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Epidemiology of Marijuana Use and Mental Health in the Context of Changing Policies

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Walden University
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Abstract

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Abstract

There is a growing body of evidence supporting the association between cannabis use and the development of mental health disorders, but few studies have addressed this association following the recent increase in marijuana legalization laws. Therefore, using the social ecological model and the self-medication theory of addiction as theoretical frameworks, the purpose of this retrospective database study was to assess the relationship between marijuana use and major depression and suicidal ideation in both adults and adolescents in 2008 and 2017. Data from the National Survey on Drug Use and Health were analyzed using logistic regression at the $p < .05$ threshold for statistical significance. Results demonstrated positive, statistically significant relationships between marijuana use and both major depression and suicidal ideation for both adults and adolescents in both 2008 and 2017. Further, the strengths of these relationships generally increased between 2008 and 2017, coincident with the increase in marijuana legalization laws. These findings provide empirical support to the association between cannabis use and the development of mental health disorders, and that the strength of these associations is increasing following the increase in marijuana legalization laws. This study has important implication for positive social change by identifying significant relationships between cannabis use and the development of mental health disorders and revealing that these relationships are strengthening over time, coincident with the increase in marijuana legalization laws.

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Dedication

I dedicate this dissertation to my mother, Barbara Anne Griffin Harvey the queen matriarch of our family. While she left us to be with the lord, she is still a very big part of our family. She always encouraged me to be the best person I could and loved me unconditionally. I miss her with all my heart and still struggle with her loss. But she would never have settled on anything less than my best. I credit her for my drive to finish this project.

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"Wisdom is the awareness and acknowledgement of the gap between life as you perceive, project and wish it to be and life as it is - and being shrewd and able (moment to moment) to flow, shift, act, adapt or just be accordingly."

— Rasheed Ogunlaru

I would like to take this opportunity to pay special regards to those individuals who supported me unconditionally throughout my journey toward earning my Master's and Doctorate in Public Health. I am proud of my perseverance, tenacity and desire to achieve more. All of this would not have been possible, though, without the wonderful network of family and friends who have guided and supported me.

To my mother, Barbara, from whom I learned kindness, understanding, self-respect and so much more. You are and always will be my heart and soul. To my father, David, who supported and encouraged me to finish what I start. Thanks for your unconditional support. To my baby sis, Deb (Gump), who encouraged and supported me during the frustrating and difficult moments. Your presence has provided me with such a sense of calm and peace at times when I thought all was lost, and never letting me lose focus of my goals. I LOVE YOU ALL!

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Chapter 1: Introduction to the Study

Substance use, abuse, and misuse is an important public health problem in the United States. According to the National Institute on Drug Abuse (NIDA) over $700 billion dollars is spent annually on the following substance use related issues: the associated health care cost (such as cancer, heart disease, and mental illness); loss productivity and wages; and crime associated with driving while impaired; accidents; violence; and child abuse (NIDA-The Science of Drug Abuse, 2016; NIDA-Magnitude, 2017). In addition to the aforementioned health care complications, substance abuse is also associated with other cost due illness, injuries, and death as "approximately 40 million debilitating illnesses or injuries occur" each year as a result of substance use, misuse, or abuse (NIDA-Magnitude, 2017, para.4). Among the substances of abuse, marijuana is the most widely used substance in the United States. In 2018, approximately 43 million Americans reportedly used marijuana in the past year (Statista, 2019). Among these were approximately 11.8 million young adults that reported using marijuana in 2018 (NIH-NIDA, 2019). The World Health Organization (WHO; 2018) further emphasized the widespread use of marijuana in a report indicating that approximately 147 million people or 2.5% of the world population use marijuana in some form each year. This is compared to 0.4% combined total of the world's population that consume cocaine and opiates annually (World Health Organization [WHO], 2018). Thus, marijuana is by far the most widely used substance in the world.

More importantly, in the United States differential marijuana legalization policies have introduced considerable controversy regarding the public health impact of these

policy changes. While increased use has led to therapeutic effects against certain medical conditions, other researchers argue that there is an increase in deleterious consequences. Therefore, understanding the nature of the relationship between marijuana, psychosis, and mental health conditions is important to developing evidence-based health policies as this information can serve to inform policy makers, practitioners, and public health professionals. This is especially important given the changing attitude and increasing legalization of marijuana which has led to the production of marijuana strains with higher levels of THC (Briggs, 2015; Cabrera, 2016).

Currently, 33 states and the District of Columbia plus Guam and Puerto Rico have passed laws legalizing medical marijuana with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018). However, these laws vary by state. For instance, in addition to legalization of medical marijuana, California's Prop 64 measure permits adults that 21 and older to possess up to one ounce of marijuana and grow six plants (Governing Data, 2018). In contrast, states like Georgia have legalized the use of marijuana for medical purposes only (Governing Data, 2018). The Georgia law which passed on April 16, 2015 allows for the use of cannabidiol (CBD) to treat various medical conditions (Governing Data, 2018). Some these of these uses include: seizure disorders; sickle cell anemia; cancer; Crohn's disease; ALS (Lou Gehrig's disease); multiple sclerosis; mitochondrial disease; and Parkinson's disease (ProCon, 2016). CBD is a compound found in marijuana that is being used for medical benefits (citation). CBD does not produce the psychoactive effects caused by tetrahydrocannabinol (THC) also found in marijuana (citation). In fact,

CBD can serve to counteract the psychoactive effects of THC and is used in treat marijuana induced psychosis (Niesink & van Laar, 2013).

Prior to legalization, THC levels ranged from a low of 4% to a high of 13% (Ramaekers et al., 2006). However, since legalization these ranges have increased dramatically. For instance, growers in Colorado have produce strains that range from a low of 6% THC to a high of 28% THC in the Williams' Screaming Gorilla strain (Cabrera, 2016). While numerous studies have been conducted assessing the lower levels of THC, fewer studies have been conducted to assess higher levels. In this study, I sought to address this gap in the research by assessing the effects of rising THC levels in legalized marijuana on mental health. This study may contribute to positive social change by informing future generations of the risk associated with highly potent marijuana and the implications of marijuana legalization on the prevalence of mental illnesses like depression.

Background

Lab tests reveal that the potency of marijuana in Colorado since legalization is more than twice as potent as illegal marijuana of the past 10 years and some strains of legal marijuana is three times as potent (Briggs, 2015). Prior to legalization the levels of THC were typically below 10%. However, research now indicates that the post legalization levels of Colorado's marijuana averages around 18.7 % with some marijuana strains containing THC levels of 30 % or more (Briggs. 2015). These findings demonstrate that legalization and relaxation of marijuana policies have created an environment that has led to increased availability of highly potent marijuana. This fact

justifies the need to address this gap in the research as most previous studies have been conducted on lower THC levels prior to legalization.

In 2016, Colorado state legislators made efforts to limit THC levels to 16% by proposing an amendment (Cabrera, 2016). However, these efforts failed as the amendment did not get enough support. Among the health and safety concerns addressed, the effects of THC on adolescent brains was one of the primary concerns of the proponents of this amendment (Cabrera, 2016). Thus, adolescents are included in the target population of this study which intends to contribute to positive social change by making information available to inform and understand the effects on future generations as a return on investment going forward.

The higher levels of THC have had a serious health toll on inexperienced users. For instance, according to the Colorado Department of Public Health and Environment, emergency room visits for marijuana associated conditions, such as psychosis has increased 29% for all Colorado residents since legalization (Cabrera, 2016). However, when inexperienced users take in too much of the highly potent marijuana, they are more likely to experience extreme anxiousness and report feelings of "impending doom" when compared to the regular heavy marijuana users that have built up a tolerance (Cabrera, 2016). This is evidenced by out of state users that are inexperienced when it comes to the high levels of THC elicited by Colorado's legal marijuana (Manella, 2016). Wherein hospitalizations for out of state visitors has risen dramatically from "78 per 10,000 visits, to 112 per 10,000 in 2013, to 163 per 10,000 in 2014" reflecting an increase of 109% between the years of 2012 and 2014 (Manella, 2016, para. 4). Thus, marijuana

legalization has led to a dramatic increase in hospitalizations especially among the inexperienced user.

Nevertheless, possible marijuana related hospitalizations for Colorado residents in 2000 prior to medical marijuana legalization (MML) was 575 per 100,000 (Colorado Department of Public Safety [CDPS], 2016). Between the years of 2001 to 2009 post MML (but prior to commercialization) the rates of hospitalizations rose to 803 per 100,000 (CDPS, 2016). However, between the years of 2010 to 2013 which reflects post commercialization of medical marijuana the rates of hospitalization rose dramatically to 1,440 per 100,000 (CDPS, 2016). With the most dramatic increase demonstrated after retail commercialization between the years of 2014 to June 2015 which demonstrated "2,413 hospitalizations per 100,000 visits" (CDPS, 2016, p.7). The THC in marijuana elicit its effects by over activating specific regions of the brain that has highest number of cells with receptors specific for THC (National Institute of Health [NIH] – Marijuana, 2016). Therefore, marijuana with higher levels of THC would be expected to have a more profound effect.

The notion that marijuana use is associated with the development of psychosis and mental health disorders is well founded as previous research has demonstrated that in addition to psychosis, anxiety and depression are also associated with regular marijuana use (Moore et al., 2007; Volkow, Ruben, Baler, Compton, & Weiss, 2014). Nevertheless, relatively few studies have addressed this association since the rise in THC demonstrated after legalization. The mental health effects are reportedly associated with long-term marijuana use in susceptible users (Cabrera, 2016). The mental effects may include

temporary symptoms of hallucinations and paranoia, which are exacerbated in schizophrenia patients. Another mental health issue associated with marijuana is suicidal thoughts in teens (Cabrera, 2016). This should be a serious public health concern especially when considering the rising THC levels which may serve to compound this problem.

As previously indicated, marijuana laws vary by state. Therefore, the availability of highly potent marijuana also varies by state as research has demonstrated a spillover effect of highly potent medical marijuana into the recreational using population (Salomonsen-Saulel, et al., 2012; Wen, Hockenberry, & Cummings, 2015). This trend has also been demonstrated in states adjacent to states with medical and recreational marijuana laws as highly potent marijuana is more readily available in states adjacent to states with relaxed marijuana laws (Hao & Cowan, 201; Ingold, 2014 7). For instance, representatives of states like Oklahoma and Nebraska have attempted to sue Colorado citing that legalized marijuana is spilling over state lines and is more readily available in these states because of legalization in Colorado (Hao & Cowan, 2017; Ingold, 2014). This understanding is evidenced in a study by Hao and Cowan (2017) wo posited that counties bordering states with recreational marijuana legalization (RML) demonstrated a significant increase in arrests for marijuana possession when compared to counties that did not border states with RML. Thus, legalization and the relaxation of marijuana policies have increased distribution of highly potent marijuana. However, Hao and Cowan (2017) did not find evidence indicating that arrest for the selling and growing marijuana, DUI arrest, and/or arrest for possession of opium/cocaine are affected by

RML in border states. Nevertheless, the aim of this current study was intended to assess the effect of marijuana policy on mental health.

Problem Statement

The level of THC in marijuana has been increasing potency since legalization began in 2012 (Cabrera, 2016). This is a growing concern since THC elicits the desired psychological effects most marijuana users seek (Bradford, 2015). Addressing this concern now is particularly important because at present 33 states and the District of Columbia have passed laws legalizing the use of marijuana for medicinal purposes (Governing Data, 2019; NCSL, 2018). With 11 of these states and the District of Columbia also legalizing recreational marijuana use (Governing Data, 2019; National Conference of State Legislatures [NCSL], 2019). Due to this widespread legalization, commercial growers of marijuana have been able to significantly improve the potency (THC content) of their marijuana containing products (Cabrera, 2016). Thus, states like Colorado now has one of the highest marijuana potency levels in the United States (Cabrera, 2016). As commercial growers can now produce marijuana strains with potency levels that can average between 6% to 28% in THC (Cabrera, 2016).

These higher levels of THC are of concern for researchers and public health officials as adolescents and young adults may be more affected psychologically (American Psychological Association [APA], 2015; Meier, 2012). Although numerous studies have been conducted to assess the effects of low THC levels (4% to 13%), few studies have been conducted to assess the effects of these higher THC levels (6% to 28%) (Cabrera, 2016; Ramaekers et al., 2006). Since lower levels of THC have been

demonstrated to have an impact on health then one would expect higher doses to have a more profound effect. Nevertheless, since legalization only began recently then time has not permitted adequate study of the effects associated with high potency marijuana. This lack of research demonstrates a gap in the knowledge that needs further study. An indication of this gap is further justified in an article presented by the American Psychological Association, wherein the author posited that "what's clearly lacking and sorely needed are studies that look at the effect of increased potency, and different modes and methods of use, on brain-related measures" (Weir, 2015, p.48). Therefore, further justify the purpose of the study which is intended to address the effects of marijuana on mental health conditions since potency has increased.

Addressing the modes and methods of use is another area of concern that may well provide support for this gap in the research. For instance, one method of use results in the production of highly concentrated resins (Weir, 2015). These resins contain even higher concentrations of THC than the high potency marijuana strains that are currently being produced (Weir, 2015). Thus, resins produced from high potency marijuana would be expected to have an even higher concentration of THC. Production of these concentrated resins could further compound the issues surrounding the future of marijuana use and the potential repercussions on health. The aim of this study is to provide a broader understanding associated with continued marijuana legalization and rising THC levels. The results of these efforts may also serve to inform the effects associated with concentrated resins and other methods of use that increase marijuana potency.

NIDA (2016) reported that many marijuana users experience feelings associated with relaxation and euphoria while other users may experience anxiety, fear, distrust, or panic. Additionally, higher doses of marijuana have been associated with symptoms of acute psychosis (NIDA, 2016). These symptoms are more profound and include hallucinations, delusions, and a loss personal identity (NIDA, 2016). NIDA further posited that "these effects are more common when too much is taken, the marijuana has an unexpectedly high potency, or a user is inexperienced" (para. 3). These concerns provide support and justification for this study which is intended to explore the relationship between marijuana legalization and the higher levels of THC in marijuana products and the effects on mental health. The primary gap in the knowledge that this study intends to address is the effect of marijuana legalization and the relationship between rising THC levels (intensity of marijuana affects) and any association with mental illness which has not been studied in a nationally representative sample.

In this study, I assessed the association between the continued widespread legalization of marijuana on mental health. More specifically, I compared an early period in marijuana legalization when only a few states had implemented MML to a later period in marijuana legalization, when several states have MMLs with many also implementing RML. At this point, it is important to emphasize that MML refers to a comprehensive medical marijuana program that allows the use of both CBD products and smokable THC products (National Conference of State Legislatures [NCSL], 2018). However, some states only have limited CBD laws and these states are not included among states with comprehensive Medical Marijuana Laws (NCSL, 2018).

Marijuana has become increasingly more available to the general public as legalization spreads across the country. Since the implementation of MML, a sort of *quasi-legalization* has occurred making highly potent marijuana more available to those who otherwise might not have access (Salomonsen-Saulel, et al., 2012). Quasi-legalization refers to the diversion of MML. More specifically, Salmonsen-Saulel et al. (2012) describes this diversion of MML as "the process in which a supply of marijuana recommended for one person is given, traded, or sold to someone else who is not a registered medical marijuana user" (para. 5). This is process is examined in a study by Salomonsen-Saulel, et al., (2012), in which the researchers used several tools to measure and analyze adolescent use of medical marijuana among patients treated at two substance abuse facilities in Denver, Colorado. The results of this study demonstrated that many adolescents, approximately 74% of the 164 adolescents in treatment, had used medical marijuana obtained from registered medical marijuana patients (Salomonsen-Saulel, et al., 2012). Thus, demonstrating a high rate and widespread pattern of medical marijuana use by the non-patient recreational using population (Salomonsen-Saulel, et al., 2012).

In 2019, 33 states and the District of Columbia plus Guam and Puerto Rico have passed laws legalizing medical marijuana, with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018; NCSL, 2019). Table 1 provides a timeline for the legalization of both medical and recreational marijuana by state. I began with 2008 since I analyzed the years 2008 and 2017 to assess the effects of legalization on mental health. In 2008, only 13 states and the District of Columbia had implemented laws legalizing marijuana use for

medical purposes only (Governing Data, 2018; NCSL, 2019;). Whereas, in 2019, 33 states and the District of Columbia had medical marijuana laws with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018; NCSL, 2019).

Table 1

Medical & Recreational Marijuana Legalization Timeline by State

Year	Medical Marijuana Laws	Recreational Marijuana Laws
2008	California (1996, 2003); Alaska, Oregon & Washington (1998); Maine (1999); Colorado, Hawaii & Nevada (2000); Montana & Vermont (2004); New Mexico & Rhode Island (2007); Michigan (2008);	
2009	New Jersey & Washington D.C.	
2010	Arizona	
2011	Delaware	
2012	Connecticut & Massachusetts	Colorado & Washington
2013	Illinois & New Hampshire	
2014	Maryland, Minnesota, & New York	Alaska, Oregon, & Washington D.C.
2016	Arkansas, Florida, North Dakota, Pennsylvania, & Ohio	California, Nevada, & Massachusetts
2017	West Virginia	
2018	Oklahoma, Missouri, & Utah	Vermont, Michigan
2019	Louisiana	Maine

Note. From "State Medical Marijuana Laws," by National Conference of State Legislatures, 2019, Retrieved from http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx

Some states with no marijuana laws approved do allow access for special situations. For instance, Alabama and Mississippi permit access for severe epileptic conditions (Governing Data, 2018). Another special situation is Virginia, which enacted laws years before most states that allow individual possession of marijuana if prescribed by a physician (Governing Data, 2018). However, federal law does not allow physicians to prescribe marijuana but, doctors can write a recommendation for medical marijuana (Governing Data, 2018). In addition, several states have CBD only laws that allow the use of products that are high in CBDs but low in THC (Governing Data, 2018). At present, only Idaho, South Dakota, Kansas, and Nebraska do not have access to a public marijuana program of any type (medical or recreational) (NCSL, 2019). Table 2 provides a breakdown of states which allow limited medical marijuana products for specific conditions.

Table 2

Limited Medical Marijuana Products [Low THC/High CBD-cannabidiol]

State	Year	Specific Conditions
Florida	2014	Cancer, and medical conditions or seizure disorders treatable with low THC products
Kentucky	2014	Intractable Seizure Disorders
Mississippi	2014	Debilitating Epileptic condition or related illness
Missouri	2014	Nonresponsive Intractable Epilepsy
North Carolina	2014	Intractable Epilepsy
South Carolina	2014	Lennox-Gastaut Syndrome; Dravet Syndrome (Severe Myoclonic Epilepsy of Infancy); or any other form of Refractory Epilepsy;

State	Year	Specific Conditions
Tennessee	2014	Intractable Seizure conditions
Utah	2014	Nonresponsive Intractable Epilepsy
Wisconsin	2014	Seizure Disorders
Georgia	2015	Cancer (end stage); Amyotrophic Lateral Sclerosis; Multiple Sclerosis; Seizure Disorders; Crohn's; Mitochondrial Disease; Parkinson's; Sickle Cell disease
Idaho	2015	Cancer; Amyotrophic Lateral Sclerosis; Seizure Disorders; Multiple Sclerosis; Crohn's Disease; Mitochondrial Disease; Fibromyalgia; Parkinson's Disease or Sickle Cell Disease
Oklahoma	2015	Minors with Lennox-Gastaut Syndrome, Dravet Syndrome, or other severe Epilepsy
Wyoming	2015	Intractable Epilepsy or Seizure disorders
Texas	2015	Intractable Epilepsy
Alabama	2016	Debilitating Epileptic conditions; life-threatening Seizures; Wasting Syndrome; Chronic Pain; Nausea; Muscle Spasms; any other sever condition resistant to conventional medicine
Pennsylvania	2016	Amyotrophic lateral sclerosis; Anxiety disorders; Autism; Cancer, including remission therapy; Crohn’s disease; Damage to the nervous tissue of the central nervous system (brain-spinal cord) with objective neurological indication of intractable spasticity, and other associated neuropathies; Dyskinetic and spastic movement disorders; Epilepsy; Glaucoma; HIV / AIDS; Huntington’s disease; Inflammatory bowel disease; Intractable seizures; Multiple sclerosis; Neurodegenerative diseases; Neuropathies; Opioid use disorder for which conventional therapeutic interventions are contraindicated or ineffective, or for which adjunctive therapy is indicated in combination with primary therapeutic interventions; Parkinson’s disease; Post-traumatic stress disorder; Severe chronic or intractable pain of neuropathic origin or severe chronic or intractable pain; Sickle cell anemia; Terminal illness; Tourette syndrome.

State	Year	Specific Conditions
Indiana	2017	Resistant Epilepsy
Virginia	2017	Intractable Epilepsy

Note. From "State Medical Marijuana Laws," by National Conference of State Legislatures, 2019, Retrieved from http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx; "Wisconsin Medical Marijuana Laws and Regulations," Americans For Safe Access, 2019, Retrieved from https://www.safeaccessnow.org/wisconsin_medical_marijuana_laws_and_regulations; Marijuana Policy Project (MPP) (2019). "Virginia's Limited CBD and THC-A Oil Law," Marijuana Policy Project, 2019, Retrieved from https://www.mpp.org/states/virginia/virginias-limited-cbd-and-thc-a-oil-law/; Wenner, D. (2019). "These 23 conditions can qualify you to get medical marijuana in Pa," by Wenner, 2019, Penn Live-Patriot News. September 3, 2019

Purpose

The purpose of this study was to provide a greater understanding of the relationship between marijuana use, legalization and the availability of highly potent marijuana and the effects on mental health. As previously indicated, since legalization the THC level of marijuana can now range from 6% to 28 % as oppose to pre-legalization lower potency levels that typically ranged between 4% to 13 % (Cabrera, 2016; Ramaekers, et al., 2006). To my knowledge, there have been relatively few studies conducted post legalization to investigate the potential effects of higher THC levels. Thus, the originality of this study or gap in the research associated with this study is based on the premise that most previous studies were conducted based on pre-legalization low THC levels. However, these studies may prove to be obsolete to informing the public and health care professionals in the future especially when considering the rising THC levels, current trend in attitude and continued legalization of high potency marijuana. I used quantitative secondary data and logistic regression analysis to assess the association

between marijuana legalization, highly potent marijuana use and mental health conditions like depression and suicide ideation (see Center for Disease Control [CDC], 2015).

The results of this study are intended to provide relevant information for future use to advise and/or inform health care professionals and public health personnel who deal with the health and medical needs of the THC using population. They are also intended to inform policy makers in states that have legalized marijuana and those considering marijuana legalization. The general population may also gain knowledge of the risk associated with high potency legalized marijuana use from this study.

Theoretical Frameworks

There are several theoretical models developed for understanding drug use, abuse, prevention, and cessation. For instance, there is a growing body of evidence supporting the association between self-medicating with marijuana and depression (see Shonesy et al., 2014). In addition, research supports the use of the social ecological model to understand substance use and abuse from a multifaceted perspective (American College Health Association [ACHA], 2018). Therefore, for the purpose of this study, the self-medication theory of addiction and social ecological model served as the conceptual framework.

The self-medication theory of addiction developed by Khantzian (1977, 1974), is a theory with over 30 years of use in research (Hall & Queener, 2007). This hypothesis suggests that individuals who are afflicted with substance abuse may also have a predisposition for psychological conditions or psychosis (Burnett & Reiman, 2014). An example appropriate to the aim of this study is described by Hallowell a physician

experience with attention deficit hyperactivity disorder (ADHD); (Khantzian, 2003). Per Hallowell, marijuana has been described as having both stimulating and sedating properties that appeal to individuals with ADHD (Khantzian, 2003). Thus, individuals with this condition presumably use marijuana for these properties to counter the restlessness and emotional instability associated with ADHD (Khantzian, 2003).

In a related study, Shonesy (2014) explored the relationship between mental health conditions like depression and anxiety, and receptors that respond to THC in the central nervous system. This system is known as the endocannabinoid system and is medicated by two cannabinoid receptors, CB1 & CB2 (Shonesy et al., 2014). These receptors respond to both endogenous and exogenous stimulation (Shonesy et al., 2014). Natural endogenous stimulation of CB1 receptors occurs through one of two THC-like, anandamide (AEA) and 2-arachidonoylglycerol (2-AG) (Shonesy et al., 2014). According to Shonesy et al., this system "is heavily implicated in the modulation of anxiety and depression" (p. #). For instance, the THC in marijuana is capable of binding CB1 receptors of the system and affecting mood (Shonesy et al., 2014). Such that reduced stimulation of these receptors results in mood destabilization and increased feelings of anxiety and depression (Shonesy et al., 2014). Thus, marijuana users who suffer from these conditions may not be able to synthesize enough of THC-like molecules (particularly 2-AG) so they use marijuana to compensate (Shonesy et al., 2014). Research suggests that individuals may actually self-medicate without knowing it to compensate for their inherent low levels of THC-like molecules (Curry, 2014; Shonesy et al., 2014). These concepts are revisited in Chapter 2.

In contrast, the social ecological model (SEM) is a theory-based multifaceted approach to understanding the dynamics associated individual and population level determinants of health (American College Health Association [ACHA], 2018). The SEM theorists recognize that health is determined by influences from multiple societal and environmental factors that affect the individual (ACHA, 2018). According to SEM, the dynamic interrelationships between five levels or factors of health determinants are significant and essential to the health behaviors of the individual (ACHA, 2018). These five levels include (a) individual, (b) interpersonal, (c) organizational/institutional, (d) community, and (e) policy (CDC-SEM, 2018). The first level is concerned with sociodemographic (i.e., age, gender, religion, etc.) and intrapersonal factors or characteristics such as knowledge, beliefs, attitudes, and behaviors of the individual that affect health decisions and outcomes (ACHA, 2018; CDC-SEM, 2018). The second or interpersonal level is concerned with close personal relationships or associates that influence the behavior and contributes to the life experience of the individual (ACHA, 2018; CDC-SEM, 2018). This can include family members, friends, coworkers, health care providers, and community health workers (ACHA, 2018; CDC-Socioecological Model [SEM], 2018). The third level is concerned with local organizations and institutions that affect individual and population health by influencing organizational systems and policies (ACHA, 2018; CDC-SEM, 2018). This includes health care systems, state and local health departments, professional organizations, and healthcare plans (ACHA, 2018; CDC-SEM, 2018). The fourth level explores community and social relationships that influence individual health determinants. This can include

employers/worksites; businesses such as bars and restaurants; community-based organizations; the media; and community; state; and regional organizations (ACHA, 2018; CDC-SEM, 2018). The final or fifth level is associated with interpreting and implementing local, state, national, and federal laws and policies (ACHA, 2018; CDC-SEM, 2018). This level is of particular interest to this study especially given the current trend in marijuana policies that favor relaxed laws and increased community acceptance of legalization for recreational and medicinal purposes. Therefore, this model can be used to inform states' local marijuana policies and may serve to inform the implementation of federal laws and regulations as well.

Research Questions

RQ1: Is marijuana use associated with depression and suicidal ideation in adults in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ2: Is marijuana use associated with depression and suicidal ideation in adolescents in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ3: Are the associations between marijuana use and depression and between marijuana use and suicide ideation higher in 2017 than in 2008 for both adults and adolescents, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

Study Hypotheses

In accordance with the study research questions, the hypotheses for this study, each stated in null form, were as follows.

For the 2008 data:

$H_0$1: There will be no statistically significant relationship between marijuana use and depression (major depressive episode in the last year) in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$2: There will be no statistically significant relationship between marijuana use and suicidal ideation in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$3: There will be no statistically significant relationship between marijuana use and depression (major depressive episode in the last year) in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$4: There will be no statistically significant relationship between marijuana use and suicidal ideation in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For the 2017 data:

$H_0$5: There will be no statistically significant relationship between marijuana use and depression (major depressive episode in the last year) in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$6: There will be no statistically significant relationship between marijuana use and suicidal ideation in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$7: There will be no statistically significant relationship between marijuana use and depression (major depressive episode in the last year) in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$8: There will be no statistically significant relationship between marijuana use and suicidal ideation in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For comparing 2008 and 2017 data:

$H_0$9: There will be no statistically significant increase in the strength of the relationships between marijuana use and depression (Major Depressive Episode in the last year) in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$10: There will be no statistically significant increase in the strength of the relationships between marijuana use and suicidal ideation in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$11: There will be no statistically significant increase in the strength of the relationships between marijuana use and depression (Major Depressive Episode in the last year) in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

$H_0$12: There will be no statistically significant increase in the strength of the relationships between marijuana use and suicidal ideation in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

Nature of the Study

For this study, I used a quantitative secondary data analysis using archived data. Logistic regression was used to assess the association between the predictor variable, marijuana and the response or outcome variable, mental health (see CDC, 2015). The analysis also used multiple logistic regression to analyze any associations between "no marijuana use" and "marijuana use" on mental health conditions like depression and suicide ideation based on national marijuana legality status. The study considered increasing marijuana potency that has risen drastically since legalization as a potential reason for increased mental health conditions from marijuana use (see CDC, 2015). The study data for 2008 and 2017 were collected by the National Survey on Drug Use and Health (NSDUH) datasets, which consisted of responses from 67,928 and 68,032 participants respectively, in the target population sample sizes (National Survey on Drug

Use and Health [NSDUH]-codebook, 2008; NSDUH-codebook, 2017). These were noninstitutionalized civilians 12 years and older living in the United States at the time of the survey (NSDUH-codebook, 2008; NSDUH-codebook, 2017).

Operational Definitions

Throughout this dissertation, terminology specific to this topic may not be familiar to the reader. Therefore, the following terms have been defined for clarification:

2-arachidonoylglycerol (2-AG): A natural ligand, 2-arachidonoylglycerol specifically activates CB1 receptors of the endocannabinoid system (Shonesy et al., 2014) Low levels of this ligand are associated with increase anxiety and depression as demonstrated in animal and human studies (Shonesy et al., 2014).

Anandamide (AEA): Anandamide is a THC-like ligand found naturally (endogenous) in the human body interacts with cannabinoid receptors of the endocannabinoid system (Shonesy et al., 2014).

Cannabidiol (CBD): Cannabidiol is a cannabinoid found in cannabis (marijuana) and is preferred for its medicinal value and is used to treat various conditions(Atakan, 2012). CBD also interacts with the endocannabinoid system of the body (Atakan, 2012). However, CBD does not bind CB1 receptors and therefore does not have psychoactive properties. CBD is used to reverse effects of marijuana-induced psychosis (Atakan, 2012).

Cannabis: Cannabis refers to a subspecies of plant, *Cannabis Indica* and *Cannabis Sativa* of which C. Sativa is preferred by users for its high THC content (Atakan, 2012).

Δ9-tetrahydrocannabinol (THC): one of many cannabinoids found in cannabis (marijuana) and is primarily responsible for the psychoactive effects that recreational users seek (Atakan, 2012). Binds to CB1 receptors in the brain and central nervous system acting as a partial agonist to elicit its effects (Atakan, 2012).

Dabbing: Dabbing is a slang term used to describe a method of using marijuana concentrates (i.e. wax) that involves conduction as the form of heating (Krauss et al., 2015). In this process the user heats the dab (marijuana or BHO concentrate) to a high temperature using a torch on a conduction surface or "hot plate" which is typically a nail; the user then inhales the vapor produced (Krauss, et al., 2015).

Depression: Depression is operationally defined as a state of an individual "who reported that during the past 12 months they had a period of depression lasting 2 weeks or longer, while also having some of the other symptoms mentioned, were classified as having past year depression" (NSDUH-codebook, 2015, p. 848).

Endocannabinoid system: Endocannabinoid system "refers to endocannabinoids and the proteins that regulate their production and degradation, as well as to the receptors through which they signal" (Silvestri & Di Marzo, 2013, para. 2).

Endogenous: Endogenous refers to the bodies naturally occurring ligands, molecules, and substances (Onaivi, Sugiura, & Di Marzo, 2005; Shonesy et al., 2014). Such as the naturally occurring cannabinoids that interact with the endocannabinoid system (Onaivi, Sugiura, & Di Marzo, 2005; Shonesy et al., 2014).

Exogenous: Exogenous refers to ligands, and other molecules and substances that are produced outside the body but are capable of interacting within the body (Onaivi,

Sugiura, & Di Marzo, 2005; Shonesy et al., 2014). Such as the THC in marijuana that interacts with receptors of the endocannabinoid system (Onaivi, Sugiura, & Di Marzo, 2005; Shonesy et al., 2014;).

Marijuana (aka cannabis): Marijuana "refers to the dried leaves and flowers from the cannabis plant which contain the mind-altering chemical delta-9-tetrahydrocannabinol (Δ9-THC) and other related compounds" (Addiction Policy Forum, 2019, para. 1).

Marijuana use: For the purpose of this study, marijuana use refers to frequency of use and states legality status (only medical marijuana legal; both recreational and medical marijuana legal; no legal marijuana status), as detailed in Chapter 3.

Rhabdomyolysis: Rhabdomyolysis is muscle injury/damage leading to breakdown and release of these contents which can in turn serious health complications such as renal failure (WebMD, 2019).

Schedule I Narcotic: A Schedule I Narcotic is a substance or chemical that does not have a currently accepted medical use and has a high potential for abuse (Drug Enforcement Agency, 2018). Examples of these drugs/narcotics include: marijuana, heroin, lysergic acid diethylamide (LSD), ecstasy (3,4-methylenedioxymethamphetamine), methaqualone, and peyote (DEA, 2018).

