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Trends in Mental Health Symptoms, Nicotine Product Use, and Their Association Over Time Among Adolescents in Canada, England, and the US: Findings From the ITC Adolescents Tobacco and Vaping Survey, 2020–2023

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Abstract

Introduction: There is a well-established bidirectional relationship between cigarette smoking and internalizing mental health (IMH) symptoms (eg, symptoms of depression, symptoms of anxiety). However, it is unclear whether IMH symptoms are associated with using different types or combinations of nicotine products (eg, combustible, noncombustible, exclusive product use, or multi-product use). The purpose of this study is to improve our understanding of the relationship between adolescent IMH symptoms and use of a wide variety of nicotine products by examining the association between IMH symptoms and current nicotine use from 2020 to 2023.

Aims and Methods: Data come from the 2020 to 2023 waves of the International Tobacco Control (ITC) Adolescents Tobacco and Vaping Survey, an online repeat cross-sectional survey of adolescents aged 16–19 in Canada, England, and the United States ($n = 80,427$). Current nicotine use was examined in four categories: (1) no use, (2) exclusive noncombustible product use, (3) exclusive combustible product use, and (4) use of both product types. Respondents reported current symptoms of depression or anxiety, and we generated a dichotomous IMH symptoms variable (yes vs. no). We examined the association between IMH symptoms and current nicotine use using multinomial logistic regression models that adjusted for covariates.

Results: IMH symptoms were most strongly associated with use of both product types (adjusted relative risk ratio [ARRR]: 1.91, 95% confidence interval [CI] 1.80 to 2.03), followed by exclusive noncombustible use (ARRR: 1.70, 95% CI = 1.61 to 1.80), and then exclusive combustible use (ARRR: 1.29, 95% CI = 1.21 to 1.37).

Conclusions: Adolescents with IMH symptoms are more likely to use nicotine products in general than adolescents without IMH symptoms. Specifically, noncombustible product use may have a particularly strong relationship with poor mental health among adolescents. Longitudinal research is needed to better understand directionality.

Implications: This study provides an up-to-date understanding of how mental health and nicotine use are related among adolescents, particularly during the COVID-19 pandemic and its aftermath. Results indicate that youth mental health may be related to nicotine use, particularly noncombustible use, which is largely driven by e-cigarette use. Efforts to reduce youth e-cigarette use may consider emphasizing its relationship with mental health. Efforts to promote e-cigarette use as a less harmful alternative to cigarette smoking should be aware of the association between vaping and youth mental health.

Introduction

Internalizing mental health (IMH) problems include symptoms of anxiety and depression,[1] and are highly prevalent among adolescents, but rarely diagnosed or treated until adulthood.[2] Adolescents with untreated IMH symptoms are at risk for a number of adverse outcomes, including substance use disorders and suicide,[3] which is the third leading cause of death among teenagers living in the United States (US).[4] Evidence shows that individuals suffering from IMH symptoms have life expectancies 25 years shorter than the general population, largely attributable to tobacco and other substance use.[5,6] Smoking initiation often occurs early in adolescence, with around 87% of daily smokers reporting they

tried their first cigarette before they turned 18[5] and that cessation during adolescence is rare, resulting in continued smoking into adulthood.[5] Adolescence is a key developmental stage that involves drastic physiological, psychosocial, and emotional changes.[6] These changes may increase adolescents' susceptibility to mental health conditions, and, additionally, substance use and poorer health outcomes.[7]

Smoking and IMH symptoms are related cross-sectionally[6–9] and longitudinally: some longitudinal studies finding that smoking causes IMH symptom onset,[10,11] some finding that the presence of IMH symptoms leads to smoking initiation,[12–15] and others finding a bidirectional relationship.[16–18] This research suggests that adolescent smoking may contribute to IMH symptoms, or that adolescents with IMH symptoms

may use nicotine to self-medicate for psychiatric symptoms, enhance cognitive deficits, or reduce unpleasant side effects of psychiatric medications.[19] These findings among adolescents are in line with abundant evidence of a connection between smoking and IMH symptoms in adulthood.[20]

Over the past decade, the types of nicotine products have grown beyond traditional combustible (eg, cigarettes, cigars, hookahs) and noncombustible tobacco products (eg, smokeless tobacco) to include products such as electronic cigarettes (e-cigarettes) and nicotine pouches. While use of any nicotine product involves potential health risks, noncombustible products are less harmful than combustible products,[21] since most carcinogens and other toxicants responsible for the health burden from tobacco use result from combustion.[22] Nevertheless, noncombustible products can still be harmful, including cardiovascular and respiratory effects, as well as the risk of nicotine addiction.[23] Beyond physical health, mental health effects of nicotine use may also be a concern among adolescents; however, more research is needed to better understand how mental health and nicotine use are related in this population.

