Concurrent Trajectories of Female Drinking and Smoking Behaviors throughout Transitions to Pregnancy and Early Parenthood

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Abstract

The purpose of this longitudinal study was to investigate whether there are distinct etiological processes explaining dual usage of alcohol and conventional cigarettes by mothers from pre-conception through the early parenting years. Data on 8,800 biological mothers were drawn from the Early Childhood Longitudinal Study-Birth Cohort (ECLS-B), representative of U.S. births in 2001. A general growth mixture model (GGMM) was used to empirically identify developmental trajectories of maternal smoking and drinking over the five-to-six year study period. Six classes defined by alcohol consumption and cigarette smoking were identified. These included a non-smoking, low probability of drinking class (41%) and two drinking classes displaying no smoking with either moderate (26%) or escalating high (8%) probability drinking. Additionally, two predominantly smoking classes were identified, one displaying temporary reduction in smoking during pregnancy and low probability of drinking (11%) and one following a trajectory of persistent heavy smoking with a declining probability of drinking (9%). The sixth class was described by temporary reduction in smoking during pregnancy with high probability of drinking (6%). Covariates differentially predicted class membership, e.g., having a high school degree but not further education predicted concurrent drinking and smoking, and breastfeeding for more than six months is protective against concurrent use. Prior to conception, during prenatal care, and in post-natal clinical visits, whether for personal or pediatric care, screening women of reproductive age via characteristics that predict heterogeneity in smoking and drinking trajectories may help guide prevention and treatment options.

Keywords

maternal smoking; maternal alcohol use; GGMM; concurrent trajectories; ECLS-B

INTRODUCTION

Alcohol use during pregnancy, discouraged by the American Academy of Pediatrics (Williams & Smith, 2015), is a leading cause of still birth, spontaneous abortion, and preterm delivery, as well as various child neurobehavioral problems, such as fetal alcohol

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syndrome (FAS) and deficits in attention, memory, and IQ (Meyer-Leu, Lemola, Daeppen, Deriaz, &Gerber, 2011). Longitudinal research suggests that even low level drinking during this critical period can be detrimental to a child's neurocognitive development, although exposure did not necessarily dictate deleterious outcomes (Streissguth, 2007). Studies of maternal smoking during pregnancy also indicate negative maternal health impacts, including reduced fertility, spontaneous abortion, and preterm delivery, as well as detriments to the child's health, including decreased birth weight and sudden infant death (Wigle et al., 2008). Such risks have inspired a growing body of epidemiological research examining the patterns of and risk factors for maternal prenatal smoking and/or alcohol consumption (Powers, McDermott, Loxton, & Chojenta, 2013) and have guided the development of effective prevention programs (Haynes et al., 2015).

Despite a significant decline in drinking and smoking from preconception to prenatal period, 52% of new mothers resume alcohol use and 24% resume smoking within a year post-delivery (Substance Abuse and Mental Health Services Administration, 2009). Evidence (Tsai et al. 2010, Powers, et al. 2013, Lange, Probst, Quere, Rehm, & Popova, 2015) suggests that 12–22% of women of reproductive age (WRA) and 8–14% of pregnant women consume both substances. Concurrent prenatal use of alcohol and cigarettes imposes added risk to maternal and child health in the form of preterm labor, low birth weight, and infant growth restrictions (Odendaal, Steyn, Elliott, & Burd, 2008). Continuing or resuming smoking and/or risky alcohol use postpartum poses threats to maternal and child health and well-being. Children's exposure to secondhand smoke is associated with Sudden Infant Death Syndrome, respiratory ailments, and infections (U.S. Department of Health and Human Services 2006). Children raised by mothers with risky drinking behaviors risk exposure to unstable environments (Jester et al. 2000) with implications for subsequent emotional/behavioral problems (Eiden, Edwards, & Leonard 2007).

The multiple mechanisms — e.g., cross-tolerance, sociobehavioral, environmental, genetic, neurochemical (McKee & Weinberger, 2013) — informing additive and multiplicative effects of concurrent drinking and smoking underscore the importance of explicating concurrent use patterns. Despite a concerning level of concurrent use during the perinatal period and shared risk factors, e.g., mental disorders (Ingersoll, Hettema, Cropsey, & Jackson, 2011), being unmarried (Tsai, et al., 2010), curtailed breastfeeding (Jagodzinski & Fleming 2007), longitudinal patterns of maternal smoking (Mumford & Liu 2015) and drinking (Liu, Mumford, & Petras, 2015) have only been modeled separately. To inform public health and clinical efforts in better allocating prevention efforts, we investigate distinct trajectories representing single and dual usage of alcohol and cigarettes by mothers from pre-conception through the early parenting years, and the extent to which mothers' baseline characteristics are associated with these patterns.

