran all models with the continuous variable.

Associations between IMH symptoms and frequency of use were examined using a Poisson regression model with frequency of use as the outcome (#1–30 days). Multinomial regression models were estimated for the outcomes of time to first use (1 h+ (reference); 31–60 min; 6–30 min; and within 5 min) and perceived addiction (not at all (reference); yes, a little addicted; yes, very addicted). For time to first use models, frequency of use was included as a covariate. Finally, logistic regression models were estimated for binary outcomes of ever having a quit attempt (no = reference) and quit intentions in the next 6 months (no = reference). We assessed the interaction between IMH symptoms and dual use of cigarettes and e-cigarettes by creating an interaction term and adding it into the adjusted models for each outcome. When the interaction term was significant, we stratified the main analyses by dual use or exclusive use and evaluated the coefficient associated with IMH.

All analyses include post-stratification sample weights, which were constructed based on population estimates for sociodemographic variables (age, sex, region in all countries; race in US only) and past 30 day smoking (based on national estimates in US and Canada; unavailable in England) (ITC Youth Tobacco and Vaping Survey, 2023). All models were adjusted for dual use, use of other tobacco products, wave, sex, gender identity, race, age, SES, and country of residence. All analyses were conducted using Stata version 18.

Results

Sample characteristics

The sample characteristics are provided in Table 1. The analytic sample ($n = 18{,}800$) included 9822 adolescents reporting

Table 1. Sample characteristics ($n = 18,800$).

Characteristics	Categories	Cigarette Use ($n = 9822$) n (weighted %)[a]	E-Cigarette Use ($n = 14,692$) n (weighted %)[b]	Dual Use ($n = 5714$) *n* (weighted %)[c]
Wave	Feb 2020	2173 (20.1%)	2751 (18.5%)	1180 (19.3%)
	Aug 2020	1535 (17.8%)	1889 (14.3%)	772 (16.0%)
	Feb 2021	1407 (16.6%)	2112 (15.3%)	767 (16.1%)
	Aug 2021	1533 (14.8%)	2285 (16.0%)	908 (15.6%)
	Aug 2022	1661 (17.1%)	2884 (18.3%)	1081 (17.8%)
	Aug 2023	1513 (13.5%)	2771 (17.7%)	1006 (15.3%)
Country	Canada	2553 (27.2%)	4672 (31.6%)	1496 (27.9%)
	England	4645 (55.1%)	4901 (34.2%)	2535 (51.7%)
	USA	2624 (17.7%)	5119 (34.2%)	1683 (20.4%)
Age	16	1638 (18.2%)	2253 (17.2%)	942 (18.4%)
	17	2310 (25.8%)	3044 (22.5%)	1251 (23.6%)
	18	3188 (31.3%)	5276 (34.7%)	1908 (32.4%)
	19	2686 (24.7%)	4119 (25.6%)	1613 (25.5%)
Sex	Male	3884 (57.1%)	4664 (48.6%)	2149 (54.9%)
	Female	5938 (42.9%)	10028 (51.4%)	3565 (45.1%)
Gender Identity	Non-cisgender	462 (3.8%)	672 (3.9%)	294 (4.2%)
	Cisgender	9360 (96.3%)	14020 (96.1%)	5420 (95.8%)
Race	White	7172 (77.1%)	10308 (75.1%)	4186 (76.6%)
	Other races	2563 (22.1%)	4245 (24.1%)	1480 (22.5%)
Perceived Family Income	Not meeting needs	840 (7.1%)	1068 (6.5%)	505 (7.6%)
	Just meeting needs	3050 (28.7%)	4438 (28.2%)	1781 (29.5%)
	Meeting needs	2944 (30.9%)	4637 (31.9%)	1708 (30.4%)
	Living comfortably	2659 (30.3%)	4042 (30.4%)	1555 (30.0%
IMH Symptoms	Yes	6951 (66.3%)	10,905 (70.1%)	4279 (71.5%)
Dual Use	Yes	5714 (55.6%)	5714 (33.9%)	5714 (100%)
	No (i.e., exclusive use)	4108 (44.4%	8978 (66.1%)	
Use of other nicotine products[d]	Yes	3300 (33.2%)	3814 (25.8%)	2235 (40.2%)
Frequency of use (#1–30 days)	Mean (SE)	13.5 (0.12)	15.2 (0.11)	15.82 (0.16)
Time to first use	Within 5 min	990 (10.6%)	2874 (19.5%)	1269 (20.8%)
	6–30 min	1793 (19.5%)	2805 (20.6%)	1180 (21.7%)
	31–60 min	1247 (14.2%)	1642 (12.3%)	750 (14.5%)
	1 h+	4850 (55.7%)	6068 (47.6%)	2139 (43.1%)
Perceived addiction	Not at all	3542 (36.4%)	5517 (41.0%)	1695 (32.0%)
	A little addicted	4351 (46.3%)	5575 (39.6%)	2447 (44.9%)
	Very addicted	1768 (17.2%)	3010 (19.4%)	1369 (23.0%)
Intend to quit within 6 months[e]	Yes	2761 (32.7%)	4076 (31.8%)	3790 (72.0%)
Ever had a quit attempt	Yes	3865 (48.3%)	6708 (46.9%)	2343 (41.3)

