With the mass shootings at schools, is there a common denominator in the subjects doing the acts? It may be the legalization and use of marijuana.

Study by Michael K. Ostrowsky; **Does marijuana use lead to aggression and violent behavior?**

Abstract

Marijuana use and violent behavior are causing widespread public concern. This article reviews theory and research on the relation between marijuana use and aggressive/violent behavior. It is evident from the inconsistent findings in the literature that the exact nature of the relation remains unclear. This article identifies several possible reasons for these contradictory findings and provides suggestions for future research. In particular, more research is needed on the different subtypes of aggressive behavior. Further research is also needed to elucidate the associations between gender, marijuana use, and violent behavior. Likewise, an important task for future research is to continue to tease apart the complex relations between gang involvement, marijuana use, and violent behavior. Longitudinal studies also warrant further investigation. Moreover, future research should control for several potentially confounding variables.

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A Review of Cases of Marijuana and Violence

Authors: Norman S. Miller, Redon Ipeku, and Thersilla Oberbarnscheidet

Abstract

Marijuana is the most consumed illicit drug in the world, with over 192 million users. Due to the current legalization push of marijuana in the United States, there has been a lack of oversight regarding its public health policies, as marijuana advocates downplay the drug's negative effects. This paper's approach is from a public health perspective, focusing specifically on the cases of violence amongst some marijuana users. Here, we present 14 cases of violence with chronic marijuana users that highlight reoccurring consequences of: marijuana induced paranoia (exaggerated, unfounded distrust) and marijuana induced psychosis (radical personality change, loss of contact with reality). When individuals suffering from pre-existing medical conditions use marijuana in an attempt to alleviate their symptoms, ultimately this worsens their conditions over time. Although marijuana effects depend on the individual's endocannabinoid receptors (which control behavioral functions, like aggression) and the potency level of tetrahydrocannabinol (THC) in the drug, scientifically documented links between certain marijuana users and violence do exist. Wider public awareness of the risks and side effects of marijuana, as well as a more prudent health policy, and government agency monitoring of the drug's composition, creation, and distribution, are needed and recommended.

Keywords: marijuana, cannabis, tetrahydrocannabinol, THC, violence, law, paranoia, delusions, psychosis, public policies

Go to:

1. Introduction

In the United States, ten states have legalized the recreational use of marijuana and over 20 states have decriminalized the recreational use of it. Recent reports suggest, however, that the increase of the recreational use of marijuana is causing detrimental effects to individuals, as well as the society as a whole [1,2,3]. These effects include, but are not limited to, the increase of violence, the increase of thriving underground marijuana markets, and increase in car accident claims after the legalization of marijuana where the recreational use of marijuana was legalized [1,2,3]. This is caused by lack of oversight. Marijuana is being legally sold with high THC concentration levels without taking into account its addictive qualities and adverse effects. On the other hand, and contrary to popular belief, marijuana is still illegal in the Netherlands and it is decriminalized. However, the consumption and storage of marijuana are limited by law and the approach taken by the Netherlands is to decriminalize the drug in order to be able to help individuals struggling with marijuana use. This prudent oversight has resulted in a decreased in violence and people are able to get the care they need to deal with addiction and become less prone to violence [1,2,3].

Furthermore, the consumption of marijuana is associated with an increase in violent behavior over the course of an individual's lifespan, a high risk of psychosis for frequent users, an increase of cardiovascular diseases, and deterioration in health for individuals who have pre-existing mental health issues such as Post Traumatic Stress Disorder, social anxiety, and depression [4,5,6].

According to research studies, marijuana use causes aggressive behavior, causes or exacerbates psychosis, and produces paranoia. These effects have been illustrated through case studies of highly publicized incidents and heightened political profiles.

These cases contain examples of repeated illustrations of aggression, psychosis and paranoia by marijuana users and intoxication. Ultimately, without the use and intoxication of marijuana, the poor judgment and misperceptions displayed by these individuals would not have been present, reducing the risk for actions that result in senseless deaths.

Import to these assertions, is that the current marijuana is far more potent in THC concentrations, the psychoactive component. Accordingly, and demonstrated in direct studies, more potent marijuana results in a greater risk for paranoid thinking and psychosis. In turn, paranoid behavior increases the risk for paranoid behaviors and predictably associated with aggressive and violent behaviors.

1. Marijuana use causes violent behavior through increased aggressiveness, paranoia, and personality changes (more suspicious, aggressive, and anger).
2. Recent illicit and "medical marijuana" (especially grown by care givers for medical marijuana) is of much high potency and more likely to cause violent behavior.
3. Marijuana use and its adverse effects should be considered in cases of acts of violence as its role is properly assigned to its high association.
4. Recognize that high potency marijuana is a predictable and preventable cause of tragic violent consequences.

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2. Case Presentation

2.1. Marijuana Violence

On March 13, 2019, Anthony Comello admitted to, and subsequently was charged for, the killing of Frank Cali, a senior leader of the Gambino family in Staten Island, New York. Both men were allegedly having an altercation over Comello's romantic interest on one of Cali's relatives. Although Comello had no previous criminal encounters with law

enforcement, reports suggest that he drew the attention of authorities by acting strangely in a federal courthouse when he offered to perform a citizen's arrest on New York City's Mayor, Bill De Blasio. Previously, Comello sought a U.S. Marshal to inquire how to perform a citizen's arrest on the United States Speaker of the House, Nancy Pelosi. Comello admitted that, at the time of Cali's killing, he was high on marijuana and shot Cali because he feared that the senior leader had a gun and would shoot him during their altercation [4,7].

On February 10, 2019, a man killed his 13-year-old nephew with a knife in Rustavi, Georgia. The man had a history of marijuana use. For days leading up to the killing, he was complaining about having dizziness, headaches, general weakness, nausea, and insomnia. He would also occasionally suffer from anxiety, irritability, and loss of appetite. His wife stated that he consumed and was under the influence of marijuana, which made his symptoms worse. The day before the killing, he tried to go to a clinic. However, the clinic rejected treatment by telling him to go to a psychiatric hospital. However, under the influence of drugs, he simply went home hours before killing his nephew [8].

On February 1, 2018, Nikolas Cruz killed 17 students and staff at the Marjory Stoneman Douglas High School in Parkland, Florida, and injured 17 others. Cruz was diagnosed as developmentally delayed at age three and had numerous disciplinary issues dating to middle school. From a young age, he started consuming marijuana heavily. He accounts that he would frequently "hear demon voices" and would consume large amount of marijuana to try and silence those voices. He also attempted suicide. During an interview after his mass shooting, he stated that he used "a lot of marijuana" as well as prescription tranquilizer Xanax [9,10].

On November 5, 2017, Devin Patrick Kelley carried out the deadliest mass shooting in Texas' history, resulting in the death of 27 people and injuries to 20 others, by opening fire at worshippers who were attending regular Sunday Service at the First Baptist Church in Sutherland Springs. Kelley was later shot by bystanders and killed during a high-speed chase with law enforcement agencies. The autopsy on Kelley revealed that

toxicology tests detected marijuana and anti-anxiety drugs in his system. A report from the Federal Bureau of Investigation revealed multiple past incidents where Kelley also been under the influence of marijuana. Kelley's first on-record interaction with law enforcement authorities was when he was arrested for possession of marijuana and, subsequently, expelled from his high school. Since then, the record shows that Kelley started using marijuana frequently, as well as developing mental health issues that would lead him to have problems in his employment with the United States Air Force and multiple instances where he abused his step-son and his wife at the time [11,12].

On May 22, 2017, a suicide bomber, Salaman Abedi, detonated an explosive device in an area of the Manchester Arena, United Kingdom. The blast killed over 20 people and injured over 100 others. Evidence shows that, from a very young age, Abedi was a "party animal" who heavily consumed marijuana. Furthermore, he was described as a person who would start fights in the street for no reason, would act rude, and would refuse to do his homework in school. He was also described as a "very slow, uneducated and passive person" who displayed aggressive tendencies. Eventually, he began shutting himself off from other people, started becoming more violent, and started showing paranoia by making statements against western societies and hanging out with dangerous crowds. Evidence suggests that this paranoia, furthered with aggressive tendencies, led to Abedi's suicide bombing attack that day [1,13].

On May 18, 2017, Richard Rojas purposely drove a car along three blocks of pavement in New York's Times Square, killing a teenager and injuring 22 other people. Evidence indicates that Rojas was a heavy marijuana user. He admitted on the consumption of spiced-up marijuana right before committing the attack. Further, the record show that Rojas suffered from paranoia and hallucination, which have led him to make odd statements and partake in actions that negatively affected him in the work place or while interacting with others. Paranoia and hallucination caused him to "hear voices" that led him to commit that attack [2,14].

