Published in final edited form as:
Addiction. 2011 October ; 106(10): 1790–1800. doi:10.1111/j.1360-0443.2011.03485.x.

The social norms of birth cohorts and adolescent marijuana use in the United States, 1976–2007

Katherine M. Keyes, PhD[1,2], **John E. Schulenberg, PhD**[3], **Patrick M. O'Malley, PhD**[3], **Lloyd D. Johnston, PhD**[3], **Jerald G. Bachman, PhD**[3], **Guohua Li, MD, DrPH**[1,4], and **Deborah Hasin, PhD**[1,2,5]

[1] Department of Epidemiology, Columbia University, New York, NY

[2] New York State Psychiatric Institute, New York, NY

[3] Institute for Social Research, University of Michigan, Ann Arbor, MI

[4] Department of Anesthesiology, Columbia University, New York, NY

[5] Department of Psychiatry, College of Physicians and Surgeons, Columbia University, New York, NY

Abstract

Aims—Studies of the relationship between social norms and marijuana use have generally focused on individual attitudes, leaving the influence of larger societal-level attitudes unknown. The present study investigated societal-level disapproval of marijuana use defined by birth cohort or by time period.

Design—Combined analysis of nationally-representative annual surveys of secondary school students in the U.S. conducted 1976–2007 as part of the Monitoring the Future study.

Setting—In-school surveys completed by adolescents in the U.S.

Participants—986,003 adolescents in grades 8, 10, and 12

Measurements—Main predictors included the percentage of students who disapproved of marijuana in each birth cohort and time period. Multi-level models with individuals clustered in time periods of observation and birth cohorts were modeled, with past-year marijuana use as the outcome.

Findings—Results indicated a significant and strong effect of birth cohort disapproval of marijuana use in predicting individual risk of marijuana use, after controlling for individual-level disapproval, perceived norms towards marijuana, and other characteristics. For example, compared to birth cohorts in which most (87–90.9%) adolescents disapproved of marijuana use, odds of marijuana use were 3.53 times higher in cohorts where less than half (42–46.9%) disapproved (99% C.I. 2.75, 4.53).

Conclusions—Individuals in birth cohorts that are more disapproving of marijuana use are less likely to use, independent of their personal attitudes towards marijuana use. Social norms and attitudes regarding marijuana use cluster in birth cohorts, and this clustering has a direct effect on marijuana use even after controlling for individual attitudes and perceptions of norms.

Introduction

Marijuana is the most commonly used illicit substance in the United States (US) and worldwide (1–4). First use most often occurs during adolescence (2, 5–8), and prospective studies indicate that heavy marijuana use in adolescence is associated with clinically serious short- and long-term outcomes (6, 8–12). To reduce these adverse outcomes, primary

prevention of adolescent marijuana initiation is central, requiring a clearer understanding of the causes of early marijuana use.

Adolescent marijuana use is most commonly explained at the individual level. Well-documented risk factors include parental history of drug use (13), parental monitoring (14–16), home environment (14, 17, 18), peer influence (19, 20), school difficulties (21, 22), personality traits, e.g., impulsivity (23), behavioral disinhibition (24, 25), and other indicators of externalizing behavior (26, 27). These and other individual factors explain a meaningful proportion of individual differences in marijuana use. However, recognition is growing that broad population-level factors such as those associated with schools, neighborhoods, and historical time periods, are also required in the etiologic model to provide a more complete explanation (28–30).

The necessity of such population-level factors becomes clear when considering the substantial changes over time in adolescent marijuana use, as the distributions of individual-level factors have not changed substantially enough to explain broad changes in the prevalence of marijuana use observed in the U.S. (31–33). Epidemiologic estimates in the U.S. indicate that adolescent marijuana use peaked in the late 1970s, decreased substantially in the 1980s, increased in the 1990s, and has declined some since then (2). One mechanism potentially underlying increases or decreases in marijuana use prevalence is change in social norms regarding use, e.g., attitudes such as disapproval. At the individual level, disapproval of marijuana use and perceptions of social norms regarding use appear to play a strong role in explaining substance use (31, 34–37). However, the effects of norms at the group or population level on substance use have seldom been studied.

While correlated with individual-level norms, population-level norms are a separate construct, important both methodologically and substantively. Methodologically, individual reports of perceptions may be influenced by biased appraisal processes (e.g., adolescent substance users may report that the community has more permissive norms than adolescents in the same community who do not use substances (38–42)). Substantively, the broader social context in which youth are embedded may influence behaviors such as marijuana use in addition to individual-level youth attitudes. Analogous with this idea, multi-level studies of adult drinking indicate that group-level social norms, with groups defined by place, e.g., at the neighborhood- and workplace-level, predict individual alcohol consumption, even after controlling for individual risk factors (43, 44).

At the population level, disapproval of marijuana use can be characterized by time period and by birth cohort. Available evidence indicates that birth cohorts whose adolescence or early adulthood occurred in the late 1960’s and 1970’s have higher incidence or prevalence of marijuana use than other cohorts (45–48), suggesting that marijuana use aggregates by birth cohorts. Using information from the Monitoring the Future (MTF), Johnston et al. (4) interpreted the staggered nature of inflection points across sequential age bands in perceived risk and disapproval as indicative of lasting cohort effects in both of these attitudes and beliefs, which they posit as having led to cohort effects in the use of a number of drugs. However, other evidence indicates that marijuana decreased across all ages in the 1990s, suggesting that marijuana use also aggregates by time period (47, 48). While these studies have been important in characterizing the overall trends in marijuana use across time, little empirical research has been conducted to study the mechanisms through which changes over time occur. In sum, while much is known about the individual-level relationship between norms and marijuana use, the population-level effects across time periods and birth cohorts provide unique and much-needed information. For example, to the extent that cohort-specific norms mediate time trends in marijuana use, population-level prevention and

intervention efforts should focus on understanding the behavior of cohorts of young people rather than specific policies and laws that affect everyone in the population simultaneously.

