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Relationships between frequency and quantity of marijuana use and last year proxy dependence among adolescents and adults in the United States[1]

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Abstract

The association between levels of marijuana use and last year dependence is investigated in a nationally representative sample of adolescents and adults, who used marijuana within the last year ($n = 9284$). Data are aggregated from three surveys (1991–1993) of the National Household Survey on Drug Abuse. A proxy measure of DSM-IV dependence criteria was developed from self-reported symptoms of dependence and drug-related problems. Both frequency and quantity of marijuana use within the last year are linearly associated with the logit of the probability of being dependent on marijuana. The associations vary significantly by age but not gender. Adolescents are dependent at a lower frequency and quantity of use than adults: the differences diverge as level of use increases. Twice as many adolescents as adults who used marijuana near-daily or daily within the last year were identified as being dependent (35% versus 18%). Frequency and quantity of use each retained a unique effect on dependence, but frequency appeared to be more important than quantity in predicting last year dependence. These results provide insight into the processes underlying the age and sex differentials observed in the prevalence of marijuana dependence. The implications of the findings for the epidemiology of marijuana use and dependence are discussed. © 1997 Elsevier Science Ireland Ltd.

Keywords: Frequency; Quantity; Adolescents; Marijuana dependence

1. Introduction

While extensive studies have been conducted on the prevalence and natural history of marijuana use in the United States population (SAMHSA, 1995c; Chen and Kandel, 1995; Johnston et al., 1995; Kandel et al., 1992), little is known about the epidemiology of marijuana dependence, the relationship between patterns of marijuana use and dependence, and the risk factors for dependence. Although extent of drug involvement is an important predictor of substance dependence (Newcomb, 1992; Tennant, 1986; Woody et al., 1993), specific frequencies or quantities of consumption that may differentially predict the probability of marijuana dependence remain to be determined, especially in various population subgroups that differ in the prevalence of dependence. We have found three distinct age and sex related patterns of dependence among those who used marijuana in the last year (Kandel et al., 1997). The rates of dependence are higher for adolescents than

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adults; in adolescents, the rates are slightly higher for females than males, while in adulthood the rates are significantly higher for males than females. Degree of involvement may account for different rates of dependence in several ways. Groups with higher rates of dependence may be using marijuana more extensively or may be more sensitive to the effects of the drug at the same intensity of use. Groups that have similar rates of dependence may be using at different levels of intensity but be differentially responsive to similar doses. Finally, different groups may experience different liability for dependence at the same levels of use.

The empirical relationships between degree of substance use and substance dependence have rarely been investigated for illicit substances. Most epidemiological studies in the general population ask in detail about frequency and quantity of use but do not assess substance use disorders. Most assessments of substance use disorders, including marijuana, are conducted on clinical samples and do not inquire about patterns of use (Morgenstern et al., 1994; Stephens and Roffman, 1993; Tennant, 1986; Woody et al., 1993). In clinical samples, the definition of substance dependence has been based mainly on criteria developed by the American Psychiatric Association (APA, 1987, 1994). Pathological use and functional impairment have been emphasized rather than levels of substance consumption. The structured diagnostic interview schedules used to measure criteria of substance use disorders have not included an assessment of levels of use, thereby limiting the investigation of the extent and nature of the association between intensity of drug use and dependence. The National Comorbidity Study (NCS) (Kessler et al., 1994; Anthony et al., 1994) is unique in that it obtained data both on patterns of use and on criteria required to establish a diagnosis of substance use disorder in the general population.

Most research on the association between degree of substance use and dependence has focused on alcohol, where a significant linear relation between average ethanol intake and alcohol dependence has been established (Grant, 1993; Grant and Harford, 1990; Harford et al., 1991; MacDonald et al., 1992). Very few studies have examined the association for marijuana dependence (Newcomb, 1992; Tennant, 1986). Although marijuana is the most frequently used illicit drug, the prevalence of marijuana dependence in the general population is low. About four percent of adults meet diagnostic criteria for a lifetime history of dependence and less than 1% for dependence in the last year (Anthony et al., 1994; Kandel et al., 1997). While intensity of use is one of the criteria used by clinicians to identify potential need for treatment (Stephens and Roffman, 1993), or to classify patients as being dependent on marijuana (Tennant, 1986), the relationship between degree of use and dependence in the general population remains to be established.

We investigated the association between intensity of marijuana use and proxy dependence in the last year among adolescents and adults in the United States. We took advantage of data on frequency and quantity of marijuana use, and on symptoms of dependence and drug related problems experienced within the last year, available in large representative national samples from the National Household Surveys on Drug Abuse (NHSDA). From these data we developed a proxy measure of last year dependence, as explained in the methods section (Kandel et al., 1997). The large size of the sample, the inclusion of adolescents, and the overrepresentation of minorities allow for subgroup comparisons not otherwise possible in any other data set. We address the following two issues:

1. What is the relationship between levels of marijuana use within the last year (indexed by frequency and quantity of use) and marijuana dependence, controlling for important background variables and use of other substances?
2. Does the association vary as a function of gender and age?

2. Methods

2.1. Sample

The data are from the 1991, 1992 and 1993 waves of the NHSDA (SAMHSA, 1993, 1995a,c), the eleventh, twelfth and thirteenth surveys in a series of national, cross-sectional multistage area probability samples of the U.S. population 12 years old and over. The target population for the NHSDA is the civilian non-institutionalized population of the U.S., which represents over 98% of the total U.S. population (SAMHSA, 1993, 1995a,c). Persons living in non-institutional group quarters, such as homeless shelters, rooming houses and college dormitories are included but individuals on active military duty, in jail, in drug treatment programs, and the non-shelter homeless are excluded. Young persons (12–34 years old) and minorities were oversampled in all surveys, as current (last month) cigarette smokers were in 1993. Completion rates were 84.0% in 1991, 82.5% in 1992 and 79.2% in 1993. A more detailed discussion of the NHSDA sampling design appears in study reports (SAMHSA, 1993, 1995a,c) and in the public release data codebooks (SAMHSA, 1992, 1994, 1995b). The present analyses were based on last year marijuana users who reported a frequency of use ($N = 9284$) from the 1991, 1992 and 1993 surveys (Total $N = 87\,915$). The three surveys were aggregated to increase statistical power and to improve the precision of the estimates. As discussed the 9,284 cases represent 82.4% of those presumed to be last-year marijuana users in those years.

Anonymous household interviews approximately one hour long were conducted with a structured schedule. Questions about the use of alcohol and illicit drugs were listed and answered on anonymous self-administered answer sheets (Turner et al., 1992). Completed sheets were placed in an envelope, sealed and mailed back to the contractor by the respondent without identifying information. The answer sheets contained no skip patterns to prevent the interviewer from identifying drug users. Lower rates of drug use among adolescents and young adults are observed in household surveys as compared with school surveys (Johnston et al., 1995; Centers for Disease Control and Prevention, 1995).

