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COMMENTARY

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Cannabis and work: Need for more research

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Abstract

Cannabis sativa is one of the oldest and most widely used plants in the world with a variety of industrial, medical, and nonmedical applications. Despite its long history, cannabis-derived products remain a source of controversy across the fields of medicine, law, and occupational safety and health. More favorable public attitudes about cannabis in the US have resulted in greater access to cannabis through legalization by states, leading to more consumption by workers. As more states adopt cannabis access laws, and as more workers choose to consume cannabis products, the implications for existing workplace policies, programs, and practices become more salient. Past workplace practices were grounded in a time when cannabis consumption was always viewed as problematic, considered a moral failing, and was universally illegal. Shifting cultural views and the changing legal status of cannabis indicate a need for research into the implications and challenges relating to cannabis and work. This commentary suggests research needs in the following areas: (a) data about industries and occupations where cannabis consumption among workers is most prevalent; (b) adverse health consequences of cannabis consumption among workers; (c) workplace supported recovery programs; (d) hazards to workers in the emerging cannabis industry; (e) relationship between cannabis consumption and occupational injuries; (f) ways to assess performance deficits and impairment from cannabis consumption; (g) consumption of synthetic cannabinoids to evade detection by drug testing; (h) cannabis consumption and its effect on occupational driving; and (i) ways to craft workplace policies and practices that take into consideration conflicting state and federal laws pertaining to cannabis.

1 | INTRODUCTION

Cannabis sativa is one of the oldest and most widely used plants in the world.[1] Native to Asia, the different cultivars of *C. sativa* have been used for a wide variety of industrial, medical, and nonmedical uses for thousands of years.[2] Despite its long history, the use of cannabis-derived products remains a source of controversy across the fields of medicine, law, and occupational safety and health.[3-6]

More favorable public attitudes about cannabis in the United States have resulted in greater access to cannabis through legalization by states and led to more consumption. In 2018, 40.3 million Americans aged 18 or older used cannabis at some time during that year.[7] Increases in use were greater in states that adopted medical cannabis access laws than nonadopting states.[8] Nearly 18% of workers employed full-time, and nearly 21% of workers employed part-time, used cannabis in 2018.[9] From 2017 to 2018, the proportion of full-time

workers reporting lifetime, past-year, and past-month cannabis consumption all increased by 1.4%, 7.3%, and 7.2%, respectively.[9] Although large-scale surveys about worker consumption are a first step, detailed occupational surveillance data are needed. Surveillance studies about the specific industries and occupations where worker cannabis consumption is most prevalent, the frequency and timing of consumption relative to work shifts, and the relationship of consumption to productivity and workplace safety, would provide a more detailed profile of worker cannabis consumption.

Studies indicate that cannabis has a role in treating chemotherapy-induced nausea and vomiting, and spasticity associated with multiple sclerosis.[10,11] As a treatment for noncancer pain, however, cannabis is unlikely to be effective.[12] Any potential benefits of cannabis in treating chronic neuropathic pain may be outweighed by its potential harms.[13] Cannabis-derived products, and synthetic products that mimic cannabis effects, can be associated with serious health effects,[14,15] including negative effects on cognition, memory, perception of time, and coordination.[16,17] These findings have raised questions about the risk of cannabis consumption and workplace safety,[5] including motor vehicle crashes.[18]

As medicalization and legalization of cannabis proceed apace with increased cannabis consumption among working adults, so does the need for employers, workers, occupational safety and health practitioners, and researchers to address the impacts that cannabis consumption is having on existing workplace safety and health policies, programs, and practices. The new realities of cannabis consumption have created a need for research attention on the implications and challenges surrounding cannabis and work. The areas of research attention include: (a) data about the industries and occupations where cannabis consumption among workers is most prevalent; (b) adverse health consequences of cannabis consumption among workers; (c) workplace supported recovery programs; (d) hazards to workers in the rapidly emerging cannabis industry; (e) relationship between cannabis consumption and occupational injuries; (f) ways to assess impairment from cannabis consumption; (g) role of workplace supported recovery programs; (h) consumption of synthetic cannabinoids to evade detection by drug testing; (i) cannabis consumption and its effect on occupational driving; and (g) ways to craft workplace policies that take into consideration conflicting state and federal laws pertaining to cannabis.

