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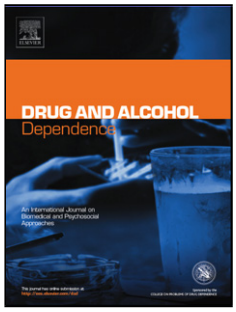

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Marijuana use during and after pregnancy and association of prenatal use on birth outcomes: a population-based study*

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Highlights

- Marijuana co-use with alcohol and tobacco is common during pregnancy.
- Postpartum marijuana use linked with depressive symptoms and shortened breastfeeding.
- Marijuana use during pregnancy associated with lower mean infant birthweight.
- After adjustment for confounders, association no longer significant.

Abstract

Background: We sought to describe the correlates of marijuana use during and after pregnancy, and to examine the independent relationship between prenatal marijuana use and infant outcomes.

Study Design: We used state-specific data from the Pregnancy Risk Assessment Monitoring System (N=9,013) to describe correlates of self-reported prenatal and postpartum marijuana use. We estimated differences in mean infant birth weight and gestational age among prenatal marijuana users and nonusers, controlling for relevant covariates (i.e., cigarette smoking).

Results: Respectively, 4.2% (95% CI: 3.8-4.7) and 6.8% (95% CI: 6.0-7.7) of women reported using marijuana during and after pregnancy. Compared to nonusers, prenatal marijuana users were more likely to be ≤24 years; non-Hispanic white, not married, have <12 years of education, have Medicaid/IHS/Other insurance, be on WIC during pregnancy, have annual household income <$20,000, cigarette smokers, and alcohol drinkers during pregnancy (p-values <0.05). After adjustment, no differences in gestational age or birthweight were observed. Postpartum users were more likely to smoke cigarettes (48.7% vs. 20.3%), experience postpartum depressive symptoms (14.0% vs. 9.0%), and breastfeed for <8 weeks (34.9% vs. 18.1%).

Conclusion: Co-use of substances was common among prenatal and postpartum marijuana users. Prenatal marijuana use was not independently associated with lower average birthweight or gestational age. Postpartum marijuana use was associated with depressive symptoms and shorter breastfeeding duration. Surveillance of marijuana use among pregnant and postpartum women is critical to better understanding the relationship of marijuana use with birth outcomes, and postpartum experiences such as depression and breastfeeding.

Keywords: Low Birth Weight, Marijuana, Pregnancy, Preterm, Postpartum

1. Introduction

Marijuana is the most commonly used federal-prohibited drug in the U.S (Ebrahim and Gfroerer, 2003). However, as of November 2017, marijuana is legalized in 29 states and the District of Columbia (D.C.) for medical use and 8 states and D.C. for recreational use (Governing, 2017). Nationally, 4% of pregnant women reported using marijuana in the past month (Ko et al., 2015). Pregnant women who reported using marijuana commonly report alcohol and tobacco use (Ko et al., 2015). Although many studies have examined the association of marijuana use during pregnancy and adverse outcomes, older studies have uncontrolled confounding, and definitive evidence from contemporary studies is limited for a causal association between marijuana use during pregnancy and adverse infant outcomes (Conner et al., 2016; English et al., 1997; Mark et al., 2016; Metz and Stickrath, 2015; National Academies of Sciences, 2017; van Gelder et al., 2010). Marijuana use during pregnancy has been associated with low birthweight (Gunn et al., 2016; Hatch and Bracken, 1986; Hayatbakhsh et al., 2012; Zuckerman et al., 1989), preterm birth (Hatch and Bracken, 1986; Hayatbakhsh et al., 2012), shorter infant length at birth (Zuckerman et al., 1989), small for gestational age (Warshak et al., 2015), and admission to a neonatal intensive care unit (NICU) (Gunn et al., 2016; Hayatbakhsh

et al., 2012; Warshak et al., 2015). Less is known regarding the prevalence of postpartum marijuana use and association with postpartum depression, and breastfeeding experiences (National Academies of Sciences, Engineering, and Medicine, 2017).

As more states legalize medical or recreational marijuana and access to marijuana increases (Azofeifa et al., 2016; Brown et al., 2016), there is a need to understand the extent that women use marijuana during and after pregnancy and correlates of use. We also sought to evaluate the relationship between marijuana use and birth outcomes with a recent population-based sample of women. The study objectives were: 1) to describe the socio-demographic and health care utilization characteristics of women who use marijuana during pregnancy; 2) to evaluate the relationship between marijuana use during pregnancy with low birth weight and preterm birth; and 3) describe the socio-demographic characteristics of women who use marijuana postpartum and associations of use with postpartum depression and breastfeeding.

2. Materials and Methods

We analyzed data from the Pregnancy Risk Assessment Monitoring System (PRAMS), an on-going population-based surveillance system conducted by state and city (NYC) health departments in collaboration with the Centers for Disease Control and Prevention (CDC). In addition to linking to birth certificate information, PRAMS collects data on maternal experiences and behaviors before, during, and after pregnancy among women who delivered a live-born infant. In each participating site, birth certificates are used to select a stratified sample of recent mothers. Women are mailed a questionnaire from 2 to 9 months after delivery, and those who do not respond to repeated mailings are contacted by telephone. Detailed information about sampling and survey methodology can be found at www.cdc.gov/PRAMS. The PRAMS

protocol was approved by the Centers for Disease Control and Prevention's Institutional Review Board, and participating sites approved the study analysis plan.

