Longitudinal Patterns of Marijuana Use Across Ages 18-50 in a US National Sample: A Descriptive Examination of Predictors and Health Correlates of Repeated Measures Latent Class Membership

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Abstract

Background—This descriptive study identified latent classes of longitudinal marijuana use from ages 18 through 50 among a national sample; examined covariate associations with class membership regarding use/non-use, use intensity, and use duration; and described associations between identified latent classes and age 50 health outcomes.

Methods—The study involved collection and primary analysis of data from 9,831 individuals first surveyed as 12th graders in the national Monitoring the Future study and followed through modal age 50. Repeated measures latent class analysis was used to identify latent classes based on self-reported past 12-month marijuana use.

Results—Seven latent classes of marijuana use from ages 18 to 50 were identified including Non-users (44%), two classes characterized by shorter-term use patterns (totaling 28%), and four classes characterized by longer-term moderate or heavy use (totaling 28%). Use reduction

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appeared particularly likely during early and late 20s. Gender, parental education, alcohol/cigarette use, religious commitment, and marital status differentiated use/non-use, use intensity, and use duration after high school. In non-causal models controlling for covariates, longer-term marijuana use classes (where use extended into the late 20s or beyond) were associated with significantly higher odds of negative health outcomes at age 50.

Conclusions—Approximately 28% of the national sample reported longer-term moderate/heavy marijuana use, which was associated with negative health outcomes at age 50. The early and late 20s may be especially important periods for marijuana use prevention and intervention efforts, which may be strengthened by recognition of characteristics that appear to have significant associations with persistent use.

Keywords

marijuana; young adults; adults; repeated measures latent class analysis; health

1 INTRODUCTION

According to the United Nations Office on Drugs and Crime (UNODC, 2015), marijuana use is increasing in the Americas and Asia, and remaining stable in Europe and Oceania. Global prevalence rates vary significantly (Degenhardt et al., 2008; UNODC, 2015). Yet, there is a surprising degree of similarity in the median age at which individuals start using marijuana (Degenhardt et al., 2008), suggesting some degree of common etiology. Key issues for understanding marijuana use etiology include what patterns of use follow onset, what proportion of the population may be expected to follow various patterns, and what outcomes may be associated with following differing use patterns.

The overall developmental trajectory for marijuana use typically involves escalation during late adolescence, peak use in early young adulthood, and then some decrease thereafter (Bachman et al., 1997; Chen and Kandel, 1995; Homel et al., 2014; Johnston et al., 2016). Yet, a great deal of inter-individual variability exists in use onset, duration, and frequency (Caldeira et al., 2012), such that distinct classes or trajectories of marijuana use can be empirically modeled and identified. Available marijuana class/trajectory research has primarily focused on use from adolescence through either the early 20s (e.g., Brown et al, 2004; Ellickson et al., 2004) or mid- to late-20s (e.g., Brook et al., 2011a; Caldeira et al., 2012; Homel et al., 2014; Jackson et al., 2008; Passarotti et al., 2015; Schulenberg et al., 2005; Silins et al., 2013). A few studies have extended into the early 30s (Brook et al., 2011b, Juon et al., 2011; Tait et al., 2011). The authors of the current study are unaware of empirical marijuana class/trajectory research extending beyond the early 30s into middle adulthood.

Longitudinal research typically identifies five general marijuana use patterns across age: non-use, time-limited low use, chronic heavy use, escalating use, and decreasing use. The utility of such research is not the number of identified patterns, but resulting theoretical and intervention implications. Ellickson et al. (2004) note that such implications involve identification of (a) estimated membership probabilities for subgroups at especially high potential risk for adverse consequences, (b) developmental ages during which specific

groups are particularly vulnerable to use onset or escalation, and (c) risk factors differentiating between use escalation and decline.

The ability to model marijuana use heterogeneity into mid-adulthood would be helpful in examining the degree to which use patterns are associated with other outcomes of interest during mid-adulthood, such as health status. Research has found significant associations between chronic high-frequency and/or high-quantity marijuana use and health outcomes. Unsurprisingly, individuals with such trajectories are at elevated risk for abuse and/or dependence (Brown et al., 2004; Flory et al., 2004; Juon et al., 2011; Lynne-Landsman et al., 2010; Nelson et al., 2015; Pardini et al., 2015; Tucker et al., 2005; Windle and Wiesner, 2004). Some studies have found significantly heightened risk for adverse psychological outcomes among chronic high-frequency marijuana use trajectories (Arria et al., 2016; Brook et al., 2011a, 2011b; Flory et al., 2004; Juon et al., 2011; Lynne-Landsman et al., 2010; Newcomb and Bentler, 1988; Pardini et al., 2015); results have been mixed or non-significant in other studies (Bechtold et al., 2015; Brown et al., 2004; Ellickson et al., 2004; Windle and Wiesner 2004). Cognitive outcomes such as verbal memory have been negatively associated with cumulative lifetime marijuana exposure (Auer et al., 2016), and there is some indication that delayed recall may improve among individuals who cease weekly marijuana use (Tait et al., 2011). Overall physical health has been found to be significantly lower and physical health service utilization higher in individuals with chronic high-frequency marijuana use trajectories than among abstainers (Arria et al., 2016; Ellickson et al., 2004). In contrast, studies have documented no differences by marijuana trajectories on some specific physical health conditions (e.g., pulmonary function, respiratory conditions, physical injury; Bechtold et al., 2015; Pletcher et al., 2012). In most of these studies, health outcomes were measured during the 20s or 30s; few studies examined outcomes during the 40s or at age 50 (Auer et a., 2016; Juon et al., 2011; Pletcher et al., 2012). Thus, the majority of research has focused on ages of relatively low health care demand; health care visits are lowest for individuals aged 18-44 (National Center for Health Statistics [NCHS], 2015).

Research on marijuana/health associations has identified several key covariates, including co-occurring tobacco and alcohol use and socioeconomic status (Bechtold et al., 2015; Budney et al., 2008; Dinitto and Choi 2011; Hall and Degenhardt, 2009; Jackson et al., 2008). Known risk factors associated with chronic heavy or increasing marijuana use during young adulthood include male gender (e.g., Ellickson et al., 2004; Juon et al., 2011; Silins et al., 2013); higher parental education (Ellickson et al., 2004; Passarotti et al., 2015); lower adolescent school performance or commitment (Flory et al., 2004; Passarotti et al., 2015); not attending college (Nelson et al., 2015; Passarotti et al., 2015); co-morbid substance use (Jackson et al., 2008; Passarotti et al., 2015; Silins et al., 2013); and low religious commitment (Brown et al., 2004; Jackson et al., 2008; Silins et al., 2013). Race/ethnicity has shown inconsistent associations with marijuana use patterns (e.g., Ellickson et al., 2004; Silins et al., 2013). Married young adults use marijuana less frequently (Bachman et al., 1997; Staff et al., 2010), and marriage is associated with lower likelihood of chronic or escalating marijuana use across the early 20s (Schulenberg et al., 2015). The extent to which these characteristics are associated with marijuana use classes/trajectories extending into middle adulthood is not known.

This paper models latent classes of marijuana use from ages 18 through 50 among a national sample, examines covariate/class membership associations to identify characteristics associated with use intensity and duration, and examines the potential utility of this approach by estimating non-causal associations between identified latent classes and health outcomes at age 50. Three research questions guided analysis: (1) How many mutually exclusive latent classes of within-person marijuana use from ages 18 to 50 can be empirically identified, and what percentage of the population is estimated to be in each class? (2) How do covariates differentiate class membership? (3) Are there indications that health outcomes at age 50 are associated with latent marijuana use class membership?