Vaping: Vaping is a slang term used to describe a method of using marijuana, marijuana products such as butane hash oil (BHO), CBD oils, synthetic marijuana and nicotine use in e-cigarettes (Budney, Sargent & Lee, 2015; Yang et al., 2018). During the vaping process, the substance to be used (liquid, oil, or plant material) is vaporized using

convection heat which releases the aerosolized active ingredients of the desired substance (i.e. THC) in the form of a water vapor mixture that is inhaled by the user (Budney, Sargent & Lee, 2015; Lepkoff, 2018; Yang et al., 2018).

Assumptions

There are several assumptions associated with this study that must be considered when reviewing the results. The first two assumptions are concerned with the sampling method as this study used secondary data. Therefore, one assumption is that the NSDUH survey provides an adequate national sample that is representative of the U.S. population. Second, since the NSDUH survey uses self-reporting then recall bias and honesty in survey responses are a serious concern. I therefore assumed that research participants answered questions truthfully and to the best of their ability, as recall bias and dishonest answers can limit the reliability and of study results (see Davis et al., 2013). Another assumption is concerned with the legal status of states under consideration and their geographical location to other states with differing laws. This is an important concern, as states with relaxed marijuana laws and policies that border states without marijuana laws may significantly affect the data obtained in the states without marijuana laws. I assumed that bordering states had no effect and the marijuana laws in the state of interest is the primary source of influence on the data obtained in the NSDUH survey.

Scope and Delimitations

The scope of this study was concerned with the association between legalization and the relaxation of marijuana policies that have made high potency marijuana more readily available. This study was intended to assess the effect of marijuana policy on

mental health. The study was limited to respondents of the 2008 and 2017 NSDUH, which included 67,928 and 68,032 respondents respectively, in the target population sample sizes (NSDUH-codebook, 2008; NSDUH-CODEBOOK, 2017). These were noninstitutionalized civilians 12 years and older living in the United States at the time of the survey (NSDUH-codebook, 20008; NSDUH-CODEBOOK, 2017).

Limitations

There are a several limitations associated with this study. First, since this study used secondary data, one possible limitation is residual confounding which can occur when variables that are critical to the current study have been omitted from the data set being used (see LaMorte & Sullivan, 2016). For instance, variables deleted to protect the confidentiality of the respondents. Therefore, data such as race, names of respondents, and zip codes that are important to the intended study may have been deleted. Residual confounding can also occur when data collected on variables of interest is not precise enough for the current study, or when no attempt is made to adjust for confounding factors as would be the case when critical variables are not included in the dataset (LaMorte & Sullivan, 2016). Another limitation is associated with the NSDUH survey which uses self-reporting to gather data on the participants. This is a concern because the reliability of self-reporting on sensitive issues like substance use and mental health issues is questionable as respondents may not be truthful due to the potential stigma associated with substance use (Davis et al., 2013). In addition, self-reporting may also be subject to recall bias and memory bias that would further limit the reliability of study results.

(Hasan, 2005). And finally, the cross-sectional nature of this study may limit inferences on causality as observations are made at one point in time (Davis et al. (2013).

Additionally, there is another potentially limiting factor associated with the NSDUH. The survey does not differentiate between the marijuana patient and nonpatient populations participating in the study (Wen, Hockenberry, & Cummings, 2015). Thus, the spillover effect may not solely reflect an increased marijuana use among registered marijuana patients as the non-patient or recreational using population may potentially contribute to a greater percentage of the individuals participating in the study (Wen et al., 2015). This limitation is evidenced in a study by Wen et al. (2015) which indicates that, among the states studied with MMLs, medical marijuana patients comprised only 0.8% of the total population.

Significance of the Study

There is a growing body of evidence supporting the association between cannabis use and the development of psychosis and mental health disorders (Moore et al., 2007). However, few studies have addressed this association since the rise in THC demonstrated post legalization. From a public health stance, addressing this concern is essential as individual with marijuana use disorder are likely to continue use despite findings of clinically significant conditions such as mental health disorders (NIDA, 2016). For many years, substance abuse and substance dependence were considered two separate categories. However, in 2013 the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) was updated such that abuse, and dependence are classified under the category of substance use disorder (NIDA, 2016). In this case marijuana or cannabis use disorder.

Note, throughout this paper the terms marijuana and cannabis are used interchangeable and considered to have the same meaning. This will become evident as some scholarly sources used in the literature and other areas of this study use cannabis whereas other sources use marijuana.

Volkow et al., (2014) posited that previous research has demonstrated that anxiety, depression, and psychosis are associated with regular marijuana use. However, causality is not well founded as addressing this association is hindered by confounders that also contribute to the development of these conditions (Volkow et al., 2014). For instance, individuals with a family history of schizophrenia and psychosis have a greater risk of developing these conditions (Volkow et al., 2014). In addition, heavy use of marijuana, highly potent marijuana, and using marijuana at an early age also exacerbate the occurrence of mental health conditions like psychosis (Volkow et al., 2014). These findings provide additional support for the current study which intends to explorer the effects of marijuana legalization on rising THC levels (increased drug potency) and mental health conditions, such as depression and suicide ideation psychosis and mental illness.

Furthermore, several studies have demonstrated that heavy marijuana use has the potential to cause psychosis or exacerbate a pre-existing psychotic illness (Bushak, 2013; Sevigny, Pacula, & Healon, 2014). Bushak (2013) listed the following symptoms of marijuana induced psychosis: hallucinations, paranoia, confusion, and anxiety. One would expect marijuana with higher THC levels to have a more profound effect. This assumption was demonstrated in a study which found that in areas where marijuana was

legalized there was a statistical correlation between increased THC levels and hospital admissions for marijuana induced psychosis (Bushak, 2013). This conjectured relationship between marijuana use and psychiatric illness is an established area of interest. Previous epidemiological studies have demonstrated that there is an increased risk of developing psychiatric disorders such as schizophrenia, associated with increased frequency of marijuana use (see Kahn & Akella, 2009). Studies have also demonstrated that marijuana is the most commonly abused substance among individuals diagnosed with bipolar disorder (Kahn & Akella, 2009). In addition, Kahn and Akella (2009) indicated that short-term, intense use of marijuana can produce exacerbations of psychotic symptoms in those with preexisting conditions. In a related study, researchers surveyed marijuana users to assess the association between marijuana and the occurrence of psychotic like symptoms (Kahn & Akella, 2009). The results of this study revealed that psychosis-like symptoms were demonstrated in 15% of survey respondents (Kahn & Akella, 2009). The most common symptoms reported included hearing voices and unwarranted feelings of persecution (Kahn & Akella, 2009). Additional related symptoms of acute marijuana intoxication include depersonalization, fear of dying, irrational panic, and paranoid ideas (Kahn & Akella, 2009). Thus, knowing how marijuana effects psychosis is also important to informing the community as well as health care and public health professionals.

As indicated, previous studies have demonstrated that brief episodes of psychosis can lead to more serious psychotic disorders, such as schizophrenia, which causes the most severe health loss of all human disorders affecting how these individuals think, feel,

and behave, and many of these patients seem to lose touch with reality (NIH, 2016). This disorder not only impacts the health of the individual but also impacts the community and effects public health (NIH, 2016), (Schoeler, Petros, & Forti, 2016). Thus, knowing how marijuana effects mental health is particularly important to the formulation of evidence-based health policies concerned with marijuana use (Schoeler et al., 2016). This is especially important considering changing public attitudes and continued legalization of marijuana (Schoeler et al., 2016). In addition, psychotic disorders such as schizophrenia are associated with a significant financial burden and are also associated with a high rate of comorbid abuse of marijuana (Schoeler et al., 2016). Therefore, knowing how marijuana effects mental conditions is important to inform policy makers and practitioners to reduce the burden of these conditions and the impact on the health of individual users, as well as public health, and the community at large (Schoeler et al., 2016). Furthermore, understanding the potential effects of increasing THC levels is essential as most studies addressing these concerns were conducted based on pre-legalization lower THC levels.

As previously stated, this research project addressed a gap in the literature by providing a better understanding of the relationship between marijuana legalization, highly potent marijuana, and the indicated variables associated with mental conditions like depression and suicide ideation. The results of this study can support professional practice by expanding the body of knowledge available to health care and public health professionals, thereby informing the practical applications addressing this concern. In addition, as indicated practical applications of the research may be demonstrated in the

form of policy making and the development of informational campaigns. These efforts may also serve in the development of training programs for personnel involved with informing the public about the responsible use of marijuana.

Finally, it is also important to understand that the effects of marijuana have a more profound neurological effect in those who started persistent use at an early age versus those who started smoking in adulthood (APA, 2015). Studies have also demonstrated that approximately 9% of adults who use marijuana become addicted versus 17% for those who began smoking as teenagers (Weir, 2015). Thus, marijuana producers have added incentive to market their product to younger users. (Weir, 2015). Therefore, I focused on younger generations for this study with the premise of effecting positive social change as a return on investment in future generations. In addition, this study is intended to contribute to positive social change by providing information relevant to informing the development of policy on states marijuana legality status and the development of evidence-based health policies as well as training programs for personnel involved with informing the public about the responsible use of marijuana.

Summary and Transition

Marijuana use is associated with both mental health issues and psychosis or psychotic events (Moore et al. 2007). Nationwide marijuana laws vary by state as 33 states and the District of Columbia plus Guam and Puerto Rico have passed laws legalizing medical marijuana with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018). Wherein, widespread marijuana legalization and the relaxation of marijuana

policies has made high potency marijuana more readily available (Sevigny et al., 2014). This study is intended to assess the effect of marijuana policy on mental health conditions like depression and suicide ideation. Chapter 2 will provide a more detailed synthesis of available literature related to the epidemiology of marijuana use and the effects on mental health and psychosis. In Chapter 2, the following topics are discussed: history of marijuana, marijuana in the United States, health effects of marijuana use, marijuana legalization and potency, marijuana and mental health disorders, marijuana and psychosis, therapeutic effects of marijuana on mental health, the endocannabinoid system, and lessons learned from states with legalized marijuana.

Chapter provides an in-depth description of the research design and statistical analysis of the NSDUH data set. In addition, Chapter 4 presents an analysis of the data explored. And finally, Chapter 5 presents the final summary of these findings, provide a discussion, comparison to current literature, and addresses recommendations for future research.

Chapter 2: Literature Review

Introduction

In the United States, substance abuse and addiction cost the American taxpayer over $700 billion dollars a year (NIDA, 2016). This spending is related to the increased cost of health care, loss of productivity and earnings in the workplace, and crime associated with theft, drugged driving, accidents, violence, and child abuse (NIDA, 2016; NIDA-Magnitude, 2017). The consequences of substance abuse are evidenced by approximately 90,000 Americans that die every year as a result of illicit and prescription drug and alcohol use (NIDA, 2016). Thus, substance abuse is an important public health concern that has a prodigious impact on our society.

Among the substances of abuse, marijuana is by far the most commonly used as n 2018, approximately 43 million Americans reportedly used marijuana in the past year (Statista, 2019). Among these were approximately 11.8 million young adults that reported using marijuana in the past year in 2018(NIH-NIDA, 2019). Additionally, marijuana is second only to alcohol for the highest rates of dependence and abuse, and in 2013 statistics indicated that with exception to marijuana and methamphetamine, the rate of use for all other drugs had stabilized or declined (NIDA-Nationwide Trends, 2015). This includes prescription drugs (i.e. pain relievers, tranquilizers, stimulants, and sedatives); hallucinogens (i.e. ecstasy and LSD); and cocaine (NIDA-Nationwide Trends, 2015). And as indicated, methamphetamine use increased between 2010 to 2013 (NIDA-Nationwide Trends, 2015).

In 2016, the NIDA reported the following rates of marijuana use among high school students: "5.4 percent among 8th graders, 9.8 percent among 10th graders, and 14.3 percent among 12th graders" (NIDA-Monitoring the Future Survey, 2016, p. or para. #). In contrast, the overall trend for "past-year prevalence of marijuana use was 4.1% (SE, 0.15) in 2001-2002 and 9.5% (SE, 0.27) in 2012-2013, a significant increase ($P < .05$)" (Hasin et al., 2015, p. #). An interesting finding that may prove relevant to this current study is that the highest rates of marijuana use was observed in states where marijuana has been legalized for medicinal purposes (NIDA-Monitoring the Future Survey, 2016).

This quantitative study focused on the use of high potency marijuana and the association with mental health disorders as it pertains to state marijuana legality status after controlling for age, sex, and socioeconomic status. Since the legalization of marijuana, the level of THC has been rising in medical and recreational marijuana (Cabrera, 2016). Thus, the purpose of this study is to provide a better understanding of the relationship between highly potent marijuana use and the indicated variables—depression and suicide ideation. The level of THC in marijuana has been increasing in potency since legalization began in 2012 (Cabrera, 2016). Since THC elicits the desired psychological effects most marijuana users seek, addressing this concern now is particularly important. Additionally, as of 2019, 33 states and the District of Columbia plus Guam and Puerto Rico have passed laws legalizing medical marijuana with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018).

Literature Review Strategy

Part of my strategy for this literature review included using the following search terms and/or phrases: *marijuana; THC levels; mental health disorders; psychosis; substance use, abuse and misuse; marijuana and THC levels; THC levels and legalization; marijuana and mental health disorders; history of marijuana; health effects of marijuana; marijuana and psychosis; adolescents, young adults and marijuana; at risk behavior; personality traits; quasi-legalization; de facto legalization of marijuana; marijuana distribution and trafficking; methods of marijuana use; vaping; dabbing; and consumption of marijuana/cannabis-infused edibles*. The search was limited to articles or text written in English from the following search engines or sources: Google and Google Scholar, Walden University library, ProQuest, SAGE Premier, Academic Premier database, MEDLINE, CINHAL Plus, and Science Direct Database.

This literature review also includes a history of marijuana in the United States, which will cover drug scheduling or classification, consumption, and medicinal use. In addition, the literature review was organized to discuss the following topics: physical, psychological and pharmacological effects of marijuana; an understanding of mental health and psychosis; rising THC levels and improved growing techniques since legalization; increasing/Rising emergency room and hospitalizations post legalization and association with rising THC levels (pre- vs. post legalization comparisons); marijuana and employment in zero tolerance environments (post legalization); marijuana and public health; substance use versus abuse; trends in marijuana consumption; at risk groups (high usage groups & age ranges); implications of marijuana legalization; previous studies on

association between marijuana, mental health disorders and psychosis; and marijuana distribution and preference.

History of Marijuana

Understanding the history of marijuana is an important aspect of this study. Thus, human consumption and utilization of marijuana (cannabis) began around 10,000 BC during the Neolithic period or the "dawn of agriculture" (Lee, 2012, p. 3). These early people realized the versatility of this resource and cultivated marijuana making use of the entire plant for various purposes. For instance, Lee (2012) posited that the plant's stem and stalk are rich in fiber and were utilized to make cords/rope and clothing; the seeds in addition to providing a source for continued cultivation were also eaten as this portion of the plant provided a source of protein and essential fatty acids; finally, the roots, leaves, and flowers were utilized for both medicinal and ritualistic purposes. While the plant is native to central Asia, knowledge of its multiple uses as a tough fiber and therapeutic agent gradually spread around the world. Thus, use of this plant or herb spread from its early origins in the Kush region of the Himalayan foothills across Eurasia into northern Europe and beyond (Lee, 2012). Documentation of marijuana for medicinal purposes occurred in 2008, when a gravesite in northwest China was discovered containing well preserved marijuana flower tops. These flower tops contained THC, the psychoactive and pharmacological agent of marijuana (Lee, 2012). The researchers concluded that this was a demonstration that the plant was being cultivated for its psychoactive properties nearly 27 centuries ago (Lee, 2012). This determination is supported by Chinese history dating back to 2700 BC during the reign of Emperor Shen Nung, commonly called the father of

traditional Chinese medicine (Lee, 2012). During this period, marijuana was introduced as a drinking tea that was utilized for a host of ailments (Lee, 2012). According to Lee (2012), a few of these uses included "female weakness; gout; rheumatism; malaria; constipation; beri-beri, and absent-mindedness" (Lee, 2012, p.5). Thus, marijuana has a long-standing history with many uses among several cultures throughout the world.

Marijuana in the United States

In the United States, marijuana has experienced a controversial and highly debated path. For many years during the 1800s and early 1900s, marijuana had multiple medicinal uses in Western world medicine (Thomas, 2010). During this time, over 100 articles were published in American and European medical journals enthusiastically praising the herb's (marijuana) medicinal purposes (Thomas, 2010). In fact, in the United States marijuana was specifically recommended for several medical conditions and was prescribed on a regular basis until the late 1930s when the Marijuana Tax Act of 1937 was enacted (Thomas, 2010). This action resulted in a tax on marijuana for both medical purposes ($1 per ounce) and recreational or other purposes ($100 per ounce) Thomas, 2010). This tax act was viewed as deception by artful subterfuge in the form of a health care policy that required the completion of arduous and burdensome amounts of paperwork required to prescribe marijuana (Thomas, 2010). The process became so troublesome that physicians eventually stopped prescribing marijuana not long after the enactment of the Tax Act of 1937 (Thomas, 2010).

Then in 1970, during the Nixon administration, the Controlled Substance Act (CSA) was signed into law (Thomas, 2010). This action placed regulated substances into

one of five categories or schedules based on the substances medicinal value, potential for abuse, and psychological and physical effects (Thomas, 2010). Marijuana was initially placed in the Schedule I category, which is the highest category and the only one that prohibits all use of the substance whether medicinal or recreational. Other drugs placed in a schedule I category include: "heroin; ecstasy; Lysergic acid diethylamide (LSD); (γ-Hydroxybutyric acid) GHB; and peyote" (Thomas, 2010, para. 8). In contrast, the following substances were placed in a less restrictive Schedule II category, that allows medicinal use by prescription: "cocaine; codeine; OxyContin; and methamphetamine" (Thomas, 2010, para. 8). However, marijuana's categorization as a Schedule I narcotic was intended to be temporary pending additional reconsideration based on an upcoming report from the National Commission on Marijuana and Drug Abuse (Thomas, 2010). This study group was comprised of members appointed and commissioned by President, Nixon. The group was in favor of decriminalizing marijuana for personal possession and private use as well non-profit private distribution of the substance in small amounts (Thomas, 2010). However, President Nixon was adamantly opposed to this decision. Ultimately the president's opinion prevailed and to this day marijuana remains a Schedule I narcotic. Being classified as a Schedule I Narcotic means that the substance is not recognized as having any medical use in the United States (U.S. Department of Justice, 2017). It also means that the substance has a high abuse potential and cannot be used safely even under medical supervision (U.S. Department of Justice, 2017). Schedule I narcotics are considered the most dangerous and as a substance scheduling numeral increases, the less dangerous they are considered (U.S. Department of Justice, 2017). For

instance, substances classified as Schedule II Narcotics are considered less dangerous than those classified as a Schedule I Narcotic with drugs classified as Schedule V Narcotics being the least dangerous.

Health Effects of Marijuana Use

A current trend in attitude favoring marijuana use for medical and recreational purposes is growing. This is evidenced by reports indicating a decline in individuals who consider the occasional use (1-2 times per week) of marijuana as a perceived risk (Schuermeyer et al., 2014). For instance, in Colorado the percent of a those who believe marijuana use is a perceived risk declined from 45% to 31% between groups studied from 2007 to 2008 and those studied from 2010 to 2011, respectively (Schuermeyer et al, 2014). This trend was consistent for all age groups studied during these time frames. While medical marijuana was approved in Colorado in November 2000, it was not until 2012 that residents of Colorado voted for Amendment 64 legalizing marijuana for recreational use as 55% of voters approved (Monte, Zane & Kennon, 2015).

In light of this current trend in marijuana liberalization, it is important for policy makers, public health, and health care personnel to emphasize or reiterate the potential adverse effects of the substance. This is especially important given the rising THC levels seen in recreational marijuana and products produced from marijuana. It is also reasonable to assume that as legalization gains greater acceptance the use of marijuana will also increase and therefore so will the occurrence of adverse effects.

The adverse effects of marijuana include a host of considerations. For instance, despite the notion that marijuana is not addictive, evidence to the contrary is widely

available and risk of dependence is based on several factors (Volkow, Baler, Compton, Weiss, 2014). This understanding is based on the dependence criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, 4th ed. (DSM-IV). The DSM-IV dependence criteria indicate that approximately nine percent or 1 out of 11 individuals who experiment with marijuana will become addicted (Volkow et al., 2014). In contrast, for those who begin using marijuana in adolescents, approximately 16% or one out of six will become addicted and the same is true for approximately 25 to 50% of those who smoke marijuana daily (Volkow et al., 2014). Thus, among other factors the risk of dependence is based on age of initial use and regularity of use. However, these criteria were presumably set prior to or does not take into consideration the rising THC content of marijuana. Hence, demonstrating support for this current study which intends to address this gap in the literature (rising THC levels). This presumption is further supported by NIDA which posited that

> Researchers do not yet know the full extent of the consequences when the body and brain (especially the developing brain) are exposed to high concentrations of THC or whether the recent increases in emergency department visits by people testing positive for marijuana are related to rising potency. (NIDA – Marijuana, 2017, p. 16)

Addiction to marijuana is associated with the body's endocannabinoid system of neurotransmitters within the brain. This system is concentration dependent such that large amounts of marijuana can result in reduced sensitivity of this system which causes an increased dependence on marijuana. (NIDA-Marijuana, 2017).

When someone smokes or ingest marijuana, there are effects on both cognitive and motor functions. These effects can range from impairments associated with memory and perception of time to impairments in coordination (Volkow et al., 2014). Regular use can have long term consequences that affect education and professional accomplishments as well as affect one's social interaction (Volkow et al., 2014). These effects can be hazardous to the public as marijuana intoxication can affect one's ability to drive and therefore operate machinery. This is evidenced by driving simulation studies which demonstrate a dose dependent relationship between blood THC concentration and an increased risk of getting involved in an accident while driving (Volkow et al., 2014). The statistical analysis presented in Volkow et al. (2014) indicated that

> Persons testing positive for THC (typical minimum level of detection, 1 ng per milliliter), and particularly those with higher blood levels, were 3 to 7 times as likely to be responsible for a motor-vehicle accident as persons who had not used drugs or alcohol before driving. (para. 12).

Add summary and synthesis to fully integrate the quote into the paragraph and create a solid conclusion.

Consequently, marijuana has promising clinical applications for treatment of various conditions. According to Volkow et al. (2014) the following conditions are receptive to treatment with marijuana or other form of cannabinoid: "Glaucoma, Nausea, AIDS – associated anorexia and wasting syndrome, Chronic pain, Inflammation, and Multiple sclerosis" (Volkow et al., 2014, para. 1-7). These are only a few of the medicinal uses of marijuana as the substance has shown to be beneficial for many more.

Marijuana Legalization and Potency

Lab test reveal that the potency of marijuana in Colorado since legalization is more than twice as potent as illegal marijuana of the past ten years and some strains of legal marijuana is three times as potent (Briggs, 2015). Prior to legalization the levels of THC were typically below ten percent. However, research now indicates that the post legalization levels of Colorado's marijuana averages around 18.7 % with some marijuana strains containing THC levels of 30% or more (Briggs. 2015). These results were provided by Charas Scientific, a Denver based lab licensed and hired by the state to test and measure the THC levels of marketable marijuana (Briggs, 2015).

Samples were also tested for the amount of cannabidiol (CBD), which is the component in marijuana with medicinal value. These samples averaged around 0.1 percent CBD and many families have relocated to Colorado to obtain a strain of marijuana referred to as 'Charlotte's Web', which reportedly can control seizures due to its CBD concentration (Briggs. 2015). Thus, while CBD has the potential to control depression, anxiety, and pain; a product with little CBD that has high THC levels could potentially exacerbate these conditions and may even increase seizures (Briggs, 2015).

In a related study, Sevigny, Pacula & Heaton (2014) addressed the potency of medical marijuana that has reportedly increased since legalization. This increase in potency is presumably due to less restrained regulations that created an environment of improved cultivation and production techniques (Sevigny, Pacula & Heaton, 2014). The researchers identify two marijuana markets, medical and recreational, indicating that these markets are interrelated such that cross over in technological advances for

production and cultivation occurs (Sevigny, Pacula & Heaton, 2014). The authors further posited that surplus medical marijuana is being diverted to the recreational market (Sevigny, Pacula & Heaton, 2014). In fact, this reported diversion of marijuana has been documented by the Denver area drug trafficking program. This agency implicates marijuana dispensaries, registered marijuana receiving patients and licensed caregivers as potential sources of medical marijuana diverted to the recreational market (Sevigny, Pacula & Heaton, 2014). In a related study Salomonsen-Sautel, et al. (2012) presented evidence that adolescents in two Denver substance abuse treatment programs used medical marijuana obtained from registered medical marijuana patients. Thus, the effects of producing high-potency medical marijuana potentially impacts the quality and availability of these highly potent marijuana strains to the recreational using market.

To address the effects of medical marijuana on potency, Sevigny, Pacula & Heaton, (2014) utilized data obtained from approximately 39,000 marijuana samples seized from all 50 states and the District of Columbia. The data was retrieved from the Mississippi's Potency Monitoring Program (PMP) which measured and reported the THC content for all samples observed. The results of this study initially demonstrated a significant increase in marijuana THC content in jurisdictions that legalized marijuana for medical purposes (Sevigny, Pacula & Heaton, 2014). The study also completed four other models which gradually increased in sophistication with each model by the addition of control and other potentially competing variables (Sevigny, Pacula & Heaton, 2014). This sequential increase in model complexity or competitiveness resulted in a decrease in the effects on marijuana potency (Sevigny, Pacula & Heaton, 2014). For instance, while the

addition of observable control variables, such as states decriminalization status of marijuana, and state law enforcement policies, resulted in a slight reduction in model two. The relationship was still positive and statistically significant, approximately 1.5 percentage points higher THC content. As oppose to the remaining three models which demonstrated results that were not statistically significant, approximately 0.5 percentage points higher THC content.

This study is important to this study because it provides information relevant to the premise that marijuana acceptance, use, potency, and adverse effects have been on the rise. This is evident as the article presented by Sevigny, Pacula & Heaton (2014) referenced several studies that support the association between the rising THC levels in marijuana and a host of negative mental health consequences, such as psychosis and anxiety.

In another study, Salomonsen-Saulel, et al. (2012) addressed the extent of medical marijuana use by the non-registered (non-patient) marijuana using population. This was achieved by assessing adolescents in substance abuse treatment programs to determine the extent of medical marijuana use among this group (Salomonsen-Saulel, et al. (2012). This sort of *de facto legalization* is believed to occur because of loopholes in the regulations that allows surplus medical marijuana to find its way into the hands of the non-patient recreational marijuana using population (Anderson & Rees, 2014). For instance, in Colorado medical marijuana caregivers can have up to two ounces of marijuana on-hand for distribution and three mature growing plants for each patient the caregiver supplies (Wirfs-Brock, Seaton, & Sutherland, 2010). The mature plants can

produce more than one pound of marijuana per plant and since there are roughly 100,000 registered marijuana users in Colorado, that transpires into approximately 300,000 plants or 300,00 pounds (150 tons) of potential surplus marijuana. (Wirfs-Brock, Seaton, & Sutherland, 2010). In fact, the Colorado Department of Public Health and Environment estimates a 20 to 64-ton surplus and that's if the plants only produce three to eight ounces per plant as oppose to the 16 ounces per pound max yield per plant (Wirfs-Brock, Seaton, & Sutherland, 2010). Most of which is surplus based on current Colorado regulations and therefore subject to diversion to the non-patient recreational using population.

The study by Salomonsen-Saulel, et al. (2012) is based on the premise that legalizing marijuana for medical use promotes the perception that marijuana is safe for recreational use (Salomonsen-Saulel, et al., 2012). Thus, increasing acceptance and encouraging recreational use as the risk or the perception of harmful health consequences decreases (Salomonsen-Saulel, et al., 2012). This premise is in converse to those who would argue that medical marijuana laws have no effect on marijuana use. Nevertheless, studies have been conducted that support both positions (Salomonsen-Saulel, et al., 2012).

Participants for the study conducted by Salomonsen-Saulel, and colleagues consisted of 164 adolescents being treated at two substance abuse facilities in Denver Colorado (Salomonsen-Saulel, et al., 2012). Patients were referred to these facilities for treatment of 'conduct and substance use disorder' by one of the following: "social services, the juvenile justice system, primary care physicians, schools as well as self-admitted participants" (Salomonsen-Saulel, et al., 2012, para. 14). The results of this

study demonstrated that, approximately 74% of the 164 adolescents in treatment had used medical marijuana obtained from registered medical marijuana patients (Salomonsen-Saulel, et al., 2012). Thus, demonstrating a high rate and widespread pattern of medical marijuana use by the non-patient recreational using population. The results also revealed that the likelihood of medical marijuana use increased with decreasing age of onset of regular marijuana use (Salomonsen-Saulel, et al., 2012). Such that the younger participants began using marijuana the more likely they were to use medical marijuana. Additionally, while both the medical marijuana using and non-medical marijuana using groups were comprised of individuals with conduct disorder and substance use disorder. Salomonsen-Saulel (2012) reports a 16% increase in the likelihood of using medical marijuana corresponding to each additional symptom of conduct disorder; such that those who used medical marijuana had at least one more symptom of conduct disorder than those who did not use medical marijuana. Similar observations were made for participants with symptoms of substance abuse or dependence. In this instance, Salomonsen-Saulel (2012) reports a 31% increase in the likelihood of using medical marijuana corresponding to increasing symptoms of substance abuse or dependence.

Wen, Hockenberry, and Cummings (2015) conducted a related study entitled: The effect of medical marijuana laws on adolescent and adult use of marijuana, alcohol, and other substances use of marijuana, alcohol, and other substances in ten states with medical marijuana laws. This article is relevant to the current study because it presents information pertaining to the implementation of medical marijuana laws (MMLs) and the availability of high potency marijuana. Wen, Hockenberry, and Cummings (2015)

posited that MMLs are intended to provide medicinal use of marijuana to a select group of patients. However, the potential for *spillover* also allows the availability of these typically highly potent marijuana strains to the non-patient or recreational using population (Wen, Hockenberry, & Cummings, 2015). The process of obtaining legal access in states with MMLs, usually involves obtaining a recommendation from a qualified physician for a condition considered eligible under state specific MMLs (Wen, Hockenberry, & Cummings, 2015). After which the patient can obtain a state issued identification card for medical marijuana use. The patient is then allowed to have a certain amount of marijuana and may also cultivate marijuana at home. (Wen, Hockenberry, & Cummings, 2015). Additionally, the patient can also purchase marijuana from nonprofit retail dispensaries, also called *compassionate centers* in some states (Wen, Hockenberry, & Cummings, 2015). This spillover effect which makes these highly potent strains available to the non-patient population occurs via one of the following four methods: 1) Patients present to physicians requesting medical marijuana for a complaint of chronic pain which is difficult to confirm or refute, thus, individuals can deceive doctors and obtain prescription MM; 2) Poorly defined eligibility criteria in some states fail to adequately distinguish between patient and non-patient populations as some states do not use a 'registry/renewal' process to re-assess and establish eligibility on a continuous basis; 3) As with prescription opioids, medical marijuana makes its way to the non-patient population through patients with marijuana prescriptions; and 4) spillover occurs because MMLs tend to support or encourage marijuana acceptance which in turn results in a reduced risk of association for recreational marijuana use in these states; thus,

in areas with MMLs individuals may be more willing to use or experiment with marijuana. (Wen, Hockenberry, & Cummings, 2015). Therefore, MMLs can result in a sort of *de facto* legalization through which medical marijuana with a high THC content is made available to the non-patient or recreational using population (Anderson & Rees, 2014).

Wen, Hockenberry, and Cummings (2015) pooled cross-sectional data obtained between 2004 and 2012 from the National Survey on Drug Use and Health (NSDUH) to address the effect of MMLs on the use of marijuana, alcohol, and other hard drugs as well as pain medication misuse. This national and state represented survey is conducted among those 12 years of age and older and is considered an important source of information on substance use behavior within the non-institutionalized portion of this population (Wen, Hockenberry, & Cummings, 2015). The study used a self-administered audio computer-assisted self-interviewing (ACASI) method for interviewing because this approach is private and confidential and tends to promote honesty which is essential as substance use behavior is a sensitive subject (Wen, Hockenberry, & Cummings, 2015).

This study demonstrated that implementation of MMLs resulted in a parallel increase in past-month marijuana use among participants age 21 and older. These increases occurred immediately after MMLs were implemented and continued for three years after implementation. Conversely, this increase was not observed among participants aged 12 to 21. The relative increase was approximately 14% from baseline or 1.32 percentage points for those age 21 and older (Wen, Hockenberry, & Cummings, 2015). Bear in mind that the NSDUH data used by this study does not differentiate

between medical marijuana and non-medical marijuana populations. Nevertheless, among states with available data the registered medical marijuana using population comprised an average of 0.8 percent of the state population (Wen, Hockenberry, & Cummings, 2015). Thus, the results obtained is not entirely from registered marijuana users and tends to support the spillover effect of MMLs on the availability of highly potent marijuana to the recreational or self-medicating non-patient using population (Wen, Hockenberry, & Cummings, 2015). The results further demonstrate an increase in daily marijuana use among those age 21 and older while those aged 12-20 continued to demonstrate no increase in frequency of use in the past month (Wen, Hockenberry, & Cummings, 2015). However, for adolescents and young adults age 12 to 21 there was a 0.32 increase in percentage points for initiation or first-time marijuana use. This translates into a five percent increase in the probability of using marijuana for the first time among these participants (Wen, Hockenberry, & Cummings, 2015). These results were not consistent among those 21 and older as this group did not demonstrate an increase in first-time use with the implementation of MMLs (Wen, Hockenberry, & Cummings, 2015).

