2017

The Association between Medical Marijuana Laws and Maternal Marijuana Use

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Abstract

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MS, North Carolina Central University, 1998

BS, University of North Carolina at Chapel Hill, 1989

Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

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Abstract

Marijuana is the most common illicit drug that is abused by pregnant women, and recently many states have adopted various levels of relaxed marijuana policies. The purpose of this study was to evaluate a potential association between residing in a state that allows medical marijuana use and maternal marijuana usage. Grounded in the theory of planned behavior, this study evaluated the prevalence and extent of maternal marijuana use in states that allow and states that do not allow medical marijuana use using the National Survey of Drug Use and Health (NSDUH). It was anticipated that more lenient subjective norms toward marijuana use and increased availability would support an increase of maternal marijuana use. The 2014 NSDUH was queried and analyzed using chi-square and logistic regression. The study revealed an increase of maternal marijuana use in states where medical marijuana was allowed, but the increase was not statistically significant. An increase of heavy users was observed in states where medical marijuana was allowed (54% versus 37%). Consistent with other research findings, this study revealed that young (OR = 3.56; 95% CI: 1.379, 9.213; $p = 0.009$) and unmarried (OR = 6.81; 95% CI: 2.485, 18.661; $p < 0.001$) pregnant woman were at higher risk for past month maternal marijuana use and had similar results for past year use. The unintended consequences of increased *in utero* marijuana exposure and its subsequent negative public health effects have been missing from the discussion of the relaxation of statewide marijuana policies. This study will provide policy makers responsible for changing marijuana policy with useful evidence on the unintended consequences of increased maternal marijuana use in areas where medical marijuana is allowed.

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Acknowledgments

I would like to take this opportunity to thank my wife, Mary, who sacrificed a great deal to allow me to take this journey. I would like to thank Doug and Veronica Lewis for their support, understanding, and encouragement. I would like to thank Dr. Charles Plate for his encouraging conversations that gave me the courage to initiate this challenge. I would like to acknowledge all of my professors at Walden who made this journey challenging and intriguing. Lastly, I would like to thank my committee chair, Dr. Michael Dunn, and committee member, Dr. Jennifer Oliphant, for their assistance and guidance through the dissertation process.

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Chapter 1: Introduction to the Study

Maternal substance misuse continues to be a significant public health concern with no statistically significant improvement in maternal abstinence over the past 2 decades (Creanga et al., 2012, Substance Abuse and Mental Health Services Administration, 2014). Maternal substance misuse has been implicated in a number of negative health outcomes including neonatal abstinence syndrome, disorders related to short gestation and low birthweight (Creanga et al., 2012), and the teratogenic effects of selected drugs or their metabolites (including marijuana) resulting in long-term neurobehavioral deficits. (Minnes, Lang, & Singer, 2011).

To address this public health concern, one specific goal included in Healthy People 2020 was to reduce the prevalence of prenatal substance exposure (Healthy People 2020, 2016). Contrary to this objective is the national trend of statewide marijuana laws policy relaxation (Morris, TenEyck, Barnes, & Kovandzic, 2014). Policy makers should be fully informed of potential unintended consequences of allowing medical marijuana use so that education, prevention, and intervention resources may be directed to this vulnerable population. In this study, I evaluated the effect of statewide marijuana policy relaxation on maternal marijuana use patterns using a large national population-based database. This chapter includes the background of maternal marijuana use and the study design including the gap in the literature, the purpose of the study, research questions, and hypotheses. The chapter will include information on my use of the theory of planned behavior as the theoretical foundation of this inquiry and a brief description of the study design.

Background

Although the overall prevalence of mothers using marijuana is low, maternal marijuana use is a significant public health concern. Marijuana, a teratogen, has been implicated as a source of a number of neurobehavioral deficits including diminished academic skills, executive function impairments, and adolescent delinquency (Minnes, Lang, & Singer, 2011, Ko, Farr, Tong, Creanga, & Callaghan, 2015). Between 1.2% and 4% of all pregnant women self-report consumption of marijuana during pregnancy; however, this prevalence estimate is considered to be an underestimate due to recall bias and deceit because of stigma and self-incrimination (Muhuri & Gfoerer, 2008; Saurel-Cubizolles, Prunet, & Blondel, 2014; Ko et al., 2015). The prevalence of maternal marijuana use is inversely proportional to income and is more prevalent among women not cohabiting with the father of the child (Saurel-Cubizolles et al., 2014; Ko et al., 2015). The prevalence of maternal marijuana use does not appear to be associated with the age of the mother (Saurel-Cubizolles et al., 2014; Roberson, Patrick, & Hurwitz, 2014).

Prenatal exposure to marijuana has not been shown to be consistent with neonatal outcome deficits such as low birthweight or small head circumference, but it has been shown to be associated with a number of neurobehavioral deficits (Hingson et al., 1986; Zuckerman et al., 1989; Conner, Carter, Tuuli, Macones, & Cahill, 2015). Deficits, such as increased tremors and startles, may be detected soon after birth and are reflective of cognitive and behavioral deficits, such as poorer academic skills and negative adolescent behaviors, which may appear later in life (Minnes et al., 2011). Additionally, children

exposed to marijuana in utero are more apt to engage in marijuana use, with female children being more likely to repeat the cycle of maternal marijuana use (Day, Goldschmidt, & Thomas, 2006).

In 1996, California passed a law allowing for the medicinal use of marijuana under certain controlled circumstances (Morris et al., 2014). Since then, over 20 states introduced laws of varying levels of policy relaxation, from allowance of marijuana for medical use up to full commercialization (Morris et al., 2014). There are many different variants of these laws, such as allowance of home cultivation, registration of users, allowance of distribution, and provision for dispensaries (Pacula, Powell, Heaton, & Sevigny, 2015). As of 2016, almost every state has either implemented a relaxed policy or has pending legislation for policy relaxation in progress (Maxwell & Mendelson, 2016). Studies on the effects of changes to these policy modifications will be discussed in detail later in this section and in Chapter 2.

The theory of planned behavior provides a clear logistic model of health behavior including initiation, maintenance, and cessation of drug use and misuse (Ajzen, 1991). Ajzen (1991) theorized that a behavior occurs following the intention to perform the behavior, and further theorized that behavioral attitudes, subjective norms, and perceived behavioral control influence intention.

The use of marijuana requires several acts of intention from obtaining the drug, preparing the drug for use (such as rolling a cigarette, packing a pipe, or baking a brownie), and eventually consuming the drug. Behavioral attitude reflects how the individual feels about performing a particular behavior such as the health risk of

performing a behavior or whether it makes them feel good or bad (Ajzen, 1991). Subjective norms describe the individual's perception of how others feel about the performance of a behavior, for example, the individual's perception of how their friends, parents, or community feel about their maternal marijuana use (Ajzen, 1991). Perceived behavioral control describes the individual's perception of how easy or difficult performing a behavior would be. In this example, that would encompass the perceived ease of obtaining marijuana or overcoming the cravings of addiction (Ajzen, 1991).

The effect of statewide policy acceptance on subjective norms and perceived behavioral control is clear and self-evident (Pacula et al., 2015). Wall and colleagues, using responses from the 2002-2008 NSDUH study, reported that the presence of medical marijuana laws were associated with higher rates of self-reported marijuana use in young adults and adolescents (Wall et al., 2011). Other national survey data sets (National Epidemiologic Survey on Alcohol and Related Conditions-Second Wave and the 1991-2011 Youth Risk Behavior Survey) determined that while this observation existed it was not attributable merely to the presence of the medical marijuana laws (Cerda, Wall, Keyes, Galea, & Hasin, 2012; Choo et al., 2014). Missing from the literature is a study evaluating the potential associations between increased marijuana usage and pregnant women. To address this gap in the literature this study will evaluate a large national population-based survey, the NSDUH, and group those results to the various statewide policies of the primary state of residence for the pregnant respondents. With long-term negative health consequences associated with prenatal marijuana exposure, understanding the factors leading to maternal marijuana use are very important.

Problem Statement

Marijuana is the most common illicit drug abused by Americans, and is the most commonly abused drug among pregnant women (Martin, Longinaker, Mark, Chisolm, & Terplan, 2015). According to the National Survey on Drug Use and Health (NSDUH) almost 4% of pregnant women self-report using marijuana within the past 30 days (Ko et al., 2015). The results of prior studies concerning the negative health effects of prenatal marijuana exposure and neonatal outcomes (such as low birthweight, short birth length, and small head circumference) have not been consistent (Conner et al., 2015). More recently, researchers have focused on long term neurobehavioral consequences of prenatal marijuana exposure presenting in adolescence including altered neural functioning, emotional deficits, behavioral deficits, low academic achievement, and increased risk of substance misuse (Minnes et al., 2011).

Current trends and societal norms regarding marijuana use are becoming more accepting and many states have adopted various levels of relaxed marijuana policies (Pacula et al., 2015). California passed the first medical marijuana law in 1996 and 10 other states followed suit over the following decade (Morris et al., 2014). Following a ballot initiative in 2012, Colorado implemented a 2014 law allowing full commercialization and recreational use of marijuana (Hawken, Caulkins, Kilmer, & Kleiman, 2013). By 2016, almost every state in the United States had created some form of marijuana law relaxation or had legislation pending (National Alliance for Model State Drug Laws, 2016). Specifically, during the 2014 survey year, 19 states plus the District of Columbia had established marijuana laws permitting use for medicinal purposes, with

three additional states approving medical marijuana throughout the survey year, 2014 (Table 1). With the establishment of these policies, licensed marijuana growers have been able to operate in an open market environment. With these changes, the potency of marijuana has risen significantly over the past 2 decades (ElSohly et al., 2016).

The association between societal norms and marijuana use has been studied within the framework of several health behavior theories but the most prevalent theory that has been utilized is the theory of planned behavior. This is primarily because of the robustness provided by the inclusion of perceived behavioral control construct (Ito, Henry, Cordova, & Bryan, 2015). The association between relaxed societal norms and/or perceived behavioral control and increased marijuana usage has been demonstrated in a number of vulnerable groups such as adolescents (Wall et al., 2011), Mexican American youths (Kam, Matsunaga, Hecht, & Ndiaye, 2009), and incoming college students (Ito et al., 2015). In the current environment of social norm relaxation and increased access to marijuana, warnings have been issued by those in the perinatology field that today's marijuana is much more potent than it was at any other time in history, and the long-term health consequences for prenatal marijuana exposure have not been fully determined (Warner, Roussos-Ross, & Behnke, 2014). However, studies of the association of medical marijuana laws and maternal marijuana usage patterns are lacking from the literature. The use of a large national population-based database such as the NSDUH to compare maternal marijuana use patterns with medical marijuana laws may potentially fill this gap in the literature.

Table 1

Medical Marijuana Law by State at the Time of the 2014 NSDUH. Nineteen (19) States Allowed Medical Marijuana Prior to the 2014 Survey and 3 States Passed a Medical Marijuana Law During the Year of the Survey.

Medical Marijuana Law	State
Approved before 2014	Alaska, Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Massachusetts, Michigan, Montana, Nevada, New Hampshire, New Jersey, Oregon, Rhode Island, Vermont, Washington, Washington DC.
Approved during 2014	Maryland, Minnesota, New York
Not Approved by 2014	Alabama, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Louisiana, New Jersey, North Carolina, North Dakota, New Mexico, Missouri, Mississippi, Nebraska, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Texas, Tennessee, Utah, Virginia, West Virginia, Wisconsin, Wyoming

Purpose of the Study

The purpose of this study was to evaluate whether there was an association between self-reported marijuana usage of pregnant women residing in states where medical marijuana was allowed, and marijuana usage of pregnant mothers residing in states where medical marijuana was not allowed. A quantitative research design was used to explore the prevalence and extent of maternal marijuana use from the responses of self-reported pregnant women to a national population-based survey. Maternal marijuana use was determined from the response to the question, "How long has it been since you last used marijuana or hashish?" specifically self-reported pregnant respondents

answering in the affirmative to past month use; and the question, "During the past year, on how many days did you use marijuana or hashish?" The state level marijuana policy was determined from the field indicating whether the respondent lived in a state where medical marijuana was allowed or not allowed at the time of the interview. This study compared survey responses from pregnant women who indicated marijuana use, amount of use, and their designation of residing in a state that allows or does not allow medical marijuana while controlling for age, race, ethnicity, education level, household income, and marital status.

Research Question and Hypotheses

The research questions and hypotheses for this study were as follows:

Research Question 1: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed?

$H_0$1: There is no difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

H_a1: There is a difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

Research Question 2: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed?

$H_0$2: There is no difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

H_a2: There is a difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

Research Question 3: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status?

$H_0$3: There is no difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

H_a3: There is a difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical

marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

Research Question 4: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status?

$H_0$4: There is no difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

H_a4: There is a difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

Research Question 5: Is there a difference in the prevalence of pregnant women that self-report heavy marijuana use compared to light marijuana use during the past year for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use?

$H_0$5: The prevalence of pregnant women that report heavy marijuana use compared to pregnant women that report light marijuana use during the past year is not different for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use.

H_a5: The prevalence of pregnant women that report heavy marijuana use compared to pregnant women that report light marijuana use during the past year is different for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use.

Conceptual Framework

Several health behavioral models have been developed for the purpose of understanding and predicting drug use initiation, abuse, addiction, and cessation, but the model that has been the most useful is the theory of planned behavior (Conner & McMillan, 1999). Understanding these behaviors through the lens of a theoretical framework allows substance abuse treatment professionals to design and implement focused and more effective intervention efforts (Ajzen, 1991). Although designed for understanding any health behavior, there are many examples in the literature of the theory of planned behavior's usefulness in understanding drug use initiation and drug use maintenance (Conner & McMillan, 1999). The cornerstone of the theory is the construct that an intention to perform a particular behavior must exist prior to performing the

behavior, and that several key factors predict the magnitude of the intention (Ajzen, 1991).

