



Understanding the Impact of National and State Medical Marijuana Policies on Adolescents

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Abstract

Purpose of Review This article provides an overview of current federal, state, and relevant international “medical marijuana” policies. We also describe the impacts of “medical marijuana” policy on adolescents’ use of marijuana and other substances.

Recent Findings Evidence on the medical benefits of marijuana in adolescents is limited in the context of risks for marijuana-related harm. The legalization of marijuana for medical purposes is associated with a decrease in marijuana risk perception in older adolescents. Marijuana-related harms have increased in states that have legalized marijuana for medical purposes or adult use.

Summary The long-term impacts on adolescents of marijuana policies for medical purposes or adult use remain poorly understood. Marijuana policy changes that liberalize access may increase rates of youth marijuana use. There is an important need for high quality research and open sharing of best practices regarding marijuana policies.

Keywords Medical marijuana · Cannabis · Substance use · Adolescents · Policy · Legalization

Introduction

Adolescence is a time of rapid physical and psychological growth. It is a period when youth acquire more responsibilities and are granted more freedom and personal decision-making. As youth develop the capacity for abstract thinking they no longer see rules as black and white but rather begin to understand limits and boundaries with nuance. When it comes to tobacco, alcohol, and other substances, adolescents and young adults are particularly susceptible to changes in rules and

regulations. For instance, the National Minimum Drinking Age Act (1984), which effectively raised the legal drinking age to 21 years in the USA, is one of many examples where shifting policy impacted substance use-related health consequences. In this case, decreased alcohol consumption by underage drivers led to a 16% reduction in motor vehicle accidents [1].

Cannabis has been available in the USA for decades, but only entered the realm of legal substances when it was first legalized for “medical” use in the state of California in 1996. (We use quotation marks with the term “medical marijuana” as it is a term that has been coined by the cannabis industry and has not been recognized by the medical system.) In the 2 decades that followed, policies that govern both “medical” and non-medical use have evolved rapidly and with them, the nature of the substance itself and its perception in the public eye [2]. In fact, the potency of smoked marijuana has increased three- to five-fold since the 1970s, while perceived riskiness associated with the regular use of marijuana is reaching new lows among adolescents [3, 4]. At the same time, marijuana-infused “edibles” have become much more common, and newer products, like highly concentrated oils and resins have become much more readily available [5].

The long-term health risks and potential benefits of “medical marijuana” remain to this day, poorly understood, and there is a pressing need for longitudinal research to identify

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the effects of marijuana use over the life course in different populations, especially adolescents [6, 7]. While marijuana remains a schedule 1 drug by federal law, the shift towards legalization of marijuana for “medical use” at the state level is now well on its way, with 29 states and Washington DC having passed legislation allowing for the possession, use and sale of marijuana for medical purposes as of December 2017.

This review briefly summarizes the prevalence of adolescent marijuana use, and the effects of marijuana on the adolescent brain. Next, current federal, state, and relevant international “medical marijuana” policies are discussed. The article concludes with a review of what is known about the impacts of “medical marijuana” policy on adolescents’ use of marijuana and other substances, and summarizes key recommendations from leading professional organizations on this topic.

Marijuana Use Prevalence Among Adolescents: “Recreational” and “Medical” Use

According to a nationally representative study of high school students, in 2016, 44.5% of 12th graders reported use of marijuana at least once in their lifetime, and 22.5% had reported use in the past month [8]. It is estimated that only a very small proportion of adolescents and young adults ages 18–20 years are registered as “medical marijuana” users and that most youth use marijuana for its psychoactive effect or for health reasons without supervision from a physician [9]. For instance, in the state of Colorado, the state that holds the most comprehensive data monitoring system on “medical” and “recreational” marijuana, 0.3% of registered “medical marijuana” users (representing approximately 300 individuals) are children under the age of 18, and another 3% of all “medical marijuana” users are between the ages of 18 and 20 [10]. The most commonly reported indication for use in children under the age of 10 is seizures, while the most common indication in all other age groups is severe pain.