With respect to alcohol use, the results of this study indicated that MML implementation did not affect the total number of drinks consumed by those aged 21 and older (Wen, Hockenberry, & Cummings, 2015). However, the results further demonstrated a positive association between binge drinking and MML implementation which was observed as a 10% increase (effect size of 0.16) in the number of binge drinking days (Wen, Hockenberry, & Cummings, 2015). This observation was also demonstrated in concurrent use of marijuana and binge drinking in the past month for

adults aged 21 and older as the simultaneous use of these substances increased by 22 percent or 1.44 percentage points with the implementation of MMLs (Wen, Hockenberry, & Cummings, 2015). In addition, there was an increase of 18% (0.82 percentage points) for the probability of using marijuana while drinking among those age 21 and older. However, these findings were not observed among the adolescent and young adult population age 12 to 20 years as no significant change in alcohol use was observed in this group with the implementation of MMLs (Wen, Hockenberry, & Cummings, 2015).

In addition, Wen, Hockenberry, & Cummings (2015) report a 10% increase in marijuana abuse/dependence among participants age 21 and older. Thus, indicating cause for public health concern as MMLs may have the potential to increase risk of progressing to marijuana abuse/dependence (Wen, Hockenberry, & Cummings, 2015). However, this finding was not consistent in either age group for alcohol abuse/dependence, non-medical use of prescription pain meds, and heroin or cocaine use as no increases was observed for these variables among adolescents and young adults or the adult population (Wen, Hockenberry, & Cummings, 2015).

Effects of Marijuana Legalization and Lessons Learned from States with Legalized Marijuana

The long-term effects of marijuana legalization and trends in acceptance have yet to be demonstrated. Nevertheless, several studies have been conducted in an attempt to assess these effects. One of which conducted by the nonprofit organization known as *Smart Approaches to Marijuana* or SAM was recently released. This study entitled: Lessons Learned from Marijuana Legalization in Four U.S. States and D.C. presented

some interesting and disturbing findings. The authors of this study posited that “Today’s highly potent marijuana represents a growing and significant threat to public health and safety, a threat that is amplified by a new marijuana industry intent on profiting from heavy use” (Smart Approaches to Marijuana [SAM] 2018, p.3). The authors further posited that while the consequences of marijuana legalization will not be realized for decades, the results of this study present some disturbing early indicators of the potential effects. Thus, marijuana legalization is leading to increased availability of highly potent marijuana that public health professionals must address as the long-term effects of highly potent marijuana remains to be seen.

SAM (2018) reports on trends demonstrated in the following five jurisdictions since legalization: Colorado; Washington; Oregon; Alaska; and the District of Colombia. Among the findings presented by SAM, includes a detailed report on the impact that marijuana legalization has had on the youth or adolescent population in these areas. SAM (2018) indicated that in the jurisdictions observed adolescents age 12-17 report an increase in past-month use of marijuana that continues to rise above the national average. In addition, states with marijuana legalization report an increase in marijuana use among young adults aged 18 to 25 (SAM, 2018). While Alaska and Oregon also report an increase in past-year marijuana use among adolescents (aged 12-17) and Colorado has seen a 65% increase in first-time marijuana use among adolescents (SAM, 2018). Colorado has also reported an increase in adolescent suicide victims testing positive for marijuana and approximately half of adolescents in outpatient treatment report using diverted medical marijuana (SAM, 2018).

Unfortunately, this is not the end of these disturbing trends as marijuana legalization has a multitude of effects on the community and health. For instance, in Washington and Oregon law enforcement has documented numerous incidents where licensed marijuana retailers were selling marijuana to minors. There has also been a rise in arrest for public consumption and distribution as in Washington, D.C. where arrest for these offenses nearly tripled. With a disproportionate number of arrests occurring among people of color in both D.C. and Colorado (SAM, 2018). In Colorado this racial discriminatory trend carries over into school related suspension for marijuana as schools with fewer children of color (25% or less) had fewer suspensions (313) when compared to schools that had more than 76% children of color which had 658 marijuana related suspensions (SAM, 2018). Marijuana legalization is also affecting the use and consumption of other drugs as alcohol consumption is not decreasing as some predicted. In fact, alcohol consumption is either not affected or increasing as Oregon State University reports that underaged (less than 21 years old) binge drinkers are among the primary groups of marijuana user's post-legalization (SAM, 2018). In addition, according to the Institute for Behavior and Health, the percentage of marijuana users who are using opioids frequently has risen dramatically as peer-reviewed research has also demonstrated that the likelihood of opioid use more than doubles for those who began using marijuana in early in life (SAM, 2018; Secades-Villa, Garcia-Rodríguez, Jin, Wang & Blanco, 2015). SAM (2018) further posited that marijuana legalization in Colorado and Washington resulted in the development of a multibillion-dollar *addiction-for-profit*

industry. With the goal of this industry being to convert adolescents and young adults from casual marijuana users into more frequent heavy users (SAM, 2018).

There is also growing concern to address the adverse health outcomes that can result because of increased legalization and acceptance of marijuana as a natural substance that is perceived as less harmful and healthier than alcohol and tobacco (SAM, 2018). This trend continues as the perceived risk of harm associated with marijuana is decreasing with increased acceptance and legalization (SAM, 2018). In converse, these assumptions and attitudes couldn't be further from the truth as research has demonstrated a direct association between the use of highly potent (higher THC) marijuana and increased frequency of marijuana use with the development of mental health conditions (SAM, 2018). Which may include conditions like psychosis, depression, anxiety, addiction and suicidal tendencies (SAM, 2018). There has also been links made between the use of highly potent legalized marijuana with the reshaping of brain matter, lung damage and cardiovascular complications like hypertension, heart attack, and stroke (SAM 2018). In addition, SAM (2018) also provides information supporting the *gateway effect* whereby marijuana use leads to a risk of progressing from marijuana to the use of other illicit.

The effects of marijuana policies are impactful and widespread as SAM (2018) further posited that in addition to having some of the highest rates of marijuana consumption in the country. According to SAM (2018) states with legalized marijuana also demonstrate the following trends: higher rates of marijuana-related driving fatalities; more marijuana-related emergency room visits, hospitalizations, and accidental

exposures; expansion of a lucrative criminal market; increases in marijuana-related crimes and juvenile offenses; and increases in workplace problems, including labor shortages and accidents as well as disproportionate legal impacts among communities of color and low-income populations.

Regarding marijuana-related driving incidents and fatalities in Colorado between 2013 and 2015 there was an 88% increase in the number of drivers charged with driving while intoxicated with marijuana and fatal car accidents associated with marijuana intoxication (SAM, 2018). In addition, the National Highway Traffic and Safety Administration reports a 66% increase in the number of marijuana traffic deaths since legalization (SAM, 2018). This trend is common across states with marijuana legalization as Washington State reports that traffic deaths related to drugged driving has doubled since legalization (SAM, 2018). Driving under the influence of drugs (DUIDs) is on the rise across states with marijuana laws (SAM, 2018). For instance, Colorado has seen a 76% increase in the number of DUIDs where marijuana was involved, and Oregon reports that in 2015, 50% of drivers tested positive for THC after being assessed by drug recognition experts (SAM, 2018).

SAM, (2018) also indicated that marijuana-related emergency room visits, hospitalizations, and accidental exposures are also on the rise as a result of legalization (SAM, 2018). This is evidenced by reports from the poison controls centers in Colorado and Washington State that report increases of 210% and 70% respectfully, in the number of marijuana related calls received after legalization (SAM, 2018). Colorado also reports a 35% increase in the number of individuals seen in hospital emergency rooms (ER) for

marijuana-related events. And Central Oregon reports that marijuana-related ER visits increased by 200% as in January 2016 there were 434 marijuana-related ER visits, whereas prior to legalization ER visits for marijuana averaged around 32 visits per month (SAM, 2018).

In addition, there has also been an increase in problems in the workplace as employer's report problems with labor shortages and on the job accidents (SAM, 2018). For example, labor shortages may be associated with the increase in number of individuals testing positive for marijuana which is double the national average in both Washington and Colorado (2018). Employers are finding it difficult to find employees because so many people cannot pass the preemployment drug screen. In one instance, a Colorado construction company had to seek employees from out of state because too many local construction workers were failing the preemployment drug screening (SAM, 2018). The drug screening problem has gotten to the point where during the three periods from 2013 to 2016 after legalization of recreational marijuana in Colorado and Washington, positive oral-fluid screening test for marijuana increased by about 75% and urine test for marijuana are now twice that of the national average (SAM, 2018). This is a serious concern as on the job accidents and therefore insurance claims are also a growing concern among employers and insurance companies in states where marijuana has been legalized (SAM, 2018). One study found that among marijuana users, work-related injuries and illnesses were 8.9% higher than non-users (SAM, 2018). Thus, companies in states with legalized marijuana are at risk of liability claims if marijuana use is tolerated or if they choose to eliminate or ignore drug screening (SAM, 2018).

SAM (2018) also showed that crime is on the rise in jurisdictions with legalized marijuana. In Colorado, since legalization took place, crime has increased at a rate that is 11 times faster than states without marijuana legalization (SAM, 2018). The Colorado Bureau of Investigation (CBI) indicated that property crimes and violent crimes have increased by 8.3% and 18.6%, respectively (SAM, 2018). The increase in crime is reportedly associated with the distribution of marijuana dispensaries as the National Institute of Health demonstrated a correlation between the density of marijuana dispensaries and an increase in property crime in regions. Police in Boulder, Colorado also report an increase of 54% in citations for public consumption of marijuana post-legalization (SAM, 2018). This disturbing trend holds true across legalized states as Alaska also reports an increase in misdemeanors and vehicle thefts since legalization. Prior to legalization, Alaska was ranked nationally as 16th for larceny and motor vehicle theft. However, post-legalization statistics has Alaska ranked second and fifth nationally for larceny and motor vehicle theft, respectively (SAM, 2018). In contrast, prior to legalization Oregon was ranked nationally as 12th for larceny, 13th for motor vehicle theft and 17th for property crime However, after legalization statistics has Oregon ranked 7th for larceny, 8th for motor vehicle theft and 11th for property crime (SAM, 2018).

In addition, the *Black Market* is also thriving and prospering in the wake of marijuana legalization as legalization is not only affecting the population within the state wherein marijuana is legalized but also effects adjacent states and other states throughout the country (SAM, 2018). For instance, SAM (2018) reports that Colorado has seen a 50% increase in the number of illegal marijuana growers across the rural areas within the

state and in 2016 law enforcement officers seized around 7,116 pounds of marijuana and made 252 felony arrest. There were also 346 highway trafficking interdictions wherein marijuana seized was destined for one of 36 other states in the U.S. (SAM, 2018). Black market activity is also affecting the mail system in the United States as there has been an 844% increase in the number of marijuana seizures since legalization. The situation has gotten so extreme that the U.S. Attorney in Oregon stated that "Oregon has a massive marijuana overproduction problem" (SAM, 2018, p.22). This comment was made in response to seizures in 2017 which amounted to "2,644 pounds of marijuana in outbound parcels and over 1.2 million dollars in cash" (SAM, 2018, p.22).

The claims by SAM (2018) about the effects of marijuana legalization on adjacent and other states throughout the nation are supported by other articles and researchers. For instance, in an article entitled: The Cross-Border Spillover Effects of Recreational Marijuana Legalization by Hao & Cowan (2017) explored this effect on counites in states bordering states with Recreation Marijuana Legalization (RML), compared to non-border counties in these states. This study focused on Colorado and Washington as these were the first two states to pass laws allowing for the use of recreational marijuana (Hao & Cowan, 2017). The effects of RML in Colorado was observed in bordering counties of the following six states: Wyoming; Utah; New Mexico; Oklahoma; Kansas; and Nebraska (Hao & Cowan, 2017). And in Washington, the researchers observed effects of RML on bordering counties in Idaho and Oregon (Hao & Cowan, 2017).

Hao & Cowan (2017) posited that RML may lead to positive fiscal impacts as demonstrated in Washington state which collected approximately $186 million in tax

revenue generated from the sale of legal recreational marijuana in 2016. RML is also expected to generate savings due to reduced cost in law enforcement and the criminal justice system which will not be investigating and prosecuting certain crimes related to the possession and use of marijuana (Hao & Cowan, 2017). However, RML has the potential for negative and detrimental effects on bordering states as marijuana purchased and possessed legally in states with RML could increase arrest and convictions for marijuana possession and marijuana-related crimes in these neighboring regions (Hao & Cowan, 2017). Thus, contributing to an increased burden on law enforcement and the criminal justice system. In fact, while the Supreme Court denied the lawsuit. Nebraska and Oklahoma, which border Colorado did initiate a lawsuit against Colorado, maintaining that legalization of marijuana in Colorado contributed to an increased financial burden on law enforcement for marijuana-related crimes and other social cost within their state (Hao & Cowan, 2017). This was a sharp increase in arrest for marijuana possession as states that shared a physical border saw an increase of 30% for this offense (Hao & Cowan, 2017).

The study by Hao & Cowan (2017), revealed a statistically significant increase in arrests for marijuana possession in counties that border regions of Colorado and Washington relative to counties that did not border these states. This observation was only seen among the adult populations within these regions as RML did appear to impact arrests of juveniles for possession of marijuana (Hao & Cowan, 2017). The researchers also found that these findings were consistent with previous studies on MMLs demonstrating that MMLs do not lead to increased consumption of marijuana by

teenagers (Hao & Cowan, 2017). The study further revealed that RML did not have a statistically significant effect on arrest for the following: the sale and/or manufacture of marijuana; DUIs; or possession of opium/cocaine (Hao & Cowan, 2017). Hao & Cowan (2017) recommend that states considering RML, also consider the potential regional and national impact as the costs and benefits of these decisions should include the consequences of the spillover effect on states without RML.

In another study, Cerda, et al., (2012) addressed the association between state-level medical marijuana legalization and marijuana use, abuse, and dependence. Cerda, et al., (2012) acknowledges that individual behaviors are not only influenced by the perceived cost and benefits of an individuals' actions but also by the approval or disapproval of society. This study is based on the premise that earlier studies on norms that predict marijuana use do not provide information of group-level norms that also likely influence individual behavior (Cerda, et al., 2012). These group norms are essentially group level acceptance or approval of a particular behavior. Such that individuals in regions where marijuana is received with societal or group level approving norms have a greater likelihood of using marijuana (Cerda, et al., 2012). The study also considers societal norms that may influence behavior independent of individual beliefs as well as policies and program interventions aimed at societal norms that have a much broader effect than individual interventions (Cerda, et al., 2012). Therefore, with respect to marijuana, the implementation of state-level MMLs can be considered an indication of group-level approval of marijuana use (Cerda, et a., 2012). Thus, implementation of

MMLs can viewed as an indicator of societal-level norms for marijuana acceptance because public opinion influences decisions on marijuana policies (Cerda, et al., 2012).

Cerda, et al., (2012) addressed the following three research questions: (1) did states that legalized medical marijuana by 2004 exhibit higher rates of past-year marijuana use and abuse/dependence in 2004-2005 than states that did not legalize it?; (2) were individuals living in states that legalized medical marijuana at higher risk for marijuana use, abuse and dependence in the past year than individuals who live in states that did not legalize medical marijuana?; and (3) among marijuana users, was residence in a state that legalized medical marijuana associated with increased risk for meeting criteria for marijuana abuse and dependence?

The study utilized data for states that had implemented MMLs by 2004. These states were coded as exposed and included the following 10 states: Alaska; California; Colorado; Hawaii; Maine; Montana; Nevada; Oregon; Vermont; and Washington (Cerda, et al., 2012). And the remaining 40 states without MMLs by 2004 were coded (designated) as unexposed (Cerda, et al., 2012). Participant data was obtained using secondary data from the following two surveys: 1) the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC); and 2) National Survey on Drug Use and Health (NSDUH) (Cerda, et al., 2012). The NESARC served as the source for primary outcome data and is a national survey that used face-to-face surveying techniques to gather data on 43,093 participants (Cerda, et al., 2012). The participants were aged 18 years and older living in the United States in homes or group quarters (Cerda, et al., 2012). In contrast, the NSDUH served as the secondary data source and is also a national

survey that used self-reporting surveying techniques to gather data on approximately 68,000 respondents (participants) (Cerda, et al., 2012). This study gathers data on U.S. residents 12 years and older living in households, non-institutional group quarters and civilians living on military bases (Cerda, et al., 2012). Participants were categorized into the following three age groups: 1) 12-17 years old; 2) 18-25 years old; and 3) 26 years old and older (Cerda, et al., 2012). However, for this study, the researchers used only those participants aged 18 years and older, yielding approximately 45,000 respondents for this studies sample from the NSDUH (Cerda, et al., 2012).

The results of this study for state-level marijuana use, abuse and dependence, demonstrated statistically significant differences between states with MMLs versus states without MMLs. For instance, based on NESARC data, in states with MMLs the average state-level prevalence of past-year marijuana use was higher (7.13%) than in states without MMLs (3.57%). In addition, according to NESARC data, the average state-level prevalence of marijuana abuse/dependence was also significantly higher in states with MMLs (2.61%) than in states without MMLs (1,27%). In contrast, NSDUH data also revealed that in states with MMLs the average state-level prevalence of past-year marijuana use was significantly higher (12.17%) than in states without MMLs (9.77%) (Cerda et al., 2012).

In addition, individual level results for odds of past-year marijuana use, abuse and dependence also yielded statistically significant results for states with MMLs versus states without MMLs (Cerda, et al., 2012). For instance, for individuals living in states with MMLs the odds of marijuana use in the past year were 1.92 times higher than

individuals living in states without MMLs (Cerda, et al., 2012). In addition, the odds of marijuana abuse/dependence were 1.81 times higher for individuals residing in states with MMLs versus individuals living in states without MMLs (Cerda, et al., 2012).

Cerda et al. (2012) conclude that the results of this study demonstrated that a causal relationship exist between MMLs and marijuana use and marijuana abuse/dependence. To understand and explain this relationship. Cerda et al. (2012) considers the following four mechanisms: 1) state-level community norms more supportive of marijuana use may contribute to the legalization of medical marijuana and to higher rates of marijuana use; 2) the enactment of medical marijuana laws could lead to a change in community attitudes on both medical and non-medical marijuana use, including reduced disapproval and perceived riskiness of use, which could subsequently influence marijuana use and abuse/dependence; 3) medical endorsement of marijuana for medical purposes encourages acceptance and use; and 4) which is related to the availability of marijuana, such that legalization of medical marijuana may lead to greater commercial promotion and availability of the substance for recreational purposes, which may contribute to greater illicit use of marijuana.

In another study, three years after Colorado legalized marijuana for recreational use the Colorado Department of Public Health Environment and The Colorado Department of Public Safety published an article to address the lessons learned from recreational legalization (Ghosh, Vigil, Maffey, Tolliver, Van Dyke, Kattari, Krug, Reed & Wolk, 2017). After legalized sales of recreational marijuana began in 2014, the Colorado department of public health developed a framework to monitor, address and

prevent or reduce harmful effects on the population (Ghosh et al., 2017). The article presented here is a testament to the lessons learned thus far. These lessons were divided into the following three broad categories: 1) lessons on health behaviors; 2) lessons on health outcomes; and 3) lessons on health policy (Ghosh, et al., 2017). Considering the importance of monitoring trends in marijuana use and identifying high risk subpopulations. Ghosh et al., (2017) stressed how essential it is for states with legal marijuana and those considering legalization to establish surveys or add marijuana questions to population-based surveys to monitor regional trends in marijuana use. Optimally, these surveys or questions should be implemented prior to changes in policies that effect marijuana legalization (Ghosh et al., 2017).

In retrospect, lessons learned on health behaviors, Ghosh et al (2017) present some interesting trends. The first lesson learned was that marijuana use did not appear to increase as a result of recreational legalization (Ghosh et al., 2017). This trend was demonstrated among the adult and youth populations as past 30-day use among adults did not change significantly between 2014 when use was observed at 13.6% and 2015 when adult 30-days use was recorded at 13.4% (Ghosh et al., 2017). In contrast, high school student marijuana use in the past 30-days and lifetime demonstrated no statistically significant change between 2013 (30-day use: 19.7%; lifetime: 36.9%) and 2015 (30-days use 21.2%; lifetime 38.0%) (Ghosh et al., 2017). However, there was a small but statistically significant decrease in youth perception of perceived risk of marijuana use as this value decreased from 54% in 2013 to 48% in 2015 (Ghosh et al., 2017). This observation may explain why the highest rates of use were seen among young adults

between the age of 18 to 25 years old with a rate of 26.1% and high school juniors and seniors with a rate of 26.3% and 27,8%, respectively. Thus, marijuana legalization while not apparently affecting marijuana use at this time, may well influence future use as youth decreased perception of perceived risk may have a significant impact on future population use. It was also learned that individuals who identified as gay, lesbian, or bisexual were far more likely than heterosexuals to use marijuana (Ghosh et al., 2017). This trend was true for all ages as adult marijuana use among those who identify as gay, lesbian or bisexual was 36.9% versus adult heterosexuals with a rate of 12.4% and youth rates for those identifying as gay, lesbian, or bisexual demonstrating a rate of use of 34.9% versus 19.5%, for heterosexual youths (Ghosh et al., 2017).

In addition, while there was lower marijuana use among Asians, there was not a significant difference in use by race/ethnicity. Ghosh et al., (2017) also report what was learned about methods of marijuana use, frequency as well as marijuana storage habits. For instance, among adults it was reported that the most common methods of use included: smoking (83.2%); eating (34.4%) and vaping (32.4%) (Ghosh et al., 2017). However, while the majority of both adult and youth users report smoking as the most common method, approximately half report using marijuana by multiple methods, such as vaping, eating and/or dabbing (Ghosh et al., 2017). Vaping is a method of use that involves using a vaporizing device to heat marijuana and the user inhales vaporized marijuana instead of smoke (Ghosh et al., 2017). Dabbing on the other hand is method that involves using solvents such as butane to create a highly concentrated form of marijuana which the user then heats and inhales the smoke (Ghosh et al., 2017). Lessons

on behavior also revealed that 7.4% of parents who use marijuana report storing marijuana and 73.4% of these parent's report storing marijuana in locked containers (Ghosh et al., 2017). This is an important public health concern as the unintentional exposure of children 8 years old and younger increased by 63% during the first year of legalization (Ghosh et al., 2017).

To evaluate health outcomes, Ghosh et al., (2017) observed data related to hospital discharges codes for marijuana related conditions and Emergency Department (ED) visits. These observations revealed a 70% increase for hospitalizations related to marijuana between 2013 and 2015 (Ghosh et al., 2017). These observations also demonstrated an increase of 19% for ED visits related to marijuana use (Ghosh et al., 2017). However, it is important to mention that the observations for marijuana related ED and hospitalizations were significantly lower than alcohol as ED visits was approximately five times higher than marijuana and hospitalizations for alcohol was almost three times higher (Ghosh et al., 2017). Post-legalization observations also revealed an increase in calls to the Poison center for adult marijuana exposure (Ghosh et al., 2017). However, unlike children eight years old and younger where exposure was usually accidental, adult exposure was usually intentional and was approximately evenly distributed for smoked and edible marijuana consumption (Ghosh et al., 2017). In addition, marijuana-related DUI's increased by 16% post-legalization and driving fatalities associated with a positive marijuana test increased by 80% (Ghosh et al., 2017).

Regarding marijuana policy post-legalization, Colorado implemented the following policy changes: added marijuana to its Clean Indoor Act; established

childproof packaging requirements for edible marijuana products; strengthened safety regulations for edible products by establishing limitations for the maximum amount of THC in a single serving; set requirements for sticker packaging or labels to identify marijuana products with universal symbols; and established restrictions to eliminate/reduce packaging of products that entice children (Ghosh et al., 2017). In addition, Colorado policy decisions were informed by social marketing research that revealed varying attitudes for marijuana use exist between the English and Spanish speaking populations, between users and non-users, and between older and younger populations (Ghosh et al., 2017). This information was used to maximize and target the impact of public health messaging for a variety of audiences (Ghosh et al., 2017). Informative messaging not only focused on health concerns, but also on general marijuana law awareness (Ghosh et al., 2017). A final major policy lesson learned was associated with aligning medical and recreational regulations. For instance, varying regulations between medical and recreational marijuana have contributed to discrepancies in marijuana taxation, testing requirements and labeling/packaging (Ghosh et al., 2017).

Ghosh et al (2017) concludes that many lessons were learned from the Colorado experience and recommends that states with and those considering marijuana legalization should establish strong surveillance systems. This system should be established to monitor both health behaviors and outcomes (Ghosh et al., 2017). Another key component should include a health policy approach that is adaptable to a rapidly changing and emerging environment (Ghosh et al., 2017).

In yet another article entitled: “Marijuana Legalization: Impact on Physicians and Public Health” presents a review of marijuana legalization and the potential impact it may have on public health (Wilkinson et al., 2016). This article also presented a review of health conditions for which marijuana has been identified as a recognized treatment option (Wilkinson et al., 2016). Wilkinson et al (2016) posited that while the relationship between marijuana legalization and prevalence is not clear. There are still serious public health concerns that states should consider relevant, especially considering the continued widespread legalization of marijuana (Wilkinson et al., 2016). Some of these concerns include: the effects of acute marijuana intoxication on driving abilities; unintentional ingestion of marijuana products by children; the relationship between marijuana and opioid use; and whether there will be an increase in health problems related to marijuana use, such as dependence/addiction, psychosis, and pulmonary disorders (Wilkinson et al., 2016). According to Wilkinson et al. (2016) in 2013 approximately 3.1 million Americans reported using marijuana in the last year and 8.1 million Americans reported using marijuana almost daily in the last month. Thus, addressing these concerns are essential given that marijuana is not only the most used illicit substance, but also gaining acceptance and the legalization trend continues as more states are considering legalizing marijuana for medical and/or recreational use (Wilkinson et al., 2016). Nevertheless, marijuana legalization remains a controversial topic as proponents persist that the positive aspects of marijuana legalization include the following: more stringent regulation and safer use of marijuana; more efficient use of law enforcement resources; a possible decline in the prevalence of marijuana use among adolescents; and a decline in the use of

"harder drugs" like cocaine and heroin (Wilkinson et al., 2016). In converse, opponents of marijuana legalization persist that adverse effects of legalization may include the following: an increase in marijuana use; and increases in health problems associated with marijuana use (Wilkinson et al., 2016). Thus, one of the primary arguments between advocates and opponents of marijuana legalization is the relationship between legalization and prevalence of use (Wilkinson et al. 2016). In general, according to Wilkinson et al. (2016), states with legalized marijuana tend to have higher rates of marijuana use than states without any form of marijuana legalization (Wilkinson et al. 2016). However, Wilkinson et al. (2016) also points out that this was often the case prior to legalization. Thus, regional variances in acceptance and permissive attitudes that contribute to a decreased in perceived risk associated with marijuana use may be contributing factors of increased use in these states (Wilkinson et al. 2016). Another important public health concern is the prevalence of use among adolescents as this group may be more susceptible to the negative health consequences of marijuana as well as poor social outcomes (Wilkinson et al., 2016). These health consequences may include: increased susceptibility to addiction/dependence; psychosis and cognitive impairment (Wilkinson et al., 2016). While poor social outcomes may include: unemployment, lower income; and lower levels of life and relationship satisfaction (Wilkinson et al., 2016). These may well be warranted as previous research data has demonstrated a clear inverse relationship between marijuana use and the perceived risk of harm associated with marijuana use (Wilkinson et al., 2016). Such that as perceived risk decreases marijuana use increases (Wilkinson et al., 2016).

Another public health concern is the diversion of legal medical and recreational marijuana from the adult population with legal access to adolescents or other individuals without legal access (Wilkinson, 2016). Support for this concern is demonstrated by a Colorado study of adolescents in outpatient treatment for substance-abuse (Wilkinson, 2016). In which, approximately half of these adolescents reported using marijuana diverted from legal access (Wilkinson, 2016). In another study, the researchers discovered even higher rates of diversion as approximately 74% of adolescents participating in substance-abuse treatment reported using marijuana diverted from or intended for medical use (Wilkinson, 2016). This sort of *de facto* distribution of marijuana has contributed to the occurrence of unintentional ingestion of marijuana by children age nine or younger (Wilkinson, 2016). This evidenced by reports indicating that there were no such marijuana-related emergency room cases between 2005 to October 2009 (Wilkinson, 2016). However, after October 2009 through 2011 there were 14 cases of unintentional marijuana ingestion by children nine years old or younger (Wilkinson, 2016). This trend holds true across states where medical marijuana is legal as an analysis of national data of states with medical marijuana laws revealed that between 2005 to 2011 there was a 30% annual rate of increase for unintentional ingestion of marijuana by children ($\leq$ 9 yrs. old) (Wilkinson, 2016). In contrast, states without legalization demonstrated no change in the rates of unintentional ingestion by children (Wilkinson, 2016). Another important concern is the association between marijuana and opioid use. Wilkinson et al. (2016) posited that while some evidence may indicate that marijuana and/or cannabinoids can be used to treat pain or discomfort. Thus, allowing opioid users

to taper off or reduce the amount of prescribed opioid they use to manage their condition. However, at the time of this study no clinical trials demonstrating that marijuana or cannabinoids could be used for this purpose (Wilkinson et al., 2016). In fact, marijuana use has traditionally been considered to contribute to an increase in opioid use (Wilkinson et al., 2016). In converse, a recent study demonstrated that MMLs may ultimately contribute to a decrease in opioid mortality when compared to estimates where these MMLs not been implemented (Wilkinson et al., 2016). However, Wilkinson et al (2016) indicates that "states with medical marijuana laws have higher rates of age-adjusted opioid overdose mortality than do states without such laws". Therefore, additional research is needed to further asses this relationship and determine if marijuana or its products will actually allow opioid patients to taper off or reduce the amount of prescribed opioid they use to manage their condition (Wilkinson et al., 2016, p. 459).

Additionally, while marijuana is still illegal at the federal level, there are several marijuana containing medications that have been approved by the Food and Drug Administration (FDA) for treatment of certain conditions (Wilkinson et al., 2016). These include: Dronabinol (Marinol®) approved for treatment of HIV/AIDS cachexia and chemotherapy induced nausea/vomiting; Nabilone (Cesamet®) for treatment of chemotherapy induced nausea/vomiting; and Nabiximols (Sativex®) approved in Canada and many European countries for spasticity in multiple sclerosis (Wilkinson et al., 2016).

Wilkinson et al (2016) ultimately concludes that given the ever-evolving legal landscape, growing social acceptance, and increasing potency of marijuana, more research is needed to ascertain the long-term effects of legalization on public health.

Literature Review on Marijuana and Mental Health Disorders

There is a growing body of evidence supporting the association between cannabis use and the development of psychotic or mental health disorders (Moore, et al., 2007). However, few studies have addressed this association since the rise in THC demonstrated post legalization. From a public health stance, addressing this concern is essential as individuals with marijuana use disorder are likely to continue use despite findings of clinically significant conditions such as mental health disorders (NIDA, 2016). For many years, substance abuse and substance dependence were considered two separate categories. However, in 2013 The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) was updated such that abuse, and dependence are classified under the category of substance use disorder (NIDA, 2016). In this case marijuana or cannabis use disorder

Volkow et al., (2014) posited that previous research has demonstrated that anxiety, depression, and psychosis are associated with regular marijuana use. However, causality is not well founded as addressing this association is hindered by confounders that also contribute to the development of these conditions (Volkow et al., 2014). For instance, individuals with a family history of schizophrenia and psychosis have a greater risk of developing these conditions (Volkow et al., 2014). In addition, heavy use of marijuana, highly potent marijuana and using marijuana at an early age also exacerbate the occurrence of psychosis (Volkow et al., 2014). These findings provided additional support for the current study which intends to address the effects of marijuana legalization and the rising THC levels (increased drug potency) on mental health.

Volkow et al., (2014) indicated that in a predisposed individual the first psychotic episode can occur years sooner in the presence of marijuana use. The importance of addressing mental health concerns early in life is essential as the Substance Abuse and Mental Health Services Administration (2017) indicated that approximately half of adults with mental illness had signs and symptoms associated with their condition that began before age 14 and three-fourths of adult mental illness began before age 24 (SAMHSA, 2017). Thus, addressing mental illness and factors such as marijuana use that may negatively impact, exacerbate or cause these conditions is a serious public health concern. This issue is especially concerning when considering current trends in attitude to toward marijuana and the rising THC levels exhibited post-legalization.

In a previous related study, Lev-Ran, et al. (2014), conducted a systematic review and meta-analysis of existing longitudinal studies to determine patterns of cannabis use that are associated with the development of depression. The authors of this study cited the following three reasons as cause for concern and justification for the study: 1) high cannabis use among adolescents and young adults; 2) the increasing potency of cannabis; and 3) the association between cannabis and mental illness (Lev-Ran, et al, 2014).

The researchers of the Lev-Ran study screened nearly 5000 peer-reviewed articles on marijuana use and the risk of developing depression. The criteria for depression was based on studies addressing major depressive disorder, dysthymia, or depressive symptoms. Ultimately, 57 studies were selected for the meta-analysis with 14 of these designated for quantitative analysis.

Statistical analysis for this study used an odds ratio as measure of risk. Studies were pooled to determine the association or increased odds of developing depression with cannabis use versus controls (Lev-Ran et al., 2014). This procedure was followed for regular to moderate cannabis use and heavy cannabis use. The results demonstrated that regular or moderate marijuana users have an increased risk of developing depression when compared to those who do not use marijuana (Lev-Ran et al., 2014). In contrast, the greatest risk of developing depression was demonstrated by heavy marijuana users (Lev-Ran et al., 2014). This is evidenced by an odds ratio of 1.17 for developing depression among regular or moderate marijuana users versus an odds ratio of 1.62 among heavy marijuana users (Lev-Ran et al., 2014).