2. METHODS

2.1 Sample

The analysis utilized data from Monitoring the Future (MTF). Detailed methodological information can be found in Bachman et al. (2015) and Johnston et al. (2016). Briefly, U.S. nationally representative samples of approximately 15,000 12th graders (modal age 18; hereafter referred to as age 18) from about 130 schools in the contiguous 48 states have been surveyed annually since 1975. Students complete self-administered surveys, typically during a normal class period. A sub-sample of about 2,400 12th graders is selected from each annual sample for longitudinal follow-up (with oversampling of drug users), randomly divided with half of each cohort surveyed one year after graduation (age 19) and half surveyed two years after graduation (age 20). Participants are then surveyed every two years up to age 29/30. Thereafter, respondents are surveyed at 5-year intervals to age 50 (ages 35, 40, 45, and 50). Follow-up questionnaires are mailed in the spring with a modest monetary incentive. The University of Michigan Institutional Review Board approved the study.

The analytic sample was limited to 12th grade cohorts from 1976-1983 (age 50 data were collected during 2008-2015). A total of 19,210 individuals were selected for follow-up participation; 9,842 (51.2%) responded at the age 50 follow-up survey. For inclusion in the current analysis, cases were limited to the 9,831 respondents providing valid responses for gender and at least one relevant health outcome, as well as valid responses to past 12-month marijuana use on at least two time points (51.2% of those selected for follow-up participation; 99.9% of those who responded at the age 50 follow-up survey). Attrition adjustments are discussed below.

2.2 Measures

2.2.1 Marijuana use—Respondents were asked, "On how many occasions (if any) have you used marijuana (weed, pot) or hashish (hash, hash oil) during the last 12 months?" (0 occasions, 1-2, 3-5, 6-9, 10-19, 20-39, and 40 or more occasions). To capture use prevalence and some indication of use frequency, trichotomies indicating no use, 1-39 use occasions, or 40+ use occasions were coded at each of the 11 data collection points. This coding identified three user types: high-frequency users (hereafter referred to as heavy users) who used on more than three occasions per month on average (40+ occasions in 12 months); infrequent or low-frequency users (hereafter referred to as moderate users) who used anywhere from one

occasion in 12 months to slightly more than three occasions per month on average (1-39 occasions in 12 months); and non-users.

2.2.2 Covariates—Covariate selection was based on key correlates of marijuana use identified in the literature review summarized above. A four-level, categorical variable identified age 18 cohort group membership (1976-1977, 1978-1979, 1980-1981, 1982-1983). Self-reported covariates assessed at age 18 included gender (male, female); race/ethnicity (White, Black, Hispanic, Other); parental education (at least one parent completed college vs. none; used as a proxy for family-of-origin socioeconomic status); religious commitment (an average of personal importance of religion and attendance at religious services, coded low, medium and high); past 2-week binge drinking (any, none); and past 30-day cigarette smoking (any, none). Covariates assessed after age 18 included ever married between ages 19-30 (yes, no); ever graduated from a 4-year college between ages 19-30 (yes, no); any income from welfare/unemployment from ages 35-45 (yes, no); average 30-day cigarette smoking frequency from ages 35-45 (an average of age 35, 40, and 45 data on the number of cigarettes smoked in the past 30 days); and average 30-day alcohol use frequency from ages 35-45 (an average of age 35, 40, and 45 data on the number of drinking occasions in the past 30 days multiplied by the usual number of drinks per drinking day).

2.2.3 Health outcomes—Selection of self-reported health outcomes at age 50 was based on key health correlates of marijuana use identified in the literature review summarized previously. Outcomes were all yes/no dichotomies and included 2+ past 30-day respiratory problems; any past 30-day cognitive problems; any past 12-month health visits for physical illness or psychological problems; poor overall physical health; and any lifetime psychiatric problems, alcohol use problems, or drug use problems (see Supplementary Material[1] for detailed information). Health outcomes were not asked at age 18.

2.3 Analysis

To address the first research question (RQ1), repeated measures latent class analysis (RMLCA; Lanza and Collins, 2006) was used to identify unique patterns of marijuana use across ages 18-50. Analyses included 11 trichotomous indicators of past 12-month marijuana use, one indicator for each of the 11 MTF data collections from ages 18-50. RMLCA was used as a data reduction technique to identify key longitudinal patterns (and corresponding prevalences) from the $3^{11}=177,147$ possible patterns (not including missing data). In addition, RMLCA enabled models to account explicitly for measurement error (i.e., mismatch between observed reports and class assignment) and missing data on indicators (Collins and Lanza, 2010). Analyses were conducted in Mplus v7.3 (Muthén and Muthén, 1998-2015) using full information maximum likelihood estimation with robust standard errors. Identification of maximum likelihood solutions was confirmed for all models using 500 initial stage random starts and 250 final stage optimizations.

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[1]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

To address RQ2, all covariates were added simultaneously to baseline-category, multinomial logistic regression models to examine whether covariates differentiated among the classes. These models were based on modal assignment of individuals to latent classes using posterior probabilities, and were corrected for classification error using an approach proposed by Vermunt (2010). This approach has been shown to be superior to traditional modal assignment without the correction (Vermunt, 2010) and to the previously recommended multiple pseudo-class draws (Asparouhov and Muthén, 2014); it is the approach currently recommended in Mplus for covariates and is implemented using the R3STEP command, wherein covariates are not allowed to affect latent class formation (Asparouhov and Muthén, 2015).

To address RQ3, logistic regression models were used to describe associations between class membership and binary health outcomes. These models were based on modal assignment of individuals to latent classes using posterior probabilities, and were corrected for classification error using an inclusive classify-analyze approach proposed by Bray et al. (2015). The approach has been shown to be superior to traditional modal assignment without the correction (Bray et al., 2015) and to the previously recommended multiple pseudo-class draws (Bray et al., 2015). RMLCAs were first re-fit in Mplus using only indicators across ages 18-45 to establish a clearer temporal ordering of class membership and outcomes at age 50. Then, for each health outcome, the inclusive classify-analyze approach was used to modally assign individuals to classes, and SAS v13.2 PROC LOGISTIC (SAS Institute Inc., 2013) was used to regress the binary health outcomes on class assignments, both bivariately and then controlling for all covariates simultaneously.

Missing data on marijuana use indicators were assumed to be missing at random and were handled using Mplus' full information maximum likelihood estimation procedure (Muthén and Muthén, 1998-2015). Missing data on covariates were handled via mean imputation (continuous variables) or missing data indicators (categorical variables). Missing data on outcomes were minimal due to analysis sample selection and were handled via casewise deletion.

All analyses used attrition weights to account for drop out between ages 18 and 50, which was differential with respect to 12th grade drug use and demographic characteristics. These inverse probability weights adjusted for the probability of responding at age 50 based on the following age 18 covariates: gender, race/ethnicity, college plans, high school grades, number of parents in the home, religiosity, parental education, alcohol use, cigarette use, marijuana use, region of the country, 12th grade cohort, and over-sampling of age 18 substance users into the longitudinal follow-up. Due to the number of statistical tests reported, only results significant at p<.01 are discussed below.

3. RESULTS

3.1 Identifying Latent Classes of Marijuana Use Across Ages 18 to 50 (RQ1)

Using indicators of past 12-month marijuana use across ages 18 to 50, RMLCAs with one to nine classes were considered. The optimal number of classes was determined by examining model fit, interpretability, parsimony, and stability/identification. When interpreting models,

item response probability values of 0.50 or higher were considered to indicate a "high" probability of endorsing the specified use level.