Adolescents’ Mechanism of Access/Accessibility to Marijuana

Given that only a small minority of adolescents who are using marijuana have legal access to it via a “medical marijuana” card, most adolescent marijuana users obtain it through other sources. The majority of adolescents access marijuana from three main sources: purchased or traded (about 40%), given for free by a friend or family member (59%), or self-grown (less than 1%) [11]. The two most common locations to conduct marijuana transactions are outdoor public areas and inside private homes [11]. Friends represent the main sources of

both free and purchased marijuana [11]. In a cross-sectional study of high-risk youth involved with the justice system, adolescents who purchase marijuana (vs obtain it for free) are at increased risk for more frequent marijuana use and related consequences, suggesting that interventions aiming to prevent illicit sales and purchasing of “medical” and non-medical marijuana could be beneficial [12].

Another possible mechanism of access is diversion of “medical marijuana.” Diversion of legally produced “medical marijuana” to states where it is prohibited and from individuals possessing “medical marijuana” cards to those who do not is common [13]. This practice has a detrimental impact on adolescents in treatment for substance use disorders: youth who have access to marijuana from a card holder tend to use more than their peers who do not have access to diverted “medical marijuana” [13, 14]. In addition, proximity to a “medical marijuana” dispensary might present a new source of access for this age group either through underage purchase or through friends or relatives [15]. Although the magnitude of this phenomenon has not been established, another potentially important access point for adolescents to purchase marijuana is through online vendors where marijuana regulation is particularly difficult to enforce. For instance, the lack of age verification on several retailer websites has been described [16].

Marijuana Use and the Adolescent Brain

The term *marijuana* refers to the psychoactive substance prepared from the dried leaves, stems, and flowers of the cannabis plant [17]. Several other cannabinoid-containing products, also known as marijuana-infused products (MIPs) exist, including “edibles,” topical products and high-potency cannabis concentrates (such as oils and resins). The cannabis plant contains more than 100 cannabinoid molecules that can bind to the body’s cannabinoid receptors and mimic the effect of the body’s naturally occurring ligands (molecules that have a special affinity for the receptors). Depending on how they are prepared, marijuana and MIPs yield different concentrations of delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD), the two exogenous cannabinoids in marijuana that are thought to have the most biological activity in humans. THC is known to carry the main psychoactive effects of marijuana, while CBD has been found to have neuroprotective and anti-inflammatory properties without the psychoactive effects [18]. In non-users, cannabinoid receptors are predominantly controlled by the body’s best described endogenous ligand, anandamide. Upon exposure to marijuana, cannabinoid receptors become saturated by an overflow of exogenous THC, which has a much stronger affinity to the receptors than anandamide. This in turn is responsible for the psychoactive effects described by marijuana users: a calming, yet euphoric

sensation, decreased coordination, and altered perceptions which for some may be pleasant, but can also include hallucinations and paranoia [19]. Cannabinoid receptors play a role in regulating the secretion of other neurotransmitters such as serotonin, dopamine, and endorphins. They are particularly abundant in the prefrontal and basal areas of the brain, notably in the nucleus accumbens, also known as the reward center of the brain which explains the addictive potential of marijuana [20], and in areas involved in learning, memory formation and executive functioning [21].

Recent advances in neuroimaging have shown that the adolescent brain, and specifically, the prefrontal cortex, continues to develop until the mid to late 20s [22]. Early exposure to marijuana during the adolescent years may have lasting consequences on the developing brain in a dose-dependent fashion, with no safe dose identified [23]. Cannabinoids are depressants and stop cells from releasing chemical messengers into the synapse. The presence of exogenous cannabinoids can interfere with normal brain development [24]. By suppressing cell signaling, exogenous cannabinoids may play a role in the process of pruning that is critical for brain development. Notably, several areas of the brain are smaller in individuals with a history of marijuana use during adolescence compared to peers [25].

Potential Harms and Benefits of Marijuana, THC and CBD

Marijuana use has been associated with multiple harms including structural deviations in brain development, substance use disorders, psychiatric problems, and social sequelae. Although this remains a controversial topic, longitudinal studies have shown an association between cannabis dependence (as defined in DSM-IV-TR [26]) and a significant loss of IQ points in adult years [27, 28]. Studies have shown that the younger the initiation of marijuana use, the higher the risk of developing a substance use disorder [29]. Youth who use marijuana are much more likely to use tobacco, alcohol and illicit drugs than their peers [30]. In addition, marijuana use in adolescence has been associated with an increased risk of developing mental health disorders such as depression, anxiety, and psychosis [31]. Research has also shown that regular cannabis users experience significantly higher rates of acute psychotic reactions and sub-clinical psychotic symptoms such as paranoia and hallucinations and that these often persist, even after marijuana use stops [32]. For youth attending school, marijuana use is linked to lower school performance and consequent impact on lifetime achievement [33]. Although more research is needed in this area, marijuana use has also been associated with many acute and chronic cardiovascular, respiratory, endocrine, and gastrointestinal problems [34].

