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Adolescent Childbirth, Miscarriage, and Abortion: Associations with Changes in Alcohol, Marijuana, and Cigarette Use

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Abstract

Background: Adolescent girls who become pregnant demonstrate greater risk for substance use than same-aged peers. However, it remains unclear how risk relates to normative changes in adolescence. Few studies have examined adolescent substance use changes before, during, and after pregnancy and considered how pregnancy outcomes (childbirth, miscarriage, abortion) differentially influence substance use changes. The present study examined associations between different adolescent pregnancy outcomes and *within-person* changes in substance use from pre- to post-pregnancy.

Methods: Participants included 2,450 girls (52% Black) oversampled from low-income urban neighborhoods in Pittsburgh, PA. Participants self-reported pregnancy outcomes and substance use frequency (alcohol, cigarette, marijuana) annually from ages 11–20. Fixed-effects regressions focused on first births, first miscarriages, and first abortions occurring from ages 12–19 to test the associations between pregnancy outcomes and within-individual changes in substance use from pre- to post-pregnancy. By design, models controlled for all potential time-stable confounds; models included age and subsequent pregnancies as time-varying covariates.

Results: Consistent with prior studies, girls who became pregnant (20%) reported greater early risk for substance use problems than never-pregnant adolescents, including earlier age of onset and more regular marijuana and cigarette use. Childbirth predicted a 26–51% within-individual reduction in alcohol, marijuana, and cigarette use that remained significantly lower than pre-pregnancy levels after childbirth. Alcohol and marijuana use decreased (32–47%) after miscarriage. Abortion was not associated with long-term changes in substance use; however, marijuana and cigarette use gradually increased (44–46%) in the years leading up to the year of and after abortion, respectively, before returning to pre-pregnancy levels.

Conclusions: Findings highlight important differences in adolescent substance use patterns based on pregnancy outcome. For pregnant adolescents with heightened pre-existing risk for

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substance use, pregnancy may be a window of opportunity for substance use screening and behavioral intervention.

Keywords

adolescence; pregnancy; teenage mothers; alcohol use; substance use

Introduction

Adolescent pregnancy rates in the United States are higher than in any other industrialized country, with 60% of pregnancies resulting in birth, and 14% and 26% resulting in miscarriage and abortion, respectively (Sedgh, Finer, Bankole, Eilers, & Singh, 2015). Consistent with problem behavior theory (Jessor, 1991), adolescents who engage in risky sexual behaviors resulting in pregnancy often engage in other risky behaviors, including substance use (Chapman & Wu, 2013; Salas-Wright, Vaughn, Ugalde, & Todic, 2015). Thus, pregnant adolescents represent a vulnerable group for lifetime substance use problems. In adult women, pregnancy is a time characterized by increased motivation for health behavior change (Crozier et al., 2009) and provides an opportunity for sustained frequent contact with medical professionals, who can identify and intervene on risky behaviors. Thus, the prenatal period may serve as an important window of opportunity for clinical intervention for high risk adolescents. Indeed, existing studies indicate that most childbearing adolescents stop or significantly decrease substance use during pregnancy, but gradually resume use within 6 months of birth (Chapman & Wu, 2013). Studies documenting this natural “buffering” effect of pregnancy conceptualize substance use reductions as a result of transitioning to new social roles of motherhood (Fletcher, 2012; Staff et al., 2010) and positive responses to public health messages (Crawford-Williams, Fielder, Mikocka-Walus, & Esterman, 2015; Jarlenski, Zank, Tarr, & Chang, 2017).