Model fit and selection criteria are reported in Table 1. Due to the use of trichotomous indicators, it was not possible to use the bootstrap likelihood ratio test as a criterion for selecting the optimal number of latent classes. Instead, 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 at selecting the "correct" latent class model (Dziak et al., 2014). Meaningful improvement in AIC, BIC, and a-BIC values did not begin to slow substantially until the 6-class model. Beginning with the 8-class model, membership probabilities for some classes dropped below 4% (and would be problematic for examining covariate associations with class membership). Thus, the 6- and 7-class models were considered for interpretation clarity and utility. Four classes characterized by non-use or moderate use were consistently found in both the 6- and 7-class models. The remaining two classes in the 6-class model were characterized by heavy use: one with high probabilities for heavy use through age 45 and the other with high probabilities through age 23/24. Membership in these classes was re-distributed in the 7-class model into three more clearly-defined heavy use patterns: high probabilities for heavy use (1) at all ages, (2) through age 29/30, and (3) through age 21/22. Given the improved differentiation of heavy use, the 7-class model was selected as optimal.

Table 2 reports class membership and item response probability parameter estimates for the 7-class solution. The overall probability of reporting no past 12-month marijuana use rose from 0.53 at age 18 to 0.88 at age 45 onward. The overall probability of reporting moderate use dropped from 0.33 at age 18 to 0.08 at age 45 onward. The overall probability of reporting heavy use was highest at ages 18 to 21/22 (0.14), but decreased to 0.04 by age 40 onward. Three latent classes were characterized by relative stability with consistent use or non-use across age; four other classes reflected declining use across age. The seven latent classes were labeled and described as follows:

1. Non-users (prevalence=0.44, indicating that an estimated 44% of the sample were members of this latent class). Probabilities of no past 12-month use were high at all ages, ranging from 0.90 at age 18 to 1.00 from age 35 onward.

2. Early Young Adult (YA) Moderate Users (22%). For this decreasing use class, probabilities of moderate use were high from ages 18 through 21/22; at all following ages, high probabilities of no use were observed.

3. YA Moderate Users (12%). For this decreasing use class, probabilities of moderate use were high from ages 18 through 27/28, with high probabilities of no use thereafter.

4. Persistent Moderate Users (6%). Members of this class reported high probabilities of moderate use from ages 18 to 45.

5. Early YA Heavy Users (6%). For this decreasing use class, high probabilities of heavy use were reported from ages 18 to 21/22. From ages 23/24 to 27/28, high

probabilities of moderate use were reported. High probabilities of no use were reported from ages 29/30 onwards.

6. YA Heavy Users (5%). For this decreasing use class, probabilities of heavy use were high from ages 18 to 29/30. At age 35, high probabilities of moderate use were reported, followed by high probabilities of no use from age 45 onwards.

7. Persistent Heavy Users (5%). Members of this class reported high probabilities of heavy use from ages 18 to 50.

None of the classes showed evidence of escalation to high probabilities of a higher use level after age 18. However, evidence of developmental progression within use level was observed. For example, while YA Moderate Users had high probabilities of using on 1-39 occasions from ages 18 to 27/28, probabilities increased from 0.51 at age 18 to 0.79 at age 23/24, and then decreased thereafter. Reduction to a lower use level appeared particularly likely at two developmental ages: early YA (around 21/22) and late YA (around 27/28 or 29/30).

3.2 Covariate Associations with Class Membership from Ages 18 to 50 (RQ2)

Table 3 provides descriptive statistics for covariates. Tables 4-6 report adjusted relative risk ratios (ARRs) from multivariable multinomial logistic regression models examining covariate associations with class membership. (Supplemental Tables 1a-3 provide 95% confidence intervals for all reported associations[2].)

3.2.1 Using versus non-using classes—Table 4 reports differences in relative risk of membership in each specified class versus the Non-user class. For example, the relative risk of membership in the Persistent Heavy class (vs. Non-users) was approximately one-and-a-half times larger for males compared with females (ARR=1.53, p=0.003), controlling for all other covariates.

Males were less likely than females to be members of the YA Moderate User class, and more likely than females to be members of any heavy use class, than Non-users. Higher parental education was associated with higher risk of membership in Persistent Moderate and all heavy use classes (vs. Non-users). The risk of being in any class involving use (vs. Non-users) was higher for those who reported age 18 binge drinking or cigarette use, but lower for those with high religious commitment at age 18. Regarding covariates measured during adulthood, marriage was associated with lower risk of membership in all using classes (vs. Non-users) other than Early YA Moderate Users. Graduating from college by age 29/30 was associated with higher risk of membership in both Early YA Moderate and YA Moderate class (vs. Non-users). Reporting income from welfare/unemployment between ages 35-45 was associated with higher risk of membership in all classes other than Early YA Moderate and Early YA Heavy Users (vs. Non-users). The risk of being in any class involving use (vs. Non-users) was greater with higher frequency of age 35-45 alcohol use or cigarette use (other than no associations for membership in Early YA Moderate or Early YA Heavy Use classes vs. Non-users by cigarette use).

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[2]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

3.2.2 Heavy versus moderate use—Table 5 presents results from three separate models for covariates differentiating between heavy and moderate use classes within the same use duration: (1) Early YA Heavy Users versus Early YA Moderate Users; (2) YA Heavy Users versus YA Moderate Users; and (3) Persistent Heavy Users versus Persistent Moderate Users. (ARRs from classes other than the specified Heavy User class not reported.) Being male or reporting age 18 binge drinking or cigarette use was associated with higher risk of heavy (vs. moderate) use for Early YA and YA durations. High parental education was associated with higher risk of heavy (vs. moderate) use during Early YA. Reporting low religious commitment at age 18 was associated with higher risk of being in heavy (vs. moderate) use classes across YA and Persistent durations. Conversely, the risk of heavy (vs. moderate) use during Early YA was lower for those who reported marriage. Risk for heavy (vs. moderate) use in Early and YA durations was lower among college graduates. Higher cigarette use frequency between ages 35-45 was associated with higher risk of heavy (vs. moderate) use in the Persistent duration.

3.2.3 Use duration—Table 6 presents results from two separate models for covariates differentiating use duration classes (Early YA, YA, or Persistent Use) within moderate and heavy use: (1) Early YA and YA Moderate Users versus Persistent Moderate Users; and (2) Early YA and YA Heavy Users versus Persistent Heavy Users. (ARRs from classes other than the specified Early YA and YA classes not reported.) Persistent Use was set as the base class (or referent group) to investigate whether covariates differentiated between Persistent versus shorter use durations. Only two age 18 covariates were associated with use duration. Those who reported binge drinking or cigarette smoking at age 18 had a higher risk of moderate use persisting across age (vs. ending in YA). Turning to adult covariates, marriage was associated with lower risk of moderate use persisting across age (vs. ending in Early YA). Any income from welfare/unemployment from ages 35-45 was associated with higher risk of both moderate and heavy use persisting (vs. ending in Early YA). Higher alcohol use frequency from ages 35-45 was associated with higher risk of moderate use persisting across age and higher risk of heavy use persisting (vs. ending in Early YA). Higher cigarette use frequency from ages 35-45 was associated with higher risk of heavy use persisting across age (vs. ending either in Early YA or YA).

3.3 Associations between Latent Classes and Health Outcomes (RQ3)

Health outcome descriptive statistics are provided in Table 3. As noted previously, in order to establish the appropriate temporal order of associations between marijuana use and health outcomes at age 50, RMLCA models were re-fit using only indicators from ages 18 to 45. Results closely replicated those using indicators from ages 18 to 50: the 7-class solution was selected as optimal; classes had the same interpretations as those describe above (see Supplementare Tables 4 and 5[3] for model selection and fit statistics, and estimated probabilities). Class membership probabilities were estimated as follows: Non-users 0.44; Early YA Moderate Users 0.20; YA Moderate Users 0.12; Persistent Moderate Users 0.07; Early YA Heavy Users 0.06; YA Heavy Users 0.05; Persistent Heavy Users 0.05.