Data on marijuana use is collected optionally by participating PRAMS states. During 2009-2011, three states (Alaska, Hawaii, and Vermont) and two states (Alaska and Vermont) collected optional information, respectively, on prenatal and postpartum marijuana use for at least two years. Each state included in the analyses met annual response rate thresholds of 65%. At the time of data collection, medical marijuana was legal in all three states, but recreational marijuana was not.

A total of 10,067 live births had information on maternal prenatal marijuana use. The sample was further restricted to singleton births and infants without birth defects who had complete information on birthweight and gestational age, yielding a final sample size of 9,013 live births for analysis of prenatal marijuana use. As only Alaska and Vermont collected postpartum marijuana use data, only 5,466 live births had postpartum marijuana use information. After applying the same restrictions (singleton births, infants without birth defects who had complete information on birthweight and gestational age), the final sample size for postpartum analyses was 4,969 births.

2.1. Measures

2.1.1. Marijuana Use. Marijuana use during pregnancy was defined as an affirmative response to smoking or using marijuana or hash during pregnancy. Postpartum marijuana use was defined as an affirmative response to smoking marijuana or hash since the new baby was born (available for Alaska and Vermont only). State-specific questions of marijuana use are available in Appendix Table 1[1].

[1] Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:...

2.1.2. Birth Outcomes and Healthcare Utilization. Infant birth weight in grams and gestational age in weeks using the clinical estimate were obtained from the birth certificate. Mean infant birthweight and gestational age were calculated and also categorized into low (<2500 g) and normal (≥2500 g) birthweight and preterm (<37 weeks) and term (≥37 weeks) births. NICU stay (yes/no) was assessed with the PRAMS question, "After your baby was born, was he or she put in an intensive care unit?" Length of hospital stay among infants admitted to the NICU (<1-2 days, 3-5 days, 6-14 days, and 14+ days) was assessed with the question, "After your baby was born, how long did he or she stay in the hospital?" Attendance at the 1-week infant check-up (yes/no) was assessed among infants with birth hospitalizations ≤ 5 days in length with the question, "Was your new baby seen by a doctor, nurse, or other health care worker for a one-week check-up after he or she was born?"

2.1.3. Socio-Demographic and Other Characteristics. Data source of demographic variables was chosen based on validity studies (Dietz et al., 2014; Dietz et al., 2015); in certain instances, data from both sources were used to minimize missing responses. Maternal age, race/ethnicity, marital status, and education were obtained from the birth certificate only. Insurance during pregnancy and annual household income were obtained from the PRAMS questionnaire only. Number of previous live births was determined from PRAMS and if missing, from the birth certificate. Participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) during pregnancy and trimester entry into prenatal care were obtained from the PRAMS questionnaire (Hawaii and Alaska) and from either birth certificate or the PRAMS questionnaire (for Vermont only, as they implemented the 2003 birth certificate revision). Pregnancies were categorized as intended (if women self-reported that they wanted to be pregnant sooner or then) or unintended (if women self-reported that they wanted to

be pregnant later or that they didn't want to be pregnant then or at any time in the future) from the PRAMS questionnaire. Self-reported stressful life events in the year before delivery were tallied and categorized none, 1-2, 3-5, and 6-13 (hospitalized family member, separation/divorce, moved, homeless, partner or respondent lost job, argued with partner more often, partner did not want pregnancy, bills that could not be paid, physical fight, partner or respondent went to jail, someone close had drinking or drug problem, someone close died). Women were categorized as binge drinkers if they self-reported having four or more alcoholic beverages in one sitting (defined as a two-hour time span) on at least one occasion during the last 3 months of pregnancy; drinkers if they indicated any amount of drinking during the last 3 months of pregnancy but not binge drinking; and non-drinkers if they did not drink during the last 3 months of pregnancy. Smoking during pregnancy was defined as self-report of smoking during the last three months of pregnancy if noted on either the PRAMS questionnaire or from report of smoking during pregnancy from the birth certificate. Physical abuse in the 12 months before pregnancy and during pregnancy, postpartum smoking, postpartum depressive symptoms, and duration of breastfeeding were obtained from the PRAMS questionnaire. Women who answered yes to "During the 12 months before you got pregnant with your new baby, did your husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?" and/or "During your most recent pregnancy, did your husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?" were categorized as experiencing physical abuse before, during, or in both time periods. Postpartum smoking was categorized by the number of cigarettes smoked daily after pregnancy. Responses to feeling down, depressed, or sad; hopeless; or slowed down by a substantial degree after childbirth were summed (never=1; rarely=2; sometimes=3; often=4; always=5) and categorized as having (sum of 10-15) or not having (sum of <10) postpartum

depressive symptoms. Breastfeeding was categorized into never; <8 weeks; and ≥8 weeks obtained from the PRAMS questionnaire.