The self-administered sections of the interview schedule included separate modules about patterns of use of 12 classes of drugs. Lifetime, last year, last month frequency of use, quantities used, and age of onset were assessed. A separate module listed six symptoms of dependence and asked whether the respondent experienced each in the last 12 months for each drug class. The six symptoms were:

1. trying to cut down on the use of drugs;
2. inability to cut down;
3. needing larger amounts to get the same effect;
4. using daily for at least two weeks;
5. feeling dependent on the drug; and
6. experiencing withdrawal symptoms

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See Table 1 for the text of items 1, 2, 3, 5, 6. Item 4 is not listed because it does not correspond to any of the DSM criteria and was not used in the analysis.

Another module asked about having experienced problems related to the use of specific drugs in the last year (i.e., 11 problems in 1991, 13 problems in 1992 and 1993)[2].

2.2. Definition of marijuana dependence

The fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (APA, 1994) defines seven diagnostic criteria and associated symptoms for substance dependence. An individual must have experienced three of the seven criteria at any time within a period of 12 months to be diagnosed with psychoactive substance dependence (Table 1). In the present study, information on the five drug dependence symptoms and drug-related problems were used as proxy measures of DSM-IV criteria to construct measures of drug-specific dependence.

We matched available items in the NHSDA to the DSM-IV diagnostic criteria and from these items constructed a proxy measure of dependence. The NHSDA items identified to approximate the DSM-IV diagnostic criteria are listed in Table 1. We do not claim that such indicators enable us to make a definite diagnosis, only that they will identify individuals who have a high probability of being dependent on a particular substance and of meeting the full diagnostic criteria. DSM-IV criteria 1, 2, 4, 6, and 7 are directly, if imperfectly, approximated by items from the NHSDA. The third criterion, whether an individual used the drug in larger amounts or over a longer period than intended, was approximated by a question that asked respondents to name the drugs for which they felt either a need or on which they felt dependent in the past 12 months. The fifth criterion was approximated by questions about frequency and quantity of use, with the assumption that heavy, chronic use was more likely to require a great deal of time to either obtain or use the substance, or to recover from its effects. While all seven criteria were used in our earlier analysis of the prevalence of substance dependence in the U.S. population (Kandel et al., 1997), we excluded criterion 5 from the definition of dependence in the present analysis because of its redundancy with level of marijuana use to be investigated in relation to dependence. An individual qualified as being dependent on marijuana within the last year if he or she met three of the six approximate indicators of the DSM-IV criteria.

Procedures used to assess the validity of the dependence algorithm were described in Kandel et al. (1997). We assessed the consistency of the prevalence estimates from the NHSDA with the dependence rates observed for comparable age ranges in two national surveys that used instruments specifically designed to assess substance use disorders, the NCS (Kessler et al., 1994) and the National Longitudinal Alcohol Epidemiologic Survey (NLAES) (Grant et al., 1995). While the NCS was designed to measure DSM-III-R diagnoses, NCS rates were estimated for this analysis using the DSM-IV algorithms. This could be accomplished because the DSM-IV combines two of the nine DSM-III-R criteria into one, drops one criterion, and eliminates the duration criterion. The rates of last year dependence for each drug and the relative ranking of different age-matched sociodemographic groups were similar across studies (Kandel et al., 1997). Furthermore, a much higher proportion of those who met criteria for proxy marijuana dependence in the NHSDA than of those who did not meet criteria reported having been in treatment for using drugs other than alcohol or cigarettes in the last year (15.8% versus 3.6%). Although we were not in a position to validate our procedure against clinical assessments, the consistency across studies and subgroups despite methodological differences and the relationship of dependence with treatment experience increased our confidence in the usefulness of the proxy dependence measures that we developed.

[2] 'Having someone suggest you seek treatment' and 'drive unsafely' were added in 1992.

Table 1
Comparison of DSM-IV criteria for substance dependence and corresponding questions in the NHSDA

DSM-IV Criteria	Questions in NHSDA
(1) Tolerance, as defined by either of the following: (a) A need for markedly increased amount of the substance to achieve intoxication or desired effect; (b) Markedly diminished effect with continued use of the same amount of the substance.	DR-3. During the past 12 months, for which drugs have you needed larger amounts to get the same effect; that is, for which drugs could you no longer get high on the same amount you used to use?
(2) Withdrawal, as defined by either of the following: (a) The characteristic withdrawal syndrome for the substance (b) The same (or a closed related) substance is taken to relieve or avoid withdrawal symptoms.	DR-6. For which drugs have you had withdrawal symptoms; that is, you felt sick because you stopped or cut down on your use of them during the past 12 months?
(3) The substance is often taken in larger amounts or over a longer period than was intended	DR-5. Which drugs have you felt that you needed or were dependent on in the past 12 months?
(4) There is a persistent desire or unsuccessful efforts to cut down or control substance use	DR-1. During the past 12 months, for which drugs have you consciously tried to cut down on your use? DR-2. During the past 12 months, for which drugs have you been unable to cut down on your use, even though you tried?
(5) A great deal of time is spent in activities necessary to obtain the substance (e.g., visiting multiple doctors or driving long distances), use the substance (e.g., chain-smoking), or recover from its effects	Drug-specific pattern of heavy use as follows: ■Tobacco: smoking 2+ packs daily in the past 30 days ■Alcohol: drinking 5+ drinks a day for 15+ days in the past 30 days; or 'gotten very high or drank' near daily (3+ days a week) in the past 12 months ■Marijuana: used 3+ joints near daily (3+ times a week) in the past 30 days; or 2+ ounces (86+ joints or 43+ grams) in the past 30 days; or traded service for marijuana ■Cocaine: about 2+ grams (37+ big lines of powder) used in the past 30 days, or traded services for cocaine/crack.
(6) Important social, occupational, or recreational activities are given up or reduced because of substance use	DP-1. As a result of drug use at any time in your life, did you, in the past 12 months... (h) get less work done than usual at school or on the job?
(7) The substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance (e.g., current cocaine use despite recognition of cocaine-induced depression, or continued drinking despite recognition that an ulcer was made worse by alcohol consumption)	DP-1. As a result of drug use at any time in your life, did you, in the past 12 months... (a) Become depressed or lose interest in things? (b) Have arguments/fights with family and friends? (c) Feel completely alone and isolated? (d) Feel very nervous and anxious? (e) Have health problems? (f) Find it difficult to think clearly? (g) Feel irritable and upset? (i) Feel suspicious and distrustful of people? (j) Find it harder to handle your problems? (k) Have to get emergency medical help? (l) Have someone suggest you seek treatment?[a] Respondent had any one of the 11 listed problems

[a]Not asked in 1991 NHSDA. An additional problem in the NHSDA (1992)-93) list, 'Drive unsafely', is a DSM-IV abuse but not a dependence criterion.