METHODS

Sample

Study data come from the Early Childhood Longitudinal Study (ECLS-B), a nationally representative study of over 10,000 children from the 2001 U.S. birth cohort and their parents. The sample was drawn from a list of registered births provided by the National

Center for Health Statistics (NCHS), using a clustered list frame sampling design with counties and county groups as the primary sampling units (PSU) (Flanagan & West, 2004). This study examines biological mothers' survey responses at four time points: child approximately 9 months old (2001–2, baseline), 2 years old (2003–04), 4 years old (2005–06, preschool), and 5 or 6 years old (2006–07, kindergarten). Trained interviewers visited the respondent (mother's) home at each wave with a $30 respondent fee for mothers and a book for the child. Smoking and alcohol use measures at three months prior to conception and during the third trimester were retrospectively collected at baseline, with the advantage of circumventing potential antenatal underreporting due to respondent beliefs about socially undesirable behaviors. In population-based studies, retrospective reports of prenatal drinking have been more forthcoming and accurate than self-reported drinking during pregnancy (Alvik, Haldorsen, Groholt, & Lindemann, 2006). Similarly, retrospective reports of prenatal smoking have been shown to align with self-reports and cotinine measurements during pregnancy (Pickett, Kasza, Biesecker, Wright, & Wakschlag, 2009). Sample n's are rounded to the nearest 50 in compliance with ECLS-B rules. Cases that missed all smoking/drinking measures (N=100) or any exogenous variables (N=1600) were excluded, resulting in an analytic sample of 8,800 (84% of the original sample) adult biological mothers. The selected sample is significantly different from the excluded cases on a number of study variables; however, the average magnitude of the difference is small, i.e., 2% for smoking measures, 6% for drinking measures, and 6% for exogenous variables (see Supplement Table 1 for details). In order to assess whether the exclusion of cases with missing data bias the study results, we conducted a sensitivity analysis and found that a 6 class model using all cases is similar in structure as the presented model (results available upon request).

Measures

Growth model indicators: Longitudinal measures of maternal smoking and drinking—Smoking is measured as the average quantity smoked in terms of cigarettes per day (CPD). A four-level categorical ordinal variable was created at each time point: never smokers, 5 CPD, 5–10 CPD, and >10 CPD (heavy smoking). Drinking quantity is measured in categories of the number of alcoholic beverages consumed in an average week (*<1, 1–3, 4–6, 7–13, 14–19, and 20 or more*). We collapsed the original measures of alcohol consumption into a four-level ordinal variable per Brown, Olson, & Croninger (2010): no alcohol, <1 drink per week, 1–3 drinks per week, and 4+ drinks per week, thereby managing low response frequencies that pose problems for model estimation (e.g., across waves, 0.1% to 7.2% of mothers drank 4+ drinks per week).

Exogenous variables—Covariates collected at baseline include: *age* (18–25, 26–35, and 36+) (Meschke, Holl, & Messelt, 2013); *education* (less than high school; high school degree; some college; college or graduate degree) (Kandel, Griesler, & Schaffran 2009); *race/ethnicity* (white, black, Hispanic, Asian or other) (Kandel et al. 2009); *postpartum depression* measured with a modified 12-item version of the Center for Epidemiologic Studies Depression Scale (CES-D) (severe or moderate depression vs. low or no depression per Paulson et al. (2009)); *marital status* (married or cohabitating vs. others)(Meschke et al. 2013); *household income-poverty* (<poverty line; 100–130% poverty line; 130–185% poverty line; >185% poverty line), reflecting common federal aid eligibility requirements

and prior research (Mumford, Hair, Yu, & Liu, 2014); *employment status* (full-time, part-time, not employed)(Cooklin, Donath, & Amir, 2008); *breastfeeding* (never, breastfed 6 months, breastfed >6 months per Ogbuanu et al. (2011)); planned pregnancy (yes, no; (Edwards & Werler, 2006)).

Analytic Plan

General growth mixture models (GGMM) (Muthén 2004) were used to empirically identify developmental trajectories of women's smoking and drinking before, during and after pregnancy using Mplus version 7.11. GGMM uses a categorical latent class variable in combination with continuous growth factors to explore population heterogeneity in the change process of the outcome of interest, i.e., whether the study population consists of two or more discrete classes of individuals with varying growth trajectories (Muthén 2004). Trajectory classes are characterized by concurrent longitudinal development of both drinking and smoking. Modeling sequence followed the guidelines for growth models with ordered categorical outcomes. The origin of time was set at baseline to support the association of baseline covariates with subsequent drinking and smoking measures (Biesanz, Deeb-Sossa, Papadakis, Bollen, & Curran, 2004). The determination of the functional form was conducted separately for smoking and alcohol consumption. A series of growth models was first estimated with fixed or random intercept and slope factors, and compared for model fit (e.g. likelihood ratio test for nested models and the Bayesian Information Criterion (BIC), parsimony and interpretability. For both smoking (LL=−19938.874 (10), BIC=39968.53) and drinking (LL=−33355.568 (10), BIC=66801.92), a model with a random intercept and a random slope best fit the data (Table 1, details available online). Heterogeneity in the longitudinal development of maternal drinking and smoking was then explored by estimating models with increasing numbers of classes. Deciding on the number of longitudinal latent classes is based on BIC as well as substantive evaluation of the classes. Entropy was obtained as a measure of classification quality. Final class membership was regressed on exogenous variables via multinomial logistic regression.