2.2. Statistical Analysis

Prevalence of marijuana use during pregnancy and postpartum were estimated. Chi-square tests were conducted to assess the differential distribution of socio-demographic, alcohol and tobacco use, and health care utilization characteristics by marijuana use status during pregnancy and postpartum. T-tests were used to assess crude differences in mean infant birth weight and gestational age by marijuana use during pregnancy. Adjusted linear regression models were used to assess differences in mean infant birth weight and gestational age by marijuana use during pregnancy. The distribution of infant birthweights and gestational ages in this analysis matched national distributions. Separate multivariable logistic regressions were used to estimate the association of marijuana use during pregnancy and categorical infant birthweight, gestational age, and admission to the NICU. A sensitivity analyses were conducted excluding macrosomic births (>4000 grams); and including records with missing covariate information in the adjusted models. Variables included in adjusted models were based on a priori directed acyclic graphs and were assessed for collinearity.

Analyses were conducted in SUDAAN Version 11.0 to account for PRAMS' complex sampling survey design. Data are weighted for sample design, non-response, and non-coverage, and represent state-residents delivering live births in the respective states.

3. Results

In our sample, women responded to the PRAMS questionnaire an average 3.9 months after delivery. The overall weighted prevalence of marijuana use during pregnancy was 4.2% (95% CI: 3.8-4.7). State-specific estimates of marijuana use during pregnancy were 6.6% (95%

CI: 5.4-8.1) for Alaska, 5.5% (95% CI: 4.8-6.5) for Vermont, and 2.8% (95% CI: 2.3-3.4) for Hawaii (Table 1). Compared to nonusers, prenatal marijuana users were more likely to be ≤24 years; non-Hispanic white, not married, have <12 years of education, have Medicaid/IHS/Other insurance, be on WIC during pregnancy, report an annual household income <$20,000, have no previous live births, enter prenatal care in the third trimester or have no prenatal care, and have an unintended pregnancy that resulted in this live birth (Table 1). Marijuana users during pregnancy also reported a higher number of stressors in the year before birth (≥3 stressors) and significantly higher prevalence of smoking cigarettes during the last 3 months of pregnancy (43.0% vs. 12.4%), binge drinking during the last 3 months of pregnancy (2.9% vs. 1.0%), drinking alcohol but not binging during the last 3 months of pregnancy (14.2% vs. 6.8%), and physical abuse only before pregnancy (8.1% vs. 1.3%), only during pregnancy (3.2% vs. 0.7%) and both before and during pregnancy (9.6% vs. 1.5%) compared to nonusers (Table 1). There was no significant difference in prevalence of low birth weight infant (5.9% vs. 5.3%), preterm infant (7.2% vs. 7.1%), term low birth weight infant (2.5% vs. 2.0%), and attendance at 1-week infant check-up compared to nonusers (91.4% vs. 93.7%) among women who reported marijuana use during pregnancy and nonusers (p's >0.05) (Table 1).

The unadjusted mean birthweight of infants born to prenatal marijuana users was significantly lower than infants of nonusers (-69.3 g; p=0.01) (Table 2). In adjusted models controlling for socio-demographics, prenatal care initiation, pre-birth stress, pregnancy intention, physical abuse, alcohol use during pregnancy, state and year, the association was significant (-61.0g among users vs. non-users; p=0.036; data not shown). However, when cigarette smoking was added to the adjusted model, the association was no longer significant. When we examined

mean gestational age in weeks, there were no differences observed in either unadjusted or adjusted models by prenatal marijuana status.

In categorical models, there was no difference in prevalence of low birthweight infant (5.9% vs. 5.3%), preterm infant (7.2% vs. 7.1%), term low birth weight infant (2.5% vs. 2.0%), and attendance at 1-week infant check-up compared to nonusers (91.4% vs. 93.7%) among women who reported marijuana use during pregnancy and nonusers (data not shown). Sensitivity analysis that excluded macrosomic infants resulted in similar prevalences and non-significant findings for adjusted models on the association between marijuana use during pregnancy and infant outcomes.

Marijuana users had a significantly lower proportion of infants who went to the NICU (6.0% vs. 8.2%, p=0.022) compared to nonusers (Table 1), but there was no difference after controlling for covariates (data not shown). There were no observed differences between prenatal marijuana use status and infant length of stay among infants admitted to NICU (p=0.38) (Table 1).

The overall weighted prevalence of marijuana use postpartum was 6.8% (95% CI: 6.0-7.6) in Alaska and Vermont combined. State-specific estimates of postpartum marijuana use were 6.8% (95%CI: 5.6-8.3) for Alaska and 6.7% (95%CI: 5.9-7.7) for Vermont (Table 3). The same subgroups that were more likely to use marijuana during pregnancy were more likely to use marijuana postpartum. Postpartum marijuana users were significantly more likely to smoke cigarettes postpartum (48.7% vs. 20.3%; p<0.001), experience postpartum depressive symptoms (14.0% vs. 9.0%; p=0.03) and breastfeed for <8 weeks (34.9% vs. 18.1%; p<0.001) (Table 3).

4. Discussion

Reported marijuana use during pregnancy ranged from 2.8% (Hawaii) to 6.6% (Alaska). Although the overall prevalence of marijuana use during pregnancy was low, subgroups with higher prevalence include younger women, women with <12 years of education, and those who initiated prenatal care late. As of November 2017, marijuana is legalized in 29 states and D.C. for medical use and 8 states and D.C. for recreational use. As of the 2009-2011 PRAMS data collection, all three states in our analyses had legalized medical marijuana; Alaska passed recreational marijuana legislation in 2014. It is unclear how legalization impacts marijuana use among pregnant women. Although states with legalized medical marijuana have higher rates of marijuana use among the general population, it is unclear whether this association is causal (Cerda et al., 2012).

