THE ROLE OF MATERNAL STRESS IN SINGLE
AND POLYSUBSTANCE USE DURING PREGNANCY

by

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ABSTRACT

Tobacco, alcohol, and cannabis are the most commonly used substances during pregnancy. Prenatal substance use is often associated with significant life stressors related to psychiatric comorbidities, financial and trauma-related personal challenges. The purpose of this study was to understand the demographic and sociologic factors associated with single (tobacco, cannabis, and alcohol) and polysubstance use during pregnancy using the Colorado Pregnancy Risk Assessment Monitoring System (PRAMS). A sample of 6,724 births representing 308,461 births was analyzed. Confirmatory factor analysis was conducted to validate the latent factor structures of socioeconomic status and four types of stress. Structural equation modeling was then used to understand the association between latent stress factors and type of substance use. Younger maternal age and increased traumatic stress were associated with cannabis use. Younger maternal age, decreased relationship stress, and increased traumatic stress were associated with tobacco use. Decreased relationship stress and increased traumatic stress were associated with polysubstance use. Increased maternal age and socioeconomic stress were associated with alcohol use, indicating that stress does not play a role in prenatal alcohol use. Traumatic stress was the only type of stressor that was significantly associated with cannabis, tobacco, and polysubstance use, and is a key factor to consider when designing interventions for substance use among pregnant people.

The form and content of this abstract are approved. I recommend its publication.

Approved: Tessa Crume

Iisa, Erika Josefiina (MS, Epidemiology Program)
The Role Of Maternal Stress In Single And Polysubstance Use During Pregnancy
Thesis directed by Associate Professor Tessa Crume
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CHAPTER I
INTRODUCTION

Specific Aims

Tobacco, alcohol, and marijuana are the substances used most commonly during pregnancy.\(^1\) Approximately 10.2\% of pregnant people consume alcohol,\(^2\) and 12.3\% use tobacco.\(^3\) Estimates are harder to obtain for cannabis, but range from 4.8\%\(^4\) to 7.1\%.\(^5\) Evidence is emerging that people who use a single substance during pregnancy are more likely to engage in polysubstance use, and the rates of polysubstance use among pregnant people are particularly high for cannabis and tobacco, with estimates as high as 85\% of those who used cannabis in pregnancy also using tobacco.\(^6\) The prevalence of the co-use of cannabis and tobacco has been estimated to be as high as 9.0\%.\(^5\) In turn, pregnant people who co-use tobacco and cannabis are more likely to engage in heavy or binge drinking compared to than people who use either substance in isolation.\(^5\) Sparse literature exists to understand demographic and sociologic factors associated with maternal polysubstance use during pregnancy. Most clinical and public health interventions to reduce substance use by pregnant people focus on one substance, thus research is need to understand the prevalence and risk factors associated with polysubstance use.

The goal of this project was to understand the demographic and sociologic factors associated with single (tobacco, cannabis, and alcohol) and polysubstance use during pregnancy among people who delivered a live born infant between 2014 and 2018 using the Colorado Pregnancy Risk Assessment Monitoring System (PRAMS). Results will inform clinical and public health interventions that consider polysubstance use in the context of maternal stress. My primary aim was to determine factor structures of socioeconomic status and different types of stress (financial, emotional, relationship, and traumatic) that are associated with single and
polysubstance use during pregnancy. I hypothesized that lower maternal education, lower socioeconomic status, and increased financial, traumatic, relationship, and emotional stress would be associated with single and polysubstance use compared to no substance use and these same factors will be more pronounced for polysubstance use compared to single substance use.
CHAPTER II
RESEARCH STRATEGY

Significance

By all accounts, prenatal substance use is a critical public health concern that is linked to several harmful maternal and fetal consequences. The most frequently used substance by pregnant people is tobacco, followed by alcohol and cannabis. Polysubstance use is often complicated by significant life stressors related to psychiatric comorbidities, financial and trauma-related personal challenges that compound the deleterious pregnancy outcomes for both mother and child.

Single substance use during pregnancy

Tobacco use

Based on data collected from 40 states and jurisdictions participating in the Pregnancy Risk Assessment Monitoring System (PRAMS), the prevalence of tobacco use during pregnancy in the U.S. decreased from 13.3% in 2000 to 12.3% in 2010. Data from U.S. birth certificates estimates a much lower prevalence of any tobacco use during pregnancy at 7.1%, and found the prevalence of high intensity smoking to be 4.2% in the first trimester, 3.2% in the second trimester, and 2.7% in the third trimester. Young maternal age is a risk factor for prenatal tobacco use. 23.0% of pregnant adolescents reported using tobacco, compared to 14.9% of pregnant adults. People who used tobacco during pregnancy were more likely to be non-Hispanic white compared to non-Hispanic black or Hispanic. People who use tobacco during pregnancy are less likely to have graduated from high school, and more likely to live in poverty, rely upon Medicaid as insurance during pregnancy, and be enrolled in WIC.