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[3]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

To avoid instability of estimates of association between health outcomes with low prevalence levels (e.g., alcohol and drug problems) and latent classes with low prevalence levels, Persistent Moderate and Persistent Heavy Use classes were combined with the corresponding Young Adult (YA) class (i.e., YA Moderate and Persistent Moderate classes were combined for 19% membership probability as "YA/Persistent Moderate Users", and YA Heavy and Persistent Heavy classes were combined for 10% membership probability as "YA/Persistent Heavy Users".) The choice to combine these specific classes was based on the literature summarized earlier, wherein studies consistently indicated that negative associations between marijuana and health primarily were associated with heavy (high-frequency) use extending over time versus lower-frequency use over time or non-use. Regressions of a single health outcome on assigned marijuana use class membership were first conducted without covariates (bivariate results reported in Supplemental Table 6[4]) and were then repeated with all covariates included simultaneously (multivariable results discussed below and reported in Table 7).

3.3.1 Using Classes Compared with Non-users—After controlling for all covariates, compared with Non-users, YA/Persistent Heavy Users had higher odds of 30-day cognitive problems, 12-month physical illness and psychological problem visits, and lifetime psychiatric, alcohol, and drug problems. Similarly, YA/Persistent Moderate Users also were more likely than Non-users to report 30-day cognitive problems, 12-month physical illness and psychological problem visits, and lifetime psychiatric, alcohol, and drug problems. Additional differences were observed between Early YA and Non-users for some outcomes. Both Early YA Moderate and Early YA Heavy Users had higher odds of 12-month psychological problem visits and lifetime psychiatric problems than Non-users. Early YA Heavy Users had higher odds of a lifetime drug problem than Non-users.

3.3.2 Duration Comparisons: Longer- versus Shorter-term Use—YA/Persistent Heavy Users had higher odds than Early YA Moderate Users of 12-month physical illness visits and lifetime alcohol and drug problems ("YA/PH vs. EYAM"). Comparing classes characterized by moderate use, odds of both 12-month psychological problem visits and lifetime alcohol problems were higher for YA/Persistent Moderate Users than Early YA Moderate Users ("YA/PM vs. EYAM"). No differences in the odds of health outcomes were observed between YA/Persistent Heavy Users and Early YA Heavy Users ("YA/PH vs. EYAH").

3.3.3 Intensity Comparisons: YA/Persistent Moderate versus Heavy Use—In models comparing YA/Persistent Heavy with YA/Persistent Moderate Users ("YA/PH vs. YA/PM"), only one health outcome showed associations: the odds of a lifetime drug problem were higher for heavy users than for moderate users.

4. DISCUSSION

This US study identified seven latent classes of past 12-month marijuana use from ages 18 to 50 in a national sample, and then described associations between latent classes and health

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outcomes at age 50. Forty-four percent of respondents were consistent Non-users. Membership for remaining respondents was distributed across six classes: two characterized by persistent use across age, and four reflecting declining use across age. No classes were defined by use escalation after age 18. Use reduction appeared particularly likely during the early and late 20s. Covariates showed associations with non-use versus use, use intensity, and use duration. After controlling for these key covariates, marijuana use latent class membership was associated with many age 50 health outcomes based on use/non-use, as well as use duration and (to a lesser extent) intensity.

This US empirical study is the first to examine latent classes of marijuana use extending beyond the early 30s. Based on US prevalence data, marijuana use and problems are important in middle adulthood. The National Epidemiologic Survey on Alcohol and Related Conditions–III estimated that 6% of US adults aged 45-64 used marijuana in the past 12 months in 2012-2013 (Hasin et al., 2015). The 2013 and 2014 National Surveys on Drug Use and Health estimated that approximately 9% of US adults aged 50-54 used marijuana in the past year (Center for Behavioral Health Statistics and Quality, 2015). The 2014 Monitoring the Future survey indicated that 13% of US adults aged 45-55 used marijuana in the past year (Johnston et al., 2016). The current study found that two classes reported high probabilities of 12-month marijuana use at ages 45 or 50: Persistent Moderate Users (6%) and Persistent Heavy Users (5%). Added together, the percentage of individuals engaged in marijuana use during middle adulthood (11%) is not only similar in magnitude to estimates obtained by other US national studies, but also indicates that those who continued to use marijuana during middle adulthood had been engaged in consistent moderate or heavy use since late adolescence. As Paddock et al. (2012) note, research that can extend beyond the early 30s can contribute to understanding use patterns during ages that may generate the greatest social costs due to consequences such as lost income generation and increased health care demands. Middle adulthood typically is associated with significantly increased health care demands (NCHS, 2015). In the current study, those who reported persistent marijuana use into middle adulthood had higher odds of may negative health outcomes, and may be a particularly high-risk population. Similar research based in settings other than the US is needed that can provide comparative models of marijuana use that extend into middle adulthood.

No latent classes were defined by escalation to a higher use level after age 18. This should not be understood to mean that no individuals progressed to heavier marijuana use after adolescence. Rather, it indicates that the number of cases with such escalation was not large enough to be identified as a unique class. These analyses included only high school senior cohorts from 1976-1983. Significant historical changes in policy and public opinion towards marijuana have occurred in the intervening years; analysis of later cohorts may identify latent classes defined by use escalation. However, the lack of identification of a use escalation class in the current analysis speaks to the importance of preventing escalation to heavy marijuana use during adolescence, because taking up heavy marijuana use thereafter has been relatively uncommon.

Approximately one-half of respondents were members of latent classes reflecting declining use across age: moving from moderate use to no use in early or later YA, or from heavy to

moderate use in early or later YA followed by moving to no use by ages 29/30 or 40. In these declining classes, an increase in use probabilities from ages 18 to 19/20 occurred. The third decade of life is known as the transition to adulthood; individuals move into adult roles and responsibilities, and experiences can influence enduring matters of health and well-being across the life course (Institute of Medicine [IOM], 2014; Schulenberg and Maggs, 2002). The current study indicates the twenties may be an especially important period for marijuana use prevention and intervention to both (a) slow the increase in use probabilities from ages 18 to 19/20, and (b) support and possibly speed use cessation and/or reduction in the early and late 20s.

This study provided an opportunity to expand knowledge of covariates differentiating classes of marijuana use. Male gender, age 18 binge drinking and cigarette use, high parental education, any income from welfare/unemployment from ages 35-45, and increasing frequency of alcohol and cigarette use from ages 35-45 were associated with membership in classes characterized by higher marijuana use intensity and/or duration. Prior research indicated membership in chronic heavy or increasing marijuana use trajectories during young adulthood was more likely for males (e.g., Ellickson et al., 2004; Juon et al., 2011; Silins et al., 2013); those reporting higher parental education (a proxy for family-of-origin socioeconomic status) (Ellickson et al., 2004; Passarotti et al., 2015; Patrick et al., 2012); and co-morbid substance users (Jackson et al 2008; Passarotti et al., 2015; Silins et al 2013). The findings from the current study indicate that these characteristics continue to be associated with membership in chronic heavy or increasing marijuana use classes extending through age 50. Characteristics associated with membership in classes characterized by lower marijuana use intensity and/or duration included high religious commitment at age 18, and marriage between ages 19/20 and 29/30. These associations are supported by prior marijuana use trajectory research (Brown et al., 2004; Jackson et al., 2008; Schulenberg et al., 2005; Silins et al., 2013) and overall young adult marijuana use studies (Staff et al., 2010). Graduating from college was associated with higher likelihood of membership in Early and YA Moderate User classes (compared with non-users), but lower likelihood of membership in heavy use classes during the Early YA and YA durations.

