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RESEARCH ARTICLE**Marijuana and Alcohol Use as Predictors of Academic Achievement: A Longitudinal Analysis Among Youth in the COMPASS Study**

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ABSTRACT

BACKGROUND

We tested the effect of initiating marijuana and alcohol use at varying frequencies on academic indices.

METHODS

In a sample of 26,475 grade 9-12 students with at least 2 years of linked longitudinal data from year 1 (Y1: 2012-2013), year 2 (Y2: 2013-2014), and year 3 (Y3: 2014-2015) of the COMPASS study, separate multinomial generalized estimating equations models tested the likelihood of responses to measures of academic goals, engagement, preparedness, and performance when shifting from never using alcohol or marijuana at baseline to using them at varying frequencies at follow-up.

RESULTS

Students who began using alcohol or marijuana were less likely to attend class regularly, complete their homework, achieve high marks, and value good grades, relative to their abstaining peers. Changing from abstaining to rare/sporadic-to-weekly drinking or rare/sporadic marijuana use predicted aspirations to continue to all levels of higher education, and initiating weekly marijuana use increased the likelihood of college ambitions, while more regular marijuana use reduced the likelihood of wanting to pursue graduate/professional degrees, over high school.

CONCLUSIONS

The importance of delaying or preventing substance use is evident in associations with student performance and engagement. The influence on academic goals varied by substance and frequency of initiated use.

Over the past 5 years, adolescent marijuana use has increased, coinciding with reductions in the number perceiving it as harmful.[1] Similar shifts in adult views are evident in the growing support for legalization. However, medical and scientific communities continue to debate its safety.[2] A general consensus exists on the greater vulnerability for adverse consequences among youth.[2-4] Imminent drug policy changes highlight the pressing need to understand the risks. To date, research on legal substances (ie, alcohol and tobacco) far exceeds that of marijuana. Of particular concern are potential detrimental effects on cognitive development and educational achievement.[2, 5-7] Deterrents to academic pursuits have critical implications for future career opportunities and successful transitions to adulthood.

Cross-sectional analyses consistently support negative associations between marijuana use and various indices of student performance, including grades, classroom participation, degree attainment, time spent studying, and attitudes toward school.[3, 5, 8-11] Similarly, a number of prospective studies found marijuana use to predict degree nonattainment.[3, 5, 6, 8, 12] Early initiation of use, in particular, is related to absenteeism and a lower likelihood of postsecondary education.[6, 13] However, other longitudinal reports have mixed results, with some suggesting the reverse. That is, school achievement and engagement appears protective for later substance use.[14, 15] In light of conflicting findings, many researchers argue causality conclusions are premature and call for further longitudinal research.[6, 7, 16]

Various theories have been proposed to account for the association. The predominant hypothesis entails a direct causal model, where marijuana use leads to cognitive or motivational deficits.[3] The human brain is still actively developing until the early 20s, and experts warn substance use prior to this age may impair neuropsychological functioning.[2-4] Adults who smoked the drug regularly during adolescence exhibit reduced neural connectivity in regions responsible for memory, learning, and inhibitory control.[2] Acute effects also have the potential to impact school performance. Short-term marijuana use disrupts attention and working memory, rendering learning and information retention difficult.[2, 9, 17] Other researchers theorize marijuana induces an “amotivational syndrome,” although its occurrence appears rare and only with heavy and prolonged use.[3, 8] Empirical support for causal mechanisms remains equivocal.[3, 8, 18]

Drawing conclusions from the available literature is complicated by varying classifications of marijuana use, and the tendency to use dichotomous variables. Often, the quantity of use present in samples is likely insufficient to have the proposed effects.[3] The dose, frequency, duration, and timing of use appear to determine the magnitude and persistence of neurological damage.[19] In terms of academic achievement, existing evidence of a dose-response relationship is mixed. Compared with abstainers, some studies indicate only frequent or heavy trajectories of use had deleterious consequences,[7, 20] whereas conflicting reports show even experimental/sporadic use predicted worse performance and early school leaving.[5, 10, 21] These latter studies suggest the association cannot be attributed to drug use alone.[5, 6, 21]

According to *common causes* hypotheses, shared underlying risk factors predispose individuals to both underachievement and substance use.[7, 22] Twin models lend support for environmental[22] and/or genetic[23] liability.[18] However, although completely ruling out confounding is not feasible, many reports indicate results persist in diverse samples and after adjustment for proposed contributors.[3-6, 8, 12] A similar theory contends drug use is simply one aspect of an overall pattern of problem behaviors.[5] Marijuana use and academic achievement tend to cluster with other risk behaviors, including the use of additional substances.[5, 24] Relatedly, many experts argue that affiliation with delinquent peer groups fosters adoption of an anti-conventional lifestyle, which both promotes substance use and discourages academic pursuits.[3, 8] If correct, the links to academic performance may have weakened with changing social norms and the increased prevalence of use, suggesting marijuana has become less reflective of nonconformist or aberrant social contexts. Overtime, findings may come to resemble those of alcohol, which appears to be a less robust predictor of academic underachievement.[3, 25, 26]