While the link between smoking and IMH in adolescence is well-established, there is less evidence surrounding the potential relationship between IMH and use of newer nicotine products. Several recent, cross-sectional studies have found positive associations between IMH symptoms and e-cigarette use,[24–27] and two longitudinal studies found that IMH symptoms predicted subsequent e-cigarette use.[28,29] A few cross-sectional studies found a gradient of association, where IMH symptoms were highest in those reporting dual use, lower in those reporting exclusive cigarette use, and lowest in those reporting exclusive e-cigarette use.[30–32] Only one study has examined the relationship between IMH symptoms and nicotine products beyond cigarettes and e-cigarettes, finding that adolescents with IMH symptoms were more likely than their counterparts to subsequentially use any tobacco product when grouping all products together compared to use of no products.[33] While this study suggests that a wide variety of tobacco products beyond cigarettes and e-cigarettes may be related to IMH symptoms among adolescents, it remains unclear which types of products or combinations of products may pose the highest risk, potentially due to specific product characteristics (eg, constituents, addictiveness, additive effects on IMH symptoms). More research is needed in this area.

The recent COVID-19 pandemic has impacted both mental health and nicotine use prevalence. From 2020-2022, young people around the world experienced significant disturbances in their lives due to both the stress of living through a pandemic and social isolation from school and public shutdowns.[34] Longitudinal studies show that COVID-19 changed adolescent mental health trajectories and resulted in significant increases in symptoms of depression and anxiety.[35] By contrast, prevalence of substance use, including tobacco, declined during COVID-19,[36] likely because of reduced opportunities to access and share products during lock downs. However, as of 2022, adolescents tobacco use prevalence may be returning to pre-COVID levels or increasing.[37,38] While surveillance of youth during the acute phase of the pandemic was incomplete because of school closures, this information suggests that the COVID-19 pandemic may have had negative effects on both the mental health and tobacco use patterns of adolescents.

The purpose of this study is to improve our understanding of the relationship between adolescent IMH symptoms and use of a wide variety of nicotine products. We hypothesize that the presence of IMH symptoms will be positively associated with all categories of current nicotine use: exclusive combustible product use, exclusive noncombustible product use, and use of both product types. In line with prior research, the strength of association between the presence of IMH symptoms and current nicotine use will follow a gradient similar with that found in studies of e-cigarette, cigarette, and dual use: weakest for exclusive use of noncombustible products, followed by exclusive use of combustible products, and strongest for use of both product types. Because of the impact of the COVID-19 pandemic, we also hypothesize that the association between IMH symptoms and current nicotine use will be moderated by time, with the association weakening over the course of the COVID-19 pandemic due to worsening mental health among the general population, regardless of their nicotine use status. Finally, given differences in nicotine use and mental health in England, Canada, and the US, we hypothesize that the relationship will be moderated by country.

Methods

Data Source

The data for this study comes from the International Tobacco Control (ITC) Policy Evaluation Project Adolescents Tobacco and Vaping Survey, a repeat cross-sectional survey of national samples of adolescents in England, Canada, and the United States.[39] This study uses six waves of the ITC Adolescents Tobacco and Vaping Survey conducted between 2020 and 2023: two surveys in 2020 (February to March; August); two in 2021 (February; August); one in 2022 (August); and one in 2023 (August). Eligible participants were between the ages of 16 and 19 living in each of the three target countries. Participants were recruited from the Nielsen Consumer Insights Global Panel, with a final sample target of 4500 participants for each country at each survey. For each survey, Nielsen selected random samples from both probability and nonprobability panels in each country.

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. After reviewing information about the study and consenting to participate, eligible participants completed the survey. The survey took approximately 20 min to answer and was available in English in all countries, plus French in Canada. Participants received renumeration in accordance with the panel incentive structure, which included point-based rewards, monetary rewards, and/or chances to win monthly prizes.

Measures

Dependent variable: current use of nicotine products

Dependent Variable: Current Use of Nicotine Products. Current nicotine use measures were adapted from the Population Assessment of Tobacco and Health (PATH) study surveys.[40] Participants reported the number of days (#0–30) in the past month that they had used cigarettes and, separately, e-cigarettes. Any past month use was considered current use (yes vs. no). Current use of little cigars or cigarillos (LCCs), cigars, bidis, smokeless tobacco, hookah, and nicotine pouches were measured with a checklist for past 30-day use of each product. Using these variables, we derived the

following product use categories: no use; exclusive combustible product use (ie, cigarettes, little cigars or cigarillos, cigars, bidis, hookah); exclusive noncombustible product use (ie, e-cigarette, smokeless tobacco, nicotine pouches); or use of both product types (at least one combusted and one noncombusted product).

Independent Variable: Internalizing Mental Health Symptoms. IMH symptoms were measured using two items from the Screening Tool for Psychological Distress (STOP-D), which has been validated among adults.[41] 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, with anchors at 0 (not at all), 3 (a little), 6 (moderately), and 9 (severely). Respondents who selected "don't know" or "refused" were excluded from the analytic sample (n = 1,250).

For the present study, we examined (1) each continuous item, (2) each binary versions of these variables (ie, validated cut-points of 4 for depression symptoms and 5 for anxiety symptoms[41]), (3) a combined continuous version (averaging scores together), and (4) a binary IMH symptoms variable indicating if respondents reported above the cut point for either depression or anxiety symptoms (1) or neither (0).

Covariates

Participants indicated their age (16, 17, 18, or 19) and sex at birth: (male, 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 nonconforming (GNC)," or "Different identity," where an open response was provided. Where possible, open responses (n = 8392) were coded as man, woman, transgender, and GNC. These categories were recoded to a binary gender minority variable where responses of "man" or "woman" were coded as 0 [reference] and other responses were coded as 1 "yes." Invalid responses, responses of "Don't know," and "Refused" were coded as missing and were excluded from analyses (n = 465).