The theory of planned behavior evolved from the theory of reasoned action, which states that intention to perform a behavior is predicted by two factors: *attitudes* and *subjective norms* (Ajzen & Madden, 1986). Ajzen (1991) stated that the magnitude of the intention to perform a behavior was predictive of the likelihood of performing the behavior. Attitudes refer to the personal belief of the outcome associated with performing the behavior, whereas subjective norms refer to the perceived acceptance of the behavior by others (Ajzen & Madden, 1986). This model was successful with the prediction of behaviors that were under the willful or volitional control of the individual, however, the effectiveness of the model was limited in situations where behaviors were not under volitional control (Ajzen, 1991).

To address this limitation, Ajzen (1991) extended the theory of reasoned action to include perceived behavioral control as an additional factor. Perceived behavioral control describes the belief of the individual of their control over performing the behavior (Ajzen & Madden, 1986). This expanded framework was named the theory of planned behavior. It was expected that the relaxation of state policy toward marijuana use will influence intentions through all three mechanisms: attitudes, subjective norms, and perceived behavioral control.

Nature of the Study

Research was conducted using a secondary data analysis from the 2014 NSDUH to investigate the association between maternal marijuana use patterns and statewide

marijuana policy in the United States. The NSDUH is a population-based national survey conducted periodically by the Substance Abuse and Mental Health Administration (SAMHSA; Center for Behavioral Health Statistics and Quality, 2015). The primary purpose of the NSDUH is to survey the drug, tobacco, and alcohol use patterns of United States citizens (non-institutionalized civilians), ages 12 years old and over (Center for Behavioral Health Statistics and Quality, 2015). The cross sectional study presented here was a quantitative design.

The category of state marijuana policy was indicated by the field noting that the state of primary residence allows or does not allow the use of medical marijuana at the time of the interview. Only women that responded in the affirmative to the question of current pregnancy were included in the study. Maternal marijuana use was assigned to individuals who selected the responses, "within the past 30 days" and "more than 30 days but within the past 12 months" to the question, "How long has it been since you last used marijuana or hashish?" The amount of consumption will be determined by the responses to the questions: "On how many days during the past 12 months did you use marijuana or hashish?" and "What is your best estimate of the number of days you used marijuana or hashish during the past 30 days?" The responses to questions of marijuana use of pregnant women from the state medical marijuana policy category will be compared using chi-squared and logistic regression to evaluate for differences and associations of use and frequency of use.

Definitions

This section defines several terms that were utilized in this study:

Attitude: The feeling (good or bad) that an individual has concerning performing a behavior (Ajzen & Madden, 1986).

Cannabis: refers to the cannabis sativa plant

Hashish and hashish oil: An extracted product of the cannabis sativa plant.

Marijuana: Material obtained from the cannabis sativa plant. It may be prepared for smoking in small cigarettes (joints), large cigars (blunts), smoked in a pipe or incorporated into foodstuffs.

Neurobehavioral: Pertaining to the association between the nervous system and behavior, typically the behavioral disorders resulting from nervous system development deficits or damage.

Perceived behavioral control: The perceived control of performing a behavior by the individual such as the ability to perform the behavior, control over performing it, and access to the resources needed to perform the behavior (Ajzen & Madden, 1986).

Subjective norm: The individual's concern associated with how others (mate, friends, parents, etc...) think about the individual performing a behavior (Ajzen & Madden, 1986).

Theory of planned behavior: This popular theory of health behavior infers that an individual must exhibit an intention to perform a behavior prior to performing the behavior. The magnitude of the intention predicts the likelihood of performing the behavior. Intention is influenced by 3 main factors – attitude, subjective norms, and perceived behavioral control (Ajzen & Madden, 1986).

Study Assumptions

A number of assumptions were required in order to accept the study results. First, the NSDUH survey team utilized a complex sampling method to select participants of the survey. I assumed this sampling method provided adequate representation of a nationwide population. Second, I assumed that the participants answered the survey truthfully and that the survey staff recorded those responses accurately. Lastly, I assumed that the statewide medical marijuana policy of the primary state of residence was the source of most influence which is an obvious limitation for those living very near the border of states with different policies.

Scope and Delimitations

The scope of the study was the association of statewide medical marijuana policy relaxation and maternal marijuana use patterns. The study was limited to female respondents that reported in the affirmative to the question of current pregnancy in the 2014 NSDUH national survey (Research Triangle Institute, RTI, 2013). The study did not include women that were institutionalized or unaware of their pregnancy (RTI, 2013). The study only included women that were currently pregnant and did not report the results of women who had recently given birth (RTI, 2013).

Study Limitations

The study was limited in a number of ways which must be considered. First, this study was a cross sectional design, which did not allow for the establishment of causation. Second, the study relied on self-report to determine maternal drug use patterns. Self-report methods of data collection are a limitation due to recall bias,

memory loss, and deception, both of which may be have been increased due to the potential stigma for this target population. Lastly, the NSDUH only surveys noninstitutionalized individuals living in a civilian household; therefore, this database does not include the imprisoned or those in the military (RTI, 2013).

Significance of the Study

Currently, no study or evaluation of statewide marijuana policy relaxation and its association to maternal marijuana usage exist. This study aims to fill this gap in the literature by comparing marijuana use patterns of pregnant women in states where medical marijuana use is allowed and states where medical marijuana is not allowed. The unintended consequences of increased *in utero* marijuana exposure and its subsequent negative public health effects have been missing from the discussion of the relaxation of statewide marijuana policies. This objective evaluation will provide useful evidence for stakeholders responsible for changing marijuana policy.

Summary

Prenatal marijuana exposure is associated with a number of negative neurobehavioral outcomes (Minnes et al., 2011). Statewide marijuana policy relaxation gives pregnant women tacit approval and increased access to marijuana use, which is contrary to an objective of Healthy People 2020 to reduce maternal substance use (Healthy People 2020, 2016). Chapter 2 will provide a more detailed examination of the literature regarding the epidemiology of maternal marijuana use and negative public health consequences of prenatal marijuana exposure. In Chapter 2, discussions about the relationship between statewide marijuana policy relaxation and a popular health behavior

model, the theory of planned behavior and its effect on the increase in marijuana potency over time will occur. Chapter 3 will dive deeper into the research design and statistical analysis of the NSDUH dataset. Findings of the analysis will be explored in Chapter 4, and Chapter 5 will summarize these findings, compare them to current extant literature, and frame future recommendations.

Chapter 2: Literature Review

Introduction

Chapter 2 will examine peer-reviewed scientific literature pertaining to prenatal marijuana exposure, neonatal outcomes, marijuana potency trends, and the effect of statewide policy on marijuana usage. The literature review contains five sections: literature search strategy, prevalence of maternal marijuana usage, the negative associations of prenatal marijuana exposure, the effect of statewide policy on marijuana usage, and trends in marijuana potency. A summary will clarify the proposed problem statement and identify a gap in the current literature.

Literature Search Strategy

Search engines Google Scholar, PubMed, and EBSCOhost were utilized during this literature search. Key search terms used to query the databases were: *maternal marijuana prevalence*; *prenatal marijuana exposure; prenatal marijuana exposure AND neonatal morbidity; prenatal marijuana exposure AND neonatal outcome; prenatal marijuana exposure AND preschooler; prenatal marijuana exposure AND adolescence; marijuana law AND marijuana use; marijuana law AND adolescence; theory of planned behavior;* and *theory of planned behavior AND marijuana.* My search identified an excess of 100 references spanning 35 years with additional pertinent references selected through citation chaining. For inclusion purposes, articles must have appeared in a peer-reviewed journal and be written in English. Due to the limited number of prospective studies of prenatal marijuana exposure, seminal works concerning the teratogenic effects of prenatal marijuana exposure from as early as 1980 were included in this review, while

the remaining search terms were limited to 2010 to 2016. I excluded conference reports and abstracts from the literature review.

Prevalence of Maternal Marijuana Use

The search strategy revealed four recent and pertinent studies on the prevalence of maternal marijuana use in various populations. Muhuri and Gfoerer (2008) pooled the marijuana use related results from the 2002-2006 NSDUH, which included the responses of 94,838 women of reproductive-age. Of these, 5,017 women were pregnant at the time of questioning. Saurel-Cubizolles, Prunet, and Blondel (2014) used France's National Perinatal Survey to survey 14,681 women on their marijuana use during a single week in March 2010. Roberson, Patrick and Hurwitz (2014) used a similar mechanism to evaluate the responses of 4,735 respondents from the State of Hawaii using the 2009-2011 Hawaii Pregnancy Risk Assessment Monitoring System (PRAMS), an operational element of the Center of Disease Control and Prevention's (CDC) national PRAMS surveillance of pregnancy. Lastly, Ko, Farr, Tong, Creanga, and Callaghan (2015) used a pooled NSDUH data set (2007-2012), which reviewed the answers from 4,971 pregnant respondents and 88,402 non-pregnant women of reproductive-age. All of these studies indicated that pregnant women, in general, are a low prevalence substance using group. The distribution of self-reported use among pregnant women, specifically age, income level, marital status, and race/ethnicity are examined in the next few sections.

Overall Prevalence

Overall, the reported prevalence of maternal marijuana use has been low across several different groups. Muhuri and Gfoerer's (2008) evaluation of 5 years of NSDUH

data revealed that 2.8% (95% CI: 2.3, 3.3) of pregnant women in the United States self-reported the use of marijuana in the past 30 days. Saurel-Cubizolles et al. (2014) reported that 1.2% (95% CI: 0.1, 3.0) of pregnant French women consumed marijuana in the past 30 days. The Hawaii PRAMS surveillance showed that 2.6% (95% CI: 2.2, 3.2) of pregnant Hawaiian women self-reported the use of marijuana during any time during the pregnancy (Roberson et al., 2014). Ko et al. (2015) reported that 3.9% (95% CI: 3.2, 4.7) of pregnant women responding to the 2007-2012 NSDUH reported using marijuana in the past 30 days. Although there are small differences in these prevalence findings, ultimately the 95% confidence intervals overlap, which suggests that between these populations the findings are not significantly different.

Maternal Age

The distribution of self-reported maternal marijuana use by age was inconsistent and if differences were observed the observation was statistically insignificant. When compared to 25-34 year old pregnant French women (the reference group), those less than 25 years old self-reported less marijuana use (OR = 0.93; 95% CI: 0.60, 1.44) and those older than 35 years old were slightly more at risk (OR = 1.25; 95% CI: 0.78, 2.01) to self-report marijuana use. Both observations were not statistically significant as the 95% confidence intervals included unity (Saurel-Cubizolles et al., 2014). Roberson et al. (2014) observed a small negative association between age and percentage of self-reported use during pregnancy for pregnant women less than 20 years old, 20-24 years old, 25-29 years old, 30-34 years old, and greater than 35 years old reporting 3.2%, 3.6%, 1.9%, 2.6%, and 2.1%, respectively; however, this trend was not significant ($P = 0.196$). Ko et

al. (2015) reported that younger pregnant women (18-25 years old) were 1.48 (95% CI: 0.8-2.6) times higher to report marijuana use during pregnancy; however, this finding was insignificant due to the 95% confidence interval including unity. Muhuri and Gfoerer (2008) did not report maternal marijuana use by age in their study.

Household Income

The association between self-reported maternal marijuana use and income is negative and, when calculated, the trend is statistically significant. In a nationwide survey of pregnant women in France, Saurel-Cubizolles et al. (2014) found a negative trend in France between income and maternal marijuana use with those earning < 1000€ (OR = 2.68; 95% CI: 1.24, 5.82) and 1000-1499€ per month (OR = 2.52; 95% CI: 1.25, 5.08) when compared to those earning between 3000€ and 4000€ and the trend was statistically significant ($P > 0.05$). Roberson et al. (2014) found a similar trend in the United States using the United States federal poverty limit to categorize income level. They found that 4.1% (95% CI: 3.1, 5.5) of those earning less than the federal poverty limit self-reported the use of marijuana during pregnancy while those earning between the poverty limit and two times the poverty limit was 2.2% (95% CI: 1.5, 3.3; Roberson et al., 2014). Pregnant Hawaiian women with reported earnings greater than two times the poverty limit was 2.0% (95% CI: 1.4-2.9), and this trend was statistically significant ($P = 0.007$; Roberson et al., 2014). Ko et al. (2015) reported a negative association between self-reported use and income, with < $20,000 (40.7%), $20,000-49,999 (34.2%), $50,000-74,999 (13.2%) and > $75,000 (12.0%). Muhuri and Gfoerer (2008) did not report maternal marijuana use by income in their study.

Marital Status

When measured, marriage and cohabitation with the father of the child appeared to have a negative association with maternal marijuana use. Saurel-Cubizolles et al. (2014) reported that the French women who self-reported using marijuana during pregnancy were less likely to be cohabitating with the father of their child (OR = 1.69; 95% CI: 1.01, 2.82; $P < 0.05$). Ko et al. (2015) reported that 70.4% (95% CI: 58.2, 80.3) of pregnant self-reporting marijuana users from the 2007-2012 NSDUH surveys were never married, while only 19.2% (95% CI: 11.7, 29.8) and 10.4% (95% CI: 4.4, 22.7) were married or divorced, separated, or widowed, respectively. Muhuri and Gfoerer (2008) and Roberson et al. (2014) did not report maternal marijuana use by marital status in their studies.