The present study utilizes the conceptual framework of multi-level models in which individuals are clustered in birth cohorts and time periods to characterize the association between population-level norms and individual-level marijuana use. We use nationally-representative data on adolescents from 1976–2007 in the Monitoring the Future project (2). We address two aims, one focused on birth cohorts and the other on time periods. First, we test whether individuals in birth cohorts with a high population-level disapproval of marijuana use during adolescence are less likely to report using marijuana in the 12 months prior to the survey, controlling for individual-level disapproval, perceptions of friends' use, demographics and period-specific disapproval. Second, we perform a similar test to determine whether living in a particular period with a high population-level disapproval of marijuana use reduces the risk for past 12-month marijuana use, controlling for individual-level disapproval, perceptions of friends' use, demographics and cohort-specific disapproval.

Methods

Study design and collection of data

The Monitoring the Future (MTF) project conducts an annual cross-sectional survey of 12th grade students in approximately 130 U.S. public and private high schools conducted during spring. High schools are selected under a multi-stage random sampling design with replacement. Schools are invited to participate for two years. Schools that decline participation are replaced with schools that are similar on geographic location, size, and urbanicity. The overall participation rates (including replacements) range from 95% to 99% for all study years. Starting in 1975, approximately 15,000 12th graders were sampled annually. Student response rates ranged from 77% (1976) to 91% (1996, 2001, 2006). Almost all non-response is due to absenteeism; less than 1% of students refuse to participate.

In 1991, 8th and 10th graders were added, with approximately 17,000 8th-grade students (in about 150 schools) and 15,000 10th-grade students (in about 125 schools) sampled annually. Self-administered questionnaires were given to students, typically in classroom settings with a teacher present. Teachers were instructed to avoid close proximity to the students during administration to ensure students could respond confidentially. Detailed description of design and procedures are provided elsewhere (2).

Included in the present study were all individuals for which birth year was available. A total of three birth years are available for 12th graders from 1976–1990, and nine birth years for 8th, 10th, and 12th graders from 1991–2007 (three birth years for each grade). Individuals who were 17 years old in 1976 (N=8,627) are of the same birth cohort (1959) as individuals who were 18 in 1977 (N=7,401) and 19 in 1978 (N=643). Thus, the 1959 birth cohort comprises 16,671 individuals. Similarly, individuals who were 13 in 2005 (N=6,820) are of the same birth cohort (1992) as individuals who were 14 in 2006 (N=11,083) and 15 in 2007 (N=7,893). Thus, the 1992 birth cohort comprises 25,796 individuals. The smallest birth cohorts are the oldest and youngest (1957, N=630; 1994, N=6,451), and the largest birth cohort is 1980 (N=49,227). In total, the present analysis includes 986,003 adolescents.

Measures

The MTF questionnaire covers drug use and related attitudes. Importantly, the measures analyzed in the present study were included at each wave of data collection. All questionnaires have a core set of items including assessment of marijuana use. Respondents are randomized to one of two to six (depending on grade and year) questionnaire forms in

which different sets of questions are included. Items relevant to the present study were asked in a minimum of one questionnaire form and a mode of two questionnaire forms.

Outcome—The outcome variable in the present analysis was a dichotomous indicator of past-year use of any cannabis (including marijuana and hashish). Given the low prevalence of hashish use compared to marijuana use in the U.S. (49), we use the term ‘marijuana’ throughout this manuscript.

Predictors—Participants are queried about whether they disapproved of individuals "smoking marijuana occasionally". Response options included ‘don’t disapprove’, ‘disapprove’, and ‘strongly disapprove’. Participants are also asked to estimate how many of their friends smoke marijuana (response options: none, a few, some, most, all), and how difficult it would be for them to get marijuana (response options: probably impossible, very difficult, fairly difficult, fairly easy and very easy). We included all three of these marijuana variables (disapproval, how many friends smoke, how difficult to get) as individual-level control variables. Previously identified demographic risk factors for marijuana use at the individual level were also included in regression models: sex, age (entered as a continuous variable), race/ethnicity, and highest level of respondent-identified parental education.

At the population level, two aggregate measures of disapproval were created, one to assess norms by time period (year) and one to assess norms by birth cohort. We first dichotomized the measure assessing disapproval of marijuana use (strongly disapprove and disapprove versus don’t disapprove). We then created variables indicating the proportion of students who disapproved of marijuana use in each year (range 42.6% in 1978 to 85.9% in 1992), and the proportion of students who disapproved of marijuana use in each birth cohort (range 44.0% in 1959 to 87.6% in 1993).

Statistical analysis

To prepare for the multi-level analyses, we created the population-level measures of disapproval described above using an approximate 1% (N=9,860) random subset of the total sample, selected using PROC SQL in SAS 9.2. These individuals were excluded from all subsequent analyses to mitigate same-source bias, a bias that can arise in multi-level studies when group-level variables are derived by aggregating the same individual-level data (50–53). The remaining 976,143 respondents provide data for the multi-level analyses. Population-level estimates of approval from the random sub-sample and the remaining sample differed only slightly, with a mean of 0.2% (range 0.01% [12-graders in 1994] to 0.4% [individuals in the 1957 birth cohort]), indicating that the random subsample provided valid estimates of the underlying larger sample. We replicated the analyses using estimates derived from the entire sample rather than a subset, and included outcome information from the entire sample; results did not change across the two methods. We present the analysis using the split sample, however, as it is a more rigorous method to use aggregated data within a sample for prediction of an outcome within the same sample.

Our principal analytic approach was to use multi-level models that included the period and cohort mechanistic variables, group-level disapproval. In these models, individuals were simultaneously clustered by time period and birth cohort as suggested by Yang and others for age-period-cohort modeling (54–56). Two group-level disapproval variables were considered: one representing the disapproval for each birth cohort, and one representing the disapproval for each time period. First, we analyzed population-level disapproval as a continuous variable, and transformed estimates to indicate the change in odds based on a 5-percentage point change in disapproval. Preliminary analyses suggested that population-level disapproval had a linear relation with log odds of marijuana use. Second, we used

categorical dummy variables for each 5-percentage point increase in population-level disapproval in order to detect any non-log-linear effects. We first estimated models adjusted for age at the individual level only, and then included individual-level covariates including personal disapproval, perceived norms, friend's use, and socio-demographics. All analyses were conducted using MPLUS version 5.2 (57) with full integration maximum-likelihood estimation methods for missing data.