Missing data on the outcome measures were accounted for by using the full information maximum likelihood (FIML) estimation method (Schafer and Graham 2002). Over 60% of the study sample had valid information on all six smoking/drinking measures and another 20% missed only one smoking/drinking measure. Complex sampling design was accounted for by computing robust standard errors using a sandwich estimator (White 1980). Results were weighted to represent the 2001 birth cohort.

RESULTS

Over half (50.6%) of the women in the sample gave birth between age 26 and 35. The majority were White (60.8%), married or cohabitating (82.1%), employed (20.8% full time and 32.8% part time) with household income higher than 185% poverty line (54.6%). Over half of the women in the sample had at least a college degree (29.6% had some college degree and 26.0% had a college or graduate degree). Over half (50.7%) of the women planned their pregnancy, and two-thirds of the sample breastfed for at least 6 months (42.6%

6 months and 27.1%> 6 months). Table 2 presents the weighted distribution of maternal alcohol and cigarette use before, during and after pregnancy.

Heterogeneity in smoking and drinking patterns

A 6-class solution (LL=−54462.96 (39), BIC=109279.97) was selected (Table 3). While the 9-class solution presents the lowest BIC, the reduction in BIC from a 4 to a 5-class solution (1815.88) or from a 5 to a 6-class solution (1484.80) is considerably greater than for the other models, indicating diminishing returns when adding additional classes. Figure 1 presents the model estimated time-specific probability of endorsing each category of smoking and drinking, given class membership. Over 40% of mothers (*non-smokers and likely non-drinkers; NS-ND*) exhibited a pattern of very low probability of smoking (<0.01) and drinking (<0.05). Nearly all NS-ND mothers reduced or quit both substances by the third trimester of pregnancy.

Two classes featured non-smoking patterns with various levels of drinking. A quarter (25.8%) in the class *non-smokers and moderate probability drinkers (NS-MPD)* remained abstinent from smoking while displaying a steady probability (about 0.6) of drinking any alcohol and a very low (<0.05) probability of drinking 4+ drinks per week. *Non-smokers and escalating high probability drinkers (NS-EHPD)* (8.4%) are presented with a near-zero probability of smoking and a steadily high probability (0.9) of drinking any alcohol outside of pregnancy with an increasing trend in quantity through early parenting. NS-EHPD mothers had a probability as high as 0.4 of consuming 4+ drinks per week by the time the child entered kindergarten.

Another two classes displayed low-level drinking with moderate to high levels of smoking. One tenth (10.7%) of the mothers (*temporary reduction smokers and low probability drinkers; TRS-LPD*) exhibited a probability of any smoking as high as close to 0.8, which dropped to 0.3 during pregnancy. While we observe a slight trend toward decreasing smoking over time, TRS-LPD mothers had about a 0.7 probability of smoking by the time their child entered kindergarten. At the same time, TRS-LPD mothers displayed a steady, low probability (<0.2) of drinking (limited to <3 drinks per week) outside of pregnancy (during which most quit drinking). By comparison to TRS-LPD mothers, the *persistent heavy smokers and declining probability drinkers (HS-DPD;* 8.6%) displayed a very high and stable probability (>0.9) of any smoking throughout the study period with a temporary reduction during pregnancy and a clear decline in drinking over time despite a slightly higher probability (0.4) of drinking any alcohol postpartum. Further, the probability of HS-DPD mothers reporting *heavy* smoking prior to conception and postpartum was as high as 0.7. Finally, *temporarily reduced smokers and stable high probability drinkers* (*TRS-HPD;* 5.9%) displayed a similar smoking trend compared to the TRS-LPD class, with a significant trend toward declining smoking probability. However, their drinking behavior closely resembled the NS-EHPD class, with a lower probability (<0.2) of 4+ weekly drinks.

Covariate effects using the non-use NS-ND class as reference

Table 4a presents the effect of covariates on the log odds of being in each of the five classes, using the non-use NS-ND class as the reference. When compared to their peers who gave

birth between 26 and 35, mothers younger than 25 were twice as likely (AOR=2.04) to be in the predominately smoking TRS-LPD class, while 80% less likely (AOR=0.17) to be in the drinking NS-EHPD class. By contrast, mothers who gave birth past age 35 were more than twice as likely (AOR=2.21) to be in the drinking NS-EHPD class, when compared to their 26–35 year-old peers. Non-white mothers, compared to whites, were consistently less likely (AORs range from 0.02 to 0.49) to be in any of the five smoking/drinking classes. Marriage or cohabitation had a protective effect (AORs range from 0.46 to 0.72) from being in each of the smoking/drinking classes (with the exception of the drinking NS-EHPD class). Mothers of higher levels of education, compared to those with less than a high school diploma, were more likely (AORs range from 1.56 to 2.48) to be in the drinking NS-MPD class while less likely (AORs range from 0.04 to 0.55) to be in the predominately smoking HS-DPD class. In addition, compared to mothers with the least education, those with at least a college degree were over five times more likely (AOR=5.40) to be in the drinking NS-EHPD class; those with some college (AOR=0.60) or at least a college degree (AOR=0.16) were less likely to be in the predominately smoking TRS-LPD class; and those with a high school degree were twice as likely (AOR=1.88) to be in concurrent use TRS-HPD class. Having a household income higher than 185% of the poverty line significantly increased the probability (AORs range from 2.25 to 6.92) of being in the two drinking classes, NS-MPD and NS-EHPD, and concurrent use TRS-HPD classes. Mothers from this income bracket were only 40% as likely (AOR=0.63) to be in the predominately smoking HS-DPD class, when compared to those who earned an income below the poverty line.