Alcohol use
The prevalence of prenatal alcohol use in the United States is approximately 10.2%, with 3.1% of people reporting that they engaged in binge-drinking. Despite clinical and public health efforts to educate mothers of the risk to the developing fetus, prenatal alcohol use has remained high. Previous research has shown that pregnant people who use alcohol during pregnancy differ in characteristics than those who use other substances. Prenatal alcohol use is associated with older maternal age, higher levels of education, and higher socioeconomic status than their non-drinking counterparts.

Cannabis use

Public health concern about prenatal cannabis use is increasing, as both the potency of cannabis has increased in the past twenty years, and the public perception of the deleterious effect of cannabis use is decreasing. The prevalence of people who use cannabis during pregnancy can be hard to ascertain as it is still an illegal substance at the federal level despite legalization in many states. Maternal self-report of cannabis use during pregnancy is low compared to estimates from universal toxicology screening results, with one study reporting an increase in prevalence from 4.2% with self-report to 7.1% by toxicology. The prevalence of cannabis use among pregnant people has been shown to decrease across trimesters, with one study finding a drop from 4.8% to 2.4% from the first trimester to the third trimester, and another found only 1.9% of all patients tested positive for cannabis at delivery. People who use cannabis during pregnancy are more likely to be younger, have a lower level of education, and rely upon Medicaid as the insurance source for pregnancy care more than their non-using counterparts.
**Polysubstance use during pregnancy**

People who use tobacco during pregnancy are more likely to also consume alcohol\(^{10,12,20}\) and polysubstance use of alcohol and tobacco is more common in those who use cannabis\(^{6,18,21,22}\). The prevalence of self-reported co-use of tobacco and cannabis among pregnant people in the U.S. from the NSDUH and was 3.3% in 2005-14, with only 1.0% reporting use of cannabis alone, and 13.3% reporting use of tobacco alone\(^{11}\). People who use cannabis and tobacco are more likely to have less than a high school education, be younger, and live in poverty compared to pregnant people who use no substances\(^{5,9,11}\). People who co-used cannabis and tobacco during pregnancy were more likely to engage in heavy or binge drinking than those who used tobacco or cannabis in isolation of other substances\(^{5}\).

**Innovation**

This analysis fills a necessary gap in the literature by providing a population level comparison of the factors associated with different types of single substance use and polysubstance use. In addition, this study uses structural equation modeling to provide more accurate characterization of the role of stress and socioeconomic status on substance use during pregnancy.

**Approach**

**Study population**

The study population derives from PRAMS, a population-based surveillance system of health behaviors and maternal experiences before, during, and after pregnancy administered to people who delivered a live-born infant. PRAMS is conducted by the Colorado Department of Public Health and Environment in collaboration with the Center for Disease Control, and survey selection is conducted monthly through a stratified random sample. Stratification by regions...
occurs based on the Denver metro area, other metro areas, and rural areas. Every month, approximately 150 individuals are chosen from all eligible birth certificates from births that occurred two to four months prior. Mothers who were less than fifteen years-old, are Colorado residents but gave birth out of state, are non-residents, or had multiple births greater than three are excluded. For those mothers who had multiple births of three or less, only one baby is selected. PRAMS surveys are administered in English or Spanish, and can be completed by written survey received in the mail, or over the phone. The survey data is linked to birth certificates, which provides additional information about birth outcomes and maternal characteristics. In order to be representative of the state-level population, the sample data is then weighted by sampling probabilities, nonresponse, and non-coverage.

**Study Design**

My specific aim was evaluated using a cross-sectional study design and analysis based on PRAMS data from 2014 through 2018.

**Core study variables**

All variables were derived from questions that were asked during the entire study period from 2014 to 2018, and the wording of the questions has not changed, with the exception of the question regarding intimate partner violence. This change and how it will be addressed is noted below.

*Definition of substance use:*

**Substance use** will split into four categorical variables, with no substance use serving as the reference group.
• **Tobacco use** was determined from the number of cigarettes consumed in an average week during the last three months of pregnancy. Any amount of tobacco use during the last three months of pregnancy was considered tobacco use.

• **Alcohol use** was determined from the number of alcoholic drinks consumed in an average week during the last three months of pregnancy. Any amount of alcohol use during the last three months of pregnancy was considered alcohol use.

• **Cannabis use** was determined from the yes or no questions that ask about the use of marijuana or hash in any form in the first three months of pregnancy, the last three months of pregnancy, or at any time during the most recent pregnancy. Any amount of cannabis use during the first three or last three months of pregnancy, or any cannabis use at any time during pregnancy was defined as cannabis use.

• **Polysubstance use** was defined as a combination of tobacco, alcohol, or cannabis use. Any endorsement of a combination of tobacco, alcohol, or cannabis was considered polysubstance use.