Sample weighting

All estimates are weighted to account for variations in school selection probability as well as between-school sample size. We account for clustering by geographic area and school by raising the critical alpha for null hypothesis rejection to $p<0.01$, as has been done previously in time trend analyses of the Monitoring the Future datasets (31, 58–61). There is no well-accepted method to combine adjustments for within-year clustered sampling in panel datasets combined across time, especially in a multi-level framework where the outcome is measured at the individual level. Failing to properly account for this clustering may underestimate standard errors at the individual level, so we interpret the statistical significance of coefficients estimated at the individual level with caution. However, this would not bias estimates from the period and cohort levels, which were the main focus of the present study.

Results

Trends over time

Figure 1 displays the trend over time in past-year marijuana use, as well as disapproval by age, period, and cohort. For period and cohort trends, we restrict presentation to the 12^{th} grade only, as 8^{th} and 10^{th} grades were included from 1991 forward only. Trends are similar for 8^{th} and 10^{th} grades, although in these grades, the prevalence of marijuana use is lower and disapproval higher. For the youngest age group (age 13), past-year marijuana use was lowest (10.1%) and disapproval highest (87.9%) compared with all other ages. By period, use was highest in 1978 (51.8%) and disapproval lowest in 1977 (43.0%); use was lowest and disapproval highest in 1992 (14.5%, 86.3%, respectively). Cohort-specific trends indicated a similar inverse relation between use and disapproval as was observed by age and period; in general, disapproval increases concurrently to use decreasing.

Multi-level models

In an age-adjusted model for period effects of disapproval (Table 1), each 5% increase in disapproval was associated with a 13% decrease in the estimated odds of marijuana use (OR=0.87, 99% C.I. 0.86–0.89, $p<0.01$). Similarly, in an age-adjusted model for cohort effects of disapproval, each five percentage point increase in cohort-specific disapproval was associated with a 12% decrease in the estimated odds of marijuana use (OR=0.88, 99% C.I. 0.87–0.89, $p<0.01$).

We then estimated a model that included both cohort- and period-specific disapproval, enabling us to test for the effects of each with the other controlled (Table 2), as well as control for individual-level covariates of disapproval, perception of availability, perception of friends' use, age, sex, parental education, and race/ethnicity. Year- and cohort-specific disapproval was correlated at 0.78. Cohort-specific disapproval remained a significant predictor of marijuana use in the last 12 months (OR=0.88, 99% C.I. 0.87–0.89, $p=0.004$), whereas period-specific disapproval is no longer significant (OR=0.95, 99% C.I. 0.91–1.06, $p=0.07$).

Results when examining cohort- and period-specific disapproval as categorical variables are shown in Figure 2. There is a stepwise decrease in the odds of marijuana use as the cohort-specific disapproval increases. For example, compared to cohorts in which most (87–90.9%) adolescents disapproved of marijuana use, odds of marijuana use significantly increased in cohorts where less than half (42–46.9%) disapproved (OR=3.53, 99% C.I. 2.75, 4.53), controlling for individual disapproval, perceptions of norms, friend's use, and socio-demographics. For period-specific disapproval, the relationship between disapproval and marijuana use was inconsistent. Those in the lowest disapproval periods (42–50.9%) have no decreased odds of marijuana use compared to those in the highest.

Sensitivity analysis: potential bias by age—Because only high school seniors were surveyed from 1976 to 1990, we were concerned that results could be confounded by age when examining overall trends from 1976 to 2007. We conducted two auxiliary analyses to examine this potential. First, we stratified each multi-level regression by year of observation, with one stratum indicating observation from 1976 through 1990 when only 12^{th} grade respondents were included, and one stratum indicating observation from 1991 forward when 8^{th}, 10^{th}, and 12^{th} grade respondents were included. The odds ratio for the effect of cohort changed from 0.88 to 0.90, and remained statistically significant. Second, we examined the relationship between cohort-specific disapproval and marijuana use within each age. Little variation in the odds ratio was found, ranging from 0.89 for age 14 to 0.75 for age 19. All odds ratios were statistically significant at $p<0.001$.

Sensitivity analysis: temporality—While we are interested in the hypothesis that social norms shape patterning of drug use, it is likely the case that, to some extent, patterning of drug use shapes the social norms in the community. To establish the temporal sequence between social norms predicting marijuana use, we created a one year time lag between marijuana use and the social norm of the birth cohort and time period. Thus, an individual's odds of marijuana use are predicted by the social norm of the n-1 time period and m-1 birth cohort, respectively. Results were unchanged. Shown in Online Table 1 is the relationship between period-specific, cohort-specific, and individual-level variables from a multilevel model with a one-year time lag. As shown, in the final model, cohort-specific disapproval remains significantly predictive of marijuana use (OR=0.87, 99% C.I. 0.83–0.92).

Discussion

The present study documents that adolescents who mature in birth cohorts with low disapproval of marijuana use are at higher risk of using marijuana during their teenage years, regardless of individual-level disapproval, perceived social norms, or perceived availability. Disapproval across cohorts, defined at the population level through multi-level modeling, remained a robust risk factor controlling for disapproval in the time period in which the adolescent was assessed, the age of the adolescent at the time of assessment, the adolescent's personal disapproval and norms perceptions surrounding marijuana, and other socio-demographic risk factors. These findings are consistent with earlier reporting of cohort effects in attitudes about drugs based on the same study, but looking at later developmental periods, starting after high school graduation (4). Our finding that marijuana use is predicted by a cohort effect rather than a period effect suggests that adolescents are more influenced by individuals of similar age than by broad socio-cultural influences that affect all adolescents simultaneously (e.g., policy and law changes). We note, however, that period and cohort disapproval are strongly associated (correlation coefficient = 0.78) such that it may not be possible to fully disentangle the effect of one from the effect of the other.