On November 23, 2016, Arcan Cetin carried out a mass shooting that killed five people and injured many others at the Cascade Mall in Washington. Evidence indicates that Cetin was a heavy marijuana consumer. Further, he had a past of violent behavior, with some incidents including the consumption of marijuana. Although doctors prescribed him medicine for Attention Deficit Hyperactivity Disorder and other mental health issues such as Post Traumatic Stress Disorder, anxiety, and depression, he stopped taking the medicine and substituted it with by excessively consuming marijuana. This led to aggravate his mood swings and being more violent. Before the shooting, he had threatened an ex-girlfriend who lived out of state. Evidence indicates that at, while committing the attack, Cetin was shouting a woman's name [15,16,17].

On July 26, 2016, Satoshi Uematsu stabbed to death at least 19 people and injured at least 26 others at a care facility in Sagamihara, Japan. Months prior the shooting, Uematsu suddenly started talking and acting strangely to his coworkers, who feared he could harm someone. Consequently, Uematsu tested positive for marijuana and was diagnosed with marijuana-induced psychosis and paranoid disorder after he delivered an ominous euthanasia letter to a Japanese House of Representative and telling his co-workers and the police that he intended to kill disabled people. Although he planned the attack in detail, evidence suggests that he later seemed to showed remorse and stated that "There was something wrong with [him]". These kinds of behaviors suggest that he was suffering from psychosis and paranoia since he was in the delusion that his acts would contribute to the Japanese society and the world [18,19].

On November 27, 2015, Robert Dear killed three people and injured nine others when he carried out a mass shooting in a Planned Parenthood clinic in Colorado Springs. Dear, along with many other users, moved to Colorado after the state legalized the recreational use of marijuana. Dear was a heavy user who was described by family and friends as "an angry and occasionally violent", and "deeply disturbed", individual who suffered from paranoia and mood swings. Moreover, he was described as

a lonely religious extremist who had a history of domestic violence against his ex-wives, who gambled, and who committed adultery on multiple occasions. About a year before the shooting, he moved to Colorado where he lived in dire conditions at a squalid trailer without running water or electricity [20,21,22].

On July 16, 2015, Muhammad Youssef Abdulazeez killed five people and injured a couple of others in his drive-by shooting at a military recruiting center in Chattanooga, Tennessee. Prone to depression and manic episodes, he started smoking marijuana heavily in high school. This addiction was going on for many years and led his mental state to deteriorate further and cause him to fail a drug test at work. Further, he started writing suicidal notes to himself and was pulled over by a police officer for driving under the influence of marijuana and alcohol. Up until the shooting, evidence indicates that Abdulazeez had a hard time keeping a job because of his manic depressive/bipolar disorder and drug use [23,24].

On June 17, 2015, 21-year-old Dylan Roof murdered nine people who were attending a prayer service in a Church in Charleston, South Carolina. He claimed that his intentions were to start a race war. His acts were preceded by years of drug abuse. Reports reveal that Roof's drug abuse started when he was 12 years old when he would smoke marijuana three times a day. When he was 16 years old, he tried to stop smoking marijuana after telling people that his daily marijuana usage caused him to be paranoid and hear voices. According to experts, Roof started suffering panic attacks when he was 16. Nonetheless, multiple accounts claim that he kept smoking marijuana and started abusing other drugs and alcohol. During his arrest for the Charleston shooting, Roof told police officers that he abused drugs before committing such heinous act [5,25,26].

On August 9, 2014, Michael Brown was fatally shot after a physical altercation with a police officer in Ferguson, Missouri. The autopsy and toxicology report revealed that Michael Brown had THC concentration of marijuana in his blood and urine. He had five nanograms of THC on his

system, which causes approximately the same level of impairment as a 0.08 percent of blood alcohol level. That much THC notably impairs someone's judgment and perception of the surrounding environment, which may lead to anxiety and paranoia. Evidence indicates that Brown tried to reach for the officer's gun during the altercations, which led to the officer shooting at him in close range. Thus, evidence suggests that Brown's behavior was most likely caused by paranoia [27,28].

On April 15, 2013, Dzhokhar Tsarnaev and his brother Tamerlan, killed three people and injured over 250 by detonating homemade pressure cooker bombs near the finish line at the Boston marathon. Both brothers were heavy marijuana users since they were young teenagers. Tamerlan was killed in a police shootout following the bombings and Dzhokhar was eventually apprehended by law enforcement officers. Several acquaintances and friends knew about both brother's marijuana consumption and sales. One of Dzhokhar friend testified that he sold marijuana to Tsarnaev days before the Boston Marathon Bombings. Unrelated to the bombings, one of Tamerlan's friends implicated Tsarnaev in the killing of three men whose bodies were found sprinkled with marijuana. Multiple accounts noticed an increase of violent behavior from Dzhokhar for some time leading up to the bombings [29,30,31,32].

On January 8, 2011, Jared Loughner shot and killed six people, while also injuring 14 others at the then-US Representative Gabrielle Giffords's constituent meeting held in Tucson, Arizona. Although friends and acquaintances described him as an "awkward but friendly" young man, they started noticing his behavior drastically change in college. In high school, Loughner smoked marijuana on most days. Moreover, he also started immersing himself in conspiracy theories displayed paranoia. He dropped out of high school during his final year, but was able to attend a community college. Some college peers described him becoming mentally unstable by saying and doing things that were frightening. Other peers feared that he would do something like what he actually did. He was suspended from college and never returned. Subsequently, he tried to join the army but he was rejected because he failed a drug test.

Consequently, he engaged in paranoid behavior that led to him to engage in anti-government speech and target then-Representative Giffords during her constituent meeting [33,34].

These are among the many nationally reported violent cases that have, among others factors, a common root to what led these young people to commit acts of violence at the detriment to society as a whole: the extensive use or abuse of marijuana. In recent years, many States within the United States, as well as some other countries around the world, have decriminalized or legalized the recreational use of marijuana [8,12,13,19].

2.2. Paranoia: Marijuana Induced

In the cases above mentioned, one of the recurring conditions that most likely led perpetrators to commit violence was paranoia. Paranoia is defined by the medical dictionary as "an unfounded or exaggerated distrust of others, sometimes reaching delusional proportions". Paranoid perceptions can co-occur with various other mental conditions as well, such as depression and dementia, and can be divided in three different psychological disorders: paranoid schizophrenia, delusional disorder (persecutory type), and paranoid personality disorder (PPD). All three conditions are similar in the sense that they all contain an "unreasonable fear" or "unreasonable belief" as the root of each condition. Hallucinations are also a common symptom on individuals who suffer from paranoia. Nonetheless, paranoia is also a likely side effect deriving from the consumption of marijuana, as well as other drugs and alcohol [3,18,31,35].

In the cases above mentioned, one of the recurring conditions that most likely led perpetrators to commit violence was paranoia. Paranoia is defined by the medical dictionary as "an unfounded or exaggerated distrust of others, sometimes reaching delusional proportions". Evidence suggests that paranoia was among the factors that contributed in the actions of Anthony Comello, Salem Abedi, Richard Rojas, Satoshi Uematsu, Robert Dear, Dylan Roof, Michael Brown, and Jared Lougher.

Each one had, in respective degrees, unreasonable beliefs. Comello admittedly shot Cali because he feared Cali had a gun and was about to shoot him. Abedi displayed paranoid beliefs while making statements against Western societies. Rojas' paranoia was displayed in his statements and action witnessed by his coworkers; also, he claims he heard voices that led him to commit the attack. Uematsu was diagnosed with Paranoid disorder and psychosis, which led him to have delusion beliefs that his despicable acts would make contributions to society. Dear was described as a lonely religious extremist but also had a history of domestic violence, gambling, and adultery. Roof wanted to start a race war. Brown was likely paranoid about his surroundings based on the report. Lougher was suffering from paranoia and was immersing himself with conspiracy theories. Many of these tragedies are committed by individuals who were paranoid and were consuming marijuana. It is very likely that marijuana played an active role in these people's paranoia, considering that the chemical composition of the drug has compounds that alter a person's perception of reality as mentioned below (Table 1, [17,36,37,38]).

Table 1

Personality change toward aggression or violence.

