

structure, the LLM was unable to reliably identify confidential content in free-text notes. Study limitations include the subjective nature of confidential adolescent content and use of only 1 site as a data source.

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ADOLESCENT MENTAL HEALTH

Substance Use, Suicidal Thoughts, and Psychiatric Comorbidities Among High School Students

Adolescents who use substances have more psychiatric symptoms than peers who do not use.^{1,2} There are, however, conflicting findings on whether various substances have unique or nonspecific associations with co-occurring psychiatric

symptoms.^{2,3} Similarly, dose dependence of these associations and presence of increased psychiatric symptoms among adolescents with infrequent use are debated.¹ With increasing rates of adolescent mental health-related problems, particularly suicide,^{4,5} clarification on these issues is needed to inform screening, prevention and intervention, and policy.⁶ We examined associations between common substances and psychiatric symptoms among adolescents.

Methods | Two large, independent surveys of high school students provided study samples. The first sample included students from 36 Massachusetts high schools who com-

+ Supplemental content

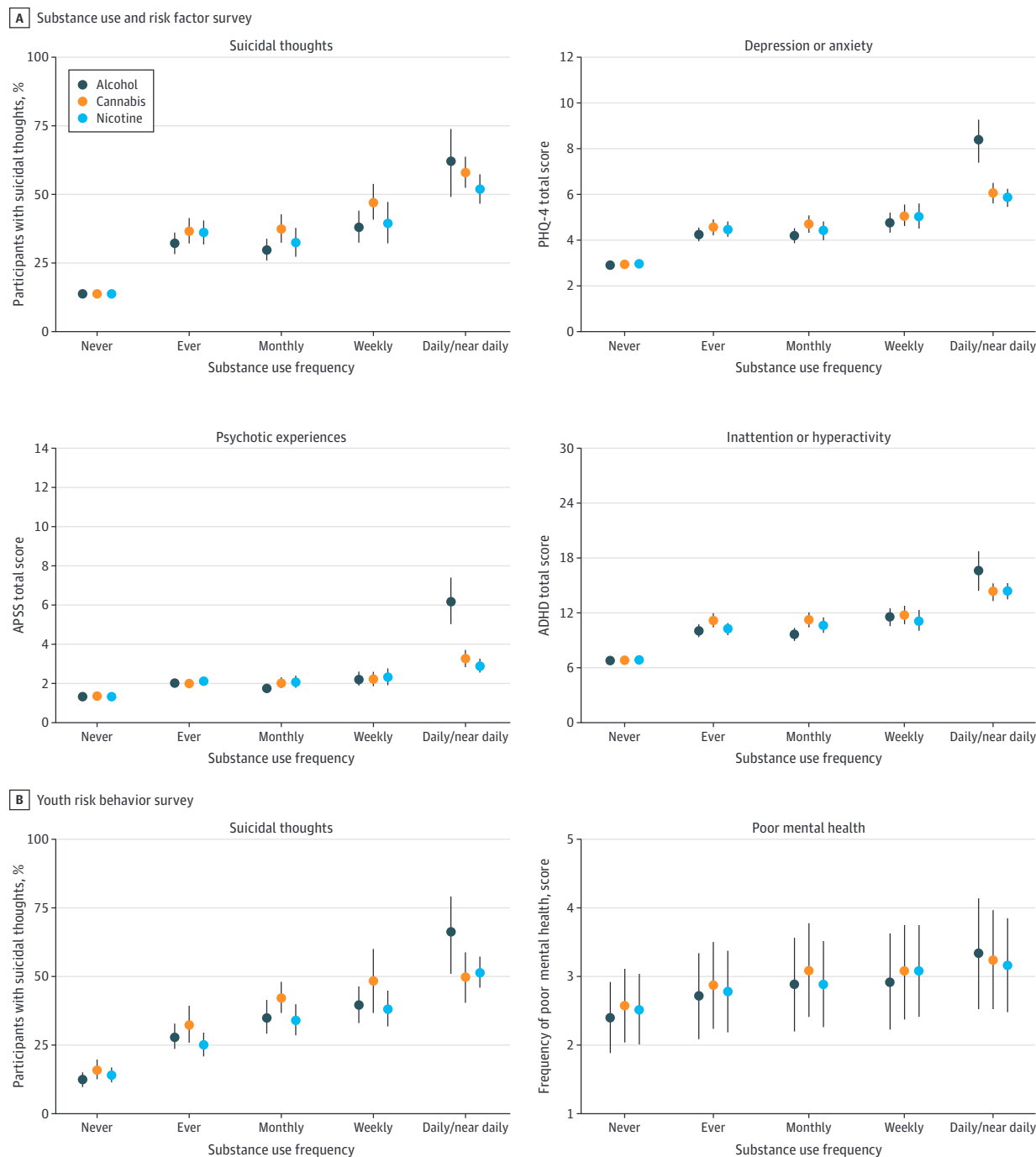
pleted the 2022-2023 Substance Use and Risk Factor (SURF) Survey. SURF participants self-reported on substance use, including lifetime and past-month alcohol, cannabis, and nicotine use (aggregated nicotine vaping, cigarette, and cigar use), and psychiatric symptoms, including past-year suicidal thoughts and current depressive or anxiety symptoms, psychotic experiences, and inattention or hyperactivity. To replicate the regional sample results in a national sample, we analyzed analogous self-reported items from the 2021 Youth Risk Behavior Survey (YRBS), including lifetime and past-month alcohol, cannabis, and nicotine use; past-year suicidal thoughts; and past-month overall mental health. The Massachusetts General Brigham Institutional Review Board approved the SURF Project and deemed the replication analyses of YRBS data exempt from review as they used deidentified data. We followed the [STROBE](#) reporting guideline.