[a]Any participants who reported cigarette use in the past 30 days.
[b]Any participants who reported e-cigarette use in the past 30 days.
[c]Any participants who reported dual use of cigarettes and e-cigarettes in the past 30 days.
[d]Use of other nicotine/tobacco products includes little cigars or cigarillos, cigars, bidis, smokeless tobacco, hookah, and nicotine pouches.
[e]Excludes participants who indicated that they are not currently smoking ($n = 1370$) or vaping ($n = 1780$).

cigarette use (exclusive = 44%, dual = 56%) and 14,692 adolescents reporting e-cigarette use (exclusive = 66%, dual = 34%). Participants who reported cigarette use had a mean age of 17.6 years old (SD = 1.02), were approximately half male (57%), mostly cisgender (96%), and mostly white (77%). Participants who reported e-cigarette use had a mean age of 17.7 years old (SD = 1.04), were approximately half female (51.4%), mostly cisgender (96%), and mostly white (75%).

Participants reporting cigarette use (9822) smoked an average of 13.5 (SD = 11.52) days per month; 11% reported smoking within 5 min of waking up, and 17% said they were very addicted to smoking cigarettes; 33% intended to quit within 6 months and 48% had attempted to quit previously. Participants reporting e-cigarette use (14,692) vaped an average of 15.2 (SD = 11.85) days per month; 20% reported vaping within 5 min of waking up, and 19% said they were very addicted to vaping; 32% intended to quit within 6 months and 47% had attempted to quit previously. We report on differences in IMH symptoms by missingness status in Supplemental Table 5.

Nicotine dependence indicators

The association between IMH symptoms and nicotine dependence outcomes are shown in Table 2. IMH symptoms were associated with frequency of cigarette use in unadjusted models, but the association was no longer significant after adjusting for covariates. IMH symptoms were positively associated with frequency of e-cigarette use (adjusted coefficient = 0.07, SE = 0.02).

IMH symptoms were positively associated with first cigarette between 6 and 30 min after waking (ARRR = 1.20, 95% CI = 1.03–1.38) and between 31 and 60 min after waking (ARRR = 1.24, 95% CI = 1.06–1.45), though not for first use within 5 min. IMH symptoms were positively associated with time to first use of e-cigarettes within 6–30 min (ARRR = 1.35, 95% CI = 1.19–1.52), and within 5 min (ARRR = 1.66, 95% CI = 1.45–1.91), but not between 31 and 60 min.

IMH symptoms were positively associated with perceiving oneself to be very addicted to cigarettes (ARRR = 1.40, 95%CI = 1.22–1.61) but unassociated with perceiving oneself

Table 2. Internalizing mental health symptoms and nicotine dependence outcomes for using cigarettes and E-cigarettes.