Participants provided country-specific race/ethnicity information in the survey; however, pooled analyses involved a binary race variable of "white only" vs. "other races or mixed race." Socioeconomic status (SES) was collected using a measure of perceived family SES, 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." Participants were asked which country they live in: Canada, the United States, or England, which was used as an indicator of location. For each data collection wave, a wave indicator was generated.

Analyses

In our assessment of the indictors of IMH symptoms, we found that symptoms of anxiety and symptoms of depression were strongly correlated (continuous measure $r = 0.76$, binary measure $r = 0.61$, $p < .001$). Sensitivity analyses of primary analyses with the measures as separate indicators and as a combined binary IMH symptoms variable produced

very similar results (see Supplementary Table S1); therefore, we used the binary IMH symptoms variable for ease of interpretation.

Trends in nicotine use and IMH symptoms over time were examined using simple prevalence rates and chi-square tests, adjusting for post-stratification weights. Adjusted multinomial regression models were estimated with a four-level product use dependent variable: no use [reference]; exclusive combustible product use; exclusive noncombustible product use; and use of both product types. The primary independent variable was IMH symptoms.

Interactions of IMH symptoms with wave and country were examined by creating an interaction term of *IMH symptoms × Wave* and *IMH symptoms × country* and including them in separate multinomial regression models. A global interaction test was conducted to determine whether the interaction terms were significant. Variables moderating the relationship between IMH symptoms and nicotine use were then examined by stratifying the main analyses by that variable (ie, stratifying the model estimating the association between IMH symptoms and nicotine use by wave).

All analyses adjusted for wave, gender minority status, sex, race, age, perceived family SES, and country of residence. In addition, sample weights were constructed based on population estimates for sociodemographic variables (age, sex, region in all countries; race in United States only) and past 30 day smoking (based on national estimates in United States and Canada; unavailable in England).[39] All analyses were conducted using Stata version 16.

Results

Sample Characteristics

The sample characteristics by wave are provided in Table 1. The full analytic sample (n = 80 427) was 23% age 16, 26% age 17, 30% age 18, and 21% age 19. The sample was 49% female and 51% male, with 4% of the sample reporting a gender minority identity. For race/ethnicity, 66% of respondents reported being white.

Current Nicotine Use

Prevalence of current nicotine product use by wave are shown in Table 1. Most (77%) of the sample reported no past 30-day use of any nicotine product, 9% reported exclusive noncombustible product use, 6% reported exclusive combustible product use, and 8% reported use of both product types.

Internalizing Mental Health Symptoms

When pooled across waves, 58% of the sample reported experiencing IMH symptoms in the past 30 days. By wave, 58% reported IMH symptoms in February 2020, 57% in August 2020, 64% in February 2021, 62% in August 2021, 58% in August 2022, and 51% in August 2023. Trends in IMH symptom prevalence by current nicotine use status is shown in Figure 1.

Associations between internalizing mental health symptoms and current nicotine use

In adjusted multinomial models (see Table 2), IMH symptoms were positively associated with all categories of current nicotine use compared to noncurrent use. Risk ratios appeared in a gradient, with the lowest risk for exclusive combustible product use (adjusted relative risk ratio

Table 1. Sample Characteristics of Adolescents in Canada, England, and the United States from 2020 to 2023 (*n* = 80 427)