Postpartum depression had a significant impact on being classified as predominately smokers, TRS-LPD (AOR=1.45) or HS-DPD (AOR=2.21). The impact of depression on the three higher drinking probability classes (NS-MPD, NS-EHPD, and TRS-HPD) failed to reach the 0.05 significance level. Compared to those who did not breastfeed, breastfeeding for at least 6 months had a protective effect (AORs range from 0.22 to 0.40) from being predominately smokers, TRS-LPD or HS-DPD, or concurrent users TRS-HPD. Despite the protective effect of breastfeeding for up to 6 months from being in the predominately smoking HS-DPD class (AOR=0.76), it increased the likelihood of being in the two drinking, NS-MPD (AOR=1.37) or NS-EHPD (AOR=1.76) classes. Further, both part-time (AOR=1.55) and full-time (AOR=1.51) employment increased the likelihood of classification in the drinking NS-MPD class. While part-time employment increased the likelihood of being classified in the drinking NS-EHPD (AOR=1.69) class, predominately smoking TRS-LPD (AOR=1.35), or the concurrent use TRS-HPD (AOR=1.76) classes, full-time employment increased the likelihood of being classified as predominately smokers HS-DPD (AOR=1.40). Finally, those who planned pregnancy were less likely to be in the two predominately smoking classes, TRS-LPD (AOR=0.73) and HS-DPD (AOR=0.65) or the concurrent use TRS-HPD class (AOR=0.69).

Covariate effects using alternative reference classes

Table 4b presents the effects of covariates using the concurrent use, TRS-HPD class as the reference, showing the distinction between the concurrent use class and the drinking or predominately smoking classes. For example, being married or cohabitating, breastfeeding for at least 6 month and planned pregnancy all had a protective effect against being in the

concurrent use class. Married or cohabitated mothers were more likely to be in predominately smoking TRS-LPD (AOR=1.56) class or the non-use NS-ND class (AOR=2.52). Compared to those who did not breastfeed, breastfeeding for at least 6 months were more likely to be in either of the two drinking classes, NS-MPD (AOR=2.63) or NS-EHPD (AOR=3.16) as well as the non-use, NS-ND class (AOR=2.53). Mothers who planned their pregnancy were more likely to be in the predominately drinking NS-EHPD class (AOR=1.93) or the non-use NS-ND class (AOR=1.46).

Table 4c presents covariate effects using the predominately smoking TRS-LPD class as the reference, showing the comparison between the three smoking classes, TRS-LPD, HS-DPD, and TRS-HPD with different quitting rate during pregnancy. Younger age, being Black or Hispanics, and having a higher education all had a protective effect against continuous smoking during pregnancy. Compared to their peers, mothers younger than 25 were 60% less likely (AOR=0.42), Black mothers were 90% less likely (AOR=0.11), Hispanic mothers were over 90% less likely (AOR=0.08), and mothers of higher education levels were less likely (AORs ranged from 0.26 to 0.65) to continue smoking during pregnancy. In contrast, postpartum depression increased the likelihood of continuous smoking through pregnancy by 50% (AOR=1.52).

DISCUSSION

Women who engage in smoking and/or risky alcohol consumption threaten their own health, and for those women contemplating motherhood, their children's health as well. Understanding the concurrent patterns of women's drinking and smoking during this critical period of time and identifying early risk factors for concurrent use constitutes the first step to inform public health and clinical efforts to prevent harmful effects. This is the first study that explicitly identifies women's trajectories of concurrent drinking and smoking over an extended period spanning from pre-conception through the child's entry to kindergarten. The large nationally representative sample allows for the identification of rare patterns. Across the full study period, our sample of U.S. mothers fell into six smoking/alcohol consumption patterns. Overall, consistent with other national data sources (Substance Abuse and Mental Health Services Administration 2014), abstinence from drinking during pregnancy was more common than from smoking, which was reportedly continued by at least one in 10 women in the third trimester of pregnancy. Education about the risks of maternal drinking during pregnancy has come from numerous sources since the 1970s (Warren 2015). Moreover, nicotine is highly addictive and pregnant women may have a harder time quitting smoking than quitting drinking (Hellerstedt, Pirie et al. 1998). Incongruously, the probability of drinking during the third trimester of pregnancy was near zero for the persistent heavy smokers (HS-DPD), but it was close to 0.2 for those who temporarily cut back on smoking during pregnancy (TRS-HPD) and those who did not smoke (NS-EHPD). Perhaps there is a behavioral time constraint, a financial constraint, or a self-moderation out of concerns of social stigma related to consuming *both* cigarettes and alcohol in larger quantities for women at this point in their life cycle. As discussed below, external factors may be augmenting stressful conditions, limiting access to health services, undermining quit efforts, or supporting continued smoking and/or alcohol consumption during pregnancy. Research is needed to untangle where these factors interact with individual dependency and behavior.