Frequency of Use[a]							
		#1–30 days					
		b (SE)	Adj. b(SE)				
Cigarettes (n = 8,517)							
IMH Symptoms	No	ref	ref				
	Yes	**−0.07 (0.02)****	−0.04 (0.02)				
E-cigarettes (n = 12,068)							
IMH Symptoms	No	ref	ref				
	Yes	**0.09 (0.02)*****	**0.07 (0.02)*****				
Time to First Use (ref >60 min)[b]							
		31–60 min		6–30 min		Within 5 min	
		RRR (95% CI)	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*
Cigarettes (n = 8,880)							
IMH Symptoms	No	ref	ref	ref	ref	ref	ref
	Yes	**1.17 (1.03–1.34)***	**1.24 (1.06–1.45)****	**1.17 (1.04–1.31)****	**1.20 (1.03–1.38)***	1.05 (0.91–1.21)	0.98 (0.82–1.17)
E-cigarettes (n = 11,158)							
IMH Symptoms	No	ref	ref	ref	ref	ref	ref
	Yes	1.06 (0.94–1.19)	1.11 (0.96–1.28)	**1.36 (1.24–1.50)*****	**1.35 (1.19–1.52)*****	**1.84 (1.66–2.05)*****	**1.66 (1.45–1.91)*****
Perceived Addiction (ref "not at all")[c]							
		A little addicted		Very addicted			
		RRR (95% CI)	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*		
Cigarettes (n = 9,661)							
IMH Symptoms	No	ref	ref	ref	ref		
	Yes	**0.89 (0.81–0.98)***	0.93 (0.84–1.03)	**1.40 (1.23–1.59)*****	**1.40 (1.22–1.61)*****		
E-cigarettes (n = 14,328)							
IMH Symptoms	No	ref	ref	ref	ref		
	Yes	**1.15 (1.06–1.24)****	**1.22 (1.12–1.32)*****	**1.87 (1.68–2.07)*****	**1.83 (1.63–2.05)*****		

RRR: relative risk ratio; ARRR: adjusted relative risk ratio; IMH: Internalizing mental health symptoms; CI: confidence interval; adj.: adjusted.
Adjusted models include dual use, other tobacco product use, age, sex, gender identity, race, socioeconomic status, wave, and country.
[a]Poisson regression models. DV: frequency of use in the prior month (range = 1–30 days).
[b]Multinomial logistic regression models. DV: Time to first use (>60 min = reference). Also adjusts for frequency of use.
[c]Multinomial logistic regression models. DV: Perceived addiction (not at all = reference).
All models are weighted. Bold indicates statistical significance.
*: $p < 0.05$.
**: $p < 0.01$.
***: $p < 0.001$.

to be a little addicted to cigarettes. IMH symptoms were positively associated with perceiving oneself to be a little addicted to e-cigarettes (ARRR = 1.22, 95% CI = 1.12–1.32) and very addicted to e-cigarettes (ARRR = 1.83, 1.63–2.05). Sensitivity analyses with the continuous IMH measure were generally consistent (see Supplemental Table 1).

Cessation variables

The association between IMH symptoms and cessation variables (i.e., quit intention and quit attempts) are shown in Table 3. IMH symptoms were not associated with intending to quit cigarettes after adjusting for covariates, but were positively associated with intending to quit e-cigarettes within 6 months (AOR = 1.16, 95% CI = 1.04–1.30). IMH symptoms were positively associated with higher odds of ever having tried to quit cigarettes (AOR = 1.49, 95% CI = 1.31–1.70). Similarly, IMH symptoms were positively associated with higher odds of ever having tried to quit e-cigarettes (AOR = 1.44, 95% CI = 1.30–1.59). Sensitivity analyses with the continuous IMH measure were generally consistent (see Supplemental Table 2).

Interaction of IMH symptoms and dual use

The interaction of IMH symptoms and dual use was statistically significant in the models for time to first cigarette, perceived addiction to cigarettes, and intention to quit cigarettes (see Supplemental Table 3). There was no interaction for e-cigarette outcomes. We stratified the significant outcomes by dual use (see Table 4).

Among adolescents reporting exclusive cigarette use, IMH symptoms were negatively associated with cigarette use within 5 min compared to using 1 h or more after waking

Table 3. Internalizing mental health symptoms and cigarette and E-cigarette cessation variables.

		Intention to Quit Within 6 Months[a]	
		OR (95% CI)	*AOR (95% CI)*
Cigarettes (n = 8,423)			
IMH Symptoms	No	ref	ref
	Yes	**1.18 (1.04–1.33)***	1.11 (0.97–1.26)
E-cigarettes (n = 12,836)			
IMH Symptoms	No	ref	ref
	Yes	**1.16 (1.05–1.29)****	**1.16 (1.04–1.30)****
		Ever Had a Quit Attempt[b]	
		OR (95% CI)	*AOR (95% CI)*
Cigarettes (n = 7,574)			
IMH Symptoms	No	ref	ref
	Yes	**1.84 (1.63–2.08)*****	**1.49 (1.31–1.70)*****
E-cigarettes (n = 14,216)			
IMH Symptoms	No	ref	ref
	Yes	**1.48 (1.35–1.63)*****	**1.44 (1.30–1.59)*****