Little research has examined substance use patterns for adolescents whose pregnancies do not result in childbirth, either due to miscarriage or abortion. Without transitioning to parenting, the post-pregnancy social environment may closely resemble pre-pregnancy. For some women, miscarriage and abortion can also include psychological and/or physical stressors (Coleman, 2009) that may impact substance use trajectories differently than pregnancies that continue. Among studies of adults, the link between abortion and miscarriage with substance use has been mixed. Substance use has been reported to increase among adult women who miscarry (Kinsey, Baptiste-Roberts, Zhu, & Kjerulff, 2015), potentially in response to grief or depression (Brier, 2008; Kersting et al., 2009). In contrast, few studies have examined miscarriage during adolescence. One study found that pregnancy predicted decreased drug use and binge drinking for childbearing adolescents, but not for those who miscarried (Fletcher, 2012). However, it is unclear if pre-existing individual differences between groups affected these results.

Similarly, some studies report no substance use changes following abortion (van Ditzhuijzen et al., 2017), whereas other studies report higher rates of alcohol and illicit substance use for women who underwent abortion compared to childbearing and never-pregnant women (Coleman, 2011; Fergusson, Horwood, & Boden, 2013). These latter studies generally

conceptualize substance use as an attempt to cope with abortion-related stress. However, most of these studies have been limited by cross-sectional designs and/or lack of appropriate comparison groups (Major et al., 2009; Steinberg, Trussell, Hall, & Guthrie, 2012; cf. Roberts, Foster, Gould, & Biggs, 2018; Roberts, Wilsnack, Foster, & Delucchi, 2014). Comparing childbearing women to women who choose abortion leads to difficulties in accounting for the vast number of pre-existing group differences (e.g., attitudes, substance use before pregnancy) that may explain group differences in post-pregnancy substance use (Steinberg & Finer, 2011). Furthermore, group differences may reflect the childbirth group *decreasing* use in the transition to parenting rather than the abortion group increasing substance use beyond their age-typical trajectory. This is a particularly important consideration during adolescence, a developmental period characterized by normative increases in substance use (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017); thus, comparing patterns *between* individuals without accounting for these normative changes can compromise hypothesis-testing.

To address these limitations, the present study employed a fixed effects regression model (Allison, 2009) to test the effect of pregnancy outcome on changes in substance use from pre- to post-pregnancy. Fixed effects regressions test how an event (e.g., childbirth) affects behavior change (e.g., drinking) *within* the context of that individual's trajectory. In these models, each participant serves as her own control, and thus *all* pre-existing time-invariant differences between individuals, including race-ethnicity, genotype, stable personality traits and attitudes, and history of specific stressors, are eliminated as potential confounds (Allison, 2009). To date, almost no studies have examined longitudinal within-person changes in adolescent substance use from pre- to post-pregnancy. Two existing studies recruited adolescent mothers during pregnancy and followed them longitudinally after childbirth: greater history of substance use predicted more use during pregnancy and greater within-person increases in use after childbirth (De Genna, Cornelius, Goldschmidt, & Day, 2015; Spears, Stein, & Koniak–Griffin, 2010). These findings highlight the importance of contextualizing prenatal and postnatal substance use relative to use *before* pregnancy. However, both studies used retrospective reports to assess pre-pregnancy substance use and limited pregnancy outcome to childbirth.

The present study investigated the association between first childbirths, miscarriages, and abortions on within-person changes in alcohol, marijuana, and cigarette use from pre- to post-pregnancy in a large longitudinal sample of girls prospectively assessed since childhood. We hypothesized that substance use would decrease during pregnancies resulting in childbirth, and then increase following childbirth. In contrast, we expected no within-person changes from pre-pregnancy levels for pregnancies resulting in miscarriage or abortion. To maximize specificity of findings, we accounted for time-varying changes in age and subsequent pregnancies during the window of analysis. Finally, as a preliminary investigation of potential explanatory factors underlying substance use changes, we examined whether effects changed after sequentially adjusting for changes in depression and peer substance use. By utilizing a within-person design sensitive to individual changes across time, our study aimed to strengthen implications for clinical care by identifying windows of opportunity for targeted substance abuse interventions for an understudied, high-risk population.