Comparison of existing literature is additionally hampered by inconsistent and narrowly defined school-related measures,[7, 11, 14] complicating interpretation and unpacking of such concepts. Degree completion often has been the sole outcome included in longitudinal research, preventing exploration of the disengagement process leading to dropout. Setbacks in education could occur for multiple reasons, such as apathy, reduced cognitive ability, truancy, or disciplinary problems. The current study incorporates a range of academic outcomes to assist in teasing apart the variables associated with marijuana use and shed light on potential mechanisms. Longitudinal analyses were conducted in a large cohort of secondary school students, in which models tested how the initiation of marijuana use at varying frequencies predicted educational performance, aspirations, and engagement. In addition, results were compared with those of alcohol use, as an example of a legal and socially accepted substance, in light of recent trends and probable future directions related to marijuana.

METHODS

Procedure

The COMPASS study (hereby referred to as COMPASS), is a prospective cohort study designed to collect hierarchical longitudinal data from a sample of grade 9 to 12 secondary school students and the schools they attend in Ontario and Alberta, Canada.[27] The current study reports longitudinal student-level linked data from Year 1 (Y₁: 2012-2013), Year 2 (Y₂: 2013-2014), and Year 3 (Y₃: 2014-2015). A complete description of the COMPASS host study methods is available in print[27] or online (www.compass.uwaterloo.ca).

Participants

In Y₁, 43 Ontario schools were purposefully recruited because they permitted use of active-information passive-consent parental permission protocols,[27] which is critical for collecting robust data within studies examining youth substance use.[28] Students could decline to participate at any time. In Y₁, data were collected from 24,173 grade 9 to 12 students (80.2% participation rate) in 43 schools. Our Y₂ data were collected from 23,424 grade 9 to 12 students (78.2% participation rate) in the same 43 schools, and an additional 46 schools were recruited into the study where data were also collected from 27,284 grade 9 to 12 students (80.2% participation rate). Our Y₃ data were collected from 42,355 grade 9 to 12 students (78.7% participation rate) in 87 schools (2 schools of the original 43 Y₁ schools dropped out between Y₂ and Y₃). Missing respondents resulted primarily from scheduled spares or absenteeism during data collection.

To explore longitudinal changes among respondents, we linked Y₁, Y₂, and Y₃ student-level data within schools. Data linkage was conducted using the same methods described for the 2-year linked dataset. [29] The process of linking the student data across waves is described in more detail by Qian et al.[29] We were not able to link the grade 12 students in Y₁ or the grade 12 students in Y₂ that graduated and would not have attended the school in Y₂ or Y₃ respectively, or the grade 9 students that were newly admitted to participating schools in Y₃. The other main reasons for nonlinkage included students transferring schools, students not providing data for grade or sex in Y₁, Y₂, or Y₃, students on spare or students who were absent at the time of a data collection in their school, students dropping out of school, or inaccurate data provided on the data linkage measures. Overall, 27,513 students were successfully linked for at least 2 years of the study, with 18.0% (N = 4960) of the sample completing the questionnaire in all 3 years. Participants missing age, sex, grade, or substance use data were removed from the analyses, leaving a final sample of 26,475 for this study. Lastly, students missing responses on the academic variables were excluded on an analysis-by-analysis basis.

Instrumentation

The student-level questionnaire for COMPASS (Cq) collects individual student data on an annual basis pertaining to multiple behavioral domains (alcohol use, tobacco use, physical activity, diet, etc), correlates of the behaviors, and demographic characteristics. In each school, the Cq was used to collect whole-school samples during class time. The Cq items were based on national standards or current national public health guidelines as described elsewhere.[27]

Substance use variables

To assess *marijuana use*, students were asked: "In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)?" Responses were recoded into "never," "rare/sporadic" if they

used it less than once month, “monthly” if reported use was once to 3 times a month, “weekly” if use ranged from once to 6 times a week, and “daily.” *Alcohol use* was determined by the question: “In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?” Responses were recoded to be analogous to the marijuana use categories.