Substance use frequency was categorized as never, ever but noncurrent, monthly, weekly, and daily or near-daily use (eTables 1 and 2 in [Supplement 1](#)). Statistical models were adjusted for age and sex and accounted for outcome and sample-specific criteria. The eAppendix in [Supplement 1](#) provides additional details on methods.

To assist in interpretation, effect sizes on original scale units were calculated as the difference between model estimates of successive levels of substance use (Δ). Multilevel models, via the `glmmTMB` package in R 4.1.2 (R Core Team), were used in SURF analyses. Primary YRBS analyses were performed with survey package in R 4.1.2. All tests were 2-sided, with $P < .05$ (false discovery rate-corrected) as the significance threshold.

Results | Samples comprised 15 626 SURF participants (7231 males [46.3%], 8344 females [53.4%]; mean [SD] age, 15.75 [1.23] years) and 17 232 YRBS participants (8816 males [51.2%], 8152 females [47.3%]; mean [SD] age, 15.67 [1.22] years). Alcohol, cannabis, and nicotine use each had significant, moderate dose-dependent associations with worse psychiatric symptoms, including suicidal thoughts in SURF and YRBS (eg, alcohol: Δ , 10.11 and 12.83; $P < .001$), depressive or anxiety symptoms (eg, alcohol: Δ , 1.38; $P < .001$), and inattention or hyperactivity (eg, alcohol: Δ , 2.18; $P < .001$) in SURF, and general mental health in YRBS (eg, alcohol: Δ , 0.21; $P < .001$) (**Figure, Table**). In pairwise comparisons, ever use vs never use of each substance was associated with

Figure. Associations Between Substance Use Frequency and Self-Reported Mental Health Symptoms in 2 Independent Samples of Adolescents



Depression or anxiety was assessed with Patient Health Questionnaire-4 (PHQ-4); psychotic experiences, with Adolescent Psychotic-Like Symptom Screener (APSS); and inattention or hyperactivity, with *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition) attention-deficit/hyperactivity

disorder (ADHD) symptoms. Measure of center (dots) and 95% CIs (error bars) were estimated from statistical models that accounted for outcome and sample-specific criteria (Supplement 1). The Table provides associated statistics.

higher psychiatric symptoms for all symptom measures in SURF and YRBS (eg, cannabis with suicidal thoughts: Δ , 22.87 [95% CI, 19.09-26.64] and 16.47 [95% CI, 12.15-20.79]; $P < .001$). Daily or near-daily use vs ever use was consistently associated with moderate increases in symptoms (eg,

alcohol with suicidal thoughts: Δ , 30.34 [95% CI, 18.03-42.64] and 38.49 [95% CI, 25.65-51.33]; $P < .001$), whereas weekly or monthly use was not (eg, monthly alcohol with suicidal thoughts: Δ , -2.40 [95% CI, -5.74 to 0.95; $P = .19$] and 7.02 [95% CI, 3.65 to 10.39; $P < .001$]).