Method

Participants and Procedures

Participants were drawn from an urban sample of 2,450 girls (52% black, 41% white, 7% multiracial/other) initially recruited in childhood from 1999–2000 based on a stratified, random household sampling of 103,238 households that oversampled low-income neighborhoods (Hipwell et al., 2002; Keenan et al., 2010). Participants have been assessed annually over the past 18 years with high retention (range: 97% to 86%). All study procedures were approved by the University of Pittsburgh Institutional Review Board (IRB). We obtained annual written informed consent from caregivers and verbal assent from girls through age 17; participants provided written informed consent for themselves from age 18 onwards.

Analyses used prospectively gathered measures of substance use and pregnancy outcomes from ages 11–20 years. We focused on first births, first miscarriages, and first abortions occurring from ages 12–19 to ensure that all participants had at least one time point of data before and after their pregnancy event. Data on all subsequent pregnancies through age 20 were also collected and included in models.

Measures

Pregnancy outcomes.

Beginning at age 11, participants answered whether they were currently pregnant, and reported births, miscarriages, and abortions occurring in the past year. Effects-coded variables (Allison, 2009) were created for each first pregnancy outcome (first childbirth, first abortion, first miscarriage) to represent: two or more years before pregnancy (T0); one year before pregnancy (T1); year of pregnancy/pregnancy outcome (T2); one year after pregnancy outcome (T3); and two or more years after pregnancy outcome (T4). Similar effects-coded variables were also created to represent all subsequent births, miscarriages, and abortions through age 20.

Substance use.

Alcohol, marijuana, and cigarette use were annually assessed using the Nicotine, Alcohol and Drug Use questionnaire (NADU; Pandina, Labouvie, & White, 1984). Participants self-reported frequency of use on an 8-point scale, from 0=*no use in past year* to 7=*every day or more than once a day*.

Depression.

Symptoms of major depressive disorder (MDD) and two related symptoms (low self-esteem, hopelessness) were assessed annually by the Child, Adolescent, or Adult Self-Report/ Symptom Inventory-4 (CSI-4; ASI-4; ASRI-4) (Gadow & Sprafkin, 1994; Gadow, Sprafkin, & Weiss, 2004). Seven symptoms were rated on 4-point scales and considered present if occurring '*a lot*' or '*all the time*'; four symptoms (change in appetite, sleep, activity, concentration) were answered as present or absent. We used a count of depression symptoms each year.

Peer substance use.

The Peer Delinquency Scale (Loeber, Farrington, Stouthamer-Loeber, & Kammen, 1998) obtained the participant's report of the number of friends in the past year who used alcohol, marijuana, and cigarettes using 4-point scales ranging from 0=*none of them* to 3=*all of them.* Items were summed to indicate total peer substance use each year.

Data Analysis Plan

Analyses were conducted in Stata 15.1 (StataCorp, 2017). Negative binomial fixed effects regressions tested the association between pregnancy outcomes and within-person changes in alcohol, marijuana, and cigarette use from age 11–20. Separate models were examined for each type of substance. First, a fixed effects regression examined the effects of first birth, miscarriage, and abortion on within-person changes in the substance use outcome, adjusting for age (categorically coded) and all subsequent pregnancy events as time-varying covariates. Substance use frequency at T0 was treated as the 'baseline' reference time-point to test whether substance use at other time points differed from pre-pregnancy level. When significant differences emerged, the reference time point was adjusted to T1, T2, and T3, respectively, to further examine changes between adjacent years. Finally, to examine whether significant changes in substance use became non-significant after adjusting for potential explanatory factors, supplemental analyses sequentially added depression symptoms and peer substance use to the model as time-varying covariates. By design, all time-stable factors varying between individuals are ruled-out as potential confounds (Allison, 2009). Fixed effects models accommodate missing data using conditional maximum likelihood estimation, which incorporates all available information in a time series to generate model parameters rather than relying on complete case analysis.