Overall, the prevalence of smoking and/or drinking both re-approached preconception levels by 9 months after child birth and thereafter remained relatively stable, with some variations from this pattern. In sum, the six classes of mothers defined by alcohol consumption and cigarette smoking over the study period not only reflect the expected patterns of each substance use (Mumford et al. 2014, Liu, Mumford, & Petras, 2016), but also identify differential patterns informing better discernment for public health education and for clinical treatment. These results identify classes of women who may benefit from closer attention to the interaction of alcohol and tobacco use to prevent amplification of deleterious outcomes (McKee & Weinberger 2013).

Results relating maternal characteristics to these patterns highlight the importance of clinical implications of risk factors for the complex spectrum of concurrent behavioral choices. Results are largely consistent with the literature regarding the effect of maternal age at childbirth (Meschke et al., 2013); education (Laborde & Mair, 2012); marital status (Tsai et al., 2010); income (Jagodzinski & Fleming, 2007); employment (Mumford & Liu, 2015); postpartum depression (Munafo, Heron, & Araya, 2008); and breastfeeding (Jagodzinski & Fleming, 2007). This study adds to the literature by examining how maternal smoking and drinking fluctuate concurrently in concert with the context of demographic and behavioral correlates.

Some particularly interesting relationships are worth highlighting. For over half of the women followed through this perinatal and parenting period, drinking and smoking reports may not be reliable reciprocal predictors, adding value to knowledge of the distinguishing correlates of separate and concurrent drinking and smoking trajectories. Younger maternal age increased the likelihood of concurrent drinking and smoking behavior, while age is more related to smoking than to drinking. However, compared to older mothers, younger mothers were more likely to temporarily quit smoking during pregnancy. Higher education consistently predicted higher likelihood of drinking and lower likelihood of smoking, and women with at a least a high school degree tended to quit smoking during pregnancy. Women who earned a high school degree but did not have further education faced an elevated risk of both smoking and drinking, as they are least likely to stay abstinence across this time period. Although employment and income overall are stronger predictors of drinking than of smoking, part-time employment suggests greater risks than full-time employment of resuming smoking post-partum and of escalating or higher probabilities of drinking. Women with higher income were also more likely to resume smoking postpartum while continuously engaging in high probability drinking. Contextual mechanisms associated with part-time work (e.g., disposable income, available free time for socializing with friends, or possibly the stressors of managing both childcare and work responsibilities) may be related to ongoing smoking and drinking and suggest opportunities for preventive health services. Postpartum depression was more related to smoking than drinking, showing particularly strong relationship to the predominately smoking classes. In that breastfeeding is negatively related to both smoking and drinking, postnatal women's health care and pediatric visits may support women maintaining reduced alcohol consumption and smoking abstinence by encouraging breastfeeding for at least six months. Finally, the finding that planned pregnancy is more protective against smoking than drinking may reflect persistent misconceptions by women of reproductive age, that is, there are some safe options for

drinking during pregnancy (Elek et al., 2013), with implications for the educational work that remains in communicating the guidelines of the American College of Obstetricians and Gynecologists (ACOG) regarding drinking during pregnancy.

This study suggests a new direction to reach the Healthy People 2020 target of minimizing maternal drinking and smoking during pregnancy, as well as during the preconception and postpartum periods. Expanding prevention of maternal smoking and alcohol misuse may require redesigning both research and clinical approaches to explicitly target all women of reproductive age, simultaneously broadening and focusing public health efforts. Building on improved screening tools, clinicians more than ever need effective intervention and treatment regimens. Unfortunately, screening and treatment guidance for women's substance use tends to be limited to the period of pregnancy. ACOG explicitly targets their guidance for providers and patients regarding alcohol use and smoking to the period of pregnancy, leaving out critical periods preconception (as women may drink alcohol before they realize they are pregnant) and during the early years of parenting. Even during pregnancy, systematic screening is not yet the reality (e.g., Oser, Biebel, Harris, Klein, & Leukefeld, 2011), suggesting an opportunity to improve provider training before, during, and after the perinatal period.

Similar to the limited focal time period for screening women for smoking and drinking behavior, interventions have also targeted a narrow window. While there is some evidence of intervention effectiveness during pregnancy on drinking (Gilinsky, Swanson, & Powers, 2011) and smoking (Lumley et al., 2009) abstinence, limited attention has been paid to the prenatal and postpartum periods. Recent reviews of postpartum home visits found no evidence of effectiveness in reducing alcohol misuse (Yonemoto, Dowswell, Nagain, & Mori, 2013) and only limited evidence for the effectiveness in promoting smoking cessation (Likis et al., 2014). However, recent success in pediatric settings of parental smoking cessation (Winickoff et al., 2013) and risky drinking interventions (Jonas et al., 2012), in concert with this study's findings of concurrent use patterns, suggest screening for concurrent maternal smoking and alcohol consumption patterns in pediatric settings may be warranted.