Academic variables

Academic aspirations and *expectations* were assessed by asking: “What is the highest level of education you would *like* to get?” and “What is the highest level of education you *think* you will get?” respectively. To measure *academic performance*, students were asked: “In your current or most recent math course, what is your approximate overall mark?” The same question was used to assess English marks. The following survey items were intended to reflect different aspects of *school engagement*. The value that students assigned to school performance was assessed by how strongly they agreed with the statement: “Getting good grades is important to me.” We used the number of classes skipped in the last 4 weeks as our measure of truancy. Lastly, participants were asked: “How often do you go to class without your homework complete?” Table 1 shows the response options for all academic variables. Some categories were collapsed if the number of responses was insufficient to be modeled.

Table 1. Baseline Frequency Statistics in the 3-Year Linked Sample of Youth From the COMPASS Study

	Girls (N [%])	Boys (N [%])	χ^2
Grade			p < .0001
9	6155 (43.9)	5563 (44.7)	
10	4403 (31.4)	3767 (30.3)	
11	3278 (23.4)	2781 (22.4)	
12	196 (1.4)	332 (2.7)	
Ethnicity			p < .0001
White	10,847 (77.3)	9373 (75.3)	
Black	392 (2.8)	539 (4.3)	
Asian	742 (5.3)	649 (5.2)	

	Girls (N [%])	Boys (N [%])	χ
Hispanic	364 (2.6)	328 (2.6)	
Off-reserve Aboriginal	252 (1.8)	271 (2.2)	
Other/mixed/missing	1435 (10.2)	1283 (10.3)	
Level of education would <i>like</i> to get			$p < .0001$
High school equivalency or less	379 (3.5)	493 (5.2)	
College diploma/trade/vocational	1830 (17.0)	2849 (30.1)	
Bachelor's degree	2299 (21.2)	2114 (22.3)	
Master's/PhD/Law/Medical/Teacher's College	6321 (58.4)	4008 (42.4)	
Level of education <i>expect</i> to get			$p < .0001$
High school equivalency or less	584 (5.7)	595 (6.3)	
College diploma/trade/vocational	2420 (23.5)	3278 (34.9)	
Bachelor's degree	2932 (28.4)	2589 (27.6)	
Master's/PhD/Law/Medical/Teacher's College	4376 (42.4)	2927 (31.2)	
Math course mark			$p < .0001$
90-100%	2883 (21.0)	2339 (19.3)	
80-89%	4400 (32.0)	3702 (30.5)	
70-79%	3359 (24.4)	3061 (25.2)	

	Girls (N [%])	Boys (N [%])	χ
60-69%	1745 (12.7)	1719 (14.2)	
Less than 60%	1371 (10.0)	1306 (10.8)	
English course mark			p < .0001
90-100%	2236 (16.3)	1058 (8.8)	
80-89%	6023 (43.8)	4126 (34.3)	
70-79%	3857 (28.1)	4356 (36.2)	
60-69%	1176 (8.3)	1709 (14.2)	
Less than 60%	458 (3.3)	782 (6.5)	
Getting good grades is important to me			p < .0001
Strongly agree	8797 (63.4)	6188 (50.7)	
Agree	4670 (33.7)	5303 (43.5)	
Disagree/strongly disagree	410 (3.0)	715 (5.9)	
How often goes to class <i>without</i> homework complete			p < .0001
Never	3415 (24.8)	2382 (19.5)	
Seldom	7671 (55.4)	6621 (54.2)	
Often	1907 (13.8)	2200 (18.0)	

	Girls (N [%])	Boys (N [%])	χ
Usually	847 (6.1)	1010 (8.3)	
Number of classes skipped in last 4 weeks			p < .0001
0	11,164 (80.5)	10,123 (82.8)	
1-5	2501 (18.0)	1860 (15.2)	
6+	202 (1.5)	246 (2.0)	
Alcohol use			p < .0001
Never	7648 (54.5)	6945 (55.8)	
Rare/Sporadic	2801 (20.0)	2127 (17.1)	
Monthly	2799 (20.0)	2408 (19.4)	
Weekly	772 (5.5)	885 (7.1)	
Daily	12 (0.1)	78 (0.6)	
Marijuana use			p < .0001
Never	11,879 (84.7)	10,395 (83.5)	
Rare/Sporadic	972 (6.9)	707 (5.7)	
Monthly	647 (4.6)	563 (4.5)	
Weekly	403 (2.9)	510 (4.1)	
Daily	131 (0.9)	268 (2.2)	
Tobacco use (cigarettes only)			p < .0001

	Girls (N [%])	Boys (N [%])	χ
Never	13,696 (97.6)	12,012 (96.5)	
Past	63 (0.5)	54 (0.4)	
Current	273 (2.0)	377 (3.0)	

Student responses are reported for the first year a respondent participated.