2.3. Degree of marijuana consumption: missing data

The NHSDA included questions about the total number of times marijuana was used lifetime, the most recent time used, frequency of use in the past 12 months, number of days used in the past 30 days, average of joints smoked per day in the past 30 days, and the total amount of marijuana con-

sumed in the past 30 days. Frequency of use in the past year and average number of joints used per day in the past 30 days were used to index level of marijuana consumption. The frequency of use data released in the official NHSDA reports include imputed values that estimate a frequency of use for individuals who were edited as being users in the last year (Dever et al., 1994). Imputation was used for 17.6% of respondents with a value on frequency of last year use. We restricted the analyses to respondents who reported an actual frequency of use, because we found no association between frequency of use and rate of proxy dependence among the imputed cases, in contrast to the strong relationship observed for non-imputed cases.

As compared with those who reported an actual frequency of use, those who did not tended to report fewer lifetime experiences with marijuana (14% used 200 times or more compared with 42%; $P < 0.01$) and a later age of onset (age 18.5 vs. age 16.1, $P < 0.01$). They were also older (mean age 31.9 years vs. 27.2 years, $P < 0.01$), more likely to be African-Americans (17% vs. 13%, $P < 0.01$) and from rural areas (15% vs. 10%, $P < 0.01$). However, the rates of last year dependence in different gender and age subgroups were similar in the analytical sample as in the total sample of last year users reported in Kandel et al. (1997) (See below).

2.4. Definition of variables

The frequency of last year use was precoded into nine categories ranging from 1–2 days a year to several times a day; we combined daily and several times a day into a single category (Table 3). The average number of joints smoked per day of use within the last 30 days was used to index the quantity of marijuana used because its relationship with rate of proxy dependence was more regular than that of total quantity used. The variable was originally coded from zero to sixty; four or more joints a day were grouped into one category because of the skewed distribution and sparse frequency in those categories. Individuals who did not use marijuana in the last 30 days were coded as zero. Age of onset was coded as years from first use, since age was also included as a covariate in the models.

In addition to gender and age, other social demographic characteristics found to be related to substance use and dependence (Kandel et al., 1997; Warner et al., 1995) were also included in the multivariate regression models (Table 7). These included ethnicity (white, black, Hispanic and other); education (4 categories from less than high school to college graduate, plus a separate category for 12–17 year olds); family income (5 categories, from less than $9000 to $75 000 or more annually); region (Northeast, North-Central, South, West); and urbanicity (Central city, other urban, rural). Age was coded into four categories: 12–17, 18–25, 26–34 and 35 years old and over.

Since most persons who used marijuana in the last year also used other drugs in the same period (98% drank alcohol, 69% smoked cigarettes, 44% used illicit drugs other than marijuana), we included the following drug use variables in the models: cigarettes smoked per day in the prior month (coded from 0 = none to 6 = 2 or more packs a day); frequency getting drunk in the past 12 months (0 = no use to 8 = daily); and number of other illicit drugs used in the past 12 months, including cocaine, heroin, inhalants, hallucinogens, non-prescribed sedatives, tranquilizers, stimulants, analgesics, and other opiates (coded from 0 = none to 3 = three or more).

2.5. Analytic procedures

One descriptive and three logit analyses were implemented. The descriptive analysis examined degree of marijuana use among last year users by gender and among the four age groups. In the multivariate analyses, the adult age groups were combined into a single category for contrast with adolescents.

First, marijuana proxy dependence was regressed separately on frequency of use in the last year and average number of joints used per day in the last 30 days among last year users, by gender and age, without controlling for any other factor. The 30-day quantity of use variable was used with the sample of last year users to retain the largest number of cases, maximize the stability of the coefficients and compare the size of the frequency and quantity coefficients for the same respondents. Analyses restricted to last month users, and not presented here, generated results very similar to those based on last year users. Two sets of logit coefficients were estimated:

1. Polynomial contrasts of categories of marijuana use levels to index the linearity of the use-dependence association. The first regression coefficients reflects the linear effect across the categories, the second reflects the quadratic effect, the third reflects the cubic effect, and so on. Only the first three coefficients are presented. A simple linear association is characterized by a significant first degree coefficient, with all other higher-order coefficients non-significant, since significant higher-order coefficients imply non-linear effects.
2. The significance of the difference between adjacent categories was used to investigate non-linear threshold effects. Each category of the predictor, except the first, was compared to the previous category.

Table 2
Prevalence of 12-month proxy dependence[a] among last-year marijuana users by age and gender (NHSDA 1991–93, $N = 9{,}284$[b])

	Total			Male			Female[c]		
Group	N[b]	%	C.I.[d]	N	%	C.I.	N	%	C.I.
Total	9284	7.3	(6.3–8.2)	5359	8.1	(6.8–9.4)	3925	5.9	(4.7–7.0)**
Age 12–17	1779	13.0	(10.3–15.7)	990	11.6	(8.2–15.0)	789	14.9	(10.5–19.3)
Age 18+	7505	6.5	(5.5–7.5)	4369	7.7	(6.4–9.0)	3136	4.5	(3.4–5.7)***
18–25	3837	7.4	(6.1–8.7)	2171	9.0	(7.1–10.9)	1666	5.0	(3.6–6.3)***
26–34	2879	6.0	(4.7–7.3)	1694	7.0	(5.1–8.9)	1185	4.2	(2.3–6.0)*
35+	789	5.7	(3.1–8.2)	504	6.5	(3.2–9.8)	285	4.1	(0.6–7.6)
Adolescent-adult difference		6.5**			3.9*			10.4***	

[a]Prevalence and standard errors were estimated on weighted sample with correction for design effects by SUDAAN.
[b]Unweighted N, excluding those missing last-year frequency of use.
[c]Chi-square test for differences between males and females per SUDAAN: *$P<0.10$; **$P<0.01$; ***$P<0.001$.
[d]95% confidence interval of the estimated prevalence (by SUDAAN).

In a second step, the models were estimated for the total sample with two-way and three-way interaction among gender, age, and intensity of use. These regressions provide two parameters of interest: a slope and an intercept for each group. The slope indicates the change in rate of dependence to increasing levels of use; the intercept indicates the response to a low level of marijuana use. Although we interpret the intercept as representing a threshold, the intercept does not strictly represent a pure threshold since it includes the effect of unmeasured variables. A large intercept reflects a low threshold, i.e., a high proportion of persons dependent at low doses; a small intercept reflects a high threshold, i.e., a low proportion of persons dependent at low doses. We compared the regression coefficients (intercepts and slopes) from these logit models between pairs of groups to determine whether variations in rates were due to differences in absolute level of response to the drug (indexed by the intercept) or differences in the rates of response to increasing levels of use (indexed by the slope), or both. When groups have different responses to the drug at low levels of use, the intercepts of the models will be significantly different from each other. Since the logistic curve reflects a multiplicative factor of the intercept along points on the curve, the interpretation of differences in slopes depends on the differences between intercepts. If the intercepts for two groups are not different and the slopes are also the same, all points for both groups lie on the same line. However, if the intercepts are different, parallel slopes on the logit scale are reflected as divergent lines in a linear probability scale. At each higher point in the scale, the same multiplier of two baselines will yield increasingly divergent values as the differences between the baseline values become increasingly wider.

