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Young Adult Longitudinal Patterns of Marijuana Use among US National Samples of 12th Grade Frequent Marijuana Users: A Repeated Measures Latent Class Analysis

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Abstract

Background and Aims: Long-term frequent marijuana use is associated with significant negative outcomes, yet little is known about the longitudinal course of marijuana use among those who start frequent use during adolescence. Objectives are (a) to identify latent patterns of within-person marijuana use from ages 19-30 among 12th graders reporting frequent marijuana use, (b) to examine if membership in identified patterns has changed across historical time, and (c) to examine if key covariates differentiate class membership.

Design, Setting, Participants: Longitudinal, national US panel data from 4,423 individuals (53.4% of the eligible sample; 2,744 [62%] males) who reported frequent marijuana use in 12th grade (modal age 18 years; senior year cohorts 1976-2006) followed biennially from age 19/20 through 29/30.

Measurements: Self-reported past 30-day marijuana use (frequent use defined as use on 20+ occasions), demographics, college graduation, marriage, and parenthood.

Findings: Repeated measures latent class analysis (RMLCA) identified five latent classes of past 30-day marijuana use from ages 19/20 through 29/30: Continued Frequent Users (estimated membership 23.4%); Frequent to Non-Frequent Users (15.5%); Consistent Non-Frequent Users (18.4%); Non-Frequent Users to Discontinuers (19.5%); and Discontinuers (23.2%). In

multivariable models, membership in the highest-risk latent class (Continued Frequent Users) versus one or more of the lower-risk latent classes was more likely for recent cohorts (p=0.038 to <0.001), as well as those who did not marry (p=0.039 to <0.001) or become parents (p=0.001) by modal age 29/30.

Conclusions: Nearly one in four 12th grade (modal age 18 years) frequent marijuana users in the US continues to report high frequency use through age 30; the proportion continuing high frequency use across young adulthood has increased among more recent cohorts.

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Introduction

High frequency marijuana use is associated with enduring negative effects [1-4], and chronic heavy use (particularly use that starts in adolescence and continues throughout young adulthood) is associated with higher degrees of impaired functioning than adolescent-limited use [3,5-11]. Yet, studies have not examined long-term marijuana use trajectories among individuals who report frequent use by the end of high school. Little is known about possible heterogeneity in later marijuana use among those who use marijuana frequently as adolescents, the stability of such patterns across historical time, or characteristics associated with diverging patterns of use across development. Such information is essential for accurate projections of future treatment demand and potential social and individual costs, given that frequent marijuana use is associated with increased addiction/dependence, cognitive impairment, diminished life satisfaction/achievement, poor psychological/physical health, etc. [2-6,8-12].

Several studies have examined developmental patterns of marijuana use from adolescence into adulthood among the general population and have identified heavy or chronic use subgroup(s) [6-10,13-20]. Similar studies are not available focusing on individuals who are heavy users by late adolescence. In one national sample of U.S. 12th grade students in 1975, 51% of those reporting frequent use (defined in the current study as use on 20 or more occasions in

the previous 30 days) in 12th grade also reported frequent use four years later, while 34% reported non-frequent use [21]. Not only are more recent data needed, but also needed is an analytical approach allowing identification of underlying use patterns across age while incorporating measurement error and providing probability-based estimates of pattern membership, and modelling of possible changes in such patterns over historical time.

Prevalence data for frequent use among both adolescents and young adults indicate there may be historical differences in developmental patterns of frequent marijuana use. Since the mid-1970s, frequent marijuana use prevalence among US 12th grade students ranged from a high of 10.7% in 1978 to a low of 1.9% in 1992; since the early 2000s, prevalence has remained near 6% [22]. National data indicate frequent marijuana use prevalence has increased significantly among young adults and adults in general [23,24]; further, the typical mid-to late 20s developmental decrease in frequent marijuana use has slowed for recent cohorts [25]. Such changes indicate the number of adolescent frequent marijuana users who continue frequent use across young adulthood may be growing, with meaningful implications for projections of future health and treatment needs.

Several key covariates may be associated with the likelihood of membership in patterns of marijuana use across young adulthood among those who initiated frequent use during adolescence. The social roles of marriage and parenthood have consistently been found to be protective against substance use [26,27]. Among the general population, lower likelihood of membership in heavy/chronic marijuana use subgroups has been found for both marriage [9,10]

and parenthood [9]. Johnston found that continued frequent marijuana use four years after 12th grade was less likely for those who were married or had children [21]. General population studies also have found membership in heavy/chronic marijuana use subgroups is more likely for men [7,9,10,15,22,28,29] and individuals whose parents have higher education levels [10,15,18,22]; mixed results have been found for both race/ethnicity and college attendance/completion in regards to heavy/chronic marijuana use patterns [10,15,17,18,29]. The extent to which these covariates differentiate long-term marijuana use patterns within individuals who initiated frequent use by late adolescence is unknown.

The current study uses US national panel data from 32 cohorts of 12th grade students (1) to identify latent, heterogeneous patterns of within-person marijuana use from ages 19-30 among individuals reporting frequent marijuana use in 12th grade; (2) to examine the extent to which latent class membership probability has varied across historical time (i.e., cohorts); and (3) to examine if sex, race/ethnicity, parental education, 4-year college experience, marital status, and parental status differentiate membership likelihood for identified classes.

Method

Participants

Since 1975, MTF has surveyed annually nationally representative cross-sectional samples of approximately 15,000 12th grade students from 130 public and private schools in the coterminous US (school samples are revised annually) [22]. About 2,450 students are selected annually for longitudinal follow-up; drug users are oversampled [24]. A random half of the

follow-up sample receives biennial follow-ups beginning one year after 12th grade (modal age 19); the other half begins biennial follow-up beginning two years after 12th grade (modal age 20). Mailed questionnaires collect data at six follow-up time points: modal ages 19/20, 21/22, 23/24, 25/26, 27/28, and 29/30 (hereafter, modal age is referred to simply as "age"). A University of Michigan Institutional Review Board approved the study.