Characteristics	Categories	Feb 2020 *n* = 13 461	Aug 2020 *n* = 14 353	Feb 2021 *n* = 13 957	Aug 2021 *n* = 13 579	Aug 2022 *n* = 12 596	Aug 2023 *n* = 12 481	Total *n* = 80,427
			n (weighted %)					
Country	Canada	4167 (30.9%)	4221 (29.4%)	4543 (32.5%)	4537 (33.4%)	4329 (34.3%)	4158 (33.2%)	25955 (32.2%)
	England	4215 (31.3%)	4215 (29.5%)	4241 (30.4%)	4251 (31.2%)	4197 (33.3%)	4201 (33.7%)	25332 (31.5%)
	United States	5079 (37.8%)	5079 (41.2%)	5173 (37.1%)	4791 (35.4%)	4070 (32.4%)	4122 (33.1%)	29140 (36.3%)
Age	16	2877 (23.7%)	3195 (23.0%)	3159 (22.2%)	2633 (22.8%)	2217 (21.7%)	2584 (23.3%)	16665 (22.8%)
	17	3108 (24.9%)	3611 (25.7%)	3951 (26.3%)	3229 (26.8%)	2915 (28.0%)	2999 (26.3%)	19813 (26.3%)
	18	4208 (30.0%)	4503 (30.9%)	4243 (31.9%)	4481 (29.7%)	4355 (30.2%)	3932 (29.6%)	25722 (30.4%)
	19	3268 (21.4%)	3044 (20.5%)	2604 (19.6%)	3236 (20.7%)	3109 (20.2%)	2966 (20.8%)	18227 (20.5%)
Sex assigned at birth	Female	8604 (48.8%)	9392 (48.9%)	9695 (48.9%)	9357 (48.9%)	8410 (48.9%)	7864 (49%)	53322 (49%)
Gender minority	Yes	307 (2.0%)	432 (2.6%)	533 (3.2%)	796 (5.0%)	774 (5.4%)	492 (3.6%)	3334 (3.6%)
Race	White	8660 (69.2%)	8429 (67.7%)	8315 (65.7%)	7513 (64.0%)	7769 (66.8%)	4781 (65.0%)	31109 (66.4%)
Perceived family socioeconomic status	Not meeting needs	765 (4.6%)	483 (3.0%)	506 (3.4%)	471 (3.1%)	687 (4.3%)	693 (4.5%)	3605 (3.8%)
	Just meeting needs	3545 (24.4%)	3302 (21.1%)	3254 (21.1%)	3195 (20.8%)	3512 (26.4%)	3640 (27.3%)	20448 (23.4%)
	Meeting needs	4329 (32.8%)	4963 (34.9%)	4532 (32.9%)	4762 (35.9%)	4147 (32.8%)	4173 (34.3%)	26906 (33.9%)
	Living comfortably	4262 (34.3%)	4890 (36.2%)	4931 (38.1%)	4508 (35.7%)	3688 (32.4%)	3451 (30.0%)	25730 (24.6%)
	No response	560 (4.0%)	715 (4.7%)	734 (4.6%)	643 (4.5%)	562 (4.1%)	524 (3.9%)	3738 (4.3%)
Depression symptoms	Yes	7508 (50.3%)	7725 (49.9%)	8591 (56.9%)	7999 (53.6%)	6959 (49.8%)	6523 (42.9%)	35542 (50.7%)
Anxiety symptoms	Yes	7085 (47.3%)	7005 (44.8%)	7829 (51.8%)	7505 (50.2%)	6566 (46.4%)	5632 (40.0%)	41622 (46.8%)
IMH symptoms	Yes	8542 (57.8%)	8838 (57.1%)	9561 (63.8%)	9111 (61.6%)	8046 (57.7%)	7008 (50.8%)	51106 (58.3%)
Current nicotine use [1]	None	9346 (74.4%)	11214 (79.3%)	10726 (78.2%)	10170 (78.1%)	8722 (73.9%)	8816 (75.8%)	58994 (76.7%)
	Exclusive combustible	1322 (9.5%)	997 (7.0%)	1216 (8.1%)	1226 (8.8%)	1572 (10.9%)	1537 (11.1%)	7870 (9.2%)
	Exclusive noncombustible	1216 (7.1%)	1071 (6.9%)	913 (6.3%)	910 (5.4%)	840 (6.5%)	771 (5.2%)	5721 (6.3%)
	Both types	1577 (9.0%)	1071 (6.8%)	1102 (7.3%)	1273 (7.7%)	1462 (8.7%)	1357 (7.9%)	7842 (7.9%)

Table displays sample characteristics by wave including country (Canada, England, or United States), age (16-19), sex assigned at birth (female, male), gender minority (yes if participants indicated a transgender or gender nonconforming identity), race (white, other races), perceived family socioeconomic status (not meeting needs, just meeting needs, meeting needs, living comfortably, or no response), symptoms of depression (yes if participants reported experiencing moderate-severe symptoms in the past 30 days), symptoms of anxiety (yes if participants reported experiencing moderate-severe symptoms in the past 30 days), internalizing mental health (IMH) symptoms (yes if participants reported either symptoms of depression or anxiety in the past 30 days), and current nicotine use (none, exclusive combustible, exclusive noncombustible, or both types).

[1]Current nicotine use includes reporting use of a nicotine product in the past 30 days. Exclusive combustible products include cigarettes, cigars, little cigars or cigarillos, bidis, and hookah. Exclusive noncombustible products include e-cigarettes, nicotine pouches, and smokeless tobacco. Both types include at least one combustible and noncombustible product. Prevalence rates are weighted.

[ARRR]: 1.29, 95% confidence interval [CI] = 1.21 to 1.37), followed by exclusive noncombustible product use (ARRR: 1.70, 95% CI = 1.61 to 1.80), and the highest risk for use of both product types (ARRR: 1.91, 95% CI = 1.80 to 2.03). Unadjusted models had the same pattern of results (see Supplemental Table S2).

Potential Moderators

Next, we added interaction terms to the adjusted multinomial models for nicotine product use to examine the moderating role of country and wave. The interaction results are shown in Supplementary Table S3. The interaction between IMH symptoms and country was statistically significant (global *F*-test *p* = .03). To better understand this interaction, we stratified our primary analyses by country (see Table 3). Patterns of association within each country were similar; however, risk ratios were highest for Canada (ie, 1.33–1.99) and lowest for the United States (ie, 1.25–1.84).