2 | USES

2.1 | Industrial

Cannabis was being used in China to make products like yarn, rope, and canvas some 6000 years ago.[19] In colonial America, cannabis was cultivated as a source of fiber on plantations like the one belonging to George Washington.[20] From the 1930s until recently, all cannabis was illegal under federal law to grow or sell. The Agricultural Improvement Act of 2018[21] legalized the cultivation, processing, marketing, and sale of cannabis that has a concentration of the psychotropic compound, delta-9-tetrahydrocannabinol (THC), of not more than 0.3% on a dry weight basis (classified legally as "industrial hemp").[22]

2.2 | Medical

Cannabis was recognized as early as 1400 to 2000 BCE in Sanskrit and Hindi literature as a medicinal.[23] In the United States, cannabis was widely used in the 19th and early 20th centuries as a patent medicine for an array of ailments.[24] From 1850 to 1942, cannabis was listed as an acceptable medicine in the *United States Pharmacopeia*,[25] but a series of federal laws beginning in the 1930s penalized the sale and use of medical cannabis, ending its legitimate medical use.[24]

C. sativa contains more than 565 chemicals, 120 of which are termed "cannabinoids."[26] Only two cannabinoids, THC and cannabidiol (CBD), have been studied extensively for medical use.[27,28] THC produces psychoactive effects by binding to the receptors of the endocannabinoid system.[29,30] One receptor is expressed in the brain and the other in the peripheral immune system.[31] CBD, a nonintoxicating cannabinoid, has potential therapeutic properties and a favorable safety profile,[32] but there is limited clinical data to support its touted medical benefits.[33,34]

Pharmaceutical-grade cannabis products have recently entered medical practice. The US Food and Drug Administration has approved one cannabis-derived drug product and three synthetic cannabis-related drug products.[35] Dronabinol, a synthetic THC, is used to treat nausea and vomiting associated with cancer chemotherapy and for anorexia associated with wasting in acquired immunodeficiency syndrome patients.[36] Nabilone, another synthetic THC analog, is used for chemotherapy-related nausea and vomiting not responsive to conventional agents.[37] In 2018, *Epidiolex*, a purified oral solution of CBD, was approved for use in two rare childhood epilepsy syndromes.[38]

2.3 | Nonmedical

Cannabis is also consumed for enjoyment, without medical justification, and involving a variety of products, administration routes, potency levels, and health effects. Most cannabis products are prepared from the flowering tops of the unfertilized female plant and contain 7% to 14% THC.[26] Analysis of the THC from cannabis samples seized by the US Drug Enforcement Administration showed that the potency of seized cannabis has increased over time from 4% in 1995 to 12% in 2014.[39] Furthermore, in a 2019 survey of nearly 700 medical dispensaries in eight states, medical cannabis was found to have a similar THC concentration (19.2% ± 6.2%) to that found in cannabis sold for nonmedical purposes (21.5% ± 6.0%).[40]

Relative to typical flower products, concentrated THC products such as oil, shatter, dab, and edibles have higher THC levels—from 60%[41] to 80%.[42] Some dispensaries list concentrates with THC potencies of 90% or more.[43] The risks of exposure to highly potent THC concentrates are unclear. Although higher potency THC concentrates have been shown to have stronger effects on memory impairment and

paranoia, especially in younger consumers,[44] other studies of ad libitum consumption have found that concentrate users do not show greater short-term subjective, cognitive, or balance impairment than consumers of lower potency THC flower products.[45] These latter findings may be due to consumers knowing their tolerance level and learning to self-titrate for the context in which cannabis is consumed, for example, work and social settings versus a laboratory impairment assessment setting (written communication with M. R. Frone PhD, July 2020).