*Covariates*

• Maternal age (continuous)

*Socioeconomic status related items*

• Medicaid status (categorical): Yes/No
  
  o Insurance type at any point during pregnancy was determined from PRAMS based on the questions “During your most recent pregnancy, what kind of health insurance did you have for your prenatal care?” and “What kind of health insurance did you have to pay for your delivery?” Respondents who answered Medicaid to either question were categorized as having Medicaid.
• WIC status (categorical): Yes or No

• Percent of the federal poverty level (categorical): <100%, 100 to <150%, 150 to <200%, 200 to <250%, and 250% or greater
  
  o Percent of the federal poverty level was determined by dividing the household income as obtained from PRAMS by the U.S. Department of Health and Human Services threshold for poverty for the number of people in the household.25

• Maternal education (categorical): less than high school, high school diploma or GED, greater than high school

*Stress-related items:*

• Stress (Categorical): Yes or No, will be used in factor analysis to determine latent constructs
  
  o PRAMS stress items will be categorized into latent constructs. As done in previous research, the item “I moved to a new address” will not be included as this can be either a positive or negative experience.26 Respondents were asked if they had experienced any of the following stress in the 12 months before their baby was born.

  ▪ “A close family member was very sick and had to go to the hospital”
  ▪ “I got separated or divorced from my husband or partner”
  ▪ “I was homeless or had to sleep outside, in a car, or in a shelter”
  ▪ “My husband or partner lost their job”
  ▪ “I lost my job even though I wanted to go on working”
  ▪ “My husband, partner, or I had a cut in work hours or pay”
• “I was apart from my husband or partner due to military deployment or extended work-related travel”
• “I argued with my husband or partner more than usual”
• “My husband or partner said they didn’t want me to be pregnant”
• “I had problems paying the mortgage, or other bills”
• “My husband, partner, or I went to jail”
• “Someone very close to me had a problem with drinking or drugs”
• “Someone very close to me died”

• Intimate Partner Violence (categorical): Yes or No
  o Intimate partner violence during pregnancy was determined by the PRAMS question “During your most recent pregnancy, did any of the following people push, hit, slap, kick, choke, or physically hurt you in any other way?”.
  o Phase 7 (2014-16) PRAMS asks about a husband or partner perpetuating violence, while Phase 8 (2016-18) PRAMS asks specifically about current or ex-husband or partner. To be consistent, any endorsement of intimate partner violence regardless of the person will be considered as having experienced intimate partner violence.

• Food insecurity (categorical): Yes or No
  o “During the 12 months before your new baby was born, did you ever eat less than you felt you should because there wasn’t enough money to buy food?”
Data analysis

Descriptive statistics

The prevalence of each type of single and polysubstance use were calculated. Maternal sociodemographic characteristics of interest were analyzed, stratified by type of substance use. All analysis incorporated weights to address the study design.

Aim 1

Theoretical latent factor structures for socioeconomic status, and different types of stress were proposed. Figure 1 depicts the hypothesized items related to socioeconomic status. Based on previous literature, it was hypothesized that there would be four distinct factor for stress: financial stress, traumatic stress, emotional stress, and relationship stress. The theoretical stress factors were modified from existing literature to include intimate partner violence, and food insecurity as potential stressors. Figures 2-5 demonstrate the hypothesized factor structure of the four types of stress. Confirmatory factor analysis (CFA) was conducted to validate the proposed structure of the latent factors. Mplus was used to conduct CFA with weighted least squares maximum likelihood (WLSMV) estimation. Cronbach’s alpha was used to assess reliability, and the root mean square error of approximation (RMSEA), confirmatory fit index (CFI), and standardized root mean square residual (SRMR) were used to assess model fit.

Once the latent factor structures of the types of stress and socioeconomic status were determined in a multiple factor CFA model, structural equation modeling was used to determine the nature of the relationship between the stress factors, maternal age, and substance use during pregnancy. Figure 6 depicts the overall hypothesized structural equation model. Four separate models were examined, one for each type of single substance use (cannabis, tobacco, and
alcohol) and one for any polysubstance use. Mplus was used for this analysis with WLSMV estimation and the RMSEA, CFI, and SRMR were used to assess model fit.
Figure 1: Hypothesized latent construct of socioeconomic status
Figure 2: Hypothesized latent construct of financial stress
Figure 3: Hypothesized latent construct of traumatic stress
Figure 4: Hypothesized latent construct of traumatic stress
Figure 5: Hypothesized latent construct of emotional stress
Figure 6: Hypothesized structural equation model
CHAPTER III

RESULTS

Descriptive Analysis

Between 2014 and 2018 there were a total of 7,166 responses to the Colorado PRAMS survey. CDC required a minimum response rate of 55% between 2015-2017 for data release, which was met. In 2014, however, the response rate of 59% did not meet the CDC threshold at the time of 60%. After excluding any plural births and anyone missing data for cannabis, alcohol, or tobacco use, there was an analytic sample size of 6,724, representing 308,461 births. Table 1 displays the sociodemographic characteristics by type of substance use.