Race/Ethnicity

The selected studies indicated that being in the racial/ethnic majority tended to be associated with a higher likelihood of self-reported marijuana use. Muhuri and Gfoerer (2008) showed a higher proportion of non-Hispanic Whites that self-reported marijuana use during the past 30 days than non-Hispanic Black or Hispanic pregnant women (7.7%, 6.5%, and 3.8%, respectively). Roberson et al. (2014) demonstrated differences of maternal marijuana usage between Hawaiian (2.8%; 95% CI: 2.1, 3.8), Asian (1.4%; 95% CI: 0.8, 2.4), White (3.8%; 95% CI: 2.8, 5.3), and other/unknown (4.6%; 95% CI: 2.7, 7.7) ethnicities; these differences were statistically significant ($P = 0.001$). In their nationwide French survey, Saurel-Cubizolles et al. (2015) reported that non-French mothers self-reported much less marijuana use during pregnancy (OR = 0.19; 95% CI:

0.08, 0.48; $P < 0.001$). Ko et al. (2015) showed that there was no statistical difference between Whites (reference) and Non-Hispanic Blacks (OR = 0.90; 95% CI: 0.7, 1.1) and a small protective factor for being Hispanic (OR = 0.6; 95% CI: 0.4, 0.8).

All four surveys found that pregnant mothers are typically a group that does not readily self-report marijuana use. The surveys examined here showed no to little variation based on age and minimal variation based on income and race/ethnicity. The most striking differences of self-reported maternal marijuana use were observed when comparing marital/cohabitation status where an approximate seven-fold difference was reported between unmarried and married mothers.

The Consequences of Prenatal Marijuana Exposure

Prenatal Marijuana Exposure and Fetal Growth Deficits

Careful review of extant literature found six studies that evaluated prenatal marijuana exposure and fetal growth characteristics such as birth length, birth weight, and head circumference. Hingson et al. (1982) conducted a prospective study of 1,690 births at Boston City Hospital using maternal self-reporting and a physical examination of the newborn. Linn et al. (1983) reported on the Delivery Interview Program at Brigham and Women's Hospital in Boston in a prospective study that included interviews with 12,825 women about their substance use behaviors for mothers that delivered from 1977 to 1980. Zuckerman et al. (1989) studied 1,226 mothers and infants recruited at the Women's and Adolescent Prenatal Clinics of Boston City Hospital between 1984 and 1987. Day et al. (1991) evaluated prospectively 1,360 women randomly selected from the outpatient clinic of Magee-Women's Hospital and University of Pittsburg from 1983 to 1986.

Hayatbakhsh et al. (2012) conducted a retrospective study of 24,874 births, inspecting routine antenatal interviews and medical records from Mater Mother's Hospital in Brisbane, Australia from 2000 to 2006. Connor et al. (2015) retrospectively reviewed the records of 8138 women that gave birth between 2004 and 2008 at St Louis Medical Center.

Several of the reports mentioned above demonstrated an association between prenatal marijuana exposure and a small reduction of birth length but not all found a significant reduction. Zuckerman et al. (1989) observed a 0.52 cm ($P = 0.02$) reduction in length at birth using a positive urinalysis result to categorize marijuana users from nonusers. Day et al. (1991) found a 0.5 cm ($P = 0.04$) negative effect on birth length but only for mothers who reported heavy usage (one joint per day on average) in the first trimester. Mothers who reported heavy marijuana use in the second and third trimesters did not produce statistically shorter newborns. Hayatbakhsh et al. (2012) reported a -1.3 cm ($P< 0.01$) birth length for mothers who self-reported marijuana use during pregnancy. Hingson et al. (1982) did not report any significant difference in length following prenatal exposure to marijuana.

Inconsistent findings for the association between prenatal marijuana exposure and newborn birth weight dominate the literature. In a prospective study of 1,690 mother-child dyads in Boston, Hingson et al. (1982) revealed that marijuana was independently associated with a 105g reduction of birth weight ($P <0.01$). Similarly, Zuckerman et al. (1989) reported a birth weight decrease of 79g ($P = 0.04$) was associated with maternal marijuana use when controlling for other drug use such as cocaine, opiates, alcohol, and

tobacco. A much larger study of 12,424 women demonstrated that newborns prenatally exposed to marijuana were more inclined to exhibit lower birth weight (OR = 1.07; CI 95%: 0.87, 1.31) but that finding was not significant (Linn et al., 1983). A large retrospective study (Conner et al., 2015) of 8,138 live singleton births showed a similar small effect on birth weight but that finding was also insignificant (OR = 1.3; CI 95%: 0.91, 1.8). At this time, no consistent evidence exists to support a negative effect of prenatal marijuana exposure on birth weight.

Zuckerman et al. (1989) identified prenatal marijuana exposure using the detection marijuana metabolites in maternal urine samples. Zuckerman and colleagues reported a head circumference for prenatally exposed infants that were 0.9 cm ($P <$ 0.001) less than those from non-using mothers. Hingson et al. (1982) and Day et al. (1991) did not report any statistical differences in head circumference for newborns of marijuana users compared to non-users.

Several explanations for the inconsistent observations of maternal marijuana use and its effect on fetal growth characteristics have been proposed (English et al., 1997). First, a random controlled trial administering measured doses of marijuana, an illicit substance, to pregnant women is impossible from an ethical perspective. Some of the studies were prospective but two of the larger studies were retrospective evaluations. All of the studies utilized self-report with only one study using an objective urine assay in tandem with self-report to classify users and non-users of marijuana. Self-report strategies underestimate drug use because of social stigma and fear of legal repercussions

(Hingson et al., 1986). The results from each study group may not be fully generalizable due to socioeconomic status, geographic location, and cultural differences.

Prenatal Marijuana Exposure and Neonatal Neurobehavioral Outcomes

My literature search revealed several studies that demonstrated an association between prenatal marijuana exposure and neonatal neurological deficits. One of the first studies to evaluate the potential effects of prenatal marijuana exposure objectively was conducted in Ottawa, Canada, where 291 women were questioned about their drug using patterns and their newborns were evaluated for neurobehavioral competency using the Neonatal Behavioral Assessment Scale (NBAS; Fried, 1980). In a larger follow up study, Fried and Makin (1987) examined 250 Canadian mothers and babies, carefully documenting the exposure to not only marijuana but alcohol and tobacco as well. Scher, Richardson, Coble, Day, and Stoffer (1988) studied the sleep patterns of 55 newborns that were selected due to prenatal exposure to marijuana or alcohol with matching unexposed controls. Lester and Dreher (1989) reported on the abnormal cry patterns of 20 marijuana exposed newborns with matching controls in a study from Jamaica.

The Maternal Lifestyle Study approached over 19,000 pregnant mothers with the primary intent to recruit 658 infants exposed to cocaine or opiates and 730 controls in order to conduct detailed maternal lifestyle interviews and thorough physical examination of the neonates but they were also able to report interesting findings associated with prenatal marijuana exposure (Lester et al., 2002). A similar study from Sao Paulo, Brazil recruited 26 marijuana exposed infants with matching controls (de Moraes Barros, 2006).

The reported neurobehavioral deficits are expressed through abnormal responses to stimuli, sleep disturbances, and abnormal cry patterns.

The effects of toxic agents on the development of central nervous system functionality may be observed as abnormal reflexes or responses to external stimuli (Minneset al., 2011). Brazelton's NBAS was developed as a standardized measure of the status of the neonate's autonomic, motor, state, and social-attention development (Brazelton & Nugent, 2011). NBAS consists of 28 behavioral tests that are scored by trained evaluators using a nine-point scale (Brazelton & Nugent, 2011).

Two NBAS items reported with abnormal occurrence by Fried (1980) and Fried and Makin (1987) for prenatal marijuana exposure was an increased number of startles and tremors. Startles (a defensive reflex action that includes the sudden contraction of the legs and arms) and tremors (sustained shakiness of the extremities or jaw) suggest potential deficits in the development of autonomic nervous systems, the portion of the nervous system that control unconscious bodily functions such as reflexes, breathing and heartbeat (Brazelton & Nugent, 2011). Fried (1980) reported that 55% of the infants born to heavy users exhibited marked startles while only 14% born to non-users exhibited marked startles ($p = 0.023$). Similarly, 73% of the infants born to heavy marijuana using mothers were observed to tremor while only 33% of the infants born to non-users tremored ($p = 0.008$; Fried, 1980). In a later study using multiple regression analysis, Fried and Makin (1987) reported heightened startles ($F = 12.89$, $p < 0.001$) and tremors ($F = 3.90$; $p = 0.05$) among prenatal marijuana exposed neonates compared to infants that were not exposed after controlling for a number of other variables.

A modification of the NBAS, the NICU Neonatal Neurobehavioral Scale (NNNS), was developed for the Maternal Lifestyle Study to enhance the detection of neurobehavioral deficits associated with maternal substance use (Lester et al., 2002). The results are summarized into 13 scales in which two of them were seen to be abnormal for marijuana exposed newborns compared to unexposed newborns (Lester et al., 2002). Lester et al. (2002) reported that the heavy use group newborns demonstrated higher excitability than unexposed neonates ($P = 0.043$). A much smaller Brazilian study, focused on marijuana exposure, showed similar findings with excitability scores of 3.27 ± 1.40 and 2.40 ± 1.57 for marijuana exposed newborns compared to unexposed newborns ($P = 0.006$; de Moraes Barros et al., 2006). The de Moraes Barros et al. (2006) study also found significant differences of arousal (4.05 ± 0.60 and 3.68 ± 0.70; $P = 0.009$) and regulation (5.75 ± 0.62 6.04 ± 0.72; P =0.048) scores for exposed and unexposed neonates, respectively.

The newborn's cry is a complex combination of the use of several anatomical features (chest, neck, pharynx, and larynx) where damage or abnormal development of specific elements of the central nervous system (vagal complex, selected cranial nerves, phrenic nerves, or thoracic nerves) may affect the acoustic quality of the cry (Lester & Dreher, 1989). The neurological integrity of the neonate may be predicted by the duration, pitch, and resonance qualities of the cry (Lester & Dreher, 1989). The duration is the average time of a cry when stimulated. Percent dysphonation is the percentage of time a cry includes inharmonic frequencies which is a proxy for turbulence in the cry. The fundamental frequency (f0) is the perceived voice pitch which is partly determined

by the vocal fold tension. In their study that compared 20 prenatally marijuana exposed Jamaican newborns to 20 unexposed Jamaican newborns, Lester and Dreher (1989) found that the cries were shorter in duration (29.85 sec ± 13.67 sec and 43.15 sec ± 20.05 sec, respectively), higher percent dysphonation (24.45 ± 15.52 and 5.05 ± 4.68, respectively), and a higher f0 resonance (457.50 ± 90.15 and 405.50 ± 50.44, respectively) for the exposed neonates. The Maternal Lifestyle Study found that heavy prenatal marijuana exposure was associated with increased mode changes (transitions between phonation and dysphonation; $P = 0.010$) and increase second formant (second harmonic frequency; $P = 0.005$; Lester et al., 2002). Additionally, Fried (1980) noted the association between prenatal marijuana exposure and "*cri de chat*", a distinct cat-like cry usually observed for infants experiencing withdrawal, but unfortunately, this observation was not expected and was not objectively measured.

Another measure used for the evaluation of the neonate's central nervous system development is the electroencephalogram (EEG) sleep patterns (Scher et al., 1988). Scher et al. (1988) noted that abnormal EEG patterns during sleep may be predictive of negative outcomes that are not yet observable. Following detailed maternal interviews, Scher and colleagues monitored the neonates for a 2-2.5 hour period using EEG during the first 2 days of life. Their findings included significant differences between unexposed and exposed neonates including lower total active sleep (46.2% and 38.0%, respectively), increased small body movement (0.02 movements/minute and 0.2 movements/minute, respectively), increased large body movement (0.2 movements/minute and 0.6

movements/minute, respectively), and reduced Rapid Eye Movement sleep (REM; 4.6 per minute and 2.5 per minute, respectively; Scher et al., 1988).

The evidence presented here consistently demonstrated the subtle effects of prenatal marijuana exposure. The observations reported here pose no immediate physical deficit or harm to the neonate but are symptomatic of subtle neurobehavioral deficits that may present as noticeable executive functioning deficits later in life (Fried & Smith, 2001). However, with any research involving maternal substance use, the findings are limited due to misclassification as a result of reliance on maternal self-report.

Prenatal Marijuana Exposure and Neurobehavioral Deficits of the Preschooler

My search identified seven studies that evaluated the associated neurobehavioral deficits of preschoolers with prenatal marijuana exposure. The MHPCD study, conducted at the University of Pittsburgh, followed up with their cohort at age 3 using the Stanford-Binet Intelligence Scale (Day et al., 1994), a sleep monitoring study (Dahl et al., 1995), and a gross motor assessment study (Chandler et al., 1996). Noland et al. (2003, 2005) evaluated a 4-year old group focusing on executive function deficits. Leech et al. (1999) continued with the Pittsburgh cohort at age 6 with an evaluation of their attention and impulsivity. Fried et al. (1992) reported their findings in their 6-year old Canadian cohort using McCarthy Scales of Children's Abilities and the Peabody Picture Vocabulary test.

To investigate potential neurobehavioral teratogenic effects of prenatal marijuana exposure, Day et al. (1994) conducted a follow up study of their 655 children from the MHPCD study in Pittsburgh. The Stanford-Binet Intelligence Scale, an intelligence and

cognitive ability test designed to evaluate young children for developmental deficits, measured the cognitive development differences between 3 year old children who were prenatally exposed to marijuana and children who were not exposed. When comparing the two groups using the entire composite score, Day et al. (1994) reported no observable differences. However, regression analysis revealed, while controlling for other substance use, a significant short term memory deficit (a single test item of the scale) among the second trimester marijuana exposed children ($\beta = -1.5$, $P = 0.05$; Day et al., 1994).