3 | ADVERSE HEALTH EFFECTS

3.1 | Acute effects

Acute health effects of cannabis consumption include dizziness, dry mouth, nausea, vomiting, drowsiness, somnolence, euphoria, disorientation, confusion, loss of balance, and hallucinations.[11] Postlegalization, emergency department visits to Colorado hospitals for acute cannabis intoxication increased 40% between 2012 and 2014.[46] The type of acute effects from cannabis consumption differed by the route of administration. Edible cannabis resulted more frequently in acute psychiatric syndromes, whereas inhaled cannabis resulted more frequently in cannabinoid hyperemesis syndrome (CHS).[47] CHS is characterized by cyclic attacks of nausea and vomiting from excessive cannabis consumption,[48] and may be caused by disruption of normal functioning of the endocannabinoid system.[49] In rare cases, CHS can lead to death.[50]

3.2 | Chronic effects

Frequent and heavy cannabis consumption can lead to dependence,[51] and withdrawal symptoms such as anxiety, irritability, insomnia, tremors, and decreased appetite.[52-54] When a consumer experiences withdrawal symptoms, fails to meet work, school, or home responsibilities, develops tolerance to a greater amount of cannabis, and exhibits other qualifying symptoms,[55] a cannabis use disorder (CUD) is present.[56-59] In 2018, 2.1% of adolescents aged 12 to 17 (512 000), 5.9% of young adults aged 18 to 25 (2.0 million), and 0.9% of adults aged 26 or older (1.9 million), suffered from a CUD.[7] While CUD incidence is known for the general population, the incidence of CUD by industry and occupation needs to be a research focus.

4 | WORKPLACE SUPPORTED RECOVERY

Workplace programs that provide access to support, counseling, and treatment can be an important means to achieve recovery from all substance use disorders, including CUD, while maintaining employment —a key goal for workers in recovery.[60] A component of the 2020 US National Drug Control Strategy, "encouraging workplace support for current employees in treatment and recovery," may reduce the stigma associated with substance use disorders and lower barriers to seeking and receiving care.[61] In 2020, the National Institute for Occupational Safety and Health (NIOSH) launched a research initiative to explore the role of workplace programs in preventing work-related exposures that may contribute to substance use disorders and providing access to support and treatment for workers in recovery.[62] Elements of a *Workplace Supported Recovery* program may include: (a) offering counseling and treatment opportunities; (b) peer support and coaching; (c) "second chance" policies, where employees who drug test positive are referred for treatment instead of being terminated; (d) and concurrent- or posttreatment assistance in returning to full employment.[62]

5 | CANNABIS INDUSTRY HAZARDS

In 2020, the cannabis industry is estimated to employ over 200 000 full-time workers across the country.[63] Cannabis industry workers engage in cultivation, harvesting, processing, distribution, and retail sales. These workers can be exposed to chemical hazards (flammable liquids and pesticides); biological hazards (fungi, bacterial endotoxins, and plant-based allergens); and physical hazards (repetitive motions, ultraviolet light, noise, and compressed gases).[64] In cannabis industry workplaces, NIOSH evaluations have found *Botrytis cinerea*, a cannabis fungal pathogen associated with hypersensitivity pneumonitis, and widespread contamination of work surfaces by various cannabinoids, highlighting the need to consider biological contamination in cannabis industry exposure assessments.[65] Further exposure assessment research is needed.

Exposures to cannabis industry hazards can also affect law enforcement, fire fighters, emergency medical technicians, and hazardous materials response personnel responding to an incident at a cannabis industry workplace. NIOSH has found that responders can be exposed to secondhand smoke containing THC at a concert event,[66] and inside a drug vault.[67] Response incidents can also involve exposures to violence, fire and electrical hazards, and oxygen deficient atmospheres.[68]

6 | CANNABIS AND WORKPLACE SAFETY

Cannabis access laws and greater cannabis consumption among workers have led to increased concerns about workplace safety.[5,69,70] The fact that cannabis can impair neurocognitive and psychomotor functions supports these concerns.[71,72] A broad systematic literature review found only 16 studies, published in 2018 and prior years, that performed a statistical comparison of work-related injuries in cannabis-consuming workers compared with noncannabis-consuming workers. Seven studies supported a positive association, one study found that the presence of cannabis metabolites reduced the risk of occupational injury, and eight studies showed no evidence of any link between occupational injury and cannabis consumption.[73]