Cannabis use

The prevalence of cannabis use alone at any time during pregnancy was 4.31% (95% CI, 3.66%-4.96%). Younger maternal age, lower levels of maternal education, lower percent of the federal poverty level, Medicaid as the primary insurance, receiving WIC, and higher numbers of stressors were associated with cannabis use compared to no substance use during pregnancy (all p<0.0001). No significant differences were detected across categories of race/ethnicity.

Tobacco use

The prevalence of tobacco use alone during the last trimester was 4.06% (95% CI, 3.47%-4.96%). Lower levels of maternal education, lower percent of the federal poverty level, Medicaid as the primary insurance, receiving WIC, and higher numbers of stressors were associated with tobacco use compared to no substance use (all p<0.0001). Young maternal age and non-Hispanic white race/ethnicity were associated with tobacco use compared to no substance use (p<0.05 and p<0.01, respectively).
Alcohol use

The prevalence of alcohol use alone during the last trimester was 13.00% (95% CI, 11.97%-14.04%). Older maternal age, higher levels of maternal education, higher percent of the federal poverty level, non-Hispanic white race/ethnicity, not receiving WIC, and not having Medicaid as primary insurance were associated with alcohol use compared to no substance use (all p<0.0001). No significant difference were detected in the number of stressors experienced in the year prior to delivery.

Polysubstance use The prevalence of any type of polysubstance use during pregnancy was 3.12% (95% CI, 2.59%-3.66%). Lower education levels, Medicaid as insurance, receiving WIC, lower percent of the federal poverty level, and a higher number of stressors were associated with any type of polysubstance use compared to no substance use (all p<0.0001). There was no significant difference in maternal age or race/ethnicity.

Aim 1 Results

Item reliability within factors

The items in the SES, financial stress, traumatic stress, and emotional stress factors were all significantly correlated. Within the proposed relationship stress factor, the item “I was apart from my husband or partner due to military deployment or extended work-related travel” was not significantly correlated with “I got separated or divorced from my husband or partner”, and had low correlations of less than 0.1 with the other relationship stress items. As such, “I was apart from my husband or partner due to military deployment or extended work-related travel” was removed from the relationship stress factor. The updated three-item factor was used for the rest of the analysis. Cronbach’s alpha was used to assess reliability and the values for each factor are displayed in Table 2. A Cronbach’s alpha of 0.7 or greater is considered acceptable reliability,
and only SES met that cutoff. Financial, traumatic, emotional, and relationship stress all had reliability scores of less than 0.7.

**Confirmatory factor analysis**

Confirmatory factor analysis was conducted with the proposed SES, financial stress, traumatic stress, emotional stress, and the three-item relationship stress factors. The model had adequate fit, with a RMSEA of 0.025, a CFI of 0.980, and an SRMR of 0.062. All of the items loaded significantly on their respective factors (all p-values <0.001) and standardized factor loadings ranged between 0.613 and 0.986. Standardized factor loadings are displayed in **Table 3**.

**Associations between type of substance use and maternal stressors**

To determine the relationship of stress and single and polysubstance use, each type of substance use (cannabis, tobacco, alcohol, and polysubstance use) was compared to the baseline of no substance use in structural equation models with maternal age, socioeconomic status, financial stress, traumatic stress, emotional stress, and relationship stress. **Table 4** summarizes the findings for each type of substance use. Financial stress and emotional stress were not significantly associated with any type of single or polysubstance use.

**Cannabis use**

There was a significant negative effect of maternal age on cannabis use, and a significant positive effect of traumatic stress on cannabis use (p-values <0.001). There was not a significant effect of socioeconomic status or relationship stress on cannabis use. **Figure 7** depicts the final cannabis use model with standardized factor loadings. While the SRMR was not ideal at 0.086, the RMSEA of 0.032 and CFI of 0.923 indicated adequate model fit.
Tobacco use

There was a significant negative effect of maternal age and relationship stress on tobacco use, and a significant positive effect of traumatic stress on tobacco use (p-values <0.01). There was no significant effect of socioeconomic status on tobacco use. Figure 8 depicts the final tobacco use model with standardized factor loadings. While the SRMR of 0.105 is not ideal, the RMSEA of 0.036 and CFI of 0.924 indicated adequate model fit.

Alcohol use

There was a significant positive effect of socioeconomic status on alcohol use (p-values <0.001). There was also a significant correlation between socioeconomic status and maternal age (p-value <0.001). The relationship between maternal age and alcohol use was not significant (p-value = 0.106). There was no significant effect of traumatic stress or relationship stress on alcohol use. Figure 9 depicts the final alcohol use model with standardized factor loadings The RMSEA, CFI, and SRMR indicated adequate model fit, at 0.030, 0.998, and 0.017 respectively.