Infants born to prenatal marijuana users had significantly lower average birthweights than nonusers; however, the association did not remain significant after adjustment for cigarette smoking. Further, we did not observe significant effects of marijuana use during pregnancy and preterm birth or healthcare utilization, similar to null findings from a contemporary retrospective clinic cohort (Mark et al., 2016). However, a meta-analysis of seven observational studies examining associations of marijuana use and infant birthweight, adjusting for cigarette smoking, found heterogeneity in outcomes based on frequency of marijuana use; women using more than 4 times a week had infants born with a 131g reduction in mean birth weight (English et al., 1997). The frequency of marijuana use was not captured on PRAMS, so we were unable to assess whether frequency or dosage of use has differential effects on birth outcomes.

Although there is limited evidence of adverse infant outcomes related to perinatal marijuana use, learning and development impairments in adolescents have been linked to in utero exposure (Campolongo et al., 2009). Thus, the American College of Obstetricians and

Gynecologists (ACOG) recommends that pregnant women or those contemplating pregnancy be encouraged to discontinue marijuana use (American College of Obstetricians and Gynecologists Committee On Obstetric Practice, 2015). Although one study found higher marijuana use among pregnant women reporting severe nausea (Roberson and Hurwitz, 2014), OB/GYNs are discouraged from prescribing marijuana for medicinal purposes. Prenatal marijuana users were more likely to use alcohol and tobacco than non-marijuana users in our study; a finding similar to other studies (Ko et al., 2015). As the relationship between marijuana and birth and developmental outcomes is still being clarified, marijuana should be included as part of a providers' comprehensive substance use screen. Similarly, since cannabis can be detected in breast milk, and it is unknown whether this exposure is safe for infant health, cessation of marijuana use by women who are breastfeeding should be encouraged (Reece-Stremtan and Marinelli, 2015).

Use of PRAMS data is a strength of this study. As a large population-based sample, PRAMS is the only surveillance system that collects state-specific data on experiences before, during, and after pregnancy. Additionally, PRAMS survey data is linked with a birth certificate, minimizing recall bias on gestational age and birthweight variables. Although marijuana data are, at present, only optionally collected by states, this analysis uses the most recent comprehensive data available on prenatal and postpartum marijuana use.

This study has a few limitations. First, marijuana use was self-reported and likely an underestimate of the true prevalence due to social reporting bias. If underreporting did occur, then misclassification of exposure status would bias results toward the null. Additionally, the PRAMS questions asked about smoking or general use of marijuana; we were unable to evaluate other routes of administration (e.g., edibles, liquid) or frequency of use. Third, results are not

generalizable outside of the study states or to women who have not delivered a live birth. Finally, approximately 10% of our sample was excluded in the adjusted models due to missing covariates. Excluded individuals were not different from marijuana use status but were different by age, marital status, education, parity, stress, smoking, and pregnancy intention. Sensitivity analyses that included missing in the adjusted models did not change observed estimates between outcomes and marijuana use.

4.1. Conclusion

These analyses, limited to three states during a three-year period, indicated that prenatal and postpartum marijuana use is associated with co-use of other substances, including tobacco and alcohol, known teratogens. Additionally, postpartum use is associated with depressive symptoms and shorter breastfeeding duration. However, marijuana use during pregnancy was not independently associated with infant birth weight or gestational age, after controlling for confounding. As ACOG recommends, clinicians should screen for marijuana use as part of a comprehensive substance use screening. Surveillance of marijuana use among pregnant and postpartum women is critical to better understanding the relationship of marijuana use with birth outcomes, postpartum depression and breastfeeding, as well as infant neurodevelopment outcomes.

Authors Disclosures

Contributors

JK conceptualized manuscript and data analysis; wrote and edited drafts. VT assisted with conceptualization of the manuscript, data analysis, writing; and reviewed drafts of the

manuscript. JB assisted in data analysis and reviewed drafts of the manuscript. DH reviewed and edited drafts of the manuscript. JD reviewed and edited drafts of the manuscript. KPH provided analytic suggestions; and reviewed and edited drafts of the manuscript. All authors have approved the final manuscript.

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Conflict of Interest

No conflict declared.

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References

Azofeifa, A., Mattson, M.E., Schauer, G., McAfee, T., Grant, A., Lyerla, R., 2016. National estimates of marijuana use and related indicators - National Survey on Drug Use and Health, United States, 2002-2014. MMWR Surveill. Summ. 65, 1-28.

Brown, Q.L., Sarvet, A.L., Shmulewitz, D., Martins, S.S., Wall, M.M., Hasin, D.S., 2017. Trends in marijuana use among pregnant and nonpregnant reproductive-aged women, 2002-2014. JAMA 317, 207-209.

Campolongo, P., Trezza, V., Palmery, M., Trabace, L., Cuomo, V., 2009. Developmental exposure to cannabinoids causes subtle and enduring neurofunctional alterations. Int. Rev. Neurobiol. 85, 117-33.

Cerda, M., Wall, M., Keyes, K.M., Galea, S., Hasin, D., 2012. Medical marijuana laws in 50 states: Investigating the relationship between state legalization of medical marijuana and marijuana use, abuse and dependence. Drug Alcohol Depend. 120, 22-7.