Results

Descriptive Statistics

Table 1 displays descriptive statistics by age. Prior to age 20, 490 girls (20%) had at least one pregnancy outcome, including 325 first births, 105 first miscarriages, and 136 first abortions. Average ages at first birth, first miscarriage, and first abortion were 17.51 years (SD=1.46), 17.38 years (SD=1.53), and 16.92 years (SD=1.69), respectively. Compared to never-pregnant girls, adolescents who became pregnant started drinking 0.34 years earlier (t=−2.03, p=.043), used marijuana 1.06 years earlier (t=−6.897, p<.001), and smoked cigarettes 0.89 years earlier (t=−4.41, p<.001). Adolescents who became pregnant were more likely to have regularly used marijuana and cigarettes, with 50% of the pregnant group having used marijuana weekly for one or more years compared to 28.6% of never-pregnant girls (χ^2=81.29, p<.001), and 48.6% having smoked cigarettes weekly compared to 27.3% of never-pregnant girls (χ^2=82.30, p<.001). Rates of regular alcohol use were comparable, with 31.4% of both groups reporting weekly alcohol use for one or more years (χ^2<.01, p=.977).

Predicting Alcohol Use Changes

Table 2 displays results from the primary fixed effects regressions, in which alcohol use at each time point was compared to T0. Relative to T0, girls used alcohol similarly the year before pregnancy (T1), but significantly less the year of pregnancy/birth (T2) and in subsequent years (T3-T4). Examining changes between adjacent years revealed that alcohol specifically decreased during the year of pregnancy/birth (T1 vs. T2: *IRR*=.55, *SE*=.06, $p<.001$), with decreases maintained for a year (T2 vs. T3: *IRR*=1.06, *SE*=.11, $p=.562$). Alcohol then increased in subsequent years (T3 vs. T4: *IRR*=1.26, *SE*=.13, $p=.026$), but remained lower than pre-pregnancy levels.

Alcohol use did not change from pre-pregnancy to year of miscarriage, but adolescents drank significantly less *after* miscarriage relative to pre-pregnancy. Comparing adjacent years, no effects reached statistical significance (T1 vs. T2: *IRR*=.81, *SE*=.11, $p=.142$; T2 vs. T3: *IRR*=.80, *SE*=.11, $p=.110$; T3 vs. T3: *IRR*=.99, *SE*=.12, $p=.945$), suggesting a gradual decrease in drinking after miscarriage that eventually became significant from pre-pregnancy levels. Finally, relative to T0, abortion was not associated with changes in drinking; alcohol frequency remained at T0 levels across all time points.

Predicting Marijuana Use Changes

Marijuana use was stable prior to pregnancy (T0 vs. T1; Table 2), but significantly decreased in the year of pregnancy/birth (T1 vs. T2: *IRR*=.52, *SE*=.07, $p<.001$) to below T0 levels (Table 2). After birth, use significantly increased (T2 vs. T3: *IRR*=1.44, *SE*=.20, $p=.007$) and stabilized thereafter (T3 vs. T4: *IRR*=.88, *SE*=.13, $p=.386$), but remained significantly lower than pre-pregnancy levels. Marijuana use was higher than T0 during year of miscarriage but did not differ from T0 in the following years. Adjacent time-point comparisons revealed no single year when marijuana use suddenly increased; instead, marijuana gradually increased leading up to year of miscarriage (T0 vs. T1: *IRR*=1.10, *SE*=.19, $p=.574$; T1 vs. T2: *IRR*=1.23, *SE*=.24, $p=.277$), followed by a gradual decline after miscarriage (T2 vs. T3: *IRR*=.85, *SE*=.16, $p=.359$) before significantly decreasing 2+ years after miscarriage (T3 vs. T4: *IRR*=.62, *SE*=.12, $p=.011$).