In a third step, we estimated hierarchical multivariate logistic regressions to predict last year marijuana proxy dependence. The predictors included variables related to the use of marijuana and other drugs and sociodemographic correlates, i.e. gender, age, race, education, family income, region of the country, and urbanicity. Marijuana use was indexed both by frequency and quantity of use, and by age of onset. A quadratic term for age of onset was included to model the potential non-linearity of the effect associated with increasing duration of use. Because of the known interrelationship in the use of marijuana and of other drugs, especially among heavy marijuana users (Kandel, 1995; SAMHSA, 1996; Stephens and Roffman, 1993), we included use of alcohol, cigarettes, and other illicit drugs in the last year to avoid possible model misspecification.

Since the NHSDA sample was stratified and clustered, standard errors of prevalence were estimated by SUDAAN (Shah et al., 1992), a software package that uses Taylor series linearization techniques to adjust for sample design effects. The logistic procedure in SUDAAN does not provide the flexibility of setting up specific contrast categories and could not be used to estimate the polynomial and adjacent contrast models. The standard errors of the logit coefficients, when these contrasts were estimated by the SPSS program, were most likely to be smaller than the true values due to design effects. The design effects for sex and age groups ranged from 1.7 to 4.4 for the rates of illicit drug use 1992, 1994, 1995b), and from 1.8 to 5.5 for the estimated dependence rates (as calculated by SUDAAN).

Table 3
Distribution of frequency of marijuana use in last year and quantity of use in last 30 days among last year users by age and gender (NHSDA 1991–93, $N = 9{,}284$[a])

Level of marijuana use	Adolescents (Ages 12–17)			Adults (Age 18+)		
	Total (1779) %	Male (990) %	Female (789) %	Total (7505) %	Male (4369) %	Female (3136) %
Frequency used last year						
1–2 times	27.9	26.5	29.7	21.8	19.0	26.6
3–5 times	13.6	13.0	14.4	14.7	13.1	17.4
6–11 times	9.1	8.9	9.4	10.8	9.4	13.0
1–2 times a month	13.1	14.4	11.4	12.3	13.4	10.5
Several times a month	9.2	8.1	10.7	9.3	9.8	8.4
1–2 times a week	10.9	10.8	11.0	11.9	13.4	9.5
Almost daily	7.9	8.8	6.7	10.7	12.8	7.2
Daily	8.3	9.6	6.6	8.5	9.1	7.4
χ^2 (sex difference) (df = 7)		9.2			198.7***	
χ^2 (age difference) (df = 7)	Total = 26.1***		Male = 26.4***		Female = 11.5	
Average amount used per day last 30 days						
Did not use in last 30 days	54.6	53.8	55.6	46.3	42.5	52.6
Used up to 1 joint	20.8	20.9	20.8	29.1	29.7	28.1
Used 2 joints	10.7	10.4	11.1	12.0	14.0	8.8
Used 3 joints	5.0	4.5	5.8	5.8	6.3	5.1
Used 4+ joints	8.8	10.4	6.7	6.7	7.4	5.5
χ^2 (sex difference) (df = 4)		4.7			94.1***	
χ^2 (age difference) (df = 4)	Total = 39.7***		Male = 39.2***		Female = 11.1*	

[a]Unweighted N, excluding those missing last-year frequency of use; weighted rates.
*$P<0.05$; **$P<0.01$; ***$P<0.001$.

3. Results

3.1. Prevalence of last year proxy dependence and level of use

The prevalence of marijuana proxy dependence in the last year is presented by gender and age in Table 2. Descriptive data on level of use, indexed by frequency and quantity of use, are presented in Table 3.

Among last year marijuana users, 7.3% met the proxy criteria for dependence. Among adults, more male than female users were dependent[3]. Among adolescents, the gender difference reversed but was not statistically significant because of large standard errors. For each gender, the rates of dependence were highest in adolescence and declined with age. Adolescent users had significantly higher rates of proxy dependence than adult users, especially females; the age differences were smaller among males than among females.

Fewer than 10% of users used marijuana on a daily basis; another 7% to 13% used it almost daily (Table 3). Almost half of those who used marijuana within the last 30 days smoked one joint or less on an average day. There were no gender differences in frequency or quantity of marijuana used among adolescents, while among adults, males used marijuana at higher frequencies and higher quantities than females. Adolescent males used less intensively than adult males; there was no age difference in frequency of use among female users. While fewer adolescents than adults had used marijuana within the last 30 days, they reported higher quantity of use (Table 3).

3.2. Intensity of marijuana use and proxy dependence

3.2.1. Frequency of use

The relationship between frequency of marijuana use and rates of last year dependence among last year users was examined in the total sample, and by gender among adolescents and adults separately (Table 4). The highest rates of last year dependence, about one-fifth of the users, occurred among those who reported using marijuana almost daily or daily. These patterns are reflected in the polynomial contrasts and in the tests of differences between coefficients for adjacent contrast categories. To improve the linearity of the associations,

[3] The rates in Table 1 are slightly different from those reported in Kandel et al. (1997) because of differences in the diagnostic algorithm and the base number of last year users. As noted, in the present analyses, the dependence definition was based on 3 positive criteria out of 6 rather than out of 7. In addition, respondents whose last year usage and frequency of marijuana use were imputed were excluded. However, the age and gender differences are the same. The rates of proxy last year dependence reported in Kandel et al. (1997) were 13.3% among adolescent males, 15.8% among adolescent females, 8.9% among adult males and 5.1% among adult females.