Paranoid Personality Disorder
A pervasive distrust and suspiciousness of others such that their motives are interpreted as malevolent, beginning by early adulthood and present in a variety of contexts, as indicated by four (or more) of the following: 1. Suspects, without sufficient bases, that others are exploiting, harming, or deceiving him or her. 2. Is preoccupied with unjustified doubts about the loyalty or trustworthiness of friends or associates. 3. Is reluctant to confide in others because of unwarranted fear that the information will be used maliciously against him or her. 4. Reads hidden demeaning or threatening meanings into benign remarks or events. 5. Persistently bears grudges (i.e., is unforgiving of insults, injuries, or slights). 6. Perceives attacks on his or her character or reputation that are not apparent to others and is quick to react angrily or to counterattack. 7. Has recurrent suspicions, without justification, regarding fidelity of spouse or sexual partner.

2.3. Psychosis: Marijuana Induced

Another condition that is commonly present in cases like the above are psychotic conditions. Psychotic conditions affect an individual's mind in a way that causes that individual to experience loss of contact with reality. During a psychotic episode, the perception of reality is altered to the point where an individual is unable to distinguish reality from hallucinations. Psychotic individual can also experience delusions (false beliefs), incoherent speech, inappropriate behavior, depression, anxiety, sleep problems, social withdrawal, lack of motivation, and difficulty functioning overall [16,17,37].

In the above-mentioned cases, Uematsu was diagnosed with marijuana-induced psychosis. His coworkers' testimony that he would talk and act inappropriately, his paranoia, and his delusion that killing patient at a care facility would benefit the society as a whole, demonstrates that he was suffering from psychotic conditions that made him lose contact with reality and led him to commit such acts. Similar symptoms were also present in cases where perpetrators acted with delusional beliefs, such as: Abedi, who suddenly started making inappropriate statements against Western societies; Dear, who was a lonely religious extremist but also had a history of domestic violence, gambling, and adultery, which strongly indicates that he was delusional, incoherent, and lost contact with reality; Rojas, Cruz, and Roof who suffered from hallucinations while having consumed large amount of marijuana throughout their lives.

Often, individuals who suffer from pre-existing medical conditions use marijuana in an attempt to alleviate their conditions. The man in Rustavi, Cruz, Kelley, Cetin, Abdulazeez, and Cruz also consumed marijuana because they were under the illusion that it would help them cope with their conditions, whether those conditions were likely induced by marijuana or not. However, it ended up worsening their conditions as time went by. What individuals are unaware of when it comes to self-medicating, is that the marijuana they consume does not have compounds that alleviate their pain or conditions; the marijuana they

consume has many compounds that negatively alter their perceptions, which leads to worse conditions (Table 2, Table 3, [2,9,10,12,39,40,41]).

Table 2

Psychosis.

Substance-Induced Psychotic Disorder
A. Presence of one or both of the following symptoms: Delusions. Hallucinations. B. There is evidence from the history, physical examination, or laboratory findings of both (1) and (2): The symptoms in Criterion A developed during or soon after substance intoxication or withdrawal or after exposure to a medication. The involved substance is capable of producing the symptoms in Criterion A. C. The disturbance is not better explained by a psychotic disorder that is not substance-induced. Such evidence of an independent psychotic disorder could include the following: The symptoms preceded the onset of the substance use; the symptoms persist for a substantial period of time (e.g., about 1 month) after the cessation of acute withdrawal or sever intoxication; or there is other evidence of an independent non-substance-induced psychotic disorder (e.g., a history of recurrent non-substance-related episodes). D. The disturbance does not occur exclusively during the course of a delirium. E. The disturbance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.

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Table 3

Paranoia.

Subtypes Delusional Disorder
Grandiose type: This subtype applies when the central theme of the delusion is the conviction of having some great (but unrecognized) talent or insight or having made some important discovery. **Persecutory type**: This subtype applies when the central theme of the delusion involves the individual's belief that he or she is being conspired against, cheated, spied on, followed, poisoned or drugged, maliciously maligned, harassed, or obstructed in the pursuit of long-term goals.

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3. Discussion

3.1. Marijuana: General Facts

Marijuana is the most consumed illicit drug in the world, with cannabis use and dependence continuing to increase over the past two decades as the trend of legalization persists. According to the United Nations Office on Drug and Crime, over 192 million of users (ages 15–64) worldwide regularly consume marijuana, with a lifetime use of 20% of the World's population and a significant number of individuals regularly consuming the drug [42]. In a 2017 study by the Global Burden of Disease, it estimated the age-standardized rate of cannabis use disorder, or CUD, was 289.7 per 100,000 population (95% Uncertainty Interval (UI) 248.9–339.1), affecting 22.1 million people (95% UI 19.0–25.9 million) [42]. The United States and Canada were in fact found to have among the highest age-standardized rates of CUDs in the world [42].

Cannabis is a complex plant that is made up of 400 chemical entities of which more than 60 are cannabinoid compounds, with delta-t-tetrahydrocannabinol and cannabidiol being the major compounds. Some of those cannabinoid compounds tend to have opposing effects as they affect a very important neurotransmitter system called endocannabinoid system [2]. Moreover, some cannabinoids bind to central cannabinoid receptors to control many behavioral functions, such as aggression. Furthermore, the delta-9-tetrahydrocannabinol (THC) is the chemical responsible for the intoxicating effects on individuals who consume marijuana. The THC level determines the potency of marijuana and high levels of THC likely lead to higher negative health consequences [43,44,45].

Researchers refer to marijuana having a "high potency" when it has a THC level of more than 10%. In the past years, the THC of confiscated marijuana samples rose from 3% in 1980 to 12% in 2012. Moreover, adolescents between 15 and 17 years old have reported significantly

higher ED visits from 2005 to 2010, which is likely caused by the increase of marijuana potency during that time period [7]. Although THC levels that exceed 10% most likely cause serious negative health consequences, it is not uncommon to find marijuana, which THC content exceeds 20% and occasionally 230%, to be sold in places where marijuana is legalized, such as the state of Colorado [7,8]. Furthermore, while daily users refer to high potency marijuana as "the good stuff", it is reported that daily users are five times more likely to find themselves in the hospital for psychosis symptoms such as delusions and hallucinations caused after consuming marijuana. As this paper will mention in the following pages, however, delusions and hallucinations are not the only negative effects stemming from the consumption of marijuana. Cardiovascular diseases, depression, anxiety, and violence are also among the common negative effects of marijuana [13,14,27,34,46].

3.2. Mental and Behavioral Changes

We apply the results of the research regarding the role of marijuana in violence. We use concepts such as personality changes, perpetrator violence, and psychosis to establish our association of marijuana with the unfortunate cases. The purpose is to illustrate negative but preventable tragic outcomes due to marijuana and its role in violence. The overall objective is to identify the role of marijuana and to suggest it is avoidable and causal nature in inducing violence [47,48,49].

In all the cases selected, marijuana use was present. For some of the individuals, marijuana use was confirmed by a physical test. In other cases, marijuana was present on their person, identifying drug use. Moreover, some individuals of the case were identified as marijuana users by outside sources.

Present in all the cases, as a result of marijuana use, was the change in personality, aggressive behavior, paranoia, and/or psychosis. All these symptoms have been documented by scientific research to be the result of marijuana use and intoxication. Another symptom, victimization, has a positive correlation with cannabis use, and the cases illustrate marijuana

users and victimization. In other words, marijuana users become victims of aggression in response to their perpetration under the influence of marijuana (Table 4, [50,51]).

Table 4

What did the cases have in common?

Cases of Marijuana Use and Symptoms	
Case	**Symptom**
Anthony Comello	Paranoia
Man in Rustavi	Aggressiveness, Personality Change
Nikolas Cruz	Psychosis, Hallucinations
Devin Patrick Kelley	Aggressiveness, Personality Change
Salaman Abedi	Aggressiveness, Personality Change, Paranoia
Richard Rojas	Paranoia, Hallucinations
Arcan Cetin	Aggressiveness, Personality Change
Stoshi Uematsu	Psychosis, Paranoia
Robert Dear	Aggressiveness, Paranoia
M.Y. Abdulazeez	Aggressiveness, Paranoia
Dylan Roof	Paranoia, Hallucinations
Michael Brown	Aggressiveness, Personality Change, Paranoia
Dzhokar Tsarnaev	Aggressiveness, Personality Change
Tamerlan Tsarnaev	Aggressiveness, Personality Change
Jared Loughner	Paranoia, Psychosis

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The DSM V provides diagnostic categories for paranoid personality, paranoia and psychosis associated with marijuana use [52].