From this same cohort, Dahl et al. (1995) selected eighteen 3 year old children from the marijuana exposed group and 20 unexposed children as controls. These children were subjected to sleep studies to discover any sleep variable differences among the two groups (Dahl et al., 1995). The children that were exposed to marijuana *in utero* showed lower sleep efficiency (exposed = 91.0 ± 3.8; unexposed = 94.4 ± 2.1; $P < 0.05$) which was the percentage of recorded sleep study time spent asleep, more awake time following sleep onset (exposed = 27.4 min. ± 20.0 min.; unexposed = 13.7 min. ± 12.4 min.; $P < 0.05$) and a higher number of arousals during sleep (exposed = 8.2 ± 5.3; unexposed = 3.2 ± 4.6; $P < 0.005$).

Chandler et al. (1996) designed a gross motor skills assessment for the MHPCD cohort that was appropriate for evaluating the motor skills of 3 year old children which included balance (walking on a line, balance beam, and standing on tip toes) and coordination tasks (ball handling such as catching, throwing, and kicking). Each completed task performed was scored along with notations showing if the child refused to perform the requested task (Chandler et al., 1996). No reported observable difference of

balance or coordination scores between the exposed and unexposed children that cooperated with the task instructions were observed (Chandler et al., 1996). However, they did observe, using Rasch Analysis, a correlation of refusal to perform tasks for those exposed to marijuana in the first trimester (balance task refusal, 0.07, $P < 0.05$) and second trimester (balance task refusal, 0.10, $P < 0.05$; ball handling task refusal, 0.07, $P < 0.05$) of gestation. Refusal to perform an activity is not a usual variable of study but in this instance it may have reflected reluctance, lack of motivation, or fear of anticipated failure.

Noland et al. (2003) followed a similar cohort of 316 children in Cleveland, OH which evaluated associations between executive function deficits at age 4 years and prenatal exposure to various substances of abuse including marijuana (Noland et al., 2003). Noland and colleagues measured executive function using a tapping inhibition test (where the child must tap a certain number of times on cue from the tester), a category fluency test (where the child provides exemplars of categories provided by the tester such as the color "red") and a motor planning task test (where the child touches his thumb to various fingers in sequence following the cue of the tester; Noland et al., 2003). Although significant differences existed between children exposed prenatally to alcohol and unexposed children, Noland et al. (2003) were not able to observe any differences for children exposed prenatally to marijuana compared to those who were unexposed. They suggested that the skills being challenged by these tests were not yet fully developed for 4 year olds such that there was no opportunity to observe a difference or that the tests being used were lacking appropriate sensitivity (Noland et al., 2003).

Noland and colleagues evaluated the same cohort of Cleveland children for selective attention deficits using two tests, the continuous performance task and a picture deletion task (Noland et al., 2005). The continuous performance task requires that the child respond to a target line picture that is randomly displayed amongst a group of other pictures that are shown in rapid order. The picture deletion task was a timed test where the child must pick 30 target pictures that are depicted in a group of 120 pictures. Errors of omission (failed to identify the picture correctly) and commission (picked the wrong picture) were noted. Regression analysis revealed that children exposed to marijuana in the first trimester were significantly more inclined to have errors of omission ($\beta = 0.32$, $P = 0.03$; Noland et al., 2005).

In Ottawa, Canada, Fried et al. (1992) reported that there were no reportable differences between 5 and 6 year old prenatally exposed children and unexposed controls using the McCarthy Scales of Children's Abilities and the Peabody Picture Vocabulary tests (two validated instruments that measure cognitive performance) suggesting that any differences previously observed in the Ottawa study had self-corrected. The MHPCD study in Pittsburgh found differences in attention and impulsivity in a follow up study of their cohort at 6 years of age. Using the continuous performance tests, like that used in the previously discussed Cleveland study, Leech et al. (1999) using regression analysis controlling for other substance use, found that 6 year old children who were exposed to marijuana *in utero* had an increase of commission errors ($R^2 = 0.149$, $\beta = 1.21$, $P < 0.01$) when compared to those who were not exposed.

These studies reinforce the previously discussed neonatal neurobehavioral studies prediction of prenatal marijuana exposure being responsible for central nervous system developmental deficits during specific times of fetal development (Fried, 1996). These deficits are responsible for subtle effects latter in the life of the child (Fried, 1996). The studies reported here are limited in that with the exception of the Cleveland study, they relied on maternal self-report to categorize prenatal substance exposure (Noland et al., 2003). The deficits observed here with the 3-6 year old children are important because it is during this time that children are preparing to embark on their primary education activities where deficits of executive function place them at a distinct disadvantage that may influence their life trajectory (Fried, 1996).

Prenatal Marijuana Exposure and Adolescent Deficits

The search identified 13 manuscripts from 3 longitudinal studies that reviewed prenatal marijuana exposure and deficits in adolescents. The Ottawa Prenatal Prospective Study (OPPS) (4 of the 13 papers) from Canada examined a cohort of low-risk, middle class newborns following the effects associated with prenatal marijuana, alcohol, and tobacco exposure. The Maternal Health Practices and Child Development Study in Pittsburgh, PA (8 of the 13 papers) prospectively followed a large cohort of high-risk children (n = 763) that examined the effects associated with prenatal exposure to marijuana and other substances of abuse. One manuscript originated from the Avon Longitudinal Study of Parents and Children in the United Kingdom, which followed 6,356 children and is the only manuscript from a large prospective study examining the effects of prenatal marijuana exposure (Zammit et al., 2009).

Deficits of attention and control of impulsivity continue into adolescence (O'Connell & Fried, 1991; Fried, Watkinson, & Gray, 1998; Fried & Watkinson, 2001; Richardson, Ryan, & Williford, 2002). Fried and Watkinson (2001) evaluated the potential impact of prenatal marijuana exposure on the attention of 13-16 years olds from the OPPS study using tools developed to explore a multifaceted concept of attention, which are focus/execute, shift/flexibility, arouse/exert, encode/retain, and stability. Seven tests for attention evaluation used for this study were the Continuous Performance Test, the Wisconsin Card Sorting Test, the Stroop Test, and the Wechsler Intelligence Scale for Children Arithmetic Test, Sentence Memory Test, Seashore Test, and Knox Cube Test. The primary finding of this study was that stability, one's ability to maintain attention over time, was negatively affected by prenatal marijuana exposure ($F = 5.1$, $P < 0.01$; Fried & Watkinson, 2001). Previous reports from this research group (O'Connell & Fried, 1991; Fried et al., 1998) also indicated potential attention deficits due to prenatal marijuana exposure at ages 9-12 but those reports noted that the differences were not statistically significant, perhaps due to the use of smaller sub-cohorts or the higher socioeconomic level of the cohort. The MHPCD cohort, at age 10, demonstrated an increase of errors of commission for the Continuous Performance Test, an Attention Task Test, which suggests that the participant has issues with impulse control ($\beta = -1.86$, $R^2 = 0.01$; Richardson et al., 2002).

The issues of attention deficit and impulse control lead to a natural consequence of poor academic performance for the prenatal marijuana exposed children. Goldschmidt, Richardson, Cornelius and Day (2004) reported that 10 year olds who were

exposed to marijuana in utero exhibited specific deficits with academic development. The MHPCD researchers tested their cohort at age 10 using the Wide Range Achievement Test-Revised, the Peabody Individual Achievement Test, and a report from their school teacher ranking their performance in various subjects (Goldschmidt et al., 2004). Heavy prenatal marijuana exposure in the first trimester was associated with decreased reading scores ($\beta = -3$, $P < 0.05$), decreased spelling scores ($\beta = 3.5$, $P < 0.05$) and lower ratings from their teachers ($\beta = 0.25$, $P < 0.05$; Goldschmidt et al., 2004). Fried, Watkinson, and Siegel (1997) also observed lower reading and language scores for their 9 and 12 year olds in the OPPS study but again this could be attributed to an insufficient number of participants; the differences were statistically insignificant.

The MCPCD study evaluated a cohort of prenatal marijuana exposed children for depressive symptoms at age 10 (Gray, Day, Leech, & Richardson, 2005). Using the Children's Depression Inventory (a validated instrument for detecting depressive symptoms), Gray et al. (2005) reported that more children that were exposed to marijuana in the first trimester and third trimester exhibited depressive symptoms ($\beta = 1.83$ and 2.58, respectively) and both findings were statistically significant ($P < 0.01$). On a similar mental health evaluation of marijuana exposed children, Zammit et al. (2009), using the Avon Longitudinal Study of Parents and Children, demonstrated no association of prenatal marijuana exposure with psychotic symptoms.

Another concern for adolescents with demonstrated neurobehavioral deficits is the presence of delinquent behaviors. The MCPCD study examined the potential relationship between prenatal marijuana exposure and delinquent behaviors at ages 10 and 14

(Goldschmidt, Day, & Richardson, 2000; Day, Leech, & Goldschmidt, 2011). Using the Swanson, Noland, and Pelham (SNAP) Test, Goldschmidt et al. (2000) found that children exposed to increasing levels of marijuana (none, light, moderate, and heavy) in the third trimester, exhibited higher scores for hyperactivity and impulsivity ($F = 5.4$, $P < 0.005$ and $F = 4.4$, $P < 0.01$, respectively). As would be expected from a child with hyperactive and impulse control issues, children exposed to marijuana *in utero* were 2.4 times higher risk (95% CI: 1.3, 4.5; $P < 0.01$) of being identified as a delinquent using the Teacher Report Form when compared to children not exposed (Goldschmidt et al., 2000). This trend continued for this cohort at age 14 using the Self-Report Delinquency Scale and the Child Behavior Checklist (Day, Leech, & Goldschmidt, 2011) where the exposed group were 1.84 times higher odds ratio (95% CI: 1.05, 2.96; $P = 0.03$) to be categorized as possessing delinquent behavior than those children who were not exposed.

These concerns lead into the final element of evidence supporting the negative consequences of prenatal marijuana exposure, which can lead to increased marijuana use among adolescents (Day, Goldschmidt, & Thomas, 2006). Using the Cox Proportional Hazards Strategy, Day and colleagues (2006) demonstrated that each additional average daily joint of maternal marijuana use was associated with a 1.14 increase ($P = 0.04$) in the hazard ratio for marijuana use at age 14. An elevated level of marijuana use continues through to young adulthood with the offspring of marijuana users having 1.22 times higher odds ratio (95% CI: 1.02, 1.44; $P = 0.019$) to use marijuana than offspring of nonusers. These users are of reproductive age, and their prior prenatal exposure and potential current use of marijuana sets the stage to expose the next generation to the

negative consequences of prenatal marijuana exposure (Sonon, Richardson, Cornelius, Kim, & Day, 2015).

Again, these studies are limited because category selection is based on maternal self-report and cohort size and selections are not necessarily generalizable. However, these children continue to demonstrate statistically significant issues with attention and impulsivity disorders. These deficits appear to manifest themselves in academic underachievement and depressive symptoms. Lastly, children, prenatally exposed to marijuana, tend to gravitate toward marijuana usage in adolescents and early adulthood (reproductive age), increasing their risk for repeating this negative cycle.

Theoretical Foundation

The Theory of Planned Behavior and Maternal Marijuana Usage

Attempting to define predictors and explanations to describe human behavior is at best an extremely complicated task. One theory that has emerged as a leading tool in the study of predicting human behavior in the field of addiction is the theory of planned behavior (Ajzen, 1991). As an extension of the theory of reasoned action, the principle element of the theory is that an individual must exhibit intention to perform a particular behavior, and that the behavior will only be performed when sufficient intention is present (Ajzen, 1991). The theory of reasoned action states that two factors, attitude and subjective norms toward the behavior, influence an individual's intention.

Attitudes toward a behavior are the beliefs of the individual toward performing a behavior (Ajzen, 1991). Does the individual have a favorable or an unfavorable attitude toward performing a behavior? For example, does the pregnant mother think that

smoking marijuana is harmful or harmless for herself or her unborn child? Does the individual think getting high feels good? Does the individual think that smoking marijuana improves their image? Although individual attitude is an important element, the environment in which the behavior is performed is just as important.

Subjective norm refers to an individual's concept of the social acceptability or opinion if a behavior is performed (Ajzen, 1991). What would my partner think of me if I smoke marijuana? Would my parents, colleagues, pastor, or neighbors have a favorable opinion of me if I smoke marijuana? Does my state of residence condone possession and usage of marijuana? Attitude and subjective norm are significant variables that influence intention to perform a behavior, however, Ajzen (1991) found that this model had limitations and proposed a third equally important factor which evolved the theory of reasoned action into the theory of planned behavior.

Perceived behavioral control focuses on the concept that the individual's perception of how much control they have over performing a behavior influences intention (Ajzen, 1991). Does the individual have control over the using marijuana? Does the individual perceive that they have control of a drug craving? Does the individual perceive that they have access to marijuana and money to purchase marijuana? Does the individual perceive that they can obtain marijuana without legal conflict? These three factors, attitude, subjective norm, and perceived behavioral control, combine to form an individual's intention to perform a behavior and they may be used to predict a behavior (Ajzen, 1991).

Studies of the Association of Medical Marijuana and Use

Marijuana continues to be the most used illicit substance in the United States therefore the downstream consequences of changes in marijuana laws or policies may potentially impose a significant public health impact. It is important to understand the influence of marijuana law changes on use and abuse among the general public and even more important to understand its influences on vulnerable groups such as adolescents and pregnant women as well. The association of the approval of medical marijuana laws, higher rates of marijuana use, and lower perceived risk of use in adult populations exists but fortunately, this trend was not observed for adolescents. Additionally, in the environment of a freer market to operate, growers have dramatically improved the potency of marijuana.