Lev-Ran, et al. (2013) concluded that the risk of developing depressive disorders is increased by cannabis use, and this risk is more significant among heavy cannabis users and those with cannabis use disorder (CUD). Lev-Ran, et al. (2013) posited that the results of this study emphasize the importance of recognizing and addressing the potential risk of heavy cannabis use, especially among adolescents as this group has the highest rates of cannabis use.

These findings are supported by van Gastel et al. (2013) which also indicated that marijuana use has been associated with psychiatric symptoms and the risk is increased by regular or heavy marijuana use. In addition, according to van Gastel et al. (2013) the risk of developing depression is more pronounced in those who began using marijuana before age 16. Observations among young adolescent marijuana users typically included:

delinquent behavior; conduct disorder; attention problems; anxiety as well psychotic and depressive symptoms (van Gastel, 2013).

Additionally, van Gastel, et al. (2013) further posited that among those who began using before the age of 16 the risk is more pronounced as increased rates of use among this group has resulted in an increase in the following: psychotic symptoms; adjustment problems; depression; crime and suicidal behavior; anxiety; externalizing behavior; attentional dysfunction; poor educational achievement and poor executive functioning.

In the study by van Gastel, et al. (2013), the researchers conducted a population-based analysis to determine whether cannabis use is associated with poor psychosocial functioning and therefore a risk factor for mental health problems in adolescents (van Gastel, et al., 2013). The sample population was select from Dutch secondary school children and included 5,179 girls and 5,145 boys ranging in age from 11 to 16 years (average age 13.9). A total of 10,324 participants who had completed a Public Health Service School Survey collecting information on demographics, substance use, school factors and stressful life events. Participants had also completed the Strengths and Difficulties Questionnaire (SQD) (van Gastel, et al., 2013). Researchers used an in-class computer-based assessment to gather data on psychosocial functioning, lifestyle and social environment, and perceived school safety (van Gastel, et al., 2013).

Data analysis used the following measurements: psychosocial functioning; use of cannabis and other substances; sociodemographic factors; school variables; and stressful life events (van Gastel, et al., 2013). This information was obtained via the Strengths and Difficulties Questionnaire (SQD), which according to van Gastel, et al., (2013) is a self-

reporting survey specifically designed for adolescents aged 11 to 16 years and intended to measure psychosocial adjustment and assess psychopathology. The SDQ reportedly has an accuracy as high as 91% for correctly predicting psychiatric diagnoses among adolescents (van Gastel, et al., 2013). Sociodemographic factors included the following four measures include: 1) age; 2) gender; 3) ethnicity; 4) level of education; and 4) household composition (refers to whether adolescent lived with both parents, just one parent or did not live with either parent) (van Gastel, et al., 2013). Additionally, having a parent that is mentally ill was considered as a genetic predisposition for mental health problems.

While van Gastel, et al. (2013) indicated that there was no significant difference between groups with respect to age, gender, and ethnicity; the study ultimately concludes that cannabis use can be considered a "risk indicator for mental health problems in adolescents." (van Gastel, et al., 2013). However, other confounding variables in the presence of cannabis use contribute to poor psychosocial functioning (van Gastel, et al., 2013). Thus, cannabis use may serve as a "marker for adolescents at risk for mental health problems" (van Gastel, et al., 2013, para. 19).

In yet another study, Medina et al. (2007) addressed the association between depression and marijuana use, decreasing white matter and hippocampal volumes in adolescents. Previous studies have demonstrated reductions in hippocampal volumes among adults with depression. Similarly, studies have demonstrated white matter reductions in adults with symptoms of depression and suicide ideation. These white matter reductions are revealed on brain magnetic resonance imaging (MRI) as

hyperintensities, which are lesions within brain white matter that results from the demyelination and degeneration of axons (Wardlaw, Hernandez, & Munoz-Maniega, 2015). While these reductions were exhibited in depressed adults, this was not the case in depressed children and adolescents as these individuals typically displayed hippocampal and white matter volumes consistent with non-depressed (healthy) controls (Medina, Nagel, Park, McQueeny, & Tapert, 2007). This is of concern as addressing adolescent marijuana use is an important topic especially considering evidence indicating that marijuana is the most commonly used substance among high school students as approximately 42% of high school seniors admit to trying marijuana in their lifetime (Medina, Nagel, Park, McQueeny, & Tapert, 2007).

The study conducted by Medina, Nagel, Park, McQueeny, and Tapert, (2007) focused on the following two goals: 1) the relationship between white matter and hippocampal volumes and depressive symptoms; and 2) whether marijuana use moderates the relationship between brain structure and depressive symptoms in a sample of 32 adolescents.

In this study, participants were fluent English-speaking adolescents aged 16 to 18 years with at least one parent or guardian available to give consent for those under age 18 and provide a history for the participant (Medina, Nagel, Park, McQueeny, & Tapert, 2007). The sample included 16 marijuana users and 16 non-drug users that were recruited from high schools, universities and through various ads (Medina, Nagel, Park, McQueeny, & Tapert, 2007). Marijuana users were excluded if they were considered heavy alcohol drinkers and if they used any substance other than marijuana, alcohol (in

moderation) or nicotine. The study also noted adolescent history, drug use and symptoms of depression with a parental interview conducted to corroborate information provided by their children

The results of this study demonstrated an additive and interactive relationship between marijuana use and white matter volume for predicting depressive symptoms. However, it is not clear which came first as Medina et al., (2007) posited that "it remains difficult to determine whether abnormal neurodevelopment caused depression, or if depression interrupts developmental myelination" (para. 30). In contrast, this study did not demonstrate a significant association between hippocampal volume and depression. Nevertheless, this study demonstrated support for the hypothesized relationship between reductions in white matter volume, depression, and marijuana use (Medina, Nagel, Park, McQueeny, & Tapert, 2007). This is evident as the reductions in white matter was most prominent among marijuana users that also exhibited symptoms of depression (Medina, Nagel, Park, McQueeny, & Tapert, 2007).

Marijuana and Psychosis

The notion that marijuana use may cause psychosis is not a new concept as several studies have demonstrated this association (Murray, Quigley, Quattrone, Englund & Di Forti, 2016). However, many of these previous studies were conducted prior to the legalization of marijuana and the concurrent increase in marijuana potency as the level of THC has been rising (Murray, Quigley, Quattrone, Englund & Di Forti, 2016). Therefore, the current study intended to address this gap in the research as the potential implications

of highly potent marijuana with elevated THC levels should be a major public health concern.

In a related study, the researchers addressed the association between marijuana use, psychosis, and schizotypal personality disorder (Davis, Compton, Wang, Levin, & Blanco, 2013). While marijuana is the most commonly used as an illicit drug in the United States it is also the most commonly used substance among those with schizophrenia and there is a growing body evidence which suggest the substance may also increase the risk of developing schizophrenia (Davis, et al., 2013). However, Davis, et al. (2013) posited that marijuana use alone is insufficient to cause schizophrenia as a host of complex factors contribute to the development of this condition and marijuana may serve to exacerbate or promote the development of psychotic symptoms (Davis, et al., 2013). In order to examine the relationship between marijuana use and these psychotic symptoms, Davis (2013) and fellow researchers examined the association between marijuana use and schizotypal personality disorder (SPD). The primary difference between SPD and Schizophrenia is concerned with duration of signs and symptoms. In SPD these symptoms are transient and not as intense as those seen in schizophrenia (Mayo Clinic, 2017).

Participants for this study included 34,365 adults (aged 18 years and older) that were selected from those completing the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) (Davis, et al, 2013). This is a national survey that covered all 50 states and the District of Columbia. Diagnostic assessment for the study utilized the Alcohol Use Disorder and Associated Disabilities Interview Schedule, which is a

structured interview designed to assess mood, anxiety, psychotic, and personality disorders (Davis, et al., 2013). The DSM-IV was used to assess substance use disorder for marijuana and nine other drug classes. In addition to substance use disorder, respondents were also evaluated for drug-specific abuse and dependence for the selected substances (Davis, et al., 2013). Lifetime cannabis users were defined as those who used cannabis at least once in their lifetime. The study compared sex, age, and race of lifetime cannabis users and non-users and assessed the "percentage of participants with lifetime cannabis use, a diagnosis of lifetime schizophrenia or a psychotic illness or episode (SPIE), and Schizotypal Personality Disorder (SPD)" (Davis, et al., 2013, para. 15).

The study used logistic regression to assess the association between the outcome variables psychosis and SPD and the following three predictor variables: 1) lifetime cannabis use; 2) lifetime cannabis abuse; and 3) lifetime cannabis dependence on psychosis (Davis, et al, 2013). This analysis provided the following results: for lifetime cannabis use "the association between cannabis use and psychosis was 1.27 (95% CI 1.03 -1.57)" and for lifetime cannabis abuse the association was 1.79 (95% CI 1.35 – 2.38) and for lifetime cannabis dependence this association was 3.69 (95% CI 2.49 – 5.47) (Davis, et al., 2013). Thus, demonstrating a dose-dependent relationship between increasing cannabis use and psychosis. Similarly, the relationship between SPD and extent of cannabis use also demonstrated a dose-dependent relationship. As observations revealed an odds ratio (OR) of 2.02 for lifetime cannabis users; OR = 2.83 for lifetime cannabis abusers; and OR = 7.32 for lifetime cannabis dependence (Davis, et al, 2013).

The results of this population-based study demonstrated cannabis use as a possible risk factor for psychosis and SPD, and the risk increases with the extent of cannabis use in a dose-dependent fashion. Furthermore, Davis et al. (2013) posited that

> "the association between cannabis use and SPIE and SPD found in this study could be explained by three mechanisms: (1) Direct pharmacological effects of cannabis lead to psychosis or schizotypal traits; (2) Psychosis or schizotypal traits lead to cannabis use as a means for individuals to cope with these symptoms; or (3) Another associative factor influences both tendency toward psychosis or schizotypal traits and cannabis use" (Davis, et al., 2013, para. 19).

The study conducted by Davis, et al. (2013) is relevant to this current research effort as the results demonstrated a dose-dependent relationship between marijuana use and psychosis and schizotypal personality disorder. Thus, confirming the importance of addressing the effects of higher THC concentrations that would be expected to simulate a higher dose in this dose-dependent relationship. Therefore, these findings further support the gap in the research as one would expect an increased prevalence of psychosis and schizotypal personality disorder to coincide with rising THC levels. My study is intended to explore this hypothesis with respect to states legality status. In addition, data obtained for the study conducted by Davis et al. (2013) was collected between 2001 and 2002 for wave 1 and between 2004 and 2005 for wave 2 by which in either case was prior to the elevated THC levels in marijuana demonstrated post-legalization.

In another study, Moore et al. (2007) conducted a literature review to address the association between psychotic or affective mental health outcomes and cannabis use. The

authors of this study stressed the importance of addressing these concerns in adolescence as these individuals are particularly susceptible to environmental exposures, such cannabis use. Moore et al. (2007) further posited that while it is established that cannabis use can produce short-lived signs and symptoms associated with psychotic and affective mental health outcomes. The long-term or chronic effects are not clearly founded and present cause for greater public health concern.

In this review of the literature, only population-based longitudinal studies or case-control studies with a longitudinal design were selected. For this study, the following conditions described psychosis: "schizophrenia, schizophreniform, schizoaffective, or psychotic disorders, non-affective or affective psychoses, psychosis not otherwise specified, psychotic symptoms, delusions, hallucinations, or thought disorder" (Moore, et al., 2007, para.10). In contrast, the following described affective health outcomes: "Affective, mood, or bipolar disorder, affective disorder not otherwise specified, depression, suicidal ideation or suicide attempts, anxiety, neurosis, and mania" (Moore, et al., 2007, para.10).

Overall, the results of this study demonstrated an increased incidence of psychosis among cannabis users wherein the rate of psychosis among regular to moderate cannabis users was approximately 40% (Moore et al., 2007). In contrast, these rates increased approximately 50-200% for heavy cannabis users as the relationship between psychosis and cannabis use exhibited a dose-response relationship (Moore, et al., 2007). Furthermore, the concept that early age of cannabis use and development of psychosis is not necessarily associated with the sensitivity of younger individuals. But

more so with a cumulative exposure effect of cannabis (Moore, et al., 2007). The literature review conducted by Moore et al. (2007) also revealed that cannabis users were at greater risk for developing affective mental health outcomes. Such as, a psychotic illness.

In a related study, Di Forti, et al. (2014) also addressed the association between the regular use of highly potent marijuana and the occurrence of psychosis. According to the researchers, marijuana users are subject to psychosis at an earlier age than non-users (Di Forti, et al., 2014). However, causality for this association is not fully understood (Di Forti, et al., 2014). Di Forte and colleagues posited that psychosis among marijuana users occurs approximately three years earlier than in non-users (Di Forti, et al., 2014). However, the researchers further posited that these results may not be generalizable as studies have demonstrated that males are subject to schizophrenia at an earlier age and are more susceptible to recreational drug use than females (Di Forti, et al., 2014). Thus, implicating gender as a potential confounding variable in previous studies (Di Forti, et al., 2014). Additionally, the association between psychosis and schizophrenia is relevant as the National Collaborating Centre for Mental Health (2014) indicates that "the term psychosis covers a set of related conditions, of which the commonest is schizophrenia, and includes schizoaffective disorder, schizophreniform disorder, delusional disorder and the so-called non-affective psychoses" (National Collaborating Centre for Mental Health [NCCMH], 2014, para.1). Nevertheless, causality for this association has been described by various theories. One of which suggest that the under-developed brain of an adolescent is more susceptible to marijuana's adverse effects (Di Forti, et al., 2014).

While another theory describes the amount of time one uses marijuana as the cause of psychosis at an earlier age than non-users or less frequent users (Di Forti, et al., 2014).

Based on this understanding, Di Forte (Di Forti, et al., 2014). and colleagues aimed to assess whether psychosis at an early age is more associated with being male versus a specific pattern of marijuana use (Di Forti, et al., 2014). To accomplish this aim, in addition to gender, Di Forte et al. (2014) also addressed the following patterns of marijuana use: 1) how often individuals used marijuana; 2) the potency ('low potency hash-type versus high potency skunk-type') of marijuana used 3) whether an individual used marijuana or not and 4) for marijuana users the age that these individuals first began using marijuana. This study is particularly relevant to the current study because it addresses the effects of highly potent marijuana such as the Skunk type described here with an approximate THC level of 16% versus low potency marijuana (hash-type) with an approximate THC content of four percent (Di Forti et al., 2014).

Participants for this study ranged in age from 18 to 65 years and were selected from patients admitted to one of two mental health facilities in the United Kingdom with a diagnosis of either non-affective or affective psychosis (Di Forte, et al., 2014). This study had varying results. For instance, with respect to gender, the study demonstrated that both male and female marijuana users had a greater likelihood of psychosis at earlier age than non-marijuana users. However, while male users demonstrated an earlier age of psychosis than females with similar marijuana using patterns. This observation was not considered statistically significant (P=.28) for the association between gender and marijuana use according to the results of the regression analysis conducted (Di Forte, et

al., 2014). In contrast, individuals who used highly potent marijuana and those who used marijuana daily had an earlier onset of psychosis than those who used lower potency marijuana and those who used marijuana less than daily, respectfully (Di Forte, et al., 2014). The study also revealed that individuals who began using marijuana at an earlier age (less than 15 years old) experienced their first psychotic episode at an earlier age (Di Forte, et al., 2014). Ultimately, daily marijuana users that preferred highly potent marijuana had the greatest risk of early psychosis (Di Forte, et al., 2014). This group on average experienced a psychotic episode approximately 6 years earlier than those who did not use marijuana (Di Forte, et al., 2014).

The Endocannabinoid System

The identification of THC as the psychoactive component in marijuana ultimately led to the discovery of an endogenous endocannabinoid system that is involved in a range of biological functions. The endocannabinoid system is comprised of cannabinoid receptors; endogenous cannabinoids; and enzymes involved in their regulation as well as an endocannabinoid receptor (Shonesy, 2014). The system is located in the central and peripheral nervous system (CNS & PNS) and mediated by two cannabinoid receptors referred to as CB1 & CB2 (Shonesy et al., 2014). CB1 receptors are primarily located in the CNS while CB2 receptors are located peripherally (Vinod and Hungund, 2006). However, recent evidence suggests that CB2 receptors are also located in the CNS (Vinod and Hungund, 2006). These receptors respond to both endogenous and exogenous stimulation (Shonesy et al., 2014). Natural endogenous stimulation of CB1 receptors occurs through one of two THC-like molecules, anandamide (AEA) and 2-

arachidonoylglycerol (2-AG) (Shonesy et al., 2014). According to Shonesy (2014) this system “is heavily implicated in the modulation of anxiety and depression”. The THC in marijuana is capable of binding CB1 receptors of the system and affects mood (Shonesy et al., 2014). Such that reduced stimulation of these receptors results in mood destabilization and increased feelings of anxiety and depression (para. 1). Thus, marijuana users who suffer from these conditions may not be able to synthesize enough of THC-like molecules (particularly 2-AG) so they self-medicate with marijuana to compensate. Suggesting the potential for treatment regimens that focus on the endocannabinoid system and ligands that bind to its receptors (Shonesy et al., 2014).

Finally, Shonesy, et al., (2014) posit that the data presented may well lend support for an *endocannabinoid deficiency* type state that can contribute to the development of anxiety and depression and therefore encourage the use of cannabis in an attempt to counter these effects. Shonesy et al., (2014) further posited that evidence demonstrating that restoration of the 2-AG signaling system can reverse the symptoms of anxiety and depression brought on by the endocannabinoid deficiency lends support for therapeutic approaches that target the ECS.

In a related article, Vinod and Hungund (2006) provided support for a possible role of the endocannabinoid system (ECS) in depression, suicide, mood disorders and substance use disorders. This article presented a review of the literature on the role of the ECS. The authors explain that CB2 receptors are associated with the immune system and located peripherally (Vinod and Hungund, 2006). While CB1 receptors are located primarily in the CNS. More specifically, within the CNS CB1 receptors are most

abundant in the cortex, hippocampus, cerebellum, and basal ganglia (Vinod and Hungund, 2006). The authors further explained that depression and suicide are associated with alterations in the prefrontal region of the cortex (Vinod and Hungund, 2006). Such that alterations in glucose metabolism in this region has been implicated in the development of depression (Vinod and Hungund, 2006). In addition, depression is also associated with reduced activity and volume of the prefrontal cortex as well as injuries to this region are commonly observed in depressed patients (Vinod and Hungund, 2006). There are also possible implications of the prefrontal cortex in behavioral inhibition, decision making, and the expression of emotions (Vinod and Hungund, 2006).

As previously indicated, the endogenous endocannabinoids (ECs), anandamide (AEA) and 2-arachidonoylglycerol (2-AG) are lipid mediators that act on cannabinoid (CB) receptors of the endocannabinoid system (Vinod and Hungund, 2006). These ECs are found in greatest abundance in the cerebral cortex, basal ganglia, and limbic structures (Vinod and Hungund, 2006). Post-mortem studies have demonstrated that depressed suicide patients have higher than normal levels of CB1 receptors in the pre-fontal cortex and also demonstrate increased activation of these G-protein linked receptors (Vinod and Hungund, 2006). Studies have also implicated an association between cannabis use, mood alteration and the endocannabinoid system in the development of schizophrenia (Vinod and Hungund, 2006). This premise is supported by postmortem studies demonstrating high than normal CB1 receptors in schizophrenics (Vinod and Hungund, 2006). In addition, animal studies on the mechanism of action of antidepressant medications indicate a possible role of CB1 receptors. For instance,

administration of Fluoxetine, an antidepressant that acts by increasing 5-hydroxytryptamine (5-HT) also known as Serotonin, a neurotransmitter that is associated with depression and suicide (Vinod and Hungund, 2006; Serra & Fratta, 2007). Animal studies have demonstrated that the rise in 5-HT caused by fluoxetine, in turn causes a decrease in CB1 receptors. Thus, suggesting a possible function of the endocannabinoid system CB1 receptors in the regulation of mood disorders (i.e. depression), cognition, motivation and emotional behavior (Vinod and Hungund, 2006).

In yet another study, Serra & Fratta (2007) presented a synthesis of the literature on available studies that address the association between the endocannabinoid system and the development of depression. Serra & Fratta (2007) present current hypotheses that attempted to explain the neurobiology behind the development of depression. One of which is the monoamine hypothesis of depression. Which posited that the development of depression is caused by reduced monoaminergic transmission (Serra & Fratta, 2007). More specifically, reduced action of neurotransmitters like noradrenaline (NA) and serotonin (5HT) are associated with the depression (Serra & Fratta, 2007). This premise has led to the development of antidepressant drugs such as selective serotonin reuptake inhibitors (SSRIs) and selective noradrenaline reuptake inhibitors (SNRIs) that increase the availability of 5HT and NE by inhibiting the reuptake of these substances (Serra & Fratta, 2007). Thereby increasing the levels of 5HT and NE at the synaptic cleft which is located between neurons where monoaminergic transmission (Serra & Fratta, 2007). Another hypothesis of depression implicates reduced hippocampal volume with the development of depression (Serra & Fratta, 2007). This hypothesis is supported by

clinical neuroimaging studies that demonstrate reduced hippocampal volume in untreated depressed patients versus no reduction in hippocampal volume in patients treated with antidepressants (Serra & Fratta, 2007). These results suggested that long-term treatment with antidepressants, such as SSRIs & SNRIs in conjunction with electroconvulsive therapy (ECT) can lead to cell proliferation and neurogenesis resulting in an antidepressant effect (Serra & Fratta, 2007).

Regulation or control of the endogenous endocannabinoids, anandamide (AEA) and 2-arachidonoylglycerol (2-AG) occurs via degradation that utilizes one of two enzymes (Serra & Fratta, 2007). Whereby the enzymes fatty acid amide hydrolase (FAAH) and monoacylglyceride lipase (MAGL) degrade and remove the activity of anandamide (AEA) and 2-arachidonoylglycerol (2-AG), respectively. Thus, studies addressing the effects of endocannabinoid system (ECS) on depression can proceed by inhibiting the activity of these enzymes (Serra & Fratta, 2007). In addition, studies of this system can also be conducted using substances that act as either agonist or antagonist of CB1 receptors (Serra & Fratta, 2007). For instance, an agonist of CB1 receptors would bind to and increase activity of this receptor. Whereas an antagonist would block or reduce the activity of CB1 receptors (Serra & Fratta, 2007). Therefore, an agonist of the ECS would be expected to increase antidepressant effects, thereby reducing symptoms of depression. Whereas, an antagonist would be expected to reduce or block the action elicited by CB1 receptors resulting in an increased risk of depression (Serra & Fratta, 2007).

Serra and Fratta (2007) present results from animal studies demonstrating that upon administration of either a re-uptake inhibitor, CB1 receptor agonist, or a competitive inhibitor of FAAH (all of which increase activity of CB1 receptors) results in an antidepressant like effect. These results support the notion that the ECS plays an important role in the development of depression. In contrast, the action of these substances is antagonized (blocked) by administration of a CB1 receptor blocker (Serra & Fratta, 2007). Thus, further supporting the role of the ECS in depression as stimulation of CB1 receptor results in antidepressant-like effect and blocking CB1 receptors reduces the antidepressant effects elicited by stimulation of these receptors (Serra & Fratta, 2007).

In contrast, Serra and Fratta (2007) report on animal studies that utilize CB1 knock out mice, which have been bred and manipulated to reduce or eliminate the presence of CB1 receptors. In this study researchers observed that CB1 knock out mice were more susceptible to developing depressive-like behavior (Serra & Fratta, 2007). These results provided additional support for the role of the ECS in the regulation of depression.

In addition to depression, the ECS has also been implicated in the development of psychosis (Bioque et al., 2009). There are several hypotheses which exist to explain the development of psychosis. Among them include several demonstrating alterations in the immune system as a possible etiology (Bioque et al., 2009). It has been proposed that immune system involvement may include both the peripheral and central nervous system in this *etiological explanation of psychosis* (Bioque et al., 2009). As previously indicated, CB2 receptors of the ECS are primarily located in and associated with the peripheral

nervous system (PNS) (Vinod and Hungund, 2006). Bioque et al., (2009) conducted a study to assess the expression and involvement of components of endocannabinoid system in the development of first-episode psychosis (FEP) versus health controls. The employed multiple logistic regression to determine which components of the ECS have a potential role as either risk or protective factors in the development of FEP (Bioque et al., 2009). This study also assessed possible alterations in the ECS due to prolonged heavy cannabis use (Bioque et al., 2009)."

The ECS components identified and studied from peripheral blood mononuclear cells (PBMC) include: Protein expression of the cannabinoid receptor 2 (CB2), which is located the PNS and associated with immune system function (Bioque et al., 2009); Protein levels of N-acyl phosphatidylethanolamine (NAPE) and diacylglycerol lipase (DAGL), the main enzymes involved in the synthesis of regulatory endocannabinoids [i.e. anandamide (AEA) and 2-arachidonoylglycerol (2-AG)]; and Fatty acid amide hydrolase (FAAH) and monoacylglycerol lipase (MAGL) the main enzymes involved in the degradation, removal and therefore inactivation of regulatory enzymes of the ECS (Bisque et al., 2009).

The researchers recruited 95 participants with FEP and 90 controls from among patients at Spanish university hospitals (Bisque et al., 2009). The results of this study revealed that individuals with FEP also had decreased expression of CB2 receptors suggesting reduced ECS activation as a possible contributor to FEP (Bisque, 2009). In addition, FEP patients also demonstrated decreased levels of NAPE and DAGL, the enzymes responsible for synthesizing the regulatory endocannabinoids, AEA and 2-AG

(Bisque, 2009). This suggest that reduced levels of these components may contribute to the development of FEP via reduced activity of the ECS (Bisque, 2009). In contrast, FEP individuals demonstrated an increased expression of FAAH and MAGL, the enzymes responsible for degrading and removing the activating/regulatory components of the ECS (Bisque, 2009). This implies that reduced activity of AEA and 2-AG led to reduced ECS function and increased risk of FEP (Bisque, 2009). Thus, CB2 receptor expression and the regulatory endocannabinoids may well serve as protective factors of the ECS, reducing the potential for the development of FEP (Bisque, 2009). While the degradation and removal enzymes, NAPE and DAG may serve as risk factors for FEP (Bisque, 2009). Finally, Bisque et al., (2009) suggest a potential role of heavy prolonged cannabis use in the etiology of FEP as these individuals demonstrated a large dysregulation of the ECS when compared to the healthy control group (Bisque et al., 2009).

Therapeutic Effects of Marijuana on Mental Health

While this literature review has focused on the causative nature of marijuana as the substance has been demonstrated to exacerbate or potentially cause psychosis, anxiety, and mental illnesses like depression and schizophrenia. However, ironically marijuana or more specifically its constituents has the potential to counteract these conditions.

Marijuana also known as Cannabis contains numerous Cannabinoids. Two of the most significant include Delta-9-Tetrahydrocannabinol (THC) and Cannabidiol (CBD). According to Zuardi et al., (2006) these substances have a divergent pathway exhibiting properties that are opposite in nature. For instance, THC is reportedly responsible for the

psychoactive effects most recreational marijuana users seek. While CBD demonstrates the opposite effects as this cannabinoid has anti-psychotic activity (Zuardi et al., 2006).

Zuardi et al. (2006) further posited that the cannabinoid, Delta-9-THC can cause anxiety and psychotic-like symptoms as demonstrated in healthy volunteers exposed to intravenous THC. Conversely, CBD does not produce these psychological effects (Zuardi et al., 2006). Studies assessing the interaction between CBD and THC demonstrated that CBD has anxiety reducing (anxiolytic) and anti-psychotic effects when co-administered with THC (Zuardi et al., 2006). Additional properties of CBD are associated with the following effects: hypnotic, anticonvulsive, neuroprotective, and hormonal (increased corticosterone and cortisol levels) (Zuardi et al., 2006). Thus, marijuana's properties, effects, and potency can vary based on the ratio of THC and CBD, and this ratio can vary based on the particular strain of marijuana, the growing conditions, and other factors (Radhakrishnan, Wilkinson & D'Souza, 2014; Zuardi et al., 2006). Nevertheless, it is this researcher's understanding that typically, as the amount of THC increases, the amount of CBD decreases and vice versa. This understanding is supported in a study by ElSohly et al. (2016) which concluded that

> "overall, the potency of illicit cannabis plant material has consistently risen over time since 1995 from approximately 4% in 1995 to approximately 12% in 2014. On the other hand, the CBD content has fallen on average from approximately 0.28% in 2001 to <0.15% in 2014, resulting in a change in the ratio of THC to CBD from 14 times in 1995 to approximately 80 times in 2014" (ElSohly et al., 2016, pg.613).

This observation provides further support to address the gap in the research created by highly potent marijuana as additional research is warranted to address the rising levels of THC demonstrated post-legalization.

Individuals may unknowingly reduce the risk of psychosis by smoking marijuana that is high in CBD as evidenced in the study by Morgan & Curran (2008), wherein the researchers support the premise of opposing actions for THC (psychotomimetic) and CBD (antipsychotic; anxiolytic). Morgan & Curran (2008) examined hair samples of known drug users and non-drug users for the presence or absence of THC and CBD. The results of the hair samples identified the following four groups of individuals: 1) THC only; 2) THC and CBD; 3) CBD only; and 4) those with no cannabinoids. Among those identified as THC only, these individuals were included only if the hair sample contained the presence of Delta-9-THC-carboxylic acid in addition to the normal Delta-9-THC (Morgan & Curran, 2008). This is because the presence of Deltal-9-THC-carboxylic acid is indicative of actual marijuana use rather than secondary or passive exposure to the substance (Morgan & Curran, 2008). In addition, the CBD only group was excluded because this sample consisted of 8 individuals and too small for statistical analysis (Morgan & Curran, 2008). The final sample therefore included the following three groups: 1) THC only; 2) THC-CBD and 3) no cannabinoids (Morgan & Curran, 2008). The results of this study reveal that the THC only group was more prone to psychosis and unusual experiences (i.e. hallucinations and delusions) than both the no cannabinoid group and the THC-CBD group (Morgan & Curran, 2008). In addition, scores for delusional thinking was higher in the THC only group than in the no cannabinoid group

and the THC-CBD group (Morgan & Curran, 2008). However, this score was also higher in the THC-CBD group than in the no cannabinoid group (Morgan & Curran, 2008). Another interesting trend is lower scores for anhedonia in the THC-CBD group than in the THC only and no cannabinoid groups (Morgan & Curran, 2008). This observation may reflect some potential protective effects of CBD, as anhedonia is described as an inability to experience pleasure and this is one of the main symptoms associated with major depressive disorder, which is an important mental health issue (Brynie, 2009; Morgan & Curran, 2008).

It is important to mention that the target population included ketamine users and this substance may have properties that could be confused with the mental health and psychotic-like conditions exhibited by THC in marijuana (Morgan & Curran, 2008; Davis, 2017). For example, ketamine is used recreationally for its hallucinogenic and dissociative properties (Davis, 2017). Thus, demonstrating a potential limitation of this study.

In yet another study, Morgan et al. (2012) further addressed the effects of THC/CBD ratios. In the previous study Morgan et al (2008) provided evidence indicating that individuals who smoked marijuana containing high or detectable levels of CBD were less prone to psychotic-like symptoms than individuals who smoked marijuana high in THC or no CBD. In this more recent study, Morgan et al. (2012) sought to determine if the potential protective effects of CBD extended beyond psychosis (psychotic-like symptoms). Thus, Morgan et al. (2012) addressed the effects of CBD on memory, depression, anxiety, and psychological well-being among marijuana users. In this study,

marijuana users were again placed into groups based on hair sample analysis. The results of this study demonstrated fewer psychosis-like symptoms in those with detectable levels of CBD than those without, and increased depression and anxiety among those with high levels of THC (Morgan et al., 2012). In addition, those with high THC levels had more problems with memory and recall than those with CBD detected (Morgan et al., 2012). Thus, while highly potent marijuana which has elevated THC levels may contribute to the development of mental health issues and psychosis (Morgan et al., 2012). This occurrence may be attenuated by marijuana with higher CBD/THC ratios as detectable levels of CBD may be protective in nature (Morgan et al., 2012).

In a related study, McGuire et al. (2017) addressed the potential antipsychotic properties of Cannabidiol (CBD) in the treatment of Schizophrenia (McGuire et al., 2017). In this study, McGuire et al. (2007) added CBD to the existing treatment regimen of schizophrenia patients. The double-blind study randomly placed schizophrenia patients into two groups (McGuire et al., 2017). Group 1 or the treatment group received CBD as an adjunct to their existing treatment antipsychotic regimen. The control group received a placebo in addition to their regular antipsychotic medication (McGuire et al., 2017).

The study results demonstrated a reduction in positive psychotic symptoms among schizophrenic patients treated with CBD and their existing antipsychotic medication (McGuire et al., 2017). In addition, the evaluating clinicians report that the CBD group demonstrated reductions in disease severity, and general improvements in overall health and cognitive function (McGuire et al., 2017). A small percentage of patients in both the CBD and placebo groups report mild adverse effects with treatment.

However, most symptoms were mild and resoled without treatment (McGuire et al., 2017). This is an important benefit as antipsychotic medications have been associated with adverse effects that can cause poor patient compliance resulting in less favorable health outcomes (McGuire et al., 2017). Another important aspect of this study is concerned with the mechanism of action associated with typical schizophrenia drugs. These drugs typically function through a dopamine receptor process (McGuire et al., 2017). Therefore, CBD which does not use this mechanism of action may offer and alternative approach that can be used in conjunction with traditional drugs (McGuire et al., 2017).

