Adolescent Use and Misuse of Marijuana

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Substance use by adolescents and young adults continues to be a serious problem. Over the past decade, marijuana has remained the most commonly used illicit substance with close to 50% of high school seniors admitting use at some time. It is estimated that each year 2.6 million individuals in this country become new users and most are younger than 19 years of age. Individuals who provide health care services to this age group must have a good understanding of the drug, its pharmacokinetics, and the many adverse effects both short and long term. Familiarity with risk factors associated with initiating use can be very helpful in screening older children and targeting anticipatory guidance toward those most likely to benefit. This article will review these issues and include commentary on a recently published review of treatment programs.

The substance

Marijuana is usually available as a green or brown mixture of dried, shredded leaves, stems, and flowers from the hemp plant (Cannabis sativa). It is most often smoked rolled in cigarette paper (joint or reefer), in cigars with the marijuana replacing tobacco (blunts), or in small pipes (bowls). Occasionally a large pipe apparatus, often water filled, is used (bong). The smoke has a pungent distinctive sweet and sour odor. Marijuana can also be eaten mixed with food, or drunk as a brewed tea [1]. Potency of the street product has increased over the past 3 decades from an average content of less than 1% of the psychoactive ingredient, delta-9-tetrahydrocannabinol (THC), in 1975 to 6% by the year 2000 [2]. Sinsemilla made from the buds or flowering tops of plants now averages about
7.5% THC with some high-grade material reported to have up to 24% active ingredient. Hashish, the sticky resin from plant flowers, and hash oil distilled from hashish can be even more potent. According to the United States Department of Justice Drug Enforcement Agency, most street marijuana found in this country is either grown in Mexico or trans shipped through Mexico from other Latin American countries. Some marijuana is also domestically grown, often hydroponically (indoors without soil), and an especially potent variety is smuggled in from Canada. Street prices were relatively stable over the past decade despite law enforcement seizures averaging 1200 metric tons per year [3]. A lower potency Mexican product may sell for as little as $25 an ounce in some southwest border areas while the highest potency Canadian sinsemilla could fetch up to $500 an ounce in major metropolitan areas [3].

**Epidemiology**

Beginning in 1975, the Monitoring the Future Study funded by the National Institute of Drug Abuse (NIDA) has tracked substance use patterns in 12th graders [3a]. Since 1991 it has also included 8th- and 10th-grade students and each year it now surveys nearly 50,000 students from almost 400 public and private schools across the country. Individuals who are truant or who have dropped out of school are not, of course, included in the surveys.

Long-term trends in marijuana annual use rates by 12th graders reached a peak of 50.8% in the 1979 survey, gradually dropped to a level of 21.9% for the class of 1992, and then rose again reaching another peak of 38.5% in 1997. Since then, annual rates for this group have leveled with a slight downward trend to 34.3% by 2004. Marijuana use rates and use of any illicit drug tend to parallel each other. The NIDA reports gradual reduction in annual, 30-day, and daily use across

![Fig. 1. Trends in prevalence of marijuana use [4].](image-url)
all three grades surveyed this century with the most significant decreases found in
eighth graders. Lifetime marijuana use rates are still high at 16.3%, 35.1%, and
45.7%, respectively, making marijuana by far the most prevalently used illicit
drug across all three grades surveyed [4].

Internationally, data show marijuana prevalence rates highest in developed
countries with youth from Australia, the United States, and Western Europe being
heavier users than those in Scandinavia and the Mediterranean [5] (Figs. 1,2 and
Table 1).

Pharmacokinetics

THC exerts many effects through the activation of G-Protein Cannaboid recep-
tors located in various parts of the body. Those found in the brain (CB-1 re-
ceptors) are mostly concentrated in areas related to motor control, cognition,
emotional responses, and motivated behavior [6]. Other body tissues have
CB-2 receptors. There is also evidence for non-receptor–dependent mechanisms

| Table 1 |
|---|---|---|---|
| | Eighth-graders | Tenth-graders | Twelfth-graders |
| Lifetime | 19.2 | 17.5 | 16.3 | 38.7 | 36.4 | 35.1 | 47.8 | 46.1 | 45.7 |
| Annual | 14.6 | 12.8 | 11.8 | 30.3 | 28.2 | 27.5 | 36.2 | 34.9 | 34.3 |
| 30-day | 8.3 | 7.5 | 6.4 | 17.8 | 17.0 | 15.9 | 21.5 | 21.2 | 19.9 |
| Daily | 1.2 | 1.0 | 0.8 | 3.9 | 3.6 | 3.2 | 6.0 | 6.0 | 5.6 |