* Numbers may not add to total because of rounding and/or missing values.

Data Analysis

We calculated frequency statistics for the sample. For time-varying measures, students' responses at first participation in the COMPASS study are presented. Chi-square analyses were conducted in SAS 9.4 to compare girls and boys on the academic measures (at baseline).

Multinomial generalized estimating equations (GEE) models were used to explain the within-individual associations of each of the academic variables with substance use. Models require specification of marginal regression models and correlations. Suppose there are J response categories and the J th category is the baseline. We modeled the marginal regression model as a baseline category logit model, such that,

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where Y_{it} is the t -th observation for student i , x_{it} is the vector of covariates or predictors, and β_{0j} and β_{1j} , are the j th category specific parameter vectors. Meanwhile, the within-individual correlations at the student level were constructed using local odds ratios. The computation was implemented using the R package `multgee`.^[30] More details can be found in Touloumis et al.^[31, 32] Separate models were constructed for the effects of initiating marijuana and alcohol use on each of the 7 academic outcome variables, giving a total of 14 models. In other words, models tested the likelihood of different possible student responses to the academic outcome measures when they shifted from never using marijuana or alcohol at baseline to using the substances on a rare/sporadic, monthly, weekly, or daily basis at follow-up, compared with those who stayed in the same predictor group at baseline and follow-up ("never" was used as the reference group). This modeling approach allowed for the inclusion of all students with complete responses for the outcome and predictor variables for 2 or 3 years of linked data (ie, possible patterns included participating in: all 3 years, Y_1 and Y_2 , Y_2 and Y_3 , or Y_1 and Y_3 , with "baseline" considered students' first year of participation and follow-up either 1 or 2 years later). All regression models were adjusted for sex, grade, ethnicity, and tobacco use (cigarettes only). Age was not included due to the high correlation with grade, which is more informative for school-based planning.

RESULTS

Baseline Descriptive Statistics

Table 1 contains baseline descriptive statistics of all modeled measures. The sample consisted of 53.0% girls. Participants were 13 to 18 years old ($M = 15$ years, $SD = 1.0$). At baseline, 44.3%, 30.9%, 22.9%, and 2.0% of students were in grade 9, 10, 11, and 12, respectively. The majority (76.4%) self-identified as white, 10.3% as other/mixed/did not respond, and the remainder were of Asian (5.3%), black (3.5%), off-reserve Aboriginal (2.6%), or Hispanic (2.0%) ethnicity. Few students were current tobacco users at baseline (cigarettes only; 2.5%), and 0.4% were past smokers. Marijuana was used by 6.3% of students on a rare/sporadic basis, 4.6% monthly, 3.5% weekly, and 1.5% daily. More students were using alcohol: 18.6% reported rare/sporadic drinking, 19.7% drank monthly, and 6.3% consumed alcohol weekly. Due to the insufficient number of students using alcohol daily (0.3%), model results for this category were not reported.

Most students aspired to attend university, and over half of girls (58.4%) and 42.4% of male students hoped to continue onto graduate/professional degrees. Almost twice as many boys reported wanting to go to college/trade school. In terms of class performance, the majority of students agreed/strongly agreed that getting good grades was important to them. About three-fourths of participants achieved over 70% in math. English grades were similar, with a sex effect favoring girls. Last, about 80% of students reported completing their homework and attending all classes when supposed to in the past 4 weeks.

Multinomial GEE Models

Table 2 presents the relative risk ratios (RRRs) of students reporting college, university, or graduate/professional academic aspirations and expectations over “high school equivalency or less,” when student reports shifted from “Never” using marijuana/alcohol at baseline to “Rare/Sporadic,” “Monthly,” “Weekly,” or “Daily” use in the 1 to 2 years following. Students who changed from never having used marijuana at baseline to regular use (at least monthly) at follow-up were *less* likely to report graduate/professional degree ambitions and expectations, than to aspire and expect to discontinue education at high school. Shifting to daily use appeared most detrimental to academic goals, based on the RRRs for university pathways, yet no significant effect resulted for college/trade school. Students who became weekly users had an *increased* likelihood of aspiring and expecting to pursue college/trade paths, rather than discontinue their education at high school. Similarly, students who began using on a rare/sporadic basis had *higher* chances of wanting to continue their education past high school. In contrast to marijuana, students who shifted from abstaining from alcohol at baseline to any alcohol use (rare/sporadic, monthly, weekly) at follow-up were *more* likely to report aspirations and expectations for all levels of postsecondary education over high school.