Marijuana Distribution and Preference

Since legalization began trends in marijuana potency, usage, distribution, preference and methods of use have also changed somewhat dramatically. For instance, during the period between the 1960s through the mid-1990s the THC content of marijuana ranged from 2 to 4%. Which is far less potent than marijuana used today as the THC content increased significantly by 212% between 1995 and 2015 (Stuyt, 2019). Such that by 2017 this sharp rise in THC concentration led to the availability of marijuana with THC levels ranging between 14 to 28 percent as found in Colorado dispensaries at that time (Stuyt, 2019). This dramatic rise in THC content is largely due to the unchecked growth and manipulation by the marijuana industry to produce far more potent strains of marijuana (Stuyt, 2019). The production of highly potent marijuana strains is advantageous to the marijuana industry as THC concentration is associated increased psychoactive effects, increased use and greater risk of addiction (Stuyt, 2019).

Ironically, this approach reflects a strategy employed by big tobacco companies. Which gradually developed and marketed tobacco products that were far more addictive, appealing and accepted (Richter & Sharon, 2014). These innovations led to changes in tobacco consumption from 1% among the American consumer in the 1880s to roughly half of the population using tobacco by the 1950s (Richter & Sharon, 2014).

As such, legalization has demonstrated a rise in marijuana use as according to Carroll (2018) "one in seven adults report using marijuana in 2017" with an overall use rate of 14.6 percent among adults in U.S. The portion of use also varies based on states legality status (para. 1). For instances, in states with no laws allowing marijuana use only 12 percent of adult's report using marijuana in the past year (Carroll, 2018). In contrast, in states with laws legalizing medical marijuana the rate of use for adults was 14 percent (Carroll, 2018). Whereas in states with recreational marijuana laws adult use in the past year rose to 20 percent (Carroll, 2018). Thus, the adult use of marijuana has doubled in the general population over the last decade according to reports in 2014. Indicating that 13.3 percent of adults reported past-year marijuana use (Keyhani, et al., 2018). These statistics are the result of a national study reported in the Annals of Internal Medicine, entitled: *Risks and Benefits of Marijuana Use: A National Survey of U.S. Adults* (Keyhani, et al., 2018). In this study, Keyhani et al., (2018) used federal surveys, peer-reviewed literature, and media reports to develop a comprehensive survey to gain a greater understanding of how adults in U.S. view marijuana. This national survey was not only designed to provide an understanding of opinions associated with marijuana acceptance and legalization. But also, to address topics such as: frequency of marijuana

use; reasons for using marijuana; as well as knowledge and behaviors associated with marijuana use (Keyhani, et al., 2018). In addition, specific areas of content included:

> "perceptions of specific risks and benefits of marijuana use, possible preventive health benefits of different methods of marijuana consumption (smoking, vaping, ingestion), addiction potential, safety of use during pregnancy, and societal effects (including secondhand smoke and driving under the influence)" (Keyhani, et al., 2018, para 14).

Finally, the survey addressed how adults view the use and effects of marijuana when compared to other legal drugs with abuse potential, such as tobacco and alcohol (Keyhani, et al., 2018).

The results of this survey had surprising and widely varied results. Regarding perceived risks and benefits, the respondent's results revealed that most adult in the U.S. (81%) believed that marijuana has at least one benefit with only 17% of respondents indicating that marijuana has no benefit (Keyhani, et al., 2018). The following is a list of perceived benefits identified and the percentage of respondents that believe marijuana is associated with those benefits. These include: 1) Pain management (65.7); 2) Treatment of disease (such as epilepsy or multiple sclerosis) (47.9%); 3) Relief of stress, anxiety, or depression (46.8%); 4) Improved appetite (35.1%); 5) Improved sleep (28.9%); 6) Help decreasing or stopping other medicines (23.3%); 7) Improved creativity (16.2%); 8) Improved focus or concentration (10.6%); 9) Increased energy (8.1%); and 10) Other benefit (5.1%) (Keyhani, et al., 2018). Regarding risk, the following is a list of the most common perceived risk identified by respondents: 1) Legal problems (51.8%); 2)

Addiction (50%); 3) Impaired memory (42%); Increased use of other drugs (37.4%); Personal or relationship problems (34.8%); Decrease in Intelligence (IQ) (28.6%); Decrease in energy (27.4%); New or worsening health problems (18%); Increase in stress, anxiety, or depression (15%); Disrupted sleep (11.3%).; and 8.8% of respondents believe marijuana use is without risk. However, most respondents (21.3%) indicated that addiction is the most important risk associated with marijuana use. The second most important risk identified was legal problems (20.7%) followed by an increased risk of using other drugs (18%) (Keyhani, et al., 2018). Nevertheless, based on the results identified it is evident that most adult respondents (81.1%) believe marijuana have some benefits whereas only 17% of respondents indicate that marijuana has no benefits. This finding is consistent with the growing trend in marijuana perception and acceptance as according to an article published by the Pew Research Center, approximately 62% of Americans believe marijuana should be legalized (Hartig & Geiger, 2018). Thus, reflecting a decrease in perceived risks associated with marijuana use. This belief and acceptance have increased steadily and relatively rapidly as in the year 2000 only 31% of Americans favored legalization (Hartig & Geiger, 2018). This finding is further evidenced by a national survey that indicates Americans perception of "great risk from weekly marijuana use dropped from 50.4% in 2002 to 33.3% in 2014" (Keyhani, et al., 2018, para. 5).

The results of Keyhani et al., (2018) also reveal that many Americans believe marijuana can reduce the risk of negative health outcomes. As 36.9% of U.S. adults surveyed believed to some degree that edible marijuana has some preventative health

benefits. Whereas, 61.9% of U.S. adults disagree with this notion (Keyhani, 2018). In contrast, 29.2% of respondents believe that smoking marijuana has some preventative health benefits with 69.8% of respondents disagreeing (Keyhani, 2018). Additionally, 29.2% of respondents indicate that vaping marijuana has preventative health benefits while 69.6% disagreed to some degree (Keyhani, 2018).

All the same, while the most common method of use is still smoking as 12.9% report smoking as their preferred method of use (Carroll, 2018). There is growing preference for other methods of use that increase potency and duration of action as 6% of respondents prefer consumption of marijuana infused products (Carroll, 2018). Followed by vaping at 4.7% then use of marijuana concentrates 1.9%, and use of topical marijuana products 0.8% (Carroll, 2018). Thus, there is a growing preference among marijuana users for highly potent marijuana and marijuana products with higher THC levels, and methods of use that produce longer and more profound effects.

In addition, when compared to other substances of use, misuse and abuse such as, tobacco and alcohol. Respondents generally believe marijuana is safer. For instance, more than one-third (37.3%) of adults surveyed believe that secondhand marijuana smoke is safer than secondhand tobacco smoke. Many respondents also believe secondhand marijuana smoke is completely safe for adults (18%) and children (7.6%). In addition, Keyhani et al., (2018) posited that 38.2% of respondents believe “that smoking 1 marijuana joint a day is much safer or somewhat safer than smoking 1 cigarette a day”, and “about 13.5% agree that smoking 1 marijuana joint per day is safer than drinking 1 glass of wine per day” (para. 18).

Regardless of public perception**,** evidenced based research to substantiate the risk and benefits of marijuana is limited. Moreover, unlike tobacco and alcohol, the marketing of marijuana is relatively free of constraints (Keyhani, 2018). As public health leaders have yet to implement widespread accompanying messages to warn the public of the potential harms associated with marijuana use (Keyhani, 2018). With such unchecked promotion, growing acceptance and continued widespread legalization it is important now more than ever to emphasize these risks, and develop strategies and regulations to protect, warn and inform the public and future generations of the potential implications of continued widespread legalization and acceptance.

Another growing concern in the wake of continued widespread legalization is trafficking and therefore distribution of legal marijuana. Which has been a concern since legalization began for recreational purpose in Colorado (Schwarz, 2017). This is evidenced by a lawsuit in which Nebraska and Oklahoma attempted to sue Colorado alleging that the state's decision to legalize recreational marijuana is a violation of the U.S. constitution and places significant burden on bordering states' law enforcement and legal systems (Schwarz, 2017). While the supreme court denied these challenges, the concern still exists as according to an article published by the Hazelden Betty Ford Foundation (HBFF) (2017),

> "Marijuana legalization efforts alter black market economics but are not effective in stopping black market sales. Perhaps due to poor regulation or supply chain issues, many young people I see from across the country talk about getting their

> ‘high quality’ marijuana and concentrates from ‘legitimate’ growers who liquidate their surplus at a heavily discounted price.” (para. 20)

This premise is further evidenced by reports from California which indicated that the majority of marijuana produced within the state, approximately 85 to 90% is trafficked out to regions without laws legalizing marijuana (Fuller, 2019). In fact, the California Department of Food and Agriculture estimates that the state produces approximately 15.5 million pounds of marijuana annually and only consumes about 2.5 million pounds within the state. This surplus marijuana is estimated at 13 times the total amount produced annually in Colorado (Fuller, 2019). Most of which is smuggled east across the Rocky Mountains and Mississippi into areas like Illinois, Connecticut and Washington, D.C. where this surplus marijuana can sale for as much as three times the original wholesale price (Fuller, 2019). Thus, highly potent marijuana produced and sold in states with medical and recreational laws is making its way into other areas without such laws (Fuller, 2019). While this trend in rising THC levels demonstrated nationally since legalization should be a growing concern. Another challenge for public health leaders is the methods of marijuana use as users and distributors are constantly finding new and innovative ways to use the substance (Keyhani, 2018). These methods have the potential to further enhance the effect of marijuana by increasing THC levels or duration of action. *Dabbing*, *vaping*, synthetic marijuana, shatter, and consumption of edible marijuana products are methods of use that have emerged to improve the psychoactive effects of marijuana (Keyhani, 2018; Murray, Quigley, Quattrone, Englund & Di Forti, 2016). In states where marijuana has been legalized for medicinal and/or recreational

purposes these methods of use are growing in popularity and are increasingly widely available (Keyhani, 2018; Murray et al., 2016). Consumption of edible products and production of concentrated oils either increase duration of action and/or THC concentration (Murray et al, 2016). For instance, methods of extracting THC from the marijuana plant have been found to produce resin oils with a THC concentration as high as 80%. Additionally, other methods of use such as vaping and *wax dabbing* also deliver a high THC concentration to the user (Murray, et al., 2016).

Dabbing is a method of marijuana use wherein the user smokes a highly potent marijuana extract commonly referred to as *wax* (Marijuana Factcheck-potency, 2019; Murray, et al., 2016). While dabbing or the use of butane hash oil is commonly considered a new method of marijuana use when in fact this method has been around since the 60s and may date back even further (Al-Zouabi, Stogner, Miller, Lane, 2018). During the Vietnam conflict (war) soldiers would use acetone or petrol to extract the THC in marijuana to create a liquid concentrate that could then be smeared on cigarettes, rolling papers or used to saturate tobacco prior to rolling or smoking by other means (Al-Zouabi, et al., 2018). Nowadays marijuana users create THC concentrates using butane instead and therefore the resulting product is termed “butane hash oil” or BHO (Al-Zouabi, et al., S2018). The concentrate produced is referred to by several names and the terminology typically describes the products consistency. For instance, other names of BHO, dabs and oils include: *shatter; honeycomb; crumble wax; budder; and earwax* (Al-Zouabi, et al., 2018, para. 2). Among these shatter is considered the most difficult form to produce and appears as a clear amber solid (Stogner & Miller, 2015). Nevertheless, since

legalization of medical and recreational marijuana these extracts are becoming increasingly popular as evidenced by studies in the United States. For instance, Zhang, Zheng, Zeng, and Leischow (2016) conducted a case study in which the researchers tracked query searches on dabs or Dabbing of BHO concentrates in the United States from January 2004 to December 2015. The study revealed that dabbing searches increased with time to reach an estimated high of 1,526,280 searches on dabbing in 2015 (Zhang, et al., 2016). In yet another study, Daniulaityte and colleagues (2015) conducted an analysis of "Twitter data on marijuana concentrates across the U.S.". The results revealed that "dabs-related tweets were highest in states that allowed recreational and/or medicinal cannabis use and lowest in states that have not passed medical cannabis use laws" (Daniulaityte, et al., 2015, p. 307). Thus, resources and information are readily available as instructional videos on various websites, and social media platforms provided easy access for the recreational home users and producers (Stogner & Miller, 2015). Reportedly these BHO concentrates can have THC levels that range as high as 80 percent (Stogner & Miller, 2015). In one study conducted in Switzerland, researchers found that while the marijuana flowers being used had a THC level of 17% the BHO concentrate produced was as much as four times that with a THC concentration as high as 71% (Cannabis Technology News, 2019).

The BHO concentrate is commonly used by one of two methods, dabbing and/or vaping. Dabbing is a method that involves using conduction as the form of heating (Krauss, et al, 2015). In this process the user heats the dab (marijuana or BHO concentrate) to a high temperature using a torch on a conduction surface or hot plate

which is typically a nail. The user then inhales the vapor produced (Krauss, et al., 2015). Many marijuana users believe that dabbing is a cleaner method of using marijuana that is less harmful than smoking (Sandoiu, 2017). However, this may not be the case as discovered by Dr. Strongin and fellow researchers at the University of Portland. While simulating the conditions of dabbing in the lab and monitoring the composition of vapor produced (Sandoiu, 2017). They found that the butane hash oil produced relatively high levels of benzene, a known cancer-causing chemical as well as methacrolein. While methacrolein is generally considered a noxious irritant, another chemical acrolein which is similar in structure to methacrolein is also a known human carcinogen (Sandoiu, 2017). Dr. Strongin and colleagues posit that "Given the widespread legalization of cannabis in the [United States], it is imperative to study the full toxicology of its consumption to guide future policy" (Sandoiu, 2017, para. 17).

In contrast, vaping and the use of e-cigarettes is growing in popular particularly among adolescents as according to one report "one in 11 middle and high school students report using an e-cigarette for marijuana, hash oil or wax" (Marijuana Factcheck [MFC]-vaping 2019, para. 1). Unlike dabbing which uses conduction heating of a metal surface where heat is directly applied to and transferred to a heating element, vaping involves convection heat (Krauss, et al., 2015). In this process the material to be inhaled (marijuana leaves, BHO concentrated oil or dab) is heated indirectly usually using a battery powered heat source that heats the coil that heats the air. The hot air moves through the marijuana product, which is vaporized, and the resulting vapor is inhaled by the user (Lepkoff, 2018; Yang et al., 2018). Users prefer vaping and e-cigarettes (e-cigs)

because they are easily concealed as these methods do not produce visible smoke and are nearly odorless (MFC-vaping, 2019; Yang et al., 2018). Users also prefer vaping and e-cigs because they are a cost-effective as a smaller amount of concentrated marijuana product (high potency THC) is required to achieve the desired effect (MFC-vaping, 2019; Yang et al., 2018).

In addition, much like with dabbing many marijuana users believe that vaping and the use of e-cigarettes are safer than traditional methods of smoking marijuana (Yang et al., 2018). While not much is known about the long-term effects of vaping and e-cigarettes as few to no studies have been conducted to address these concerns. There may be some merit to the perceived potential health benefits or reduced health risk (Budney, Sargent & Lee, 2015). This is because the use of e-cigarettes and/or vaping of marijuana and marijuana products such as waxes oils and concentrates does reduce the amount of toxins and carcinogens typically inhaled by traditional smoking methods. Thus, reducing the amount of carbon monoxide, tar, ammonia and hydrogen cyanide inhaled by the user (Budney, Sargent & Lee, 2015). In fact, Blundell, Dargan & Wood (2017) posited that "Cannabis smoke is also comparable to tobacco smoke containing phenols, ammonia, hydrogen cyanide, nitrosamines and carcinogens such as benzopyrene and benzanthracene" (para, 9). However, according to an article published in the Public Health England review. Vapor produced and inhaled from e-cigarettes is approximately "95% safer than cigarette smoke from this perspective as the harmful constituents of e-cigarette vapour are below 5% of smoking doses and far below safety limits for occupational exposure" (para. 9).

Another potential benefit is a reduction in exposure to secondhand smoke to other non-users since these methods typically do not produce smoke and are virtually odorless (Budney, Sargent & Lee, 2015). Additionally, those who vape or use e-cigarettes to consume marijuana (cannabis) also report fewer symptoms of respiratory problems. However, once again no long-term studies are available to compare vaping versus traditional smoking methods (Budney, Sargent & Lee, 2015).

Despite these seemingly potential benefits, vaping and use of e-cigarettes are not without risk and great concern for the community and public health leaders. Yang et al., (2018) points out a particularly troublesome aspect of these methods of use is marijuana marketing to our youths and young adults. Which is overwhelmingly provided, promoted and obtained through social media platforms that are difficult to monitor, control and/or regulate (Yang et al., 2018). These various sources often contribute to a reduction in perceived risk associated with vaping and the use of e-cigarettes. In one study by Budney, Sargent and Lee (2015), the researchers posited that several studies have been conducted and indicate that these reductions in perceived risk may in turn lead to the following: an earlier age of initial use; increased frequency of use; and a decreased motivation to quit or reduce use. In addition, marijuana users typically smoke or use less marijuana than the average tobacco user. This comparatively results in the perception (and rightly so) that marijuana users should have fewer concerns about complications associated with regular tobacco use (i.e. lung cancer and chronic lung disease). However, while this may be the case. The primary concerns with a reduction in perceived marijuana risk are associated with misuse and addiction. This is of particular importance for our youths and young

adults as according to Budney, Sargent & Lee (2015), chronic marijuana use can lead to the following psychological and neurocognitive consequences: increased risk behaviors; poor school or job performance; family and interpersonal problems; accidents; memory and motivational problems; and the development of addiction.

Another concern associated with vaping and e-cigarettes is the use of these methods to inhale or ingest synthetic cannabinoids or other substances. The synthetic cannabinoids are structurally similar and function much like THC (Castellanos & Gralnik, 2016). These substances also known as cannabimimetics have been around since the 1960s. However, their popularity increased between 2004 and 2008 when they evolved into recreational drugs across Europe and then growing in acceptance worldwide (Castellanos & Gralnik, 2016). Since then producers have been developing newer and more potent forms that when coupled with methods of use like vaping and e-cigarettes pose a much more dangerous threat (Castellanos & Gralnik, 2016). Synthetic cannabinoids are a serious concern for public health leaders as youths and young adults are using and abusing these substances in increasing numbers. Which are reportedly much more potent than natural forms of marijuana (Castellanos & Gralnik; Pelt, 2012; Wood, 2013).

Originally synthetic cannabinoids and synthetic stimulants referred to as *incense* and *bath salts* respectively were sold legally in the United States (Perrone, Helgesen & Fischer, 2013). The incense or synthetic cannabinoids are intended to mimic the effects of marijuana whereas the synthetic stimulants or bath salts are intended to mimic the effects of methamphetamine. As mentioned in the mid-2000s the US Drug Enforcement

Agency (DEA) had not yet banned mephedrone (the stimulant found in bath salts) nor had they banned the synthetic cannabinoids. Thus, many users perceived these substances as legal substitutes to the illegal substances they mimic (Perrone, Helgesen & Fischer, 2013). In a study conducted by Perrone et al., (2013) some users sought to avoid positive test on drug screenings and still others sought to avoid criminal prosecution for position of illegal substances. While other users were classified as into one of the following groups: attending abstinence-only drug treatment programs; under community correction programs; or pursuing a career in the US military, all of which require mandatory random drug testing (Perrone et al., 2013). The availability of these substances is only exacerbated by the internet which has not only made it easier to purchase these substances, but also serves to promote their use as some websites not only promote these substances but also provide directions for new users (Pelt, 2012).

The trend in abuse of Bath salts and Synthetic Cannabinoids demonstrated an increase from 2009 to 2011 (Wood, 2013). However, in 2012 the abuse of bath salts began to decline while the abuse of synthetic marijuana increased with most bath salts users being young men who primarily inhaled the substance (Wood, 2013). In addition, Wood (2013) provides the following demographics for total exposure to synthetic bath salts and cannabinoids (THC) by age range for 2009 – 2012. For synthetic bath salts: Age range 13-19 (16.2%); 20-29 (43.1%); 30-39 (23.7%); 40-49 (12.1%); 50-59 (3.1%). For Synthetic THC: Age range 13-19 (48.8%); 20-29 (34.4%); 30-39 (9.1%); 40-49 (3.9%); 50-59 (1.7%) (Wood, 2013). Values for age ranges below 12 years of age and above 60 years of age were negligible. Nevertheless, this trend demonstrates that most bath salts

users were between the age of 20-29. Whereas most Synthetic marijuana users were between the ages of 13-19 (Wood, 2013).

The misconception that these substances are safe substitutes has been dismissed as the National Institute of health reports that "Thousands of teens and young adults, mostly young males, are ending up in emergency rooms with severe symptoms that may include vomiting, racing heartbeat, elevated blood pressure, seizures, or hallucinations" because of synthetic marijuana use (NIH-NIDA, 2013, para. 1). In addition, per a news release from the U.S. Substance Abuse and Mental Health Services Administration and reported in Health Day (2013) the "Street drugs called 'bath salts' were linked to nearly 23,000 emergency department visits in the United States in 2011" (para. 1).

In a more recent study, Castellanos & Gralnik (2016) provided an update on synthetic cannabinoids informing pediatricians of clinical presentations to look for when treating adolescents and encourage physicians to become familiar with these drugs. According to the researchers, the synthetic cannabinoids have evolved rapidly since their introduction with the potential for dangerous health effects that exceed that of traditional marijuana use (Castellanos & Gralnik, 2016). The potential detrimental health effects of these compounds include: Gastrointestinal problems (nausea and vomiting); Neurologic signs and symptoms (such as tremors, ataxia, fasciculations, and hyperreflexia); Metabolic disturbances (hypokalemia, hyperglycemia, acidosis and diaphoresis); Rhabdomyolysis (muscle damage and breakdown); Renal Damage; Seizures; and Myocardial Infarction; (Castellanos & Gralnik, 2016; WebMD, 2019). In addition, Castellanos & Gralnik (2016) also report the following psychoactive effects: Cognitive

complications (attention, concentration and memory deficits, confusion); Affective disorders (anxiety and panic); as well as Behavioral disfunctions (restlessness, agitation, violence, and aggression) and Psychosis (hallucinations, delusions and disorganized thoughts). Further compounding the challenge of addressing this concern are the new methods of use. Vaping and e-cigarettes allow manufactures to present these products as natural cannabis resins, CBD oils, and liquid cartridges (Castellanos & Gralnik, 2016; Popp, 2018).

While the prevalence of marijuana use, vaping, dabbing and the use of concentrated products may be higher in areas with medical and/or recreational marijuana laws (Keyhani, 2018). Areas without medical marijuana laws or limited medical marijuana laws are not immune. For instance, in the Atlanta Georgia area with only limited medical marijuana laws there have been numerous incidents where individuals (most notably youths and young adults) have utilized these products with detrimental effects. In many cases they are being sold legally as *bath salt* or *labeled as not for human consumption* (Castellanos & Gralnik, 2016; Popp, 2018). In Forsyth County, which is located just North of Atlanta two high school students had to be transferred to the hospital in 2017 after vaping CBD oils (Popp, 2018). In another situation, authorities in Forsyth county have been warning parents and students about new types of synthetic THC and CBD oils (Popp, 2018). Proper use of these liquids involves adding them to e-cigarette nicotine liquid allowing the user to achieve an added high. However, problems arise when individuals, mostly students, vape the liquid straight as oppose to adding them to nicotine liquid (Popp, 2018). Authorities warn that the outcome can be disastrous

resulting in a medical emergency with symptoms of suppressed respiratory function and increased heart rate. Consequently, mimicking that of an opioid overdose (Popp, 2018). The names of these products (synthetic marijuana or CBD oils) include: *Kronic Juice, Galaxy, Diamond and Lyft* and they are being sold in vape shops, head shops and CBD shops in and around the Atlanta area (Popp, 2018). Among these, Kronic Juice has been associated with seizures and unconsciousness when not used as instructed (Popp, 2018).

One reason vaping, and e-cigarettes are growing in popularity is because the use of substances by these means are easily concealed, smokeless and virtually odorless (Yang et al., 2018; MFC-vaping, 2019). School administrators, principals and teachers in Forsyth county Georgia emphasize the problems with addressing this concern as they have observed vaping devices designed in the form of everyday objects like phones, pens, and flash drives (Popp, 2018). Thus, making them difficult to detect (Popp, 2018).

While the use of concentrated marijuana products such as BHO and methods of use like dabbing, vaping and e-cigarettes are a growing concern. Another issue facing public health and health care professionals is the consumption of edible products infused with marijuana. These products are growing in popularity and come in many forms such as, candy; cookies; brownies; and even popular breakfast cereal (i.e. Fruity Pebbles) (Cao, Srisuma, Bronstein & Hoyte, 2016; Haney, 2019)

Even though smoking marijuana remains the most common method of use (Keyhani et al., 2018). Since the implementation of medical marijuana laws alternative methods of marijuana use have been on the rise and warrants public health attention (Keyhani et al., 2016). This rise in alternative methods of use is evidenced in a study by

Borodovsky, Crosier, Lee, Sargent, & Budney (2016), in which the researchers sought to assess whether marijuana (cannabis) legalization impacted methods of marijuana use (Borodovsky, et al., 2016). Based on States medical marijuana status, duration of medical marijuana status, and the density of marijuana dispensaries in the state. The researchers analyzed whether individuals ever used marijuana, preference for marijuana use, and age at which individuals started smoking, vaping and eating marijuana (Borodovsky, et al., 2016). The results revealed that in states with MMLs the odds of an individual using alternative methods were significantly higher for vaping and edibles (OR: 1.78, 99% CI: when compared to states without MMLs (Borodovsky, et al., 2016). The rise in use via vaping and edibles would be expectedly higher in states with both medical marijuana laws (MMLs) and recreational marijuana laws (RMLs) as in states with RMLs the availability of BHO concentrates and edible products is greater and more highly marketed to the public (Borodovsky et al.; 2016Carroll, 2018; Keyhani et al., 2018;).

Thus, consumption of marijuana-infused products have been gaining popularity along with the spread of medical and recreational marijuana legalization (Barrus et al., 2016; Montgomery, 2017). This is evidenced by booming sales of marijuana infused edibles and drinks in states like California and Colorado that have legalized recreational marijuana (Montgomery, 2017). For instance, in California edible marijuana sales reached $181 million in 2016, and in Colorado sales reached $53 million during the third quarter of 2016 where sales were just $17 million during the first quarter of 2014 (Montgomery, 2017). Demonstrating a three-fold increase in Colorado sales in less than

two years. However, while consumption of marijuana products is growing in popularity it is not without risk and challenges.

In a related article, Barrus et al. (2016) explores various aspects surrounding edible marijuana products with particular attention on challenges arising for users and policy makers as well as attempts at regulation (Barrus et al., 2016). The researchers first explain the process involved with producing the cannabinoid-infused oil required for making edible marijuana products (Barrus et al., 2016). This involves extracting the primary cannabinoids (THC & CBD) from the marijuana plant. Which is achieved by heating the raw female marijuana plant (flowers and leaves) in an oil-based liquid (Barrus et al., 2016). Heating of the marijuana plant products serves to convert THC from its non-psychoactive form, Delta-9-tetrahydrocannbinolic Acid (THCA) into its psychoactive form, Delta-9-tetrahydrocannabinol (Δ^9-THC) (Barrus et al., 2016). This psychoactive form is responsible for the high that many marijuana users seek. It along with other cannabinoids, such as CBD the medicinal (non-psychoactive) cannabinoid is extracted into the oil-based liquid (Barrus et al., 2016). The remaining plant products are removed and discarded, and the cannabinoid-infused oil is ready for use in consumable products and/or retail sale in dispensaries (Barrus et al., 2016). The researchers report that in Colorado, while consumption of edibles accounts for a significant amount of use by both medical and recreational marijuana users (Barrus et al., 2016). The actual rates of edible use by both populations is likely underestimated because data obtained only represents sales of cannabis-infused products. This data does not reflect how much cannabinoid-infused oil or cannabis was bought and used by consumers to make homemade edibles.

Nor does it reflect inter-state transfer of these products to other regions (states) for medicinal and/or recreational use (Barrus, et al., 2016). Nevertheless, in Colorado in 2014, medicinal cannabis infused products with high CBD low THC concentrations, and retail cannabis-infused products (high THC low CBD) accounted for approximately 45% of all cannabis sales in the state (Barrus et al., 2016).

Barrus et al., (2016) identifies the following three perceptions that may be attributing to the increased interest in edible products: "(1) edibles are a discreet and more convenient way to consume cannabis; (2) edibles offer a "high" that is calmer and more relaxing than smoking cannabis; and (3) edibles avoid the harmful toxins and health risks that come with smoking cannabis" (para. 12).

Regardless of the method of marijuana use, whether it be smoking, vaping, or consumption of edibles. Or the reason (medical or recreational) the primary goal among marijuana users is to feel better (Barrus et al., 2016). However, while there has been a significant amount of research conducted on the health benefits of marijuana. Most of these studies have focused on pharmaceutical preparations of synthetic analogs of THC as oppose to natural marijuana use, and/or products containing natural preparations of THC and CBD cannabinoids (Barrus, 2016). Nevertheless, the studies that have been conducted typically focused on the following limited number of medical conditions: muscle spasms; chronic pain; nausea and vomiting; epilepsy; appetite stimulation; cancer; post-traumatic stress disorder; anxiety; and depression (Barrus et al., 2016). Wherein the benefits of marijuana for these conditions has primarily been based personal proclamations rather than facts or research (Barrus et al., 2016). Thus, evidence based on

well controlled clinical studies is limited. Barrus et al., (2016) posited that the lack of strong studies on the therapeutic effectiveness of cannabis and cannabinoid products is due in part to the continued classification of cannabis (marijuana) as a Schedule I drug by the U.S. Drug Enforcement Agency. However, Barrus and fellow colleagues hold promise that the widespread and continued state-level legalization of medical and recreation marijuana may serve as the driving force to promote funding for better controlled studies (Barrus et al., 2016). Which is needed as there has only been a limited number of studies comparing pharmaceutical products of synthetic Δ^9-THC to natural preparations and other methods of cannabis use. However, the limited studies available tend to indicate that most patients prefer natural products and uses as oppose to the synthetic preparations (Barrus et al., 2016). In addition, according to subjective patient reports the natural methods of smoking and consumption of edibles produce less adverse effects and better efficacy than synthetic preparations (Barrus et al., 2016).

The consumption of edibles for medicinal and recreational purposes has several benefits. Among these include a longer duration of action when compared to smoking and the consumption of edibles in easier to conceal. Both of which are especially advantageous to the medicinal user as smoking marijuana is still illegal in many states with medical marijuana laws (Barrus el al., 2016). So, the medicinal user can consume edibles at work and in public without exposing their use, and the longer duration of action mean reduced dosing times. The concealability of marijuana infused products is also advantageous because despite growing acceptance many patients and recreational users still express concerns about the stigma associated with the perception of marijuana use

(Barrus et al., 2016). Thus, some users may prefer the consumption of edibles in public or in the workplace. Choosing to vape or smoke at home and outside of work (Barrus rt al., 2016). Another significant reason why many users prefer the consumption of marijuana-infused products is the perception that this method of use is less harmful than smoking marijuana (Barrus, 2016). This is because of the perception that smoking marijuana may pose risk and other harmful effects similar to smoking tobacco (Barrus, 2016).

Until recent events in Colorado, marijuana had not been directly attributed to any lethal consequences as no deaths had been associated with acute marijuana toxicity (Barrus et al., 2016). However, serious and severe consequences have occurred in association with marijuana toxicity or overdose. Barrus et al., (2016) provided support for this understanding based on reports from 65% of medicinal cannabis users that indicate overuse has resulted in the following signs and symptoms: cognitive and motor impairment; extreme sedation; agitation; anxiety; cardiac stress; and vomiting (Barrus et al., 2016); In addition, larger doses of Δ^9-THC have been associated with *cannabis-induced psychosis* while usually transient in healthy adult users some users report symptoms that persist for several days. These psychotic symptoms reportedly can include hallucinations, delusions, and anxiety (Barrus et al., 2016).

While the information on cannabis-induced psychosis is limited reports indicate than many of these cases are the result of ingestion/overconsumption of edible marijuana products (Barrus, et al., 2016). The reason why this may occur more commonly with ingestion as oppose to smoking is most likely associated with the route of administration and cannabinoid pharmacokinetics (Barrus et al., 2016). This simply means how

marijuana is processed by the body when it is eaten versus smoked. For instance, when someone ingestion cannabis-infused products it is first processed in the gastrointestinal tract where Δ^9-THC is absorbed enters the blood stream and travels to the liver (Barrus et al., 2016). Once in the liver, Δ^9-THC is converted to 11-hydroxytetrahydrocannabinol (11-OH-THC). This hydroxylation step is mediated primarily by the cytochrome-P450 enzymatic system of the liver (Barrus et al., 2016). More importantly, 11-OH-THC is a potent psychoactive metabolite of Δ^9-THC that can easily cross the blood brain barrier to elicit its effects (Barrus et al., 2016). Consequently, 11-OH-THC is more potent than Δ^9-THC and ingestion of marijuana results in higher blood levels of 11-OH-THC than smoking (Barrus et al., 2016). Hence, the stronger effects and longer duration of action demonstrated when someone ingest cannabis-infused products (Barrus et al., 2016).