Similarly, marijuana use was higher during year of abortion relative to T0 but did not differ from T0 in subsequent years. Comparing adjacent years showed no single year when the increase in marijuana occurred; there was a gradual increase leading up to year of abortion (T0 vs. T1: *IRR*=1.27, *SE*=.20, $p=.131$; T1 vs. T2: *IRR*=1.15, *SE*=.21, $p=.458$), followed by a significant decrease the year after abortion (T2 vs. T3: *IRR*=.67, *SE*=.12, $p=.025$) and no changes in subsequent years (T3 vs. T4: *IRR*=1.28, *SE*=.22, $p=.144$).

Predicting Cigarette Use Changes

Relative to T0 (Table 2), cigarette use was stable the year before pregnancy (T1), but significantly lower during year of pregnancy/birth (T2) and subsequent years (T3-T4). Smoking reductions occurred specifically during the transition to pregnancy (T1 vs. T2: *IRR*=.67, *SE*=.09, $p=.004$) and remained stable in subsequent years. Miscarriage was not associated with changes in cigarette use. However, relative to T0, we observed more cigarette use the year after abortion, but no differences from T0 in subsequent years.

Comparisons between adjacent years demonstrated no specific year that this increase occurred; instead, cigarette use showed a gradual nonsignificant trend upwards in the years leading up to the year of abortion (T0 vs. T1: *IRR*=1.20, *SE*=.23, *p*=.328; T1 vs. T2: *IRR*=1.14, *SE*=.24, *p*=.527), stabilized in the year after abortion (T2 vs. T3: *IRR*=1.05, *SE*=.19, *p*=.788), and then showed a nonsignificant trend downwards back to pre-pregnancy levels (T3 vs. T4: *IRR*=.85, *SE*=.14, *p*=.325).

Potential Explanatory Factors

Supplemental analyses tested whether any significant effects (bolded in Table 2) became nonsignificant after sequentially adjusting for time-varying changes in depression and peer substance use. After adjusting for depression, elevations in marijuana use during year of and year after miscarriage became nonsignificant (T2 vs. T0: *IRR*=1.32, *SE*=.21, *p*=.079; T3 vs. T0: *IRR*=1.15, *SE*=.18, *p*=.370, respectively). After adjusting for peer substance use, long-term decreases in marijuana use after miscarriage and alcohol use after childbirth became nonsignificant (T4 vs. T0: *IRR*=.76, *SE*=.13, *p*=.116; T4 vs. T0: *IRR*=.87, *SE*=.09, *p*=.166, respectively). Thus, changes in peer context may partially explain the long-term reductions in alcohol and marijuana following childbirth and miscarriage, respectively. All other significant effects in Table 2 ($p<.05$) were maintained after adjusting for depression and peer substance use.

Discussion

This is the first study to use a fixed effects regression approach to prospectively examine associations between adolescent pregnancy outcomes and changes in alcohol, marijuana, and cigarette use. Our study addressed several key limitations of existing research. The within-person design enabled control of all potential time-invariant confounds that may have impacted significance testing in previous studies. In addition, we accounted for normative age-related changes in substance use from age 11–20 and effects of subsequent pregnancies. Two main findings emerged: first, consistent with prior studies (Chapman & Wu, 2013; Salas-Wright et al., 2015), adolescent girls who became pregnant had greater early risk for substance use problems compared to never-pregnant girls, including earlier age of onset for all three substances and greater likelihood of engaging in weekly marijuana and cigarette use. Second, substance use patterns across pre- to post-pregnancy differed based on type of pregnancy outcome and substance. Whereas childbirth predicted within-person reductions in all three substances, gradual increases in marijuana were observed leading up to miscarriage, and marijuana and alcohol use decreased after miscarriage. Abortion was not associated with enduring changes in substances beyond normative age-related changes; however, marijuana and cigarette use gradually increased in the years leading up to abortion before returning to pre-pregnancy levels.