Thus, these findings enhance our understanding of the basic relationship between social norms and marijuana use. Recent literature has indicated that student's individual-level

perceptions of norms may not be salient predictors of marijuana use in adolescence (62); rather, prior drug use and peer affiliation alone explain the relationship between norm perception and use. Our results add to this literature by suggesting that aggregated norms measured at the group level provide explanatory power predicting marijuana use over and above individual-level attitudes and perceptions of norms. Further, birth cohort rather than period effects suggest that factors that aggregate within birth cohort specifically, rather than those that simply change across time, should be pursued when attempting to explain why marijuana use changes over time.

Sociological research has long documented that individuals are powerfully influenced by norms (63–65), and that social pressures towards group conformity influence the acquisition of norms and the decision to engage in behaviors once norms are internalized. The cohesive and collective power of societies and communities (sometimes termed ‘collective efficacy’ (66, 67)) to influence individual behavior has been documented for a range of health outcomes (67). These results indicate that birth cohorts can be conceptualized as collective agencies at the structural level (68, 69), with attributes (e.g., the acceptance of marijuana use) that have no exact analogue at the individual level.

The present study represents a methodological advance combining two recently emerging lines of thinking in age-period-cohort research and methods. First, Yang and colleagues (54–56) have proposed the use of multi-level modeling to overcome methodological issues in the simultaneous estimation of age, period, and cohort effects, with period and cohort cross-classified as random effects. However, they have not incorporated potential explanatory mechanisms in their work. Second, Winship and Harding (70) have proposed that age-period-cohort research is most informative when the mechanisms hypothesized to underlie age effects, period effects, and cohort effects are explicitly tested. However, they have not used multi-level models to test mechanistic variables. The present paper is the first, to our knowledge, to combine these two methods, utilizing a multi-level model with a mechanism hypothesized to underlie period and cohort effects specified as an explanatory variable at the group level. Previous research has shown a combination of birth cohort and period effects in marijuana use over time among both adolescents (45–47) and adults (48); we extend this research by examining one potential group-level mechanism through which birth cohort effects in marijuana use emerge: changing social norms. (54–56).

Results in this paper support a range of theories regarding the role of the environment in the transmission of health behaviors such as marijuana use. Observational learning theory suggests that individuals may model behavior that is passively observed in the environment, independent of direct positive or negative reinforcement (71–73). The impact of observational learning on marijuana use has been previously tested, especially in substance intervention research (74–78). Johnston (79) posits that epidemics of drug use occur within and across socio-historical time periods due to a combination of factors, including willingness to violate disapproving social norms as well as access to and awareness of the drug, suggesting a strong role for social norms and other group-level processes such as laws and policies in the propagation of drug epidemics among adolescent populations. Further testing of mechanistic models will aid in the elucidation birth cohort and time period influence on adolescent marijuana use.

Limitations of the study are noted. Participation in the survey may be somewhat associated with disapproval of marijuana use; more rule-abiding students may be more likely to both participate and disapprove of marijuana use. This would bias results if participation rates exhibited similar temporal trends as marijuana use (80), however, participation rates are high across all years (77–91%) and exhibit no temporal trends (2) suggesting little threat to validity by informative participation. Further, we did not have information on the

geographical norms for each student (e.g. school, neighborhood, county, state, etc.). Substantial research has indicated that variability in geographic norms is an important predictor of marijuana use (81–83), and this literature would be enriched by future studies that incorporate both geographical and temporal norms. Finally, because MTF is a school-based survey, high school drop-outs are not included in any survey estimates. This is a minor issue for the eighth grade survey; however, by tenth grade approximately 5% of adolescents drop-out, and by twelfth grade between 15 to 20% of each cohort is missing due to drop out (2). The conclusions from this study can be generalized only to students attending high school, which represent the large majority of adolescents in the United States.

Despite these limitations, the present study represents an important advance in the understanding of multi-level effects on marijuana use. This study lays the foundation for future work on the population-level effects of social norms and provides compelling evidence regarding the advantages of ongoing cohort sequential designs. Building on this foundation and such designs, future research should recognize and model the non-independence of individuals born in the same year, and test hypotheses about the mechanisms through which norms may exert an influence on marijuana use and other problem and health related behaviors. As more comprehensive models of the etiology of adolescent marijuana use are developed, the risk conferred by time and place are important components to understand.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was supported in part by a fellowship from the National Institute on Drug Abuse (F31 DA026689, K. Keyes), grants from the National Institute on Drug Abuse (R01 DA001411, Johnston; R21 DA029670, Li), National Institute on Alcoholism and Alcohol Abuse (K05 AA014223, Hasin; R01 AA09963, Li), and support from New York State Psychiatric Institute (Hasin). We would like to thank Benjamin Feld for his assistance in these analyses.