There is evidence of potential therapeutic benefits of cannabinoids, including in the form of marijuana as medication in children and adolescents. To date, only three cannabinoid preparations are FDA approved: Dronabinol, available in two formulations—Marinol, an oral capsule and Syndros, an oral liquid solution; and Nabilone, only available in pill form and sold under the name Cesamet. All three of these medications have a structure that highly resembles the molecular structure of THC, but are produced synthetically and not extracted from the cannabis plant [35]. A small number of trials have looked at the effectiveness of dronabinol and nabilone in children and adolescents, but they are currently not approved for pediatric use by the FDA [36, 37]. Some argue that patients who could potentially benefit from cannabinoids should be given access to marijuana. Unfortunately, there are several issues surrounding using crude marijuana as a medication, especially in children where dosage, consistency, and formulation are critically important [38].

The strongest evidence in favor of the medical use of marijuana in pediatric populations is for the treatment of medication-induced nausea, vomiting and weight loss, especially in the context of chemotherapy [7]. Emerging evidence has also shown that the oral administration of CBD extracts can reduce the frequency of seizures in youth with refractory epilepsy [39]. Other experimental uses of marijuana include the treatment of sleep problems and chronic pain, but evidence for these indications is often conflicting [40].

“Medical” and “Adult Use” Marijuana Policies: Federal, State, and International Policies

In the USA, marijuana is a schedule 1 drug which implies that it has (1) a potential for abuse, (2) no currently accepted medical use in treatment, and (3) a lack of accepted safety for use under medical supervision [41]. According to the federal law, marijuana cannot be prescribed for medical use. Other schedule 1 drugs include heroin, LSD, and ecstasy. In 2009, the Ogden memorandum [42], adopted under the Obama administration under the Controlled Substances Act stipulated a federal non-interference policy with states concerning marijuana enforcement. This memo enabled the legalization of “medical” and “adult use” marijuana policies in several states. The Ogden memo was modified in 2011 and subsequently replaced by the Cole memorandum in August 2013 [43, 44] which requires states to implement a strict regulatory framework for the production, distribution and sale of regulated marijuana products to effectively prevent diversion and to ensure that the marijuana market is transparent and accountable. More specifically, the Cole memo listed a series of priorities which included preventing (1) the distribution of marijuana to minors, (2) marijuana from

becoming accessible in states where it is illegal, and (3) driving under the influence of marijuana and other negative public health effects associated with marijuana use.

At the end of 2017, “medical marijuana” was legal in 29 states, Puerto Rico, and the District of Columbia, which combined account for more than 60% of the US population. In each of these states, an active and comprehensive “medical marijuana” program is in place though details vary considerably among locales. Of the remaining states, all except Idaho, South Dakota, and Kansas, where cannabis remains prohibited, have allowed the use of low THC, high CBD products for medical reasons in certain limited situations or as a legal defense. More details about the latest updates of state-specific legislation can be found on the website of the [National Conference of State Legislatures](#) [45]. Of note, adult use of marijuana (often termed “recreational”) has been legalized for individuals over the age of 21 in eight states and the District of Columbia, which combined account for 20% of the US population [46, 47].

Internationally, the legal status for the possession, production, distribution, and consumption of marijuana varies on a spectrum ranging from illegal to legal [46]. In fact, marijuana legalization has a very different meaning in different jurisdictions. This is illustrated in Fig. 1, which presents a continuum of scenarios ranging from extreme prohibition to unrestricted commercialization.

Israel and Canada were among the first countries to legalize “medical marijuana” in the 1990s and early 2000s and currently have well-established production and distribution industries. More recently, countries in Europe (Spain, Germany, Croatia, Macedonia, the Netherlands, Poland, Italy, Turkey, and Greece), the Americas (Mexico, Columbia, Peru, and Uruguay), and the Eastern and Southern hemispheres (Australia, North Korea, and South Africa) have also legalized marijuana for medical or adult use. Portugal is currently the only country where the possession and consumption of all recreational drugs, including marijuana, has been decriminalized (since 2001).