Analysis was limited to 12th grade cohorts with the opportunity for age 29/30 follow-up survey participation as of the date of analysis: 1976-2006 12th grade cohorts (age 29/30 data collected during 1987-2017). Twelfth grade student response rates averaged 82.7%; absenteeism was the primary reason for nonresponse [22]. Of the 74,525 individuals selected for follow-up, 72,643 (97.5%) provided valid data on 12th grade past 30-day marijuana use; 8,279 (11.4%) reported frequent use (use on 20 or more occasions in the past 30 days). Given the analytical focus of use throughout the 20s and covariates including marriage, parenthood, etc., included cases were required to respond to at least one of the age 25/26, 27/28 or 29/30 follow-up surveys. Among 12th grade frequent marijuana users, 4,676 (56.5%) responded to at least one of these surveys; 4,423 (53.4%) provided valid data on past 30-day marijuana use and covariates (2,744 (62.0% male) (see Supplement Figure 1 for sample flow chart). The mean number of marijuana use responses per respondent was 4.9 (42% of respondents provided data at all 6; 25% 5; 18% 4; 10% 3; 4% 2, and 1% only 1). Attrition adjustments are discussed below.

Measures

Marijuana use. At each survey, participants were asked about the number of occasions (if any) they used marijuana or hashish during the past 30 days. Given the primary interest in examining patterns of frequent marijuana use across development, as well as the desire to model non-frequent use, responses (on a 7-point scale of 0, 1-2, 3-5, 6-9, 10-19, 20-39, 40 or more occasions) were recoded into a trichotomy of frequent use (20 or more occasions), non-frequent use (1 to 19 occasions), and no use (0 occasions).

Cohort (indicating year of 12th grade survey) was coded into six non-overlapping groups: 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, and 2001-2006.

Covariates. Sex (male, female), race/ethnicity (African American, Hispanic, White, or other [including multiracial identity]), and parental education (at least one parent had "some college" or more) were self-reported at 12th grade. Remaining covariates were measured from ages 19/20-29/30, and indicated if respondents reported the following at any follow-up survey: 4-year college experience (ever graduating; attending but not graduating; not attending); ever married (yes/no); having one or more children at any survey (yes/no).

Analysis

Descriptive analysis was conducted using SAS v.9.4; repeated measures latent class analysis (RMLCA) models were fit in Mplus v.7.4 [30], using full information maximum likelihood estimation with robust standard errors. RMLCA models used six trichotomous past 30-day marijuana use indicators (one for each follow-up survey). Because the six indicators could result in 3^6 (729) possible patterns (not including missingness), RMLCA provided both a

data reduction technique to identify key longitudinal patterns and the ability to account explicitly for both measurement error (i.e., mismatch between observed reports and class assignment) and missing marijuana use indicator data [31]. Missing data on marijuana use indicators were assumed to be missing at random and were handled using Mplus' full information maximum likelihood estimation procedure [30]. Cases with missing data on covariates were excluded. Maximum likelihood solution identification was confirmed using 500 initial stage random starts and 250 final stage optimizations. Because trichotomous indicators preclude use of the bootstrap likelihood ratio test as a criterion for selection of the optimal number of classes, a variety of fit criteria were relied on, of which the BIC and sample size-adjusted BIC (a-BIC) have been shown in simulations to perform particularly well for selecting "correct" latent class models [32]. Using the R3STEP command (wherein the latent class model is estimated first, the most likely class variable is then created using the latent class posterior distribution taking into account measurement error, and finally auxiliary variables are included [33]), covariates were added (first bivariately, then all simultaneously) as auxiliary variables to baseline-category, multinomial logistic regression models including all cases. Unadjusted covariate prevalence estimates across latent classes were obtained using the BCH command. By design, covariates are not permitted to affect latent class formation in either R3STEP or BCH [33]. All analyses were weighted using an attrition weight, calculated as the inverse of the probability of responding at age 29/30 based on 12^{th} grade covariates, including the sampling weight correcting for over-sampling of 12^{th} grade substance users [9].

Results

Descriptive statistics

Age 18 frequent marijuana users were primarily male (68%) and White (79%); most (62%) reported at least one parent had attained some college education (see Table 1). By age 29/30, 24% had completed a 4-year college degree; approximately half reported ever being married (49%) or having children (50%).

[Table 1 about here]

Latent marijuana use classes

RMLCAs with one to seven classes were considered. The optimal number of classes was determined by examining model fit, interpretability, parsimony, and stability/identification. Item response probability values of 0.50 or higher were considered to indicate "high" probability of endorsing the specified marijuana use level; in the absence of probabilities $\geq$0.50, the next highest probability value was considered. Table 2 reports model fit/selection criteria. No improvement in BIC was seen between the 6- and 7-class model; thus, 5- and 6-class models were considered for interpretation clarity and utility. Because the 6-class model included one class for which interpretation was questionable, the 5-class model was selected as optimal.

[Table 2 about here]

Table 3 reports class membership and item response probability parameter estimates for the 5-class solution (see Supplement Figure 2 for graphical representation). The overall probability of reporting frequent marijuana use in the past 30 days dropped from 0.483 to 0.237

between ages 19/20 and 29/30. The overall probability of reporting non-frequent use was approximately 0.334 from ages 19/20-23/24, and then decreased to 0.266 by age 29/30. The overall probability of reporting no past 30-day marijuana use increased from 0.183 to 0.497 from ages 19/20-29/30. Thus, overall, the probability of continuing frequent marijuana use dropped by approximately 50%, the probability of discontinuation more than doubled, and the probability of non-frequent use dropped by approximately 20%. Latent classes were labeled and described as follows:

1. Continued Frequent Users (estimated membership probability=0.234 [estimated n=1,033], indicating 23.4% of those reporting frequent marijuana use as 12^{th} grade students exhibited this pattern of 30-day marijuana use from ages 19/20-29/30): high probabilities (0.753-0.840) of frequent past 30-day marijuana use from ages 19/20-29/30.
2. Frequent to Non-Frequent Users (15.5%, n=687): high probabilities (0.646-0.771) of frequent use from ages 19/20-23/24, and high probabilities (0.426-0.608) of non-frequent use from ages 25/26-29/30.
3. Consistent Non-Frequent Users (18.4%, n=816): high probabilities (0.473-0.746) of non-frequent use from ages 19/20-29/30.
4. Non-Frequent Users to Discontinuers (19.5%, n=863): high probabilities (0.501-0.626) of non-frequent use from ages 19/20-23/24, and high probabilities (0.683-0.879) of discontinuation from ages 25/26-29/30.