Observed latent marijuana use classes were significantly associated with many age 50 negative health outcomes, even after controlling for key covariates. While marijuana may demonstrate some medical utility (IOM, 1999), professional medical organizations have acknowledged the reality of adverse health effects from marijuana use for both adolescents and adults (American College of Pediatricians, 2015; IOM, 1999). In the current study, negative health associations were not limited to YA/Persistent Heavy Users. The number of adverse health associations was positively associated with marijuana use duration and (to a lesser extent) intensity.

Lifetime marijuana dependence prevalence is estimated at approximately 9%, increasing to about 1 in 6 among those who start use as adolescents, and to at least 25% among individuals who progress to daily use (Budney et al., 2008; Hall and Degenhardt, 2009; Volkow et al., 2014). Thus, research indicates that both duration and intensity of marijuana use are strongly associated with dependence. In the current study, higher odds of reporting

both alcohol and drug problems were observed as marijuana use and intensity increased across latent classes.

All marijuana-using classes were associated with higher odds of psychiatric health visits and lifetime psychiatric problems than Non-users. In prior research, chronic marijuana use has been associated with lower life satisfaction and higher risk for depression, anxiety, and chronic psychosis disorders (Budney et al 2008; Fergusson et al., 2015; Hall and Degenhardt, 2009; Volkow et al., 2014, 2016), as well as higher mental health service utilization and functional impairment (Arria et al., 2016). Studies have substantiated psychological associations after controlling for reverse causation (i.e., psychological problems leading to marijuana use), but causality is difficult to determine due to the possibility of common causal agents (Fergusson et al., 2015; Hall and Degenhardt, 2009; Horwood et al., 2012; McGee et al., 2000; Volkow et al., 2014).

The current study found persistent moderate and heavy marijuana use were associated with higher odds of cognitive problems at age 50. Heavy marijuana use is associated with decreased educational attainment (Maggs et al., 2015); adult cannabis use disorder is associated with cognitive difficulties (Schulenberg et al., 2015). Prospective studies have been mixed as to the effects of marijuana on neuropsychological outcomes (Jackson et al., 2016; Meier et al., 2012; Mokrysz et al., 2016). Yet, marijuana's established effects on cognitive ability include impaired learning and memory, information integration deficits (Auer et al., 2016, Budney et al., 2008; Grant et al., 2012; Hall and Degenhardt, 2009; Volkow et al., 2014, 2016), and structural changes in brain regions responsible for cognitive functions (particularly if use starts during adolescence or young adulthood) (Volkow et al, 2014, 2016).

Longer-term moderate or heavy use also was associated with higher odds of physical illness visits at age 50. While no adverse associations have been found between occasional/low cumulative marijuana use and pulmonary function (Pletcher et al., 2012), chronic marijuana smoking is associated with outpatient visits due to respiratory illness, particularly bronchitis (characterized by chronic cough, sputum production, shortness of breath, wheezing; Budney et al., 2008; Hall and Degenhardt, 2009; IOM 1999; Volkow et al., 2014). In bivariate models (Supplement Table 6[5]), Persistent Moderate and Heavy Use classes were associated with higher odds of respiratory health problems and poor overall physical health. Additional models (not shown) found that the bivariate associations became non-significant after controlling for average 30-day cigarette smoking frequency from ages 35-45.

4.1 Strengths and Limitations

The current study was based on large national US samples followed from ages 18 through 50, using consistent procedures and measures throughout, permitting robust analysis of latent classes of marijuana use and associations between identified classes and midlife health outcomes. The current study is also subject to limitations. Findings may not generalize to different historical time periods, to settings outside of the US, or to individuals who drop out of high school. Lower educational attainment is associated with higher marijuana and other

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[5]Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

substance use (Substance Abuse and Mental Health Services Administration, 2013), suggesting that our findings are likely conservative with respect to heavy marijuana use. The degree to which school drop-out may affect health outcomes is not clear; however, prospective birth cohort research (not affected by school-based sample limitations) has supported associations between longer-term marijuana use trajectories and negative health outcomes (Meier et al., 2012). Analyses cannot account for marijuana use prior to age 18, or fluctuations in use occurring between data collection intervals occurring every 2 years through age 30, and every 5 years thereafter. All data are based on self-reports, which have been found to be reasonably reliable and valid under appropriate conditions which the MTF study has striven to provide (Brener et al., 2003; Miech et al., 2015; O'Malley et al., 1983). It is possible that covariates measured during adulthood (marital status, education, income, alcohol and cigarette use) may have been affected to some degree by preceding marijuana use. The degree to which confounding can be addressed by statistical controls is limited; no information was available on pre-existing health issues prior to marijuana use initiation. Studies are needed that include confirmed reliable and valid health diagnoses, a focus on associations between polydrug use and health outcomes, and a focus on marijuana and mental health issues. These limitations notwithstanding, the current study contributes significantly to available knowledge on marijuana use classes among the general adult population of high school graduates, and associations between such classes and age 50 health outcomes.

4.2. Conclusions

This national US longitudinal study of marijuana use from ages 18 to 50 provided estimated membership probabilities for classes at especially high risk for potential adverse consequences. Approximately 28% of the national sample reported longer-term moderate/ heavy marijuana use, which was associated with negative health outcomes at age 50 in non-causal models. Results indicated that the early and late 20s may be especially important periods for marijuana use prevention and intervention efforts, which may be strengthened by recognition of characteristics that appear to have significant associations with persistent use. The perceived risk of marijuana use has decreased significantly in recent years (Miech et al., 2015). While there is a clear need for objective evidence on the health consequences of marijuana use that can help inform decisions made by individuals considering marijuana use as well as policy makers considering future marijuana legislation, the current paper adds to a growing literature indicating that increasing marijuana use duration and/or intensity is associated with a higher likelihood of negative long-term health issues.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Identified 7 latent marijuana use classes from ages 18-50 among a national sample.

- Twenty-eight percent of respondents reported longer-term moderate/heavy use.

- Use reduction appeared particularly likely during early and late young adulthood.

- Key characteristics differentiated between use/non-use, use intensity and duration.

- Adverse health outcome likelihood increased with use intensity and duration.

Table 1

Fit Information for RMLCAs Modeling Past 12-Month Marijuana Use from Ages 18 through 50 with 1-9 Latent Classes

Classes	df	AIC	BIC	a-BIC	VLMR[a]	Entropy	loglikelihood	Stability
1	175114	143786.7	143944.9	143875.0			−71871.3	1.000
2	175601	109999.3	110323.0	110180.0	0.000	0.935	−54954.6	1.000
3	175907	102107.1	102596.2	102380.1	0.000	0.892	−50985.5	1.000
4	175953	99342.6	99997.2	99708.0	0.640	0.847	−49580.3	1.000
5	176002	98032.1	98852.1	98489.8	0.761	0.852	−48902.0	1.000
6	175992	97153.8	98139.3	97703.9	0.762	0.832	−48439.9	0.692
7	**176004**	**96549.3**	**97700.2**	**97191.8**	**0.772**	**0.834**	**−48114.7**	**0.540**
8	175992	96100.7	97417.0	96835.5	0.761	0.836	−47867.3	0.564
9	175972	95791.9	97273.7	96619.1	0.760	0.837	−47689.9	0.100

Notes: Unweighted n=9.831. RMLCA=repeated measures latent class analysis; AIC=Akaike information criterion; BIC=Bayesian information criterion; a-BIC=adjusted BIC; VLMR=Vuong-Lo-Mendell-Rubin likelihood ratio test; 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.

[a] P-values for both the Vuong-Lo-Mendell-Rubin likelihood ratio test and Lo-Mendell-Rubin adjusted likelihood ratio test were identical; only the VLMR shown.