Results are consistent with previous studies reporting a “buffering” effect of childbirth for adolescent substance use (Chapman & Wu, 2013). Our findings suggest that these effects generalize to adolescents oversampled from neighborhoods exposed to chronic stress/poverty. Prior studies reported that adolescent mothers resume drinking within 6 months postpartum (Gilchrist, Hussey, Gillmore, Lohr, & Morrison, 1996; Spears et al., 2010). Our

findings suggest that when examined through a within-person lens, alcohol and marijuana use does increase after childbirth but remains significantly lower than pre-pregnancy levels after adjusting for age, whereas pregnancy-related reductions in cigarette use remain stable after childbirth. These results highlight pregnancy as a sensitive period for substance use intervention, given that adolescent girls with pre-existing risk for substance use problems demonstrate natural reductions in use during pregnancy. The transition to motherhood is associated with significant shifts in social responsibilities that may impact substance use (Fletcher, 2012; Staff et al., 2010). Although future studies are needed to test mediation, our preliminary analyses suggest that alcohol reductions after childbirth may reflect changes in mothers' peer environments.

Whereas previous studies of adults found that miscarriage is unrelated to substance use changes and may even increase use temporarily (Kinsey et al., 2015), our study of adolescents found transient elevations in marijuana use from pre-pregnancy to year of miscarriage, followed by significant *reductions* in marijuana and alcohol (but not cigarette) use after miscarriage. Miscarriage in adults can be associated with guilt or self-blame (Beutel, Deckardt, von Rad, & Weiner, 1995; Brier, 2008); adolescents may experience similar feelings that affect their substance use. Indeed, supplemental analyses suggest that increases in depression from pre-pregnancy to miscarriage may partially account for marijuana increases, whereas changes in peer environment may partially account for decreases in marijuana and alcohol use after miscarriage. Given the scarcity of evidence regarding psychosocial correlates of adolescent miscarriage, more studies are needed to substantiate these results.

Finally, whereas other studies have been limited in their ability to control for differences between women who did or did not have an abortion, our study found that when examining within-person changes, abortion was not associated with long-term changes in adolescent alcohol, marijuana, or cigarette use relative to pre-pregnancy levels. However, transient fluctuations were observed depending on substance type. Abortion was not associated with changes in drinking from pre-pregnancy levels, consistent with well-controlled between-subject studies (Roberts et al., 2014). In contrast, we observed gradual increases in marijuana and cigarette use in the years leading up to abortion, with greater marijuana use during year of abortion and more cigarette use the year after abortion relative to pre-pregnancy. Both marijuana and cigarette use returned to pre-pregnancy levels in subsequent years. Importantly, examination of changes between adjacent years demonstrated no specific year in which substance use suddenly increased, but instead suggested a gradual increase beginning before pregnancy that "peaked" during year of abortion. Thus, results do not support abortion as a causal factor underlying increased substance use but do suggest that there are unmeasured factors influencing substance use (e.g., stress, other risky behaviors) that occur during the time period leading up to abortion.

Our findings should be interpreted in the context of several study limitations. First, although participants reported substance use annually from ages 11–20, our study did not capture fine-grained day-to-day changes. This is an important consideration when interpreting the directionality of effects, given that substance use and pregnancy outcomes were measured in the same time frame. Second, data on gestational timing were unavailable. Late miscarriages

may impact psychological/behavioral outcomes differently than early miscarriages, a consideration for future studies. Third, although our supplemental analyses provided preliminary suggestions of explanatory factors, studies are needed to directly test for mediation effects. Finally, findings are based on adolescent girls oversampled from low-income, urban neighborhoods and may not generalize to other groups.

Conclusions

Together, these results highlight pregnancy during adolescence as a critical and potentially unique window of opportunity for substance use screening and intervention, which is important given that adolescents who become pregnant have greater pre-existing risk for substance use disorders compared to same-aged peers. Adolescent childbirth and miscarriage were associated with decreased substance use in our sample. Studies are needed to clarify the social-emotional and motivational factors that contribute to this behavior change; directly integrating these factors into clinical care may help to magnify the effectiveness of interventions. In contrast, our results highlight the years leading up to abortion as an important period for alcohol and marijuana use screening/intervention. Although results suggest that abortion is not a causal factor underlying increases in substance use, and changes were relatively transient (returning to pre-pregnancy levels after abortion), more research is needed to understand the broader social/psychological experiences occurring during the years leading up to abortion that may influence substance use. Despite the serious implications of substance use for individual and offspring outcomes, few gender-informed treatments exist that target substance use during pregnancy for adolescents. Our results support the need to develop treatments that directly address the unique developmental needs and behavior patterns of pregnant adolescent girls.