Conner, S.N., Bedell, V., Lipsey, K., Macones, G.A., Cahill, A.G., Tuuli, M.G., 2016. Maternal marijuana use and adverse neonatal outcomes: A systematic review and meta-analysis. Obstet. Gynecol. 128, 713-23.

Dietz, P., Bombard, J., Mulready-Ward, C., Gauthier, J., Sackoff, J., Brozicevic, P., Gambatese, M., Nyland-Funke, M., England, L., Harrison, L., Taylor, A., 2014. Validation of self-reported maternal and infant health indicators in the Pregnancy Risk Assessment Monitoring System. Matern. Child Health J. 18, 2489-98.

Dietz, P., Bombard, J., Mulready-Ward, C., Gauthier, J., Sackoff, J., Brozicevic, P., Gambatese, M., Nyland-Funke, M., England, L., Harrison, L., Farr, S., 2015. Validation of selected

items on the 2003 U.S. standard certificate of live birth: New York City and Vermont. Public Health Rep. 130, 60-70.

Ebrahim, S.H., Gfroerer, J., 2003. Pregnancy-related substance use in the United States during 1996-1998. Obstet. Gynecol. 101, 374-9.

Governing, 2018. The states and localities. State marijuana laws in 2018. http://www.governing.com/gov-data/state-marijuana-laws-map-medical-recreational.html. Last accessed January 8, 2018.

Gunn, J.K., Rosales, C.B., Center, K.E., Nunez, A., Gibson, S.J., Christ, C., Ehiri, J.E., 2016. Prenatal exposure to cannabis and maternal and child health outcomes: a systematic review and meta-analysis. BMJ Open 6, e009986.

Hatch, E.E., Bracken, M.B., 1986. Effect of marijuana use in pregnancy on fetal growth. Am. J. Epidemiol. 124, 986-93.

Hayatbakhsh, M.R., Flenady, V.J., Gibbons, K.S., Kingsbury, A.M., Hurrion, E., Mamun, A.A., Najman, J.M., 2012. Birth outcomes associated with cannabis use before and during pregnancy. Pediatr. Res. 71, 215-9.

Ko, J.Y., Farr, S.L., Tong, V.T., Creanga, A.A., Callaghan, W.M.,2015. Prevalence and patterns of marijuana use among pregnant and nonpregnant women of reproductive age. Am. J. Obstet. Gynecol. 213, 201.

Mark, K., Desai, A., Terplan, M., 2016. Marijuana use and pregnancy: prevalence, associated characteristics, and birth outcomes. Arch. Womens Ment. Health 19, 105-11.

Metz, T.D., Stickrath, E.H.,2015. Marijuana use in pregnancy and lactation: A review of the evidence. Am. J. Obstet. Gynecol. 213, 761-78.

National Academies of Sciences, Engineering, and Medicine. 2017. The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research. English, D.R., Hulse, G.K., Milne, E., Holman, C.D., Bower C.I.,1997. Maternal cannabis use and birth weight: a meta-analysis. Addiction 92 1553-60.

Reece-Stremtan, S., Marinelli, K.A.,2015. ABM clinical protocol #21: guidelines for breastfeeding and substance use or substance use disorder, revised 2015. Breastfeed. Med. 10, 135-41.

Roberson, E.K., Hurwitz, E.L., 2014. Prescription drug use during and immediately before pregnancy in Hawai'i-findings from the Hawai'i Pregnancy Risk Assessment Monitoring System, 2009-2011. Hawaii J. Med. Public Health 73, 382-6.

van Gelder, M.M., Reefhuis, J., Caton, A.R., Werler, M.M., Druschel, C.M., Roeleveld, N., 2010. Characteristics of pregnant illicit drug users and associations between cannabis use and perinatal outcome in a population-based study. Drug Alcohol Depend. 109, 243-7.

Warshak, C.R., Regan, J., Moore, B., Magner, K., Kritzer, S., Van Hook, J., 2015. Association between marijuana use and adverse obstetrical and neonatal outcomes. J. Perinatol. 35, 991-5.

Zuckerman, B., Frank, D.A., Hingson, R., Amaro, H., Levenson, S.M., Kayne, H., Parker, S., Vinci, R., Aboagye, K., Fried, L.E., Cabral, H., Timperi, R., Bauchner, H., 1989. Effects maternal marijuana and cocaine use on fetal growth. N. Engl. J. Med. 320, 762-8.

Table 1. Characteristics of the sample by prenatal marijuana use status[a]

	Unweighted N	Marijuana Use During Pregnancy % (95% CI)
Overall	9,013	4.2 (3.8-4.7)
State		
Alaska	2,003	6.6 (5.4-8.1)
Hawaii	4,051	2.8 (2.3-3.4)
Vermont	2,959	5.5 (4.8-6.5)