5. Discontinuers (23.2%, n=1,024): high probabilities (0.552-0.924) of no past 30-day marijuana use from ages 19/20-29/30.

[Table 3 about here]

Covariate associations

Multinomial logistic regression models examined associations between covariates and membership likelihood in (a) the Continued Frequent Users class versus other classes, and (b) the Discontinuers class versus other classes. Table 4 presents unadjusted covariate prevalence estimates across latent classes and summarizes significant bivariate and multivariable analyses reported in Tables 5-8.

[Table 4 about here]

Referent=Continued Frequent Users. In Table 4, significantly (p<0.05) different membership likelihoods in the noted class versus Continued Frequent Users (or CFU, Class 1) by covariates in bivariate and multivariate models are indicated by the superscripts "1a" and "1b", respectively. For example, the "$0.606^{1a,1b}$" for males in the Non-Frequent Users to Discontinuers class (Class 4) column indicates that membership likelihood for this class versus CFU differed significantly by sex in bivariate and multivariable models. The estimated proportion of the class that was male was 0.606 for Non-Frequent Users to Discontinuers versus 0.712 for CFU. Tables 5 and 6 provide unadjusted and adjusted relative risk ratios (RRs and ARRs, respectively), 95% confidence intervals, and exact p-values for all associations. To continue the example above, the likelihood of membership in the Non-Frequent Users to Discontinuers class versus CFU was

significantly lower for males than females (Table 5 RR=0.62, $p<0.001$; Table 6 ARR=0.62, $p=0.001$). Below, we discuss only significant multivariable associations.

[Tables 5 and 6 about here]

Membership likelihood in the Frequent to Non-Frequent Users class (Class 2) versus CFU was significantly higher for the 1976-1980 (vs. 2001-2006) cohorts. Membership likelihood in the Consistent Non-Frequent Users class (Class 3) versus CFU was significantly higher for those never married and the 1976-1980 and 1981-1985 (vs. 2001-2006) cohorts. Membership in the Non-Frequent Users to Discontinuers class (Class 4) versus CFU was significantly more likely for females (as presented above), those whose parents had any college education, those graduating from a 4-year college, and the 1976-1980, 1981-1985, 1986-1990, and 1991-1995 (vs. 2001-2006) cohorts. Membership in the Discontinuers class (Class 5) versus CFU was significantly more likely for African American and Hispanic than White individuals, for those ever married, and those having at least one child; membership was significantly less likely for the 1976-1980 (vs. 2001-2006) cohorts.

Referent=Discontinuers. In Table 4, significantly different likelihood of membership in the noted class versus the Discontinuers class in bivariate and multivariable models is indicated by superscripts “5a” and “5b”, respectively. Tables 7 and 8 provide RRs and ARRs, 95% confidence intervals, and exact *p*-values. Covariate associations differentiating membership in the CFU class versus Discontinuers were discussed above; the following focuses on significant multivariable covariate associations with membership in the Frequent to Non-Frequent Users,

Consistent Non-Frequent Users, and Non-Frequent Users to Discontinuers classes versus Discontinuers.

[Tables 7 and 8 about here]

Membership likelihood in the Frequent to Non-Frequent Users class (Class 2) versus Discontinuers was significantly higher for those never married and the 1976-1980 (vs. 2001-2006) cohorts. Membership likelihood in the Consistent Non-Frequent Users class (Class 3) versus Discontinuers was significantly higher for those never married and the 1976-1980, 1981-1985, and 1991-1995 (vs. 2001-2006) cohorts. The likelihood of membership in the Non-Frequent Users to Discontinuers class (Class 4) versus Discontinuers was significantly higher for females, those whose parents had some college education, those who graduated from a 4-year college, those who never married, and the 1976-1980, 1981-1985, 1986-1990, and 1991-1995 (vs. 2001-2006) cohorts.

Discussion

Using data from multiple cohorts of US nationally representative samples of 12th grade students who were followed longitudinally on a biennial basis, we found that those who reported frequent marijuana use as 12th grade students (approximately 6% of recent 12th grade samples [22]) could be meaningfully separated into five latent classes based on longitudinal patterns of past 30-day marijuana use from ages 19/20-29/30. Latent class membership was associated significantly with sociodemographic covariates and varied across cohorts. The highest risk for

continued frequent marijuana use belonged to individuals in more recent cohorts and those who did not enter roles of marriage and parenthood.

These results support findings from prior studies showing strong connections between adolescent marijuana use and continued use during adulthood [34], particularly among adolescents reporting frequent use [8]. Almost 60% of 12th grade frequent marijuana users were estimated to be members of latent classes involving some level of past 30-day marijuana use through age 29/30. Yet, approximately 40% of 12th grade frequent users ceased reporting past 30-day marijuana use by age 29/30—slightly more than half of these individuals discontinued from age 19/20 onwards. Observed cohort differences indicated that the likelihood of being in either "extreme" class (CFU or Discontinuers) compared with other classes was significantly higher for more recent cohorts (2001-2006). What might be behind increasing membership likelihood in these very different classes?

Growing CFU class membership indicates that an increasing number of individuals who were frequent marijuana users as 12th graders have continued frequent use through age 29/30 versus exhibiting age-related developmental decreases in use. Such increases would be consistent with recent MTF research finding (a) historically recent high levels of frequent marijuana use among young adults aged 27-30 in general [24]; and (b) developmental patterns of frequent marijuana use that do not reflect convergence to lower use levels by age 29/30 among recent cohorts [25].