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Key Points

- Adolescent girls who become pregnant demonstrate greater risk for substance use than same-aged peers. However, it remains unclear how risk relates to normative changes in adolescence and whether patterns differ based on pregnancy outcome.
- In this prospective longitudinal study of adolescent girls assessed from ages 11–20 years, significant and enduring within-person reductions in alcohol, marijuana, and cigarette use were observed after childbirth.
- Alcohol and marijuana use decreased after miscarriage, whereas substance use after abortion was comparable to pre-pregnancy levels after accounting for normative age-related increases.
- Findings highlight critical differences in adolescent substance use patterns based on pregnancy outcome.
- For pregnant adolescents with pre-existing risk for substance use, pregnancy may be a unique window of opportunity for clinical screening and intervention.

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Table 1

Descriptive statistics for pregnancy outcomes and substance use in adolescent girls (N=2,450)

	Age 11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Substance use	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Alcohol use										
(0) None	89.7	88.3	84.1	78.1	72.4	66.7	60.1	44.8	36.3	29.0
(1–2) < 1x/month	9.4	10.8	14.5	19.0	23.2	25.5	28.6	35.1	34.3	36.5
(3–4) ≤ 1x/week	0.9	0.8	1.1	2.1	3.3	6.4	9.4	16.9	22.0	25.3
(5–7) > 1x/week	0.0	0.0	0.1	0.7	1.0	1.3	1.9	4.1	7.5	9.0
Marijuana use										
(0) None	99.5	98.2	95.7	88.6	83.0	78.9	75.3	68.1	65.5	65.6
(1–2) < 1x/month	0.4	1.4	2.9	7.1	9.6	11.3	11.8	14.8	15.0	9.3
(3–4) ≤ 1x/week	0.1	0.1	0.7	1.5	2.8	3.7	5.1	5.7	6.4	3.6
(5–7) > 1x/week	0.0	0.4	0.6	2.7	4.6	6.1	7.8	11.5	13.2	21.5
Cigarette use										
(0) None	97.8	96.8	94.3	90.1	86.4	82.5	79.1	72.7	70.4	67.8
(1–2) < 1x/month	1.9	2.3	3.3	5.2	5.2	5.8	4.7	5.9	6.6	11.7
(3–4) ≤ 1x/week	0.1	0.5	0.6	1.3	1.4	2.0	2.3	2.8	2.5	5.6
(5–7) > 1x/week	0.2	0.4	1.8	3.4	7.0	9.7	13.9	18.6	20.5	15.0
Pregnancies from age 12–19	N[a]	N	N	N	N	N	N	N	N	N[a]
First childbirth (N=325)	--	1	1	7	33	34	59	84	106	--
First miscarriage (N=105)	--	0	2	5	4	17	19	28	30	--
First abortion (N=136)	--	0	3	7	22	25	23	21	35	--
Potential explanatory factors	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Depression symptoms	1.48 (1.58)	1.33 (1.55)	1.36 (1.63)	1.45 (1.71)	1.32 (1.69)	1.24 (1.72)	1.21 (1.76)	1.11 (1.66)	1.23 (1.8)	1.39 (1.95)
Peer substance use	0.28 (0.84)	0.8 (1.59)	1.62 (2.17)	2.17 (2.28)	3.03 (2.51)	3.67 (2.64)	3.8 (2.68)	4.53 (2.48)	4.78 (2.35)	4.99 (2.23)

Note.