Table 4
Prevalence of last year proxy dependence among last year marijuana users by frequency of marijuana use, by gender and age (NHSDA 91–93, $N = 9284$)

		Adolescents (Ages 12–17)			Adults (Age 18+)		
Frequency of use	Total	Total	Males	Females	Total	Males	Females
Rate of last year dependence (%)	7.3%	13.0%	11.6%	14.9%	6.5%	7.7%	4.5%
1–2 times	0.7	0.8	0.2	1.5	0.7	0.6	0.8
3–5 times	1.8	3.8	2.3	5.6	1.6	2.6	0.3
6–11 times	2.9	13.8	13.3	14.5	1.7	2.1	1.2
1–2 times/month	4.9	7.1	7.1	7.3	4.6	4.2	5.4
Several times a month	8.5	17.9	15.2	20.5	7.3	6.7	8.5
1–2 day/week	11.4	25.4	23.9	27.5	9.8	10.4	8.3
Almost daily	19.8	40.1	33.3	51.9	17.9	19.3	13.6
Daily	20.3	29.9	24.1	40.8	19.1	21.6	14.2
Logit model with polynomial contrast (log mid-point of number of days per year)[a]							
(1) linear effect	2.43***	2.43***	2.66***	2.47***	2.53***	2.38***	2.70***
(2) quadratic effect	−0.31*	−0.53	−0.98*	−0.10	−0.22	0.04	−0.77**
(3) cubic effect	0.12	0.47	0.68	0.42	−0.06	−0.04	−0.07
Adjacent difference contrast[b] *(Odds ratio)*							
1–5 times (reference)	–	–	–	–	–	–	–
6–11 times	2.59***	8.96***	17.28***	5.82**	1.65	1.54	1.96
1–2 times/month	1.74*	0.49	0.50	0.46	2.67**	2.02	4.73**
Several times a month	1.81**	2.68*	2.37	3.27	1.65*	1.64	1.62
1–2 day/week	1.38*	1.62	1.74	1.47	1.36	1.60*	0.98
Near daily or daily	1.94***	1.64	1.27	2.28*	2.08***	2.18***	1.78*

[a]Logistic regression of last year dependence with polynomial contrasts. The 1st degree of freedom contains the linear effects across the categories of the independent variable; the 2nd contains the quadratic effect; and so on. Higher order effects not shown. All logit models are based on six categories of use frequency by combining the first two and the last two categories so as to achieve better linearity. The six categories in polynormial contrast are coded as the log mid-point in terms of number of days used in last 12 months (i.e. 3, 9, 18, 36, 96, 260 days transformed into log values of 1.1, 1.8, 2.9, 3.6, 4.6, 5.6).
[b]Logistic regression of last year dependence with comparison of adjacent categories, based on combined 6 categories. Each category of the independent variable, except the first, is compared with the previous category.
*$P<0.05$; **$P<0.01$; ***$P<0.001$.

the first two and last two categories were combined in the logit analyses, yielding a total of six categories of frequency of use. The linear effects were very significant ($P < 0.001$), while the quadratic effects were significant only for the total sample as well as for adolescent males and adult females. The more frequent the use, up to a certain level, the more likely are men and women to become dependent on marijuana. Once the drug is used almost daily, more frequent use is not associated with increased risk of dependence.

Similar linear patterns were observed for all subgroups. However, the rate of dependence among the near daily users was twice as high among adolescents as among adults, and much higher among adolescent girls (46.4%) than adolescent boys (28.5%, $P < 0.01$). The rates declined with age among adults, from 21.2% among users aged 18–25, 18.5% among those aged 26–34, to 14.3% among those age 35 and over (data for age subgroups among adults not shown). Female adult users reported the lowest rate of last year dependence for almost every level of use.

While the major trend was linear, non-linear variation was evident. The contrasts between adjacent frequencies of use revealed some points of sharp difference for each subgroup (Table 4). Rates of dependence increased sharply for use at 6 to 11 times a year for adolescents, and near-daily for all groups except adolescent boys.

The age differences in the relationships between frequency of use and proxy dependence were greater for females than males. This is seen clearly in Fig. 1, which displays the predicted relationships between frequency of use and dependence by gender among adolescents and adults in the form of logistic functions.

3.3. Quantity of use

The relationships between quantities used in the last 30 days and last year proxy dependence were very similar to those observed for frequency of use (Table 5). Although the association exclusively linear for all subgroups except adult males, the contrasts between adjacent coefficients revealed gender differences among

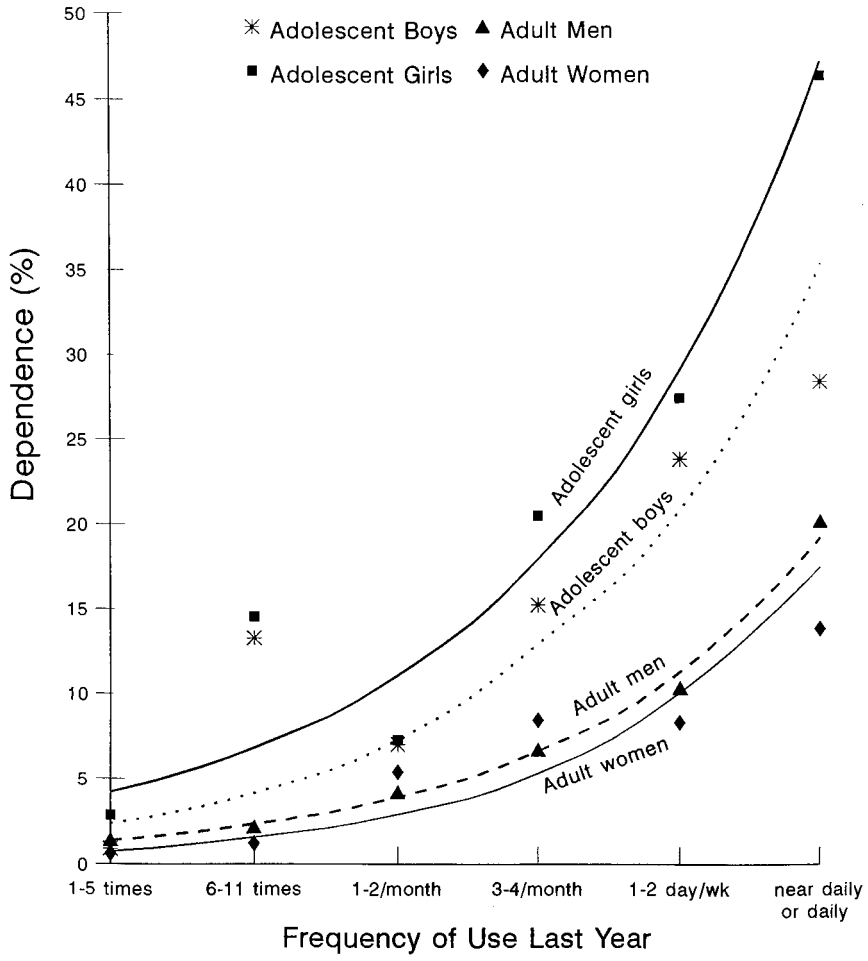

Fig. 1. Predicted logistic relationship between frequency of marijuana use and last year dependence among last year users by sex among adolescents and adults (NHSDA 1991–93, $N = 9284$).

adults: among adult male users the rate of last year proxy dependence increased significantly from 2 joints (8.3%) to 3 joints a day (20.9%; OR = 2.90, $P < 0.001$), while among adult females the largest change occurred at a lower level, namely from 1 joint to 2 joints a day (OR = 3.70, $P < 0.001$). The difference between 3 joints and 4 or more joints a day among adult females was also statistically significant (OR = 2.26, $P < 0.05$), while the same increase in quantity showed no difference among adult males.