Increasing CFU class membership may be associated with changes in marijuana potency and perceived risk, as well as changing trends related to adult social roles. US marijuana potency has increased notably since the 1980s [35,36]; increasing potency may be associated with higher dependence among long-term frequent marijuana users [37,38], and decreased likelihood of reducing use with age. The protective association between perceived risk of marijuana use and actual use likelihood also has weakened among those aged 26-30 in recent cohorts [39]. A weakened perceived risk/use association in the late 20s may be contributing to decreased likelihood of age-related use reduction. A third possibility for CFU class growth may be changing involvement in social roles of marriage and parenthood [26]. Both marriage and parenthood are associated with increased likelihood of decreasing/stopping marijuana use [26,40-42]. A growing percentage of US young adults are delaying marriage [43] and parenthood [44-46]. To the extent that the analytic sample reflects decreasing rates of marriage and parenthood, recent cohorts would experience fewer reasons to move towards lower levels of marijuana use across age. Additional analyses confirmed that this was, indeed, the case. The percentage of the analytic sample reporting ever marrying by age 29/30 decreased linearly from 66.6% among the 1976-1980 cohort group to 29.0% among the 2001-2006 cohort group, and the percentage who reported parenthood decreased linearly from 54.6% to 44.0% (Mantel-Haenszel chi square p=<0.001 for both). Whatever the contributing factors may be, growing CFU class membership indicates increased health risks associated with chronic frequent marijuana use [2-6,8,10,11] for US adults entering their 30s.

Given the potential factors behind increasing CFU class membership discussed above, a co-occurring historical increase in the Discontinuers class appeared all the more surprising. Prior research examining desistance versus continued use among young adult heavy marijuana users wishing to stop use found that those who successfully desisted pointed to a key life event that induced quitting: either experiencing acute negative effects of use, or an event that resulted in marijuana no longer being a suitable part of their lives [47]. From this perspective, both increasing marijuana potency and historical change in social roles may be contributing to growing Discontinuers class membership. Increasing potency is linked with negative experiences such as psychotic outcomes [48]. More recent 12th grade cohorts who report frequent use are experiencing higher-potency marijuana than prior cohorts, and may be at higher risk for negative acute effects. Historical change in social roles may also be a factor, in that while marriage and parenthood are decreasing, college attendance has increased markedly [49]. Marijuana use, particularly frequent marijuana use, among full-time college students is markedly lower than among others [24], and the percentage of the analytic sample who reported ever graduating with a 4-year college degree by age 29/30 increased linearly from 19.1% among the 1976-1980 cohort group to 31.5% among the 2001-2006 cohort group (Mantel-Haenszel chi square $p<0.001$). To the extent that a 12th grade frequent marijuana user considers such use to be incongruent with a desired transition to college, the end of high school may provide a key life event precipitating discontinuation from ages 19/20 onward. More generally, our findings regarding cohort variation

in the trajectories indicate that the etiology of frequent marijuana use has shifted in important ways over the past three decades.

With respect to covariates other than cohort, the strongest associations with class membership were related to social roles of marriage and parenthood, with slightly weaker associations related to college attendance. These findings are consistent with prior substance use trajectory research among the general population [27], and may help identify individuals at higher risk of continuing frequent marijuana use. To the extent that national trends in marriage, parenthood, and college attendance continue, continued increases in the percentage of individuals who continue frequent marijuana use across young adulthood may be likely.

Strengths and limitations

All data were self-report, based on individuals who reported frequent marijuana use in 12th grade. School dropout is associated with higher marijuana use [50]; results may or may not generalize to frequent marijuana users who drop out prior to 12th grade. The sample was also subject to attrition. While use of weighting adjustments addressed attrition in part, frequent marijuana use is likely associated with missingness; estimated membership prevalence for the CFU class may thus be somewhat underestimated. Future research should examine if the associations between the social roles of marriage and parenthood and class membership vary between men and women. Such limitations notwithstanding, the current study's strengths include multi-cohort longitudinal data based on nationally representative samples of 12th grade students, collected using consistent measurement over four decades (1976 to 2017).

Conclusions

Across the past three decades, almost one in four US 12th grade frequent marijuana users continued high frequency use across young adulthood. The proportion of continuing frequent marijuana users has increased among more recent cohorts, with meaningful implications for future treatment demand and potential social and individual costs.

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Table 1. Sample Descriptives: 12th grade frequent marijuana users followed through age 29/30

	%	(SE)		%	(SE)
Sex[a]			Ever married[b]		
Female	31.7	(0.74)	No	51.1	(0.84)
Male	68.3	(0.74)	Yes	48.9	(0.84)
Race/ethnicity[a]			Ever have a child[b]		
White	79.0	(0.83)	No	50.0	(0.84)
Black	8.5	(0.63)	Yes	50.0	(0.84)
Hispanic	5.9	(0.51)			
Other	6.6	(0.45)	Cohort group		
Parental education[a]			1976-1980	24.5	(0.61)
No college education	38.5	(0.82)	1981-1985	16.7	(0.57)
Any college education	61.5	(0.82)	1986-1990	9.7	(0.48)
4-year college experience[b]			1991-1995	9.3	(0.50)
Not attend	64.9	(0.80)	1996-2000	18.7	(0.73)
Attend only	11.3	(0.54)	2001-2006	21.2	(0.79)
Graduate	23.8	(0.70)			

Notes: Sample n (unwtd) = 4,423.
[a] Reported at 12th grade survey.
[b] Reported from ages 19/20 through 29/30.

Table 2. Fit Information for RMLCAs Modeling Past 30-day Marijuana Use from Ages 19/20 through 29/30 with 1–7 Latent Classes

Classes	*df*	AIC	BIC	a-BIC	Entropy	Stability
1	716	44687.77	44764.51	44726.37		1.0000
2	703	39182.36	39342.22	39262.78	0.78	1.0000
3	690	37898.43	38141.43	38020.68	0.71	1.0000
4	677	37640.65	37966.77	37804.72	0.67	0.9760
5	**664**	**37491.95**	**37901.20**	**37697.84**	**0.65**	**0.7200**
6	651	37393.67	37886.06	37641.38	0.63	0.4960
7	638	37321.58	37897.09	37611.10	0.63	0.6080

Notes: Sample n (unwtd) = 4,423. RMLCA = repeated measures latent class analysis; AIC = Akaike information criterion; BIC = Bayesian information criterion; a-BIC = adjusted BIC; Stability = proportion of time the maximum-likelihood solution was selected out of 250 final stage optimizations (preceded by 500 initial stage sets of random starting values). Bold font indicates selected model.