Medical Marijuana Laws and Increased Use

Two national surveys, the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) and the National Survey on Drug Use and Health (NSDUH), examined the evidence of the influence of state level marijuana policy on marijuana use (Cerda et al., 2012). An evaluation of the two surveys by Cerda and colleagues (2012) showed significant increases in past year marijuana use among respondents living in states with medical marijuana laws (OR = 1.92; 95% CI: 1.49, 2.47). Their study was based on a simple variable of the allowance of medical marijuana by year 2004 and was limited in the inability to demonstrate causality. Pacula and colleagues (2015) also investigated whether marijuana use was increased in states that passed new laws using data from the Treatment Episodes Data System (TEDS) and the National Longitudinal

Survey of Youth (NLSY97). Pacula and colleagues (2015) noted that statewide marijuana policy is not homogeneous but is a complex variable including such elements as mandatory registries, allowance of home cultivation, and provision of commercial dispensaries. Further complicating the examination is a time lag between implementation of the law and measurement of use, allowing for various elements to be missed or misrepresented (Pacula et al., 2015). Presence of legally operating dispensaries was a significant predictor ($\beta = 0.204 \pm 0.069$, $P < 0.01$) of increased marijuana use according to treatment admissions (Pacula et al., 2015). These studies evaluated observations made on use of marijuana in the general public and did not address specific vulnerable groups.

Medical Marijuana Laws and Increased Adolescent Use

A group considered to be at higher risk when modifying marijuana law and policy are adolescents. This group is at a developmental stage where neurobehavioral development is still ongoing, the risk for developing negative health behaviors is higher, and in the context of this manuscript they represent a population entering the age of reproduction (Wall, Poh, Cerda, Keyes, Galea, & Hasin, 2011). Wall and colleagues conducted a simple review of the prevalence of marijuana use among adolescent respondents to the NSDUH between 2002 and 2008. Their findings showed that adolescent marijuana use was higher in adolescents living in states that allowed medical marijuana than use among those who lived in states that did not allow medical marijuana (8.68%, 95% CI: 7.95%, 9.42% and 6.94%, 95% CI: 6.60%, 7.28%, respectively). Equally troublesome was the observation that fewer adolescents living in states that allowed medical marijuana perceived marijuana use as health risk than adolescents that

lived in states that did not allow medical marijuana (30.5% and 35.7%, respectively; Wall et al., 2011). Wall et al. (2011) noted that this study was limited in that causation was not demonstrated because there are many different elements to marijuana policy and the policy may simply reflect an already present pro-marijuana population (Wall et al., 2011).

The following year, another study attempted to replicate these findings using the same databases but used a more complex difference in differences regression approach in an attempt to demonstrate evidence of causation (Harper, Strumpf, & Kaufman, 2012). Similar to Wall et al. (2011), Harper et al. (2012) observed an increase of adolescent marijuana usage of nearly 2% ($\beta = 1.87$, 95% CI: 1.5, 2.2) when fixing year effects to overall secular trends of marijuana use, but when the difference in differences approach included a fixed effect by state trend, they observed a slight decrease in adolescent marijuana use ($\beta = -0.59$, 95% CI: -1.1, -0.1). Using a similar approach with data from the Youth Risk Behavior Survey (YRBS), Lynne-Landsman, Livingston, and Wagenaar (2013) found no evidence of medical marijuana law causation of increased adolescent marijuana use when comparing four states with medical marijuana laws against each other before and after marijuana law adoption. Choo, Benz, Zaller, Warren, Rising, and McConnell (2014) compared states that allowed medical marijuana to a proximal state that does not allow medical marijuana and did not observe any association with increased adolescent marijuana use. The 95% confidence interval for all comparisons included zero which implies an insignificant observation. According to these approaches, there

was a lack of evidence that the adoption of more relaxed statewide marijuana policies caused an increase in adolescent marijuana use.

Current Trends of Marijuana Potency

Cannabis refers to the plant *Cannbis sativa L* which has been used recreationally, medicinally, and for religious ceremonies by humans for thousands of years (ElSohly & Gul, 2014). The term cannabinoids refers to compounds unique to *Cannabis sativa* as well as all of their derivatives and metabolites (biotransformation products) (ElSohly & Gul, 2014). At this time there are 545 cannabinoids defined and described in the scientific literature (ElSohly & Gul, 2014). Phytocannabinoids refer specifically to the compounds that originate from the plant itself and currently there are 104 phytocannabinoids defined and described in the literature (ElSohly & Gul, 2014). The principle psychoactive phytocannabinoid is (-)-Δ^9-tetrahydrocannabinol (Δ^9-THC; ElSohly & Gul, 2014).

The National Institute on Drug Abuse (NIDA) maintains a contract with the University of Mississippi to cultivate marijuana for research purposes and to operate the Potency Monitoring Program (Mehmedic et al., 2010). This program analyzes cannabis seizures from around the country for the purpose of monitoring the product being distributed over time (Mehmedic et al., 2010). The program analyzed thousands of samples from seized contraband annually for a number of phytocannabinoids, including Δ^9-THC (Mehmedic et al., 2010). The results from these analyses are periodically cumulated and reported in forensic literature (Mehmedic et al., 2010).

The most recent Potency Monitoring Program report states that the potency of cannabis (dry weight percentage of Δ^9-THC) has been steadily increasing (ElSohly et al., 2016). In the 1990's, cannabis typically contained 3-4% Δ^9-THC whereas the most recent average seizures contain 11-12% Δ^9-THC (ElSohly et al., 2016). From 1995 to 2014, the proportion of contraband samples that contained an excess of 12% Δ^9-THC has risen sharply (0.64% to 41.22%), while the proportion of contraband samples that contained < 3% Δ^9-THC has dropped dramatically (28.43% to 7.73), further illustrating the improvement of the quality of illicit cannabis available to the public (ElSohly et al., 2016).

This alarming trend of increased marijuana potency has stimulated concerns in many different fields of substance use and abuse. Sevigny et al. (2014) demonstrated that potency has increased in association with adoption of laws allowing medical marijuana. Concern has also been raised about the effects of stronger marijuana from a perspective of its unintended influences on drugged driving, drug-induced psychoses, and adolescent use (Sevigny et al., 2014). Regardless of causation or association, the potency of marijuana has dramatically increased over the past two decades and the impact of that increase raises public health concerns in many areas of study.

Summary

Marijuana is the most prevalent illicit drug used in the United States, however perceptions of its harmfulness has been declining. Often thought of as harmless, this literature review demonstrated that maternal marijuana use is associated with a number of neurobehavioral deficits that initiate a cascade of deficits for the remainder of the

exposed newborn's life. Newborns exposed to marijuana exhibit abnormal tremors and startles as well has abnormal sleep behaviors which is consistent with an under lying neurological abnormalities to be expressed later in life. Marijuana exposed newborns demonstrate lower academic achievement and increased behavioral problems during their preschool and adolescent years and finally culminate in an increased odds ratio for adolescent drug initiation early on in their reproductive ages. This completes a repetitive cycle of deficit.

With the knowledge of the negative consequences of maternal marijuana use, policymakers must be aware of the unintended consequences of statewide marijuana policy relaxation. Policy allowing for the cultivation and commercialization of marijuana influences perceived behavioral control by making marijuana more easily obtainable in the community without fear of negative legal consequences. Marijuana cultivators operating in a free market atmosphere are producing product with dramatically higher concentrations of THC. The adoption of medical marijuana laws with the implication that marijuana as medicine must be good for you, may influence social norms to lower the perceived risk of marijuana use among pregnant women. Over time, as the social norms evolve and perceived behavioral control increase, so too will attitudes toward use, as has been demonstrated with young adults. Using the theory of planned behavior as a theoretical foundation, the effect of statewide marijuana policy relaxation on attitude, social norms, and perceived behavioral control are key factors that increase intent to use marijuana which in turn leads to increased use of marijuana as predicted by the theory.

Studies of the influence of statewide marijuana policy relaxation on the general population, and specifically on adolescents, exist, but studies are lacking when it comes to the evaluation of prenatal marijuana use. This work is important because the negative health consequences of marijuana use are not only confined to the user, but these consequences are also transferred to the unborn baby whose quality of life may be diminished through the action of another. This study will attempt to evaluate the influence of statewide marijuana policy relaxation on pregnant women by comparing the prevalence and frequency of use of marijuana by pregnant women living in states with varying levels of marijuana control. Understanding the unintended negative consequences of statewide marijuana policy relaxation will allow policymakers to consider specific exemptions for vulnerable population and allow public health professionals to better design and implement appropriate interventions.

Chapter 3: Research Method

The purpose of this quantitative secondary analysis was to evaluate a potential association between statewide medical marijuana policy and maternal marijuana usage. This section explores the research design and rationale, methodology, including a description of the population, the sampling design, data collection, and the plan to analyze the data. The section ends with a discussion of the threats to the validity of the study, calculation of the required sample size, and a discussion of ethical concerns.

Research Design and Rationale

The outcome or dependent variables for this study were maternal use of marijuana and the amount of self-reported maternal marijuana use. Two questions from the National Survey of Drug Use and Health (NSDUH) that were used for this study are, "How long has it been since you last used marijuana or hashish?" and "On how many days in the past year did you use marijuana or hashish?" NSDUH, creating a dichotomous dependent variable, defined maternal marijuana use as a woman who was aware of pregnancy, reporting the use of marijuana within the past month or year. The amount of maternal marijuana use was defined by the response to the question, "On how many days in the past month did you use marijuana or hashish?" Answers were recoded into categories of light and heavy for ease of analysis. Light use was defined as less than 100 days and heavy use was equal to or more than 100 days of use.

The independent variable for this study was the dichotomous entry of a variable which reflected the approval of medical marijuana in the state of primary residence of the respondent. States were categorized according to medical marijuana law policy effective

at the time the study was conducted. The categories were medical marijuana use permitted and medical marijuana not permitted. Covariates used for further evaluation were age, race/ethnicity, education level, household income, and marital status.

Using the responses from the NSDUH, comparisons were made between the prevalence and the amount of self-reported maternal marijuana use between the two categories of statewide medical marijuana policy in a particular time period. A cross-sectional quantitative study design was used to evaluate these findings. In Chapter 2, reviews of several cross-sectional quantitative studies that used national databases to evaluate potential factors of substance use were assessed (Muhuri & Gfoerer, 2008; Saurel-Cubizolles et al., 2014; Ko et al., 2015).

Methodology

Population

The NSDUH is a nationwide survey conducted periodically by the Center for Behavioral Health Statistics and Quality (CBHSQ), a department within SAMHSA, for the purpose of providing accurate surveillance data of drug use patterns within the United States (CBHSQ, 2015). The CBHSQ targets respondents ages 12 years and older residing in civilian, non-institutional, settings (CBHSQ, 2015). The survey did not include individuals in the military, incarcerated, or homeless not living in shelters. However, the survey did include civilians living on military installations and homeless individuals residing in shelters (CBHSQ, 2015). A staff of approximately 700 field investigators conducted over 67,000 interviews for the 2014 NSDUH (CBHSQ, 2015).

Sampling

The NSDUH sampling plan used a multidimensional stratification to ensure adequate representation of the national population. The primary level of stratification was the state, including the District of Columbia (SBHSQ, 2015). The second layer of stratification consisted of 750 equally sized state sampling regions (SSR; SBHSQ, 2015). Census tracts (n = 48) within each SSR were identified, census block groups were established within each census tract, and area segments selected from the census block groups were designed to create the third level of stratification (SBHSQ, 2015). A designated number of dwelling units were selected, depending on state and/or location, to recruit respondents (SBHSQ, 2015). Lastly, in each dwelling unit, up to two participants were selected to participate in the survey (SBHSQ, 2015).

Data Collection

Following the identification of the dwelling units, a letter of introduction was mailed to the dwelling unit informing them that they had been randomly selected to participate in the NSDUH (SBHSQ, 2015). Trained field interviewers visited the location, requested to speak to an adult, and conducted a brief interview to obtain basic demographic information (SBHSQ, 2015). This information was entered into a handheld computer system that randomly selected between zero and two participants for the survey from that dwelling unit (SBHSQ, 2015).

The field interviewer and the participant proceeded to a private area within the dwelling unit to complete the survey using two different information gathering platforms (SBHSQ, 2015). A computer-assisted personal interview (where the interviewer read

questions and recorded the responses) and an audio computer-assisted self-interview (where the survey questions were read from a computer screen or heard by participants using headphones), and the responses were recorded by the participant on the computer (SBHSQ, 2015). The results were securely transferred to the study headquarters for analysis (SBHSQ, 2015). Participants received $30 upon completion of the survey (SBHSQ, 2015). The data, along with the codebook, are available in the public domain for download at SAMHSA's website.

Data Analysis Plan

I used IBM SPSS Statistics (version 23) to perform all calculations. Descriptive statistics calculations included prevalence of past 30 day and past year self-reported marijuana use, distribution of past month number of days marijuana use, age categories, racial/ethnicity distribution, household income distribution, education distribution and marital status distribution. The frequency and percentage of each descriptive statistic were reported.

Inferential statistics were calculated to test the following research hypotheses: Research Question 1: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed?

> $H_0$1: There is no difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where

medical marijuana is allowed compared to states where medical marijuana is not allowed.

H_a1: There is a difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

Research Question 2: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed?

H_02: There is no difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

H_a2: There is a difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed.

Research Question 3: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status?

$H_0$3: There is no difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

H_a3: There is a difference between the proportions of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

Research Question 4: Are there significant differences in the proportion of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status?