References

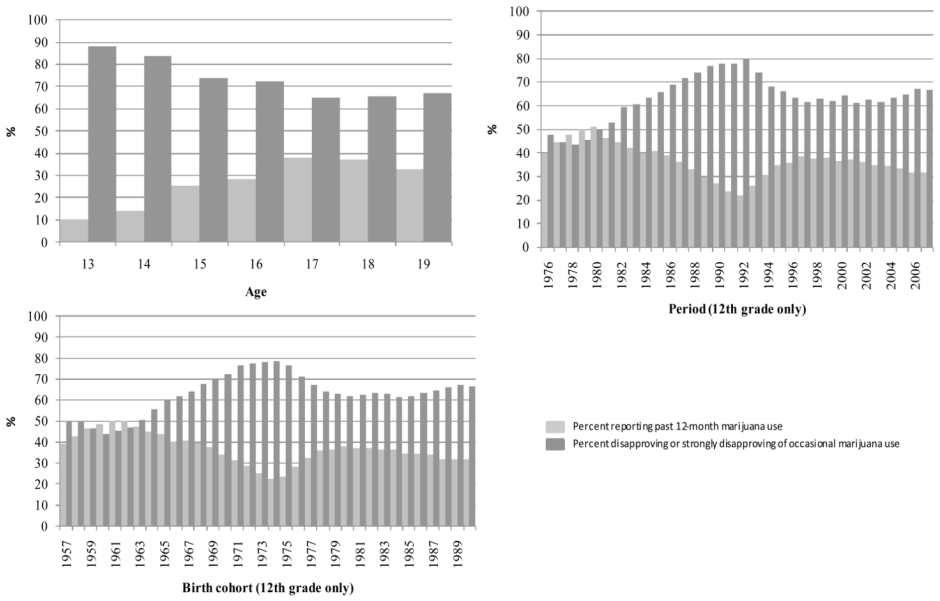
1. Substance Abuse and Mental Health Services Administration (SAMHSA). N S H-, DHHS Publication No. SMA 05-4062. Office of Applied Studies; Rockville, MD: 2005. Results from the 2004 National Survey on Drug Use and Health: National Findings.
2. Johnston, LD.; O'Malley, PM.; Bachman, JG.; Schulenberg, JE. Monitoring the Future national survey results on drug use, 1975–2006: Volume I, Secondary school students. Bethesda, MD: National Institute on Drug Abuse; 2007. http://monitoringthefuture.org/
3. Hibell, B.; Guttormsson, U.; Ahlstrom, S., et al. The 2007 ESPAD Report -Substance Use Among Students in 35 European Countries. The Swedish Council for Information on Alcohol and Other Drugs (CAN); 2009. Available at: http://www.espad.org/espad-reports
4. Johnston, LD.; O'Malley, PM.; Bachman, JG.; Schulenberg, JE. Monitoring the Future national survey results on drug use, 1975–2009. Volume II: College students and adults ages 19–50 (NIH Publication No. 10-7585). Bethesda, MD: National Institute on Drug Abuse; 2010.
5. King KM, Chassin L. A prospective study of the effects of age of initiation of alcohol and drug use on young adult substance dependence. J Stud Alcohol Drugs. 2007; 68:256–65. [PubMed: 17286344]
6. Kandel DB, Yamaguchi K, Chen K. Stages of progression in drug involvement from adolescence to adulthood: further evidence for the gateway theory. J Stud Alcohol. 1992; 53:447–57. [PubMed: 1405637]

7. Grant BF. Age at smoking onset and its association with alcohol consumption and DSM-IV alcohol abuse and dependence: results from the National Longitudinal Alcohol Epidemiologic Survey. J Subst Abuse. 1998; 10:59–73. [PubMed: 9720007]
8. Chen CY, Storr CL, Anthony JC. Early-onset drug use and risk for drug dependence problems. Addict Behav. 2009; 34:319–22. [PubMed: 19022584]
9. Lynskey M, Hall W. The effects of adolescent cannabis use on educational attainment: a review. Addiction. 2000; 95:1621–30. [PubMed: 11219366]
10. Chatterji P. Illicit drug use and educational attainment. Health Econ. 2006; 15:489–511. [PubMed: 16389630]
11. Lemstra M, Bennett NR, Neudorf C, et al. A meta-analysis of marijuana and alcohol use by socio-economic status in adolescents aged 10–15 years. Can J Public Health. 2008; 99:172–7. [PubMed: 18615935]
12. Merline AC, O'Malley PM, Schulenberg JE, Bachman JG, Johnston LD. Substance use among adults 35 years of age: prevalence, adulthood predictors, and impact of adolescent substance use. Am J Public Health. 2004; 94:96–102. [PubMed: 14713705]
13. Fergusson DM, Woodward LJ, Horwood LJ. Maternal smoking during pregnancy and psychiatric adjustment in late adolescence. Archives of General Psychiatry. 1998; 55:721–727. [PubMed: 9707383]
14. Biglan A, Duncan TE, Ary DV, Smolkowski K. Peer and parental influences on adolescent tobacco use. J Behav Med. 1995; 18:315–30. [PubMed: 7500324]
15. Hill KG, Hawkins JD, Catalano RF, Abbott RD, Guo J. Family influences on the risk of daily smoking initiation. J Adolesc Health. 2005; 37:202–10. [PubMed: 16109339]
16. Pilgrim CC, Schulenberg JE, O'Malley PM, Bachman JG, Johnston LD. Mediators and moderators of parental involvement on substance use: a national study of adolescents. Prev Sci. 2006; 7:75–89. [PubMed: 16572302]
17. Fergusson DM, Horwood LJ, Lynskey MT. Parental Separation, Adolescent Psychopathology, and Problem Behaviors. Journal of the American Academy of Child and Adolescent Psychiatry. 1994; 33:1122–1131. [PubMed: 7982863]
18. Burt SA, Barnes AR, McGue M, Iacono WG. Parental divorce and adolescent delinquency: ruling out the impact of common genes. Dev Psychol. 2008; 44:1668–77. [PubMed: 18999329]
19. Kandel, DB. On Process of Peer Influences in Adolescent Drug Use: A Developmental Perspective. In: Brook, DW.; Lettieri, DJ., editors. Alcohol and substance abuse in adolescence. Routledge: 1985.
20. Wang J, Simons-Morton BG, Farhat T, Luk JW. Socio-Demographic Variability in Adolescent Substance Use: Mediation by Parents and Peers. Prev Sci. 2009
21. Bachman, JG.; O'Malley, PM.; Schulenberg, JE., et al. The education-drug use connection: How successes and failures in school relate to adolescent smoking, drinking, drug use, and delinquency. New York: Lawrence Erlbaum Associations/Taylor & Francis; 2008.
22. Bryant AL, Schulenberg JE, O'Malley PM, Bachman JG, Johnston LD. How academic achievement, attitudes, and behaviors relate to the course of substance use during adolescence: a six-year multi-wave national longitudinal study. Journal of Research on Adolescence. 2003; 13:361–397.
23. Krueger RF, Hicks BM, Patrick CJ, et al. Etiologic connections among substance dependence, antisocial behavior, and personality: modeling the externalizing spectrum. J Abnorm Psychol. 2002; 111:411–24. [PubMed: 12150417]
24. Iacono WG, Carlson SR, Taylor J, Elkins IJ, McGue M. Behavioral disinhibition and the development of substance-use disorders: findings from the Minnesota Twin Family Study. Dev Psychopathol. 1999; 11:869–900. [PubMed: 10624730]
25. Iacono WG, Malone SM, McGue M. Behavioral disinhibition and the development of early-onset addiction: common and specific influences. Annu Rev Clin Psychol. 2008; 4:325–48. [PubMed: 18370620]
26. Keyes MA, Iacono WG, McGue M. Early onset problem behavior, young adult psychopathology, and contextual risk. Twin Res Hum Genet. 2007; 10:45–53. [PubMed: 17539364]