Table 2. Multinomial GEE Models of Marijuana and Alcohol Use With Academic Aspirations and Expectations in the 3-Year Linked Sample From the COMPASS Study (Relative Risk Ratios [RRR] ^{*} [95% CI])

Level of education would *like* to get (versus High school equivalency or less)

Marijuana	College/Trade	Bachelor's	Master's/PhD/MD/Teacher's
Rare/Sporadic	1.67 (1.34, 2.09), p < .0001	1.63 (1.31, 2.03), p < .0001	1.34 (1.09, 1.67), p = .0066
Monthly	1.14 (0.92, 1.43), p = .2335	1.00 (0.80, 1.24), p = .9649	0.77 (0.63, 0.96), p = .0185
Weekly	1.43 (1.10, 1.85), p = .0074	0.97 (0.74, 1.26), p = .8087	0.75 (0.58, 0.97), p = .0289
Daily	0.82 (0.59, 1.12), p = .2101	0.41 (0.30, 0.58), p < .0001	0.53 (0.39, 0.72), p = .0001
Alcohol	College/Trade	Bachelor's	Master's/PhD/MD/Teacher's
Rare/Sporadic	2.15 (1.82, 2.54), p < .0001	2.16 (1.83, 2.54), p < .0001	1.92 (1.64, 2.24), p < .0001
Monthly	1.80 (1.55, 2.10), p < .0001	1.74 (1.50, 2.03), p < .0001	1.44 (1.25, 1.67), p < .0001
Weekly	1.83 (1.46, 2.29), p < .0001	1.59 (1.27, 1.99), p < .0001	1.25 (1.01, 1.56), p < .0417

Level of education *expect* to get (versus High school equivalency or less)

Marijuana	College/Trade	Bachelor's	Master's/PhD/MD/Teacher's
Rare/Sporadic	1.43 (1.20, 1.70), p = .0001	1.35 (1.14, 1.60), p = .0006	1.06 (0.90, 1.26), p = .4956
Monthly	1.13 (0.93, 1.38), p = .2072	0.97 (0.80, 1.17), p = .7664	0.72 (0.60, 0.87), p = .0007
Weekly	1.35 (1.08, 1.69), p = .0088	0.88 (0.70, 1.10), p = .2461	0.67 (0.53, 0.83), p = .0003
Daily	0.94 (0.71, 1.26), p = .6793	0.49 (0.36, 0.66), p < .0001	0.65 (0.49, 0.87), p = .0041
Alcohol	College/Trade	Bachelor's	Master's/PhD/MD/Teacher's
Rare/Sporadic	1.63 (1.43, 1.86), p < .0001	1.63 (1.43, 1.84), p < .0001	1.44 (1.27, 1.63), p < .0001
Monthly	1.71 (1.50, 1.96),	1.62 (1.42,	1.35 (1.19, 1.54), p < .0001

	p < .0001	1.84), p < .0001	
Weekly	1.87 (1.53, 2.29), p < .0001	1.55 (1.27, 1.88), p < .0001	1.28 (1.05, 1.56), p = .0124

Results reflect the likelihood of students reporting the response category (college, university, or graduate/professional school) relative to “High school equivalency or less” when they shift from reporting “Never” using marijuana/alcohol at baseline to “Rare/Sporadic,” “Monthly,” “Weekly,” or “Daily” use at follow-up.

* Adjusted for sex, grade, ethnicity, and tobacco use.

Tables 3 and 4 present the academic engagement and performance models, respectively. Students who changed from reporting no marijuana or alcohol use at baseline to any frequency of use 1 or 2 years following were *less* likely to report completing their homework, attending class when supposed to, and to strongly agree that good grades were important to them, relative to the alternative responses. Similarly, there was a *lower* likelihood of achieving high English and math grades, as opposed to marks less than 60%, in students who shifted from never having used marijuana or alcohol to an increased frequency of using either substance.

Table 3. Multinomial GEE Models of Marijuana and Alcohol Use With Academic Engagement Among Youth in the 3-Year Linked Data From the COMPASS Study (Relative Risk Ratios [RRR] [95% CI])

How often do you go to class without your homework complete? (versus Never)			
	Seldom	Often	Usually
Marijuana			
Rare/Sporadic	1.73 (1.58, 1.89), p < .0001	2.34 (2.11, 2.59), p < .0001	2.36 (2.07, 2.68), p < .0001
Monthly	1.89 (1.68, 2.12), p < .0001	2.97 (2.61, 3.39), p < .0001	3.09 (2.64, 3.61), p < .0001
Weekly	1.84 (1.60, 2.12), p < .0001	3.65 (3.13, 4.25), p < .0001	3.71 (3.12, 4.42), p < .0001
Daily	0.87 (0.72, 1.04), p = .1297	1.56 (1.27, 1.91), p < .0001	3.05 (2.46, 3.79), p < .0001
Alcohol			
Rare/Sporadic	1.73 (1.63, 1.84), p < .0001	2.12 (1.96, 2.28), p < .0001	2.01 (1.82, 2.22), p < .0001