$H_0$4: There is no difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

H_a4: There is a difference between the proportions of pregnant women that self-report marijuana use during the past year living in states where medical

marijuana is allowed compared to states where medical marijuana is not allowed while controlling for the covariates age, income, race/ethnicity, educational level, and marital status.

Research Question 5: Is there a difference in the prevalence of pregnant women that self-report heavy marijuana use compared to light marijuana use during the past year for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use?

$H_0$5: The prevalence of pregnant women that report heavy marijuana use compared to pregnant women that report light marijuana use during the past year is not different for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use.

H_a5: The prevalence of pregnant women that report heavy marijuana use compared to pregnant women that report light marijuana use during the past year is different for women living in states that allow medical marijuana use and women living in states that do not allow medical marijuana use.

The independent variable for questions 1 and 2 was the category of state medical marijuana policy, a dichotomous variable. The dependent variables for research question 1 and 2 were the self-reported past 30-day use of marijuana, a dichotomous variable (yes/no) and the self-reported past year use of marijuana, also a dichotomous variable (yes/no). The appropriate inferential statistic to test $H_0$1 and $H_0$2 was Pearson's χ^2 test (Green and Salkind, 2014). A *P*-value less than 0.05 allows for the rejection of $H_0$1 and $H_0$2 (Green and Salkind, 2014).

The independent variable for questions 3 and 4 was, again, the category of state medical marijuana policy, a dichotomous variable. The dependent variable for research questions 3 and 4 was the self-reported past 30-day use of marijuana, a dichotomous variable (yes/no) and the self-reported past year use of marijuana, also a dichotomous variable (yes/no). The covariates age, income, educational level are ordinal variables and the covariates race/ethnicity and marital status are nominal variables. The appropriate inferential statistic to test $H_0$3 and $H_0$4 was the multiple logistic regression.

The independent variable for questions 5 was the category of state medical marijuana policy, a dichotomous variable. The dependent variable for research question 5 was the level of self-reported past year use of marijuana, heavy use (≥ 100 days) and light use (< 100 days). The appropriate inferential statistic to test $H_0$5 was Pearson's χ^2 test (Green & Salkind, 2014). A *P*-value that was less than 0.05 will allow for the rejection of $H_0$5 (Green & Salkind, 2014).

Measures

Pregnant. This study was limited to only pregnant women who successfully completed the NSDUH in 2014. The variable PREGNANT recorded the participant's response to the question, "Are you currently pregnant?" The responses were recorded as "Yes," "No," "Don't Know," "Refused," "Blank," or "Legitimate Skip." Only the respondents with a response of "Yes" were included in this study.

Maternal marijuana use past month. One of the dependent variables of this study was past month maternal marijuana use as defined using the variable MRJMON, which was a recoded variable from the response to the question, "How long has it been

since you last used marijuana or hashish?" The responses recorded from the original question were, "Within the past 30 days," "More than 30 days ago but within the past 12 months," "More than 12 months ago," "Used at some point within the past 12 months - logically assigned," "Used at some point in the lifetime – logically assigned," "Used in the past 30 days – logically assigned," "Never used marijuana," "Refused," and "Blank." Responses recorded as "Within the past 30 days" and "Used in the past 30 days – logically assigned." From this data, MRJMON was a convenient recode of past month use recorded as "did not use in the past month" or "did use in the past month."

Maternal marijuana use past year. Another of the dependent variables of this study was past year maternal marijuana use as defined using the variable MRJYR, which was a recoded variable from the response to the question, "How long has it been since you last used marijuana or hashish?" which was detailed above. From this data, MRJYR was a convenient recode of past year use recorded as, "Did not use in the past year" or "Did use in the past year."

Frequency of use. The variable MRJYDAYS defined frequency of use which was the response to the question, "During the past year, on how many days did you use marijuana or hashish?" Responses were recorded into the categories, "1-11 days," 12-49 days," 50-99 days," 100-299 days," "300-365 days," or "nonuser or did not use in past year." This variable was further aggregated into less than 100 days as light use and 100 or more days as heavy use.

Medical marijuana policy of state of primary residence. The variable MEDMJST2 defined the medical marijuana policy of the respondent's state of primary

residence at the time of the interview. The variable was recorded as either, "In state where marijuana is approved for medical use before interview" or "Not in state where marijuana is approved for medical use by interview date."

Age. The variable PREGAGE2 defined maternal age. This variable was recoded as "1 = 15-17 years old," "2 = 18-25 years old," "3 = 26-44 years old," and "4 = Otherwise."

Race/Ethnicity. The variable NEWRACE2 defined race. The variable was recorded as "1 = NonHisp White," "2 = NonHisp Black/Afr Am," "3 = NonHisp Am/Ak Native," "4 = NonHisp Native HI/Other Pac Isl," "5 = NonHisp Asian," "6 = NonHisp more than one race," and "7 = Hispanic."

Education level. The variable EDUCCAT2 defined the education level of the participant. The variable was recorded as "1 = Less than high school," "2 = High school graduate," "3 = Some college," "4 = College graduate," and "5 = 12 to 17 years old."

Household income. The variable INCOME defined the income of the household that the participant resides in. The variable was recorded as "1 = Less than $20,000," "2 = $20,000 - $49,999," "3 = $50,000 - $74,999," and "5 = $75,000 or More."

Marital status. The variable IRMARIT defined the marital status of the respondent. The variable was recorded as "1 = Married," "2 = Widowed," "3 = Divorced or separated," "4 = Never been married," and "99 = Legitimate skip respondent less than 14 years old."

Threats to Validity

External validity threats included the representativeness of the sample and reactive arrangements during the execution of the survey (Frankfort-Nachmias & Nachmias, 2008). The NSDUH mitigated the first of these concerns by the use of a complex multistage random selection process that randomly picked households across 750 equally distributed state sampling regions. The interviewers conducted the survey at the respondent's home, in a private area of the home, and used a private computer or audio based system to record answers in private. The private de-identified nature of the survey mitigated the external threat of reactive arrangements.

Threats to internal validity refer to various aspects of a study that unintentionally affect the outcome of an experiment or survey (Creswell, 2009). The cross-sectional, non-experimental, and random selection design of the NSDUH survey mitigated a number of these recognized threats. The cross-sectional design eliminated the threats due to history, maturation, mortality, and testing. The non-experimental nature of the study mitigated potential internal threats due to diffusion of treatment, compensatory demoralization, and compensatory rivalry. Additionally, the multistage random selection of dwelling units mitigated threats due to regression and selection.

SBHSQ assessed the reliability of the interview process in 2006 by re-interviewing 3,136 respondents 5 to 15 days following the initial interview (SBHSQ, 2015). The assessment compared the responses of the two interviews and calculated Cohen's kappa (SBHSQ, 2015). Questions concerning the use of marijuana were very consistent with kappa values for past year use of 0.82 and lifetime use of 0.93 (SBHSQ,

2015). Cohen (1960) considered kappa values greater than 0.81 to reflect nearly perfect agreement.

Statistical conclusion validity refers to the situation where an inappropriate sample size was used for interpretation of outcomes (Creswell, 2009). The number of respondents used in a study must be large enough to have sufficient statistical power yet small enough to be feasible to execute. A power of 0.80 is the commonly accepted level of sufficient statistical power (Creswell, 2009). To mitigate this potential threat, calculations were performed to determine the number of respondents required for this study in the following subsection "Sample size."

Sample Size

The 2014 NSDUH is considered a large dataset with over 60,000 respondents recorded. This study evaluated pregnant women, a small subset of the total database, therefore it was necessary to determine if the number of pregnant women that responded to the NSDUH provided sufficient power for this analysis. According to Ellis (2010), the sample size required for a study is related to three variables, the significance criterion (α), the power ($1-\beta$), and the effect size (d).

The significance criterion (α) is a measure of the Type I error which represents the probability of incorrectly rejecting a true null hypothesis and the commonly desired level of α is 0.05 (Ellis, 2010). Type II error (β), the probability of accepting a false null hypothesis, is related to the power ($1-\beta$) and the commonly desired power is 0.80 (Ellis, 2010). The effect size represents the strength of an observation and the value used for a prospective sample size analysis is grounded by the observed effect sizes of related

studies (Ellis, 2010). Based on the work of Cerda et al. (2012) and Pacula et al. (2015), I chose a small effect size of 0.1 for this calculation.

Estimates were calculated using G*Power 3.1.9.2 software. The Test Family selection was "z tests" and the Statistical Test selected was "logistic regression." The effect size (odds ratio = 1.3), the desired α error probability (0.05), the desired power (0.80), and the number of categories (3) was entered in the software form. The program estimated that 557 respondents were necessary for the study.

Ethical Procedures

All participants provided informed consent following protocols approved by Research Triangle Institute's Institutional Review Board (IRB; RTI, 2013). Survey personnel captured the data in a confidential manner and transmitted the data securely to the NSDUH study headquarters (RTI, 2013). De-identified data is available to the public through internet download for secondary data analysis without further IRB approval.

All of the data used for this study was anonymous. Although the de-identified secondary data is freely available to the public, Walden University IRB approval was required for this study. Walden University IRB granted approval on October 27, 2016 with approval number 10-27-16-0262348.

Summary

In this chapter, I provided a detailed discussion of the research design and methodology used in this quantitative secondary analysis of the 2014 NSDUH survey. The variables used in this study were defined and operationalized. The plan of data

analysis and *a priori* sample size calculation were described. Lastly, the threats to the validity of the study and the ethical procedures were discussed.

Chapter 4: Results

Introduction

The purpose of this study was to evaluate the association of state medical marijuana laws and maternal marijuana use. Marijuana has been classified as a teratogen and prenatal marijuana exposure has been linked to a number of neurobehavioral deficits. The study compared the responses of pregnant women from a large national survey regarding their marijuana consumption during the past 30 days and past year. The pregnant women were categorized into two groups, those residing in states that allow medical marijuana and those residing in states that do not allow medical marijuana at the time of interview.

Five research questions were used to evaluate the association of state medical marijuana laws and maternal marijuana use. The first research question asked if there were significant differences in the proportion of pregnant women that self-report marijuana use during the past 30 days living in states where medical marijuana was allowed compared to states where medical marijuana was not allowed. The second research question asked if there were significant differences in the proportion of pregnant women that self-report marijuana use during the past year living in states where medical marijuana was allowed compared to states where medical marijuana was not allowed. The third and fourth research questions were follow up questions to research questions 1 and 2 that control for age, income, education, race/ethnicity, and marital status. Research question 5 asked if there was a difference in the level (light use versus heavy use) of past year marijuana use for pregnant women where medical marijuana was allowed compared

to states where medical marijuana was not allowed. The theory of planned behavior suggests that the increased subjective norm and perceived behavioral control associated with a jurisdiction that allows medical marijuana use would increase the intention of an individual to use marijuana leading to increased use in the population.

This study utilized the 2014 National Survey on Drug Use and Health (NSDUH). This chapter will provide details concerning the collection of the data, descriptive statistics of the respondents, and inferential statistics of their responses to the survey questions used to answer the research questions summarized above. Lastly, a summary of the results section will conclude the chapter.

Data Collection

This study did not require any direct contact with any of the survey participants. This project was a secondary analysis of the 2014 NSDUH which is a de-identified dataset available for public use. Following approval by the Walden University Institutional Review Board (IRB approval number 10-27-16-0262348) and registration with the Interuniversity Consortium for Political and Social Research (ICPSR), the 2014 data were imported into Statistical Package for the Social Sciences (SPSS, version 23). The 2014 NSDUH dataset contained responses from 55,271 participants. A selection was performed to only include women that responded in the affirmative to the question, "Are you currently pregnant" ($N = 758$). The age range of the self-reported pregnant respondents was 14-44 years of age. There were no discrepancies from the plan described in Chapter 3.

Descriptive Statistics

Of the 55,271 randomly selected respondents that participated in the 2014 NSDUH, 758 reported that they were pregnant at the time of interview. There were 3 (0.4%) individuals that were 14 years old, 20 (2.6%) in the 15-17 year old age group, 390 (51.5%) in the 18-25 year old age group, and 345 (45.5%) in the 26-44 year old age group. The family annual income distribution was 210 (27.7%) with family income less than $20,000, 244 (32.2%) between $20,000 and $49,999, 124 (16.4%) between $50,000 and $74,999, and 180 (23.7%) over $75,000. The respondents reported that 117 (15.4%) did not finish high school, 215 (28.4%) completed high school, 190 (25.1%) obtained some college, and 213 (28.1%) completed college. The race/ethnicity distribution was 414 (54.6%) non-Hispanic White, 108 (14.2%) non-Hispanic Black, 20 (2.6%) Native American/Alaska Native, 10 (1.3%) Hawaiian/Pacific Islander, 34 (4.5%) Asian, 25 (3.3%) multiracial, and 147 (19.4%) Hispanics. There were 391 (51.6%) married respondents, 43 (5.7%) divorced/separated, and 321 (42.3%) never married. At the time of interview, 306 (40.4%) respondents lived in a state that allowed medical marijuana while 452 (59.6%) did not. These results are listed in Table 2.

An overview of the prevalence and frequency of maternal marijuana use appears in Table 3. The survey revealed 48 (6.3%) pregnant women self-reported marijuana use within the past 30 days and 122 (16.1%) pregnant women self-reported marijuana use during the past year. The survey showed that 636 (83.9%) of the pregnant women did not use any marijuana during the previous year while 30 (4.0%) used 1-11 days, 22 (2.9%)

used 12-49 days, 16 (2.1%) used 50-99 days, 41 (5.4%) used 100-299 days, and 13 (1.7%) used 300-365 days during the past 12 months.