27. Donohew RL, Hoyle RH, Clayton RR, et al. Sensation seeking and drug use by adolescents and their friends: models for marijuana and alcohol. J Stud Alcohol. 1999; 60:622–31. [PubMed: 10487731]
28. Galea S, Hall C, Kaplan GA. Social epidemiology and complex system dynamic modelling as applied to health behaviour and drug use research. Int J Drug Policy. 2009; 20:209–16. [PubMed: 18930649]
29. Gilmore I. Action needed to tackle a global drinking problem. Lancet. 2009; 373:2174–2176. [PubMed: 19560584]
30. Wells JE, Degenhardt L, Bohnert KM, et al. Geographical clustering of cannabis use: results from the New Zealand Mental Health Survey 2003–2004. Drug Alcohol Depend. 2009; 99:309–316. [PubMed: 18990513]
31. Bachman JG, Johnson LD, O'Malley PM. Explaining recent increases in students' marijuana use: impacts of perceived risks and disapproval, 1976 through 1996. Am J Public Health. 1998; 88:887–92. [PubMed: 9618614]
32. Bachman JG, Johnston LD, O'Malley PM, Humphrey RH. Explaining the recent decline in marijuana use: differentiating the effects of perceived risks, disapproval, and general lifestyle factors. J Health Soc Behav. 1988; 29:92–112. [PubMed: 3367032]
33. Nelson TF, Xuan Z, Lee H, Weitzman ER, Wechsler H. Persistence of heavy drinking and ensuing consequences at heavy drinking colleges. J Stud Alcohol Drugs. 2009; 70:726–34. [PubMed: 19737497]
34. Fishbein, M.; Ajzen, I. Beliefs, attitude, intention, and behavior. Reading, MA: Addison Wesley; 1975.
35. Jessor R. Problem-Behavior Theory, Psychosocial Development, and Adolescent Problem Drinking. Br J Addict. 1987; 82:331–342. [PubMed: 3472582]
36. Baranowski, T.; Perry, CL.; Parcel, GS. How individuals, environments, and health behaviors interact: Social Cognitive Theory. In: Glanz, K.; Lewis, FM.; Rimer, BK., editors. Health Behavior and Health Education: Theory, Research, and Practive. San Francisco: Jossey-Bass Inc; 1997.
37. Strecher, VJ.; Rosenstock, IM. The Health Belief Model. In: Glanz, K.; Lewis, FM.; Rimer, BK., editors. Health Behavior and Health Eduction: Theory, Research and Practice. San Francisco: Jossey-Bass; 1997.
38. Dembo R, Blount WR, Schmeidler J, Burgos W. Perceived environmental drug use risk and the correlates of early drug use or nonuse among inner-city youths: the motivated actor. Int J Addict. 1986; 21:977–1000. [PubMed: 3491796]
39. Blount WR, Dembo R. The effect of perceived neighborhood setting on self-reported tobacco, alcohol, and marijuana use among inner-city minority junior high school youth. Int J Addict. 1984; 19:175–98. [PubMed: 6724762]
40. Nurco DN, Kinlock T, O'Grady K, Lerner M, Hanlon TE. Perceptions of social pathology in the neighborhood and the etiology of narcotic addiction. A retrospective study. J Nerv Ment Dis. 1996; 184:35–42. [PubMed: 8551287]
41. Yarnold BM, Patterson V. Marijuana use among Miami's adolescents, 1992. J Health Soc Policy. 1998; 10:65–79. [PubMed: 10180255]
42. Perkins HW, Haines MP, Rice R. Misperceiving the college drinking norm and related problems: a nationwide study of exposure to prevention information, perceived norms and student alcohol misuse. J Stud Alcohol. 2005; 66:470–8. [PubMed: 16240554]
43. Ahern J, Galea S, Hubbard A, Midanik L, Syme SL. "Culture of drinking" and individual problems with alcohol use. Am J Epidemiol. 2008; 167:1041–9. [PubMed: 18310621]
44. Barrientos-Gutierrez T, Gimeno D, Mangione TW, Harrist RB, Amick BC. Drinking social norms and drinking behaviours: a multilevel analysis of 137 workgroups in 16 worksites. Occup Environ Med. 2007; 64:602–8. [PubMed: 17525095]
45. O'Malley PM, Bachman JG, Johnston LD. Period, age, and cohort effects on substance use among American youth, 1976–82. Am J Public Health. 1984; 74:682–8. [PubMed: 6742254]