Monthly	1.95 (1.83, 2.08), p < .0001	2.87 (2.65, 3.10), p < .0001	2.45 (2.22, 2.70), p < .0001
Weekly	1.92 (1.73, 2.13), p < .0001	3.58 (3.18, 4.02), p < .0001	3.42 (2.97, 3.94), p < .0001

Number of classes skipped (when not supposed to) in the last 4 weeks (versus 0)

Marijuana	1-5	6+
Rare/Sporadic	2.51 (2.35, 2.68), p < .0001	2.75 (2.29, 3.31), p < .0001
Monthly	3.79 (3.50, 4.10), p < .0001	6.26 (5.24, 7.48), p < .0001
Weekly	4.44 (4.04, 4.88), p < .0001	8.91 (7.39, 10.75), p < .0001
Daily	4.12 (3.57, 4.76), p < .0001	18.10 (14.51, 22.56), p < .0001

Alcohol	1-5	6+
Rare/Sporadic	2.35 (2.21, 2.50), p < .0001	1.86 (1.55, 2.23), p < .0001
Monthly	3.84 (3.62, 4.07), p < .0001	3.89 (3.30, 4.57), p < .0001
Weekly	5.77 (5.33, 6.25), p < .0001	9.50 (7.92, 11.39), p < .0001

"Getting good grades is important to me" (vs. strongly agree)

Marijuana	Agree	Disagree/strongly disagree
Rare/Sporadic	1.39 (1.31, 1.48), p < .0001	1.62 (1.41, 1.85), p < .0001
Monthly	1.74 (1.62, 1.87), p < .0001	2.12 (1.81, 2.48), p < .0001
Weekly	2.06 (1.89, 2.25), p < .0001	3.14 (2.66, 3.72), p < .0001
Daily	1.81 (1.58, 2.07), p < .0001	4.22 (3.42, 5.21), p < .0001

	.0001	
Alcohol	Agree	Disagree/strongly disagree
Rare/Sporadic	1.22 (1.16, 1.28), p < .0001	1.30 (1.17, 1.46), p < .0001
Monthly	1.42 (1.36, 1.49), p < .0001	1.46 (1.30, 1.63), p < .0001
Weekly	1.85 (1.73, 1.99), p < .0001	2.35 (2.02, 2.72), p < .0001

Results reflect the likelihood of students reporting the response category ("Seldom," "Often," or "Usually;" "1-5" or "6+;" "Agree" or "Disagree/Strongly disagree") relative to the reference category ("Never;" "0;" "Strongly agree") when they shift from reporting "Never" using marijuana/alcohol at baseline to "Rare/Sporadic," "Monthly," "Weekly," or "Daily" use at follow-up.

* Adjusted for sex, grade, ethnicity, and tobacco use.

Table 4. Multinomial GEE Models of Frequency of Alcohol and Marijuana Use With School Grades Among Youth in the 3-Year Linked Data of the COMPASS Study (Relative Risk Ratios [RRR] [95% CI])

Mark in most recent *English* course (versus Less than 60%)

	60-69%	70-79%	80-89%	90-100%
Marijuana				
Rare/Sporadic	0.91 (0.77, 1.07) p = .2591	0.85 (0.73, 0.98) p = .0227	0.75 (0.65, 0.87) p < .0001	0.56 (0.48, 0.65) p < .0001
Monthly	0.79 (0.66, 0.94) p = .0071	0.62 (0.53, 0.73) p < .0001	0.52 (0.45, 0.61) p < .0001	0.39 (0.33, 0.47) p < .0001
Weekly	0.78 (0.64, 0.95) p = .0129	0.58 (0.49, 0.70) p < .0001	0.46 (0.39, 0.55) p < .0001	0.31 (0.25, 0.38) p < .0001
Daily	0.61 (0.47, 0.78) p < .0001	0.41 (0.33, 0.51) p < .0001	0.34 (0.27, 0.43) p < .0001	0.49 (0.38, 0.64) p < .0001
Alcohol				
Rare/Sporadic	0.92 (0.81, 1.05) p = .2060	0.91 (0.81, 1.02) p = .1085	0.91 (0.81, 1.001) p = .0836	0.77 (0.68, 0.87) p < .0001