Table. Dose Associations and Pairwise Differences Among Substances and Mental Health Symptoms in 2 Independent Samples of Adolescents^a

	Dose association ^b Difference, Δ ^c	Pairwise difference between substance use frequency		P value ^d	Ever vs never Difference, Δ (95% CI) ^c	Monthly vs ever		P value ^d	Weekly vs ever Difference, Δ (95% CI) ^c	P value ^d	Daily or near-daily vs ever	
		Difference, Δ (95% CI) ^c	P value ^d			Difference, Δ (95% CI) ^c	P value ^d				Difference, Δ (95% CI) ^c	P value ^d
SURF Survey												
Suicidal thoughts ^e												
Alcohol	10.11	<.001	18.19 (15.46 to 20.92)	<.001	18.19 (15.46 to 20.92)	<.001	-2.40 (-5.74 to 0.95)	.19	6.08 (0.77 to 11.38)	.03	30.34 (18.03 to 42.64)	<.001
Cannabis	7.15	<.001	22.87 (19.09 to 26.64)	<.001	22.87 (19.09 to 26.64)	<.001	0.56 (-4.85 to 5.97)	.85	10.37 (3.80 to 16.94)	.003	21.44 (15.43 to 27.45)	<.001
Nicotine	5.30	<.001	22.00 (18.59 to 25.41)	<.001	22.00 (18.59 to 25.41)	<.001	-3.69 (-8.97 to 1.59)	.20	3.39 (-4.03 to 10.82)	.39	15.91 (10.67 to 21.15)	<.001
Depressive or anxiety symptoms ^f												
Alcohol	1.38	<.001	1.32 (1.14 to 1.50)	<.001	1.32 (1.14 to 1.50)	<.001	-0.04 (-0.28 to 0.20)	.76	0.53 (0.15 to 0.91)	.008	4.15 (3.22 to 5.07)	<.001
Cannabis	0.50	<.001	1.60 (1.35 to 1.86)	<.001	1.60 (1.35 to 1.86)	<.001	0.13 (-0.26 to 0.51)	.54	0.50 (0.04 to 0.96)	.04	1.50 (1.06 to 1.95)	<.001
Nicotine	0.46	<.001	1.52 (1.29 to 1.74)	<.001	1.52 (1.29 to 1.74)	<.001	-0.06 (-0.44 to 0.33)	.80	0.56 (0.03 to 1.10)	.047	1.37 (0.99 to 1.75)	<.001
Psychotic experiences ^g												
Alcohol	1.37	<.001	0.70 (0.57 to 0.84)	<.001	0.70 (0.57 to 0.84)	<.001	-0.26 (-0.44 to -0.09)	.004	0.17 (-0.12 to 0.46)	.26	4.11 (2.96 to 5.27)	<.001
Cannabis	0.42	<.001	0.63 (0.45 to 0.82)	<.001	0.63 (0.45 to 0.82)	<.001	0.02 (-0.25 to 0.29)	.89	0.23 (-0.11 to 0.56)	.20	1.26 (0.89 to 1.64)	<.001
Nicotine	0.26	<.001	0.78 (0.61 to 0.95)	<.001	0.78 (0.61 to 0.95)	<.001	-0.04 (-0.32 to 0.24)	.80	0.19 (-0.21 to 0.59)	.36	0.79 (0.48 to 1.10)	<.001
Inattention or hyperactivity ^h												
Alcohol	2.18	<.001	3.17 (2.79 to 3.54)	<.001	3.17 (2.79 to 3.54)	<.001	-0.35 (-0.86 to 0.15)	.20	1.52 (0.72 to 2.32)	<.001	6.54 (4.44 to 8.65)	<.001
Cannabis	1.05	<.001	4.30 (3.76 to 4.84)	<.001	4.30 (3.76 to 4.84)	<.001	0.08 (-0.74 to 0.89)	.86	0.60 (-0.36 to 1.56)	.25	3.14 (2.21 to 4.07)	<.001
Nicotine	1.40	<.001	3.33 (2.86 to 3.80)	<.001	3.33 (2.86 to 3.80)	<.001	0.46 (-0.34 to 1.26)	.28	0.93 (-0.15 to 2.02)	.11	4.20 (3.40 to 4.99)	<.001
YRBS												
Suicidal thoughts ^e												
Alcohol	12.83	<.001	15.58 (12.68 to 18.48)	<.001	15.58 (12.68 to 18.48)	<.001	7.02 (3.65 to 10.39)	<.001	11.62 (6.84 to 16.40)	<.001	38.49 (25.65 to 51.33)	<.001
Cannabis	5.80	<.001	16.47 (12.15 to 20.79)	<.001	16.47 (12.15 to 20.79)	<.001	9.87 (6.28 to 13.47)	<.001	16.11 (7.41 to 24.81)	<.001	17.40 (10.35 to 24.45)	<.001
Nicotine	8.85	<.001	10.95 (8.17 to 13.73)	<.001	10.95 (8.17 to 13.73)	<.001	9.10 (5.37 to 12.82)	<.001	13.18 (7.37 to 19.00)	<.001	26.56 (22.08 to 31.04)	<.001
Poor mental health ⁱ												
Alcohol	0.21	<.001	0.31 (0.19 to 0.43)	<.001	0.31 (0.19 to 0.43)	<.001	0.17 (0.09 to 0.25)	<.001	0.21 (0.09 to 0.33)	<.001	0.62 (0.36 to 0.88)	<.001
Cannabis	0.12	<.001	0.30 (0.19 to 0.40)	<.001	0.30 (0.19 to 0.40)	<.001	0.22 (0.12 to 0.32)	<.001	0.19 (0.05 to 0.34)	.01	0.37 (0.24 to 0.50)	<.001
Nicotine	0.12	<.001	0.27 (0.18 to 0.36)	<.001	0.27 (0.18 to 0.36)	<.001	0.10 (0.02 to 0.19)	.02	0.30 (0.17 to 0.42)	<.001	0.37 (0.26 to 0.49)	<.001