Results should be interpreted in the context of the following limitations. First, this study relies on self-reports of the ECLS-B measures of smoking and alcohol consumption. Self-reports of perinatal smoking behavior, at least, are highly correlated with maternal (Pickett et al., 2009) and co-resident children's urinary cotinine levels (Ino, Ohtani et al. 2011). Second, two time points of the outcome measures are collected restrospectively, but retrospective measures of smoking (Dietz et al., 2011) and drinking (Alvik et al., 2006) during pregnancy have been shown to exceed underreporting that may have reflected awareness of social desirability of maternal pregnancy behaviors. Third, the data do not support investigation of whether greater quantities of weekly alcohol consumption are clustered in sessions of binge drinking or are spread out as more moderate daily consumption. Fourth, while there is no evidence of secular changes in women's smoking behavior in the years since the ECLS-B data were collected (Centers for Disease Control and Prevention, 2011), there has been some decline in women's drinking during pregnancy(Substance Abuse and Mental Health Services Administration, 2002, 2014).

Likewise, it is possible that the pattern of *concurrent* alcohol use and smoking by women at this developmental point in their life course has changed significantly in the years from the results presented here. Fifth, the current study does not account for a range of social and environmental factors that may be related to women's smoking and drinking behavior at this point in their life course. For example, while low income is a known risk factor for smoking behavior, food insecurity and social networks within disadvantaged neighborhoods may also merit investigation for impact on women's concurrent use behavior (Castro, Heck, Forster, Widome, & Cubbin, 2015). Addressing individual risk behaviors, particularly in advance of conception, in the context of engaged community structures and attention to environmental influences (e.g., education, employment, access to health services, housing) as a model for programming (e.g., Preconception Stress and Resiliency Pathways (PSRP) model; see Ramey et al. 2015) as well as research regarding concurrent substance use pathways is warranted.

Compliance with Ethical Standards

a. This research was funded by the National Institute on Drug Abuse (1R01DA030496).

b. The authors declare that they have no conflict of interest.

c. All procedures were in accordance with the ethical standards of the NORC IRB and 1964 Helsinki declaration and its later amendments or comparable ethical standards.

d. For this secondary data analysis study, formal consent is not required.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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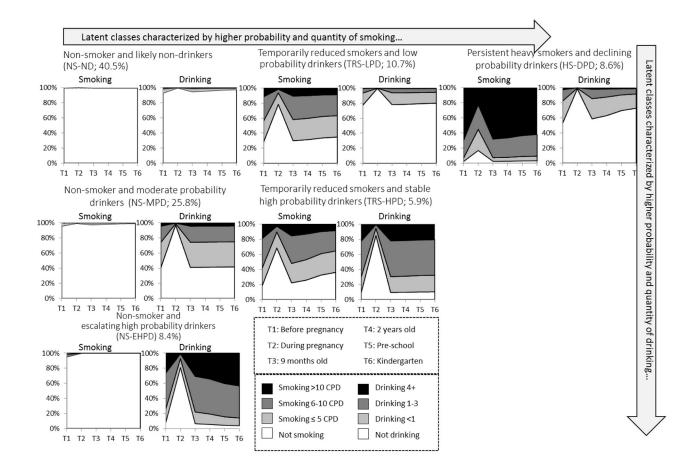
Figure 1.

Conditional 6 Class Model of Maternal Smoking and Drinking, ECLS-B*

*The trend during pregnancy may not be reflected in class labels due to limited space. Specifically, mothers in the TRS-LPD class significantly reduced smoking and quit drinking during pregnancy. A similar trend is reflected in the HS-DPD class. Mothers in the NS-MPD class and the NS-EHPD class reduced or quit drinking, and mothers in the TRS-HPD class also reduced both smoking and drinking during pregnancy (see Result section for details).

Table 1

Parameters estimated in the functional form for smoking and drinking in Logit coeffients[*]

	Intercept		Slope		Thresholds for during pregnancy (2nd time point)			Thresholds for all other time points		
					#1	#2	#3	#1	#2	#3
Smoking										
	Mean	Variance	Mean	Variance						
	0.000	46.030	−0.280	0.274	9.258	11.163	13.492	6.311	7.869	10.291
Drinking										
	Mean	Variance	Mean	Variance						
	0.000	8.421	−0.113	0.189	6.240	7.536	10.248	1.217	2.959	5.569

[*]
Results based on a model a random intercept and a random slope as it best fits the data (for details, please see online supplement material). All parameters presented in the table were statistically significant (P-value<.01).