Monthly	0.95 (0.84, 1.07) p = .4106	0.94 (0.84, 1.05) p = .2510	0.82 (0.74, 0.92) p = .0008	0.63 (0.56, 0.71) p < .0001
Weekly	0.89 (0.75, 1.05) p = .1718	0.77 (0.66, 0.90) p = .0010	0.66 (0.56, 0.76) p < .0001	0.43 (0.36, 0.51) p < .0001

Mark in most recent *Math* course (versus Less than 60%)

	Marijuana	60-69%	70-79%	80-89%	90-100%
Rare/Sporadic	0.89 (0.79, 1.00) p = .0467	0.82 (0.74, 0.91) p = .0002	0.77 (0.70, 0.85) p < .0001	0.62 (0.55, 0.69) p < .0001	
Monthly	0.87 (0.76, 1.00) p = .0461	0.74 (0.66, 0.84) p < .0001	0.63 (0.56, 0.71) p < .0001	0.52 (0.45, 0.59) p < .0001	
Weekly	0.76 (0.65, 0.88) p = .0004	0.66 (0.57, 0.76) p < .0001	0.54 (0.47, 0.62) p < .0001	0.42 (0.36, 0.49) p < .0001	
Daily	0.68 (0.54, 0.84) p = .0005	0.55 (0.45, 0.67) p < .0001	0.46 (0.38, 0.55) p < .0001	0.65 (0.53, 0.79) p < .0001	
	Alcohol	60-69%	70-79%	80-89%	90-100%
Rare/Sporadic	1.00 (0.91, 1.09) p = .9208	0.90 (0.83, 0.97) p = .0098	0.91 (0.84, 0.99) p = .0256	0.78 (0.72, 0.85) p < .0001	
Monthly	0.91 (0.83, 1.00) p = .0419	0.88 (0.81, 0.96) p = .0029	0.80 (0.74, 0.87) p < .0001	0.63 (0.58, 0.69) p < .0001	
Weekly	0.79 (0.70, 0.90) p = .0003	0.78 (0.70, 0.88) p < .0001	0.66 (0.59, 0.74) p < .0001	0.50 (0.44, 0.56) p < .0001	

Results reflect the likelihood of students reporting the response category ("60-69%," "70-79%," "80-89%," or "90-100%") relative to "Less than 60%," when they shift from reporting "Never" using marijuana/alcohol at baseline to "Rare/Sporadic," "Monthly," "Weekly," or "Daily" use at follow-up.

* Adjusted for sex, grade, ethnicity, and tobacco use.

DISCUSSION

Youth appear more vulnerable to adverse consequences from marijuana use, particularly in terms of their educational achievement. Several theories have been proposed for the link; however, the majority of longitudinal research has focused solely on degree attainment, limiting insight into disengagement preceding dropout. Moreover, the temporal relationship remains unclear, leading researchers to call for

further longitudinal analyses. Accordingly, we tested the relative likelihood of different responses to indices of academic performance, engagement, and future goals when students reported varying frequencies of marijuana use at follow-up, after reporting no use at baseline. In addition, results were compared with those of alcohol use, as an example of a legal and socially accepted substance.

The models indicate that students who started using marijuana or alcohol were more likely report academic disengagement and poor performance than to regularly attend class, complete their homework, consider good grades important, and achieve high marks. Comparing the substances, the influence on school engagement and performance appeared similar, with marijuana having a somewhat more adverse impact. As marijuana remains illegal in Canada, and less prevalent and accepted than alcohol, differences may reflect greater affiliation with delinquent peer groups or patterns of problem behavior among students regularly using the drug. If recent trends continue, the marijuana results may come to align with those of alcohol. The alcohol models resemble existing literature demonstrating less robust associations with academic achievement relative to other drug use.[3, 25, 26] Ongoing investigation into these relationships will be particularly important should marijuana be legalized.

Results become more complicated when modeling the education level students aspire and expect to achieve, which varied by substance and frequency of initiated use. A change to rare/sporadic marijuana use did not appear to deter academic goals. In fact, these students were more likely to report ambitions for all categories of higher education, as opposed to stopping their schooling at high school. Similarly, shifts to weekly use increased the chances of aspirations to continue past secondary school onto college/trade school. However, among students who started weekly, monthly, or daily marijuana use, goals of attending graduate/professional school were less likely than reports of wanting to discontinue their education at high school. Also, a change to daily marijuana use decreased the chances of aspirations to complete a bachelor's degree over high school. In contrast, students reporting any level of alcohol use (rare/sporadic, monthly, weekly) at follow-up were more likely to aspire and expect to pursue all forms of postsecondary education, including graduate/professional degrees, than to aim for high school or less. Based on these results, only initiating more frequent marijuana use appears to dissuade university ambitions. This finding requires further exploration moving forward.