Only three studies could demonstrate that cannabis consumption occurred *before* the injury; no study could ensure that the workers were impaired from cannabis *at the time* of the injury; and there was a failure to adjust adequately for confounding in most of the studies.[73] The authors recommend that future research should consider the temporal relation

between use and injury; confounding variables that contribute to both cannabis consumption and occupational injury (eg, gender, personality, safety climate, training, and fatigue); and the factors potentially influencing work impairment from cannabis consumption, such as "the intensity, duration, timing, route of administration, and potency."[73] Additional research is needed to explore workplace safety and cannabis consumption by working adults.

7 | ASSESSING WORK IMPAIRMENT

Cannabis consumption can impair worker productivity (eg, attendance behaviors, job injuries, and job performance) by adversely affecting neurocognitive functioning, for example, difficulty in concentration, alterations in thought formation and expression; psychomotor functioning, for example, reduced perceptual and motor coordination skills; and physiological functioning, for example, drowsiness and sedation.[15] Determining when and to what degree the on-the-job performance of a worker who consumed cannabis meets an employer's (or a legal) threshold for being impaired is challenging. Detecting use is far easier. The method that has been used most often to detect use is a drug test—chemical analysis of urine, blood, or saliva to detect the presence of THC or its metabolites.[74,75]

7.1 | Drug testing

The Drug Free Workplace Act of 1988[76] began the current era of workplace drug testing in both the public[77] and private sectors.[74] In the case of cannabis, a positive drug test—usually a urine sample—raises the possibility of impairment. However, urine THC metabolite tests are not designed to determine impairment.[78] Cannabis is stored in body fat and is released into the bloodstream over days or weeks from the time of actual consumption, complicating the interpretation of THC levels measured in urine or blood.[79] The duration and severity of impairment from THC-containing cannabis vary with the dose, route of administration, and a consumer's experience with the drug.[80]

Analysis of cannabis drug tests does not permit sound inferences about the frequency of cannabis consumption, specific time of last use, or cannabis-related impairment.[74,75,81] As a result, a worker may be unjustifiably penalized,[82] which can lead to unintended consequences, such as underreporting of work injuries.[74] Furthermore, evidence of the effectiveness of drug testing as a deterrent to drug use or as a strategy to reduce injury rates is weak.[83] Coupled with labor shortages and an aversion to drug testing by job candidates, there has been declining use of workplace drug testing.[74,84]

7.2 | Impairment testing

There is interest in alternatives to drug testing to assess the level of a worker's cognitive function and motor skills that would indicate impairment. An ideal test of work-related impairment needs to be relevant to the specific job skills, produce reliable results, be simple to administer, be sensitive to meaningful changes in performance for a specific job skill, and adjust for learning from repeated uses.[85] The traditional field sobriety test has been used as a model for various real-time, on-the-job evaluations of impairment from multiple causes such as lack of sleep, fatigue, chronic medical conditions, effects from physician-prescribed medications, and self-prescribed drugs, including cannabis consumption.[86] Employers using impairment testing have found that it reduced workplace safety incidents, was accepted by employees, and that it was superior to drug testing in achieving these objectives.[87] Newer digital technologies to assess impairment are beginning to be used in various workplace settings.[88] Although impairment testing holds promise to determine if a worker poses a safety risk in the workplace, more intervention studies are needed to validate the effectiveness of tests used in the workplace.[89]

8 | SYNTHETIC CANNABINOIDS

Cannabis consumption detection can be avoided by using synthetic cannabinoids (SCs), or "fake marijuana," since SCs do not cross-react with many commercially available drug tests.[90-93] SCs are made in clandestine labs, sold under names like *Spice* and *K2*, and labeled "not for human consumption" to avoid being classified as a controlled substance under federal laws.[94,95] SCs are used as powders sprayed on inert plant material and then smoked or vaped.