Polysubstance use

There was a significant positive effect of traumatic stress on polysubstance use, and a negative effect of relationship stress on polysubstance use (p-values <0.05). There was no significant effect of maternal age on polysubstance use. Figure 10 depicts the final polysubstance use model with standardized factor loadings The model had adequate fit, with a RMSEA of 0.010, CFI of 0.996, and an SRMR of 0.040.
Table 1: Summary of associations between type of substance use and types of stress, SES, and maternal age

<table>
<thead>
<tr>
<th></th>
<th>Cannabis</th>
<th>Tobacco</th>
<th>Alcohol</th>
<th>Polysubstance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>NS</td>
</tr>
<tr>
<td>SES</td>
<td>NS</td>
<td>NS</td>
<td>+</td>
<td>NS</td>
</tr>
<tr>
<td>Financial Stress</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Traumatic Stress</td>
<td>+</td>
<td>+</td>
<td>NS</td>
<td>+</td>
</tr>
<tr>
<td>Emotional Stress</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Relationship Stress</td>
<td>NS</td>
<td>-</td>
<td>NS</td>
<td>-</td>
</tr>
</tbody>
</table>

- indicates a significant negative association
+ indicates a significant positive association
NS indicates no significant association
**Table 2: Prevalence of self-reported substance use by select maternal characteristics, Colorado PRAMS 2014-2018**

<table>
<thead>
<tr>
<th>Maternal Education</th>
<th>Cannabis Only</th>
<th>Tobacco Only</th>
<th>Alcohol Only</th>
<th>Polysubstance</th>
<th>No Substance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; High School</td>
<td>17.68</td>
<td>22.57</td>
<td>4.98</td>
<td>20.25</td>
<td>10.11</td>
<td>10.60</td>
</tr>
<tr>
<td>High School</td>
<td>32.45</td>
<td>34.37</td>
<td>9.76</td>
<td>27.12</td>
<td>19.49</td>
<td>19.63</td>
</tr>
<tr>
<td>Diploma or Equivalent</td>
<td>(24.86, 40.03)</td>
<td>(27.23, 41.51)</td>
<td>(7.06, 12.46)</td>
<td>(19.28, 34.95)</td>
<td>(17.98, 21.00)</td>
<td>(18.32, 20.94)</td>
</tr>
<tr>
<td>&gt; High School</td>
<td>49.88</td>
<td>43.06</td>
<td>85.26</td>
<td>52.63</td>
<td>70.4</td>
<td>69.77</td>
</tr>
<tr>
<td></td>
<td>(42.10, 57.66)</td>
<td>(35.84, 50.28)</td>
<td>(81.96, 88.55)</td>
<td>(43.89, 61.38)</td>
<td>(68.67, 72.12)</td>
<td>(68.27, 71.27)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maternal Race/Ethnicity</th>
<th>Cannabis Only</th>
<th>Tobacco Only</th>
<th>Alcohol Only</th>
<th>Polysubstance</th>
<th>No Substance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>30.75</td>
<td>15.5</td>
<td>19.24</td>
<td>23.31</td>
<td>29.94</td>
<td>27.79</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>56.22</td>
<td>72.51</td>
<td>72.71</td>
<td>66.33</td>
<td>58.8</td>
<td>61.28</td>
</tr>
<tr>
<td></td>
<td>(48.48, 63.96)</td>
<td>(65.52, 79.51)</td>
<td>(68.71, 76.72)</td>
<td>(58.00, 74.67)</td>
<td>(57.02, 60.58)</td>
<td>(59.74, 62.82)</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>4.91</td>
<td>4.62</td>
<td>2.31</td>
<td>3.46</td>
<td>4.06</td>
<td>3.87</td>
</tr>
<tr>
<td></td>
<td>(0.81, 9.01)</td>
<td>(0.76, 8.49)</td>
<td>(0.84, 3.78)</td>
<td>(0.00, 7.33)</td>
<td>(3.22, 4.89)</td>
<td>(3.16, 4.58)</td>
</tr>
<tr>
<td>Non-Hispanic Other</td>
<td>8.12</td>
<td>7.36</td>
<td>5.74</td>
<td>6.91</td>
<td>7.21</td>
<td>7.05</td>
</tr>
<tr>
<td></td>
<td>(4.04, 12.20)</td>
<td>(3.13, 11.60)</td>
<td>(3.81, 7.67)</td>
<td>(3.09, 10.72)</td>
<td>(6.26, 8.15)</td>
<td>(6.25, 7.86)</td>
</tr>
</tbody>
</table>

*p-value* is from the Rao-Scott Chi-square test of each type of substance use category compared to no substance use.
Table 1 Continued Prevalence of self-reported substance use by select maternal characteristics, Colorado PRAMS 2014-2018