	Total % (95% CI)	Prenatal marijuana user (unweighted n=463) % (95% CI)	Nonuser (unweighted n=8,549) % (95% CI)
Maternal age (years)[b]			
<18	2.2 (1.9-2.7)	5.4 (3.1-9.3)	2.1 (1.7-2.5)
18-24	30.5 (29.3-31.8)	47.3 (41.7-53.1)	29.8 (28.5-31.0)
25-29	28.2 (27.0-29.4)	20.8 (17.0-25.2)	28.5 (27.3-29.8)
30-34	23.7 (22.6-24.8)	16.7 (12.9-21.3)	24.0 (22.9-25.1)
≥35	15.3 (14.4-16.3)	9.7 (6.7-13.9)	15.6 (14.7-16.6)
Race/ethnicity[b]			
Non-Hispanic white	44.4 (43.3-45.5)	54.3 (48.6-59.9)	44.0 (42.8-45.1)
Other	55.6 (54.5-56.7)	45.7 (40.1-51.4)	56.0 (54.9-57.2)
Marital status[b]			
Not married	39.1 (37.8-40.3)	71.8 (66.5-76.6)	37.6 (36.3-38.9)
Married	60.9 (59.7-62.2)	28.2 (23.4-33.5)	62.4 (61.1-63.7)
Education[b]			
<12 Years	9.1 (8.4-9.9)	19.8 (15.3-25.2)	8.6 (7.9-9.4)
12 Years	37.7 (36.4-39.0)	41.8 (36.3-47.5)	37.5 (36.2-38.8)
>12 Years	53.2 (51.9-54.5)	38.4 (33.2-44.0)	53.9 (52.5-55.2)
Health insurance coverage during pregnancy[b,c]			
Private/Military	62.9 (61.6-64.1)	30.5 (25.4-36.1)	64.3 (63.0-65.5)
Medicaid/IHS/Other	35.3 (34.1-36.5)	67.9 (62.3-73.1)	33.8 (32.6-35.1)
None	1.9 (1.5-2.3)	1.6 (0.7-3.5)	1.9 (1.5-2.3)
Prenatal WIC enrollment[b]			
Yes	46.8 (45.5-48.1)	69.0 (63.5-73.9)	45.8 (44.5-47.2)
No	53.2 (51.9-54.5)	31.0 (26.1-36.5)	54.2 (52.8-55.5)
Household income[b]			
<$20,000	31.2 (30.0-32.5)	54.6 (48.8-60.4)	30.2 (28.9-31.5)
$20,000-49,999	32.5 (31.2-33.8)	30.9 (25.7-36.6)	32.6 (31.2-33.9)
≥$50,000	36.3 (35.0-37.6)	14.5 (10.7-19.3)	37.3 (35.9-38.6)
Number of previous live births[b]			
1+	55.5 (54.2-56.8)	48.3 (42.6-54.0)	56.1 (54.8-57.5)
None	44.5 (43.2-45.8)	51.7 (46.0-57.4)	43.9 (42.5-45.2)
Prenatal care initiation[b]			
First trimester	85.3 (84.3-86.2)	76.0 (70.7-80.7)	85.7 (84.7-86.6)
Second trimester	12.3 (11.5-13.2)	16.7 (12.8-21.5)	12.2 (11.3-13.1)
Third trimester or none	2.3 (2.0-2.8)	7.3 (4.7-11.1)	2.1 (1.8-2.5)
Pregnancy intention[b]			
Intended	56.6 (55.3-58.0)	43.6 (38.0-49.3)	57.2 (55.8-58.6)

Unintended	43.4 (42.0-44.7)	56.4 (50.7-62.0)	42.8 (41.4-44.2)
Number of stressful life events 12 months before baby was born[b]			
None	32.5 (31.2-33.8)	11.2 (8.1-15.4)	33.4 (32.1-34.7)
1-2	41.7 (40.4-43.0)	28.3 (23.5-33.6)	42.3 (40.9-43.6)
3-5	20.9 (19.8-22.0)	35.6 (30.2-41.3)	20.2 (19.1-21.3)
6-13	5.0 (4.4-5.6)	25.0 (20.1-30.5)	4.1 (3.6-4.7)
Cigarette smoking during pregnancy[b]			
Yes	13.7 (12.8-14.6)	43.0 (37.4-48.8)	12.4 (11.6-13.3)
No	86.3 (85.4-87.2)	57.0 (51.2-62.6)	87.6 (86.7-88.4)
Drinking during last 3 months of pregnancy[b]			
No alcohol use	91.9 (91.2-92.5)	82.9 (78.3-86.8)	92.3 (91.6-92.9)
Any alcohol use but no binge drinking	7.1 (6.5-7.7)	14.2 (10.7-18.5)	6.8 (6.2-7.4)
Binge drinking	1.0 (0.8-1.3)	2.9 (1.4-5.7)	1.0 (0.8-1.3)
Physical abuse 12 months before or during pregnancy[b]			
None	95.7 (95.1-96.2)	79.1 (73.6-83.7)	96.4 (95.9-96.9)
Before pregnancy only	1.6 (1.3-1.9)	8.1 (5.2-12.3)	1.3 (1.0-1.6)
During pregnancy only	0.8 (0.6-1.1)	3.2 (1.4-7.2)	0.7 (0.5-1.0)
During and before pregnancy	1.9 (1.5-2.3)	9.6 (6.7-13.7)	1.5 (1.2-1.9)
Low birthweight infant			
Yes	5.3 (5.1-5.5)	5.9 (4.8-7.2)	5.3 (5.1-5.5)
No	94.7 (94.5-94.9)	94.1 (92.8-95.2)	94.7 (94.5-94.9)
Preterm infant			
Yes	7.1 (6.6-7.6)	7.2 (5.1-9.9)	7.1 (6.5-7.6)
No	92.9 (92.4-93.4)	92.8 (90.1-94.9)	92.9 (92.4-93.5)
Term low birthweight infant			
Yes	2.0 (1.9-2.2)	2.5 (1.8-3.3)	2.0 (1.9-2.2)
No	98.0 (97.8-98.1)	97.5 (96.7-98.2)	98.0 (97.8-98.1)
Attendance at 1-week infant check-up			
Yes	93.6 (92.8-94.2)	91.4 (86.7-94.5)	93.7 (92.9-94.3)
No	6.4 (5.8-7.2)	8.6 (5.5-13.3)	6.3 (5.7-7.1)
NICU admission[b]			
Yes	8.1 (7.5-8.8)	6.0 (4.6-7.9)	8.2 (7.5-8.9)
No	91.9 (91.2-92.5)	94.0 (92.1-95.4)	91.8 (91.1-92.5)
Length of stay among NICU infants			
≤2 Days	21.1 (17.6-25.2)	16.7 (7.9-31.8)	21.3 (17.6-25.4)
3-5 Days	26.1 (22.3-30.3)	18.8 (9.5-33.7)	26.3 (22.4-30.7)
6-14 Days	29.7 (26.2-33.5)	36.6 (24.8-50.4)	29.5 (25.8-33.4)
>14 Days	23.1 (20.4-26.0)	27.9 (19.3-38.4)	22.9 (20.1-26.0)