OR: relative risk ratio; AOR: adjusted odds ratio; IMH: Internalizing mental health symptoms; CI – confidence interval.
Adjusted models include dual use, other tobacco product use, age, sex, gender identity, race, socioeconomic status, wave, and country.
[a]Logistic regression models. DV: Intention to quit in next 6 months (no = reference). Excludes participants who indicated that they are not currently smoking (n = 1,370) or vaping (n = 1,780).
[b]Logistic regression models. DV: Ever having quit attempt (no = reference). Excludes February 2020 wave due to administration differences.
All models are weighted. Bold indicates statistical significance.
*: $p < 0.05$.
**: $p < 0.01$.
***: $p < 0.001$.

Table 4. IMH symptoms and time to first cigarette, perceived addiction, and intention to quit cigarettes stratified by dual use.

Time to First Cigarette[a]							
		31–60 min		**6–30 min**		**Within 5 min**	
		RRR (95% CI)	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*
Exclusive cigarette (n = 3,736)							
IMH Symptoms	**No**	ref	ref	ref	ref	ref	ref
	Yes	1.09 (0.90–1.31)	1.21 (0.96–1.53)	1.16 (0.97–1.37)	1.12 (0.89–1.40)	**0.74 (0.60–0.93)****	**0.70 (0.53–0.92)****
Dual use (n = 5,144)							
IMH Symptoms	**No**	ref	ref	ref	ref	ref	ref
	Yes	**1.34 (1.11–1.61)****	**1.28 (1.03–1.59)***	**1.19 (1.02–1.40)***	**1.30 (1.07–1.58)****	**1.43 (1.16–1.76)****	**1.42 (1.12–1.80)****
Perceived Addiction to Cigarettes[b]							
		A little addicted		**Very addicted**			
		RRR (95% CI)	*ARRR (95% CI)*	*RRR (95% CI)*	*ARRR (95% CI)*		
Exclusive cigarette (n = 4,522)							
IMH Symptoms	**No**	ref	ref	ref	ref		
	Yes	**0.79 (0.69–0.90)*****	**0.84 (0.73–0.97)***	**1.24 (1.03–1.49)***	1.15 (0.94–1.40)		
Dual use (n = 5,636)							
IMH Symptoms	**No**	ref	ref	ref	ref		
	Yes	0.91 (0.80–1.04)	1.00 (0.87–1.15)	**1.51 (1.26–1.82)*****	**1.64 (1.35–1.99)*****		
Intention to Quit Cigarettes[c]							
		OR (95% CI)	*AOR (95% CI)*				
Exclusive cigarette (n = 3514)							
IMH Symptoms	**No**	ref	ref				
	Yes	1.03 (0.86–1.24)	1.01 (0.84–1.22)				
Dual use (n = 4909)							
IMH Symptoms	**No**	ref	ref				
	Yes	**1.29 (1.09–1.52)****	**1.23 (1.03–1.47)***				

RRR: relative risk ratio; ARRR: adjusted relative risk ratio; CI: confidence interval; IMH: Internalizing mental health symptoms.
Models adjust for IMH symptoms, other tobacco product use, age, sex, gender identity, race, socioeconomic status, wave, and country.
[a]Multinomial logistic regression models. DV: Time to first use (>60 min, 31–60 min, 6–30 min, within 5 min). Also adjusts for frequency of use.
[b]Multinomial logistic regression models. DV: Perceived addiction (not at all vs. a little, very).
[c]Logistic regression models. DV: Intention to quit (yes vs. no).
All models are weighted. Bold indicates statistical significance.
*: $p < 0.05$.
**: $p < 0.01$.
***: $p < 0.001$.

(ARRR = 0.70, 95% CI = 0.53–0.92), but not with other categories. Alternatively, among adolescents reporting dual use, IMH symptoms were positively associated with all categories of earlier time to first use, where the strongest association was within 5 min (ARRR = 1.42, 95% CI = 1.12–1.80), followed by 6–30 min (ARRR = 1.30, 95% CI = 1.07–1.58), and then 31–60 min (ARRR = 1.28, 95% CI = 1.03–1.59).