The interaction between IMH symptoms and survey wave was also statistically significant (global *F*-test *p* < .001). The component interaction is shown in Supplementary Table S3. To better understand the interaction between IMH symptoms
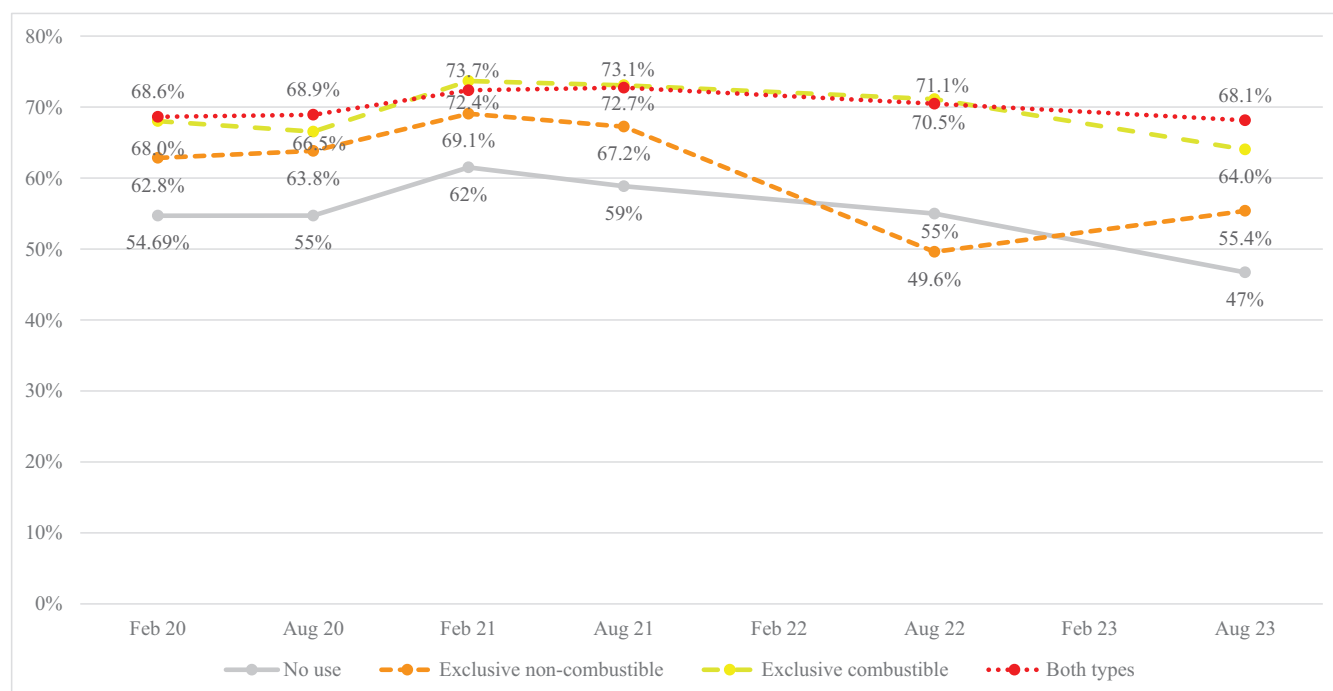
Figure 1. Trends in internalizing mental health symptom prevalence by current nicotine use (*n* = 80 427). Figure illustrates weighted prevalence of internalizing mental health symptoms by nicotine use type among adolescents in Canada, England, and the United States from 2020 to 2023. Participants with internalizing mental health (IMH) symptoms indicated experiencing either symptoms of depression or anxiety moderately severely in the past 30 days. Current nicotine use includes reporting use of a nicotine product in the past 30 days. Exclusive combustible products include cigarettes, cigars, little cigars or cigarillos, bidis, and hookah. Exclusive noncombustible products include e-cigarettes, nicotine pouches, and smokeless tobacco. Both types include at least one combustible and noncombustible product. Nonuse is the reference.

and wave, we stratified our primary analyses by wave (see Table 3). In all individual waves except for August 2022, we found the same patterns of statistically significant ARRRs for IMH symptoms and the current nicotine use categories: strongest for those who use both product types, followed by exclusive noncombustible product use, and then exclusive combustible product use. However, in August 2022, IMH symptoms were not associated with exclusive combustible product use, but were associated with exclusive noncombustible product use (ARRR: 1.80, 95% CI = 1.58 to 2.04) and use of both product types (ARRR: 1.81, 95% CI = 1.56 to 2.10). In August 2023, patterns returned to mirror those in the initial waves.

Discussion

This study found that the presence of IMH symptoms is associated with current nicotine use among adolescents, adding to the robust literature of the strong association between IMH problems and cigarette smoking[6–18] and more recently developing literature finding a link between IMH problems and e-cigarette use.[24–32] This finding also aligns with the study of IMH problems and multiple tobacco products.[33]

When examining the relationship between IMH symptoms and nicotine use categorized by combustibility, this study provides evidence of a gradient where IMH symptoms are most likely among adolescents using both combustible and noncombustible products, second most likely among those using exclusively noncombustible products, and least likely among those using exclusively combustible products. However, all groups were more likely to report IMH symptoms compared to adolescents not currently using any

nicotine product. This differs from previous studies and our hypothesis that dual use and exclusive cigarette use would be associated with a higher risk for IMH problems compared exclusive e-cigarette use.[30–32] These studies were conducted prior to 2020, so perhaps the relationship between e-cigarette use and IMH symptoms has changed. Indeed, our results suggest that noncombustible product use, largely driven by e-cigarette use, may increase the risk of IMH problems beyond that of combustible product use. Another possible explanation is that adolescents using noncombustible products may be more nicotine dependent than those using combustible products, given that noncombustible products are easier to conceal,[42,43] may have greater nicotine dosage,[42,44,45] or are advertised via media channels like social media that are used more frequently by those with IMH problems.[46] More research is needed to replicate and better understand this finding.