CI: confidence interval, IHS: Indian Health Service

[a] Includes Alaska (2009-2010), Hawaii (2009-2011), and Vermont (2009-2011) (unweighted n=9,013).

[b] Significant differences using chi-square test, $p<0.05$.

[c] Military Insurance includes TRICARE, other military health insurance. Other includes state-specific State Children's Health Insurance Program or Children's Health Insurance Program.

Table 2. Unadjusted and adjusted linear regression results on birthweight and gestational age by marijuana use status during pregnancy[a]

	Birthweight (grams)					
	Mean birth weight (SE)	**Unadjusted mean difference (95% CI)[b]**	**P-value[c]**	**Mean birth weight (SE)**	**Adjusted mean difference (95% CI)[d]**	**P-value[e]**
Nonusers (unweighted n=8,550)	3361.0 (6.4)	Ref	Ref	3364.3 (6.7)	Ref	Ref
Marijuana users (unweighted n=463)	3291.7 (26.4)	-69.3 (-122.6, -16.0)	0.011	3328.2 (28.8)	-36.1 (-93.9, 21.8)	0.222
	Gestational age (weeks)					
	Mean gestational age (SE)	**Unadjusted mean difference (95% CI)[b]**	**P-value[c]**	**Mean gestational age (SE)**	**Adjusted mean difference (95% CI)[d]**	**P-value[e]**
Nonusers (unweighted n=8,550)	38.8 (0.02)	Ref	Ref	38.8 (0.02)	Ref	Ref
Marijuana users (unweighted n=463)	39.0 (0.09)	0.15 (-0.03, 0.33)	0.112	38.9 (0.10)	0.12 (-0.08, 0.31)	0.236

SE: Standard error

[a] Includes Alaska (2009-2010), Hawaii (2009-2011), and Vermont (2009-2011) (unweighted n=9,013)

[b] Mean difference using non-user as referent category

[c] *P*-value of t-statistic to assess statistical significance of mean difference using nonuser as referent category

[d] Mean difference using non-user as referent category, adjusted for age, race/ethnicity, marital status, education, number of previous live births, trimester of prenatal care initiation, pregnancy intention, pre-birth stressful life events, cigarette use during pregnancy, binge drinking during pregnancy, physical abuse, state, and infant birth year

[e] *P*-value of t-statistic to assess statistical significance of mean difference using nonuser as referent category, adjusted for previous described covariates.

Table 3. Prevalence of postpartum marijuana status by selected covariates[a]

	Unweighted N	Marijuana Use After Pregnancy % (95% CI)
Overall	4,969	6.8 (6.0-7.6)
State		
Alaska	2,007	6.8 (5.6-8.3)
Vermont	2,962	6.7 (5.9-7.7)