Table 2

Seven-Class Model of Past 12-Month Marijuana Use from Ages 18 through 50

Modal Age	Overall Proportion	Non-Users	Early YA Moderate Users	YA Moderate Users	Persistent Moderate Users	Early YA Heavy Users	YA Heavy Users	Persistent Heavy Users
		Latent Class Membership Probabilities						
		0.44	0.22	0.12	0.06	0.06	0.05	0.05
		Item Response Probabilities						
		0 Occasions in past 12 months						
18	0.53	0.90	0.31	0.43	0.15	0.07	0.07	0.08
19/20	0.53	0.95	0.23	0.34	0.12	0.02	0.07	0.04
21/22	0.56	0.95	0.44	0.22	0.14	0.03	0.00	0.02
23/24	0.62	0.96	0.69	0.18	0.15	0.08	0.01	0.02
25/26	0.68	0.98	0.90	0.20	0.18	0.21	0.02	0.03
27/28	0.74	0.98	0.96	0.47	0.17	0.40	0.03	0.03
29/30	0.79	0.99	0.98	0.65	0.25	0.63	0.07	0.03
35	0.84	1.00	0.96	0.86	0.30	0.86	0.29	0.03
40	0.86	1.00	0.96	0.93	0.22	0.96	0.48	0.04
45	0.88	1.00	0.95	0.98	0.38	0.95	0.61	0.03
50	0.88	1.00	0.95	0.95	0.44	0.91	0.65	0.09
		1-39 Occasions in past 12 months						
18	0.33	0.10	0.59	0.51	0.60	0.37	0.36	0.32
19/20	0.32	0.05	0.70	0.64	0.62	0.26	0.22	0.23
21/22	0.30	0.05	0.55	0.73	0.67	0.32	0.13	0.18
23/24	0.26	0.04	0.30	0.79	0.73	0.50	0.11	0.17
25/26	0.22	0.02	0.10	0.78	0.76	0.58	0.16	0.14
27/28	0.18	0.02	0.04	0.51	0.78	0.53	0.30	0.13
29/30	0.14	0.01	0.02	0.34	0.68	0.36	0.42	0.16
35	0.11	0.01	0.04	0.13	0.62	0.13	0.53	0.15
40	0.09	0.00	0.04	0.07	0.70	0.04	0.45	0.16
45	0.08	0.00	0.05	0.02	0.56	0.05	0.38	0.24
50	0.08	0.01	0.04	0.04	0.49	0.07	0.31	0.24

Modal Age	Overall Proportion	Non-Users	Early YA Moderate Users	YA Moderate Users	Persistent Moderate Users	Early YA Heavy Users	YA Heavy Users	Persistent Heavy Users
			40+ Occasions in past 12 months					
18	0.14	0.00	0.10	0.06	0.25	**0.56**	**0.56**	**0.61**
19/20	0.14	0.00	0.07	0.01	0.26	**0.72**	**0.72**	**0.73**
21/22	0.14	0.00	0.01	0.05	0.19	**0.65**	**0.86**	**0.80**
23/24	0.12	0.00	0.00	0.04	0.13	0.43	**0.87**	**0.81**
25/26	0.10	0.00	0.00	0.03	0.06	0.20	**0.82**	**0.84**
27/28	0.08	0.00	0.00	0.02	0.05	0.07	**0.67**	**0.85**
29/30	0.07	0.00	0.00	0.01	0.07	0.01	**0.51**	**0.81**
35	0.05	0.00	0.00	0.01	0.08	0.01	0.19	**0.82**
40	0.04	0.00	0.00	0.00	0.08	0.00	0.07	**0.80**
45	0.04	0.00	0.00	0.00	0.07	0.00	0.01	**0.73**
50	0.04	0.00	0.00	0.01	0.08	0.02	0.04	**0.67**

Notes: Unweighted n=9,831. YA = young adult. Bold font indicates item-response probabilities of >.50. Latent class membership 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 18, the overall probability of not using marijuana use in the past 12 months was 0.53, the probability of using on 1-39 occasions was 0.33, and was 0.14 for using on 40+ occasions.

Table 3

Covariate and Health Outcome Descriptives

	%	(SE)		%/Mean	(SE)	Range
Covariates measured at age 18 (n = 9,831)			Covariates measured during adulthood (n = 9,831)			
Gender[a]			Ever married (ages 19/20 to 29/30)[a]			
Female	51.5%	(0.574)	No	29.8%	(0.535)	
Male	48.5%	(0.574)	Yes	70.2%	(0.535)	
Race/ethnicity			Ever graduate from 4-year college (ages 19/20 to 29/30)[a]			
Black	12.6%	(0.491)	No	65.1%	(0.533)	
Hispanic	3.1%	(0.254)	Yes	34.9%	(0.533)	
White	78.5%	(0.568)	Any income from welfare/unemployment (ages 35-45)			
Other	4.7%	(0.269)	No	79.9%	(0.471)	
Missing	1.1%		Yes	18.3%	(0.453)	
Average parental education			Missing	1.8%		
No college education	47.3%	(0.574)	Average 30-day cigarette smoking frequency (ages 35-45)			
At least some college education	47.4%	(0.569)	Average frequency measure	3.3	(0.085)	0-40
Missing	5.3%		Missing indicator measure	1.6%		
Religious commitment			Average 30-day alcohol use frequency (ages 35-45)			
High	38.1%	(0.555)	Average frequency measure	1.5	(0.018)	0-12
Medium	31.4%	(0.534)	Missing indicator measure	1.8%		
Low	28.5%	(0.510)				
Missing	2.0%		Health outcomes measured at age 50 (n = 9,620 to 9,638)			
Binge drinking (age 18)			Respiratory health problems (2+)[b]	18.2%	(0.453)	
None	56.3%	(0.566)	Cognitive health problems (any)[b]	44.8%	(0.574)	
Any	37.3%	(0.542)	Overall poor physical health	13.5%	(0.394)	
Missing	6.4%		Physical illness visits (any)[c]	50.1%	(0.579)	
Past 30-day cigarette smoking (age 18)			Psychological problem visits (any)[c]	10.1%	(0.336)	
None	65.9%	(0.537)	Psychiatric problem (any)[d]	10.7%	(0.343)	
Any	31.8%	(0.525)	Alcohol problem (any)[d]	2.3%	(0.171)	
Missing	2.3%		Drug problem (any)[d]	1.3%	(0.126)	

Notes: Ns provided are unweighted; all estimates have been weighted using attrition weights. SE=standard error (SE not reported for missing dummy terms).

[a]No missing data for these covariates.

[b]Within the past 30 days at age 50.

[c]Within the past 12 months at age 50.

[d]Within individual's lifetime.

Table 4

Adjusted Relative Risk Ratios from Multivariable Multinomial Logistic Regression of Latent Marijuana Class Membership on Covariates: Base Class = Non-Users