3.3. Marijuana and Violence

As mentioned above, some compounds found in marijuana have an effect on central endocannabinoid receptors that control many behavioral functions, including aggression. Although there are some instances where marijuana consumption causes mild euphoria and relaxation on

users, adverse acute psychopharmacological effects are very likely to occur. A study that collected data from half a century points out that even a single dose of cannabis may cause “impairments in behavioral control that may underlie impulsive, violent behavior” by altering “the normal functioning of its underlying natural substrate, the ventrolateral prefrontal cortex in man”. Furthermore, the results collected in that study provide a strong indication that chronic marijuana use suggests a possible causal effect with predicting future violence. More studies have reported that panic attacks, confusion, hallucinations, suspiciousness, and paranoia often occur in chronic marijuana users, affecting their cognition in ways that enhance aggressive responses to perceived provocations. Further, recent studies have proven causal connections between marijuana and psychosis [38,39,53].

Studies Show Violence and Aggression Associated with Marijuana Use

Marijuana intoxication results in panic reactions and paranoid feelings whose symptoms lead to violence [49]. The sense of fear, loss of control, and panic is associated with violence [4,54,55]. Also marijuana use increases heart rate, which may be associated with violent behavior [34,47,56,57].

When people stop using marijuana they may experience a variety of withdrawal symptoms, including sleep disturbance, irritability or restlessness, loss of appetite, anxiety, and sweating [46,58]. Experiencing any of these symptoms can make a person angry, ranging from mild irritation to violent rage. Marijuana withdrawal can lead to intimidating violent or bullying behavior, endangering the perpetrator or other people and property [59].

In incarcerated subjects, studies found that one-third of the subjects that committed homicide had used marijuana twenty-four hours before the homicide. Further, three-quarters of those subjects were experiencing at least one mental or physical effect from marijuana intoxication when the homicide occurred.

Similarly, individuals in remote Aboriginal Australian Communities who reported current cannabis use were nearly four times more likely than nonusers to present at least once for violent trauma. Homicide offenses have been repeatedly documented to be connected to drug use, and marijuana is often one of those drugs [60].

Marijuana use is also indicative of intimate partner violence [61]. Consistent use of marijuana during adolescence was the most predictive indicator of intimate partner violence [31]. Also, marijuana use during adolescence was associated with perpetration or both perpetration and victimization by an intimate partner in early adulthood [62].

There is also a positive association between peer victimization and cannabis use in adolescents. Cannabis use is likely to be associated with perpetrator victims, those who initiate violence while using marijuana and experience retaliation to their aggressive acts. This trend suggests that cannabis use might be strongly related to outward aggression by the user [1].

Cannabis use also increases an adolescent's own likelihood of being victimized by peers. In particular, mental effects of cannabis has the potential to decrease the ability to accurately identify, evaluate, or avoid potentially dangerous persons or situations [59].

3.4. Psychosis

Psychosis is defined by the medial journal as "a symptom or feature of mental illness typical characterized by radical changes in personality, impaired functioning, and a distorted or nonexistent sense of objective reality". Psychosis causes individuals to have an impaired perception of reality, consisting of hallucinations and paranoia [2,8,16]. Consumption of marijuana also proportionally increased the risk of other mental illnesses, such as schizophrenia and other types of psychoses. These marijuana use disorders are often associated with its dependence, since a user's brain requires more and more substance use to keep the desired euphoric effect in the brain. Thus, a user is most likely to experience

withdrawal symptoms when not taking the drug. Irritability, anger, and aggression are common withdrawal symptoms that former marijuana users, or marijuana users who try to quit the consumption, experience [46]. Although marijuana advocates generally state that the consumption of the drug helps individuals who suffer from PTSD or other psychiatric conditions, studies suggest that the consumption of marijuana in patients with PTSD, and in patients following a psychiatric discharge, increases the likelihood of those patients being prone to violence compared to patients who do not consume the drug [4,37]. A 50 year-span study on adult patients in the United Kingdom indicated that continued cannabis use by an individual leads is associated with a 7-fold greater odds for commission of subsequent violent crimes. The authors of that study suggest that marijuana consumption would cause impairments in neurological circuits controlling behavior that makes a user prone to violent behavior [36].

Marijuana advocates downplay the risks associated with its unrestricted consumption by saying that the drug is safe, which is a similar approach adopted by Big Tobacco years ago to downplay the risks of smoking. Yet, despite tobacco being legal, people today are well aware of the risks associated with its consumption. Stating that consuming marijuana is safe goes against many studies and researches performed that prove negative health consequences associated with the consumption of marijuana due to the multitude of compounds present and high THC levels being consumed by individuals [9,10,11,19,21].

Studies Show Psychosis and Paranoia

Cannabis intoxication leads to acute psychosis in many individuals and can produce short-term exacerbations of preexisting psychotic diseases [63,64,65,66]. Cannabis use also causes symptoms of depersonalization, fear of dying, irrational panic and paranoid ideas which coincide with acute intoxication and remit quickly [67].

It was reported that 15% of cannabis users identified psychotic-like symptoms, the most common being hearing voices or having

unwarranted feelings of intimidation and persecution or paranoid thoughts [38].

The potency of the marijuana has varying effects on users. A study analyzed the proportion of patients in South London with first episode psychosis attributable to high-potency cannabis use and found that the use of high-potency cannabis (skunk) confers an increased risk of psychosis compared with traditional low-potency cannabis (hash) [68].

The risk of individuals having a psychotic disorder showed a roughly three times increase in users of skunk-like cannabis (high-potency) compared with those who never used cannabis. Use of skunk-like cannabis everyday conferred the highest risk of psychotic disorders compared with no use of cannabis [69]. Potency in these studies is similar to marijuana currently available in the U.S. Direct administration of cannabis resulted in predictable increased occurrence of paranoia in comparison to those who received placebo.

Epidemiological studies showed that cannabis is the most frequently used drug among those diagnosed with bipolar disorder [70]. Studies have also shown that as the frequency of cannabis use increases, so does the risk for psychotic disorders, such as schizophrenia [71]. The investigators of Schizophrenia Commission concluded that cannabis use is the most preventable risk factor for psychosis [72,73,74,75,76,77]. High proportions of persons with schizophrenia report regular cannabis use and meet criteria for cannabis use disorder [78].

Findings suggest that activity in the basal lateral medulla is involved in marijuana-induced paranoia (state of becoming afraid of things that would normally trigger fear) [77]. That means marijuana is actually enhancing type of learning about fear, leading the brain to jump to conclusions about the mild experiences, perceiving them as scarier and more strongly connected to other scary situations than they are. This marijuana induced fear-based learning helps explain why marijuana users tend to see patterns in events that are not real, such as conspiracies [78].

In a study analyzing a college population, heavy users of marijuana displayed significantly greater impairment than light users on intentional/executive functions. This led to the conclusion that heavy marijuana use is associated with residual neuropsychological effects even after a day of supervised abstinence from the drug [53,79].

3.5. Public Policies

These negative effects of marijuana need to be taken into account for public policy in order to treat people with addiction and possibly avoid the tragedies above mentioned. The public should know the negative consequences associated with the compounds present within the marijuana products they consume. The current legalization push in the United States lacks prudent public policy and control over the process. A prudent public policy would be to decriminalize the drug and have its composition, creation, and distribution controlled by an agency that would keep THC levels at a minimum. Moreover, studies that try to find ways to treat individuals addicted to marijuana and ways to make the drug safer by pinpointing each compound and determine whether some compounds may indeed help people who have curable health conditions. This approach would reduce the negative effects of high THC on the human body and would decrease violence occurring during marijuana deals in the black market. Furthermore, this approach will likely decrease the violence caused by marijuana and, most importantly, it would prevent tragedies such as the ones mentioned above [8,13,31,80].

Go to:

4. Conclusions

The main scope of this paper was to inform the general public about the relationships between marijuana and violence in the general population and in individuals with mental illnesses, as recent findings do link marijuana with cases where psychosis was present. This article is a case review and not a research study; therefore, the chief limitations regard inferences that can be made from a case study. However, the findings

suggest a further need for research on marijuana and violence. The authors of this paper did not intend to take sides regarding the legalization of marijuana. The focus was public health in regards to marijuana [2,11,14,18,36].

Go to:

Author Contributions

Conceptualization, N.S.M.; supervision, N.S.M.; writing—original draft, N.S.M. and R.I.; research, R.I.; writing—review and editing, T.O. All authors have read and agreed to the published version of the manuscript.

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Violence and Cannabis Use: A Focused Review of a Forgotten Aspect in the Era of Liberalizing Cannabis. By Laura Dellazizzo, Stephane Potvin, Maria Athanassiou and Alexandre Dumais.