Fig. 2. Marijuana trends in annual use and perception of risk.
of action [7]. The receptors are part of an endogenous cannabinoid system that has important regulatory functions throughout the body in all vertebrates. Outside the brain, the body’s endogenous cannabis-like substances, which are lipid derived, play crucial roles in modulation of the autonomic nervous system, the immune system, and microcirculation [6]. Recently cannabinoid receptor agonists and antagonists were synthesized leading to a better understanding of the system and potentially to a pharmacological approach to treatment of some substance use disorders [6]. The pharmacokinetics of THC varies depending on the route of administration. Inhalation of marijuana results in maximal plasma concentrations within minutes. Psychotropic effects start within seconds, reach a maximum after 15 to 30 minutes, and taper off over 2 to 3 hours. With oral ingestion, onset of effects have a delay of 30 to 90 minutes, peak in 2 to 3 hours, and may last 4 to 12 hours depending on dose [7]. Most users inhale the smoke of burning marijuana to achieve the most intense response. THC effects include euphoria and relaxation, perceptual alterations, time distortion, and intensification of sensory experiences such as eating, watching video, or listening to music [8]. Heart rate increases by 20% to 50% within minutes of inhalation and may remain elevated for 3 hours. Blood pressure is elevated if sitting, but can decrease if standing [8]. Overdosing may precipitate anxiety or panic feelings as well as further increase of heart rate. Naive users are most susceptible to panic sensations that could deter further use. Sudden respiratory arrest with marijuana use alone in humans is not reported, probably because of an absence of CB-1 receptors in the brainstem. High concentrations of receptors are found in the hippocampus. Functional magnetic resonance imaging has demonstrated abnormal hippocampal activity in abstinent cannabis users during mnemonic tasks. Specifically, the right hippocampal area failed to deactivate during tasks. This is the likely mechanism for short-term memory problems in users [9]. There are also concentrations of CB-1 receptors in the cerebellum. Activation of these receptors likely impacts negatively on coordination contributing to observed higher accident rates in users [10]. The euphoria sought and experienced by users appears to result from stimulation of the dopamine pathway to the nucleus accumbens of the forebrain, the brain reward center [10].

Adverse effects of marijuana

Pulmonary effects

Cannabis smoke contains a similar range of harmful chemicals as tobacco. Almost all studies indicate that the pulmonary effects of cannabis smoking appear additive to those of tobacco smoke that many substance users also inhale. Cannabis smoke has 50% to 70% more carcinogenic hydrocarbons than does tobacco [1]. Additionally, marijuana smokers tend to inhale more deeply than tobacco-only smokers because the increased puff volume produces significant
increases in plasma THC levels and the subjective “high” feeling [11]. The histopathological effects of marijuana smoke exposure include changes consistent with acute and chronic bronchitis. Cellular dysplasia has been observed suggesting a potential to cause malignancy [12]. Longitudinal observations over 8 years monitoring the pulmonary function tests of young adult marijuana smokers revealed a dose-dependent relationship between cumulative marijuana inhalation and declining FEV1 VC ratio measurements [13]. Regular marijuana use can lead to extensive airway injury and alteration in the structure and function of alveolar macrophages predisposing to pulmonary infection [14]. Symptoms of cough, wheezing, and early morning sputum production are common even in young individuals who smoke marijuana alone [8,12]. Marijuana-only users are reported to have more school or work absences because of respiratory illnesses than nonsmokers [1,15].

Cognitive effects

Electrophysiological and neuropsychological studies show that long-term cannabis use produces measurable impairment of memory, attention, and the organization and integration of complex information.

It remains unclear whether these effects are reversed after extended periods of abstinence [8,10]. There is growing evidence that early and regular marijuana use may significantly increase the risk of poor school performance and, in particular, leaving school early [16].

Mental health effects

There is increasing data noting the association of marijuana use and schizophrenia. Data show support for an earlier age of onset of the first psychotic episode in males who use marijuana. In a Dutch study, male users of cannabis presented with dysfunctional symptoms of schizophrenia 6.9 years earlier on average than non-users [17]. It is postulated that marijuana use may precipitate schizophrenia in predisposed individuals [8]. There is also a rare, brief psychosis reportedly induced by very high doses of THC in some individuals [18]. Reports of increasing risks for depression, suicidal ideation, and suicidal attempts in cannabis users exist; however, causation is unclear in these often high-risk individuals [19].