46. O'Malley PM, Bachman JG, Johnston LD. Period, Age, and Cohort Effects on Substance Use among Young Americans: A Decade of Change, 1976–1986. Am J Public Health. 1988; 78:1315–1321. [PubMed: 3421387]
47. Johnson RA, Gerstein DR. Age, period, and cohort effects in marijuana and alcohol incidence: United States females and males, 1961–1990. Subst Use Misuse. 2000; 35:925–48. [PubMed: 10847217]
48. Kerr WC, Greenfield TK, Bond J, Ye Y, Rehm J. Age-period-cohort influences on trends in past year marijuana use in the US from the 1984, 1990, 1995 and 2000 National Alcohol Surveys. Drug Alcohol Depend. 2007; 86:132–8. [PubMed: 16806739]
49. Mehmedic Z, Chandra S, Slade D, et al. Potency trends of Delta9-THC and other cannabinoids in confiscated cannabis preparations from 1993 to 2008. J Forensic Sci. 2010; 55:1209–17. [PubMed: 20487147]
50. Diez Roux AV. Neighborhoods and health: where are we and were do we go from here? Rev Epidemiol Sante Publique. 2007; 55:13–21. [PubMed: 17320330]
51. Raudenbush SW, Sampson R. Ecometrics: toward a science of assessing ecological settings, with application to the systematic social observations of neighborhoods. Sociol Methodol. 1999; 29
52. Duncan GJ, Raudenbush SW. Assessing the effects of context in studies of child and youth development. Educat Psychol. 1999; 34:29–41.
53. Ostroff C, Kinicki AJ, Clark MA. Substantive and Operational Issues of Response Bias Across Levels of Analysis: An Example of Climate-Satisfaction Relationships. Journal of Applied Psychology. 2002; 87:355–368. [PubMed: 12002963]
54. Reither EN, Hauser RM, Yang Y. Do birth cohorts matter? Age-period-cohort analyses of the obesity epidemic in the United States. Social Science and Medicine. 2009; 69:1439–48. [PubMed: 19773107]
55. Yang, Y.; Land, KC. A Mixed Models Approach to Age-Period-Cohort Analysis of Repeated Cross-Section Surveys: Trends in Verbal Test Scores. In: Stolzenberg, RM., editor. Sociological Methodology. Boston: Blackwell Publishing; 2006.
56. Yang Y, Land KC. Age-Period-Cohort Analysis of Repeated Cross-Section Surveys: Fixed or Random Effects? American Sociological Review. 2008; 36:297–326.
57. Muthen, LK.; Muthen, BO. Mplus user's guide. 5. Los Angeles, CA: 2009.
58. Brown TN, Schulenberg JE, Bachman JG, O'Malley PM, Johnston LD. Are risk and protective factors for substance use consistent across historical time? National data from twenty-two consecutive cohorts of high school seniors. Prev Sci. 2001; 2:29–43. [PubMed: 11519373]
59. Patrick ME, Schulenberg JE, O'Malley PM, et al. Age-related changese in reasons for using alcohol and marijuana from ages 18 to 30 in a national sample. Psychology of Addictive Behaviors. in press.
60. Schulenberg, JE.; Patrick, ME. Historical and developmental patterns of alcohol and drug use among college students: framing the problem. In: White, HR.; Rabiner, D., editors. College Student Drinking and Drug Use: Multiple Perspectives on a Complex Problem. New York: Guildford; in press
61. Bachman, JG.; Johnston, L.; O'Malley, PM. How changes in drug use are linked to perceived risks and disapproval: Evidence from national studies that youth and young adults respond to information about the consequences of drug use. In: Donohew, H.; Sypher, H.; Bukowski, W., editors. Persuasive Communication and drug abuse prevention. Hillsdale, NJ: Lawrence Erlbaum Associates; 1991. p. 133-156.
62. Juvonen J, Martino SC, Ellickson PL, Longshore D. "But Others Do It!" Do Misperceptions of Schoolmate Alcohol and Marijuana Use Predict Subsequent Drug Use Among Young Adolescents? Journal of Applied Social Psychology. 2007; 37:740–758.
63. Durkheim, E. The Rules of Sociological Method. New York: The Free Press; 1938.
64. Cullen, FT. Rethinking Crime and Deviance Theory: The Emergence of a Structuring Tradition. Totowa, NJ: Roman & Allenheld; 1983.
65. Asch, SE. Social Psychology. Upper Sadle River, NJ: Prentice Hall; 1952.
66. Sampson JR, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. Science. 1997; 277:918–924. [PubMed: 9252316]

67. Kawachi, I.; Berkman, L. Social cohesion, social capital, and health. In: Berkman, L.; Kawachi, I., editors. Social Epidemiology. New York: Oxford University Press; 2000. p. 174-190.
68. Ryder NB. The cohort as a concept in the study of social change. Am Sociol Rev. 1965; 30:843–61. [PubMed: 5846306]
69. Alwin DF, McCammon RJ. Rethinking Generations. Research in Human Development. 2007; 4:219–237.
70. Winship C, Harding DJ. A Mechanism-Based Approach to the Identification of Age-Period-Cohort Models. American Sociological Review. 2008; 36:362–401.
71. Bandura A, Ross D, Ross SA. Transmission of agressions through imitation of agressive models. Journal of Abnormal and Social Psychology. 1961; 63:575–582. [PubMed: 13864605]
72. Bandura, A. Social Learning Theory. Prentice Hall; 1977.
73. Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Clin Psychol. 2001; 52:1–26.
74. Akers RL, Lee G. A longitudinal test of social learning theory: adolescent smoking. Journal of Drug Issues. 1996; 26:317–343.
75. Werch CE, Pappas DM, Carlson JM, et al. Results of a social norm intervention to prevent binge drinking among first-year residential college students. J Am Coll Health. 2000; 49:85–92. [PubMed: 11016132]
76. Werch CE, DiClemente CC. A multi-component stage model for matching drug prevention strategies and messages to youth stage of use. Health Education Research. 1994; 9:37–46. [PubMed: 10172040]
77. Botvin GJ, Schinke SP, Epstein JA, Diaz T, Botvin EM. Effectiveness of culturally-focused and generic skills training approaches to alcohol and drug abuse prevention among minority adolescents: two-year follow-up results. Psychology of Addictive Behaviors. 1995; 9:183–194.
78. Akers RL, Krohn MD, Lanza-Kaduce L, Radosevich M. Social learning and deviant behavior: a specific test of a general theory. Am Sociol Rev. 1979; 44:636–55. [PubMed: 389120]
79. Johnston, LD. Toward a theory of drug epidemics. In: Donohew, L.; Sypher, HE.; Bukoski, WJ., editors. Persuasive communication and drug abuse prevention. Hillsdale, N.J: Lawrence Erlbaum; 1991. p. 93-131.
80. Chaix B, Billaudeau N, Thomas F, et al. Neighborhood effects on health: correcting bias from neighborhood effects on participation. Epidemiology. 2011; 22:18–26. [PubMed: 21150351]
81. Kuntsche E, Jordan MD. Adolescent alcohol and cannabis use in relation to peer and school factors. Results of multilevel analyses. Drug Alcohol Depend. 2006; 84:167–74. [PubMed: 16542799]
82. Kumar R, O'Malley PM, Johnston LD, Schulenberg JE, Bachman JG. Effects of school-level norms on student substance use. Prev Sci. 2002; 3:105–24. [PubMed: 12088136]
83. Musick K, Seltzer JA, Schwartz CR. Neighborhood Norms and Substance Use among Teens. Soc Sci Res. 2008; 37:138–155. [PubMed: 18496598]