There has been a shift surrounding societal and legal perspectives on cannabis reflecting changing public attitudes towards the perceived safety and social acceptability of cannabis use. With cannabis liberalization internationally, the focus of most cannabis-related harms has been on effects with users themselves. Harm-to-others including injuries from violence have nevertheless been unfortunately largely overlooked. While studies remain heterogeneous, there is meta-analytical evidence pointing towards an association. The aims of this focused review are two-fold: (I) review the evidence from meta-analyses on the association between cannabis and violence; and (II) provide an overview of possible mechanisms relating cannabis use to violence. First, evidence from meta-analytical studies in youths, intimate partners, and individuals with severe mental disorders have shown that there is a global moderate association between cannabis use and violence, which is stronger in the latter more at-risk population. Preliminary data has even highlighted a potential dose-response relationship with larger effects in more frequent users. Although of importance, this subject has remained essentially forgotten as a public health concern. While literature remains inconclusive, data has suggested potential increases in cannabis use following liberalization policies. This may increase violent outcomes if the effect is directly related to the use of cannabis by means of its psychophysiological modifications. However, for the moment, the mechanisms associating cannabis use and violence remain to be

clearly resolved. Considering the recency of policy changes on cannabis, further methodologically sound research using longitudinal designs should examine the effects that cannabis use may have on different forms of violence and the trends that emerge, while evaluating the effects of possible confounding factors (e.g. other substance use). In addition, as evidence-based research from meta-analyses have shown that cannabis use is associated with violence, measures must be taken to mitigate the risks.

Introduction

Worldwide populational data shows that roughly 200 million individuals have used cannabis in the past year (1) and 13 million have a cannabis use disorder (CUD) (2). In recent years, there has been a shift surrounding societal and legal perspectives on cannabis reflecting changing public attitudes towards the perceived safety and social acceptability of its use (3). There is thus a growing number of U.S. states (e.g. Washington, Colorado) and countries (e.g. Portugal, Canada, Netherlands) that have liberalized their cannabis laws by decriminalizing (i.e. lessening the penalties for cannabis offenses) or legalizing its use for medical or recreational purposes (3, 4). Following these policy changes, although literature remains inconclusive and very preliminary with some studies having found no effect, there is some evidence that has also suggested a certain increase of cannabis use in some age groups such as young adults and older adult populations (4–7). Some data likewise suggested changes in frequency of use following recreational cannabis legalization in the U.S. with findings showing a small increase in adolescent CUD and increases in past-month cannabis use, past-month frequent cannabis use, and past-year CUD among adults over 26 years (8). Of note, studies, furthermore, suggest that cannabis has grown more potent as measured by the proportion of Δ^9-tetrahydrocannabinol (THC) content in relation to cannabidiol (CBD) content (THC to CBD ratio) (9, 10). Accordingly, with policy changes, there has been increased attention into cannabis-related harms such as motor vehicle accidents, emergency medical attendances and hospitalizations, severe mental

disorders (SMD) as well as suicides (1, 7). Harm-to-others including injuries from violence have nevertheless been unfortunately largely overlooked (11). Violence is a complex and multifactorial issue that has serious health and social consequences (12). The association between cannabis and violence has created a range of debates. Although studies remain heterogeneous [i.e. (13–20)], there is meta-analytical evidence pointing towards an association. Particularly with liberalization policies aiming for public health and safety while using cannabis, harm-to-others should constitute an essential element for outcome monitoring (7, 11). The aims of this focused review are two-fold: (I) review evidence from meta-analyses on the association between cannabis and violence; and (II) provide an overview of possible mechanisms relating cannabis use to violence.

Reviewing Evidence on the Cannabis-Violence Association

Meta-Analytical Evidence

Our team conducted a systematic search of literature in the online databases of PubMed, PsycINFO, Web of Science and Google Scholar to identify all relevant research reporting on the cannabis-violence relationship with no restriction as to the type of population being investigated. Additional records were identified through cross-referencing. Searches used key words that were inclusive for violence [e.g. (aggression, violent)] and cannabis use [e.g. (marijuana, cannabis)]. The search syntax was tailored for each database. No setting, date or geographical restrictions were applied. Searches were limited to English and French language sources and meta-analytical study designs. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart for the inclusion of meta-analyses within this review is found in Figure 1.

FIGURE 1

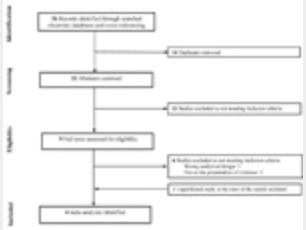

Figure 1 Flow-chart depicting the search strategy employed to find the meta-analyses included in this review.

Below is a description of findings from meta-analyses in (i) youths and emerging adults, (ii) intimate partners, and (iii) individuals with SMD. To ensure clarity, the following qualitative descriptions of the strength of reported effects were used for (i) Odds Ratio [OR (21); small = 1.0–1.5, moderate = 1.6–2.5, strong = 2.6–9.9, and very strong = ≥ 10.0] and (ii) Cohen's d [d (22); small = 0.2, medium = 0.5, and large = > 0.8].

Youths and Emerging Adults

Our team chose to conduct a meta-analysis to clarify the association between cannabis use and violence, more precisely, the perpetration of any type of physical violence by adolescents and young adults (23). Studies were included so long as the behaviors being reported comprised acts of physical violence (e.g. aggravated assault, sexual aggression, fighting, robbery). Studies were excluded if the definition of violence was unclear or included other types of behaviors (e.g. delinquency, verbal aggression, victimization, suicidality). As for cannabis use, all types of frequency measures (e.g. lifetime, occasional, frequent use) were extracted to examine a potential "*dose-response*" relationship in our sub-analyses. Based on this meta-analysis of 30 study arms, a moderate association between cannabis use and the perpetration of physical violence was observed [OR = 2.11, Confidence interval (CI) = 1.64–2.72]. This emerged from studies amounting from a large sample of 296,815 adolescents and young adults and showing no publication bias. It is, however, important to note that there was a high level of heterogeneity between studies,

which may be due to the heterogeneous methods used in studies to measure and define physical violence. A challenge in the interpretation of findings is to rule out alternative explanations on the association itself and its direction, which this meta-analysis has attempted to do with the sub-analyses. First, preliminary findings on the effects of frequency do suggest a potential dose-response relationship, while mostly driven by two studies reporting high ORs (24, 25). More specifically, frequent, persistent and long-term users (i.e. early onset cannabis users) have been shown to experience more mental health and behavioral problems, such as aggression and delinquency (25–28). Beyond frequency of use, current studies did not conduct a detailed assessment of cannabis exposure/usage patterns (e.g. type of cannabis, number of joints, dosage, cannabis potency) (29), which may differentially be associated with violence. Second, the effect remained significant when considering studies additionally adjusting for several covariates including sociodemographic variables and other important confounding factors that may have better explained the relationship (e.g. other substance use such as alcohol, stimulants, conduct problems or psychopathic traits and prior violence) (30). Importantly, results showed that the effect size estimates did not differ substantially between studies that controlled for confounders versus those that did not (OR = 2.01 and OR = 2.62, respectively), meaning that the association is unlikely to be fully explained by confounders. Third, concerning the directionality of the association, we performed a sub-analysis with available data specifically from longitudinal studies and findings showed that cannabis use during adolescence may indeed lead individuals to perpetrate physical violence in early adulthood (OR = 2.02). Of note, the results from longitudinal studies may also be attributed to reverse causality (31, 32). A limited number of authors have indeed reported findings consistent with reverse causality suggesting that physical violence in adolescents and young adults may increase the risk of initiating the use of cannabis later in life (27, 31–33). This still needs further investigation.