Table 2

Weighted distribution of maternal alcohol and cigarette use before, during and after pregnancy (N=8,800), ECLS-B

Maternal Alcohol Use		Maternal Smoking	
3 months before pregnancy			
No alcohol use	60.2%	No smoking	75.9%
Less than 1 drink a week	16.3%	Smoking <5 CPD	6.0%
1–3 drinks a week	16.6%	Smoking 6–10 CPD	8.4%
4 or more drinks a week	7.0%	Smoking >10 CPD	9.8%
Last 3 months of pregnancy			
No alcohol use	96.7%	No smoking	88.7%
Less than 1 drink a week	2.2%	Smoking <5 CPD	5.4%
1–3 drinks a week	1.1%	Smoking 6–10 CPD	3.7%
4 or more drinks a week	0.1%	Smoking >10 CPD	2.2%
9 month post- partum			
No alcohol use	63.1%	No smoking	80.1%
Less than 1 drink a week	20.0%	Smoking <5 CPD	5.7%
1–3 drinks a week	13.2%	Smoking 6–10 CPD	7.3%
4 or more drinks a week	3.7%	Smoking >10 CPD	6.9%
2 years post- partum			
No alcohol use	68.7%	No smoking	80.7%
Less than 1 drink a week	15.6%	Smoking <5 CPD	5.4%
1–3 drinks a week	11.2%	Smoking 6–10 CPD	7.3%
4 or more drinks a week	4.5%	Smoking >10 CPD	6.6%
Child in Preschool			
No alcohol use	64.0%	No smoking	81.3%
Less than 1 drink a week	14.6%	Smoking <5 CPD	4.6%
1–3 drinks a week	15.0%	Smoking 6–10 CPD	7.2%
4 or more drinks a week	6.4%	Smoking >10 CPD	6.9%
Child in Kindergarten			
No alcohol use	64.8%	No smoking	82.8%
Less than 1 drink a week	13.5%	Smoking <5 CPD	5.0%
1–3 drinks a week	14.6%	Smoking 6–10 CPD	6.1%
4 or more drinks a week	7.2%	Smoking >10 CPD	6.1%

Table 3

Determining the number of classes in GGMM (N=8,800), ECLS-B

Model	LL	# of parameters	BIC[a]	Entropy[b]
1 class model	−71759.190	14	143645.474	1
2 class model	−61631.708	19	123435.901	0.962
3 class model	−57202.961	24	114623.799	0.886
4 class model	−56158.689	29	112580.645	0.881
5 class model	−55228.056	34	110764.769	0.861
6 class model	−54462.962	39	109279.972	0.859
7 class model	−54093.646	44	108586.732	0.863
8 class model	−53863.760	49	108172.350	0.856
9 class model	−53688.713	54	107867.648	0.857

[a]Bayesian Information Criterion, lower values indicating better fit.

[b]Entropy ranges from 0 to 1 and indicates a better classification of individuals as values approach 1.

Table 4a

Covariate [a] effects on Maternal Smoking and Drinking Trajectories (N=8,800), ECLS-B (Reference class: NS-ND)

	Drinking Classes		Concurrent Users		
			Predominantly Smokers		Both Alc/Cigs
	NS-MPD (25.8%)	NS-EHPD (8.4%)	TRS-LPD (10.7%)	HS-DPD (8.6%)	TRS-HPD (5.9%)
	AOR[b]	AOR	AOR	AOR	AOR
Maternal Age					
Age 18–25	–	0.17**	2.04**	–	–
Age 36+	–	2.21**	–	–	–
Maternal Race/Ethnicity					
Black	0.45**	0.19**	0.27**	0.03**	0.40**
Hispanic	0.37**	0.26**	0.23**	0.02**	0.14**
Asian and Others	0.42**	0.21**	0.41**	0.28**	0.49**
Mother Married or Cohabiting with Partner					
Yes	0.58**	–	0.72*	0.65*	0.46**
Maternal Education					
High school	1.56*	–	–	0.55**	1.88*
Some college	2.18**	–	0.60*	0.29**	–
College or grad school	2.48**	5.40*	0.16**	0.04**	–
Household Income (proportion of federal poverty line)					
100–130%	–	–	–	–	–
130–185%	–	–	–	–	–
>185%	2.43**	6.92*	–	0.63*	2.25**
Moderate or Severe Postpartum Depression					
Depressed	–	–	1.45**	2.21*	–
Breastfeeding					
6 months	1.37*	1.76*	–	0.76*	–

	Drinking Classes		Concurrent Users		
			Predominantly Smokers		Both Alc/Cigs
	NS-MPD (25.8%)	NS-EHPD (8.4%)	TRS-LPD (10.7%)	HS-DPD (8.6%)	TRS-HPD (5.9%)
	AOR[b]	AOR	AOR	AOR	AOR
> 6 months	–	–	0.32 **	0.22 **	0.40 **
Maternal Employment Status					
Part-time	1.55 **	1.69 **	1.35 *	–	1.76 **
Full-time	1.51 **	–	–	1.40 *	–
Planned pregnancy	–	–	0.73 *	0.65 **	0.69 *

*
P-value <0.05

**
P-value<0.01

[a]The choice of reference category for each covariates were carefully selected based on theory, empirical distribution, as well as past literature. The reference category for Maternal Age is *26–35*, for Maternal Race/Ethnicity is *White*, for Maternal Education is *Less than high school*, for Household Income is *Lower than poverty line*, for Breastfeeding is *Never breastfeed*, and for Employment Status is *Not employed*.

[b]Adjusted Odds Ratio; AOR greater than 1 represents increasing log odds of being assigned to a given class compared to the NS-ND class.