Table 3. Five-class model of past 30-day marijuana use from ages 19/20 through 29/30 among 12th grade frequent marijuana users

	Modal age	Overall probability	Continued Frequent Users	Frequent to Non-Frequent Users	Consistent Non-Frequent Users	Non-Frequent Users to Discontinuers	Discontinuers
			Latent class membership probabilities (estimated class counts)				
			0.234 (1,033)	0.155 (687)	0.184 (816)	0.195 (863)	0.232 (1,024)
			Item response probabilities				
Frequent 30-day use							
	19/20	0.483	**0.760**	**0.771**	0.377	0.418	0.107
	21/22	0.374	**0.753**	**0.771**	0.166	0.212	0.016
	23/24	0.327	**0.800**	**0.646**	0.106	0.059	0.030
	25/26	0.277	**0.799**	0.368	0.136	0.014	0.016
	27/28	0.251	**0.840**	0.104	0.174	0.000	0.015
	29/30	0.237	**0.772**	0.104	0.171	0.005	0.022
Non-frequent 30-day use							
	19/20	0.334	0.180	0.193	***0.473***	**0.501**	0.341
	21/22	0.347	0.171	0.229	**0.658**	**0.626**	0.119
	23/24	0.335	0.138	0.316	**0.695**	**0.524**	0.086
	25/26	0.322	0.162	***0.426***	**0.746**	0.303	0.085
	27/28	0.297	0.122	**0.608**	**0.720**	0.123	0.074
	29/30	0.266	0.170	***0.495***	**0.613**	0.116	0.054
No 30-day use							
	19/20	0.183	0.060	0.035	0.149	0.081	**0.552**
	21/22	0.279	0.077	0.000	0.176	0.162	**0.865**

23/24	0.338	0.062	0.038	0.198	0.418	**0.884**
25/26	0.401	0.039	0.206	0.118	**0.683**	**0.899**
27/28	0.453	0.038	0.288	0.106	**0.877**	**0.911**
29/30	0.497	0.059	0.402	0.216	**0.880**	**0.924**

Notes: Sample n (unwtd) = 4,423. Estimated class counts obtained from estimated posterior probabilities. Bold font indicates item-response probabilities of ≥ 0.50. Bold and italicized font indicates the highest observed item-response probabilities when no probabilities ≥ .50 are observed. Latent class membership probabilities sum to 1 horizontally. Item response probabilities (reflecting the probabilities of each level of use for the sample overall, as well as within latent classes), sum to 1 vertically within age. For example, at age 19/20, the overall probability of using marijuana frequently in the past 30 days was 0.483, the probability of using non-frequently was 0.334, and was 0.183 for not using in the past 30 days.

Table 4. Estimated unadjusted proportions of covariates across five-class model of past 30-day marijuana use from ages 19/20 through 29/30 among 12th grade frequent marijuana users

	Class 1: Continued Frequent Users	Class 2: Frequent to Non-Frequent Users	Class 3: Consistent Non-Frequent Users	Class 4: Non-Frequent Users to Discontinuers	Class 5: Discontinuers
	Prop. (SE)	Prop. (SE)	Prop. (SE)	Prop. (SE)	Prop. (SE)
Covariates measured at 12th grade survey					
Sex					
Female (ref)	0.288 (0.018)	0.311 (0.030)	0.265 (0.024)	0.394 (0.025)	0.327 (0.020)
Male	0.712 (0.018)	0.689 (0.030)	0.735 (0.024)	0.606 (0.025)[1a,1b,5b]	0.673 (0.020)
Race/ethnicity					
White (ref)	0.819 (0.020)	0.777 (0.033)	0.816 (0.028)	0.828 (0.027)	0.718 (0.023)
African American	0.071 (0.015)[5a,5b]	0.072 (0.025)	0.101 (0.023)	0.060 (0.019)	0.117 (0.018)[1a,1b]
Hispanic	0.050 (0.012)[5a,5b]	0.067 (0.021)	0.037 (0.015)[5a]	0.042 (0.016)	0.093 (0.016)[1a,1b]
Other	0.060 (0.011)	0.084 (0.019)	0.047 (0.014)	0.070 (0.016)	0.072 (0.012)
Parental education					
No college education (ref)	0.372 (0.020)	0.407 (0.033)	0.363 (0.027)	0.350 (0.026)	0.429 (0.022)
Any college education	0.628 (0.020)	0.593 (0.033)	0.637 (0.027)	0.650 (0.026)[1b,5a,5b]	0.571 (0.022)
Covariates measured from ages 19/20-29/30					
4-Year college experience					
Not attend	0.642 (0.020)	0.683 (0.032)	0.662 (0.027)	0.597 (0.026)	0.666 (0.021)
Attend only	0.116 (0.014)	0.108 (0.022)	0.093 (0.016)	0.126 (0.017)	0.117 (0.015)
Graduate	0.242 (0.018)	0.209 (0.028)	0.245 (0.024)	0.277 (0.023) [1b,5b]	0.217 (0.018)
Ever married					
No (ref)	0.591 (0.021)	0.499 (0.034)	0.607 (0.027)	0.437 (0.028)	0.423 (0.023)
Yes	0.409 (0.021)[5a,5b]	0.501 (0.034)[1a,5b]	0.393 (0.027)[1b,5a,5b]	0.563 (0.028)[1a,5b]	0.577 (0.023)[1a,1b]

Ever have a child					
No (ref)	0.572 (0.021)	0.495 (0.034)	0.556 (0.028)	0.500 (0.027)	0.387 (0.022)
Yes	0.428 (0.021)[5a,5b]	0.505 (0.034)[5a]	0.444 (0.028)[5a]	0.500 (0.027)[1a,5a]	0.613 (0.022)[1a,1b]
Cohort group					
1976-1980	0.170 (0.014)[5b]	0.350 (0.029)[1a,1b,5a,5b]	0.282 (0.022)[1a,1b,5a,5b]	0.334 (0.023)[1a,1b,5a,5b]	0.146 (0.013)[1b]
1981-1985	0.118 (0.013)	0.149 (0.022)[1a]	0.209 (0.021)[1a,1b,5a,5b]	0.200 (0.020)[1a,1b,5a,5b]	0.166 (0.015)
1986-1990	0.107 (0.012)	0.081 (0.019)	0.074 (0.015)	0.118 (0.017)[1a,1b,5a,5b]	0.097 (0.013)
1991-1995	0.103 (0.013)	0.072 (0.019)	0.097 (0.017)[5b]	0.094 (0.017)[1a,1b,5a,5b]	0.090 (0.013)
1996-2000	0.223 (0.019)	0.160 (0.030)	0.156 (0.024)	0.146 (0.022)	0.230 (0.020)
2001-2006 (ref)	0.279 (0.020)	0.186 (0.031)	0.183 (0.026)	0.107 (0.024)	0.271 (0.022)

Notes: Sample n (unwtd) = 4,423.