Intimate Partners

Physical dating violence perpetration is an example of a behavioral problem that could be influenced by cannabis use in youths as well as in adults. A meta-analysis by Johnson et al. (34) focused on U.S. adolescents and emerging adults aged 11 to 21 and defined physical dating violence as any non-sexual physically aggressive behavior among current or former romantic, sexual/intimate or dating partners. They retrieved 11 studies with six on adolescents and five on emerging adults, which provided evidence for an association between cannabis use and violence perpetration. Globally, there was a 45% increase in the odds of perpetration (OR = 1.45, CI = 1.20–1.76) in cannabis users. As observed in the meta-analysis above, there was minimal evidence of publication bias, but a substantial amount of heterogeneity between studies. As stated by the authors of the meta-analysis, this was mostly the case of five included studies with methodological differences focusing on emerging adults. In comparison to adolescent literature, these latter studies comprised heterogeneous samples (e.g. 60% on college students, at least 70% Caucasians), a variety of study designs (e.g. cross-sectional, longitudinal, daily diary) and most adjusted for alcohol use. Another review by Moore et al. (35) quantitatively evaluated the empirical evidence on the relationship between several types of drugs, including cannabis, and partner aggression perpetration (psychological aggression, physical abuse, sexual coercion/abuse, and mixed forms) in a variety of populations (e.g. substance abuse treatment facilities, community samples). In the 15 studies retrieved for cannabis use, a small effect size (d = 0.22, CI = 0.21–0.28) was found for all types of interpersonal violence including psychological, physical, sexual abuse, and mixed. Effect sizes were larger for psychological aggression broadly defined (d = 0.35, CI = 0.19–0.50), and physical aggression (d = 0.21, CI = 0.14–0.27) in comparison to other forms of aggression. Notably, men's use of cannabis was positively related to the perpetration of aggression. This study found that the relationship between cannabis use and intimate partner aggression was stable

and reflected little variability in the effect sizes across studies. While both these meta-analyses found a positive association between cannabis use and violence, unfortunately, with the limited studies included, they did not conduct supplementary sub-analyses to further examine the direction of the association.

Individuals With Severe Mental Disorders

We conducted a meta-analysis to examine the association between cannabis use/misuse and the perpetration of violence in adult individuals with SMD (schizophrenia, schizophreniform disorder, schizoaffective disorder, delusional disorder, bipolar disorder, and major depression) (36). Notably, these individuals are already at an elevated risk of violence in comparison to the general population (37, 38). To be as inclusive as possible, studies were not restricted so long as they evaluated any type of violence/aggression by any means such as clinical observation and self-reports. The meta-analysis included 12 final articles amounting to a total of 3,873 subjects. Results showed a moderate association between cannabis use and violence in individuals with SMD (OR = 3.02, CI = 2.01–4.54). As observed in the other meta-analyses, there was no publication bias, however, the database was characterized by high heterogeneity. This may partly be due to the studies displaying a variety of definitions for violence and assessment methods. Importantly, to determine whether other factors may have modified the effect, we also conducted sub-analyses. When considering adjusted studies only, the effect was slightly smaller, but remained significant (OR = 2.82, CI = 1.89–4.23). The four studies adjusted for several factors including sociodemographic variables and other confounding factors such as substance use and presence of psychiatric disorders. Of clinical interest, the association was significantly higher for cannabis misuse in comparison to cannabis use (OR = 5.8, CI = 3.27–10.28 versus OR = 2.04, CI = 1.36–3.05). In contrast to our meta-analysis in youths, this frequency association was not driven by any

individual studies. Beyond frequency of use, it was not possible to examine other cannabis exposure patterns (e.g. type of cannabis, dosage, potency). Moreover, since most data was cross-sectional and retrospective, evidence was limited as a basis for concluding on the direction of the association. Longitudinal studies examining the association between cannabis use and violent behavior in patients with SMD are critically needed.

Summary: Public health significance of evidence

- There is a *moderate* association between cannabis use and physical viol in youths and emerging adults, with a potential *dose-response* association. Moreover, longitudinal evidence suggests that cannabis use may lead to futu violent outbursts.
- There is a *small to moderate* association between cannabis use/misuse a intimate partner aggression perpetration.
- There is a *moderate* association between cannabis use and violence in populations with severe mental disorders, with a significant increase for frequ users or those with a cannabis use disorder.
- Evidence highlights that violence should be an *important indicator to mon* considering recent cannabis liberalizations in several countries.

Overview of Potential Mechanisms Explaining Violent Behavior and the Potential Impact With Cannabis Legalization

Harm-to-others such as violence constitutes an essential outcome to monitor in a public health perspective (7, 11). There are two main positions that have prevailed as to the consequence cannabis use policies might have on violence outcomes that depends chiefly on the impact these policies have on cannabis use as well as the mechanism by which cannabis and violence are associated (e.g. psychophysiological effects versus social context described below).

Hence, although literature remains inconclusive, it has been hypothesized that there may be an increase in the number of cannabis users following the legalization of medical and recreational cannabis more particularly for adult samples (4–7, 39). Accordingly, for illustrative purposes, considering an expected increase of cannabis use:

i. A rise in the rate of violence may be observed if the mechanisms involved is psychophysiological (e.g. increase of aggression-related effects while intoxicated or during withdrawal) Or
ii. A reduction in the risk of violence may be observed if the mechanisms involved is social (e.g. reduction of black-market-, gang-related violence).

The following describes both these mechanisms and briefly explores the support for these mechanisms from literature on the legalization of recreational cannabis in the U.S. Markedly, the first four states to legalize cannabis for recreational use were Colorado and Washington in 2014 and Alaska and Oregon in 2015.

Psychophysiological Mechanisms

From a neurobiological perspective, cannabinoid receptors, CB-1 and CB-2, bind endogenous ligands, primarily anandamide and 2-arachidonoylglycerol to modulate neural activity (40). Amid receptors, CB-1 receptors are the predominant cannabinoid receptor type within the central nervous system and have been shown to mediate the effects of exogenous cannabinoids (41, 42). The main active ingredient in cannabis, THC, acts as a partial agonist for CB-1 receptors in the brain (43). With a lower efficacy than at CB-1 receptors, THC also demonstrates partial agonist properties for CB-2 receptors (44). CB-1 receptors are abundant in several cerebral regions, such as the cerebellum, basal ganglia, cingulate cortex, amygdala, hippocampus and frontal cortex that participate in several functions (e.g. executive, emotional, reward, and memory processing) (40, 45). Such brain function modulation occurs *via* direct interactions with the endocannabinoid system and indirect

effects on neurotransmitter systems including the glutamatergic, GABAergic and dopaminergic systems (40, 45). Animal studies have shown that THC produces morphological changes (e.g. reductions in synapses, cell body size and dendritic length) in these brain regions with high CB-1 receptor expression (46–50).

Animal studies have found that THC produces complex effects on aggression. Indeed, animal studies have not produced clear-cut results, as both anti-aggressive as well as aggressive-inducing effects of THC have been documented [see (51–53) for reviews]. Discrepant results are likely related to several laboratory factors with the dose, delivery of administration and concurrent environmental manipulations being prominent aspects to consider. Based on a review of animal studies (52), it has been generally found that studies using smaller doses of THC/cannabis have been less likely to report the emergence of aggression, whereas studies using higher doses and more chronic exposure have rather led to an increase in aggressiveness. Such dose-dependent effects on aggression have been stated to be due to the fact that CB-1 agonists at low doses may increase serotonin (a key neurotransmitter system derived mainly from dorsal and medial raphe involved in aggression control), while at higher doses, they may induce a decrease of serotonin, thereby increasing aggression (54). In addition, experiments with genetically modified animal models, such as mice, lacking CB-1 receptors (CB-1KO) have also revealed alterations in the regulation of emotion and aggressive behaviors (55). For instance, CB-1KO mice exhibited stronger aggressive responses than wild-type mice when exposed to social interaction tests (56, 57). This may be explained by differences in serotonin that were observed in CB-1KO mice. While they appeared to better metabolize serotonin due to an increase in catechol-O-methyltransferase levels in the raphe nucleus and amygdala, gene expression of monoamine oxidase-A was also augmented in the amygdala, which may have reduced serotonin levels leading to increased aggressiveness (57). This supports the role of CB-1

receptors in aggressive behaviors. In all, animal models are necessary since they allow to generate hypotheses and may provide some parallels to aggression in humans (53). Although such findings on animal studies in controlled laboratory environments do not necessarily translate to human studies, they provide evidence of a relationship between CB-1 receptor and aggressive states.