We found evidence of moderation between both country and IMH symptoms and survey wave and IMH symptoms. When stratifying the results by country, we found very similar results across the countries, with slightly different strengths of association. This suggests that the association between IMH symptoms and nicotine use is generally consistent across the three countries. In recent years, many countries have implemented policies to reduce combustible tobacco use (e.g., taxes, smoke-free policies, sales and marketing restrictions).[47] By contrast, a few countries have adopted harm reduction policies, such as in the United Kingdom,[48] that promote switching to e-cigarettes as a lower risk alternative for adults who smoke and want to quit. E-cigarette use has remained relatively stable or decreased in countries without such policies (i.e., Canada and United States).[37,38] Given these differences, future studies may wish to examine specific country-level

Table 2. Correlates of Current Nicotine Use Among Adolescents in Canada, England, and the United States from 2020 to 2023 (*n* = 80 427)

	Category	Nonuse (*n* = 58 994)	Exclusive combustible (*n* = 5721)		Exclusive noncombustible (*n* = 7870)		Both (*n* = 7842)	
		%	%	ARRR(95% CI)[1]	%	ARRR(95% CI)[1]	%	ARRR(95% CI)[1]
IMH Symptoms	No	44.6	38.4	Ref	30.7	Ref	29.8%	Ref
	Yes	55.4	61.6	**1.29 (1.21–1.37)*****	69.3	**1.70 (1.61–1.80)*****	70.2%	**1.91 (1.80–2.03)*****
Wave	Feb 20	16.2	19.1	Ref	17.4	Ref	19.0	Ref
	Aug 20	18.4%	19.5	0.95 (0.86–1.04)	13.7	**0.71 (0.65–0.77)*****	15.5	**0.76 (0.69–0.83)*****
	Feb 21	17.7	17.6	**0.86 (0.78–0.95)****	15.4	**0.81 (0.74–0.88)*****	16.1	**0.79 (0.72–0.86)*****
	Aug 21	17.2	14.5	**0.73 (0.66–0.80)*****	16.3	**0.91 (0.84–0.99)***	16.6	**0.84 (0.77–0.92)*****
	Aug 22	15.1	16.3	**0.89 (0.80–0.98)***	18.6	**1.17 (1.08–1.28)*****	17.3	0.96 (0.88–1.05)
	Aug 23	15.4	13.0	**0.70 (0.63–0.78)*****	18.8	**1.21 (1.12–1.32)*****	15.6	**0.89 (0.81–0.97)****
Country	Canada	32.8	27.6	Ref	33.4	Ref	28.5	Ref
	England	29.4	49.4	**1.98 (1.84–2.12)*****	25.7	**0.78 (0.73–0.83)*****	44.1	**1.64 (1.54–1.75)*****
	United States	27.7	23.0	**0.69 (0.64–0.75)*****	40.9	1.00 (0.94–1.06)	27.4	**0.78 (0.73–0.84)*****
Age	16	24.5	16.7	Ref	17.1	Ref	17.3	Ref
	17	27.3	25.0	**1.38 (1.26–1.51)*****	22.7	**1.16 (1.07–1.25)*****	21.8	**1.14 (1.05–1.24)****
	18	29.3	32.4	**1.57 (1.44–1.72)*****	35.3	**1.64 (1.53–1.76)*****	33.8	**1.53 (1.42–1.65)*****
	19	18.9	25.8	**2.01 (1.84–2.21)*****	24.9	**1.75 (1.62–1.89)*****	27.1	**1.92 (1.77–2.09)*****
Sex	Female	49.3	41.0	Ref	56.3	Ref	42.9	Ref
	Male	50.8	59.0	**1.54 (1.45–1.63)*****	43.7	**0.86 (0.82–0.91)*****	57.1	**1.56 (1.47–1.64)*****
Gender minority	No	96.0	96.1	Ref	95.8	Ref	95.0	Ref
	Yes	3.5	3.4	1.05 (0.89–1.23)	3.7	**0.80 (0.70–0.92)****	4.4	**1.17 (1.03–1.34)***
Race	White	64.7	67.6	Ref	74.8	Ref	72.2	Ref
	Other	34.2	31.1	**0.87 (0.82–0.93)*****	24.4	**0.56 (0.53–0.60)*****	26.8	**0.67 (0.63–0.71)*****
Perceived family SES	Not meeting needs	3.0	6.6	Ref	5.0	Ref	8.4	Ref
	Just meeting needs	21.9	28.8	**0.56 (0.49–0.63)*****	27.0	**0.77 (0.68–0.87)*****	29.4	**0.47 (0.42–0.52)*****
	Meeting needs	34.7	30.8	**0.38 (0.33–0.43)*****	33.0	**0.62 (0.55–0.70)*****	30.0	**0.31 (0.28–0.35)*****
	Living comfortably	35.8	30.2	**0.36 (0.32–0.41)*****	31.5	**0.59 (0.52–0.67)*****	30.0	**0.31 (0.28–0.34)*****
	No response	4.7	3.7	**0.34 (0.28–0.41)*****	3.5	**0.54 (0.45–0.64)*****	2.3	**0.19 (0.16–0.23)*****