When someone smokes or vapes marijuana the effects are almost immediate, occurring within minutes and peaking about 20 to 30 minutes after inhalation (Barrus et al., 2016). With the effects usually lasting about 2-3 hours (Barrus et al., 2016). Conversely, when someone ingest marijuana it takes about 30 to 90 minutes for the psychoactive effects to kick in and they last longer as the effects of edibles does not typically peak until about 2 to 4 hours after ingestion (Barrus et al., 2016). Further complicating the matter is the fact that the concentration of Δ^9-THC found in edible products can vary across edible products and batches (Barrus et al., 2016). This lack of consistency and delay onset of action may lead to increased ingestion of cannabis-infused products resulting in unintentional consequences (Barrus et al., 2016). Attempts at regulation have set the limit for a maximum recommend dose of Δ^9-THC at 10 mg per

serving (Barrus et al., 2016). However, Barrus et al., (2016) posited that "a single chocolate bar could contain 100 milligrams (10) servings of Δ^9-THC" (para. 31). But the delayed onset of action and small portions may make it difficult for the user to control their intake resulting in serious and potentially lethal consequences (Barrus et al., 2016). This is evidenced by one tragic event in which a 19-year-old Colorado man was instructed to eat just one-sixth (one serving) of a cookie that contained approximately 10 mg of Δ^9-THC (Barrus et al., 2016). However, after about an hour the man had not felt any effects and consumed the remain amount over a 2-hour period (Barrus et al., 2016). Unfortunately, the intoxicating effects resulted in his death after he jumped off a fourth-floor balcony (Barrus et al., 2016). At autopsy the examiner identified cannabis intoxication as the primary cause of death. This event while tragic, lead to the implementation of packaging and labeling regulations in Colorado that require clear demarcations of the standardized 10 mg dose servings of cannabis-infused products (Barrus et al., 2016). The state of Washington has also implemented similar regulations (Barrus et al., 2016).

Thus, regulation of edibles occurs at the state level, this is because marijuana is still illegal at the federal level (Barrus et al., 2016). Therefore, various entities within each individual state regulate the taxing, licensing for cultivation and distribution, and retail sales by marijuana dispensaries on a state-by-state basis (Barrus et al., 2016). Therefore, states that have legalized marijuana for recreational sales have specific state-level requirements for labeling of cannabis-infused edibles (Barrus et al.,2016). Typically, these requirements must include warnings about potential harmful and

intoxicating effects as well as nutritional information (Barrus et al., 2016). However, nutritional information usually various by state. For instance, Colorado and Oregon require that information on labels of cannabis-infused products to be much like that on regular food products (Barrus et al., 2016). Whereas, Washington state only requires that labels include a listing of ingredients (Barrus et al., 2016). But most states have requirements for labeling that include pesticides used during production as well as requirements for an expiration or best if used by date (Barrus et al., 2016).

Thus, while many medicinal and recreational users view consumption of marijuana edibles as a safe alternative method of with marijuana use that is more convenient and easier to conceal than smoking (Wardarski, 2015). It's important to point out these are not the marijuana products of years ago and edible products are usually more potent than smokable marijuana products (Wardarski, 2015). For instance, while strains of marijuana sold in most dispensaries for smoking typically has a THC level in the range of 12 to 25 percent. Marijuana infused edibles are being made using marijuana concentrates as potent as 50 to 90 percent THC (Wardarski, 2015). This is a serious concern as in Colorado alone, where some doctors posited that consumption of edibles are responsible for the rise in marijuana related hospitalizations (Wardarski, 2015). Which has more than doubled since 2009 after commercialization and expansion of medical marijuana (Rocky Mountain High Intensity Drug Trafficking Area (RMHIDTA), 2014; Wardarski, 2015;).

Barrus et al., (2016) posited that an important concern for public safety is the lack of available research comparing the *therapeutic efficacy* and *subjective effects* of

marijuana ingestion to other methods of use. In addition, accidental ingestion and over consumption, whether it be intentional or unintentional is another concern for public health and health care leaders (Cao, Srisuma, Bronstein, & Hoyte, 2016). As previously stated, over consumption of edible products is commonly associated with the delayed onset of action observed with ingestion as the effects are not immediate like smoking (Barrus et al., 2016). This may prompt the user to consume more product in an attempt to achieve the desired effect resulting in over consumption and leading to unintended adverse effects (Barrus et al., 2016).

In a related broad-based study, Cao, Srisuma, Bronstein, & Hoyte, (2016) conducted a national analysis of human exposure calls for consumption/ingestion of marijuana products reported to poison control centers around the United States. These state-level centers intern report data to the National Poison Data System (NPDS). In this retrospective study, Cao et al., (2016) obtained data reported to the NPDS over a 36-month period between January 2013 through December 2015. The study analyzed subgroups based on age and state level marijuana laws for ingestion of edible marijuana products (Cao et al., 2016). The marijuana infused products included: cookies; candies; brownies; beverages and other food products (Cao et al., 2016, para. 1). The researchers also considered both intentional and unintentional exposures as these products are often indistinguishable from similar non-marijuana infused products (Cao et al., 2016). As children as well as adults are typically unable to recognize differences in taste or appearance (Cao et al., 2016).

The results of this study revealed that the majority of calls for exposure were for individuals less than or equal to five years of age (Cao et al., 2016). With 99% of these incidents due to unintentional exposure. Individuals age 1-19 years old represented the next highest age group for exposure calls with individuals age 20-29 years of age making up the third highest age group (Cao et al., 2016). Among these individuals those age 6-19 predominated the intentional exposure group with 89% of these due to abuse versus 10% for misuse (Cao et al., 2016). Additionally, among the states observed Colorado and Washington led the way with the highest number of exposure calls as overall states with MMLs and/or RMLs accounted for approximately 91% of all calls (Cao et al., 2016). Thus, lending support to the premise that marijuana legislation effects marijuana use, abuse, misuse, exposure and preference.

Furthermore, the methods of use that further increase the potency of an already highly potent marijuana product should definitely be a serious concern of public health leaders. This is evidenced a related study conducted in the Netherlands researchers explored the relationship between changes in marijuana potency and admissions to drug treatment programs (Freeman, et al., 2018). This 16-year study analyzed THC concentrations sold at retail stores from the year 2000 through 2015. This analysis revealed that THC concentrations increased from 8.62% to 20.38 % from 2000 to 2004 and decreased in 2015 to 15.31% (Freeman, et al., 2018). During this time first admissions to drug treatment increased from 7.08% to 26.36% between 2000 to 2010 and decreased to around 20% in 2015 (Freeman, et al., 2018).

Freeman, et al., (2018), concluded that a positive time-dependent association does exists between changes in marijuana potency and first-time admissions to drug treatment. The researchers also point out that other factors may also be important. Nevertheless, the results indicate that the strongest association occurred at 5 years into the study, and after adjusting for participant demographics and non-cannabis drug treatment admissions the results reveal a statistically significant positive association (Freeman, et al., 2018). Which is evident as Freeman, et al., (2018), posits that "each 1% increase in THC was associated with a 0.082 (0.052, 0.111) rise in first-time admissions per 100,000" (para.14). The researchers further posited that these trends are not confined to the Netherlands as increases in first time admissions to drug treatment programs for marijuana are consistent across all of Europe (Freeman, et al., 2018). As was indicated in an analysis submitted to the European Monitoring Centre for Drugs and Drug Addiction which reported increases in admissions in 16 out of 22 European countries examined (Freeman, et al., 2018).

While there is limited literature available on the effects of medical and recreational marijuana laws on marijuana potency, that which is available suggest that these laws have not only led to increased potency but also to increases in unintentional childhood exposure as well as adult cannabis use and adult cannabis use disorder (Hasin, 2017). In addition, some studies also suggest that medical marijuana laws have led to increased use of cannabis as substitutes for opioids and psychiatric medications (Hasin, 2017). Thus, supporting to the premise that some marijuana users may be self-medicating for various conditions.

Based on my understanding of the literature review, as more states continue to implement MMLs and RMLs access to marijuana and marijuana products will continue to increase while public perception of risk and social stigma associated with marijuana use will continue to decrease. Thus, the combined effects of these events may lead to an overall increase in marijuana use and exposure, both intentional and unintentional. In addition, there is also lack of sufficient literature from evidenced-based studies on the long-term effects of legalization, rising THC levels, consumption of marijuana-infused products, use of concentrated marijuana products, and methods of marijuana use like, dabbing, vaping and e-cigarettes.

Therefore, peer-reviewed articles such as those presented here provide additional support for the premise of this study which seeks to explore the possible associations between medical and recreational laws, marijuana potency and the effects on mental health conditions like depression and suicide ideation. This is particularly important as those who serve in public health and health care have an obligation to inform the public about the risk associated with marijuana use, especially when considering trends of increasing potency, growing public acceptance, decreased risk perception of marijuana use and the continued wide spread legalization of marijuana.

Critique of Methods

Salomonsen-Saulel et al. (2012) utilized the several tools to measure and analyze adolescent use of medical marijuana among patients treated at two substance abuse facilities in Denver Colorado. The results of this study demonstrated that the majority of adolescents, approximately 74% of the 164 adolescents in treatment, had used medical

marijuana obtained from registered medical marijuana patients (Salomonsen-Saulel, et al., 2012). Thus, demonstrating a high rate and widespread pattern of medical marijuana use by the non-patient recreational using population (Salomonsen-Saulel, et al., 2012). However, the study results may be limited by a lack of comparison between states where marijuana is legal versus illegal. One example wherein this comparison would be relevant is in areas where legalization of medical marijuana contributed to greater acceptance of marijuana because of a more favorable marijuana attitude or a decrease in perceived risk post-legalization (Salomonsen-Saulel et al., 2017). As a result, the use of marijuana may be higher in these areas and reflected in the results of the study versus areas without legalization where marijuana use may be lower. In addition, this study was conducted at two rehabilitation facilities at one point in time (Salomonsen-Saulel et al., 2017). This would in turn effect determination of causality (Salomonsen-Saulel, et al., 2017). Thus, comparing marijuana use to states with varying laws in other states and at different points in time is essential to making inferences about causality (Salomonsen-Saulel et al., 2017). Finally, Salomonsen-Saulel et al. (2012) also indicates that the timing of marijuana law implementation may also affect studies on patterns of marijuana use. Therefore, additional time may be needed to observe the effects of recently implemented laws (Salomonsen-Saulel et al., 2017).

In a related study by Wen, Hockenberry, & Cummings (2015), the researchers addressed the effect of medical marijuana laws on marijuana use in ten states with medical marijuana laws. The study also addressed the effects of MMLs on the use of use alcohol, and other hard drugs (such as, cocaine and heroin) as well as pain medication

misuse (Wen et al., 2015). While this study presented relevant data implementing MMLs to a rise in marijuana use as well as an increase in abuse/dependence among participants age 21 and older. A potential limiting factor is concerned with the National Survey on Drug Use and Health (NSDUH) used in this study. This survey does not differentiate between the marijuana patient and non-patient populations participating in the study (Wen et al., 2015). Thus, the spillover effect may not solely reflect an increased marijuana use among registered marijuana patients as the non-patient or recreational using population may potentially contribute to a greater percentage of the individuals participating in the study (Wen et al., 2015). This limitation is evidenced by Wen et al., (2015) which indicates that, among the states studied with MMLs, medical marijuana patients comprised only 0.8 percent of the total population.

Regarding methods used to assess the association between mental health and marijuana use. A notable study reviewed here by van Gastel, et al., (2013), used a population-based analysis to determine whether cannabis use is associated with poor psychosocial functioning and therefore a potential risk factor for future mental health problems (van Gastel, et al., 2013). While the results of this study demonstrated a potential association between the use of marijuana and future mental health problems, the study was not without limitations. Most importantly, is the cross-sectional approach that is limited because it provides an analysis of the association between variables (exposure and outcome) at one point in time and therefore does not provide information relevant to the time spatial association between the exposure and outcome variables (Christian, 2015). Thus, limiting conclusions with respect to the causal inference between these

conditions. In addition, since the methods used to gather data involved self-reporting then another study limitation may result from over or under reporting which is observed when gathering information of sensitive issues, such as drug use (van Gastel, et al., 2013).

The notion that marijuana use may cause psychosis is not a new concept as several studies have demonstrated this association (Murray, Quigley, Quattrone, Englund & Di Forti, 2016). In one such study, Davis, Compton, Wang, Levin, & Blanco (2013) conducted a population-based study demonstrating that the use of marijuana may serve as a possible risk factor for psychosis and schizotypal personality disorder (SPD). The study further demonstrated that the risk of psychosis and SPD increased with the extent of marijuana use in a dose-dependent fashion (Davis et al., 2013). Which supports this current studies premise that highly potent marijuana would be expected to increase the occurrence or exacerbate these conditions. However, the cross-sectional nature of this population-based study limits inferences about causality or the time-spatial relationship between marijuana use and the development of psychosis and SPD (Davis et al., 2013). In addition, this study used self-reporting to gather data on the participants diagnosis of schizophrenia or psychotic disorders. And according to Davis et al (2013) the reliability of self-reporting on these diagnoses is questionable. Which may limit the results of this study. In addition, self-reporting may also be subject to recall bias (Hasan, 2005). And finally, the cross-sectional nature of this study may limit inferences on causality as observations are made at one point in time (Davis et al., 2013). However, the researchers also point out that previous studies utilizing self-reporting for these diagnoses are consistent with the findings presented (Davis et al., 2013).

In a related literature review, Moore et al. (2007) provided support for the results observed in the study by Davis and fellow colleagues. Wherein Moore et al. (2007) addressed the association between marijuana use and the development of psychosis or affective mental health outcomes. This study demonstrated an increase in psychosis and affective mental health outcomes with a dose-response relationship as the rate of psychosis increased 50 to 200% for heavy marijuana users versus moderate users and non-marijuana users (Moore et al., 2007). However, since a review of the literature is typically observational in nature, then the study is subject to several limitations. One limitation of this approach is publication bias as studies presenting statistically significant results may be selected for publication and cited more often than others and are therefore more likely to be included in literature reviews (Egger, Dickersin & Smith, 2001). Another limitation is the methodology or findings of the articles reviewed. If the data or results of these studies are compromised, then the results presented by the literature review will subsequently be affected as well (Egger et al., 2001). In addition, a literature review may be subject to a form of selection bias, wherein researchers select particular articles or studies for review based on the results that favor the researchers' premise (Egger et al., 2001).

Knowledge Gap

The study conducted by Salomonsen-Saulel and colleagues which demonstrated that medical marijuana is finding its way into the hands of the non-patient recreational using population in Denver, CO (Salomonsen-Saulel et al., 2012). However, this study was limited to adolescent patients from two substance abuse treatment facilities

(Salomonsen-Saulel, et al., 2012). Therefore, demonstrating a potential gap in the research as the results may not be representative of the general population of marijuana users. Support for this premise is provided by Salomonsen-Saulel, et al. (2012) which posited that additional research should focus on patterns of medical marijuana use and diversion of medical marijuana within the general adolescent population (Salomonsen-Saulel, et al., 2012). Addressing his gap would also require focusing on young and older adults in the population as these groups also contribute to the general marijuana using population

Sevigny, Pacula & Healon, (2014) addressed the effects of marijuana legalization on potency ultimately demonstrating no statistically significant association between these two variables. However, the authors acknowledge that previous studies on the effect on legalization on potency have revealed mixed results both for and against the premise that marijuana legalization has contributed to a rise in marijuana potency. However, Sevigny et al., (2014) further identified a possible gap in the research as the lack of studies to assess the effects of rising marijuana potency on marijuana use.

Sevigny et al., (2014) also identified other areas for future research. For instance, the researchers surmised that use of highly potent marijuana could possibly result in a decrease in marijuana use as less marijuana would be required to achieve the desired effect. Another area for additional research is the possibility that highly potent marijuana may also contribute to a decrease in charges for Driving While Impaired (DWI) as individuals who use both alcohol and marijuana would be less prone to drive after concurrent use of these substances (Sevigny et al, 2014) In addition, Sevigny et al.,

(2014) further posited that the use of highly potently marijuana may result in a decrease in the amount of opiate pain relievers taken as less medication may be required due to the pain relieving effects of highly potent marijuana. In fact, some patients taking opiate pain relievers may opt to use marijuana for pain relief as oppose to narcotics (Sevigny, Pacula & Healon, 201).

The study conducted by van Gastel, et al., (2013), presented relevant information on the association between the use of marijuana and future mental health problems. This study demonstrated that marijuana use, and factors associated with marijuana use and poor psychosocial functioning may serve as *indicators of risk* for future adolescent mental health problems (van Gastel, et al., 2013). The researchers however point out that future research and public health efforts should focus on using the indicators of risk identified in this study to design an adolescent risk profile (van Gastel, et al., 2013).

The study conducted by Moore et al. (2007) served to demonstrate an increase in psychosis and affective mental health outcomes with a dose-response relationship among marijuana users. The researchers point out the need for additional research to determine if younger marijuana users are subjected to greater risk or more harmful effects (Moore et al., 2007). The researchers also indicate that additional research should address the effects of genetics and other factors on these results (Moore et al., 2007).

Summary and Conclusions

In the United States, substance abuse and addiction cost the American tax payer over $700 billion dollars a year (NIDA, 2016). The consequences of substance abuse are evidenced by approximately 90,000 Americans that die every year as a result of illicit and

prescription drug and alcohol use (NIDA, 2016). Thus, substance abuse is an important public health concern that has a prodigious impact on our society.

Among the substances of abuse, marijuana is by far the most commonly used as in 2018, 43 million Americans reportedly used marijuana in the past year (Statista, 2019). A growing public health concern is the potency of marijuana as the level of Tetrahydrocannabinol (THC) has been increasing since legalization began in 2012 (Cabrera, 2016). This is a growing concern since THC elicits the desired psychological effects most marijuana users seek (Bradford, 2015).

Lab test reveal that the potency of marijuana in Colorado since legalization is more than twice as potent as illegal marijuana of the past ten years and some strains of legal marijuana is three times as potent (Briggs, 2015). Prior to legalization the levels of THC were typically below 10 percent. However, research now indicates that the post-legalization levels of Colorado's marijuana averages around 18.7 percent with some marijuana strains containing THC levels of 30 percent or more (Briggs. 2015). These results were provided by Charas Scientific, a Denver based lab licensed and hired by the state to test and measure the THC levels of marketable marijuana (Briggs, 2015).

Addressing this concern at this point in time is particularly important because as of as 2019, 33 states and the District of Columbia plus Guam and Puerto Rico have had passed laws legalizing medical marijuana with 11 of these states and the District of Columbia also implementing recreational marijuana laws (Hartig & Geiger, 2018; NCSL, 2019; Governing Data, 2019) However, these laws vary by state. For instance, Colorado has legalized marijuana for both recreational and medical use (Governing, 2018). While

other states, like Georgia have only legalized medical marijuana products that have High CBD/Low THC concentrations for specific medical conditions (Governing Data, 2018; National Conference of State Legislatures [NCSL], 2019). With only a few states like Idaho that have not legalized marijuana for any reason (Governing, 2018; NCSL, 2019). Nevertheless, the trend in attitude toward marijuana is ever evolving. My study was intended to address the effects of continued marijuana legalization on the mental health conditions, depression and suicide ideation. This aim was achieved by comparing the year 2008 when only 13 states had legalized medical marijuana to the year 2017 when 27 states and District of Columbia had legalized medical marijuana with seven of these states and the District of Columbia also legalizing recreational marijuana (Governing Data, 2018; NCSL, 2019).

In the United States, marijuana has experienced a controversial and highly debated path. For several years proponents of marijuana have lobbied for legalization of the substance touting the medical implications and attempting to the discredit the implications of its harmful effects. However, despite these efforts the Drug Enforcement Administration (DEA) still classifies marijuana as a schedule I controlled substance (U.S. Department of Justice, 2017). Nevertheless, the current trend in attitude favoring marijuana use for medical and recreational purposes is growing. This is evidenced by reports indicating a decline in individuals who consider the occasional use (1-2 times per week) of marijuana as a perceived risk (Schuermeyer et al., 2014). For instance, in Colorado the percent of those who believe marijuana use is a perceived risk declined

from 45% to 31% between groups studied from 2007 to 2008 and those studied from 2010 to 2011, respectively (Schuermeyer, et al, 2014).

Considering the current trend in marijuana liberalization, it is more important now than ever for policy makers, public health and health care personnel to emphasize or reiterate the potential adverse effects of the substance. This is especially important given the rising THC levels seen in medical and recreational marijuana and products produced from marijuana. It is also reasonable to assume that as legalization gains greater acceptance the use of marijuana will also increase and therefore so will the occurrence of adverse effects.

Sevigny et al., (2014) addressed the potency of medical marijuana that has reportedly increased since legalization. This increase in potency is presumably due to less restrained regulations that created an environment of improved cultivation and production techniques. Sevigny et al., (2014) identified two marijuana markets, medical and recreational, and these markets are interrelated such that cross over in technological advances for production and cultivation occurs. The authors further posited that surplus medical marijuana is being diverted to the recreational market (Sevigny, Pacula, & Heaton, 2014). The results of the first model in this study demonstrated a significant increase in marijuana THC content in jurisdictions that legalized marijuana for medical purposes (Sevigny et al., 2014). However, the remaining models added potentially competing variables which provided results that were not statistically significant.

In addition, support for the cross-over or diversion of marijuana premise presented by Sevigny and colleagues is provided in a related study. In which

Salomonsen-Saulel, et al. (2012) addressed the extent of medical marijuana use by the non-registered (non-patient) marijuana using population. The results of this study demonstrated that the majority, approximately 74% adolescents in treatment had used medical marijuana obtained from registered medical marijuana patients (Salomonsen-Saulel et al., 2012). Thus, demonstrating a high rate and widespread pattern of medical marijuana use by the non-patient recreational using population. Thus, the effects of producing high-potency medical marijuana potentially impacts the quality and availability of these highly potent marijuana strains to the recreational using market.

In another study, Wen, Hockenberry, and Cummings (2015) addressed the effects of MMLs on the use of marijuana and other controlled substances. This study demonstrated that implementation of MMLs resulted in a parallel increase in marijuana use among participants age 21 and older (Wen et al., 2015). These increases occurred immediately after MMLs were implemented and continued for three years after implementation (Wen et al., 2015). In addition, Wen et al., (2015) reported a 10% increase in marijuana abuse/dependence among participants age 21 and older. Thus, indicating cause for public health concern as MMLs may have the potential to increase risk of progressing to marijuana abuse/dependence (Wen et al., 2015).

The effects of marijuana potency on health is an important public health concern as there is a growing body of evidence supporting the association between cannabis use and the development of psychotic or mental health disorders (Moore et al., 2007). However, few studies have addressed this association since the rise in THC demonstrated post legalization. Volkow et al., (2014) posited that previous research has demonstrated

that anxiety, depression, and psychosis are associated with regular marijuana use. However, causality is not well founded as determining causality is hindered by confounders that also contribute to the development of these conditions (Volkow et al., 2014).

In a previous related study, Lev-Ran et al. (2014) conducted a systematic review and meta-analysis of existing longitudinal studies to determine patterns of cannabis use that are associated with the development of depression. Lev-Ran et al. (2013) concludes that the risk of developing depressive disorders is increased by cannabis use, and this risk is more significant among heavy cannabis users and those with cannabis use disorder. These findings are supported by van Gastel et al. (2013) which also indicates that marijuana use has been associated with psychiatric symptoms and the risk is increased by regular or heavy marijuana use.

These studies demonstrate support for the gap in the research that highly potent marijuana presents and this study intended to address. The notion that marijuana use may cause or exacerbate mental illness and psychosis is not a new concept as several studies have demonstrated this association (Murray et al., 2016). However, many of these previous studies were conducted prior to the legalization of marijuana and the concurrent increase in marijuana potency as the level of THC has been rising. The use of highly potent marijuana would be expected to have effects similar to that seen in heavy users or those who abuse marijuana. Additional support for this gap in the research is provided by Di forte et al. (2009) which posited that previous studies have demonstrated an increase of psychosis in association with marijuana use. However, Di forte et al. (2009) further

posited that “these studies have not collected detailed data on the patterns of use or potency of the cannabis used, which may be important factors moderating the associated risk” (para. 6). Therefore, my current study intended to address this gap in the research as the potential implications of widespread legalization and highly potent marijuana with elevated THC levels should be a major public health concern. Chapter three which follows is intended to provide an in-depth description of the research design and statistical analysis, the National Survey on Drug Use and Health (NSDUH) data set.

Chapter 3: Research Method

Population

The NSDUH is conducted by RTI International, Research Triangle Park, North Carolina and sponsored by the Center for Behavioral Health Statistics and Quality (CBHSQ), Substance Abuse and Mental Health Services Administration (SAMHSA), an agency within the U.S. Department of Health and Human Services (NSDUH-codebook, 2017; NCBI, 2018). The mission of SAMHSA is "to reduce the impact of substance abuse and mental illness on America's communities" (National Center for Biotechnology [NCBI], 2018; para. 1). Therefore, understanding the nature of the relationship between marijuana and mental health conditions is important to developing evidence-based health policies as this information can serve to inform policy makers, practitioners, and public health professionals.

Sampling

In order to ensure adequate representation, the NSDUH sampling plan used multilayer stratification which consisted of three levels or strata. For the first or primary level, each state was divided into state sampling regions (SSRs) that were approximately equal in size geographically. Such that each SSR would yield about the same number of interviews per sampling period. Nevertheless, in all the United States was divided into 750 SSRs, with the following breakdown by state,

> "36 SSRs in California; 30 SSRs each in Florida, New York, and Texas; 24 SSRs each in Illinois, Michigan, Ohio, and Pennsylvania; 15 SSRs each in Georgia,

New Jersey, North Carolina, and Virginia; and 12 SSRs each in the remaining 38 states and the District of Columbia" (NSDUH-codebook, 2015, p. i-14).

The second level (strata) was based on census tracts that were aggregated within SSRs to meet the minimum number of dwelling unit (DU) requirements by state. Each SSR included 48 census tracts. The third level or strata was created by establishing census block groups within each census tract. Each census block group was then partitioned into smaller geographical regions and grouped into adjacent clusters. These geographical clusters or tertiary sampling units (TSUs) were used for the coordinated sampling design (NSDUH-codebook, 2017.

Data Collection

Prior to participant recruitment, census tracts, census blocks, and census segments were selected within each SSR (NSDUH-codebook, 2017). After which DUs were then identified within each census segment. DU selection was based on the classification of the state where the segment belonged (NSDUH-codebook, 2017). Once the DUs were identified, individuals were then selected based on the age of residents within the DU (NSDUH-codebook, 2017). The DU would then receive an introductory letter informing the residents that they had been randomly selected for participation in the NSDUH (Center for Behavioral Health Statistics and Quality [CBHSQ], 2016). The field interviewer conducted in-person interview with an adult respondent of the dwelling unit to obtain basic demographic information. Then depending on the composition of the household, two residents of the DU were selected for interviewing based on a preprogrammed selection algorithm (CBHSQ, 2016). After the screening process, the

interview was conducted in a private area of the home. The interviewer used both computer-assisted personal interviewing (CAPI) and audio computer-assisted self-interviewing (ACASI) techniques (CBHSQ, 2016). The CAPI portion of the interview was used to collect and record verbal responses to questions read aloud by the interviewer who entered these responses into a computer (CBHSQ, 2016). In contrast, the ACASI portion of the interview is used to collect information on answers to sensitive questions (NSDUH-codebook, 2017). During this portion of the interview, respondents use headphones to listen to questions and enters responses directly into a computer (NSDUH-codebook, 2017). Throughout the interview process (written and oral) respondents are assured that their confidentiality, anonymity, and responses are protected and handled according to federal law compliance regulations (CBHSQ, 2016; NSDUH-codebook, 2017). After the respondent completed the ACAI portion of the interview, the field interviewer returned to CAPI mode to complete the interview by asking questions pertaining to the respondent's household composition, health insurance, and personal and family income, handled in strict compliance with federal law (CBHSQ, 2016). Finally, each respondent that completed the survey process was given $30 cash incentive (CBHSQ, 2016).

Data Analysis Plan

In my study, I assessed whether the trend in marijuana policies and legalization which favor marijuana acceptance for both medical and recreational use effects mental health conditions. Moreover, I addressed depression and suicide ideation and compared early marijuana legalization years when only a few states had medical marijuana laws to

later marijuana legalization years when numerous states have adopted medical and recreational marijuana laws. For this purpose, two years were selected for comparing these periods in time. For early marijuana legalization period, 2008 NSDUH data was selected and for later marijuana legalization period, 2017 NSDUH data was selected. In 2008, only 13 states had implemented laws legalizing marijuana use for medical purposes only (NCSL, 2019). By 2017, 29 states and the District of Columbia had passed laws legalizing medical marijuana with seven of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2018; NCSL, 2019). Further support for the premise of this study is provided by Keyhani, et al., (2018) who posited that "these legal changes have been accompanied by an increase in daily marijuana use, as well as in marijuana dependence, among adults in the U.S. population" (para. 1). This is evidenced by an increase in prevalence for marijuana use among adults in the general population which has doubled over the course of the last decade as 13.3% of respondents in this group reported using marijuana during the past year in 2014 (Keyhani, et al., 2018).

I used Chi-Square and complex samples logistic regression analyses in this quantitative study to assess the statistical significance of marijuana use and mental health as legalization changed from 2008 to 2017. In order to derive the weighing amounts, certain calculations were made first. Three steps of calculations were made for sample weights. First of all, the final probability was determined by calculating the product of the probability of an individual being selected, the probability of the household being selected, the probability of the section of the PSU being selected, and the probability of

the PSU being selected (CDC, 2020). This then had to be adjusted for nonresponse. The final adjustment that is made is the poststratification adjustment for the purpose of matching the control totals derived from the year 2000 and 2010 United States Census population. SPSS statistical software was used to perform all calculations. Descriptive statistics include past year marijuana use, state medical marijuana status, age, sex, and socioeconomic status, as well as adult and youth major depressive episodes and suicide ideation in the past year.

Inferential statistics for this analysis were conducted based on the following research questions and hypotheses.

Research Questions

This study was guided by three research questions to assess the association between marijuana and depression, between marijuana and suicide ideation, and whether these associations were stronger in 2017 than in 2008 for both adults and adolescents. The research questions were as follows.

RQ1: Is marijuana use associated with depression and suicidal ideation in adults in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ2: Is marijuana use associated with depression and suicidal ideation in adolescents in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ3: Are the associations between marijuana use and depression and between marijuana use and suicide ideation higher in 2017 than in 2008 for both adults and

adolescents, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

Study Hypotheses

Accordingly, the hypotheses for this study, each stated in null form, were as follows.

For the 2008 data:

$H_0$1: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$2: There will be no statistically significant relationship between MJ use and suicidal ideation in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$3: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$4: There will be no statistically significant relationship between MJ use and suicidal ideation in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For the 2017 data:

$H_0$5: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$6: There will be no statistically significant relationship between MJ use and suicidal ideation in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$7: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$8: There will be no statistically significant relationship between MJ use and suicidal ideation in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For comparing 2008 and 2017 data:

$H_0$9: There will be no statistically significant increase in the strength of the relationships between MJ use and depression (Major Depressive Episode in the last year) in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$10: There will be no statistically significant increase in the strength of the relationships between MJ use and suicidal ideation in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$11: There will be no statistically significant increase in the strength of the relationships between MJ use and depression (Major Depressive Episode in the last year) in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

$H_0$12: There will be no statistically significant increase in the strength of the relationships between MJ use and suicidal ideation in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

I used crosstabs and a logistic regression analysis to assess the association between the dependent variable(s) and the independent variable. The early legalization year was appointed as 2008 and later legalization year as 2017. The independent variable for these research questions was past year marijuana use while the dependent variables were depression and suicide ideation. I also used Pearson's $\chi 2$ test to determine inferential statistics for $H_0$1 and H_a1. To reject the null hypotheses the proper P-value is less than 0.05 (KSU, 2018). Table 3 describes the independent, dependent, and control variables.

Table 3

Variable Table

Variable Name	Type Variable	Level of Measurement
Marijuana Use	Independent Variable	Nominal Dichotomous
Age	Control Variable	Interval/Ratio
Sex	Control Variable	Nominal Dichotomous
Level of Education	Control Variable	Interval/Ratio
Family Income	Control Variable	Interval/Ratio
Depression	Dependent Variable	Nominal Dichotomous
Suicide Ideation	Dependent Variable	Nominal Dichotomous

Measures

The NSDUH-Codebook (2017) provides the following descriptions and recoding for measures (variables & covariates) used:

Marijuana Past Year Use

The independent variable MRJYR defines marijuana use in the past year. The variable was recoded as "0 = Did not use in the past year" and "1= used within the past year" (NSDUH-codebook, 2008 p.130)."

Adolescent (Youth) Major Depression Past Year

This variable was coded as YMDEYR and identifies and individual as having a major depressive episode in the past year. The variable was recoded as YMDEYR = 1 for "respondents who were classified with lifetime MDE (YMDELT=1) and who reported that during the past 12 months they had a period of depression lasting 2 weeks or longer, while also having some of the other symptoms mentioned, were classified as having past year depression" (NSDUH-codebook, 2017, p. 454-455). While YMDEYR = 2 for "respondents with no lifetime MDE (YMDELT=1 for youths) or respondents with

lifetime MDE (YMDELT=1) but no period of depression lasting 2 weeks or longer while having other symptoms were defined as not having past year MDE" (NSDUH-codebook, 2017, p.454-455).