Similar to animal models, alterations in brain regions have been observed in human studies, particularly in CB-1 receptor rich areas mediating not only executive and cognitive functions, but also emotional and affective processing [see (58) for a review]. These alterations in humans may lead to aggressive tendencies. While functional imaging studies on aggression as an outcome per se in association to cannabis use are lacking in human literature, changes observed in key regions involved in emotional processing such as the amygdala and the anterior cingulate cortex may be relevant to the regulation of negative emotions such as anger and hostility. Several studies have indeed found that acute cannabis use may alter the activity of these regions when presented with stimuli of negative valence, notably threatening stimuli (e.g. fearful and angry valence) (59–65). For instance, it was found that inhaling 6 mg of THC impaired task performance for matching emotional faces with negative emotional content, but not those with positive content (59). While processing stimuli with a negative emotional content, there was a reduction in neural activity in a network of brain regions including the amygdala, orbitofrontal gyrus, hippocampus, and prefrontal cortex. A further study showed that THC reduced the functional coupling between the basolateral amygdala with the rostral anterior cingulate cortex and the superficial amygdala with the medial prefrontal cortex (62). It is worth noting that the net effects of orally administered THC and CBD on amygdala activation during the processing of fearful faces have shown to be in the opposite direction (64). Further evidence of emotion dysregulation after chronic cannabis use is provided in functional imaging studies (66–70). Reductions in response

within the cingulate, frontal cortex, and the amygdala during the presentation of negative emotional stimuli have been observed in literature on chronic cannabis use (68, 70). While passively exposed to negative and neutral valence pictures, negative emotional stimuli produced hypoconnectivity between the amygdala and dorsolateral prefrontal cortex in active users and orbitofronto-striatal and amygdala hyper-connectivity following 28 days of abstinence (67). Overall, cannabis users appear to process emotional stimuli differently in comparison to non-users and this may explain their impairment in the recognition of affect (68). Therefore, neutral stimuli can attain emotional/affective salience during the use of cannabis (71). Deficits in emotion recognition have been associated with violence (72, 73) and thus cannabis use inducing such impairments may increase the risk of violent acts. At the moment, the potential association between cannabis-induced changes in neural functioning and violent behavior in humans remains speculative, and future fMRI studies will need to directly measure levels of irritability and/or aggressiveness in cannabis users to determine if there is an association or not.

Compared to the general adult population, youths are particularly vulnerable to the neural effects of cannabis that is worthy of discussion. Preclinical studies have evidenced that the endocannabinoid system matures slowly during development, with maximal CB-1 receptor abundance achieved during adolescence, and that this system plays a key role in neural refinement during adolescence (74). More precisely, it has been shown that the chronic activation of CB-1 receptors by exogenous cannabinoids during adolescence could disrupt the maturation of GABAergic interneurons in the prefrontal cortex and disrupts the GABA-glutamate balance (75, 76). As a result, youths may be more vulnerable to the adverse consequences of cannabis use. In human literature, reviews have concluded that frequent cannabis use in adolescents and young adults is associated with anomalies in brain structure, including alterations in the basal ganglia, hippocampus, amygdala, cerebellum,

cingulate cortex, and prefrontal cortex (58, 77–79). The findings suggest that earlier initiation of cannabis use is associated with more prominent alterations (79). Thus far, the most consistent alterations produced by cannabis use, mostly its chronic use, during youth have been observed in the prefrontal cortex. Such alterations may potentially lead to a long-term disruption of cognitive and executive functions (80). Interestingly, early and frequent cannabis use in adolescence predicts poor cognition and even emotional processing in adulthood (81), which may increase the likelihood of aggressiveness later in life. There are indeed indications that continued exposure to cannabis in youths is associated with a higher risk of subsequent violent behavior in later adulthood (27).

At the behavioral level, both acute and chronic cannabis intoxication may (i) impair neurocognitive domains (e.g. executive functioning) and create perceptional distortions (e.g. interpreting neutral actions as aggressive), (ii) impair a user's ability to suppress aggressiveness, (iii) heighten physiological arousal making users feel paranoid, anxious or panicky (35). Withdrawal symptoms, which are reported by up to a third of regular users are of clinical significance as they can be impairing and associated with trouble ceasing use (82). These symptoms typically onset within 24 to 48 h following abrupt cessation in frequent users and contribute to irritability, restlessness, and anxiety that may likewise be associated with aggression (35, 83). These effects apply to psychiatric samples such as those with SMD as well. Both the acute intoxication and chronic use, in addition to the effects stated above, may lead to poor clinical outcomes and interfere with treatment by worsening and promoting psychiatric symptoms (84–86). Early regular and frequent cannabis use has been shown to be associated with onset of psychosis and worsens the course of the disorders (87, 88). Moreover, cannabis use may exacerbate psychotic symptoms such as delusions, which, in combination with the intoxicating effects of cannabis, may increase the risk of violence (13, 35). It is essential to note that individuals with SMD are also more likely to use

cannabis and have comorbid substance use disorders in comparison to the general population (5, 89–93). This may reflect an attempt to cope with psychological distress (e.g. negative affective symptoms) or relieve the side effects of medication (e.g. antipsychotics) through cannabis use (e.g. self-medication) (94). Given the risks of continued substance use, it is important to identify the emergence of problematic use even more so as this population is at an increased risk of exhibiting aggressive behavior (37, 38). Lastly, distal influences (e.g. psychiatric disorders, childhood abuse, history of substance use) in concurrence with proximal factors (e.g. acute intoxication, impulsivity, emotional reactivity, encounter setting) may help to explain the increase in the risk for aggression when in the context of a conflictual interaction (35, 95). For example, cannabis intoxication in individuals with stable personality traits such as hostility and callousness may lead them to act aggressively when triggered in a fight. Although, it is worth noting that it is not only the psychophysiological effects of cannabis use per se that might induce violence, but also factors associated with substance use in general. As an example, the use of substances and related environments may lead to relational frictions, thereby increasing the chances of violence in conflictual circumstances (35).

Support From Cannabis Legalization Literature

A few scholars have recently found results showing that legalizing recreational cannabis may increase violence. Hughes et al. (96) assessed the relationship between both medical as well as recreational cannabis dispensaries and yearly neighborhood crime in Denver between 2012 and 2015, including the two-year period immediately following commencement of legal retail sales in January 2014. This was examined by controlling for correlates of neighborhood crime, including socioeconomic disadvantage and the concentration of high-risk commercial establishments. The authors found that the presence of at least one medical/recreational cannabis dispensary was associated with a statistically significant increase in neighborhood crime (e.g. robbery and

aggravated assault). At the state-level, Lu et al. (97), comparing rates of crime in Washington and Colorado to states not legalizing cannabis, found some immediate increases in crime at the point of recreational legalization. Moreover, Lin et al. (98) conducted a non-peer reviewed quasi-experimental difference-in-difference analysis to study the potential effect of cannabis use on domestic violence by exploiting municipal and temporal variations in the enactment of recreational cannabis laws in Denver-Aurora-Lakewood Metropolitan Statistical Area from 2011 to 2016. They found that the enactment of recreational cannabis laws in 2014 led to a substantial increase in domestic violence. Denver and Aurora experienced a 48.2% increase in domestic violence rate as compared to their two control cities. Since the legal age to procure recreational marijuana is 21 years old, they even observed that the effect was only significant for perpetrators over that age. The effect was significant across gender and ethnic groups. As for offence severity, the effect concentrated for categories of simple assault, intimidation, minor injury, and no injury. As alcohol interacts with cannabis use, the authors found that the main findings were not driven by co-use of alcohol and cannabis.

Social Mechanism

Supplementary explanations relate to the interaction between people and their social environments specifically. In jurisdictions where cannabis is illegal, users may obtain cannabis in the black market, thereby potentially exposing individuals to the risk of violence (99). The association between cannabis use and violence perpetration could be more broadly situational. For instance, selling or purchasing cannabis may promote criminal behavior for economic motives or to sustain substance use behaviors. While this may seem less relevant for intimate partners, relationships could be placed at risk of intimate partner aggression by supporting a habit related to use (e.g. stealing money) or by means of procuring a substance (e.g. forcing a partner to obtain a substance) (95). Aggressive tendencies may also occur within the broader system of drug use within the black-market (e.g. disputes over neglecting to

pay debts) (95, 100). Legalizing recreational cannabis would ensure that citizens can procure the substance in places not governed by organized crime. Consequently, consumers would be less likely exposed to violent/criminal lifestyles.

Support From Cannabis Legalization Literature

Further analyses of recreational law reforms may best demonstrate whether eliminating the cannabis black-market might affect violent and property crime. Research has therefore also found support for the claim that legalizing recreational cannabis may reduce violent outcomes. Brinkman et al. (101) observed reductions on crime rates in geographical proximity to cannabis dispensaries in Colorado. There were no significant effects in crime on neighboring dispensary density. They found that a supplementary dispensary in a neighborhood led to a decline of 17 crimes per month per 10,000 citizens. This finding corresponded to a nearly 19% reduction in relation to the typical crime rate. The effect was generally stronger for nonviolent crimes (e.g. criminal trespassing, public-order crimes, criminal mischief, and simple assault). Dragone et al. (102) further examined crime rates from 2010 to 2014 in counties along the Washington-Oregon border before and after legalization in Washington. They used a quasi-experiment research design that combined a difference-in-difference design (where Washington acted as the treatment group, Oregon as the control group, 2010–2012 was the pre-legalization period and 2013–2014 was the post-legalization period) and spatial regression discontinuity designs (where the border marked a discontinuity in the legal status of cannabis in 2013–2014). The authors noted significant drops in rape and property crime in Washington side counties relative to Oregon-side counties. The study by Lin et al. (98) did find reductions in high gang-related crimes including aggravated assault and robbery, supporting the social mechanism as well. Moreover, Lu et al. (97) used a quasi-experimental, multi-group interrupted time-series design to examine crime rates in Colorado and

Washington and determine if and how these rates were influenced by the legalization of recreational cannabis in 2012 and the beginning of retail sales in 2014. This study suggested that cannabis laws more broadly, and the legalization of recreational cannabis, have had minimal effects on major crime. While there were some short-term increases as stated in the section above, these did not result in long-term effects. They observed no statistically significant long-term effects apart from a significant decrease of burglary in Washington.