<table>
<thead>
<tr>
<th>Percent 95% Confidence Interval</th>
<th>Cannabis Only</th>
<th>Tobacco Only</th>
<th>Alcohol Only</th>
<th>Polysubstance</th>
<th>No Substance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicaid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>72.63</td>
<td>74.13</td>
<td>21.71</td>
<td>73.25</td>
<td>39.91</td>
<td>41.3869</td>
</tr>
<tr>
<td></td>
<td>(66.00, 79.26)</td>
<td>(67.35, 80.92)</td>
<td>(18.11, 25.31)</td>
<td>(66.12, 80.39)</td>
<td>(38.15, 41.67)</td>
<td>(39.86, 42.92)</td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td>WIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46.9</td>
<td>48.91</td>
<td>14.3</td>
<td>52.8</td>
<td>27.85</td>
<td>28.5483</td>
</tr>
<tr>
<td></td>
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<td>(41.46, 56.36)</td>
<td>(11.30, 17.30)</td>
<td>(44.16, 61.43)</td>
<td>(26.22, 29.48)</td>
<td>(27.13, 29.97)</td>
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<td>&lt;0.0001</td>
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<td>&lt;100%</td>
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<td>55.24</td>
<td>8.63</td>
<td>56.78</td>
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<td>(38.73, 54.55)</td>
<td>(47.67, 62.81)</td>
<td>(6.28, 10.98)</td>
<td>(48.15, 65.42)</td>
<td>(22.53, 25.77)</td>
<td>(23.95, 26.78)</td>
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<td>100-149%</td>
<td>25.55</td>
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<td>9.64</td>
<td>15.42</td>
<td>15.39</td>
<td>15.1701</td>
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<td>(18.26, 32.85)</td>
<td>(11.97, 23.36)</td>
<td>(7.06, 12.22)</td>
<td>(9.09, 21.74)</td>
<td>(14.08, 16.71)</td>
<td>(14.03, 16.31)</td>
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<td>150-200%</td>
<td>5.58</td>
<td>7.07</td>
<td>6.8</td>
<td>2.36</td>
<td>8.41</td>
<td>7.8332</td>
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<td>(2.41, 8.76)</td>
<td>(3.62, 10.52)</td>
<td>(4.64, 8.96)</td>
<td>(0.29, 4.44)</td>
<td>(7.42, 9.41)</td>
<td>(7.01, 8.66)</td>
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<td>200-249%</td>
<td>3.74</td>
<td>6.41</td>
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<td>(0.87, 6.62)</td>
<td>(2.42, 10.40)</td>
<td>(4.31, 9.19)</td>
<td>(1.89, 9.52)</td>
<td>(7.28, 9.19)</td>
<td>(6.86, 8.51)</td>
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<td>250%+</td>
<td>18.48</td>
<td>13.62</td>
<td>68.18</td>
<td>19.74</td>
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<td>(42.41, 45.49)</td>
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<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>reference</td>
<td></td>
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<td>Number of Stressors</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>None</td>
<td>12.47</td>
<td>17.11</td>
<td>33.84</td>
<td>15.24</td>
<td>31.89</td>
<td>30.1913</td>
</tr>
<tr>
<td></td>
<td>(6.97, 17.97)</td>
<td>(11.67, 22.55)</td>
<td>(29.83, 37.85)</td>
<td>(8.48, 22.00)</td>
<td>(30.23, 33.55)</td>
<td>(28.77, 31.61)</td>
</tr>
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<td>1 to 2</td>
<td>35.45</td>
<td>32.81</td>
<td>44.27</td>
<td>22.69</td>
<td>44.63</td>
<td>43.0234</td>
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<tr>
<td></td>
<td>(28.08, 42.82)</td>
<td>(25.92, 39.71)</td>
<td>(40.02, 48.52)</td>
<td>(16.11, 29.27)</td>
<td>(42.87, 46.39)</td>
<td>(41.50, 44.55)</td>
</tr>
<tr>
<td>3 to 5</td>
<td>33.49</td>
<td>33.61</td>
<td>19.21</td>
<td>39.91</td>
<td>19.31</td>
<td>21.1317</td>
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<tr>
<td></td>
<td>(26.34, 40.64)</td>
<td>(26.40, 40.81)</td>
<td>(15.71, 22.70)</td>
<td>(31.49, 48.33)</td>
<td>(17.94, 20.68)</td>
<td>(19.89, 22.38)</td>
</tr>
<tr>
<td>6 or more</td>
<td>18.59</td>
<td>16.47</td>
<td>2.68</td>
<td>22.16</td>
<td>4.16</td>
<td>5.6536</td>
</tr>
<tr>
<td></td>
<td>(12.19, 25.00)</td>
<td>(10.92, 22.03)</td>
<td>(1.30, 4.07)</td>
<td>(14.54, 29.79)</td>
<td>(3.44, 4.88)</td>
<td>(4.92, 6.39)</td>
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<td>&lt;0.0001</td>
<td>0.3745</td>
<td>&lt;0.0001</td>
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</table>