A thorough review of international “medical marijuana” laws is beyond the scope of this article. Nonetheless, it is worth noting that rules and regulations vary widely between countries that have legalized marijuana for medical use. In countries where marijuana remains illegal or prohibited, level of enforcement is highly variable. In countries where marijuana is legal, there are usually no age restrictions for the medical use of marijuana. In Israel, the country that has produced the greatest number of clinical trials testing the medical benefits of “medical marijuana,” distribution is tightly regulated by a government-run agency. This has not prevented an important increase in rates of non-medical marijuana use, which has been associated with a worrisome increase in rates of illicit drug use, notably ecstasy and LSD [48].

Marijuana Policies and Perceived Risk of Marijuana-Related Harm among Adolescents

Research examining the impacts of changing marijuana laws on the health and well-being of adolescents is emerging. Specifically, marijuana legalization has been associated with decreased perception of risk by older adolescents [4]. Perceived riskiness of marijuana, which has been inversely associated with marijuana use, is at its lowest in more than 3 decades, with only 32% of high school seniors who consider that daily use of marijuana poses a risk for health [8]. Rates of tobacco, alcohol, and illicit drug use have also been trending down significantly in adolescents during that same period [49]. Meanwhile, national rates of adolescent marijuana use have remained relatively stable in recent years, but there has been a significant increase in rates of regular marijuana use in adolescents deemed at low or high risk, based on history of alcohol and nicotine use [50, 51]. This apparent discrepancy can be explained by examining marijuana use rates within risk groups. The number of “high risk” teens—i.e., those who use alcohol and/or tobacco and are thus much more likely to try marijuana—has fallen substantially over the past 20 years. The two factors (decreased perceived risk of marijuana and fewer “high risk” teens) push use rates in opposite directions; as a result, the overall rate of marijuana use has remained stable even as rates of alcohol and tobacco use have fallen [51]. The impact of “medical marijuana” laws appears to differ by age groups; perceived risk of harm has overall risen among eighth grade students in states where “medical marijuana” laws were adopted together with a decrease in rates of marijuana use [52].

Marijuana Laws and Use of Marijuana and Other Substances

There is controversy regarding the impact of “medical marijuana” laws on rates of adolescent marijuana use [53, 54, 55]. A study of more than 11 million students contributing 20 years of data did not find significant increases in rates of marijuana use in states that had legalized “medical marijuana” [54]. A second, similar study reached the same conclusion, but also highlighted that baseline adolescent marijuana use is significantly higher in states with “medical marijuana” laws [56]. In a third study looking at the effects of “medical marijuana” laws by age and gender, it was found that legalization was not associated with an increase in rates of past month or past year marijuana use in adolescents and young adults, male or female. However, legalization of marijuana for medical purposes was associated with a significant increase in rates of daily marijuana use in adults aged 26 and above [57]. Nonetheless, questions remain. Specific components of laws, number of years since establishment and regional effects may

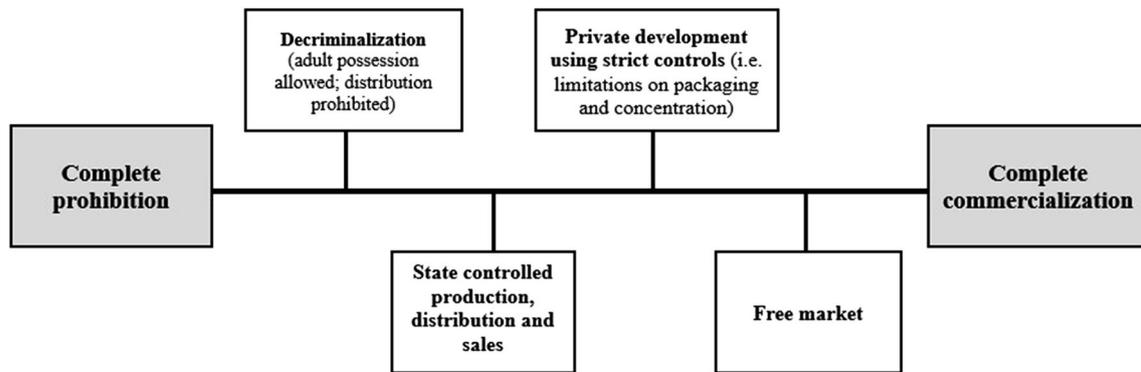


Fig. 1 Continuum of marijuana legalization and commercialization. Adapted from [46]

need to be considered in evaluating the impact of these laws on adolescent marijuana use [58].