As was observed for frequency, the age differences in the relationship between quantity of use and proxy dependence were greater for females than males.

3.4. Group differences

Logistic regressions were estimated to permit a systematic test of age and gender variations in the effects of level of marijuana use on proxy dependence (Table 6). The models, estimated separately for frequency and quantity of use, included age, gender and an age-by-gender interaction term. A model with all interactions between age, gender and frequency (or quantity) of use was estimated but is not shown since none of the interactions between frequency and quantity of use and sex and/or age were statistically significant; the backwards elimination of non-significant terms produced results identical to those of the models presented in Table 6.

Differences between the regression coefficients for adolescents and adults and for each gender in each of these major age groups were tested. The results of the statistical tests were identical for frequency and quantity of use. In these analyses, slopes, intercepts and the differences in these coefficients are crucial to an understanding of group differences in the rates of dependence. The slope indexes the strength of the relationship between level of use and dependence; the intercept indexes the rate of proxy dependence at the lowest level of use of the substance, which by definition has to be greater than zero. As noted earlier, a high intercept reflects a high proportion of persons dependent at low doses; a low intercept reflects a low proportion of persons dependent at low doses.

Table 5
Prevalence of last year proxy dependence among last year marijuana users by quantity of marijuana use last 30 days, by gender and age (NHSDA 91–93)

		Adolescents (Age 12–17)			Adults (Age 18+)		
Joints used per day	Total	Total	Males	Females	Total	Males	Females
Rate of last year dependence (%)	6.8	12.7	11.1	14.6	6.4	7.1	4.4
No use last month	3.3	6.6	4.8	8.8	2.8	3.1	2.5
Up to 1 joint	5.2	10.2	9.2	11.5	4.8	5.8	3.1
2 joints	9.8	17.9	14.7	21.6	8.9	8.3	10.5
3 joints	18.1	30.7	26.8	34.5	16.7	20.9	8.1
4 or more joints	22.4	39.4	37.1	44.0	19.5	20.8	16.5
Logit model with polynomial contrast[a]							
(1) linear effect	1.78***	1.87***	1.96***	1.77***	1.75***	1.79***	1.63***
(2) quadratic effect	−0.10	0.01	−0.05	0.03	−0.15	−0.16	−0.11
(3) cubic effect	−0.20	−0.12	−0.04	−0.22	−0.21	−0.26*	0.01
Adjacent difference contrast[b] *(Odds ratio)*							
No use last month (reference)	–	–	–	–	–	–	–
Up to 1 joint	1.60***	1.61	1.99	1.35	1.68***	1.89***	1.26
2 joints	1.97***	1.90	1.70	2.12	1.89***	1.49*	3.70***
3 joints	2.02***	2.01	2.14	1.91	2.09***	2.90***	0.75
4 or more joints	1.31	1.59	1.61	1.49	1.20	1.00	2.26*

[a]Logistic regression of last year dependence with polynomial contrasts. The 1st degree of freedom contains the linear effects across the categories of the independent variable; the 2nd contains the quadratic effect; and so on. Higher order effects not shown.
[b]Logistic regression of last year dependence with comparison of adjacent categories. Each category of the independent variable except the first is compared with the previous category.
[c]Excluding those missing quantity of use in last 30 days ($N = 829$).
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

There were no significant age or gender differences in the slopes either for frequency or quantity of use (full model not shown). An increase in frequency or quantity of use increased the log-odds of the rate of proxy dependence to the same extent for both adolescents and adults. The model in Table 6, which includes all the significant effects from the full interaction model, provides the basis for the remaining interpretations.

Among both males and females, adults were less likely to be currently dependent on marijuana than adolescents. The age effects were highly significant: −1.44 for females (odds ratio OR = 0.24; $P < 0.001$) and −0.66 for males ($-1.44 + 0.78$, OR = 0.52; $P < 0.01$). At each level of frequency or quantity of use, the rate of proxy dependence was higher for adolescents than for adults, although the overall relationship between use and proxy dependence (as indexed by the slope) was the same for both age groups. A higher rate of proxy dependence was observed at a lower level of use among adolescents than adults. Although the parallel slopes imply that each unit change in level of use produces the same increase in log-odds of the rate of dependence, because the metric is logistic the significant differences at the lowest value (intercept) will lead to increasingly wider age difference as the level of use increases. When frequency of use reached near daily or daily use, the rate of last year proxy dependence was almost twice as high among adolescents (34.8%) as adults (18.4%) (see Table 4).

The age effect was greater among females than males. The tendency for adolescent marijuana users to be more dependent within the last year than adults was stronger among females than among males (see Fig. 1 and Table 5).

There were significant age-by-gender interactions in rates of proxy dependence, whether controlling for frequency ($P < 0.05$) or quantity of use ($P < 0.01$). The gender differences among adults were in the reverse direction from those observed among adolescents, and slightly more significant for quantity than for frequency of use. Among adolescents, males were slightly less likely than females to be dependent at the same levels of use (−0.49 for frequency of use, −0.43 for quantity of use, $P < 0.10$). Among adults, the reverse was observed: the coefficient for frequency of use was 0.29 ($-0.49 + 0.78$, $P < 0.10$) and for quantity 0.38 ($-0.43 + 0.81$, $P < 0.05$).

3.5. Multivariate logit models

We conducted a series of multivariate analyses to determine the unique effects of age of use onset, frequency and quantity of marijuana use on last year proxy dependence controlling for potential con-

Table 6
Logistic regressions of last year marijuana proxy dependence on frequency and quantity of use, age and gender among last year users[a] (NHSDA 1991–93)

	Use level indexed by frequency of use[b]		Use level indexed by quantity of use	
	β	s.e.	β	s.e.
Level of use	0.64***	(0.05)	0.55***	(0.05)
Sex (male vs. female)	−0.49†	(0.26)	−0.43†	(0.26)
Age (adults vs. adolescent)	−1.44***	(0.23)	−1.35***	(0.24)
Sex by age	0.78*	(0.31)	0.81**	(0.23)
(Intercept)	−3.82***	(0.24)	−2.41***	(0.21)

[a]Coefficients and standard errors were estimated on weighted sample with correction of complex sample design effects by SUDAAN.
[b]Frequency of use is coded as log the mid-point in term of numbers of days used in last year.
†$P<0.10$; *$P<0.05$; **$P<0.01$; ***$P<0.001$.

founders (Table 7). The control variables included sociodemographic characteristics and the frequency of use of other substances, i.e., cigarettes, alcohol and illicit drugs. Both intensity of marijuana use measures were entered as continuous variables, based on the previous findings of a predominant linear association between use and dependence. Four models were estimated to identify the unique effect of frequency and quantity of use, controlling for other covariates. Only the last model is displayed in Table 7. The base model included all the covariates, except the two marijuana use intensity variables, to estimate the explanatory power contributed by all other covariates potentially related to marijuana dependence. Two subsequent models added either frequency or quantity of use by itself. The last model added both frequency and quantity of use (see Panel B in Table 7). All univariate effects are displayed in Panel A.