*p-value is from the Rao-Scott Chi-square test of each type of substance use category compared to no substance use.
<table>
<thead>
<tr>
<th></th>
<th>SES</th>
<th>Financial Stress</th>
<th>Traumatic Stress</th>
<th>Emotional Stress</th>
<th>Relationship Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s alpha</td>
<td>0.82</td>
<td>0.66</td>
<td>0.54</td>
<td>0.56</td>
<td>0.56</td>
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Table 4: Standardized factor loadings from the confirmatory factor analysis

<table>
<thead>
<tr>
<th>Item</th>
<th>SES</th>
<th>Financial Stress</th>
<th>Traumatic Stress</th>
<th>Emotional Stress</th>
<th>Relationship Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of the Federal Poverty Level</td>
<td>0.952</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIC Status</td>
<td>0.855</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>0.937</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal Education</td>
<td>0.676</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I had problems paying the rent, mortgage, or other bills</td>
<td></td>
<td>0.899</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My husband or partner lost their job</td>
<td></td>
<td></td>
<td>0.721</td>
<td></td>
<td></td>
</tr>
<tr>
<td>My husband, partner, or I had a cut in work hours of pay</td>
<td></td>
<td></td>
<td>0.613</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I lost my job even though I wanted to go on working</td>
<td></td>
<td></td>
<td>0.649</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you ever eat less than you felt you should because there wasn’t enough money to buy food?</td>
<td></td>
<td></td>
<td></td>
<td>0.820</td>
<td></td>
</tr>
<tr>
<td>Someone very close to me had a problem with drinking or drugs</td>
<td></td>
<td></td>
<td></td>
<td>0.624</td>
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<tr>
<td>My husband, partner, or I went to jail</td>
<td></td>
<td></td>
<td></td>
<td>0.783</td>
<td></td>
</tr>
<tr>
<td>I was homeless or had to sleep outside, in a car, or in a shelter</td>
<td></td>
<td></td>
<td></td>
<td>0.870</td>
<td></td>
</tr>
<tr>
<td>Intimate Partner Violence</td>
<td></td>
<td></td>
<td></td>
<td>0.766</td>
<td></td>
</tr>
<tr>
<td>A close family member was very sick and had to go into the hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.641</td>
</tr>
<tr>
<td>Someone very close to me died</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.986</td>
</tr>
<tr>
<td>My husband or partner said they didn’t want me to be pregnant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.766</td>
</tr>
<tr>
<td>I got separated or divorced from my husband or partner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.853</td>
</tr>
<tr>
<td>I argued with my husband or partner more than usual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.740</td>
</tr>
</tbody>
</table>
Figure 7: Standard coefficients of conceptual model of maternal age and traumatic stress with cannabis use
Figure 8: Standard coefficients of conceptual model of maternal age, traumatic stress, and relationship stress with tobacco use
Figure 9: Standard coefficients of conceptual model of maternal age and socioeconomic status with alcohol use
Figure 10: Standard coefficients of conceptual model of socioeconomic status, relationship stress, and traumatic stress with polysubstance use
CHAPTER IV

DISCUSSION

Our findings provide novel insight into the complex interplay between with different types of maternal stress during pregnancy, socioeconomic status and single- and poly-substance use during pregnancy in Colorado. Alcohol was the most frequently reported substance at 13.0%. The prevalence of cannabis and tobacco were similar at 4.3% and 4.1%, respectively, and polysubstance use had a prevalence of 3.1%. By using structural equation modeling, we were able to determine that different patterns of stress are associated with each type of substance use. While the proposed factor structures had poor reliability with the exception of socioeconomic status, the adequate model fit from the confirmatory factor analysis and the strong loadings of each item on its respective factor allowed us to use these factors. Younger maternal age and traumatic stress are associated with both cannabis and tobacco use. Tobacco and polysubstance use were also associated with decreased relationship stress. Alcohol use alone was associated with higher SES and no maternal stressors were identified as predictors. Polysubstance use was associated with increased traumatic stress and decreased relationship stress. Of all the types of stress examined, traumatic stress was the only type of stressor that was significantly associated with cannabis, tobacco, and polysubstance use. Traumatic stress represents the most intense type of stressors and consisted of homelessness, incarceration, a partner’s substance use problems, and intimate partner violence. Financial and emotional stress were not significantly associated with any type of substance use. Our results suggest that traumatic stress is a key factor to consider when designing interventions for substance use among pregnant people, particularly for tobacco, cannabis and polysubstance use. Obstetric providers should also emphasize that no amount of alcohol is safe to use during pregnancy.
While the prevalence of cannabis use was consistent with previous findings,\textsuperscript{4,17} the prevalence of tobacco use was lower than other studies have found. However, this study looked only at tobacco use during the third trimester, and estimated the prevalence of tobacco use in the absence of any other substance use. Both reasons explain a lower prevalence of tobacco use. Our findings on the relationship between stress and cannabis, tobacco, and polysubstance use are consistent with previous research. Prenatal cannabis use has consistently been shown to be higher for younger maternal age,\textsuperscript{4,10,17,19} and increased traumatic stress levels.\textsuperscript{29} Prenatal tobacco use has also been associated with younger age,\textsuperscript{3,9,10} and that those with more stressful life events were less likely to quit smoking during pregnancy.\textsuperscript{29} The significant inverse relationship between relationship stress and tobacco and polysubstance use is also consistent with previous findings. Continued tobacco use during pregnancy is associated with having a partner who smokes,\textsuperscript{30-33} as tobacco use may be perceived as a shared behavior to reduce relationship conflict.\textsuperscript{34,35}