[a]Models focused on pregnancy events occurring from ages 12–19 to ensure that all participants had at least one time point of data before and after the pregnancy event.

Table 2

Fixed effects negative binomial regressions testing the associations between pregnancy outcomes and within-person changes in alcohol, marijuana, and cigarette use from ages 11–20 years

	Alcohol use				Marijuana use				Cigarette use			
	IRR	**SE**	***p***	**95% CI**	**IRR**	**SE**	***p***	**95% CI**	**IRR**	**SE**	***p***	**95% CI**
Childbirth												
T1 (1 yr pre-preg)	0.99	0.09	.914	[0.83, 1.19]	0.96	0.11	.682	[0.77, 1.19]	1.10	0.13	.406	[0.87, 1.39]
T2 (yr of preg/birth)	**0.54**	**0.05**	**<.001**	**[0.45, 0.65]**	**0.49**	**0.06**	**.000**	**[0.39, 0.61]**	**0.74**	**0.08**	**.008**	**[0.60, 0.92]**
T3 (1 yr after)	**0.58**	**0.05**	**<.001**	**[0.48, 0.69]**	**0.71**	**0.08**	**.004**	**[0.56, 0.90]**	**0.68**	**0.09**	**.002**	**[0.53, 0.87]**
T4 (2+ yrs after)	**0.72**	**0.07**	**.001**	**[0.60, 0.88]**	**0.63**	**0.08**	**.001**	**[0.48, 0.82]**	**0.66**	**0.09**	**.003**	**[0.50, 0.87]**
Miscarriage												
T1 (1 yr pre-preg)	1.08	0.13	.529	[0.85, 1.37]	1.10	0.19	.574	[0.79, 1.54]	1.28	0.21	.131	[0.93, 1.77]
T2 (yr of miscarriage)	0.88	0.11	.289	[0.69, 1.12]	**1.36**	**0.21**	**.049**	**[1.00, 1.85]**	1.25	0.20	.156	[0.92, 1.72]
T3 (1 yr after)	**0.70**	**0.09**	**.006**	**[0.54, 0.90]**	1.15	0.19	.387	[0.83, 1.59]	1.22	0.20	.224	[0.89, 1.67]
T4 (2+ yrs after)	**0.53**	**0.07**	**<.001**	**[0.41, 0.69]**	**0.68**	**0.12**	**.032**	**[0.48, 0.97]**	1.04	0.17	.793	[0.76, 1.44]
Abortion												
T1 (1 yr pre-preg)	0.87	0.12	.336	[0.66, 1.15]	1.27	0.20	.131	[0.93, 1.73]	1.20	0.23	.328	[0.83, 1.74]
T2 (yr of abortion)	1.21	0.14	.098	[0.97, 1.51]	**1.46**	**0.22**	**.011**	**[1.09, 1.95]**	1.37	0.23	.057	[0.99, 1.91]
T3 (1 yr after)	0.94	0.11	.579	[0.74, 1.18]	0.97	0.16	.867	[0.70, 1.35]	**1.44**	**0.23**	**.025**	**[1.05, 1.98]**
T4 (2+ yrs after)	0.93	0.11	.530	[0.74, 1.17]	1.25	0.18	.119	[0.94, 1.64]	1.23	0.19	.175	[0.91, 1.68]

Note. Baseline alcohol, marijuana, and cigarette use frequency at T0 (2 or more years before pregnancy) was the reference time point in these models. T1 = 1 year before pregnancy, T2 = year of pregnancy/pregnancy event, T3 = 1 year after pregnancy event, T4 = 2 or more years after pregnancy event. IRR = incidence rate ratio. SE = standard error. Significant effects ($p < .05$) are bolded for emphasis. Models included age and all subsequent pregnancy events as time-varying covariates. Participants who experienced no within-person changes in the outcome (i.e., $n = 433$ for alcohol, $n = 1{,}046$ for marijuana, and $n = 1{,}201$ for cigarette use) are dropped from fixed effects models by default.