Abbreviations: SURF, Substance Use and Risk Factor; YRBS, Youth Risk Behavior Survey.

^a Estimates and significance testing via marginal means from statistical models that accounted for outcome and sample-specific criteria (eAppendix in Supplement 1). Group means are shown in the Figure.

^b Significance testing of dose association via a post hoc linear contrast among levels of use groups (ie, ever, monthly, weekly, daily or near-daily).

^c Mean difference in original scale units between successive levels of use.

^d P values were corrected for multiple comparison using false discovery rate, with P < .05 serving as the threshold for significance.

^e Past-year suicidal thoughts of percentage of participants; score range: 0%-100%, with higher scores indicating more participants with suicidal thoughts.

more participants with suicidal thoughts.
^f Assessed using Patient Health Questionnaire-4; total score range: 0-12, with higher scores indicating more severe depressive or anxiety symptoms.

^g Assessed using Adolescent Psychotic-Like Symptom Screener; total score range: 0-14, with higher scores indicating more psychosis risk.

^h Assessed using *Diagnostic and Statistical Manual of Mental Disorders* (Fifth Edition)-endorsed attention-deficit/hyperactivity disorder symptoms; score range: 0-30, with higher scores indicating more severe inattention or hyperactivity symptoms.

ⁱ Frequency of poor mental health in the past 30 days; score range, 1 (never) to 5 (always).

Discussion | Adolescent substance use had a dose-dependent association with past-year suicidal thoughts and other psychiatric symptoms. Findings do not support hypotheses linking a single substance to a single psychiatric symptom. This pattern of multiple substances associated with multiple psychiatric comorbidities emphasizes transdiagnostic and comprehensive psychiatric screening, intervention and prevention, and policy for adolescents with substance use involvement.¹ Due to associations between increasing use of all substances and higher psychiatric symptoms and because higher psychiatric symptoms could be seen among adolescents with relatively low levels of use, clinical efforts across the spectrum of substance use severity may be warranted. Additionally, high-frequency use was associated with greater psychiatric symptoms, providing an opportunity for targeted approaches.

Study limitations include use of cross-sectional self-report. Although replicated across 2 data sets, such data cannot show directionality between substance use and psychiatric symptoms and need longitudinal and additional validated measures. Future work may also seek to personalize these associations toward individual-level factors (eg, age, sex).

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ARTIFICIAL INTELLIGENCE AND PEDIATRIC CARE

Diagnostic Accuracy of a Large Language Model in Pediatric Case Studies

The capacity of large language models (LLMs) to process information and provide users with insights from vast amounts of data makes the technology well suited for algorithmic problem-solving. A recent study¹ investigated the diagnostic accuracy of ChatGPT version 4 and found that the artificial intelligence (AI) chatbot rendered a correct diagnosis in 39% of *New England Journal of Medicine (NEJM)* case challenges. This suggests LLM-based chatbots could be used as a supplementary tool for clinicians in diagnosing and developing a differential list for complex cases. To our knowledge, no research has explored the accuracy of LLM-based chatbots in solely pediatric scenarios, which require the consideration of the patient's age alongside symptoms. We assessed this accuracy across *JAMA Pediatrics* and *NEJM* pediatric case challenges.

Methods | *JAMA Pediatrics* and the *NEJM* were accessed for pediatric case challenges (N = 100). The text from each case was pasted into ChatGPT version 3.5 with the prompt *List a*