	Total % (95% CI)	Postpartum marijuana user (unweighted n=345) % (95% CI)	Nonuser (unweighted n=4,624) % (95% CI)
Maternal age (years)[b]			
<18	2.5 (2.0-3.2)	6.9 (3.9-12.1)	2.2 (1.7-2.8)
18-24	30.4 (28.9-32.0)	47.4 (41.0-53.9)	29.2 (27.7-30.8)
25-29	29.2 (27.7-30.7)	25.8 (20.6-31.7)	29.4 (27.9-31.0)
30-34	24.2 (22.8-25.6)	11.8 (8.7-15.7)	25.1 (23.6-26.6)
≥35	13.7 (12.7-14.8)	8.1 (5.3-12.0)	14.1 (13.0-15.2)
Race/ethnicity[b]			
Non-Hispanic white	74.3 (73.0-75.6)	68.2 (62.1-73.7)	74.8 (73.4-76.1)
Other	25.7 (24.4-27.0)	31.8 (26.3-37.9)	25.2 (23.9-26.6)
Marital status[b]			
Not married	38.1 (36.5-39.7)	36.1(34.5-37.7)	66.2 (59.9-72.0)
Married	61.9 (60.3-63.5)	63.9 (62.3-65.5)	33.8 (28.0-40.1)
Education[b]			
<12 Years	10.7 (9.7-11.8)	24.7 (19.3-31.2)	9.7 (8.7-10.8)
12 Years	33.0 (31.4-34.6)	39.9 (33.7-46.4)	32.5 (30.9-34.1)
>12 Years	56.3 (54.7-57.9)	35.4 (29.8-41.4)	57.8 (56.2-59.5)
Health insurance coverage during pregnancy[b,c]			
Private/Military	55.4 (53.7-57.0)	29.2 (23.6-35.4)	57.2 (55.6-58.9)
Medicaid/IHS/Other	41.9 (40.3-43.5)	69.6 (63.3-75.2)	39.9 (38.3-41.6)
None	2.7 (2.2-3.4)	1.3 (0.4-4.3)	2.8 (2.3-3.6)
Prenatal WIC enrollment[b]			
Yes	47.8 (46.2-49.5)	68.6 (62.3-74.3)	46.3 (44.7-48.0)
No	52.2 (50.5-53.8)	31.4 (25.7-37.7)	53.7 (52.0-55.3)
Annual household income[b]			
<$20,000	29.1 (27.6-30.6)	50.9 (44.2-57.5)	27.5 (26.0-29.1)
$20,000-49,999	31.5 (29.9-33.1)	28.7 (23.0-35.1)	31.7 (30.1-33.4)
≥$50,000	39.4 (37.8-41.1)	20.5 (15.5-26.5)	40.8 (39.1-42.5)
Number of previous live births[b]			
1+	56.3 (54.7-58.0)	49.4 (43.0-55.9)	56.8 (55.1-58.5)
None	43.7 (42.0-45.3)	50.6 (44.1-57.0)	43.2 (41.5-44.9)
Prenatal care initiation			
First trimester	84.5 (83.2-85.7)	82.2 (76.5-86.8)	84.6 (83.3-85.9)
Second trimester	12.8 (11.7-14.0)	14.8 (10.7-20.1)	12.7 (11.5-13.9)

Third trimester or none	2.7 (2.2-3.4)	3.0 (1.2-7.1)	2.7 (2.2-3.3)
Pregnancy intention[b]			
Intended	60.9 (59.3-62.6)	51.7 (45.2-58.2)	61.6 (59.9-63.3)
Unintended	39.1 (37.4-40.7)	48.3 (41.8-54.8)	38.4 (36.7-40.1)
Number of stressful life events 12 months before baby was born[b]			
None	30.3 (28.8-31.9)	13.7 (10.2-18.2)	31.5 (29.9-33.2)
1-2	42.5 (40.8-44.1)	33.4 (27.5-39.8)	43.1 (41.4-44.8)
3-5	21.0 (19.6-22.4)	34.5 (28.3-41.1)	20.0 (18.7-21.4)
6-13	6.2 (5.4-7.1)	18.5 (13.8-24.3)	5.4 (4.6-6.3)
Cigarette smoking after pregnancy[b]			
Yes	22.2 (20.9-23.6)	48.7 (42.3-55.1)	20.3 (19.0-21.7)
No	77.8 (76.4-79.1)	51.3 (44.9-57.7)	79.7 (78.3-81.0)
Drinking during last 3 months of pregnancy[b]			
No alcohol use	90.4 (89.5-91.3)	84.8 (79.9-88.7)	90.8 (89.8-91.7)
Any alcohol use but no binge drinking	8.7 (7.8-9.6)	12.3 (9.1-16.5)	8.4 (7.6-9.3)
Binge drinking	0.9 (0.6-1.3)	2.9 (1.1-7.1)	0.8 (0.5-1.2)
Physical abuse 12 months before or during pregnancy[b]			
None	95.3 (94.5-96.0)	88.6 (84.0-92.1)	95.7 (94.9-96.4)
Before pregnancy only	1.8 (1.4-2.3)	3.4 (1.8-6.5)	1.6 (1.2-2.2)
During pregnancy only	0.9 (0.6-1.3)	1.9 (0.9-4.0)	0.8 (0.5-1.2)
During and before pregnancy	2.1 (1.6-2.6)	6.0 (3.5-10.0)	1.8 (1.4-2.4)
Postpartum Depression[b]			
Yes	9.4 (8.5-10.4)	14.1 (10.2-19.1)	9.0 (8.1-10.0)
No	90.6 (89.6-91.5)	85.9 (80.9-89.8)	91.0 (90.0-91.9)
Breastfeeding[b]			
Never Breastfed	9.7 (8.7-10.7)	11.3 (7.8-16.0)	9.6 (8.6-10.6)
Breastfed <8 Weeks	19.2 (17.9-20.5)	34.9 (28.7-41.8)	18.0 (16.7-19.4)
Breastfed ≥8 Weeks	71.2 (69.6-72.7)	53.8 (47.1-60.4)	72.4 (70.8-73.9)

CI: confidence interval; IHS: Indian Health Service

[a] Includes Alaska (2009-2010) and Vermont (2009-2011); (unweighted n=4,969)

[b] Significant differences using chi-square test, $p<.05$.

[c] Military Insurance includes TRICARE, other military health insurance. Other includes state-specific State Children's Health Insurance Program or Children's Health Insurance Program.