	Non-users	Early YA Moderate Users		YA Moderate Users		Persistent Moderate Users		Early YA Heavy Users		YA Heavy Users		Persistent Heavy Users	
	[Base Class]	ARR	p	ARR	p	ARR	p	ARR	p	ARR	p	ARR	p
Gender (referent=female)													
Male		0.84	0.068	**0.66**	**<0.001**	1.01	0.954	**1.57**	**0.001**	**2.06**	**<0.001**	**1.53**	**0.003**
Race/ethnicity (referent=White)													
Black		1.22	0.257	1.33	0.129	1.74	0.021	1.12	0.755	1.29	0.333	1.67	0.085
Hispanic		1.31	0.353	0.91	0.794	1.01	0.982	0.97	0.947	1.27	0.618	1.07	0.923
Other		0.81	0.345	0.92	0.767	0.71	0.349	0.45	0.049	0.90	0.702	0.83	0.531
Parental education (referent=no college)													
Some college		1.15	0.134	1.26	0.030	**1.53**	**0.002**	**1.84**	**<0.001**	**1.83**	**<0.001**	**2.18**	**<0.001**
Religious commitment at age 18 (referent=high)													
Medium		**1.83**	**<0.001**	**1.65**	**<0.001**	**1.71**	**0.001**	**2.87**	**<0.001**	**2.89**	**<0.001**	**2.49**	**<0.001**
Low		**2.31**	**<0.001**	**1.94**	**<0.001**	**2.52**	**<0.001**	**3.58**	**<0.001**	**4.04**	**<0.001**	**4.42**	**<0.001**
Binge drinking at age 18 (referent=none)													
Any		**3.71**	**<0.001**	**2.64**	**<0.001**	**5.31**	**<0.001**	**5.46**	**<0.001**	**6.81**	**<0.001**	**4.93**	**<0.001**
Cigarette smoking at age 18 (referent=none)													
Any		**3.15**	**<0.001**	**1.95**	**<0.001**	**4.11**	**<0.001**	**6.63**	**<0.001**	**4.86**	**<0.001**	**4.45**	**<0.001**
Ever married between ages 19/20 to 29/30 (referent=no)													
Yes		1.16	0.153	**0.55**	**<0.001**	**0.48**	**<0.001**	**0.66**	**0.004**	**0.58**	**<0.001**	**0.48**	**<0.001**
Ever graduate from college between ages 19/20 to 29/30 (referent=no)													
Yes		**1.34**	**0.003**	**1.34**	**0.008**	1.25	0.129	0.87	0.357	0.82	0.221	0.92	0.557
Income from welfare/unemployment between ages 35 to 45 (referent=none)													
Any		1.21	0.134	**1.58**	**0.001**	**2.35**	**<0.001**	0.85	0.439	**2.38**	**<0.001**	**2.17**	**<0.001**
Alcohol use from ages 35 to 45 (past 30 days)													
Average frequency		**1.57**	**<0.001**	**1.82**	**<0.001**	**2.04**	**<0.001**	**1.57**	**<0.001**	**1.93**	**<0.001**	**2.11**	**<0.001**
Cigarette use from ages 35 to 45 (past 30 days)													
Average frequency		1.02	0.028	**1.04**	**0.001**	**1.04**	**0.001**	1.02	0.052	**1.04**	**<0.001**	**1.08**	**<0.001**

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Notes: N (unweighted) = 9,831. YA = young adult. ARR = Adjusted relative risk ratio; obtained from models simultaneously including past 12-month marijuana use latent class membership as well as gender, race/ethnicity, parental education, religious commitment, age 18 binge drinking and cigarette use, marriage, college graduation, ages 35–45 income from welfare/unemployment, ages 35–45 cigarette use frequency, ages 35–45 alcohol use frequency, and cohort. Missing data on covariates were addressed by imputing means (for continuous measures) together with the use of missing data indicators (results for missing indicators not shown). Bold font indicates significant (p<.01) estimates.

Table 5

Adjusted Relative Risk Ratios from Multivariable Multinomial Logistic Regressions of Latent Marijuana Class Membership on Covariates: Moderate versus Heavy Use within Classes of the Same Use Duration Pattern

	Early Young Adult			Young Adult			Persistent		
	Moderate Users	Heavy Users		Moderate Users	Heavy Users		Moderate Users	Heavy Users	
	[Base Class]	ARR	p	[Base Class]	ARR	p	[Base Class]	ARR	p
Gender (referent=female)									
Male		**1.87**	**<0.001**		**3.10**	**<0.001**		1.52	0.014
Race/ethnicity (referent=White)									
Black		0.92	0.816		0.97	0.925		0.96	0.904
Hispanic		0.74	0.540		1.40	0.539		1.06	0.940
Other		0.56	0.167		0.97	0.934		1.16	0.702
Parental education (referent=no college)									
Some college		**1.60**	**0.001**		1.45	0.014		1.42	0.036
Religious commitment at age 18 (referent=high)									
Medium		1.57	0.012		**1.75**	**0.004**		1.46	0.086
Low		1.55	0.013		**2.09**	**<0.001**		**1.75**	**0.006**
Binge drinking at age 18 (referent=none)									
Any		**1.47**	**0.009**		**2.58**	**<0.001**		0.93	0.699
Cigarette smoking at age 18 (referent=none)									
Any		**2.10**	**<0.001**		**2.49**	**<0.001**		1.08	0.668
Ever married between ages 19/20 to 29/30 (referent=no)									
Yes		**0.57**	**<0.001**		1.05	0.749		1.01	0.971
Ever graduate from college between ages 19/20 to 29/30 (referent=no)									
Yes		**0.65**	**0.004**		**0.61**	**0.005**		0.73	0.090
Income from welfare/unemployment between ages 35 to 45 (referent=none)									
Any		0.70	0.082		1.51	0.022		0.93	0.663
Alcohol use from ages 35 to 45 (past 30 days)									
Average frequency		1.00	0.970		1.06	0.125		1.03	0.353
Cigarette use from ages 35 to 45 (past 30 days)									
Average frequency		1.00	0.694		1.01	0.484		**1.04**	**<0.001**

Notes: N (unweighted) = 9,831. ARR = Adjusted relative risk ratio; obtained from models simultaneously controlling for past 12-month marijuana use latent class membership as well as gender, race/ethnicity, parental education, religious commitment, age 18 binge drinking and cigarette use, marriage, college graduation, ages 35-45 income from welfare/unemployment, ages 35-45 cigarette use frequency, ages 35-45 alcohol use frequency, and cohort. Missing data on covariates were addressed by imputing means (for continuous measures) together with the use of missing data indicators (results for missing indicators not shown). Bold font indicates significant (p<.01) estimates. ARRs from classes other than specified heavy users not shown.

Table 6

Adjusted Relative Risk Ratios from Multivariable Multinomial Logistic Regressions of Latent Marijuana Class Membership on Covariates: Early Young Adult and Young Adult versus Persistent Use Duration Patterns

	Early YA Moderate Users		YA Moderate Users		Persistent Moderate Users [Base Class]	Early YA Heavy Users	YA Heavy Users		Persistent Heavy Users [Base Class]
	ARR	p	ARR	p		ARR	ARR	p	p
Gender (referent=female)									
Male	0.83	0.182	0.66	0.014		1.03	1.35	0.860	0.096
Race/ethnicity (referent=White)									
Black	0.70	0.174	0.76	0.354		0.67	0.77	0.334	0.487
Hispanic	1.30	0.576	0.90	0.849		0.91	1.19	0.894	0.822
Other	1.13	0.725	1.30	0.547		0.55	1.08	0.191	0.829
Parental education (referent=no college)									
Some college	0.75	0.040	0.82	0.242		0.85	0.84	0.310	0.315
Religious commitment at age 18 (referent=high)									
Medium	1.07	0.672	0.96	0.844		1.15	1.16	0.537	0.528
Low	0.91	0.584	0.77	0.178		0.81	0.91	0.330	0.688
Binge drinking at age 18 (referent=none)									
Any	0.70	0.016	**0.50**	**<0.001**		1.11	1.38	0.589	0.113
Cigarette smoking at age 18 (referent=none)									
Any	0.77	0.075	**0.48**	**<0.001**		1.49	1.09	0.035	0.645
Ever married between ages 19/20 to 29/30 (referent=no)									
Yes	**2.44**	**<0.001**	1.15	0.378		1.39	1.21	0.046	0.282
Ever graduate from college between ages 19/20 to 29/30 (referent=no)									
Yes	1.07	0.635	1.07	0.676		0.95	0.89	0.790	0.598
Income from welfare/unemployment between ages 35 to 45 (referent=none)									
Any	**0.52**	**<0.001**	0.67	0.032		**0.39**	1.09	**<0.001**	0.632
Alcohol use from ages 35 to 45 (past 30 days)									
Average frequency	**0.77**	**<0.001**	**0.89**	**<0.001**		**0.74**	0.92	**<0.001**	0.015
Cigarette use from ages 35 to 45 (past 30 days)									
Average frequency	0.99	0.149	1.00	0.930		**0.95**	**0.97**	**<0.001**	**<0.001**

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Notes. N (unweighted) = 9,831. ARR = Adjusted relative risk ratio; obtained from models simultaneously controlling for past 12-month marijuana use latent class membership as well as gender, race/ ethnicity, parental education, religious commitment, age 18 binge drinking and cigarette use, marriage, college graduation, ages 35-45 income from welfare/unemployment, ages 35-45 cigarette use frequency, and 35-45 alcohol use frequency, and cohort. Missing data on covariates were addressed by imputing means (for continuous measures) together with the use of missing data indicators (results for missing indicators not shown). Bold font indicates significant (p<.01) estimates. ARRs from classes other than specified early young adult and young adult users not shown.