Both frequency of marijuana use in the last year and quantity used in the last 30 days made significant contributions to last year marijuana proxy dependence. However, frequency of use appeared to be the more important factor of the two. The greater importance of frequency than quantity of use was reflected in the partial correlation coefficients (0.25 versus 0.07) and the improvement in the goodness-of-fit statistics for the models. The log-likelihood chi-square for the model which added frequency of use to the base model was 5.7% lower than that which added quantity of use (3918.4 versus 4153.6, models not shown). By contrast, the inclusion of quantity decreased the chi-square of the frequency model by only 1.0% (3877.7 versus 3918.4, models not shown). Frequency of marijuana use by itself provided more explanatory power than the full set of covariates. The improvement in chi-square from adding frequency of marijuana use to the base model was 428.3, compared with an improvement of 402.1 of the base model over the initial log-likelihood function (Models not shown). The inclusion of frequency of use to the base model reduced the size of the coefficients indexing age of onset (i.e., years since first marijuana use) as well as the gender effect. The gender difference in dependence observed in the total sample was explained by the higher frequency of use by males than females, supporting the interpretation offered above. Number of illicit drugs used last year had a highly significant effect on last year marijuana dependence over and beyond intensity of marijuana use (Table 7). The positive effect of frequency of getting drunk that was present when each of the two marijuana use variables was included separately in the models disappeared when both marijuana use variables were included in the model.

Other significant predictors of last year proxy dependence included being an adolescent, having graduated from high school or college, having a family income between $40 000 and $75 000, and living in the West (compared with living in the Northeast). Controlling for other covariates, there were no overall ethnic differences in rates of last year marijuana proxy dependence.

Similar conclusions held when parallel analyses were conducted for each of the four sex and age subgroups separately, and in the restricted sample of last month users (data not presented). We reestimated the same multivariate model among last-month users in order to restrict the two measures of use level to the same 30 day period. This reduced the sample by 45%. The conclusions were unchanged: the use-dependence relationships were predominately linear, and frequency of use (indexed by number of days used in last 30 days) explained more variance in the rate of proxy dependence than quantity of use. Furthermore, the predictive strength of frequency and quantity of use were similar among last month users (partial $r = 0.24$ for frequency, partial$r = 0.13$ for quantity) as among last year users.

Table 7
Odds ratios from univariate and multivariate logit models of last year proxy dependence on frequency and quantity of marijuana use and other covariates among last year users (NHSDA 1991–93, $N = 9284$)

	A. Univariate model		B. Multivariate model		
Predictors	Odds ratio	95% C.I.	Odds ratio	95% C.I.	r[a]
Male (vs. female)	1.19***	1.09–1.30	1.03	0.94–1.13	0.00
Age (vs. 35+)					(0.08)
12–17	2.49***	1.91–3.24	2.68***	1.55–4.63	0.05
18–25	1.33*	1.05–1.67	1.02	0.67–1.54	0.00
26–34	1.06	0.83–1.36	0.86	0.62–1.19	0.00
Race (vs. White)					
Blacks	0.93	0.73–1.19	0.92	0.70–1.22	0.00
Hispanic	1.24	0.93–1.64	1.07	0.78–1.47	0.00
Other	0.95	0.57–1.60	0.93	0.52–1.63	0.00
Education (vs.<high school)					(0.02)
College graduate	0.70*	0.52–0.95	1.47*	1.03–2.10	0.03
Some college	0.66**	0.51–0.86	1.11	0.83–1.49	0.00
High school	0.99	0.79–1.24	1.31*	1.02–1.68	0.03
Family Income (vs.<$8999)					(0.04)
$75 000+	0.75	0.49–1.14	0.92	0.58–1.45	0.00
$40 000–74 999	1.26	0.98–1.61	1.36*	1.03–1.80	0.03
$20 000–39 999	0.98	0.77–1.25	0.97	0.74–1.26	0.00
$9000–19 999	1.01	0.78–1.30	0.87	0.66–1.15	0.00
Region (vs. West)					(0.05)
Northeast	0.56***	0.43–0.72	0.57**	0.44–0.76	−0.06
North-central	0.76*	0.60–0.95	0.73*	0.57–0.95	−0.03
South	0.96	0.79–1.16	0.89	0.72–1.11	0.00
Urbanicity (vs. Rural)					
Central city	0.86	0.58–1.28	1.11	0.71–1.74	0.00
Other urban	0.99	0.77–1.29	1.04	0.78–1.39	0.00
Cigarettes smoked per day last month	1.07**	1.03–1.11	1.00	0.96–1.05	0.00
Frequency getting drunk last year	1.20***	1.15–1.24	1.03	0.99–1.07	0.01
Number of other illicit drugs used last year[b]	1.51***	1.44–1.59	1.20***	1.13–1.28	0.09
History of marijuana use:					
Years since 1st marijuana use[c]	1.04	0.999–1.08	1.02	0.97–1.08	0.00
Squared years since 1st use	0.998**	0.996–0.999	0.998	0.996–1.00	−0.01
Frequency used last year[d]	1.90***	1.79–2.01	1.72***	1.61–1.85	0.25
Quantity used last 30 days[e]	1.75***	1.64–1.85	1.19***	1.11–1.29	0.07

[a]Partial correlation coefficient in multivariate logistic regression.
[b]Number of any illicit drug other than marijuana used in the last year.
[c]Current age minus age of onset.
[d]Frequency coded as log the mid-point in terms of number of days used last year.
[e]Missing was controlled by a separate dummy variable.
*$P<0.05$; **$P<0.01$; ***$P<0.001$.

4. Discussion

We examined the relationships between level of marijuana use and dependence among last year marijuana users in a nationally representative sample of adolescents and adults, using a proxy measure of last year marijuana dependence that only approximated DSM-IV criteria. Data were from three aggregated annual NHSDA surveys (1991, 1992, 1993). A distinguishing feature of our study is the presentation of the detailed relationship between marijuana use and dependence at different levels of frequency and quantity of use by gender and age. We reported several novel findings, including an interaction between age and sex in the association between last year marijuana use and proxy dependence.

Adolescents, especially adolescent males, use marijuana at slightly lower frequency than adults but use at higher quantity. Adolescent males and females use at similar levels, while adult males use at higher levels than adult females. Frequency and quantity of marijuana use are linearly associated with the logit of the probability of being dependent on marijuana. The association does not vary significantly either by age or by gender. However, adolescents are more likely than adults to be dependent at every level of frequency and quantity used.