Table displays correlates of current nicotine use among adolescents in Canada, England, and the United States from 2020 to 2023. Current nicotine use includes reporting use of a nicotine product in the past 30 days. Exclusive combustible products include cigarettes, cigars, little cigars or cigarillos, bidis, and hookah. Exclusive noncombustible products include e-cigarettes, nicotine pouches, and smokeless tobacco. Both types include at least one combustible and noncombustible product. Nonuse is the reference.
Potential correlates include country (Canada, England, or United States), age (16–19), sex assigned at birth (female, male), gender minority (yes if participants indicated a transgender or gender nonconforming identity), race (white, other races), perceived family socioeconomic status (SES) (not meeting needs, just meeting needs, meeting needs, living comfortably, or no response), and internalizing mental health (IMH) symptoms (yes if participants reported either symptoms of depression or anxiety moderately-severely in the past 30 days).
ARRR = adjusted relative risk ratio; CI = confidence interval.
[1]ARRRs were estimated in multinomial regression model with current nicotine use (ref = no use) as the outcome. Model adjusted for IMH symptoms, wave, country, age, sex, gender identity, race, and SES.
Bold indicates statistical significance. *p* < .05:*, *p* < .01:**, *p* < .001: *** All models and prevalence rates are weighted.

differences in nicotine use prevalence and the strength of association with IMH symptoms.

In terms of survey wave, we found that the relationship between IMH symptoms and nicotine use was moderated by time. When examining the analyses stratified by wave, we found that the strength of association between IMH symptoms and all types of nicotine use was positive for all waves except for exclusive combustible use in August 2022. Indeed, there was no association between IMH symptoms and exclusive combustible use in August of 2022. However, the results for August 2023 were the same as all previous waves, suggesting that the change in August 2022 was temporary and has resolved; however, these findings may also be due to statistical error or chance. Still, our findings suggest that the association between IMH symptoms and combustible nicotine use needs to be monitored, as this shift could

signal a possible change. For example, perhaps adolescents who have IMH symptoms are shifting towards noncombustible products for a variety of reasons, including that they are better able to satisfy their nicotine cravings, they are easier to use discreetly, they are cheaper than cigarettes, they are more socially acceptable, or because of advertising for e-cigarettes targeting adolescents. Research is needed to understand the relationship between IMH symptoms and nicotine dependence of e-cigarette and dual use. Longitudinal research may be needed to understand whether people with IMH symptoms are more likely to escalate use or whether people who use start to express IMH symptoms, perhaps because they are becoming dependent and experience withdrawal symptoms. Future studies should also examine if the relationship between IMH symptoms and nicotine use is moderated by other characteristics, such as sociodemographic characteristics that

Table 3. Association Between Internalizing Mental Health Symptoms and Current Nicotine Use Stratified by Wave and Country Among Adolescents from Canada, England, and the United States from 2020 to 2023 (*n* = 80 427)

Strata	IMH symptoms	Exclusive combustible use		Exclusive noncombustible use		Both	
		RRR (95% CI)	*ARRR(95% CI)[1]*	*RRR (95% CI)*	*ARRR(95% CI)[1]*	*RRR (95% CI)*	*ARRR(95% CI)[1]*
Stratified by wave							
February 2020 (*n* = 13 461)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.40 (1.22–1.61)***	1.22 (1.05–1.41)**	1.76 (1.56–1.99)***	1.67 (1.46–1.90)***	1.81 (1.59–2.06)***	1.89 (1.65–2.17)***
August 2020 (*n* = 14 353)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.46 (1.28–1.67)***	1.45 (1.25–1.67)***	1.65 (1.44–1.89)***	1.60 (1.39–1.85)***	1.84 (1.60–2.11)***	1.98 (1.71–2.29)***
February 2021 (*n* = 13 957)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.40 (1.21–1.62)***	1.39 (1.19–1.63)***	1.75 (1.53–2.01)***	1.59 (1.38–1.84)***	1.63 (1.42–1.89)***	1.63 (1.40–1.89)***
August 2021 (*n* = 13 579)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.44 (1.22–1.68)***	1.47 (1.24–1.73)***	1.90 (1.66–2.17)***	1.82 (1.58–2.09)***	1.87 (1.62–2.15)***	2.00 (1.73–2.32)***
August 2022 (*n* = 12 596)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	0.81 (0.70–0.93)**	0.95 (0.81–1.11)	2.02 (1.78–2.28)***	1.80 (1.58–2.05)***	1.95 (1.71–2.24)***	1.82 (1.57–2.10)***
August 2023 (*n* = 12 481)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.39 (1.19–1.61)***	1.39 (1.18–1.65)***	2.04 (1.82–2.29)***	1.73 (1.53–1.96)***	2.40 (2.12–2.72)***	2.20 (1.90–2.56)***
Stratified By Country							
Canada (*n* = 25 955)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.29 (1.16–1.45)***	1.33 (1.18–1.50)***	1.96 (1.79–2.15)***	1.81 (1.65–2.00)***	2.00 (1.79–2.22)***	1.99 (1.78–2.23)***
England (*n* = 25 332)	No	Ref	Ref	Ref	Ref	Ref	Ref
	Yes	1.27 (1.17–1.39)***	1.28 (1.17–1.41)***	1.63 (1.47–1.80)***	1.63 (1.46–1.81)***	1.95 (1.78–2.12)***	1.94 (1.77–2.13)***
United States (*n* = 29 140)	No	Ref	ref	ref	Ref	Ref	Ref
	Yes	1.26 (1.11–1.42)***	1.25 (1.10–1.42)**	1.85 (1.70–2.00)***	1.68 (1.54–1.83)***	1.67 (1.51–1.85)***	1.84 (1.65–2.05)***