“Medical marijuana” laws vary considerably with some states allowing for vast distribution systems supplying a large number of patients, and others permitting only a small number of patients and highly regulated distribution. Combining data from these disparate programs may obscure effects and underestimate the impact of marijuana distribution mechanisms on rates of use [59,60]. In addition, the impact of a new law can take many years to come to fruition as newly passed laws are translated into regulations, distribution systems are approved and built, etc. Many laws regulating the medical use of marijuana are relatively new: many studies have been done shortly after laws were enacted and may not identify all of the ultimate impacts.

Higher possession limits and voluntary (vs mandatory) registration for “medical marijuana” users are associated with higher rates of past 30-day and heavy marijuana use in a recent study [61]. Proximity to a dispensary has also been correlated with initiation of marijuana use, especially among younger adolescents [15•]. A strong association has been found between marijuana legalization and increases in cigarette smoking [62], though the impact of marijuana laws on the use of alcohol and illicit drugs appears to be more complex, sensitive to the age group studied, and mediated by a number of other factors including how long policies have been in place [63, 64•]. Nevertheless, adolescents who use marijuana are more likely to use illicit drugs and develop substance use disorders later in life and this effect is amplified in youth who also use alcohol and tobacco [65].

“Medical Marijuana” Legalization and Marijuana-Related Harms

The combination of decreases in perceived risk of harm, increases in marijuana availability and new marijuana products and documented increases in rates of marijuana use among youth raise significant concerns for an increase in marijuana-related harms. In its latest report, the Rocky Mountain High

Intensity Drug Trafficking Areas (HIDTA) Program described a 48% increase in marijuana-related traffic deaths in the 3 years following recreational marijuana legalization in 2012 [66•]. Young drivers were disproportionately involved in motor vehicle crashes, both as drivers and passengers [67]. While THC can be detected in urine and other body fluids long after the period of acute intoxication has passed, there is currently no consensus definition of “driving while impaired” for marijuana. Unlike blood alcohol levels where there is a clear correlation between breath or blood levels and level of impairment, the correlation is much less evident for marijuana and there is currently no reliable non-invasive test (i.e., breath test) to measure marijuana levels [68]. Given marijuana’s impact on coordination and driving skills, the lack of clear limits represents an important risk to public safety [69].

In Colorado, the number of marijuana-related emergency department visits and hospitalizations increased by 49 and 32%, respectively, among adolescents ages 12–17 in the 2-year period following legalization of marijuana for adult use [66•]. Additionally, there was a three-fold increase in emergency room visits for marijuana-related concerns among youth ages 12–17 in the year following the legalization of “medical marijuana” [66•]. Similar findings are described in a detailed report from the Northwestern branch of the HIDTA, covering the state of Washington, where one in four grade 12 students reported riding with a driver (age not specified) who had appeared to be under the influence of marijuana and one in six reported driving a vehicle within 3 hours of using marijuana [70]. Calls to the Poison Center regarding marijuana-infused products and marijuana oil increased by 36 and 105%, respectively, between the years 2014 and 2016 following legalization of marijuana for adult use.

Effects of “Medical Marijuana” Policy on Marijuana Products

Marijuana products can vary widely in potency, depending on local laws and regulations [71]. In principle, the legalization of

marijuana could result in increased control over the composition, quality and potency of marijuana products. However, a recent study found that legal dispensaries are associated with a significant 1% increase in the THC-content of smoked marijuana [72]. This finding raises concern given that potency is associated with several health risks for youth, including increased risk for drugged driving and psychotic disorders, especially in regular users [73].