Adult Major Depression Past Year

This variable was coded as AMDEYR and identifies and individual as having a major depressive episode in the past year. The variable was recoded as AMDEYR = 1 for "respondents who were classified with lifetime MDE (AMDELT=1) and who reported that during the past 12 months they had a period of depression lasting 2 weeks or longer, while also having some of the other symptoms mentioned, were classified as having past year depression" (NSDUH-codebook, 2017, p.454-455) While AMDEYR = 2 for "respondents with no lifetime MDE (AMDELT=2 for adults) or respondents with lifetime MDE (AMDELT=1) but no period of depression lasting 2 weeks or longer while having other symptoms were defined as not having past year MDE" (NSDUH-codebook, 2017, p.454-455).

Suicide Ideation

This variable was coded as MHSUITHK and identifies individuals that "seriously thought about killing self in past year" (NSDUH-codebook, 2008, p.464, 467)." The variable was coded as SUICTHNK. Wherein 0 = No (SUICTHNK=2) and 1 = Yes (SUICTHN=1) (NSDUH-codebook, 2008, p.464, 467).

Age

This covariable coded as CATAG6 defines the age of participants and was recoded as "1=12-17 years old," "2=18-25 years old," "3=26-34 years old," "4=35-49," "5=50-64 years old," "6=65 or older" (NSDUH-codebook, 2017, p.548).

Sex

This covariable SEX defines the gender of participants and recoded as 1=Male, and 2=Female.

Socioeconomic Status

Respondent's Family income was used for Socioeconomic Status. The variable IRFAMIN3 defines the income of the household that the participant resides in. This variable was recoded as "1 = Less than $10,000", "2 = $10,000 - $19,000," "3 = $20,000 - $29,999," "4 = $30,000 – 39,999"; "5 = $40,000 – 49,999"; "6 = $50,000 - $74,999" and "7 = $75,000 or More" (NSDUH-codebook, 2017, P.575).

Education

For Adult level of education, this covariable coded as EDUCCAT2 defines the level of education adults achieved. This variable was recoded as "1= Less than High School Diploma", "2 = Completed High School", "3 = Some College", "4 = Completed College" and "5 = 12 to 17-year old" (NSDUH-codebook, 2008, p. 598).

For Adolescent level of education, this covariable coded as EDUSCHGRD2 defines the level of education adolescents achieved "1 = 5^{th} Grade or lower", "2 = 6^{th} Grade", "3 = 7^{th} Grade", "4 = 8^{th} Grade", "5 = 9^{th} Grade", "6 = 10^{th} Grade", "7 = 11^{th} Grade", "8 = 12^{th} Grade", 9 = College or university/1st year", 10 = College or

university/2nd Year, 3rd year, 11 = College or university/4th Year, 5th or higher year" (NSDUH-codebook, 2017, p. 550).

Threats to Validity

Addressing threats to external validity is important to ensuring that the research study sample and results are generalizable to the population of interest as well as across different populations, settings, & time (Laerd dissertation, 2012). Researchers must therefore mitigate these threats to ensure that conclusions or inferences made are due to the study design and not some other factor (Creswell, 2009). Threats to internal validity occurs when there are problems with the experimental procedure, treatments or participant experiences that threaten the researchers' ability to make correct inferences about the population of interest using the data obtained. According to Creswell (2009) the following list represents examples of threats to internal validity: History; Maturation; Regression; Selection; Mortality; Diffusion; Compensatory Demoralization; Compensatory Rivalry; Testing and Instrumentation. This study utilizes secondary data obtained from the NSDUH which utilizes a cross-sectional, non-experimental, random selection approach which served to reduce or eliminate many of these threats. For instance, the cross-sectional approach reduces or eliminates threats associated with history, maturation, and testing (Laerd Dissertation – Internal Validity, (2012), p.1-3). In contrast, the non-experimental nature of the study reduces threats associated with diffusion of treatment, compensatory demoralization, and compensatory rivalry (Laerd Dissertation – Internal Validity, 2012, p.4). Finally, random selection reduces threats

associated with regression and selection (Laerd Dissertation – Internal Validity, (2012), p.5).

In contrast, threats to external validity occurs when the researcher applies incorrect inferences to other populations, settings, or time (Creswell, 2009). Thus, threats to external validity are concerned with the generalizability of the study's results (Frankfort-Nachmias & Nachmias, 2007). According to Frankfort-Nachmias and Nachmias (2007) there are three major concerns when addressing external threats to validity these include: 1) Representativeness of the sample; and 2) Reactive rearrangements in the research procedure; and 3) Interaction of selection and treatment; To reduce these threats the NSDUH sampling plan utilized multilayer stratification which consisted of three levels or strata (NSDUH-codebook, 2017). For the first or primary level, each state was divided into State Sampling Regions (SSRs) that were approximately equal in size geographically; such that each SSR would yield about the same number of interviews per sampling period (NSDUH-codebook, 2017). The second level (strata) was based on census tracts that were aggregated within SSRs to meet the minimum number of dwelling unit (DU) requirements by state. The third level or strata was created by establishing census block groups within each census tract. Each census block group was then partitioned into smaller geographical regions and grouped into adjacent clusters. These geographical clusters or tertiary sampling units (TSUs) were used for the coordinated sampling design (NSDUH-codebook, 2017). External threats were further reduced by the data collection process, wherein the interview was conducted in a private area of the home using both computer-assisted personal interviewing (CAPI)

and audio computer-assisted self-interviewing (ACASI) techniques (CBHSQ, 2016). The CAPI portion of the interview was used to collect and record verbal responses to questions read aloud by the interviewer who entered these responses into a computer and the ACASI portion of the interview is used to collect information on answers to sensitive questions (CBHSQ, 2016; NSDUH-codebook, 2017). During the ACASI portion of the interview, respondents used headphones to listen to questions and enter responses directly into a computer (NSDUH-codebook, 2075). All information was de-identified and throughout the interview process (written and oral) respondents were assured that their confidentiality, anonymity, and responses were protected and handled according to federal law compliance regulations (CBHSQ, 2016; NSDUH-codebook, 2017).

Sample Size

The sample size for the 2008 and 2017 NSDUH datasets consisted of responses from 67,928 and 68,032 participants, respectively (NSDUH-codebook, 2008; NSDUH-codebook, 2017). In this study I evaluated U.S. residents 12 years and older residing in all 50 states and the District of Columbia. The quantitative approach allows one to study effects in small groups of people and make inferences about larger populations (Ellis, 2010). However, obtaining statistically significant results is reliant on sample size as the larger the sample size the more likely an effect will be accepted as statistically significant (Ellis, 2010). For instance, Ellis (2010) posit that "if the expected effect size is overestimated, required sample sizes will be underestimated and the study will be inadequately powered" (p.61).

Determining an appropriate sample size relies on three variables: 1) the significance level or criterion *(α)*, the power *(1-β)*, and the effect size *(d)* (Ellis, 2010). The significance criterion or Alpha *(α)* level is the error rate that the researcher is willing to accept and is often set at .05 or .01 (Ellis, 2010; Suresh & Chandrashekara, 2012). In this study, I used an Alpha level of .05 and this means I was willing to accept that there is a 5% (or five percent?) chance that the study results are due to chance (Ellis, 2010; Suresh & Chandrashekara, 2012). The alpha *(α)* level is a measure of Type I error which occurs when the null hypothesis is inadvertently rejected when it is actually true (Banerjee, Chitnis, Jadhav, Bhawalkar, & Chaudhry, 2009). In contrast, power refers to the likelihood that a statistical analysis will correctly identify an effect in a population if one exists. Power *(1-β)* is inversely related to the probability of making a type II error which occurs when the null hypothesis is not rejected when it is actually false (Banerjee, Chitnis, Jadhav, Bhawalkar, & Chaudhry, 2009). The commonly set value for power is 0.80 (Ellis, 2010). Type I and II errors can lead to erroneous inferences that researchers seek to avoid by selecting an appropriate sample size as larger sample sizes are less likely to differ substantially from the study population (Banerjee et al., 2009). Finally, effect size is related to the magnitude of difference that exists between two groups and is quantified as the size of the association that a study seeks to detect in a sample (Ellis, 2010; Banerjee et al., 2009).

The sample size was calculated utilizing G*Power software, obtained from the Heinrich Heine University website (Heinrich Heine University Dusseldorf [HHU], 2018). In this study I used multiple logistic regression with one dependent variable and multiple

independent variables. Therefore, the test family selected was “z tests” with logistic regression selected as the statistical test. The following values were entered into the G*Power software: an α error probability of 0.05, the desired power was 0.80, and an effect size (odds ratio) of 1.3 was designated as demonstrated in similar studies of this type (Han, Compton, Blanco, & Jones, 2018). The G*Power software estimated a minimal sample size of 1,447. To ensure adequate power, I used a larger sample size than the minimal recommended by G*Power software.

Ethical Considerations/Procedures

Since I used secondary data obtained from the NSDUH then informed consent was obtained, and data was de-identified prior to my use (NSDUH-codebook, 2017). For instance, in order to protect the confidentiality of data the NSDUH used a statistical disclosure limitation method which served to eliminate all personal identifying information such as, name, phone number, address, and geographical information (NSDUH-codebook, 2017). In addition, the NSDUH obtains information in a secure manner and this data is available for public use. Nevertheless, the Walden Institutional Review Board (IRB) confirmed that this doctoral capstone meets the University’s ethical standards and will oversee the capstone data analysis and results reporting. Approved on 12-3-2018, IRB Approval number 12-3-18-0188278.

Summary

This chapter presents a detailed description of the research methods used in this study. The chapter begins with a description of the NSDUH, the source of secondary data intended for use in this study, a description of the research design and rationale and the

methodology used to identify the target population, as well as sampling, and data collection methods. This chapter then describes the data analysis plan which includes the research questions and a description of the independent and dependent variables, measures, and coding/re-coding of variables. Finally, this chapter describes and addresses threats to validity, provides an explanation for determining sample size and discusses ethical considerations of the study. Chapter 4 which follows will serve to analyze, present, and describe research findings.

Chapter 4: Results

Introduction

This quantitative study was designed to investigate whether there were statistically significant associations between marijuana use and the mental health conditions (MHC) of MDE and suicide ideation in adolescents and adults, and whether these associations increased from 2008 to 2017. Study data from the NSDUH database were used to compare an early medical marijuana legalization year (2008), when only 13 states had legalized marijuana for medicinal purposes only, to a more current legalization year (2017), when 28 states and the District of Columbia had implemented medical marijuana laws and eight of these states plus the District of Columbia also legalized recreational marijuana (Governing Data, 2018; NCSL, 2019).

This chapter begins with a review of the research questions and study hypotheses. Data collection steps are reviewed, followed by a review of the data analysis plan. Results from hypothesis testing are provided. This chapter ends with a summary of major findings.

Research Questions

In this study I was guided by three research questions to assess the association between marijuana and depression, between marijuana and suicide ideation, and whether these associations were stronger in 2017 than in 2008 for both adults and adolescents. The research questions were as follows.

RQ1: Is marijuana use associated with depression and suicidal ideation in adults in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ2: Is marijuana use associated with depression and suicidal ideation in adolescents in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

RQ3: Are the associations between marijuana use and depression and between marijuana use and suicide ideation higher in 2017 than in 2008 for both adults and adolescents, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education?

Study Hypotheses

Accordingly, the hypotheses for this study, each stated in null form, were as follows.

For the 2008 data:

$H_0$1: There will be no statistically significant relationship between marijuana (MJ) use and depression (major depressive episode in the last year) in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$2: There will be no statistically significant relationship between MJ use and suicidal ideation in the adult 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$3: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$4: There will be no statistically significant relationship between MJ use and suicidal ideation in the adolescent 2008 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For the 2017 data:

$H_0$5: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$6: There will be no statistically significant relationship between MJ use and suicidal ideation in the adult 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$7: There will be no statistically significant relationship between MJ use and depression (major depressive episode in the last year) in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

$H_0$8: There will be no statistically significant relationship between MJ use and suicidal ideation in the adolescent 2017 cohort, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

For comparing 2008 and 2017 data:

$H_0$9: There will be no statistically significant increase in the strength of the relationships between MJ use and depression (Major Depressive Episode in the last year) in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$10: There will be no statistically significant increase in the strength of the relationships between MJ use and suicidal ideation in the adult 2017 cohort compared to the adult 2008 cohort.

$H_0$11: There will be no statistically significant increase in the strength of the relationships between MJ use and depression (Major Depressive Episode in the last year) in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

$H_0$12: There will be no statistically significant increase in the strength of the relationships between MJ use and suicidal ideation in the adolescent 2017 cohort compared to the adolescent 2008 cohort.

Data Collection

Data were obtained from the years 2008 and 2017 NSDUH databases. Since this study used deidentified secondary data, there was no direct contact with survey participants. After receiving approval from the Walden University (approval number 12-03-18-0188278) and registration with the Interuniversity Consortium for Political and

Social Research, the 2008 and 2017 data were downloaded from NSDUH in SPSS (Statistical Package for the Social Sciences, version 23) format. The 2008 NSDUH dataset included 37,504 adult cases and 17,606 adolescent cases. The 2017 NSDUH dataset included 42,554 adult cases and 13,722 adolescent cases (NSDUH-codebook, 2008; NSDUH-codebook, 2017). Cases for each analysis were included if they were not missing the data necessary to address the research questions, so the sample sizes varied somewhat from analysis to analysis. For example, the sample sizes for adolescent suicidal ideation were smaller than for adolescent MDE because of missing values for the adolescent cohorts.

Data Analysis

Data descriptive included frequencies percentages or means and standard deviation, as appropriate, for sex, age, level of education, family income distribution, major depression episode and suicide ideation. Hypothesis testing with inferential statistics consisted odds ratios (ORs) with 95% confidence intervals derived from crosstabs to determine ORs in isolation and with binary logistic regression to account for age, sex, family income, and education. Differences were considered to be statistically significant at the $p < .05$ threshold. For simplicity, results are presented for 2008 adults, 2008 adolescents, 2017 adults, and 2017 adolescents, with a summary section to address the research questions.

2008 Adult Results

2008 Adult Descriptive Statistics

Table 4 shows that the 2008 adult sample was well divided between males (47%) and females (53%). Ages ranged from 18 to over 65. Roughly half of cases were between 20 and 34 years old (51%). Education levels ranged from less than high school diploma to college degree. Roughly half (49%) had some college education or completed college. Annual family incomes ranged from less than $10,000 to $75,000 or greater. Roughly half (52%) reported annual family incomes of $40,000 or greater.

Table 4

2008 Adults Demographic Frequencies and Percentages (N = 34,504)

Demographic	*n*	%
Sex		
Males	17440	47
Females	20064	53
Age		
18	2811	7
19	2468	7
20	2280	6
21	2342	6
22 or 23	4520	12
24 or 25	4468	12
26 to 29	2732	7
30 to 34	2806	7
35 to 49	7788	21
50 to 64	3290	9
65 or older	1999	5
Education Level		
Less than High School Diploma	6682	18
Completed High School	12489	33
Some College	10811	29
Completed College	7522	20
Family Income Distribution		
Less than $10,000	4303	11
$10,000 - $19,999	4844	13
$20,000 - $29,999	4414	12
$30,000 - $39,999	4387	12
$40,000 - $49,999	4303	11
$50,000 - $74,999	6441	17
$75,000 or more	8812	23

2008 Adult Hypothesis Testing

Marijuana use and depression, 2008 Adults. Overall MJ use was 18% in the 2008 Adult cohort (6810 of 37186) for this analysis and the rate of MDE was 8% (3024 of 37186). Table 5 shows that 12% of MJ users reported MDE in the recent year compared to (7%) for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 171.8, p < .0001. The odds of MDE was 0.14 for users and .08 for non-users. The odds ratio of 1.75, indicated that adult MJ users had 75% greater odds of having MDE in the previous year than non-users (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 1 ($H_0$1).

Table 5

Marijuana and Depression: 2008 Adults

Marijuana		Major Depressive Episode			
Use	Stat	Yes	No	Total	Odds
No	Count	2203	28173	30376	0.08
	%	7%	93%	100%	
Yes	Count	821	5989	6810	0.14
	%	12%	88%	100%	
Total	Count	3024	34162	37186	1.75
	%	8%	92%	100%	Odds Ratio

Table 6 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and MDE in adults was 1.39 (p < .0001). This finding indicates that adult MJ users had 39% greater odds of having MDE in the previous year than non-users (see Gertsman, 2008), after accounting for age, sex, family income, and level of education. This statistically significant finding rejected Null Hypothesis 1.

Table 6

Coefficients Table: 2008 Adults MDE

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.33	0.11	1	0.005	1.39	1.11	1.75
No	Reference						
Sex							
Female	.88	0.12	1	<.0001	2.42	1.87	3.13
Male	Reference						
Income	-.04	0.02	1	0.09	0.95	0.90	1.01
Education							
Less than High School	-.03	0.12	1	0.82	0.97	0.77	1.23
High School Graduate	-.40	0.16	1	0.02	0.68	0.49	0.94
Some College	-.04	0.14	1	0.78	0.96	0.73	1.26
Completed College	Reference						
Age	.02	0.03	1	0.48	1.02	0.96	1.09

Note: The degrees of freedom in computing the confidence limits is 60

Marijuana use and suicidal ideation, 2008 Adults. Overall adult MJ use in the 2008 cohort was 18% (6,849 of 37,360) for this analysis. Table 7 shows that 11% of MJ users reported suicidal ideation in the recent year compared to 5% for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 353.4, p < .0001.

Table 7

Marijuana and Suicidal Ideation: 2008 Adults

Marijuana		Suicidal Ideation			
Use	Stat	Yes	No	Total	Odds
No	Count	1383	29128	30511	0.05
	%	5%	95%	100%	
Yes	Count	706	6143	6849	0.11
	%	10%	90%	100%	
Total	Count	2089	35271	37360	2.42
	%	94%	6%	100%	Odds Ratio

The odds of suicide ideation were 0.11 for users and 0.05 for nonusers. The odds ratio of 2.42 indicated that adult MJ users had more than double the odds of having suicidal ideation in the previous year than nonusers. This statistically significant finding rejected Null Hypothesis 2.

Table 8 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and suicidal ideation was 1.50 (p = .0016) This finding indicates that adult MJ users had 50% greater odds of having suicidal ideation in the previous year than nonusers (see Gertsman, 2008), after accounting for age, sex, family income, and level of education. This statistically significant finding rejected Null Hypothesis 2.

Table 8

Coefficients Table: 2008 Adults Suicide Ideation

Variable	B	S.E.	*df*	*p*-value	*OR*	Confidence Intervals	
Marijuana Use							
Yes	.40	.12	1	.002	1.50	1.18	1.92
No	Reference						
Sex							
Female	.33	.14	1	.02	1.40	1.05	1.87
Male	Reference						
Income	-.01	.02	1	.63	.99	.94	1.04
Education	-.08	.06	1	.18	.92	.81	1.04
Less than HS	.16	.43	1	.71	1.17	.50	2.77
HS Graduate	.04	.48	1	.93	1.04	.40	2.70
At least some College	Reference						
Age	-.05	.03	1	.16	.95	.89	1.02

Note: The degrees of freedom in computing the confidence limits is 60

Summary of 2008 Adult Cohort. Combined, these findings indicate a statistically significant relationship between MJ use and MDE ($H_0$1) and between MJ use and suicidal ideation ($H_0$2) in the 2008 Adult cohort.

2008 Adolescent Results

2008 Adolescent Descriptive Statistics

Table 9 shows that the 2008 adolescent sample was well divided between males (51%) and females (49%). Ages ranged from 12 to 17. Roughly half of cases were less than 15 years old (47%). Education ranged from fifth grade to college level. Roughly half (55%) reported an education level of ninth grade or lower. Annual family incomes ranged

from less than $10,000 to $75,000 or greater. Roughly half (49%) reported annual family incomes of less than $50,000.

Table 9

2008 Adolescent Demographic Frequencies and Percentages (N =17,606)

Demographic	*n*	%
Sex		
Males	8988	51
Females	8618	49
Age		
12	2615	15
13	2781	16
14	2884	16
15	3062	17
16	3180	18
17	3084	18
Education Level		
5th Grade	84	<1
6th Grade	971	6
7th Grade	2591	15
8th Grade	2835	16
9th Grade	3016	17
10th Grade	3045	17
11th Grade	2954	17
12th Grade	1695	10
Some College/University	138	1
Family Income Distribution		
Less than $10,000	967	5
$10,000 - $19,999	1850	11
$20,000 - $29,999	1892	11
$30,000 - $39,999	1937	11
$40,000 - $49,999	1939	11
$50,000 - $74,999	3344	19
$75,000 or more	5677	32

2008 Adolescent Hypothesis Testing

Marijuana use and depression, 2008 Adolescents. Overall MJ use was 14% in the 2008 Adolescent cohort (2,348 of 17,254) for this analysis and the rate of MDE was 8% (1,471 of 17,254). Table 10 shows that 18% of MJ users reported MDE in the recent year compared to 8% for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 141.9, p < .0001. The odds of MDE was 0.18 for users and 0.08 for nonusers. The odds ratio of 2.15 indicated that 2008 adolescent MJ users had greater than double the odds of having MDE in the previous year than nonusers. This statistically significant finding rejected Null Hypothesis 3.

Table 10

Marijuana and Depression: 2008 Adolescents

Marijuana		Major Depressive Episode			
Use	Stat	Yes	No	Total	Odds
No	Count	1121	13785	14906	0.08
	%	8%	92%	100%	
Yes	Count	350	1998	2348	0.18
	%	15%	85%	100%	
Total	Count	1471	15783	17254	2.15
	%	9%	91%	100%	Odds Ratio

Table 11 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and MDE in 2008 adolescents was 1.99 (p < .0001). This finding indicates that adolescent MJ users had double odds of having MDE in the previous year than non-users (see Gertsman, 2008), after accounting for age, sex, family income, and level of education. This statistically significant finding rejected Null Hypothesis 3.

Table 11

Coefficients Table: 2008 Adolescent MDE

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.68	.09	1	<.0001	1.99	1.63	2.42
No	Reference						
Sex							
Female	1.17	.08	1	<.0001	3.24	2.72	3.86
Male	Reference						
Income	-.006	.02	1	.77	0.99	0.95	1.04
Education	-.02	.05	1	.40	0.95	0.85	1.07
Age	.20	.06	1	.002	1.22	1.08	1.38

Note: The degrees of freedom in computing the confidence limits is 60

Marijuana use and suicidal ideation, 2008 Adolescents. Overall MJ use was 22% in the 2008 Adolescent cohort (1867 of 2623) for this analysis and the rate of suicidal ideation was 71% (1471 of 2623). Table 12 shows that 78% of MJ users reported suicidal ideation in the recent year compared to 69% for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 17.5, p < .0001. The odds of suicidal ideation were 3.59 for users and 2.25 for non-users. The odds ratio of 1.59, indicated that adolescent MJ users had 59% greater odds of having suicidal ideation in the previous year than non-users (see Gertsman, 2008). This finding rejected Null Hypothesis 4.

Table 12

Marijuana and Suicidal Ideation: 2008 Adolescents

Marijuana		Suicidal Ideation			
Use	Stat	Yes	No	Total	Odds
No	Count	1422	632	2054	2.25
	%	69%	31%	100%	
Yes	Count	445	124	569	3.59
	%	78%	22%	100%	
Total	Count	1867	756	2623	1.59
	%	71%	29%	100%	Odds Ratio

Table 13 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and suicidal ideation in 2008 adolescents was 1.74 (p = .0001). This finding indicates that adolescent MJ users had 74% greater odds of having suicidal ideation in the previous year than non-users, after accounting for age, sex, family income, and level of education (Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 4.

Table 13

Coefficients Table: 2008 Adolescent Suicide Ideation

Variable	B	S.E,	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.55	.13	1	.0001	1.74	1.33	2.29
No	Reference						
Sex							
Female	.58	.12	1	<.0001	1.80	1.40	2.32
Male	Reference						
Income	-.01	.02	1	.69	.99	.93	1.05
Education	-.02	.09	1	.80	.98	.80	1.19
Age	-.02	.10	1	.84	.98	.80	1.20

Note: The degrees of freedom in computing the confidence limits is 60

Summary of 2008 Adolescent Cohort. Combined, these findings indicate a statistically significant relationship between MJ use and MDE ($H_0$3) and between MJ use and suicidal ideation ($H_0$4) in the 2008 Adolescent cohort.

2017 Adult Results

2017 Adult Descriptive Statistics

Table 14 shows that the 2017 adult sample was well divided between males (47%) and females (53%). Ages ranged from 18 to over 65. Roughly half of cases were between 20 and 34 years old (53%). Education levels ranged from less than high school diploma to college degree. More than half (61%) had some college education or completed college. Annual family incomes ranged from less than $10,000 to $75,000 or greater. Roughly half (49%) reported annual family incomes of $40,000 or greater.

Table 13

2017 Adults Demographic Frequencies and Percentages (N = 42,554)

Demographic	*n*	%
Sex		
Males	19987	47
Females	22567	53
Age		
18	1730	4
19	1626	4
20	1636	4
21	1614	4
22 or 23	3555	8
24 or 25	3679	9
26 to 29	3989	9
30 to 34	4797	11
35 to 49	11214	26
50 to 64	4997	12
65 or older	3717	9
Education Level		
Less than High School Diploma	5395	13
Completed High School	11269	26
Some College	14288	34
Completed College	11602	27
Family Income Distribution		
Less than $10,000	3677	9
$10,000 - $19,999	4693	11
$20,000 - $29,999	4555	11
$30,000 - $39,999	4410	10
$40,000 - $49,999	4356	10
$50,000 - $74,999	6704	16
$75,000 or more	14159	33

2017 Adult Hypothesis Testing

Marijuana use and depression, 2017 Adults. Overall MJ use was 21% in the 2017 Adult cohort (8912 of 42066) for this analysis and the rate of MDE was 9% (3024 of 42066). Table 15 shows that .19 of MJ users reported MDE in the recent year compared to 0.08 for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 633.8, $p < .0001$.

Table 14

Marijuana and Depression: 2017 Adults

Marijuana		Major Depressive Episode			
Use	Stat	Yes	No	Total	Odds
No	Count	2497	30657	33154	0.08
	%	8%	93%	100%	
Yes	Count	1452	7460	8912	0.19
	%	16%	84%	100%	
Total	Count	3949	38117	42066	2.39
	%	9%	91%	100%	Odds Ratio

The odds of MDE was 0.19 for users and .08 for non-users. The odds ratio of 2.39 indicated that adult MJ users had more than double the odds of having MDE in the previous year than non-users (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 5.

Table 16 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and MDE in 2017 adults was 2.19 ($p < .0001$). This finding indicates that adult MJ users had more than double the odds of having MDE in the previous year than non-users, after accounting for age, sex, family income, and level of education. This statistically finding rejected Null Hypothesis 5.

Table 16

Coefficients Table: 2017 Adult MDE

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.78	.05	1	<.0001	2.19	1.97	2.43
No	Reference						
Sex							
Female	.58	.04	1	<.0001	1.79	1.63	1.97
Male	Reference						
Income	-.11	.01	1	<.0001	.89	.862	.913
Education	.07	.01	1	<.0001	1.08	1.05	1.11
Age	-.11	.01	1	<.0001	.89	.876	.911

Note: The degrees of freedom in computing the confidence limits is 50

Marijuana use and suicidal ideation, 2017 Adults. Overall MJ use was 21% (8952 of 42240) for this analysis. Table 17 shows that 12% of MJ users reported suicidal ideation in the recent year compared to 4% for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 744.2, p < .0001. The odds of suicide ideation were 0.14 for users and 0.05 for non-users. The odds ratio of 2.98 indicated that adult MJ users had roughly three times greater odds of having suicidal ideation in the previous year than non-users (see Gertsman, 2008). This statistically finding rejected Null Hypothesis 6.

Table 15

Marijuana and Suicidal Ideation: 2017 Adults

Marijuana		Suicidal Ideation			
Use	Stat	Yes	No	Total	Odds
No	Count	1490	31798	33288	0.05
	%	4%	96%	100%	
Yes	Count	1098	7854	8952	0.14
	%	12%	88%	100%	
Total	Count	2588	39652	42240	2.98
	%	6%	94%	100%	Odds Ratio

Table 18 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and suicidal ideation was 2.29 ($p <$ .0001) This finding indicates that adult MJ users had more than double the odds of having suicidal ideation in the previous year than non-users, after accounting for age, sex, family income, and level of education (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 6.

Table 18

Coefficients Table: 2017 Adult Suicide Ideation

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.82	.06	1	<.0001	2.29	2.00	2.61
No	Reference						
Sex							
Female	.18	.05	1	.003	1.21	1.07	1.36
Male	Reference						
Income	-.10	.01	1	<.0001	.90	.87	.93
Education	.03	.01	1	.108	1.03	.99	1.08
Age	-.16	.01	1	<.0001	.85	.83	.87

Note: The degrees of freedom in Computing the Confidence Limits is 50

Summary of 2017 Adult Cohort. Combined, these findings indicate a statistically significant relationship between MJ use and MDE and between MJ use and suicidal ideation in the 2017 Adult cohort.

2017 Adolescent Results

2017 Adolescent Descriptive Statistics

Table 19 shows that the 2017 adolescent sample was well divided between males (51%) and females (49%). Ages ranged from 12 to 17. Roughly half of cases were less than 15 years old (47%). Education ranged from fifth grade to college level. Roughly half (55%) reported an education level of ninth grade or lower. Annual family incomes ranged from less than $10,000 to $75,000 or greater. Roughly half (49%) reported annual family incomes of less than $50,000.

Table 16

2017 Adolescent Demographic Frequencies and Percentages (N = 13,722)

Demographic	*n*	%
Sex		
Males	7050	51
Females	6672	49
Age		
12	2039	15
13	2268	17
14	2278	17
15	2381	17
16	2400	17
17	2356	17
Education Level		
5th Grade	735	5
6th Grade	1959	14
7th Grade	2174	16
8th Grade	2465	18
9th Grade	2333	17
10th Grade	2341	17
11th Grade	1560	11
12th Grade	129	1
Some College	26	<1
Family Income Distribution		
Less than $10,000	721	5
$10,000 - $19,999	1485	11
$20,000 - $29,999	1403	10
$30,000 - $39,999	1222	9
$40,000 - $49,999	1275	9
$50,000 - $74,999	2043	15
$75,000 or more	5573	41

2017 Adolescent Hypothesis Testing

Marijuana use and depression, 2017 Adolescents. Overall MJ use was 14% in the 2017 Adolescent cohort (1814 of 13330) for this analysis and the rate of MDE was 8% (2348 of 13330). Table 20 shows that 25% of MJ users reported MDE in the recent

year compared to (12%) for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 235.1, p < .0001. The odds of MDE was 0.33 for users and 0.13 for non-users. The odds ratio of 2.50 indicated that 2017 adolescent MJ users had two and a half times odds of having MDE in the previous year than non-users (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 7.

Table 17

Marijuana and Depression: 2017 Adolescents

Marijuana		Major Depressive Episode			
Use	Stat	Yes	No	Total	Odds
No	Count	1359	10157	11516	0.13
	%	12%	88%	100%	
Yes	Count	455	1359	1814	0.33
	%	25%	75%	100%	
Total	Count	1814	11516	13330	2.50
	%	14%	86%	100%	Odds Ratio

Table 21 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and MDE in 2017 adolescents was 1.81 (p < .0001). This finding indicates that adolescent MJ users had 81% greater odds of having MDE in the previous year than non-users, after accounting for age, sex, family income, and level of education (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 7.

Table 21

Coefficients Table: 2017 Adolescent MDE

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.59	.08	1	<.0001	1.81	1.53	2.14
No	Reference						
Sex							
Female	1.22	.08	1	<.0001	3.41	2.89	4.03
Male	Reference						
Income	.02	.01	1	.16	1.03	..99	1.06
Education	.07	.04	1	.12	1.08	.98	1.18
Age	.15	.05	1	.004	1.16	1.05	1.29

Note: The degrees of freedom in computing the confidence limits is 50

Marijuana use and suicidal ideation, 2017 Adolescents. Overall MJ use was 23% in the 2017 Adolescent cohort (643 of 2623) for this analysis and the rate of suicidal ideation was 77% (2127 of 2623). Table 22 shows that 81% of MJ users reported suicidal ideation in the recent year compared to 76% for non-MJ users. This disproportionality was statistically significant, X^2 (df = 1) = 8.5, p < .01. The odds of suicidal ideation were 4.40 for users and 3.16 for non-users. The odds ratio of 1.39 indicated that 2017 adolescent MJ users had 39% greater odds of having suicidal ideation in the previous year than non-users (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 8.

Table 18

Marijuana and Suicidal Ideation: 2017 Adolescents

Marijuana		Suicidal Ideation			
Use	Stat	Yes	No	Total	Odds
No	Count	1603	507	2110	3.16
	%	76%	24%	100%	
Yes	Count	524	119	643	4.40
	%	81%	19%	100%	
Total	Count	2127	626	2623	1.39
	%	77%	23%	100%	Odds Ratio

Table 23 shows that, after accounting for age, sex, family income, and education level, the odds ratio for the relationship between MJ and suicidal ideation in 2017 adolescents was 1.24 ($p < .0001$). This finding indicates that in 2017 adolescent MJ users had 24% greater odds of having suicidal ideation in the previous year than non-users, after accounting for age, sex, family income, and level of education (see Gertsman, 2008). This statistically significant finding rejected Null Hypothesis 8.

Table 23

Coefficients Table: 2017 Adolescent Suicide Ideation

Variable	B	S.E.	*df*	*p*-value	OR	Confidence Intervals	
Marijuana Use							
Yes	.21	.17	1	.22	1.24	.87	1.76
No	Reference						
Sex							
Female	.54	.10	1	<.0001	1.73	1.39	2.15
Male	Reference						
Income	-.003	.03	1	.92	.99	.93	1.07
Education	-.05	.09	1	.56	.95	.79	1.14
Age	.06	.09	1	.49	1.06	.89	1.28

Note: The degrees of freedom in Computing the Confidence Limits is 50

Summary of 2017 Adolescent Cohort. Combined, these findings indicate a statistically significant relationship between MJ use and MDE ($H_0$7) and between MJ use and suicidal ideation ($H_0$8) in the 2017 Adolescent cohort.