Behavioral effects

There is a reported increase of weapon possession and physical fighting by youth who use marijuana [20]. Likewise, there is greater risk for unwanted and unprotected sexual encounters in marijuana users [21]. Early cannabis use may be associated with adoption of an anticonventional lifestyle characterized by affiliations with delinquent and substance-using peers and the adoption of delinquent roles including school drop-out, running away, and early parenthood
In the past, the association of early cannabis use and poor school performance led to the hypothesis of an “amotivational syndrome.” There is little empirical support for this hypothesis [16,22]. A study comparing the differences between heavy and light marijuana users who were in treatment found that depression accounted for the amotivational symptoms in both groups [23].

Driving

There are reports that recreational doses of acute cannabis have similar effects on driving skill and coordination as do blood alcohol concentrations between 0.07 and 0.10% [8]. A recent report on 322 motor vehicle crash victims presenting to a level 1 trauma center over a 6-month period found 59.3% of the victims testing positive for either commonly used drugs or alcohol with more testing positive for drugs. While 33.5% tested positive for drugs alone, 9.9% were positive for both drugs and alcohol. Marijuana was the most frequently encountered drug. In this study, drug driving was more associated with accident injuries than drunk driving [24]. Reviews have noted young males to be overrepresented in drug driver reports and to perceive marijuana to be less impairing than alcohol [25].

Reproductive system effects

In animals, exposure to high doses of THC lowers testosterone secretion, impairs sperm production and motility, and generally disrupts the ovulatory cycle. Human studies are small and inconsistent [8,26].

Pregnancy

Among adolescents with unintended pregnancies, marijuana use is associated with greater odds of choosing abortion than among non-users [27]. Adolescents who continue their pregnancy trend to decrease or discontinue use. Frequency of use and amounts used in most studies were very low compared with adult samples of pregnant women. There is evidence that teenagers perceive substance use as a risk to their unborn child [28]. Within this context, pregnancy appears to play a positive role. There are reports of lower birth weight of babies born to women who continue marijuana smoking during pregnancy but the effect appears less than tobacco smoking [8]. It is unlikely that marijuana use contributes to birth defects; however, there is suggested evidence of associations of in utero cannabis exposure and later problems with attention, memory, and higher cognitive functioning in children [8].

Stroke

Marijuana abusers are at increased risk for stroke. A recent report describes three cases of cerebellar ischemic infarction following heavy cannabis use that
presented to the same tertiary care center over a 5-year span [29]. A study of cerebral blood flow velocity by transcranial doppler sonography in abstinent marijuana abusers ages 18 to 30 found cerebral profusion comparable to that of healthy 60-year-olds [30].

Cardiovascular

Besides the well-accepted dose-dependent heart rate increases, marijuana generally raised blood pressure when seated and contributes to orthostatic symptoms upon standing as a result of decreases in vascular resistance. There are well-documented decreases in exercise tolerance. In individuals with heart disease, cannabis use can precipitate angina or myocardial infarction [31].

Initiation of use

The choice to use marijuana by a teen appears related to a number of familiar social and environmental variables. Risk for use escalates when adolescents are exposed to pro-marijuana influences and by the number of offers they receive to try the substance [32,33]. Curiosity and a desire to fit into a social group are common reasons given for initiation. Family and peer attitudes regarding substance use have strong influences on choice to use [34]. Teens from two-parent families and teens whose parents maintain high levels of family management during adolescent years are less likely to initiate use [35]. Families who eat together with their adolescents five or more times a week and teens who are not left home alone often, are less likely to use marijuana [35]. Conversely parents who disengage from close supervision and foster premature adolescent autonomy after puberty are more likely to encounter deviant friendships, antisocial behavior, and cannabis use among their children [36]. Middle school children who report latch key status two or more times a week are more likely to become involved with marijuana and alcohol during middle school years [35]. Teens who express strong religious beliefs reportedly use less cannabis [37]. There is evidence that work intensity, such as longer hours, fosters disproportionate acceleration of both alcohol and marijuana use by white teens as compared with ethnic minorities [38]. Schools and school districts that have higher endowments and higher discretionary dollars per pupil are linked to both lower initiation rates and lower overall use rates of both tobacco and marijuana by their students. The additional monies can support innovative curricula and foster quality after-school programs that enhance school connectedness [39]. Studies have found that across ages, marijuana initiation was predicted by tobacco smoking (gateway effect), frequency of marijuana offers (environmental effect), and poor grades (school connection effect). Marijuana beliefs were relatively weak predictors of initiation of use after controlling for pro-marijuana social influences [32]. Another recent study found that friends’ use was significantly related to initiation of marijuana
by adolescents of all ages, whereas the perceived harmfulness of the substance did not correlate with use (Box 1) [33].