Table 2

Core Demographic Frequencies and Percentages of Pregnant Women Respondents of the 2014 NSDUH (N = 758)

	n	%
Age Group		
15-17	20	2.6
18-25	390	51.5
26-44	345	45.5
Otherwise	3	0.4
Family Income		
Less than $20,000	210	27.7
$20,000-$49,999	244	32.2
$50,000 - $74,999	124	16.4
$75,000 or more	180	23.7
Education Level		
Did not finish high school	117	15.4
High School Graduate	215	28.4
Some College	190	25.1
College Graduate	213	28.1
Race Ethnicity		
Non-Hispanic White	414	54.6
Non-Hispanic Black	108	14.2
Non-Hispanic Native Am/AK	20	2.6
Non-Hispanic HI/Other Pac Island	10	1.3
Non-Hispanic Asian	34	4.5
Multiracial	25	3.3
Hispanic	147	19.4
Marital Status		
Married	391	51.6
Divorced/Separated	43	5.7
Never Married	321	42.3
State Marijuana Law Status		
Medical Marijuana Allowed	306	40.4
Medical Marijuana Not Allowed	452	59.6

Table 3

Frequencies and Percentages of Marijuana Use for Pregnant Women Respondents of the 2014 NSDUH (N = 758)

	n	%
Used Marijuana		
Past Month	48	6.3
Past Year	122	16.1
Number of Days Used Past Year		
Did Not Use	636	83.9
1-11 Days	30	4.0
12-49 Days	22	2.9
50-99 Days	16	2.1
100-299	41	5.4
300-365	13	1.7

Inferential Statistics

Research Question 1.

Pearson Chi-square was used to evaluate the potential association between past month maternal marijuana use and residing in a state that allows or does not allow medical marijuana use. Of the 452 women that lived in a state where medical marijuana was not allowed, 26 (5.8%) reported that they used marijuana within the past month of the interview. Of the 306 women that lived in a state where medical marijuana was allowed, 22 (7.2%) reported past month use of marijuana. Pearson Chi-square analysis (Table 4) revealed that this was not a significant association with χ^2 (df = 1, N = 758) = 0.636, p = 0.425; Φ = -0.029. Therefore, the null hypothesis could not be rejected.

Research Question 2.

Pearson Chi-square was used to evaluate the potential association between past year maternal marijuana use and residing in a state which allows or does not allow for

medical marijuana use. Of the 452 women that lived in a state where medical marijuana was not allowed, 68 (15.0%) reported that they used marijuana within the past year of the interview. Of the 306 women that lived in a state where medical marijuana was allowed, 54 (17.6%) reported past year use of marijuana. Pearson Chi-square analysis (Table 4) revealed that this was not a significant association with χ^2 (df = 1, N = 758) = 0.915, p = 0.339; Φ = -0.035. Therefore, the null hypothesis could not be rejected.

Research Question 3.

Logistic regression was used to examine the potential association of living in an area that allows medical marijuana and past month maternal marijuana use while controlling for several covariates including age, income, education, race/ethnicity, and marital status. Several transformations were performed due to low responses to several subcategories. Age was transformed from four age categories to two age categories, 14-25 years old and 26-44 years old. Race/ethnicity was compiled from six categories to three categories, non-Hispanic White, non-Hispanic other, and Hispanic. The category divorced/separated and never married was combined to form not married.

The model summary suggested that this evaluation was significant with $\chi^2(11)$ = 59.556, $p < 0.001$. The odds ratios and significance calculations are listed in Table 5. This model showed that state medical marijuana law, family income, education level, and race/ethnicity were not significantly associated with increased maternal marijuana use.

Table 4

Prevalence of Past Month and Past Year Marijuana Use for Pregnant Women Respondents of the 2014 NSDUH (N = 758) in States that Allow Medical Marijuana and States that do not Allow Medical Marijuana.

	Medical Marijuana			
	Allowed (%)	Not Allowed (%)	*p* value	Φ
Past Month Use	7.2	5.8	0.425	-0.029
Past Year Use	17.6	15.0	0.339	-0.035

The odds ratio of pregnant women to report past month maternal marijuana use that were 25 years old or younger was higher (OR = 3.565; 95% CI: 1.379 – 9.231; p =0.009) than pregnant women that were 26 years old or older. Unmarried women reported significantly higher past month marijuana use than married women (OR = 6.81; 95% CI: 2.485 – 18.661; $p < 0.001$).

Research Question 4.

A parallel evaluation to research question 3 was executed to examine the participant responses to past year maternal marijuana use. As before, this model was significant with $\chi^2(11) = 79.237$, $p < 0.001$. Similar to the previous evaluation, state medical marijuana law, age, family income, and education level were not significantly associated with an increased prevalence of past year maternal marijuana use. The odds ratio for pregnant women that were 25 years old or younger was 2.185 times higher (95% CI: 1.294 – 3.689; $p = 0.003$) to report past month maternal marijuana use than pregnant women that were 26 years old or older. Unmarried women were 4.650 times higher (95% CI: 2.713 – 7.971; $p < 0.001$) to report past month marijuana use than married women. Different from the past month maternal marijuana use analysis, past year

maternal marijuana use analysis suggested that being Hispanic provided a degree of protection with a 45.8% reduced odds of self-reported past year marijuana use (OR:0.458; 95% CI: 0.252 – 0.831; p = 0.010) compared to non-Hispanic Whites (Table 6).

Table 5

Past Month Use Reported by Pregnant Respondents of the 2014 NSDUH (N = 758)

	β	SE	Odds Ratio	*P*	Confidence Intervals
Medical Marijuana					
Not Allowed	ref	ref	ref	ref	ref
Allowed	0.424	0.320	1.52	0.185	0.816 - 2.859
Age Group					
14-25	1.271	0.484	3.565	0.009	1.379 – 9.213
26-44	ref	ref	ref	ref	ref
Family Income					
Less than $20,000	0.129	0.571	1.138	0.821	0.372 – 3.482
$20,000-$49,999	0.359	0.549	1.433	0.513	0.488 – 4.203
$50,000 - $74,999	-0.157	0.718	0.855	0.827	0.209 – 3.490
$75,000 or more	ref	ref	ref	ref	ref
Education Level					
Did not finish high school	0.619	0.739	1.858	0.402	0.437 – 7.901
High School Graduate	-0.007	0.736	0.993	0.992	0.235 – 4.202
Some College	0.597	0.705	1.817	0.397	0.456 – 7.239
College Graduate	ref	ref	ref	ref	ref
Race Ethnicity					
Non-Hispanic White	ref	ref	ref	ref	ref
Non-Hispanic Other	-0.122	0.359	0.886	0.735	0.438 – 1.789
Hispanic	-0.885	0.460	0.413	0.054	0.168 – 1.017
Marital Status					
Married	ref	ref	ref	ref	ref
Not Married	1.918	0.769	6.810	<0.001	2.485 – 18.661

Table 6

Past Year Use Reported by Pregnant Respondents of the 2014 NSDUH (N = 758)

	β	SE	Odds Ratio	*P*	Confidence Intervals
Medical Marijuana					
Not Allowed	ref	ref	ref	ref	ref
Allowed	0.375	0.215	1.456	0.081	0.955 – 2.220
Age Group					
14-25	0.782	0.267	2.185	0.003	1.294 – 3.689
26-44	ref	ref	ref	ref	ref
Family Income					
Less than $20,000	0.238	0.362	1.269	0.511	0.624 – 2.580
$20,000-$49,999	0.139	0.341	1.149	0.684	0.589 – 2.243
$50,000 - $74,999	0.265	0.388	1.304	0.494	0.610 – 2.790
$75,000 or more	ref	ref	ref	ref	ref
Education Level					
Did not finish high school	0.005	0.397	1.005	0.989	0.462 – 2.190
High School Graduate	-0.587	0.388	0.556	0.130	0.260 – 1.188
Some College	-0.121	0.360	0.886	0.736	0.438 – 1.792
College Graduate	ref	ref	ref	ref	Ref
Race Ethnicity					
Non-Hispanic White	ref	ref	ref	ref	ref
Non-Hispanic Other	-0.229	0.248	0.796	0.357	0.489 – 1.294
Hispanic	-0.781	0.304	0.458	0.010	0.252 – 0.831
Marital Status					
Married	ref	ref	ref	ref	ref
Not Married	1.537	0.335	4.650	<0.001	2.713 – 7.971

Research Question 5.

Chi-squared analysis was used to evaluate the association of state medical marijuana laws on the level of self-reported maternal marijuana use. The response to the question of how many days did you use during the past year was transformed into a dichotomous variable

(Table 7). The self-reported use of marijuana for 1-99 days during the past year defined light use. One hundred (100) or more days of self-reported marijuana use identified heavy use.

Table 7

Level of Past Year Marijuana Use for Pregnant Women Respondents of the 2014 NSDUH (N = 758) in States that Allow Medical Marijuana and States that do not Allow Medical Marijuana.

	Medical Marijuana	
	Allowed (%)	Not Allowed (%)
Light Use (1-99 days)	25 (46)	43 (63)
Heavy Use (≥ 100 days)	29 (54)	25 (37)

$p = 0.061$, $\Phi = -0.169$

Of the 68 women who reported past year marijuana use that lived in a state where medical marijuana use was not allowed, heavy users accounted for 25 (36.8%) of the respondents. Of the 54 women who reported past year marijuana use that lived in a state where medical marijuana was allowed, the proportion of heavy users increased to 29 (53.7%) . Pearson Chi-square analysis (Table 6) revealed that this was not a significant association with χ^2 ($df = 1$, N = 122) = 3.501, $p = 0.060$; $\Phi = -0.169$. Although very close to $p = 0.05$ the null hypothesis could not be rejected.

Summary

This chapter presented the results of the secondary analysis with regard to statewide medical marijuana laws and self-reported maternal marijuana use using the 2014 NSDUH. Women responding in the affirmative to the question of being pregnant were selected and categorized into two groups, those that resided in a state that allowed

medical marijuana at the time of the interview and those that did not reside in a state that allowed medical marijuana.

The survey recorded the responses of 758 pregnant women and analyzed for prevalence and usage level. The prevalence of self-reported maternal marijuana use was higher for both past month (7.2% versus 5.8%) and past year (17.6% versus 15.0%) use for women living in states that allow medical marijuana, however, in both instances the increases were not significant ($p = 0.425$ and $p = 0.339$, respectively). Additionally, when controlling for age, family income, education, race/ethnicity, and marital status, no significant association existed between state medical laws and maternal marijuana use. Heavy use (using 100 days or more per year) was higher in states that allowed medical marijuana (54% compared to 37%) than in states that did not allow medical marijuana. Chapter 5 includes a discussion of the significance of these findings in the context of current knowledge, limitations of the study, recommendations for further research, and implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Maternal marijuana use is a significant public health issue due to the long term negative neurobehavioral deficits seen in children born to these mothers. Many states are relaxing their marijuana policies to include medicinal and recreational use, creating a general environment of reduced perception of risk of use. This change created an environment where the potency of marijuana increased dramatically over the past 2 decades and marijuana has become much more accessible (ElSohly et al., 2016). There are numerous studies evaluating the potential association between residing in a state where medical marijuana use is allowed and adolescent use initiation, increased use in selected minorities, and increased use in the general population (Wall et al., 2011; Harper et al., 2012; Schmidt et al., 2016; Chasnoff, 2017). However, studies evaluating the association of medical marijuana laws and maternal marijuana use are lacking in the literature. The purpose of this study was to fill that gap in the literature.

Interpretation of Findings

Research questions 1 and 2 were composed to evaluate the differences of past month and past year maternal marijuana use in states that allow medical marijuana use and states that do not allow medical marijuana. This study demonstrated that the prevalence of maternal marijuana use was higher in states where medical marijuana was allowed for both past month (7.2% compared to 5.8%) and past year use (17.6% compared to 15.0%). However, in both cases, the increase was not statistically

significant ($p = 0.452$ and $p = 0.339$, respectively). This observation was similar to findings of another vulnerable population, adolescents, which was reviewed in Chapter 2.

Several studies have specifically reviewed adolescent marijuana use using NSDUH data with mixed results. Wall et al. (2011) compared adolescent marijuana use between 2002 and 2008 in states where medical marijuana was allowed compared to states where it was not allowed. They reported a higher average adolescent marijuana use in states where medical marijuana was allowed (8.68% compared to 6.94%). Due to its cross-sectional design, this study did not attribute the increase solely to the allowance of medical marijuana use in given states.

Harper et al. (2013) evaluated the same data set using a more complex design in an attempt to isolate the influence over time of the presence of medical marijuana laws on adolescent marijuana use. Harper et al. (2013) confirmed an increase in adolescent marijuana use in states with medical marijuana laws observed by Wall et al. (2011). However, when applying a more complex analysis using a difference in differences approach they reported that the passage of medical marijuana laws presented no significant affect ($\beta = -0.53$; 95% CI: -1.0, 0.0).

Stolzenberg, D'Alessio, and Dariano (2016) recently reviewed NSDUH results but chose to use a cross-sectional, pooled-time series in 2 year increments from 2002-2011. Stolzenberg and colleagues (2016) geocoded the data and created dummy variables to reflect the timing of the passage of state law as well as other elements of the laws, including possession limits and product availability. They also confirmed increased levels of adolescent marijuana use in states that allowed medical marijuana, and when

controlling for a number of other factors such as possession limits and availability, they observed a statistically significant influence of the presence of medical marijuana laws ($\beta = 0.861$; $p = <0.001$).

The purpose of research questions 3 and 4 was to investigate the differences of past month and past year maternal marijuana use in states that allow medical marijuana use and states that do not allow medical marijuana use while controlling for age, family income, educational level, race/ethnicity, and marital status. Controlling for these demographic elements did not reveal a significant influence of state medical marijuana laws ($\beta = 0.424$; $p = 0.185$) on self-reported maternal marijuana use. Additionally, there was no apparent statistically significant influence observed for family income level or educational level. However, as demonstrated in other studies of other populations, there was an association between maternal marijuana use and age, marital status, and race/ethnicity.