[1a] Significantly different ($p < 0.05$ or stronger) odds than referent category vs. Class 1 (Continued Frequent Users) in bivariate models; exact *p*-values reported in Table 5.

[1b] Significantly different ($p < 0.05$ or stronger) odds than referent category vs. Class 1 (Continued Frequent Users) in multivariable models; exact *p*-values reported in Table 6.

[5a] Significantly different ($p < 0.05$ or stronger) odds than referent category vs. Class 5 (Discontinuers) in bivariate models; exact *p*-values reported in Table 7.

[5b] Significantly different ($p < 0.05$ or stronger) odds than referent category vs. Class 5 (Discontinuers) in multivariable models; exact *p*-values reported in Table 8.

Table 5. Unadjusted relative risk ratios from bivariate multinomial logistic regressions of past 30-day marijuana use latent class membership on covariates: Referent class = Continued Frequent Users

	Class 2: Frequent to Non-Frequent Users [v. CFU]			Class 3: Consistent Non-Frequent Users [v. CFU]			Class 4: Non-Frequent Users to Discontinuers [v. CFU]			Class 5: Discontinuers [v. CFU]		
	RR	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***
Covariates measured at 12th grade survey												
Sex												
Female	(ref)			(ref)			(ref)			(ref)		
Male	0.90	(0.63, 1.28)	0.555	1.12	(0.82, 1.52)	0.469	0.62	(0.48, 0.81)	<0.001	0.83	(0.65, 1.07)	0.151
Race/ethnicity												
White	(ref)			(ref)			(ref)			(ref)		
African American	1.08	(0.42, 2.79)	0.875	1.43	(0.72, 2.85)	0.308	0.84	(0.39, 1.84)	0.670	1.90	(1.08, 3.34)	0.026
Hispanic	1.41	(0.56, 3.54)	0.466	0.74	(0.28, 1.94)	0.537	0.83	(0.34, 2.03)	0.682	2.12	(1.15, 3.89)	0.016
Other	1.47	(0.74, 2.94)	0.276	0.78	(0.37, 1.62)	0.507	1.15	(0.64, 2.08)	0.633	1.37	(0.81, 2.31)	0.238
Parental education												
No college education	(ref)			(ref)			(ref)			(ref)		
Any college education	0.86	(0.60, 1.23)	0.416	1.04	(0.77, 1.40)	0.809	1.10	(0.83, 1.44)	0.513	0.79	(0.61, 1.01)	0.057
Covariates measured from ages 19/20-29/30												
4-Year college experience												
Not attend	(ref)			(ref)			(ref)			(ref)		
Attend only	0.87	(0.48, 1.57)	0.649	0.77	(0.47, 1.25)	0.296	1.16	(0.77, 1.74)	0.469	0.97	(0.65, 1.44)	0.873
Graduate	0.81	(0.53, 1.24)	0.336	0.98	(0.70, 1.37)	0.906	1.23	(0.91, 1.66)	0.172	0.86	(0.64, 1.15)	0.318
Ever married												
No	(ref)			(ref)			(ref)			(ref)		

Yes	1.45	(1.03, 2.06)	0.036	0.93	(0.70, 1.25)	0.644	1.86	(1.42, 2.44)	<0.001	1.97	(1.54, 2.53)	<0.001
Ever have a child												
No	(ref)			(ref)			(ref)			(ref)		
Yes	1.37	(0.96, 1.94)	0.081	1.07	(0.80, 1.43)	0.658	1.34	(1.03, 1.75)	0.031	2.12	(1.65, 2.72)	<0.001
Cohort group												
1976-1980	3.10	(1.84, 5.23)	<0.001	2.54	(1.62, 3.97)	<0.001	5.14	(3.00, 8.82)	<0.001	0.89	(0.62, 1.28)	0.527
1981-1985	1.90	(1.03, 3.50)	0.040	2.70	(1.65, 4.42)	<0.001	4.43	(2.49, 7.90)	<0.001	1.45	(0.98, 2.14)	0.064
1986-1990	1.14	(0.54, 2.42)	0.723	1.07	(0.58, 1.96)	0.840	2.88	(1.54, 5.39)	0.001	0.94	(0.60, 1.47)	0.791
1991-1995	1.05	(0.47, 2.33)	0.904	1.43	(0.79, 2.60)	0.239	2.38	(1.22, 4.62)	0.011	0.90	(0.56, 1.44)	0.649
1996-2000	1.08	(0.55, 2.12)	0.833	1.07	(0.61, 1.86)	0.815	1.71	(0.92, 3.18)	0.091	1.06	(0.73, 1.55)	0.748
2001-2006	(ref)			(ref)			(ref)			(ref)		

Notes: Sample n (unwtd) = 4,423. CFU = Consistent Frequent Users; RR = Relative risk ratio (obtained from models regressing past 30-day marijuana use latent class membership on one covariate at a time).