Previous literature shows that people who consume alcohol during pregnancy are more likely to be older and have higher SES.\textsuperscript{12-14,36,37} We observed a slightly higher prevalence of alcohol use than previous estimates,\textsuperscript{2,10} and found a positive association between alcohol use and SES. Our results regarding maternal age and SES are also consistent with previous national-level PRAMS research.\textsuperscript{37,38} Existing research is less clear on the relationship between stress and prenatal alcohol use. Pregnant people who experiences stressful life events prior to pregnancy were more likely to drink during pregnancy, while those who experienced stressful life events during pregnancy were less likely to continue consuming alcohol through the third trimester.\textsuperscript{36} We found no significant association between any of the types of stressors and prenatal alcohol use. Our findings, along with existing literature, indicate that alcohol use during pregnancy has different risk factors than other types of substance use. The increased prevalence of alcohol use
among higher SES pregnant people is likely due to a lower perceived risk of drinking a moderate amount during pregnancy. A study of predominantly higher educated white women found that moderate alcohol use during pregnancy was not necessarily viewed as dangerous, and structured interviews found a persistent belief that there was a safe level of alcohol consumption during pregnancy.

This research highlights the relationship between the social determinants of health and substance use during pregnancy. From a broad public health standpoint, it is imperative to ensure that pregnant people have the resources and support necessary to have a low-stress, healthy pregnancy. This includes providing adequate and affordable housing and making sure there are both mental health and social support resources that are accessible to everyone in the community. It is important that clinicians continue to emphasize that no amount of alcohol is safe during pregnancy, and discuss the risks of any type of substance use during pregnancy. Screening for various stressful life events should be conducted simultaneously with screening for substance use, and conversations regarding a patient’s substance use should not be punitive, but rather should focus on cessation for the health benefits to the mother and baby. This research also emphasizes the co-occurrence of substance use during pregnancy and traumatic life events. Using trauma-informed prenatal care and cessation counseling is imperative to helping mothers feel safe and be successful in stopping substance use while pregnant. Recognizing and acknowledging the experiences of trauma and other stressors in patients’ lives is key to helping reduce the prevalence of substance use during pregnancy.

This study had several strengths and limitations. PRAMS is a state-based survey of all births in Colorado, so the results are generalizable to the state. Examining each type of substance use alone as well as polysubstance use allowed for a better understanding of the
differing characteristics of people who use substances during pregnancy. While this analysis attempts to address confounding due to other substance use, PRAMS only looks at tobacco, alcohol, and cannabis use. Additional substance use cannot be accounted for in this analysis. Due to sample size limitations, we are unable to examine specific categories of polysubstance use, but have to examine any type of polysubstance use as a single category. Additionally, PRAMS only asks about tobacco and alcohol use during the third trimester, so there are some pregnant people who consumed tobacco or alcohol during the first or second trimesters that were identified as not using substances. Since tobacco and alcohol use were examined at the third trimester, this analysis likely captured the highest intensity substance users. Future research should examine potential differences in the people who stopped using tobacco or alcohol before the third trimester compared to those who continued use through the end of pregnancy. Previous research has shown that self-report of substance use during pregnancy is less reliable than toxicology reports. Self-report is subject to both recall and social desirability bias, likely resulting in underreporting of substance use. PRAMS is administered 2-4 months postpartum, which could result in a greater amount of recall bias as respondents may not remember their behavior 2-11 months prior. However, previous research with PRAMS has shown that people are more likely to report their tobacco use during pregnancy in a self-reported survey than to a clinician.
CHAPTER V

CONCLUSION

By providing evidence of the association between maternal stress and cannabis, alcohol, and tobacco use, this study adds to the mounting evidence that the social determinants of health are a significant contributor to health. Addressing some of these specific stressors, including homelessness, a partner’s substance use, intimate partner violence, and incarceration, could provide an important intervention point to reduce substance use during pregnancy.
References