While family, school, and social environment substantially influence the choice to initiate marijuana use, they appear to play an insignificant role in the individual’s transition to marijuana use patterns of abuse or dependency. Ge-

<table>
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<th>Box 1. Factors affecting risk for initial marijuana use</th>
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<td>Abusive parents</td>
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<td><strong>Protective Factors</strong></td>
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<td>School has quality program</td>
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netic influences seem to be key determinants of risk for serious use problems [40–43].

Abuse, dependency, and withdrawal

Adolescents who use marijuana may meet Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) [44] criteria for a substance abuse disorder if their maladaptive use leads to one or more of the following occurring within a 12-month period:

1. Having absences, suspensions, or expulsions from school or work related to marijuana use.
2. Repeatedly placing themselves in harm’s way, such as driving while under the influence of the substance.
3. Having recurrent legal problems such as arrests for possession of the substance or probation violations for continued use.

Marijuana-using adolescents may also meet DSM-IV criteria for substance dependency if they have clinically significant impairment in any three of seven areas occurring within the same 12-month period. This could be met by the following:

1. Being unable to reduce or control marijuana use despite a desire to do so.
2. Spending a great deal of time to obtain the substance or recover from its effects.
3. Giving up or reducing important social or recreational activities because of marijuana use.
4. Marijuana use is continued despite knowledge that it is causing harm such as lowered school performance, school failure, or respiratory difficulties.
5. Development of tolerance to marijuana such that the effect is less or more is used to obtain the desired effect.

The current edition of the DSM-IV does not contain a specific marijuana withdrawal syndrome [44]. A recently published review article on this issue noted that that there is substantial evidence for a significant portion of heavy (daily or dependent) marijuana users to report withdrawal symptoms. The incidence of experiencing multiple symptoms on cessation of use appears to be more than 50% and among treatment seekers the proportion is likely higher [45]. A study of cannabis dependent adult outpatients found 67% experiencing 4 or more withdrawal symptoms of at least moderate severity [46]. Abstinence symptoms are observable by persons living with an abstaining user and the symptoms appear to be disruptive of daily living [47,48]. It has been suggested that the severity of cannabis withdrawal may be comparable to that of to-
Bacco withdrawal. Criteria for a cannabis withdrawal syndrome were proposed (Box 2) [45].

**Testing policy**

Physicians caring for adolescents should be fully aware of the American Academy of Pediatrics policy regarding testing for drugs of abuse in children and adolescents [49]. The policy strongly supports voluntary testing in adolescents with decision-making capacity. To ignore this could create an adversarial relationship between the physician and the adolescent’s patients and might jeopardize any future therapeutic relationships. Parents may have different viewpoints. One recent report surveying suburban families found 81% of middle class parents in favor of drug screening of their child without their child’s consent [50]. Physicians should also be familiar with the various testing methods available to detect marijuana use and their costs and limitations.

**Drug tests**

*Enzyme Multiplied Immunoassay Technique test*

The Enzyme Multiplied Immunoassay Technique (EMIT) screening test of urine is the least costly, easiest to use, and most widely encountered. It is based
on an antigen/antibody reaction using antibodies against metabolites of THC. Among eight commercially available on-site tests, sensitivities were found to vary between 88% and 98% and specificity was between 95% and 100%. False positives occur especially if the individual has taken certain nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen. False negatives can also result with urine dilution or adulterants [51,52].

**Radio Immunoassay**

Radio immunoassay (RIA) is considered the best of the urine screening test methods, but because of radioactive waste products, it is usually used by government agencies that are equipped to deal with the byproducts [51].

**Gas Chromatography/Mass Spectrometry**

Gas chromatography/mass spectrometry (GC/MS) is clearly the most precise detection method and the one typically used to verify positive screening tests. It is a two-step process where GC separates the sample into its parts while MS provides the exact molecular identification of the compounds present. Urine is the usual substance tested, however sweat, collected on skin patches, can also provide accurate results. The testing equipment is expensive, $50,000 and up, and individual tests average around $200 [51,53].