Among adolescents reporting exclusive cigarette use, IMH symptoms were negatively associated with perceiving oneself to be a little addicted to cigarettes (ARRR = 0.84, 95% CI = 0.73–0.97) and positively associated with perceiving oneself to be very addicted to cigarettes, but only in the unadjusted model. Among adolescents reporting dual use, IMH symptoms were positively associated with perceiving oneself to be very addicted to cigarettes (ARRR = 1.64, 95% CI = 1.35–1.99), but unassociated with perceiving oneself to be a little addicted to cigarettes. Among those reporting exclusive cigarette use, IMH symptoms were unassociated with intention to quit cigarettes; however, among those reporting dual use, IMH symptoms were positively associated with intention to quit (AOR = 1.23, 95% CI = 1.03–1.47). Sensitivity analyses were consistent. Sensitivity analyses with the continuous IMH measure were generally consistent (see Supplemental Table 4).

Discussion

This study found that adolescents with IMH symptoms have different patterns of cigarette and/or e-cigarette use than those who do not have IMH symptoms. We found that IMH symptoms were positively associated with several indicators of e-cigarette dependence. We also found that IMH symptoms were positively associated with ever having a quit attempt for both cigarettes and e-cigarettes. IMH symptoms were positively associated with quit intention for e-cigarettes but not for cigarettes. Finally, we found that the relationship between IMH symptoms and some cigarette outcomes were moderated by dual use status, where positive associations were found between IMH symptoms and outcomes for those reporting dual use, but not for those reporting exclusive use of cigarettes. While this is the first study to examine the interaction of mental health and dual use, studies have found that the relationship between mental health and nicotine use is stronger for those who report dual use compared to those who exclusively use cigarettes (Dunbar et al., 2017; Leventhal et al., 2016; Wills et al., 2015).

Our findings that IMH symptoms were positively associated with e-cigarette use frequency but not with cigarette use frequency are consistent with another study that evaluated depressive symptoms among adolescents (Lechner et al., 2017). Previous studies focusing on the association between mental health and cigarette smoking frequency found a positive association (Ferreira et al., 2019; Goodwin et al., 2005; Grunau et al., 2010; Johnson et al., 2000; Kubik et al., 2003), though all analyzed data collected prior to 2017, when e-cigarette use became more popular among adolescents. Our study, with more recent data, suggests that this association may be shifting away from cigarette smoking and toward e-cigarette use. Adolescents with IMH symptoms may be more likely to use e-cigarettes frequently due to the fact that e-cigarettes are easier to hide and use discretely than cigarettes (Bold et al., 2016), or due to shifting norms

where e-cigarettes are considered more acceptable than cigarettes (Gorukanti et al., 2017). Longitudinal research is needed to explore this relationship and the extent to which mental health plays a role.

We found that for those reporting e-cigarette use, IMH symptoms were positively associated with earlier time to first use of e-cigarettes and perceiving oneself to be addicted to e-cigarettes. While no prior studies have examined the association between IMH symptoms and time to first use or perceived addiction among adolescents, these findings aligns with our finding for frequency of use. As these variables are indicators of nicotine dependence and are correlated, these findings suggest that IMH symptoms are positively associated with nicotine dependence among those using e-cigarettes regardless of nicotine dependence measurement. Studies have found that IMH symptoms are positively associated with various measures of nicotine dependence among adolescents (Fergusson et al., 1996; Miller et al., 2011; Scherphof et al., 2013; Sonntag et al., 2000).

We also found that IMH symptoms were positively associated with intention to quit e-cigarettes, which differs from our hypotheses. Indeed, research among adults suggests that poor mental health is negatively associated with intention to quit (Taylor et al., 2014, 2021) and that intention to quit is considered an indicator of readiness to engage in cessation-behaviors and associated with higher likelihood of future quit attempts (Hummel et al., 2018). A lack of intention to quit has been associated with higher levels of nicotine dependence among adults (Fagan et al., 2007; Lin et al., 2021), which tends to be more prevalent among individuals with mental health conditions. Given that our sample is adolescents, it is possible that the relationship between mental health and quit intention is different than adults who are likely smoking more heavily. This highlights a critical need for targeted interventions and further research to understand and address the unique challenges faced by this population in building motivation and capacity to quit smoking.