SCs exhibit more powerful "cannabimimetic" effects than THC because, unlike THC, which is only a partial agonist at endocannabinoid receptors,[96] SCs are full agonists due to their higher receptor binding affinity.[97] As a result, SCs produce greater cognitive and psychomotor impairment, enhanced sensory perception changes, intense visual hallucinations, severe paranoid feelings, and behavioral disturbances.[98-100] Widespread use of SCs has led to more calls to the US poison control centers[101] and visits to emergency departments.[102,103] Production of new SCs by clandestine laboratories outpaces the ability of the federal government to regulate their use.[104]

SCs can not only pose a danger for those who use SCs, but they can pose a hazard for law enforcement during raids of clandestine laboratories. During a *Spice* laboratory raid, NIOSH documented that officers reported symptoms when handling the SCs. Urine analysis before and after the raid detected two SCs in six of nine officers—chemicals that were not present before the raid.[105] As with cannabis consumption by workers, the prevalence of synthetic cannabinoids consumption among working adults by industry and occupation is unknown and our knowledge of its prevalence by industry and occupational would benefit from additional surveillance research.

9 | DRIVING UNDER THE INFLUENCE OF CANNABIS

In 2018, nearly 5% of the US population 16 years or older reported driving under the influence of cannabis.[106] The prevalence of

cannabis consumption by workers who drive automobiles or trucks as a part of their job is uncertain. However, considerable research about cannabis consumption, driver performance, and vehicular crashes has been published finding that driving under the influence of cannabis does increase the risk of traffic collisions.[58,69,71,107-110] However, the magnitude of risk is low in comparison to alcohol, and the risk reported varies by the geographic location of the study, the type of collision involved (eg, property damage, injury, or fatality), and the biological cutoff level for determining driver impairment.[111]

Several studies have sought to correlate THC blood concentrations with driver impairment.[112-114] These studies have been used to make recommendations about using THC plasma levels along with other medical signs to assess impairment.[69] A few states have adopted laws that specify an upper limit for THC (or its metabolites) in blood—ranging from 1 to 5 ng/mL—above which the driver is presumed to be legally impaired ("per se" laws).[115,116]

Determining a THC threshold like the "per se" blood alcohol threshold of 0.8% will be challenging. Alcohol has ideal physicochemical, pharmacokinetic, and pharmacodynamic properties for drug testing purposes.[79] Cannabis does not share those properties.[75] The National Highway Traffic Safety Administration has noted that the pharmacokinetics of cannabis are "very different from the case with alcohol" and that "the poor correlation of THC levels in the blood or oral fluid with impairment precludes using THC blood or oral fluid levels as an indicator of driver impairment."[117]

Novel testing technologies using THC in expired air would be easier to administer by law enforcement in the field than urine or blood testing.[115] Although promising, expired air technology faces challenges and its utility may grow with additional research efforts. The window for detecting cannabis is less than 2 hours following acute exposure.[118] In addition, the effect of passive smoking exposure on breath measurement in a nonconsuming bystander is unknown.[119]

10 | LEGAL LANDSCAPE

10.1 | Federal prohibitions

A series of federal prohibitions against cannabis began with the Marihuana Tax Act of 1937.[120] In 1970, the Controlled Substances Act (CSA) consolidated all federal laws that regulated controlled substances, including cannabis.[121] The CSA made it unlawful to manufacture, distribute, dispense, or possess a controlled substance (21 U.S.C.§841(a)) and imposed substantial fines and imprisonment for violations (21 U.S.C. §841(b)(1)(B)).[121]

Controlled substances are arranged into five schedules in the CSA. Marijuana (cannabis) is on Schedule I with other substances that have a high potential for abuse, no currently accepted medical use in treatment in the United States, and exhibit a lack of accepted safety for use under medical supervision (21 U.S.C. § 812(b)).[121] Petitions to reschedule cannabis from Schedule I to Schedule II have been lodged periodically based on emerging evidence of its medical utility for various conditions. In 2016, the most recent petition to reschedule cannabis was denied.[122]