*8th and 10th grades were added in 1991 forward; trends are similar for 8th and 10th grades as for 12th grades although absolute magnitude of marijuana is lower and disapproval higher.

Figure 1.

Percentage of past year marijuana use and percentage of marijuana use disapproval by age, periods of observation (12th grade only*) and birth cohorts (12th grade only*) among U.S. adolescents, 1976–2006

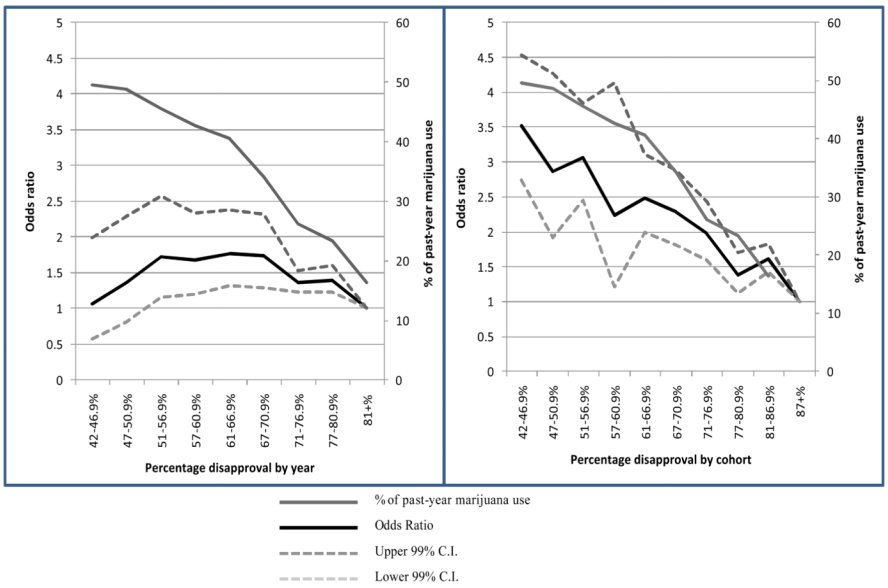


Figure 2.

Percentage of past-year marijuana useand odds ratio for the effect of cohort-specific and period-specific disapproval on past year marijuana use among high school students in the U.S. from 1976–2007 (N=986,003)

Table 1

Multi-level models for the period- and cohort-level associations between past-year marijuana use, year-specific disapproval and cohort-specific disapproval, controlling for age at the individual-level (N=986,003)

	Model 1*			Model 2*		
	OR	**99% Confidence interval**	**p-value**	**OR**	**99% Confidence interval**	**p-value**
Period-specific disapproval	0.87	(0.86–0.89)	<0.01			
Cohort-specific disapproval	--		--	0.88	(0.87–0.89)	<0.01
Age	1.32	(1.26–1.38)	<0.01	1.30	(1.27–1.33)	<0.01
R-squared within	0.060		<0.01	0.065		<0.01
R-squared between	0.854		<0.01	0.760		<0.01

*Model 1 contains only period-specific disapproval at the group level and age at the individual-level.

Model 2 contains only cohort-specific disapproval at the group level and age at the individual level.

Table 2

Multi-level model for the year- and cohort-level associations between past-year marijuana use, year-specific disapproval and cohort-specific disapproval, controlling for age, race, sex, disapproval and perceptions of friends' use at the individual-level (N=986,003)

		OR	99% Confidence interval	p-value
Group-level covariates:				
Year-specific disapproval		0.95	(0.91–1.06)	0.07
Cohort-specific disapproval		0.88	(0.87–0.89)	0.004
Individual-level covariates:				
Individual attitude:				
	Strongly disapprove	15.38	(14.34–16.49)	<0.001
	Disapprove	3.43	(3.25–3.62)	<0.001
	Don't disapprove	1.00		
Proportion of friends who use:				
	All	23.88	(17.26–33.03)	<0.001
	Most	13.71	(10.12–18.58)	<0.001
	Some	6.1	(4.61–8.08)	<0.001
	A few	2.79	(2.16–3.61)	<0.001
	None	1.00		
Ease of marijuana access:				
	Very easy	5.42	(4.60–6.39)	<0.001
	Fairly easy	3.23	(3.01–4.13)	<0.001
	Fairly difficult	2.13	(1.86–2.43)	<0.001
	Very difficult	1.4	(0.94–1.64)	0.3
	Probably impossible	1.00		
Age		1.04	(1.01–1.08)	0.003
Race/ethnicity:				
	Non-white	0.68	(0.61–0.77)	<0.001
	White	1.00		
Sex:				
	Male	1.16	(1.12–1.21)	<0.001
	Female	1.00		
Highest parental education:				
	More than high school	0.80	(0.75–0.84)	<0.001
	High school	0.71	(0.66–0.76)	<0.001
	Less than high school	1.00		
R-Squared within	0.605, p<0.01			
R-squared between	0.825, p<0.01			