Table 6. Adjusted relative risk ratios from multivariable multinomial logistic regressions of past 30-day marijuana use latent class membership on covariates: Referent class = Continued Frequent Users

	Class 2: Frequent to Non-Frequent Users [v. CFU]			Class 3: Consistent Non-Frequent Users [v. CFU]			Class 4: Non-Frequent Users to Discontinuers [v. CFU]			Class 5: Discontinuers [v. CFU]		
	ARR	**(95% CI)**	***p***	**ARR**	**(95% CI)**	***p***	**ARR**	**(95% CI)**	***p***	**ARR**	**(95% CI)**	***p***
Covariates measured at 12th grade survey												
Sex												
Female	(ref)			(ref)			(ref)			(ref)		
Male	0.98	(0.66, 1.45)	0.920	1.14	(0.83, 1.58)	0.423	0.62	(0.47, 0.81)	0.001	0.98	(0.75, 1.29)	0.893
Race/ethnicity												
White	(ref)			(ref)			(ref)			(ref)		
African American	1.05	(0.36, 3.04)	0.929	1.38	(0.68, 2.78)	0.373	0.94	(0.43, 2.06)	0.884	2.00	(1.09, 3.67)	0.025
Hispanic	2.00	(0.76, 5.29)	0.163	0.94	(0.33, 2.68)	0.911	1.29	(0.52, 3.18)	0.583	2.23	(1.16, 4.26)	0.016
Other	1.59	(0.75, 3.40)	0.230	0.88	(0.42, 1.85)	0.733	1.26	(0.65, 2.45)	0.503	1.51	(0.86, 2.66)	0.153
Parental education												
No college education	(ref)			(ref)			(ref)			(ref)		
Any college education	1.16	(0.75, 1.79)	0.496	1.24	(0.89, 1.72)	0.208	1.36	(1.00, 1.83)	0.048	0.89	(0.68, 1.18)	0.427
Covariates measured from ages 19/20-29/30												
4-Year college experience												
Not attend	(ref)			(ref)			(ref)			(ref)		
Attend only	0.96	(0.51, 1.78)	0.884	0.77	(0.45, 1.31)	0.332	1.42	(0.93, 2.16)	0.100	1.06	(0.70, 1.60)	0.785
Graduate	0.94	(0.59, 1.52)	0.817	1.14	(0.79, 1.64)	0.491	1.57	(1.12, 2.18)	0.008	1.01	(0.72, 1.41)	0.978
Ever married												
No	(ref)			(ref)			(ref)			(ref)		

Yes	1.04	(0.66, 1.63)	0.875	0.69	(0.48, 0.98)	0.039	1.26	(0.92, 1.72)	0.152	1.84	(1.36, 2.48)	<0.001
Ever have a child												
No	(ref)			(ref)			(ref)			(ref)		
Yes	1.28	(0.79, 2.06)	0.319	1.24	(0.85, 1.81)	0.269	1.19	(0.87, 1.62)	0.282	1.63	(1.21, 2.21)	0.001
Cohort group												
1976-1980	3.18	(1.76, 5.75)	<0.001	2.98	(1.85, 4.80)	<0.001	5.82	(3.33, 10.18)	<0.001	0.65	(0.43, 0.98)	0.038
1981-1985	1.88	(0.96, 3.66)	0.065	3.00	(1.79, 5.02)	<0.001	5.16	(2.85, 9.32)	<0.001	1.15	(0.76, 1.74)	0.517
1986-1990	1.18	(0.55, 2.54)	0.673	1.19	(0.64, 2.22)	0.585	3.06	(1.62, 5.77)	0.001	0.85	(0.54, 1.33)	0.475
1991-1995	1.01	(0.44, 2.28)	0.990	1.59	(0.87, 2.89)	0.133	2.44	(1.26, 4.72)	0.008	0.76	(0.47, 1.24)	0.272
1996-2000	1.04	(0.52, 2.09)	0.916	1.11	(0.63, 1.94)	0.720	1.82	(0.98, 3.39)	0.057	0.92	(0.62, 1.37)	0.677
2001-2006	(ref)			(ref)			(ref)			(ref)		

Notes: Sample n (unwtd) = 4,423. CFU = Consistent Frequent Users; ARR = Adjusted relative risk ratio (obtained from models regressing past 30-day marijuana use latent class membership on all listed covariates simultaneously).

Table 7. Unadjusted relative risk ratios from bivariate multinomial logistic regressions of past 30-day marijuana use latent class membership on covariates: Referent class = Discontinuers

	Class 1: Continued Frequent Users [v. Discontinuers]			**Class 2: Frequent to Non-Frequent Users [v. Discontinuers]**			**Class 3: Consistent Non-Frequent Users [v. Discontinuers]**			**Class 4: Non-Frequent Users to Discontinuers [v. Discontinuers]**		
	RR	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***	**RR**	**(95% CI)**	***p***
Covariates measured at 12th grade survey												
Sex												
Female	(ref)			(ref)			(ref)			(ref)		
Male	1.20	(0.94, 1.54)	0.151	1.08	(0.78, 1.48)	0.645	1.34	(1.00, 1.81)	0.052	0.75	(0.55, 1.02)	0.065
Race/ethnicity												
White	(ref)			(ref)			(ref)			(ref)		
African American	0.53	(0.30, 0.93)	0.026	0.57	(0.26, 1.25)	0.161	0.75	(0.41, 1.37)	0.355	0.44	(0.19, 1.02)	0.055
Hispanic	0.47	(0.26, 0.87)	0.016	0.67	(0.32, 1.40)	0.285	0.35	(0.14, 0.86)	0.021	0.39	(0.15, 1.02)	0.055
Other	0.73	(0.43, 1.23)	0.238	1.08	(0.59, 1.96)	0.812	0.57	(0.28, 1.16)	0.122	0.84	(0.43, 1.67)	0.627
Parental education												
No college education	(ref)			(ref)			(ref)			(ref)		
Any college education	1.27	(0.99, 1.63)	0.057	1.10	(0.80, 1.51)	0.567	1.32	(0.99, 1.77)	0.063	1.39	(1.01, 1.93)	0.045
Covariates measured from ages 19/20-29/30												
4-Year college experience												
Not attend	(ref)			(ref)			(ref)			(ref)		
Attend only	1.03	(0.69, 1.54)	0.873	0.90	(0.53, 1.54)	0.702	0.80	(0.49, 1.30)	0.365	1.20	(0.73, 1.97)	0.469
Graduate	1.16	(0.87, 1.55)	0.318	0.94	(0.64, 1.39)	0.756	1.14	(0.81, 1.60)	0.459	1.43	(0.99, 2.05)	0.054
Ever married												
No	(ref)			(ref)			(ref)			(ref)		