10.2 | State access laws

Changing public attitudes about cannabis have led 33 states, and the District of Columbia, to approve access laws that make cannabis available to consumers with qualifying medical conditions.[123] To qualify for medical cannabis, a consumer must have a diagnosed condition on their state's list of qualifying medical conditions. Although the types of qualifying conditions vary by state, each state includes a lengthy number of conditions, including, but not limited to, cancer, acquired immunodeficiency syndrome, epilepsy, glaucoma, posttraumatic stress disorder, chronic pain, arthritis, and many others.[124] Eleven states and the District of Columbia have the most expansive access laws, allowing consumer access to cannabis for medical and nonmedical uses.[123] Several states have decriminalized the possession and use of small amounts of cannabis, reducing the penalty from a state crime to a local infraction without possibility of jail penalty.[125] States have also passed laws that expunge or vacate prior criminal records for cannabis convictions under specified conditions, which can positively impact employment opportunities for individuals convicted under a state's prior cannabis prohibitions.[125] The legalization of cannabis consumption on the state level, while federal prohibitions still exist, has created uncertainty regarding workplace drug testing programs and employment litigation over the role of state-sanctioned cannabis consumption by workers.

Although no state requires an employer to accommodate cannabis consumption *at the workplace*, 12 states and the District of Columbia have adopted express employment provisions prohibiting an employer from taking action against an employee in hiring, termination, or imposing any other penalty if that employee has qualified for medical cannabis under that state's program.[123] Exceptions are provided if a worker is found to pose a safety risk at work or holds a position subject to federal drug testing regulations.[77] On 5 June 2019, Nevada became the first state to legally prohibit, with certain exceptions, an employer from denying employment to a prospective employee because the prospective employee submitted to a drug screening test that indicated the presence of cannabis (effective 1 January 2020).[126] As of 10 May 2020, covered employers in New York City are not permitted to test job candidates for THC as a condition of employment.[127]

Employers who have taken action against an employee for medical cannabis consumption outside the workplace may find themselves in court for violating (a) an express state employment provision requiring employers to accommodate an employee's medical cannabis use; or (b) a duty implied by the state's medical cannabis access laws and/or the state's general antidiscrimination laws.[128] In defense, employers have argued that federal law prohibits cannabis consumption and pre-empts state law.[128,129] Most state court decisions support employers, but a few recent cases support the employee.[128] Employers should review their drug-free workplace policies and drug testing practices against their state's employment protections for medical cannabis consumers. Policy research efforts could focus on developing a model workplace cannabis program that would most effectively reconcile conflicting state and federal cannabis laws.

10.3 | National legalization

Proponents of national legalization claim that cannabis is less harmful than many legally prescribed medications; prohibition distracts law enforcement from investigating more serious crimes; prosecution of, and imprisonment for, cannabis offenses is costly to state and federal governments; and prohibition exacerbates racism because a disproportionate number of racial minorities are arrested for cannabis offenses.[130,131] Opponents of national legalization argue that national legalization could increase adolescent use; result in more vehicular crashes; lead to a higher incidence of CUD; lead to active promotion of cannabis consumption similar to alcohol products; and jeopardize international treaty commitments.[129,132,133] As the national legalization debate continues, some have decried the current federal-state conflict of laws as a "rather bizarre system in which state officials hand out licenses to commit federal felonies."[133]

11 | CONCLUSION

As more states adopt cannabis access laws, the implications for existing workplace policies, programs, and practices become more salient. Past workplace practices were grounded in a time when cannabis consumption was always viewed as problematic, considered a moral failing, and universally illegal. Now, as cannabis is legally available to workers in many states, research attention needs to be focused on the implications and challenges surrounding cannabis and work.

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The authors conceived and drafted the work; revised it critically for important intellectual content; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ETHICS APPROVAL AND INFORMED CONSENT

No ethics review nor informed consent was required as no human subjects research was involved.

DISCLAIMER

The findings and conclusions in this report of the authors do not necessarily represent the views of the National Institute for Occupational Safety and Health, the Centers for Disease Control and Prevention, or the US Department of Health and Human Services.

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