These results provide insight into the processes underlying the age and sex differentials observed in the prevalence of marijuana proxy dependence. The
lence of last year proxy dependence is higher among adolescent users than adult users, and higher among

Table 8
Schematic summary of group differences in marijuana use behavior and multivariate coefficients by age and age and gender in NHSDA (1991–1993)

Group Contrasts	Dependence rates	Distributions		Slopes		Intercepts	
		Frequency	Quantity	Frequency	Quantity	Frequency	Quantity
Female: Adolescents vs Adults	Adol > Adults	Same	Adol > Adults	Same	Same	Adol > Adults	Adol > Adults
Male: Adolescents vs Adults	Adol > Adults	Adol < Adults	Adol > Adults	Same	Same	Adol > Adults	Adol > Adults
Adolescents: Males vs Females	M < F?	Same	Same	Same	Same	M < F[a]	M < F[a]
Adults: Males vs Females	M > F	M > F	M > F	Same	Same	M > F[a]	M > F

[a]P < 0.10; ? = not significant in marginal distribution, significant in multivariate models.

adult male users than adult female users. The gender difference in adolescence, with females higher than males, becomes marginally ($P < 0.10$) significant controlling for frequency or quantity of use. The major group differences and mechanisms underlying these differences are summarized in Table 8. Among last year marijuana users, adolescents experience higher rates of proxy dependence than adults, not because they use marijuana more frequently than adults (although they used at higher quantities), but because they appear to be more sensitive to the effects of the drug: at a very low dose adolescents are more likely to be dependent than adults; this pattern is stronger for females than for males. Furthermore, the tendency for being dependent in the last year at each level of use is higher for adolescent girls than for boys. The relative rate of increase in the log-odds of the rates of dependence given increasing level of use does not depend on age. However, because of differences in the intercepts, at the same levels of frequency or quantity of use adolescents experience higher rates of dependence than adults. Adult males experience higher rates of dependence than adult females not only because they are more likely than females to be drug dependent at the same levels of use, as reflected in their higher intercept (reflecting a higher rate of dependence at a very low dose of marijuana), but also because they use at higher frequency and quantity than females.

We speculate that among adolescents the absence of gender differences in the crude rate of dependence occurs as the result of two offsetting forces:

1. girls are more likely to be drug dependent than boys at the same level of use;
2. boys tend to use marijuana at higher intensity than girls, although the differences are not statistically significant.

An important contribution of this study is to bridge research on substance dependence in treated samples, which emphasizes functional impairment to the neglect of patterns of use, and epidemiological research on substance use in the population, which usually ignores dependence or abuse criteria. In the absence of abuse or dependence measures, studies based on general population samples have used daily or near-daily use as a criterion for serious substance involvement or abuse (Anthony, 1983; Kandel and Davis, 1992; Johnston et al., 1995). A major finding of our study is that at the same level of near-daily or daily use, the rate of last year proxy dependence among last year users decreases sharply with age. Adolescents are more likely than adults to be dependent at a given level of marijuana use.

We hypothesized that this age-related trend might reflect a process of increased physiological tolerance to marijuana with increasing age. An examination of the symptoms reported by adolescents and adults provided partial support for this interpretation. Except for feeling dependent, more adolescent than adult last year users mentioned each symptom, whether physiological or non-physiological (data not shown). Factor analyses of the dependence symptoms showed similar solutions and loading coefficients among adolescent and adult marijuana users. Whereas these age comparisons were based on cross-sectional surveys, a longitudinal follow-up of the same birth cohorts would better establish the distribution and clustering of dependence symptoms at different phases of the lifecycle.

We can only speculate as to the reasons underlying the observation that at the same levels of use adolescents are more likely than adults to meet criteria for dependence. Adolescents may be more vulnerable than adults to the social and psychological consequences of marijuana use. Adolescents may interpret the symptoms that they experience and the questions about these symptoms differently from adults. This may explain, for instance, why 14% of adolescents who reported to have used marijuana only to 11 times in the last year reported to have experienced at least three of the six

approximate symptoms of dependence. Similarly, in another sample of adolescents administered a diagnostic instrument specially designed for adolescents, the DISC-2.3 (Shaffer et al., 1996), 19.4% of those who reported having used alcohol or an illicit drug only once or twice in the last year met criteria for any substance use disorder (Kandel et al., 1997). Adolescents may misunderstand the questions on dependence symptoms and incorrectly assess their symptoms. However, the validity of these reports is confirmed by the finding that among adolescents as among adults, those who meet criteria for dependence, irrespective of level of use, are much more likely than those who do not meet these criteria to have been in treatment for a drug related problem. The age-related differences need to be further investigated and confirmed in clinical samples as well as in epidemiological studies specifically designed to investigate this issue. Diagnostic algorithms for psychiatric disorders have been developed on and for adults, and have been mostly adopted for children and adolescents. Especially with respect to substance use disorders, diagnostic studies based on adolescents are required.

Multivariate analyses indicated that frequency of use in the last year and quantity of use per day in the last 30 days both retained a unique effect on last year proxy dependence after controlling for other covariates. However, frequency of use appeared to be more important than quantity. This finding is consonant with Newcomb's results based on a factor analytical model among adolescents: the loading coefficient from a latent factor of marijuana consumption was twice as high for a manifest indicator of frequency as for quantity of use (Newcomb, 1992).

We want to stress the limitation of this study that derives from the proxy measure of marijuana dependence. The NHSDA is unique in that it is an ongoing annual epidemiological monitoring effort of drug behavior in large national representative samples. However, the NHSDA was developed to estimate the prevalence of legal and illegal drug use in the United States. It was not designed for estimating substance dependence. Because of time constraints in the interview, only a limited number of dependence criteria were introduced ten years ago, each criterion measured by a very small number of symptoms. While we approximated available items in the NHSDA with the DSM-IV criteria, diagnostic data were not obtained from structured interviews specifically designed to assess these criteria. As we have stressed (Kandel et al., 1997), we do not claim that such approximated criteria enable us to make a definite diagnosis of substance use disorder, only that they will identify individuals who have a high probability of being dependent. A more exact assessment of the relationship between marijuana use and dependence requires measures of full DSM-IV criteria from an instrument specifically designed for that purpose. Furthermore, it is assumed that the criteria and symptoms of dependence are the same throughout the lifespan. This assumption underlies the development of psychiatric assessments schedules for children and adolescents for disorders assumed to occur in adolescence as well as adulthood, such as the DISC (Shaffer et al., 1996). This assumption, however, remains to be tested as regards substance use disorders.

Our results provide some understanding of what specific patterns of drug use represent in terms of problematic use and need for treatment in the general population. Adolescents appear to be particularly vulnerable, even at low levels of marijuana use. The results also provide some understanding of the factors that account for differences in rates of dependence observed among adolescents and adults, and among males and females in adolescence and adulthood. However, this work is just a first step in the investigation of substance dependence in the general population. It provides a descriptive basis for the epidemiology of substance use disorders, especially in adolescence, which is necessary for the planning of more sophisticated longitudinal research on the progression from drug use to drug dependence.

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