A report developed in collaboration with the Maryland School of Public Health found that marijuana legalization allowed the emergence of a “florid”, legal marijuana-industry, that offers a multitude of marijuana and marijuana-infused products to marijuana users [74]. While marijuana legalization does reduce illicit sales, it does not prevent them completely, especially when it comes to high-potency products that might not be allowed by the legal market [75]. Adolescents with their propensity for risk taking might be prone to experiment with dangerous products that continue to be available through an illicit market [76].

Studying the Effects of Marijuana and Cannabinoids in Youth

The paucity of high quality research examining the therapeutic benefits versus harms of marijuana in adolescents poses difficult ethical dilemmas: 1) How to weigh those risks and benefits with so little information and 2) how to make recommendations about a product with known risks [77]? The lack of regulatory structure governing the study of marijuana for therapeutic purposes has been described and results in a lack of guidance for Institutional Review Boards [78]. Conducting randomized controlled trials involving the administration of marijuana requires a clear understanding of the composition of the products administered. Providing children with a crude or uncontrolled form of marijuana would prove to be unethical in many circumstances, given risks of harm to the adolescent brain [24]. A notable exception is the use and study of marijuana, either in plant form or high concentration oral preparations, for youth with refractory epilepsy. A recent review of the literature found only four studies on this topic and suggests that additional research is needed before recommendations can be made for this population [79]. Nonetheless, a study of 74 patients ages 1–18 found that the administration of a CBD-enriched cannabis oil showed promise for reducing seizure frequency in this population [80].

To better understand the impact of marijuana use on brain development, the National Institutes of Health have funded the most ambitious long-term observational study of brain development in the USA (the Adolescent Brain Cognitive Development, or ABCD study) [81]. This study is currently in the process of recruiting 10,000 children ages 9–10 and will follow them over a period of 10 years with serial brain imaging (MRI), neuropsychological and cognitive testing, and self-reports of marijuana and other substance use among other

assessments. This will be the most comprehensive study of the impact of marijuana use on the developing brain; the first results from this work are expected in several years.

Professional Organization Statements and Policy Recommendations

The American Academy of Pediatrics (AAP) [38], the American Academy of Child and Adolescent Psychiatry [82], and the American Society of Addiction Medicine [83] have all clearly stated opposition to the legalization of “medical” marijuana outside of the FDA approval process. In its policy statement on “medical marijuana,” the AAP emphasizes that the evidence for the effectiveness of marijuana, especially in youth, remains thin and that increasing the accessibility of marijuana represents an important risk for youth whose brains are still developing. While the American Medical Association (AMA) and the American College of Physicians (ACP) have not formally published their positions on the issue of “medical marijuana,” they warn about potential risks associated with legalization.

To promote high quality research on the medical benefits and harms of marijuana, both the AMA and the ACP support the revision of schedule 1 to schedule 2 status for marijuana, a position also supported by the AAP. The AAP also recommends strict governmental surveillance regarding the impacts of marijuana on youth and recognizes the importance for adults to model healthy behaviors by avoiding using marijuana in the presence of children and adolescents [38].

Conclusions

Marijuana policies in the USA and around the world are rapidly changing and the impacts of these changes are not fully understood. Specific components of laws, number of years since enactment and regional effects (e.g., variations in size and regulation of distribution systems) need to be considered in evaluating the impact of these laws on adolescent marijuana use. Marijuana policy changes that liberalize access may increase in rates of youth marijuana use. Studies from both Colorado and Washington have begun documenting these impacts.

THC, administered in the form of marijuana, can reduce chronic medication-related nausea and vomiting in adolescents and CBD may be useful for treating intractable epilepsy in children though optimal formulation has yet to be assessed. The effectiveness of cannabinoids remains unsupported by evidence for other adolescent health conditions.

There is an important need for high quality research and open sharing of best practices regarding marijuana policy. Recommendations from national professional societies are clear: changes in marijuana policy should be made with

caution as these changes can have important impacts on children and adolescents. Most importantly, the interests of the rapidly growing cannabis industry should not come to the expense of decades of progress in the prevention and treatment of adolescent substance use.

Compliance with Ethical Standards

Conflict of Interest Nicholas Chadi has served voluntarily on the Massachusetts Cannabis Control Advisory Board. Elissa R. Weitzman declares that she has no conflict of interest. Sharon Levy has served voluntarily on the Massachusetts Cannabis Control Advisory Board.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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