Table 7

Multivariable Associations between Past 12-Month Marijuana Use Latent Class Membership and Age 50 Health Outcomes

	%[a]	AOR[b]	(99% CI[c])	p	%	AOR	(99% CI)	p
	30-day respiratory health problems				30-day cognitive health problems			
Non-users	16.7	(ref)			42.7	(ref)		
Early Young Adult Moderate (EYAM)	17.9	0.98	(0.83, 1.16)	0.763	44.9	1.06	(0.94, 1.21)	0.211
Young Adult/Persistent Moderate (YA/PM)	20.0	1.04	(0.88, 1.23)	0.578	48.1	**1.21**	**(1.06, 1.38)**	**<0.001**
Early Young Adult Heavy (EYAH)	17.4	0.87	(0.66, 1.15)	0.205	44.8	1.09	(0.88, 1.34)	0.316
Young Adult/Persistent Heavy (YA/PH)	23.1	1.00	(0.80, 1.24)	0.990	48.4	**1.22**	**(1.02, 1.45)**	**0.004**
YA/PH vs. EYAM (ref)		1.02	(0.81, 1.27)	0.832		1.14	(0.96, 1.37)	0.052
YA/PM vs. EYAM (ref)		1.06	(0.88, 1.28)	0.440		1.14	(0.98, 1.31)	0.025
YA/PH vs. EYAH (ref)		1.15	(0.85, 1.55)	0.249		1.12	(0.89, 1.42)	0.214
YA/PH vs. YA/PM (ref)		0.96	(0.77, 1.20)	0.655		1.01	(0.85, 1.20)	0.911
	Overall poor physical health				12-month physical illness visits			
Non-users	12.8	(ref)			49.2	(ref)		
Early Young Adult Moderate	12.9	0.93	(0.77, 1.12)	0.308	49.6	1.04	(0.91, 1.17)	0.473
Young Adult/Persistent Moderate	14.6	0.98	(0.80, 1.18)	0.739	51.9	**1.18**	**(1.04, 1.35)**	**0.001**
Early Young Adult Heavy Users	12.7	0.86	(0.62, 1.18)	0.219	48.9	1.05	(0.85, 1.30)	0.533
Young Adult/Persistent Heavy	16.3	0.95	(0.74, 1.22)	0.604	52.0	**1.29**	**(1.08, 1.53)**	**<0.001**
YA/PH vs. EYAM (ref)		1.03	(0.80, 1.32)	0.803		**1.24**	**(1.04, 1.48)**	**0.002**
YA/PM vs. EYAM (ref)		1.05	(0.85, 1.30)	0.552		1.14	(0.99, 1.32)	0.018
YA/PH vs. EYAH (ref)		1.11	(0.78, 1.57)	0.447		1.22	(0.97, 1.55)	0.028
YA/PH vs. YA/PM (ref)		0.98	(0.76, 1.25)	0.797		1.09	(0.91, 1.30)	0.228
	12-month psychological visits				Lifetime psychiatric problem			
Non-users	7.7	(ref)			8.7	(ref)		
Early Young Adult Moderate	11.0	**1.53**	**(1.24, 1.89)**	**<0.001**	11.6	**1.42**	**(1.15, 1.74)**	**<0.001**
Young Adult/Persistent Moderate	13.7	**1.96**	**(1.59, 2.41)**	**<0.001**	12.9	**1.59**	**(1.29, 1.96)**	**<0.001**
Early Young Adult Heavy Users	11.6	**1.80**	**(1.29, 2.51)**	**<0.001**	12.5	**1.64**	**(1.18, 2.28)**	**<0.001**
Young Adult/Persistent Heavy	11.5	**1.85**	**(1.39, 2.46)**	**<0.001**	12.9	**1.76**	**(1.34, 2.32)**	**<0.001**
YA/PH vs. EYAM (ref)		1.21	(0.91, 1.60)	0.083		1.25	(0.95, 1.64)	0.038
YA/PM vs. EYAM (ref)		**1.28**	**(1.02, 1.59)**	**0.005**		1.12	(0.90, 1.40)	0.187
YA/PH vs. EYAH (ref)		1.03	(0.72, 1.48)	0.831		1.07	(0.75, 1.53)	0.609
YA/PH vs. YA/PM (ref)		0.95	(0.72, 1.24)	0.600		1.11	(0.85, 1.45)	0.307
	Lifetime alcohol problem				Lifetime drug problem			
Non-users	1.0	(ref)			0.5	(ref)		
Early Young Adult Moderate	1.6	1.00	(0.58, 1.71)	0.999	0.9	1.64	(0.80, 3.39)	0.078
Young Adult/Persistent Moderate	3.5	**1.74**	**(1.08, 2.80)**	**0.003**	1.5	**2.45**	**(1.26, 4.75)**	**0.001**
Early Young Adult Heavy Users	3.1	1.61	(0.82, 3.15)	0.068	2.2	**3.93**	**(1.70, 9.13)**	**<0.001**
Young Adult/Persistent Heavy	7.0	**2.35**	**(1.40, 3.93)**	**<0.001**	5.0	**7.78**	**(3.99,15.17)**	**<0.001**
YA/PH vs. EYAM (ref)		**2.35**	**(1.40, 3.93)**	**<0.001**		**4.74**	**(2.46, 9.11)**	**<0.001**

	%[a]	AOR[b]	(99% CI[c])	p	%	AOR	(99% CI)	p
YA/PM vs. EYAM (ref)		**1.74**	**(1.05, 2.86)**	**0.004**		1.49	(0.75, 2.96)	0.133
YA/PH vs. EYAH (ref)		1.46	(0.79, 2.70)	0.115		1.98	(0.96, 4.09)	0.016
YA/PH vs. YA/PM (ref)		1.35	(0.89, 2.06)	0.065		**3.18**	**(1.81, 5.57)**	**<0.001**

Notes: Ns (unweighted) for each outcome: respiratory problems = 9,636; cognitive problems = 9,631; overall physical health = 9,538; physical illness visits = 9,624; psychological problem visits = 9,620; psychiatric problem = 9,624; alcohol problem = 9,634; drug problem = 9,631. All other estimates have been weighted using attrition weights. Bold font indicates associations significant at p <.01 or stronger.

[a]Unadjusted weighted percentage of each specified class reporting the listed age 50 health outcome.

[b]AOR=Adjusted odds ratio; obtained from models simultaneously controlling for past 12-month marijuana use latent class membership as well as gender, race/ethnicity, parental education, religious commitment, age 18 binge drinking and cigarette use, marriage, college graduation, ages 35-45 income from welfare/unemployment, ages 35-45 cigarette use frequency, ages 35-45 alcohol use frequency, and cohort. Missing data on covariates were addressed by imputing means (for continuous measures) together with the use of missing data indicators.

[c]CI=Confidence interval.