Table 4b

Covariate [a] effects on Maternal Smoking and Drinking Trajectories (N=8,800), ECLS-B (Reference class: TRS-HPD)

	Drinking Classes		Concurrent Users		
			Predominantly Smokers		Non-use class
	NS-MPD (25.8%)	NS-EHPD (8.4%)	TRS-LPD (10.7%)	HS-DPD (8.6%)	NS-ND (40.5%)
	AOR[b]	AOR	AOR	AOR	AOR
Maternal Age					
Age 18–25	0.70*	0.13**	1.51*	--	--
Age 36+	--	--	--	--	--
Maternal Race/Ethnicity					
Black	--	--	--	0.07**	2.52**
Hispanic	2.75**	--	--	0.13**	7.40**
Asian and Others	--	0.44*	--	--	2.04**
Mother Married or Cohabiting with Partner					
Yes	--	--	1.56*	--	2.17*
Maternal Education					
High school	--	--	0.45**	0.29**	0.53*
Some college	--	--	0.39**	0.19**	--
College or grad school	2.82**	6.15*	0.18**	0.05**	--
Household Income (proportion of federal poverty line)					
100–130%	--	--	0.44**	--	--
130–185%	--	--	--	--	--
>185%	--	--	--	0.28**	0.44**
Moderate or Severe Postpartum Depression					
Depressed	--	--	--	1.74**	--
Breastfeeding					
6 months	--	--	--	0.63*	--

	Drinking Classes		Concurrent Users		
			Predominantly Smokers		Non-use class
	NS-MPD (25.8%)	NS-EHPD (8.4%)	TRS-LPD (10.7%)	HS-DPD (8.6%)	NS-ND (40.5%)
	AOR[b]	AOR	AOR	AOR	AOR
> 6 months	2.63**	3.16**	--	--	2.53**
Maternal Employment Status					
Part-time	--	--	--	0.50**	0.57**
Full-time	--	--	--	--	--
Planned pregnancy	--	1.93**	--	--	1.46*

*
P-value <0.05

**
P-value<0.01

[a] The choice of reference category for each covariates were carefully selected based on theory, empirical distribution, as well as past literature. The reference category for Maternal Age is *26–35*, for Maternal Race/Ethnicity is *White*, for Maternal Education is *Less than high school*, for Household Income is *Lower than poverty line*, for Breastfeeding is *Never breastfeed, and for Employment Status is Not employed.*

[b] Adjusted Odds Ratio; AOR greater than 1 represents increasing log odds of being assigned to a given class compared to the TRS-HPD class.

Table 4c

Covariate[a] effects on Maternal Smoking and Drinking Trajectories (N=8,800), ECLS-B (Reference class: TRS-LPD)

	Drinking Classes		Concurrent Users		Non-user class
			Predominantly Smokers	Both Alc/Cigs	
	NS-MPD (25.8%)	NS-EHPD (8.4%)	HS-DPD (8.6%)	TRS-HPD (5.9%)	NS-ND (40.5%)
	AOR[b]	AOR	AOR	AOR	AOR
Maternal Age					
Age 18–25	0.46**	0.08**	0.42**	0.66*	0.49**
Age 36+	--	2.31**	--	--	--
Maternal Race/Ethnicity					
Black	1.70*	--	0.11**	--	3.76**
Hispanic	1.61*	--	0.08**	--	4.34**
Asian and Others	--	0.52*	--	--	2.41**
Mother Married or Cohabiting with Partner					
Yes	--	--	--	0.64*	1.39*
Maternal Education					
High school	1.86**	--	0.65*	2.23**	--
Some college	3.63**	--	0.49*	2.54**	1.66*
College or grad school	15.30**	33.35**	0.26*	5.41**	6.17**
Household Income (proportion of federal poverty line)					
100–130%	--	--	--	--	--
130–185%	--	--	--	--	--
>185%	2.47**	7.02*	--	2.29*	--
Moderate or Severe Postpartum Depression					
Depressed	--	--	1.52*	--	0.69**
Breastfeeding					
6 months	--	1.69*	0.73*	--	--

	Drinking Classes		Concurrent Users		Non-user class
			Predominantly Smokers	Both Alc/Cigs	
	NS-MPD (25.8%)	NS-EHPD (8.4%)	HS-DPD (8.6%)	TRS-HPD (5.9%)	NS-ND (40.5%)
	AOR[b]	AOR	AOR	AOR	AOR
> 6 months	3.29 **	3.95 **	--	--	3.16 **
Maternal Employment Status					
Part-time	--	--	--	--	0.74 *
Full-time	1.59 **	--	--	--	--
Planned pregnancy	--	1.81 **	--	--	1.37 *

*
P-value <0.05

**
P-value<0.01

[a]The choice of reference category for each covariates were carefully selected based on theory, empirical distribution, as well as past literature. The reference category for Maternal Age is *26–35*, for Maternal Race/Ethnicity is *White*, for Maternal Education is *Less than high school*, for Household Income is *Lower than poverty line*, for Breastfeeding is *Never breastfeed*, and for Employment Status is *Not employed*.

[b]Adjusted Odds Ratio; AOR greater than 1 represents increasing log odds of being assigned to a given class compared to the TRS-LPD class.