Summary of Findings

Overall, there is evidence demonstrating an increase as well as a decline in general criminality/violence following the legalization of recreational cannabis, thus supporting both mechanisms. Under the first paradigm, research reinforces that legalizing cannabis policies may be expected to show a potential increase in cannabis use (while literature remains inconclusive in this regard) and may alter some users' behavior, thereby increasing aggression. Under the second paradigm, the underground cannabis market intertwined with criminality is expected to diminish as the cannabis market becomes legalized. It may be possible that both a rise and reduction in different violent outcomes may emerge following cannabis legalization since both the psychophysiological and social effects can occur simultaneously as has been observed in the study by Lin et al. (98). The limited literature on policy changes have therefore not elucidated the mechanisms associating cannabis use and violence since the studies have been conducted in various settings and have used a variety of methodologies (i.e., quasi-experimental difference-in-difference analysis, quasi-experimental, multi-group interrupted time-series design). Globally, supporting studies for both paradigms have assessed how crime is related to the density of cannabis outlets or they have examined state-level changes. Using more rigorous methodologies, some authors have also considered pre-legalization trends in their analyses and

controlled for confounding factors, providing better quality evidence for both mechanisms. More thorough investigations are still warranted.

Discussion

Considering international cannabis policy changes, this focused review aimed to revise the evidence on the association between cannabis use and violence as well as to examine the potential mechanisms involved. Available evidence from meta-analytical studies in youths, intimate partners, and individuals with SMD have shown that there is a global moderate association between cannabis use and violence, which may be stronger in the latter more at-risk population. Though, not only is any type of use of cannabis associated with violence, but preliminary data has highlighted a potential dose-response relationship with larger effects in more frequent users. In this sense, the association between cannabis use and violence is not to be overlooked.

Of interest, positive associations between cannabis use and violence have also emerged in more recent studies following these meta-analyses. For instance, scholars have observed an association between cannabis and violence in intimate partners [e.g. (103–105)]. Our team conducted four additional studies to elucidate the association using more robust methodological strategies and well-known databases in youth populations from the Quebec Health Survey of High School Students (106) and Longitudinal Studies of Child Abuse and Neglect (107) as well as in samples with SMD from the MacArthur Violence Risk Assessment Study (108) and Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) (109). Beyond associational research, our studies using longitudinal designs were conducted in the aim to further understand the direction of the cannabis-violence association as solely few investigations have been carried out on the matter (27, 31, 33, 107–110). Our studies on psychiatric samples have supported the finding of a unidirectional association between cannabis use and violence (108, 109). In this regard, our research team has recently re-analyzed data from the NIHM-funded CATIE trial. In a sample of 965 patients followed for 12 months, a

cross-lag model was implemented to examine the association between cannabis use and violent behavior. Results showed that persistent cannabis use predicted subsequent violent behavior, while the reverse relationship was not significant. Results remained significant after controlling for alcohol and stimulant use. As such, this analysis of longitudinal data showed a unidirectional association between cannabis and violence in schizophrenia (109). On the other hand, our study on adolescents also supported a reverse relationship, that is that externalizing behavior in youths may lead to the subsequent use of cannabis. Hence, using developmental joint trajectory models, it was found that higher levels of trait aggression at ages 10 to 16 were associated with cannabis use at 16–18 years old (107), which supported some scholars' claim that the association is bidirectional (27, 111). This highlights the importance of better understanding the direction of the association. Although the mechanism associating cannabis and violence remains to be clearly resolved, a variety of strategies should be implemented in order to reduce the negative impacts of cannabis legalization (82). From a biological perspective, as CBD is more reliably associated to therapeutic properties (such as neuroleptic, relaxant and neuroprotective effects), increasing CBD content may prove to be a sustainable strategy to mitigate cannabis-induced harms (112). Nevertheless, the effects of CBD on violence remain unknown. From a social perspective, preventative measures and intervention programs on mental health and risk behavior should be implemented in school settings since youths remain predominantly susceptible to the detrimental effects of cannabis. They should be provided critical educational information for decision-making and discouraged from initiating and adopting more chronic patterns of use (113). Awareness should be prioritized among professionals (e.g. social workers, educators, clinicians) who are in contact with more vulnerable or violence-prone populations. Professionals should take the necessary measures to further diffuse their knowledge through psychoeducation to their treating individuals. Markedly, efforts should be

made to deter violence-prone populations from using cannabis. These at-risk populations include samples from forensic and carceral settings. Noteworthy, in comparison to other drugs, lifetime and regular cannabis use remains the highest drug of use in inmates and the highest drug at time of offence (114). In this sense, crime and substance misuse comprise public health issues for criminal offenders who are released from carceral settings. Interventions should ultimately aim to decrease post-release risky behavior (e.g. cannabis use) among inmates or forensic patients returning to the community (115). Mental health clinicians should screen their patients for cannabis use patterns and related adverse effects of aggression (82). Until a secure exposure pattern (e.g. quantity of cannabis, potency level) is determined by research, withholding from regularly using cannabis may be a better option in these at-risk and vulnerable populations. Moreover, evidence-based treatments and interventions, such as contingency management, relapse prevention, motivational interviewing, and cognitive behavioral therapy showing promising results (116), should be offered to those with problematic cannabis use.

Limitations

Albeit the important contributions brought forth by the current literature, several limitations must be acknowledged. Upon reviewing the limited available evidence, one important discrepancy involves the heterogeneity among studies. For instance, studies used heterogeneous methods to measure and define violence. Accordingly, it becomes difficult to ascertain whether different constructs of violence were investigated. Further examinations into the essence of the construct should be considered for future research. Of importance, it is necessary to better understand the direction of the cannabis-violence association. In this regard, longitudinal studies should further investigate the direction of the association. Regarding the literature pertaining to policy changes, particularly for recreational cannabis, the vast heterogeneity surrounding study methodologies restrict our ability to precisely evaluate the

mechanism associating cannabis and violence. A further predominant limitation in the literature regard the assessment of cannabis exposure/use patterns, such as the type of product consumed (edible, joint, beverages), number of products consumed, dosage, frequency, and THC to CBD ratio, which limits our ability to accurately determine how THC may be associated with violent tendencies. This information in relation to violence will be particularly important to define in the context of public health strategies since legalization aims at the regulation of dosage and potency of the products. This is more so important as health promotion strategies enhance health literacy by providing reliable evidence-based research.

Conclusion

In all, evidence-based research from meta-analyses have indeed shown that cannabis is associated to violence and therefore measures should be taken to mitigate the risk. Nevertheless, there remains questions as to the direction of the association and the potential mechanisms involved, which may be answered with the changes observed following the liberalization of cannabis. Hence, biopsychosocial research should continue to monitor the association following policy changes more thoroughly by examining different types of violent outcomes. Research should account for trends before legalization and consider the profiles of individuals using cannabis before and after legalization. This methodological consideration has been lacking in most studies in the literature. Moreover, since meta-analytical evidence has found an association between cannabis use and violence in intimate partners, further data on post-liberalization prevalence for dating and intimate partner violence is warranted. Similarly, studies on the effects of cannabis policies in at-risk populations such as individuals with SMD and prisoners leaving carceral settings is necessary. Additional biological studies using neuroimaging, for instance, are currently needed to further shed light into the mechanisms associating cannabis and violence. If causation is established, it will be more so crucial to determine a specific type of exposure pattern (e.g. quantity of

cannabis consumed or its potency level) that may be more associated to violent tendencies. For all these reasons and considering the recency of policy changes on cannabis, further methodologically-sound research using longitudinal designs should examine the effects that cannabis may have on different forms of violence and seek to evaluate the trends that emerge in different populations. This should be done while evaluating the effects of possible confounding factors (e.g. other substance use, psychopathic traits).

Author Contributions

AD, LD, and SP contributed to study planning and design. LD and MA conducted the literature search. LD wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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