The positive link between marijuana and plans for college/trade school, alongside its negative association with university pathways, is particularly interesting relative to the alcohol findings. Results raise the question of whether the image of particular substances accounts for their different relationships with future goals. Drinking has long been tied to university settings, resulting in interventions to alter their culture and correct misperceptions of student drinking norms.[33] There has been less study of marijuana in this context. In light of trends, monitoring the social norms of marijuana use associated with certain academic institutions is advised. It is plausible that perceptions of different academic institutions or fields play a role in substance use earlier on, among adolescents planning to pursue certain scholarly or career opportunities. Addressing this possibility may prove a valuable area for future research.

Limitations

Strengths of this study include the longitudinal design, large sample, inclusion of several academic outcome measures, robust statistical procedures, and modeling the initiation of substance use in varying frequencies, as opposed to the more commonly used dichotomous measures. However, a number of limitations merit discussion. Due to space restrictions, other category shifts were not modeled (ie, changing from "monthly" to "weekly" use), but shifts from "never" were judged more informative from a prevention standpoint. Also, whereas reverse causation cannot be ruled out, the

study's longitudinal design and statistical procedures add strength to the study conclusions. Similarly, confounding can never be discounted in observational research; however, grade, ethnicity, sex, as well as tobacco use were adjusted for, and smoking tends to cluster with other potential confounders related to suggested noncausal theories. Last, retrospective and self-report questionnaires are subject to recall bias and underreporting, and linkage rates tend to be lower for students who use alcohol/marijuana and are less engaged in school.[29] To minimize these possibilities, passive-consent procedures were used and students were not aware of the data collection date ahead of time. Regardless, inclusion of these students would expectedly strengthen the observed associations.

Conclusion

Results highlight the importance of preventing and delaying the initiation and escalation of substance use among adolescents. More youth today use marijuana than cigarettes[34] yet public health prevention efforts lag behind those of alcohol and tobacco. Our study builds on literature demonstrating a link between substance use and degree attainment by examining the disengagement, performance, and motivational processes that may lead to early school leaving. Both alcohol and marijuana appear detrimental to student attendance, homework completion, grades, and perceived value of school achievement, which often conflict with their future academic goals. Youth are said to become increasingly disengaged as they progress through secondary school.[11] Deterring substance use may circumvent this downward trend, and in turn, avoid academic failure, school dropout, and the many adverse psychosocial consequences. Preventative efforts should be a priority among educational systems, as health and risk behaviors are increasingly shown to be strongly linked to academic achievement.[35] Countering the drinking culture image associated with postsecondary pathways may prove valuable.

IMPLICATIONS FOR SCHOOL HEALTH

Substance use prevention is increasingly daunting in a more permissive environment. Risk perceptions of marijuana use have substantially declined,[1] with probable further reductions, pending legalization. Countering implied messages of harmlessness, and raising awareness of links with academic non-achievement, are essential considering these trends. In particular, targeting younger populations to delay substance use should be a priority, as differences in degree attainment appear to originate in early adolescence.[7] Poor academic performance and disengagement have broad public health implications. School failure, non-completion, and truancy increase the likelihood of numerous problems later in life, including health risk behaviors, criminality, violence, unemployment, and poverty.[13]

Results of the current study indicate school-based prevention programs may ultimately benefit not only students' well-being but also their academic performance. Therefore, such efforts have the potential to achieve the primary objectives of both educators and public health professionals. This conclusion aligns with arguments for incorporating health into all educational policies and curriculum, based on a growing evidence base demonstrating the strong links between student health and academic achievement.[35]

Whereas the academic aspiration and expectation model results may at first appear counterintuitive, they are not entirely surprising considering the drinking culture of postsecondary institutions that is commonly portrayed in popular media. Substance use is often seen as an accepted, expected, and even promoted behavior among postsecondary students, whereas, evidence of links to postsecondary failure is seldom acknowledged. As a result, youth may underestimate the potential detrimental effects on their

future. Tackling the university and college party culture may assist in discouraging substance use at earlier ages. One promising approach involves policies addressing the alcohol advertisements and popular media that target youth and depict substance use as desirable. In terms of targeted programs, students struggling with school performance are easily identified, as opposed to other risk factors (eg, family dysfunction) for substance problems. Results suggest truancy, homework noncompletion, and lower grades may precede the higher dropout rates found in past reports, and therefore, represent key markers of at-risk students.

Human Subjects Approval Statement

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the University of Waterloo Office of Research Ethics (OR File Number: 17264), and appropriate school board review panels.

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