Comparisons Between 2008 and 2017 Results

It was hypothesized that the relationship between MJ use and depression and the relationship between MJ use and suicidal ideation would increase in magnitude from 2008 to 2017 for adults and for adolescents. To test these hypotheses, the ORs for 2017 were assessed to determine whether they were outside of the 95% confidence intervals (95% CI) for the corresponding 2008 OR results. This assessment was conducted for depression and for suicidal ideation, with analyses for adults and adolescents conducted in parallel analyses. ORs were tested using both raw (unadjusted) values and using ORs that were adjusted for age, sex, annual family income, and level of education. If a 2017 OR was outside of the 95% CI for the corresponding 2008 data, the difference was statistically significant at the $p < .05$ threshold.

MJ and Depression Changes from 2008 to 2017

The depression ORs for MJ users and non-users for the Adult and Adolescent 2008 and 2017 cohorts are displayed in Table 24. The 95% CIs are also included to foster testing the hypotheses.

Adult MJ-related depression changes from 2008 to 2017. The 2017 raw (unadjusted) Adult OR of 2.39 was higher than the 95% CI for the 2008 unadjusted OR (1.61-1.91). The 2017 adjusted Adult OR of 2.18 was higher than the 95% CI for the 2008 adjusted OR (1.10-1.74). These findings rejected null hypothesis 9 ($H_0$9), which

stated that there will be no significant increase in the strength of the relationships between MJ use and MDE (see Gertsman, 2008).

Adolescent MJ-related depression changes from 2008 to 2017. The 2017 raw (unadjusted) Adolescent OR of 2.50 was higher than the 95% CI for the 2008 unadjusted OR (1.90-2.46). The 2017 adjusted Adolescent OR of 1.81 was not outside of the 95% CI for the 2008 adjusted OR (1.63-2.41). These findings partially rejected null Hypothesis 11 ($H_0$11), which stated that there will be no statistically significant increase in the strength of the relationships between MJ use and MDE in the adolescent 2017 cohort compared to the adolescent 2008 cohort (see Gertsman, 2008).

Table 19

Depression Raw and Adjusted ORs for Adults and Adolescents: 2008 and 2017

Age	Year	Raw	95% CI		Adjusted	95% CI	
		OR	Lower	Upper	OR	Lower	Upper
Adult	2008	1.75	1.61	1.91	1.39	1.10	1.74
	2017	2.39	2.23	2.56	2.18	1.96	2.43
Child	2008	2.16	1.90	2.46	1.98	1.63	2.41
	2017	2.50	2.22	2.82	1.81	1.53	2.13

MJ and Suicide Ideation Changes from 2008 to 2017

The suicide ideation ORs for MJ users and non-users for the Adult and Adolescent 2008 and 2017 cohorts are displayed in Table 25. The 95% CIs are also included to foster testing the hypotheses.

Adult MJ-related suicidal ideation changes from 2008 to 2017. The 2017 raw (unadjusted) Adult OR of 2.98 was significantly higher than the 95% CI for the 2008 unadjusted OR (2.20-2.66). The 2017 adjusted Adult OR of 2.40 was higher than the 95%

CI for the 2008 adjusted OR (1.89-2.31). These findings rejected the null hypothesis 10 ($H_0$10), which stated that there will be no statistically significant increase in the strength of the relationships between MJ use and suicide ideation in the adult 2017 cohort compared to the adult 2008 cohort (see Gertsman, 2008).

Adolescent MJ-related suicide ideation changes from 2008 to 2017. The 2017 raw (unadjusted) Adolescent OR of 1.39 was within the 95% CI for the 2008 unadjusted OR (1.28-2.01). The 2017 adjusted Adolescent OR of 1.24 was not outside of the 95% CI for the 2008 adjusted OR (1.32-2.29). These non-significant findings failed to reject the null hypothesis 12 ($H_0$12), which stated that there will be no statistically significant increase in the strength of the relationships between MJ use and suicidal ideation in the adolescent 2017 cohort compared to the adolescent 2008 cohort (see Gertsman, 2008).

Table 20

Suicidal Ideation Raw and Adjusted ORs for Adults and Adolescents: 2008 and 2017

Age	Year	Raw	95% CI		Adjusted	95% CI	
		OR	Lower	Upper	OR	Lower	Upper
Adult	2008	2.42	2.20	2.66	1.50	1.17	1.92
	2017	2.98	2.75	3.24	2.28	2.00	2.60
Child	2008	1.61	1.28	2.01	1.74	1.32	2.29
	2017	1.39	1.11	1.74	1.24	.877	1.76

Summary of Results

The summary of results by hypothesis are displayed in Table 26. This study of data from the 2008 and 2017 National Survey on Drug Use and Health (NSDUH) database revealed that MJ use was associated with significant odds of greater depression and suicidal ideation for adults and for adolescents in 2008 and in 2017. These findings

were consistent whether ORs were calculated using raw (unadjusted) values or when values are adjusted for age, sex, family income, and education level using binary logistic regression. These findings reject Null Hypothesis 1 ($H_0$1) through Null Hypothesis 8 ($H_0$8) and were consistent with the alternative hypothesis that MJ use was associated with both depression and suicidal ideation in adults and adolescents in the 2008 and the 2017 cohorts.

Table 21

Summary of Results by Hypothesis

Hypothesis	Year	Age	MHC	Statistically Significant?	
				Raw OR	Adjusted OR
$H_0$1	2008	Adult	Depression	Yes	Yes
$H_0$2	2008	Adult	Suicidal Ideation	Yes	Yes
$H_0$3	2008	Adolescent	Depression	Yes	Yes
$H_0$4	2008	Adolescent	Suicidal Ideation	Yes	Yes
$H_0$5	2017	Adult	Depression	Yes	Yes
$H_0$6	2017	Adult	Suicidal Ideation	Yes	Yes
$H_0$7	2017	Adolescent	Depression	Yes	Yes
$H_0$8	2017	Adolescent	Suicidal Ideation	Yes	Yes
$H_0$9	2008 vs 2017	Adult	Depression	Yes	Yes
$H_0$10	2008 vs 2017	Adult	Suicidal Ideation	Yes	Yes
$H_0$11	2008 vs 2017	Adolescent	Depression	Yes	No
$H_0$12	2008 vs 2017	Adolescent	Suicidal Ideation	No	No

Note. MHC = mental health condition.

There were statistically significant increases in the strength of the relationships between MJ use and depression ($H_0$1) and between MJ use and suicidal ideation ($H_0$10) in adults between 2008 and 2017. Adolescent results were mixed regarding changes over time. There was a statistically significant increase in the strength of the relationship

between MJ use and depression between 2008 and 2017 in adolescents using raw (unadjusted) values ($H_0$11), but this pattern was not statistically significant when values were adjusted for age, sex, annual family income, and education. Further, there was no evidence of statistically significant increases in the strength of the relationships between MJ use and suicidal ideation from 2008 to 2017 in Adolescents ($H_0$12). Thus, the Null hypothesis ($H_0$12) is not rejected.

The following chapter provides a summary of the present study, along with recommendations and conclusions.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The changing epidemiology of marijuana legalization, use, acceptance, and potency and the effects on mental health conditions is an important concern for policy makers as well as public health and health care professionals. The purpose of this study was to assess the association between marijuana use, the continued widespread legalization of marijuana, the availability of highly potent marijuana and the effects on mental health conditions. The literature review suggested that marijuana legalization has led to the production of highly potent marijuana strains. This is evidenced by reports indicating that since legalization the THC level of marijuana can now range from 6% to 28 % as oppose to pre-legalization lower potency levels that typically ranged between 4% to 13 % (Cabrera, 2016; Ramaekers et al., 2006). Furthermore, the notion that marijuana use is associated with the development of psychosis and mental health disorders is well founded (Moore et al., 2007; Volkow, Ruben, Baler, Compton, & Weiss, 2014). As previous research has demonstrated that in addition to psychosis, conditions like anxiety and depression are also associated with regular marijuana use (Moore et al., 2007; Volkow et al., 2014). However, very little research has been conducted post-legalization to assess the effects of legalization and the rising THC levels. Nevertheless, since THC is the responsible agent for the psychoactive effects of marijuana then it is highly probable that this rise in THC concentration and ease of marijuana accessibility may contribute to an increase in mental health consequences. This premise is evidenced by increases in hospital admissions for psychosis and overdoses associated with marijuana intoxication

since widespread legalization began. For instance, in Colorado, the higher levels of THC have had a serious health toll on inexperienced users. According to the Colorado Department of Public Health and Environment, emergency room visits for marijuana associated conditions, such as psychosis, has increased 29% for since legalization (Cabrera, 2016). However, when inexperienced users take in too much highly potent marijuana, they are more likely to experience extreme anxiousness and report feelings of "impending dome" when compared to the regular heavy marijuana users that have built up a tolerance (Cabrera, 2016, para. 23). This is evidenced by out of state users that are inexperienced when it comes to the high levels of THC elicited by Colorado's legal marijuana (Manella, 2016). Hospitalizations for out of state visitors has risen dramatically, from 78 per 10,000 visits in 2012 to 163 per 10,000 in 2014, reflecting an increase of 109% between the years of 2012 and 2014 (Manella, 2016).

Interpretation of Findings

Present findings revealed that marijuana use increased among the adult cohort between 2008 and 2017. This increase in marijuana use may be the result of easing of marijuana acceptance and reduced stigma associated with marijuana use. This finding could also be attributed to the continued spread of marijuana legalization. In 2008, only 13 states and the District of Columbia had implemented laws legalizing marijuana use for medical purposes only (Governing Data, 2019; NCSL, 2019), but by 2017, 29 states and the District of Columbia had medical marijuana laws, with seven of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2018; Hartig & Geiger, 2018; NCSL, 2019). Thus, more adults may use marijuana now

that the risk of legal actions are reduced. Further support for this premise is provide by Keyhani, et al. (2018), which posited that changes in marijuana laws "have been accompanied by an increase in daily marijuana use, as well as in marijuana dependence, among adults in the U.S. population" (para. 1). This is supported by an increased prevalence of marijuana use among adults in the general population, which has doubled over the course of the last decade (Keyhani et al., 2018).

Research Question 1

RQ1 asked whether marijuana use was associated with depression and suicide ideation in adults in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education. The prevalence of MDE) was higher among marijuana users than nonusers in the adult 2008 cohort, and adult marijuana users had three times greater odds of having MDE in the previous year than nonusers in the 2008 cohort. This statistically significant finding was also evident after accounting for age, sex, family income, and education level. In the 2017 adult cohort, adult marijuana users had more than double the odds of having MDE in the previous year than nonusers, even after accounting for age, sex, family income, and education level.

There is a growing body of evidence supporting the association between cannabis use and the development of psychotic or mental health disorders (Moore, et al., 2007). However, Volkow et al. (2014) posited that causality is not well founded because addressing this association is hindered by confounders that also contribute to the development of these conditions. Lev-Ran et al. (2014) conducted a systematic review

and meta-analysis of existing longitudinal studies to determine patterns of cannabis use that are associated with the development of depression. Lev-Ran, et al. cited three reasons as cause for concern and justification for the study: (a) high cannabis use among adolescents and young adults, (b) the increasing potency of cannabis, and (c) the association between cannabis and mental illness. Further, regular or moderate marijuana users have an increased risk of developing depression when compared to those who do not use marijuana, with the greatest risk of developing depression in heavy marijuana users (Lev-Ran et al., 2014). Lev-Ran et al. emphasized the importance of recognizing and addressing the potential risk of heavy cannabis use, especially among adolescents because this group has the highest rates of cannabis use.

However, conversely a study by Denson and Earleywine (2006) found the risk of depression is not increased in adults by the use of marijuana. As according to Denson and Earleywine, "those who used once per week or less had less depressed mood, more positive affect, and fewer somatic complaints than non-users (p.738)." In addition, "daily users reported less depressed mood and more positive affect than non-users" (Denson & Earleywine, 2006, p.738). These findings are supported Hader, Morral, and Arkes (2006), which concluded that, "past-year marijuana use does not significantly predict later development of depression" (p. 1463). Thus, causality between marijuana use and depression is not well founded.

Regarding suicide ideation among adults in 2008, the results of this study revealed that in the 2008 adult cohort, marijuana users had more than double the odds of having suicidal ideation in the previous year than nonusers. This statistically significant

findings were consistent after accounting for age, sex, family income, and education level. The adult 2017 cohort demonstrated that adult marijuana users again had more than double the odds of having suicide ideation in the previous year than nonusers, even after accounting for age, sex, family income, and education level.

In a related study, Oquendo, Currier, and Mann, (2006) addressed predictive risk factors associated with suicidal behavior in major depressive disorders and found that the best predictors of suicidal behavior were a past history of suicidal behavior and a history of refractory or recurrent depressions. This evidence was consistent with the results of the present study, which found an increase in suicidal ideation and an increase in depression in 2017 versus 2008. Thus, the increase in suicide ideation may be associated with the increasing rates of depression. It is also important to mention that these rates increased concurrently with the continued spread of legalization and rising potency of marijuana. Only 13 states and the District of Columbia had implemented laws legalizing marijuana use for medical purposes only in 2008(NCSL, 2019; Governing Data, 2018). In 2017, 29 states and the District of Columbia had medical marijuana laws with seven of these states and the District of Columbia also implementing recreational marijuana laws (Governing Data, 2019; Hartig & Geiger, 2018; NCSL, 2019). Additionally, prior to legalization, THC levels ranged from a low of 4% to a high of 13% (Ramaekers et al. 2006). But, since legalization these ranges have increased dramatically, such that marijuana can now range from a low of 6% THC to a high of 28% THC (Cabrera, 2016).

Research Question 2

RQ2 asked whether marijuana use evaluated marijuana use and the association with depression and suicide ideation for adolescents in 2008 and 2017, either in isolation using raw (unadjusted) values or using values adjusted for age, sex, annual family income, and education.

Marijuana use among the adolescent cohorts did not change between 2008 and 2017, with both adolescent cohorts measured at 14% marijuana use. This contrast with the increase in adult marijuana use may be attributed to the fact the adults can legally buy marijuana while adolescents cannot (Governing Data, 2018; NCSL, 2019).

Among the 2008 adolescent cohort, marijuana users had greater than double the odds of having MDE in the previous year than non-users, even after accounting for age, sex, family income, and education level. In comparison, among the 2017 adolescent cohort, marijuana users had two and a half times greater odds of having MDE in the previous year than nonusers, even after accounting for age, sex, family income, and education level. Thus, the rates of marijuana associated depression increased concurrent with the continued widespread legalization of marijuana. These rates are also concurrent with the rising THC levels in marijuana that has occurred with the continued widespread legalization (Cabrera, 2016).

Additionally, these findings are supported by previous research as van Gastel et al. (2013) which indicated that marijuana use has been associated with psychiatric symptoms and the risk is increased by regular or heavy marijuana use. According to van Gastel et al., the risk of developing depression is more pronounced in those who began

using marijuana before age 16. Observations among young adolescent marijuana users typically include “delinquent behavior; conduct disorder; attention problems; anxiety as well psychotic and depressive symptoms” (van Gastel, 2013, p.1849). Thus, developing evidenced based interventions to address the association between marijuana and mental health conditions is essential to ensuring the health and well fare adolescents and therefore future generations.

With regard to suicide ideation among the 2008 adolescent cohort, marijuana users demonstrated a doubled risk of suicide ideation than nonusers, even after accounting for age, sex, family income, and education level, with even higher values for the 2017 adolescent cohort. These results are consistent with peer-reviewed research showing that suicidal ideation, attempts, and completions have been associated with both depression and substance use in adolescence (Chabrol, Chauchard, & Girabet, 2008; Field, Diego, & Sanders, 2001). Social factors and mental health problems in general have been identified as associated risk factors for suicidal behaviors in adolescents. Among these, depression has been established as a significant or major risk factor for suicide behaviors (Chabrol et al., 2008; Field et al., 2001). In addition, Field et al. (2001) identified marijuana use and a family history of depression, particularly maternal depression, as important variables in adolescent suicide ideation.

Research Question 3

RQ3 asked whether the associations between marijuana use and MDE and between marijuana use and suicidal ideation are significantly higher in 2017 than in 2008 for both adults and adolescents. Adult MDE and suicidal ideation increased significantly

from 2008 to 2017. Results for the adolescents were mixed, with statistically significant increases in depression from 2008 to 2017 evident using unadjusted values, but not accounting for age, sex, family income, and education level. Further, not statistically significant increases from 2008 to 2017 in suicidal ideation for adolescents were present.

Suicide is one of the most common causes of death worldwide among adolescents and young adults aged 10-24, (Serafini et al., 2013). Previous research suggests that marijuana use may be a contributing factor in the development of suicide behavior and depression (Gander, 2019; Serafini et al., 2013). For example, Gander (2019) pooled existing studies to assess the association between marijuana use, depression and suicidal behavior and found that adolescents who use marijuana are at a greater risk of experiencing depression and suicidal behavior, including suicide ideation and suicide attempts. However, Gander acknowledged that it is difficult to assess whether confounding variables may have affected the results, such as amount of marijuana use, use of other substances of abuse, and marijuana potency (which has increased substantially since legalization). Gander further offered that individuals with a predisposition to depression or those who begin to experience symptoms of depression may self-medicate as a way to ease these symptoms or just think and/or feel better. In contrast, Anderson, Rees, and Sabin (2014) compared the rates of suicide in states with medical marijuana legalization to states that did not legalize medical marijuana and found a decrease in suicides among men aged 20 to 39 in states with medical marijuana laws. Anderson et al. (2014) hypothesized that this negative relationship between marijuana

legalization and suicide rates may be attributed to the use of marijuana as a method of coping with stress.

Analysis of Theoretical Framework

There are several theoretical models developed for understanding drug use, abuse, prevention, and cessation. For instance, there is a growing body of evidence supporting the association between self-medicating with marijuana and depression (Shonesy et al., 2014). Research supports the use of the SEM to understand substance use and abuse from a multifaceted perspective (American College Health Association [ACHA], 2018). Theorists of the self-medication theory of addiction developed by Khantzian (1977, 1974) suggested that individuals who are afflicted with substance abuse may also have a predisposition for psychological conditions or psychosis (Burnett & Reiman, 2014). Self-medication theory has over 30 years of use in research (Hall & Queener, 2007). Therefore, I used both the self-medication theory of addiction and SEM as the conceptual frameworks.

Shonesy (2014) explored the relationship between mental health conditions, like depression and anxiety, and receptors that respond to THC in the central nervous system. This system is known as the endocannabinoid system and is medicated by two cannabinoid receptors, CB1 and CB2 (Shonesy et al., 2014). These receptors respond to both endogenous and exogenous stimulation (Shonesy et al., 2014). Natural endogenous stimulation of CB1 receptors occurs through one of two THC-like substances, anandamide (AEA) and 2-arachidonoylglycerol (2-AG, Shonesy et al., 2014). According to Shonesy (2014) this system “is heavily implicated in the modulation of anxiety and

depressive behavior and emotional learning" (p.1644). The THC in marijuana is capable of binding CB1 receptors of the system and affects mood, such that reduced stimulation of these receptors results in mood destabilization and increased feelings of anxiety and depression (Shonesy et al., 2014). Thus, marijuana users who suffer from these conditions may not be able to synthesize enough of THC-like molecules (particularly 2-AG) so they use marijuana to compensate, suggesting that individuals may actually self-medicate without knowing it to compensate for their inherent low levels of THC-like molecules (Curry, 2014; Shonesy et al., 2014).

However, results of the present study and other supporting literature suggest that marijuana use is associated with an increased risk of depression and suicide ideation. Nevertheless, an explanation for these contradicting theories may lie in the ratio of THC to CBD in marijuana. It has been demonstrated that CBD has effects that counteract the effects of THC (Niesink & van Laar, 2013). CBD is a compound found in marijuana that is being used for medical benefits. CBD does not produce the psychoactive effects caused by the THC found in marijuana. In fact, CBD can serve to counteract the psychoactive effects of THC and is used for treating marijuana induced psychosis (Niesink & van Laar, 2013). Thus, it is possible marijuana that has a high CBD to THC ratio may counter the effects of THC-induced depression.

The (SEM is a theory-based multifaceted approach to understanding the dynamics associated individual and population level determinants of health (ACHA, 2018). The SEM recognizes that health is determined by influences from multiple societal and environmental factors that affect the individual (ACHA, 2018). According to the SEM,

the dynamic interrelationships between five levels or factors of health determinants are significant and essential to the health behaviors of the individual (ACHA, 2018). These five levels include (a) individual, (b) interpersonal, (c) organizational/institutional, (d) community, and (e) policy (CDC-SEM, 2018). The first or individual level is concerned with sociodemographic (i.e., age, gender, religion, etc.) and intrapersonal factors or characteristics such as knowledge, beliefs, attitudes, and behaviors of the individual that affect health decisions and outcomes (ACHA, 2018; CDC-SEM, 2018). The second or interpersonal level is concerned with close personal relationships or associates that influence the behavior and contributes to the life experience of the individual (ACHA, 2018; CDC-SEM, 2018). This can include family members, friends, coworkers, health care providers, and community health workers (ACHA, 2018; CDC-SEM, 2018). These first two levels may be associated with an increase in marijuana use as continued legalization may result in decreased perceived risk and reduced stigma associated with marijuana use.

The third level of SEM is concerned with local organizations and institutions that affect individual and population health by influencing organizational systems and policies (ACHA, 2018; CDC-SEM, 2018). This includes health care systems; state and local health departments; professional organizations; and healthcare plans (ACHA, 2018; CDC-SEM, 2018). The fourth level explores community and social relationships that influence individual health determinants. This can include employers/worksites, businesses such as bars and restaurants, community-based organizations, the media as well as community, state and regional organizations (ACHA, 2018; CDC-SEM, 2018).

Thus, the third and fourth levels may be associated reduced or no change in marijuana use. This is because the third level associated with health care systems, state and local health departments, professional organizations, and healthcare plans, may serve to inform individuals and the public about the negative impact or consequences of marijuana use. In addition, the fourth level is associated with organizations such as employers/worksites many of which require drug screenings that include marijuana, thus deterring marijuana use.

The fifth level of SEM is associated with interpreting and implementing local, state, national, and federal laws and policies (ACHA, 2018; CDC-SEM, 2018). This level is of particular interest to the present study, given the current trend in marijuana policies that favor relaxed laws and increased community acceptance of legalization for recreational and medicinal purposes. The fifth level may thereby be associated with an increase in marijuana use as state laws favoring marijuana continue to spread. As individuals may feel more comfortable purchasing and using marijuana without legal consequences. However, this fifth level may result in a decrease or no change in marijuana use as federal laws still prohibit marijuana use. Therefore, this SEM model can be used to inform States local marijuana policies and may serve to inform the implementation of federal laws and regulations as well.

With respect to this study, the SEM suggest that the first (individual), second (interpersonal), and fifth (policy) levels may be associated with increased marijuana use. As increased legalization (policy), reduced stigma associated with marijuana use and decreased perceived risk associated with the individual, interpersonal and community

effects may serve to increase marijuana use and affect the results of this study. In contrast, the third (organizational/institutional) and fourth (community) levels may be associated with a decrease or no change in marijuana use as the groups associated with these levels may serve to deter marijuana use.

Limitations

In this study I was limited by sample, measures, and research design. The target population for the NSDUH included non-institutionalized civilians 12 years and older living in the United States at the time of the survey. Approximately three percent of the US population was excluded this includes active-duty military and institutionalized groups, such those in prisons, hospitals, nursing homes, treatment centers, etc. In all the 2008 and 2017 NSDUH datasets consisted of responses from 67,928 and 68,032 participants, respectively (NSDUH-codebook, 2008; NSDUH-codebook, 2017). Based on this information it is important to acknowledge the exclusion of institutionalized, incarcerated and homeless individuals because according to a report provided by the Center for Prisoner Health and Human Rights (2019), "approximately half of prison and jail inmates meet the requirements of the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) for drug abuse or dependence" (para. 2). In addition, according to the U.S Department of Housing and Urban Development (2016), among the roughly 550,000 homeless persons, approximately 95,500 (17%) of these individuals suffer from chronic substance abuse. So, inclusion of the incarcerated and homeless populations in the demographics of NSDUH would have increased the number of users in the study disproportionately and potentially altered the outcomes observed. Thus, while

exclusion of these individuals may have limited the representativeness of the sample, inclusion of these individuals may have altered the study's results by increasing the number of marijuana users disproportionately.

Even though the NSDUH presented samples that were stratified to be representative of the nation's adult and adolescent populations, in my present study I did not explore state by state differences. Thus, while a nationwide analysis was conducted, the NSDUH does not differentiate between states with marijuana laws compared to states without marijuana laws. In addition, THE NSDUH was retrospective in nature and it did not include random assignment into group or experimentally controlled levels of marijuana use. In contrast with a true experimental design that would include random assignment and experimentally controlled usage to assess true cause-and-effect relationships (Creswell, 2009).

In this study I was also limited by self-reporting, which is subject to recall bias, which can therefore result in erroneous responses due to lapses in memory (Althubaiti, 2016). Self-reporting is also subject to social desirability bias, especially in this case which involves responses related drug use (Althubaiti, 2016). To alleviate these concerns, the NSDUH interviewer conducted the interview in a private area of the home and used both computer-assisted personal interviewing (CAPI) and audio computer-assisted self-interviewing (ACASI) techniques (CBHSQ, 2016). The CAPI portion of the interview was used to collect and record verbal responses to questions read aloud by the interviewer who enters these responses into a computer (CBHSQ, 2016). In contrast, the ACASI portion of the interview was used to collect information on answers to sensitive

questions. During his portion of the interview, respondents used headphones to listen to questions and enters responses directly into a computer (NSDUH-codebook, 2017). Throughout the interview process (written and oral), respondents were assured that their confidentiality, anonymity, and responses were protected and handled according to federal law compliance regulations (CBHSQ, 2016; NSDUH-codebook, 2017). Nevertheless, even though the NSDUH assured participants anonymity and confidentiality, respondents may still have felt uncomfortable and may therefore not have been completely truthful about marijuana use or may have underestimated usage amounts or frequency (Althubaiti, 2016). Thus, socially acceptable or bias responses could have therefore effected survey results on the prevalence and extent of marijuana use because individuals may still have concerns about social stigma or self-incrimination (McDonald, 2008).

In my present study I only used one measure per construct. In addition, my study was missing important variables, such as frequency and amount of marijuana use. I did not assess whether respondents had a history of major depressive episode or suicide ideation prior to marijuana use.

My present study was also limited by the design. Even though my study was longitudinal in nature regarding statistical comparisons of cohorts at two time periods, the same respondents were not followed over time because there was no tracking between the cohort years of 2008 and 2017. Therefore, there is no way to tell if respondents changed behavior based on marijuana laws or trends in growing acceptance of marijuana use. Also, there was no long-term follow up after 2017. Because this was not a true

longitudinal study, cause and effect inference is limited, and the results do not provide strong evidence of causality between marijuana use and the mental health conditions of MDE and suicide ideation

Areas for Future Research

An important approach for future scholars is to replicate this research using methods to address, overcome, or reduce the limitations of this study. For instance, future research should include variables with multiple measures of construct, such as how much or how often individuals use marijuana. Another limitation that should be addressed are those associated with self-reporting, including overcoming recall and social desirability biases.

Another important approach for future scholars is to explore state-level data to compare states with marijuana laws to states without marijuana laws. In states with marijuana laws, future researcher should explore changes in mental health status in years prior to legalization of marijuana to years after legalization (pre vs post-legalization). In my present study I sought to explore and compare state-level data. However, this information is only available on-site at one of three Research Data Centers (RDCs) in the U.S. managed by the National Center for Health Statistics.

Future scholars should also consider whether participants had previous history of marijuana use as well as histories of MDE and suicide ideation prior to using marijuana. Additionally, future research should consider conducting long-term follow up as well. Thus, to guarantee optimal outcomes and present strong evidence of causality, future research is warranted to confirm the present findings and assess (determine) whether the

effects observed in this study would be statistically significant in a true longitudinal study.

Implications for Positive Social Change

The results of my study may contribute to positive social change by contributing to present knowledge on the association between marijuana use and the mental health conditions, depression and suicide ideation. The findings presented here imply that marijuana use can increase the risk of depression and suicide ideation.

Addressing these concerns at this time is of particular importance given the trends in marijuana legalization and growing acceptance. Current trends indicate that, as marijuana legalization continues to spread, the perceived risk of marijuana use is decreasing. These trends may contribute to an increase in marijuana use as was demonstrated among the adult cohorts from 2008 compared to 2017 (Lynskey & Hall, 2016). In addition, with the exception of marijuana use, substance use in general has declined among high school seniors (Lanza, Vasilenko, Dziak & Butera, 2015). Marijuana is still the most widely used illicit substance in the world and in the United States as in 2018, approximately 43 million Americans reportedly used marijuana in the past year (Statista, 2019). Among these were approximately 11.8 million young adults that reported using marijuana in the past year in 2018 (NIH-NIDA, 2019). The World Health Organization (2018) further emphasizes the widespread use of marijuana in a report indicating that approximately 147 million people or 2.5% of the world population utilize marijuana in some form each year. This is compared to 0.4% combined totals of

the world's population that consume cocaine and opiates annually (WHO, 2018)., demonstrating that marijuana is by far the most widely used illicit substance in the world.

The findings presented here also contribute to positive social change because according to the NSDUH, in 2017 approximately 17.3 million adults 18 years old or older and 3.2 million adolescents aged 12-17 years old had at least one major depressive episode (NIMH, 2019). In addition, suicide is the tenth leading cause of death in the United States. Thus, addressing suicidal behavior, such as suicide ideation is an important preventive measure for public health concern.

The results of my study demonstrated a statistically significant association between marijuana use an increased risk of major depressive episode (MDE) in both adults and adolescents, and therefore support and extend previous reports. Furthermore, my study also demonstrated positive correlations between time (corresponding to increasing marijuana legalization) and rising rates or risk for MDE and suicide ideation as the rates for these conditions increased for marijuana users from 2008 to 2017. The findings presented here along with continued widespread marijuana legalization, increasing permissive attitudes toward marijuana use, and decreasing perceived risk demand that policymakers and public health professionals direct informative and preventive efforts to reduce these risks.

The increasing permissive attitudes and decreasing perceived risk of marijuana use among adolescents is a serious concern for the future of public health as these individuals are entering their reproductive years and will therefore affect future generations. In addition, it has also been demonstrated that an association exists between

age of initiation of substance use and increased risk of substance dependency later in life (Jordan & Andersen, 2017; CDC, 2019). Therefore, a positive social change implication is to encourage policy makers and public health professionals in jurisdictions with laws legalizing marijuana and those considering legalization of marijuana, to take these results into consideration and improve efforts to inform the public about the increased risk associated with marijuana use and the potential effects on mental health.

Another contribution to positive social change addressed by my study is the increasing potency of marijuana and marijuana products. Prior to legalization, THC levels ranged from a low of 4% to a high of 13% (Ramaekers, et al. 2006). However, since legalization these ranges have increased dramatically. For instance, growers in Colorado have produce strains that range from a low of 6% THC to a high of 28% THC in the Williams' Screaming Gorilla strain (Cabrera, 2016). This concern was addressed by the Colorado state legislator which proposed an amendment to limit the THC concentration of marijuana to 16% (Cabrera, 2016). However, these efforts failed as the amendment did not get enough support. Previous studies have been conducted assessing the lower levels of THC fewer studies have been conducted to assess higher levels. My study contributes to positive social change by informing future generations of the risk associated with highly potent marijuana and the implications of marijuana legalization on the prevalence of mental illnesses like depression. In addition, among the health and safety concerns addressed by the Colorado state legislator, the effects of THC on adolescent brains was one of the primary concerns of the proponents of this amendment (Cabrera, 2016). Thus, adolescents were included in the target population of my study

which intended to contribute to positive social change by making information available to inform and understand the effects on future generations as a future return on investments.

Conclusions

In my study I found that higher rates of major depressive episode and suicide ideation in adults and adolescents were associated with marijuana use. Furthermore, I also found that there were statistically significant increases in the strength of the relationships between marijuana use and depression and between marijuana use and suicidal ideation in adults between 2008 and 2017, as marijuana legalization increased. However, adolescent results were mixed. In addition, the adult rates of marijuana use increased between 2008 and 2017. These findings may be attributed to by the fact adults can legally buy marijuana therefore increasing availability and use among this group. Additionally, adults in states with recreational marijuana laws have greater access to the highly potent marijuana being sold in dispensaries. Thus, more adults may use marijuana now that the risk of legal actions are reduced contributing to the results observed in this study.

Finally, the increasing permissive attitudes and decreasing perceived risk of marijuana use among adolescents is a serious concern for the future of public health because these individuals are entering into their reproductive years and will therefore affect future generations. In addition, it has also been demonstrated that an association exists between age of initiation of substance use and increased risk of substance dependency later in life (Jordan & Andersen, 2017; CDC, 2019). As adolescents aged 12-17 years old are considered to be in the critical risk period of life for initiation of

substance use associated with greater risk of substance abuse and dependence in later life (Strashny, 2014). Therefore, policy makers and public health professionals in jurisdictions with laws legalizing marijuana and those considering legalization of marijuana have an obligation to intervene in this vulnerable population. In an effort to improve prevention and inform the public about the increased risk associated with marijuana use and the potential effects on mental health to initiate positive social change.

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