**Hair tests**

These are commercially available. THC metabolites circulating through the blood stream become permanently imbedded in hair. The hair obtained for testing is dissolved in a series of solvents and then tested by GC/MS for THC metabolites. Since hair grows at an average rate of ¼ inch per month, the test may detect use over a significant period of time [51].

A whole new business has arisen to market and sell to the public kits for home testing for drugs of abuse. The tests are often marketed through the Internet toward parents and employers. They are available at nominal cost for either a single drug such as THC or for detection of multiple drugs of abuse. Most use urine, but saliva-based tests are also available. Saliva testing avoids most adulterants and appears less likely to reflect false positives because of passive exposure to marijuana smoke [54]. Some firms offer GC/MS confirmation of positive screening tests and others do not. Some sites sell only test kits, whereas at least one offers information about behavior that might suggest substance use in adolescents along with advice about what to do next if a home drug test is positive [55]. Likewise, there is an Internet-based business selling adulterants and other techniques, including “clean” urine, to “beat” the tests. There is evidence
that some adulterants, mostly oxidizers, can result in negative urine immunoassay tests while not triggering monitoring parameters that most laboratories use to indicate adulteration [56]. A study by the Armed Forces Institute of Pathology reported a 94% reduction in detectable THC metabolites with some oxidizers added to urine samples using GC/MS test technique [57].

**Treatment**

There is a wise saying, “An ounce of prevention is worth a pound of cure” that certainly would apply to the problem of substance use by adolescents. All health care providers of children and adolescents should learn to incorporate anticipatory guidance about drug avoidance to both parents and older children. Parents must understand the dangerous environment many teens must navigate before reaching mature adulthood. As we learn more about marijuana, it becomes clearer that it is easier to predict risk factors for initial use than predict who may develop serious problems with the substance. Focusing efforts to avoid use, especially in the groups more likely to try the substance, makes sense. Interventions to reduce or prevent substance use that focus on the adolescents’ social environment show the most promise [58]. Strategies can be taught and rehearsed to assist adolescents to avoid using drugs. Many teens could turn down the offer to share a joint with the remark, “My mom drug tests me so I’m not going to do any of that stuff or I’ll be grounded” and not lose face among his peers. Parents and teens can develop simple rescue strategies incorporating code phrases that clue the parent to suddenly manufacture a family crisis and go and pick up a teen. Calling on a cell phone and telling a parent “everything is super” might be a prearranged signal to them that the party is out of control with drug use and the teen needs an excuse to leave. Additionally, parents of teens need assistance in identifying early signs of illicit drug use when interventions are easier (Box 3).

Multiple types of treatment programs are available, however it is estimated that only 10% of adolescents with illicit drug problems are receiving treatment compared with 20% of adults [59]. There are several different program approaches to adolescent substance abuse treatment including programs based on the 12-steps, cognitive-behavioral therapy, motivational enhancement, and multidimensional family therapy.

Treatment effectiveness research for adolescent substance abuse and particularly marijuana abuse is lacking. Results of a national survey of the 144 most highly regarded adolescent substance abuse treatment programs found many shortcomings. The highest scores were in the area of staffing, with approximately 50% of programs scoring highly. The worst area was in outcomes, with fewer than 10% of programs having any rigorous scientific follow-up of client outcome. Other measures of performance in key elements such as assessment, family involvement, gender and cultural competence, retention, and continuing care were somewhere in-between. Accreditation of a program was not shown to distinguish quality in this survey [60].
Parents, physicians, and counselors need to have information about the efficacy of programs in their community to help with the difficult decision of finding the most appropriate treatment options for adolescents in trouble with marijuana and other illicit drugs of abuse.

References


Box 3. Signs of marijuana use

Acutely while “high”

A teen might act dizzy or have difficulty walking
He or she may seem silly or giggly for no reason
He or she will have red bloodshot eyes
May have difficulty remembering things that just happened
Will often become sleepy as the high wears off

More subtle or less-specific signs

Careless grooming
Loss of interest in school, sports or other favorite activities
Changing friends, changing sleep habits
Evasiveness about whereabouts
Deteriorating relationships with parents or friends
Emotional distancing
Increased absenteeism or truancy
Odor on clothes or in their bedroom
Use of eye drops
Discovery of drug paraphernalia