Yes	0.51	(0.39, 0.65)	<0.001	0.74	(0.54, 1.01)	0.059	0.47	(0.35, 0.63)	<0.001	0.94	(0.68, 1.31)	0.727
Ever have a child												
No	(ref)			(ref)			(ref)			(ref)		
Yes	0.47	(0.37, 0.61)	<0.001	0.64	(0.47, 0.89)	0.007	0.50	(0.38, 0.68)	<0.001	0.63	(0.46, 0.87)	0.005
Cohort group												
1976-1980	1.12	(0.78, 1.61)	0.527	3.48	(2.16, 5.61)	<0.001	2.85	(1.81, 4.49)	<0.001	5.78	(3.10, 10.79)	<0.001
1981-1985	0.69	(0.47, 1.02)	0.064	1.31	(0.76, 2.25)	0.326	1.87	(1.16, 3.01)	0.010	3.06	(1.60, 5.87)	0.001
1986-1990	1.06	(0.68, 1.65)	0.791	1.22	(0.61, 2.40)	0.576	1.13	(0.61, 2.08)	0.694	3.06	(1.47, 6.36)	0.003
1991-1995	1.12	(0.69, 1.79)	0.649	1.17	(0.57, 2.43)	0.668	1.60	(0.88, 2.92)	0.127	2.65	(1.22, 5.77)	0.014
1996-2000	0.94	(0.65, 1.37)	0.748	1.01	(0.55, 1.87)	0.971	1.00	(0.58, 1.74)	0.988	1.61	(0.79, 3.27)	0.190
2001-2006	(ref)			(ref)			(ref)			(ref)		

Notes: Sample n (unwtd) = 4,423. RR = Relative risk ratio (obtained from models regressing past 30-day marijuana use latent class membership on one covariate at a time).

Table 8. Adjusted relative risk ratios from multivariable multinomial logistic regressions of past 30-day marijuana use latent class membership on covariates: Referent class = Discontinuers

	Class 1: Continued Frequent Users [v. Discontinuers]			**Class 2: Frequent to Non-Frequent Users [v. Discontinuers]**			**Class 3: Consistent Non-Frequent Users [v. Discontinuers]**			**Class 4: Non-Frequent Users to Discontinuers [v. Discontinuers]**		
	ARR	**(95% CI)**	**p**	**ARR**	**(95% CI)**	**p**	**ARR**	**(95% CI)**	**p**	**ARR**	**(95% CI)**	**p**
Covariates measured at 12th grade survey												
Sex												
Female	(ref)			(ref)			(ref)			(ref)		
Male	1.02	(0.78, 1.33)	0.893	1.00	(0.70, 1.42)	0.993	1.16	(0.84, 1.62)	0.367	0.63	(0.45, 0.88)	0.006
Race/ethnicity												
White	(ref)			(ref)			(ref)			(ref)		
African American	0.50	(0.27, 0.92)	0.025	0.53	(0.22, 1.24)	0.140	0.69	(0.38, 1.26)	0.226	0.47	(0.21, 1.07)	0.073
Hispanic	0.45	(0.23, 0.86)	0.016	0.90	(0.41, 1.97)	0.787	0.42	(0.16, 1.15)	0.091	0.58	(0.24, 1.42)	0.233
Other	0.66	(0.38, 1.16)	0.153	1.05	(0.55, 2.01)	0.873	0.58	(0.29, 1.18)	0.135	0.83	(0.39, 1.79)	0.638
Parental education												
No college education	(ref)			(ref)			(ref)			(ref)		
Any college education	1.12	(0.85, 1.47)	0.427	1.30	(0.88, 1.92)	0.185	1.38	(0.99, 1.93)	0.056	1.52	(1.07, 2.16)	0.021
Covariates measured from ages 19/20-29/30												
4-Year college experience												
Not attend	(ref)			(ref)			(ref)			(ref)		
Attend only	0.94	(0.62, 1.43)	0.785	0.90	(0.51, 1.59)	0.721	0.72	(0.42, 1.26)	0.250	1.34	(0.80, 2.24)	0.260
Graduate	1.00	(0.71, 1.40)	0.978	0.94	(0.60, 1.47)	0.788	1.13	(0.77, 1.66)	0.527	1.56	(1.02, 2.38)	0.040
Ever married												
No	(ref)			(ref)			(ref)			(ref)		

Yes	0.54	(0.40, 0.74)	<0.001	0.56	(0.38, 0.85)	0.006	0.37	(0.26, 0.53)	<0.001	0.68	(0.47, 0.99)	0.047
Ever have a child												
No	(ref)			(ref)			(ref)			(ref)		
Yes	0.61	(0.45, 0.83)	0.001	0.78	(0.51, 1.20)	0.255	0.76	(0.52, 1.11)	0.150	0.73	(0.50, 1.05)	0.089
Cohort group												
1976-1980	1.54	(1.02, 2.33)	0.038	4.91	(2.82, 8.53)	<0.001	4.60	(2.77, 7.65)	<0.001	9.00	(4.60, 17.59)	<0.001
1981-1985	0.87	(0.57, 1.32)	0.517	1.64	(0.90, 2.96)	0.103	2.61	(1.56, 4.37)	<0.001	4.49	(2.27, 8.87)	<0.001
1986-1990	1.18	(0.75, 1.85)	0.475	1.39	(0.69, 2.81)	0.360	1.40	(0.75, 2.63)	0.293	3.60	(1.70, 7.61)	0.001
1991-1995	1.32	(0.81, 2.15)	0.272	1.32	(0.62, 2.81)	0.466	2.09	(1.12, 3.88)	0.020	3.20	(1.47, 6.99)	0.003
1996-2000	1.09	(0.73, 1.62)	0.677	1.13	(0.60, 2.14)	0.709	1.20	(0.68, 2.13)	0.521	1.98	(0.96, 4.09)	0.063
2001-2006	(ref)			(ref)			(ref)			(ref)		

Notes: Sample n (unwtd) = 4,423. ARR = Adjusted relative risk ratio (obtained from models regressing past 30-day marijuana use latent class membership on all listed covariates simultaneously).