Young mothers between the ages of 14-25 years old self-reported more past month use during pregnancy (OR = 3.565; 95% CI: 1.379, 9.213; $p = 0.009$) and past year use during pregnancy (OR = 2.185; 95% CI: 1.294, 3.689; $p = 0.003$). The odds ratio for unmarried women was 6.81 times higher for past month use than married women (95% CI: 2.485, 18.661; $p < 0.001$) and 4.650 times higher for past year use (95% CI: 2.713, 7.971; $p < 0.001$). However, being Hispanic provided an apparent degree of protection, where the odds ratio was less than half to report maternal marijuana past month use (OR = 0.413; $p = 0.054$; 95% CI: 0.168, 1.017) and past year marijuana use (OR = 0.458; $p = 0.010$; 95% CI: 0.252, 0.831) compared to non-Hispanic Whites.

A study of the responses to the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) showed a similar trend of use by age in the general population (Hasin et al., 2015). Among 18-29 year olds, 10.5% reported past-year marijuana use compared to the next highest age group (30-34 years old) only reporting 4.1% in the NESARC Wave I in 2001-2002 (Hasin et al., 2015). NESARC Wave II (2012-2013) showed past year marijuana use of 18-29 year olds at 21.2% compared to 30-34 year olds at 10.1%. Ko et al. (2015) showed in their study of the NSDUH (2007-2012) that over half of the pregnant mothers reporting past month marijuana use were between the ages of 18-25 years old (66.7%), which was similar to their findings among non-pregnant females ages 18-25 years old (54.8%). These findings consistently showed that young people, whether pregnant or simply part of the general population, were at higher risk to self-report marijuana use.

Marital status has also been a consistent predictor of self-reported marijuana use. The 2012-2013 Wave II of the NESARC showed that unmarried people (21.0%) were much more inclined to report past year marijuana use than widowed/separated people (8.3%) or married individuals (5.5%; Hasin et al., 2016). The NSDUH (2007-2012) data showed that 70.4% of pregnant women that reported past month marijuana use were never married (Ko et al., 2015). Saurel-Cubizolles and Blondel (2014) also observed this trend in a French national study where the odds of women that did not cohabitate with the child's father were 1.69 times higher (95% CI: 1.01, 2.82; $p < 0.05$) to report marijuana use during pregnancy than pregnant women cohabitating with their partner.

Race/ethnicity provided an interesting comparison, in which Hispanics tended to self-report less marijuana use than Non-Hispanics. In the NESARC Wave II in 2012 and 2013, Hasin et al. (2015) observed in the general population a prevalence of past year marijuana use of 8.4% while non-Hispanic Whites and Blacks reported use at much higher rates (9.4% and 12.7%, respectively). Ko and colleagues (2015), reported in their study using the NSDUH (2007-2012) that pregnant Hispanic women were less inclined to report past year marijuana use (OR = 0.6; 95% CI: 0.4, 0.8) when compared to Non-Hispanic Whites.

The purpose of research question 5 was to evaluate a potential increase in heavy marijuana use among pregnant women in states that allow medical marijuana use compared to pregnant women who lived in states that do not allow medical marijuana use. Light marijuana use was defined as using 99 days or less per year while heavy use was defined as using 100 or more days per year. Of the pregnant women that reported past year marijuana use living in a state that does not allow medical marijuana use, 37% self-reported as heavy users. In states that allowed medical marijuana use, 54% categorized as heavy users. While this was a large increase, the finding approached statistical significance ($p = 0.061$).

This finding is consistent with a recent report evaluating concentrations of marijuana metabolite (THCA) in newborn meconium before and after legalization of recreational marijuana use in Colorado (Chasnoff, 2017). Meconium is the first fecal material excreted by the newborn that has accumulated in the large intestine of the neonate during the second and third trimesters (Gareri, Klein, & Koren, 2006).

Meconium has been considered for many years to be the gold standard specimen type to determine prenatal drug exposure because of its long window and detection, availability, and noninvasive collection procedure (Gareri et al., 2006).

Chasnoff (2017) referred to preliminary data indicating that a significant increase in the prevalence of positive meconium specimens was not observed following the implementation of recreational marijuana law in Colorado. However, there was a significant increase in the observed mean concentrations of THCA found in newborn meconium following implementation of the Colorado law (213 ± 230 ng/g compared to 361 ± 420 ng/g; $p = 0.013$) which indicated an increase in heavy marijuana use among those that chose to use. This observation aligns with the findings reported here where an increase of heavy users over light users was observed in states that allow for medical marijuana.

Analysis of theoretical framework

I selected the theory of planned behavior as the theoretical framework to ground this study. The theory proposes that performing behaviors such as exercise, dieting, drug use initiation, drug use maintenance, or drug use cessation precede the intention to perform the behavior (Ajzen, 1991). The magnitude of the intention is proportional to the probability the individual will perform the behavior (Ajzen, 1991). Attitude, subjective norms, and perceived behavioral control influence the intention to perform a behavior.

The presence of a statewide policy allowing medical marijuana represents a subjective norm expected to influence the intention to use marijuana. If the state approves the use of marijuana, the expectation of a decrease of the negative perception of

marijuana use exists. The increased pervasiveness of marijuana in the environment to satisfy the medical marijuana demand makes obtaining marijuana easier, which increases perceived behavioral control. The findings reported in the study are supported by the theory of planned behavior because although technically not statistically significant, the observed increases in prevalence and amount of use were in the expected direction predicted by the theory.

Limitations

The major advantages of using the NSDUH were the size, and inclusion of the new question about the presence of medical marijuana law at the time of inquiry. The NSDUH reports the national sampling of close to 60,000 participants, which included 758 pregnant women. The NSDUH employed a complex sampling strategy to ensure that the respondents were an accurate representation of the national demographic. Inclusion of the new questionnaire item indicating the presence of state medical marijuana laws at the time of interview allowed for simple yet accurate categorization of the dependent variable.

The most significant limitation to this study was its reliance on self-report of drug use behavior. The prevalence and extent of marijuana use was expected to be under-reported due to reasons of self-incrimination and stigma. McDonald (2008) concluded that individuals in general answer questions in a manner that is more socially acceptable. The survey attempted to mitigate these concerns by conducting the interview in a private area away from others and by the use of a computer assisted protocol.

The NSDUH does not include institutionalized, incarcerated, or homeless individuals in their survey. Historically, these populations have been at high risk for substance use and abuse. A survey conducted by the U.S. Bureau of Prisons reported that 53.4% of state prison inmates and 45.5% of federal prison inmates met the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (DMS-IV) requirements of drug dependence or abuse (Mumola & Karberg, 2006). According to the U.S. Department of Housing and Urban Development (2016), of the approximately 550,000 homeless individuals in the United States, up to 20% suffered from long term ongoing substance use and abuse issues. Inclusion of these demographics would have disproportionately increased the number of users in the study and perhaps altered the outcome.

Lastly, this survey did not capture information regarding the participants residing in a state that adopted a recreational marijuana law. At the time of this survey, two states (Colorado and Washington) had adopted policies that allowed for recreational marijuana use in addition to medical marijuana use (NAMSDL, 2016). The influence of a state recreational marijuana law may not be equivalent to that of a state medical marijuana law. This study only considered the presence of statewide medical marijuana laws and may underestimate increases which may be observed in areas that permit recreational use.

Recommendations

Maternal marijuana use has been associated with a number of long-term negative neurobehavioral consequences for newborns (Minnes & Singer, 2011). In contradiction to the HealthyPeople 2020 goal of reducing maternal drug use (including marijuana),

there has been a long term trend of increased permissive views among adolescents concerning marijuana use (Schmidt, Jacobs, & Spetz, 2016) and an increase in the number of jurisdictions that allow medical and recreational marijuana (NAMSDL, 2016). This environment, coupled with the findings of this study, warrant further investigation on the factors associated with maternal marijuana use. I recommend that this study be replicated with subsequent waves of NSDUH, with the inclusion of marijuana use questions as general core questions in the Pregnancy Risk Assessment Monitoring System (PRAMS), and inclusion of an objective long term biomarker in a survey of neonates coming from various geographical areas.

The 2014 NSDUH was the first wave of NSDUH that included survey item MEDMJST2, which is a dichotomous variable indicating the allowance of medical marijuana in the participant's state of primary residence at the time of interview. The inclusion of this variable in this and subsequent surveys allows for accurate and simple evaluation of the prevalence and extent of marijuana use among a variety of demographics including pregnant women. As the number of states that allow medical marijuana increase, replicating this study over time may provide useful insight. An additional improvement may be in the inclusion of a variable indicating the allowance of recreational marijuana use in subsequent rounds of the NSDUH survey.

The PRAMS survey, sponsored by the CDC, includes a common core set of questions and participating states around the country execute the survey post-partum. Each State's Department of Health may also include an additional battery of questions of local concern. At this time, only the State of Hawaii includes a question concerning

maternal marijuana use. Inclusion of a question concerning maternal marijuana use in the PRAMS general core may provide improved accuracy because the survey is not performed while the mother is pregnant but is conducted following the birth of the child. In instances where the child is apparently healthy, the reduction of potential stigma encourages the mother to more accurately self-report marijuana use during pregnancy.

Lastly, I recommend the inclusion of a long term biomarker of marijuana consumption in a national survey to improve the accuracy of monitoring maternal marijuana use. Maternal marijuana use is under-reported using self-report strategies due to self-incrimination and negative stigma reasons (Ko et al., 2015). The detection of THC and/or its metabolites in biological specimens such as meconium, umbilical cord tissue, and hair can provide useful and objective information concerning *in utero* drug exposure (Chasnoff, 2017; Gray & Huestis, 2007). Additionally, informing participants about the inclusion of a biological measure in a survey improves self-report accuracy (Hahn et al., 2012).

Implications for Positive Social Change

An association exists between *in utero* exposure to marijuana and long-term neurobehavioral deficits and these marijuana induced deficits are 100% preventable. The results of this study confirm previous reports in that marijuana use in jurisdictions that allow medical marijuana, while statistically insignificant, are higher than in jurisdiction that do not allow for medical marijuana. Furthermore, among those that reside in states that allow medical marijuana and that choose to use during pregnancy, use more frequently than their counterparts in states that do not allow medical marijuana. This

study also aligns with previous reports stating that younger and unmarried women are at higher risk of maternal marijuana use than other women. These findings along with increasing permissive views of marijuana use among adolescents and an increase in the number of states that allow medical marijuana use demand that policymakers direct prevention efforts to these higher risk group.

The increase of permissive views of marijuana use among adolescents presents a compounded set of public health issues. An association between age of substance use initiation and higher substance dependency later in life exists. Additionally, the adolescent demographic are entering into the reproductive age range. Policymakers in all jurisdictions but especially in those jurisdictions that either allow medical marijuana or are considering the allowance of medical marijuana should focus substance use prevention resources to their adolescent constituents including information concerning the long term neurobehavioral deficits associated with maternal marijuana use.

Policymakers in all states but especially in states that allow medical marijuana or states considering the allowance of medical marijuana should provide additional resources for substance use prevention for young unmarried women. This study was consistent with previous reports showing that these two characteristics are at a statistically significant increased risk over other demographics studied. Additionally, young, unmarried women are more apt to not have adequate healthcare coverage which may present a barrier to prenatal treatment and a conduit for substance use prevention efforts.

The most important social change implication emanating from this study is the need to improve maternal access to information about the long term negative neurobehavioral deficits associated with maternal marijuana use. The literature review presented here clearly demonstrates the association between maternal marijuana use and long-term neurobehavioral deficit among babies. The study findings, while statistically insignificant, show consistently higher rates of maternal marijuana use in states that allow medical marijuana than in states that do not allow medical marijuana. Additionally, in states where medical marijuana is allowed, mothers that used marijuana used more than their peers in states that did not allow medical marijuana. However, a recent study of pregnant women's access to information regarding the potential harmful effects of prenatal marijuana exposure was disappointing (Jarlenski, Tarr, Holland, Farrell, & Chang, 2016).

Jalenski et al. (2016) noted that women mostly relied on internet searches for prenatal marijuana exposure information and the experiences of family or friends. This study only included women with access to prenatal care yet only a few of the pregnant women received pertinent information concerning prenatal marijuana exposure from their healthcare provider (Jalenski et al., 2016). The participants reported the desire to obtain specific information concerning the potential of harmful effects of maternal marijuana use and for those that did receive feedback they questioned the quality of the information they received (Jalenski et al., 2016). The findings of Jalenski et al. (2016) coupled with the findings of this study identify an opportunity for policymakers and public health

professionals to intervene in this vulnerable population with targeted substance use prevention efforts to initiate positive social change.

Conclusion

The study presented here evaluated, for the first time, the association of maternal marijuana use for women that reside in states that allow medical marijuana and women that reside in states that do not allow medical marijuana. The prevalence of past-month and past-year maternal marijuana use was higher for women that resided in states that allowed medical marijuana, however, that increase was not statistically significant. The proportion of heavy users (defined as using 100 days or more during the past year) in states that allow medical marijuana compared to light users (using 99 days or less during the past year) was higher compared to their marijuana using peers in states that do not allow medical marijuana. This finding approached statistical significance ($p = 0.06$). In addition, the findings presented here were consistent with other reports that show young and unmarried pregnant women to be at higher risk of self-reported marijuana use. Maternal marijuana use is associated with negative long term public health consequences and coupled with these findings present an opportunity for public health policymakers and healthcare professionals to provide targeted intervention for positive social change.

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