For time to first cigarette, perceived addiction to cigarettes, and intention to quit cigarettes, the association between IMH symptoms and each outcome was moderated by dual use, while no such moderation was found for any e-cigarette outcomes. Adolescents reporting exclusive cigarette use had either no association or a negative association between IMH symptoms and these outcomes. Alternatively, those reporting dual use of cigarettes and e-cigarettes showed a positive association between IMH symptoms and these outcomes for cigarettes. This is the first study to examine the interaction of mental health and dual use. Past studies have found strong associations between mental health and nicotine dependence of cigarettes (Fergusson et al., 1996; Miller et al., 2011; Scherphof et al., 2013; Sonntag et al., 2000); however, similar to the findings related to use frequency, these studies were conducted before e-cigarettes became more popular among youth. It is possible that adolescents with mental health symptoms that previously would have smoked cigarettes in an e-cigarette-free environment have shifted toward dual use as opposed to exclusive use of cigarettes, as a form of self-medication or withdrawal symptom management, as e-cigarettes are easier to conceal. Alternatively, given that we found positive associations between IMH symptoms and nicotine dependence indicators, it is possible that a causal pathway exists between nicotine use and developing IMH symptoms, or the opposite (i.e., the presence of IMH symptoms increase likelihood of subsequent nicotine use). Finally, it is also possible that this finding is an artifact of sample heterogeneity. Longitudinal studies are needed to better understand the pattern and directionality of these relationships.

We found that IMH symptoms were positively associated with having attempted to quit both cigarettes and e-cigarettes. This finding may be due to the nicotine withdrawal symptoms during quit attempts. For example, nicotine withdrawal results in worsened mental health symptoms which are then alleviated by continuing to use nicotine in the short term (Parrott, 1995). Indeed, adolescents with poor mental health may be more likely to relapse when they try to quit, as found in one prior study (Yimsaard et al., 2023). Furthermore, a recent study found that adults with depression who smoke cigarettes were more likely to attempt to quit than those without depression (46), though, to our knowledge, no such studies have been conducted among adolescents. It is important to highlight that our measure of quit attempts refers to 'ever' having a quit attempt, and therefore it may not be related to mental health. as some quit attempts may have occurred well before current symptom reporting. More research is needed to better understand cessation behaviors and beliefs among adolescents to better understand these findings, including longitudinal studies that evaluate subsequent quit attempts.

This study has several strengths, including using large, national data sets from three countries, with the data weighted to draw population-level inferences. The measures were the same for both cigarettes and e-cigarettes, facilitating comparisons around the strength of associations across products. However, there are limitations to this study. First, causation cannot be concluded from these cross-sectional data, and future studies with longitudinal data will be required to confirm directionality. Another limitation is that the IMH measures have only been validated in adults at the present. However, the prevalence rates of any symptoms of depression and anxiety found by these measures are similar to population-level prevalence rates found using other measures (Horn et al., 2004), suggesting that our measurements are appropriate for the adolescent population. Furthermore, our sensitivity analyses indicate consistent results between the continuous and dichotomous version of the IMH variable.

Another possible limitation of this study is the potential effect of missingness of outcomes. While the missingness (see Supplemental Table 5) was not strongly associated with IMH symptoms, there was a tendency for more missingness among adolescents who smoked cigarettes with IMH symptoms. Therefore, it is possible that the results underestimate the effect of IMH symptoms, particularly on cigarette smoking outcomes. This study did not specifically examine changes over time; however, it should be noted that the prevalence of cigarette use and e-cigarette use varied greatly from February 2020-August 2023, likely because of the

COVID-19 pandemic and policy changes (Hackworth et al., 2025). Future research should continue to monitor how prevalence of these products changes over time among adolescents.

While some interpretations of our findings warrant further research, our results suggest that IMH problems are prevalent and comorbid with more frequent use and dependence of nicotine products, particularly e-cigarettes, in adolescents. Other studies show that smoking cessation interventions for adolescents should include coping and stress management skills, as well as mental health referral protocols (Horn et al., 2013). Indeed, stress reduction techniques that include physical activity have been found to increase smoking cessation success rates among teenagers (Horn et al., 2013) and may work for e-cigarette cessation, as well. Similarly, nicotine use prevention campaigns targeting adolescents may wish to include testimonials from individuals with IMH problems who struggle with cessation, as this type of campaign was shown to be effective (Prochaska et al., 2019). Recent campaigns from public health organizations including the Truth Initiative have begun incorporating concerns about mental health among adolescents who use nicotine products (Mental Health & Nicotine Resources, 2024), and our results support this approach.

Disclosure statement

DH has provided expert witness testimony on behalf of governments and public health authorities in legal challenges initiated by tobacco and vaping companies. All other authors have no disclosures.

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Data availability statement

Deidentified study data may be made available on request to researchers who submit a proposal that is approved by the principal investigator. Proposals should be submitted to David Hammond (dhammond@uwaterloo.ca).

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