Table displays association between internalizing mental health (IMH) symptoms and current nicotine use among adolescents in Canada, England, and the United States from 2020 to 2023, stratified by survey wave and country. Current nicotine use includes reporting use of a nicotine product in the past 30 days. Exclusive combustible products include cigarettes, cigars, little cigars or cigarillos, bidis, and hookah. Exclusive noncombustible products include e-cigarettes, nicotine pouches, and smokeless tobacco. Both types include at least one combustible and noncombustible product. Nonuse is the reference. Participants with internalizing mental health (IMH) symptoms indicated experiencing either symptoms of depression or anxiety moderately-severely in the past 30 days.
Models adjust for country (Canada, England, or United States), age (16–19), sex assigned at birth (female, male), gender minority (yes if participants indicated a transgender or gender nonconforming identity), race (white, other races), and perceived family socioeconomic status (SES) (not meeting needs, just meeting needs, meeting needs, living comfortably, or no response).
RRR = relative risk ratio; ARRR = adjusted relative risk ratio; CI = confidence interval; IMH = internalizing mental health.
[1]ARRRs were estimated in multinomial regression model with current nicotine use (ref = no use) as the outcome.
Bold indicates statistical significance. *p* <.05: *, *p* < .01: **, *p* < .001: *** All models and prevalence rates are weighted.

we found were correlated of nicotine use, including gender identity, race, and SES.

This study has several strengths, including using a large, national data set from three separate countries, over multiple survey waves. The consistent results between the countries suggest that the relationship between nicotine use and IMH symptoms is consistent across geography, culture, and policy contexts. There are several limitations to this study. First, as this is cross-sectional data, causation cannot be concluded from these results. Future studies of these relationships may

use longitudinal data to confirm directionality. Regardless of the directionality of the association, the strong relationship between nicotine use and IMH symptoms found in this study is cause for concern. It is apparent that use of nicotine resulting in IMH symptoms is a problem. However, it is also concerning in the other direction (ie, IMH symptoms resulting in nicotine use). Some research indicates that people with mental health problems may use nicotine to manage IMH symptoms[19]; however, in our cross-sectional study, our measure of current IMH symptoms, as opposed to IMH diagnosis, being associated with current nicotine use suggests that if this is the case, the management of symptoms using nicotine may not be effective. Indeed, the standard of care of IMH conditions among adolescents is well-established and involves cognitive-behavioral therapy or interpersonal therapy, pharmacological treatment of selective serotonin reuptake inhibitors, or a combination of both.[49] Furthermore, tobacco cessation interventions for adolescents are effective at reducing tobacco use among adolescents and have been found to result in improved mental health.[50]

Another limitation of this study is that the IMH measure has only been validated in adults at the present. However, the prevalence rates of symptoms of depression and anxiety found by these measures are similar to population-level prevalence rates found using other measures.[51] Furthermore, given that diagnoses of IMH conditions does not occur until adulthood for most people,[2] measuring self-reported experiences with common IMH symptoms (ie, feeling depressed, feeling worried) appears to be a reasonable way to measure IMH symptoms in adolescents. Additionally, these measures cannot distinguish whether the respondents are suffering from acute or chronic mental health symptoms, which may have differential impact on their reasons for and perceived benefit of their nicotine use. Future studies should explore how youth use nicotine and other substances differently based on the patterns of IMH symptoms and appropriately inform tailored nicotine cessation interventions.

Overall, this study describes the relationship between IMH symptoms and nicotine use among adolescents in three countries before, during, and after the acute phase of the COVID-19 pandemic. Findings suggest that nicotine use remains a potential risk factor for IMH problems among this population. Indeed, the likelihood of IMH problems was highest for e-cigarettes, which have replaced combusted cigarettes as the most popular nicotine product among adolescents in Canada, England, and the US. This study highlights a need to address both the high nicotine use rates among adolescents in all three countries, and the widespread mental health challenges confronting adolescents.

Supplementary material

Supplementary material is available at *Nicotine and Tobacco Research* online.

Funding

Declaration of Interests

JFT and DH have served as expert witnesses on behalf of governments in litigation involving the tobacco industry. The remaining authors declare that they do not have any conflicts of interest.

Data availability

Data are available on reasonable request. Deidentified data will be made available to researchers who provide a methodologically sound proposal for use in achieving the goals of the approved proposal. Proposals should be submitted to DH (dhammond@uwaterloo.ca).

Author Contributions

Emily Hackworth (Conceptualization [lead], Formal analysis [lead], Validation [lead], Visualization [lead], Writing—original draft [lead]), Dèsirée Vidaña-Pérez (Writing—review & editing [equal]), Riley O'Neal (Formal analysis [Supporting], Writing—review & editing [equal]), Minji Kim (Writing—review & editing [equal]), Jennifer Fillo (Writing—review & editing [equal]), David Hammond (Data curation [equal], Funding acquisition [equal], Project administration [equal], Resources [equal], Writing—review & editing [equal]), and James Thrasher (Conceptualization [Supporting], Supervision [equal], Writing—review & editing [equal])

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