Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

HHS Public Access

Author manuscript

Neurotoxicol Teratol. Author manuscript; available in PMC 2016 August 08.

Published in final edited form as:

Neurotoxicol Teratol. 2016 ; 55: 8–15. doi:10.1016/j.ntt.2016.03.001.

Prenatal alcohol and other early childhood adverse exposures: Direct and indirect pathways to adolescent drinking

Marie D. Cornelius[a,*], **Natacha M. De Genna**[a], **Lidush Goldschmidt**[b], **Cynthia Larkby**[a], and **Nancy L. Day**[a]

[a]University of Pittsburgh, School of Medicine, Department of Psychiatry, United States

[b]University of Pittsburgh Medical Center, United States

Abstract

We examined direct and indirect pathways between adverse environmental exposures during gestation and childhood and drinking in mid-adolescence. Mothers and their offspring (n = 917 mother/child dyads) were followed prospectively from second trimester to a 16-year follow-up assessment. Interim assessments occurred at delivery, 6, 10, and 14 years. Adverse environmental factors included gestational exposures to alcohol, tobacco, and marijuana, exposures to childhood maltreatment and violence, maternal psychological symptoms, parenting practices, economic and home environments, and demographic characteristics of the mother and child. Indirect effects of early child behavioral characteristics including externalizing, internalizing activity, attention, and impulsivity were also examined. Polytomous logistic regression analyses were used to evaluate direct effects of adverse environmental exposures with level of adolescent drinking. Structural equation modeling (SEM) was applied to simultaneously estimate the relation between early adversity variables, childhood characteristics, and drinking level at age 16 while controlling for significant covariates. Level of drinking among the adolescent offspring was directly predicted by prenatal exposure to alcohol, less parental strictness, and exposures to maltreatment and violence during childhood. Whites and offspring with older mothers were more likely to drink at higher levels. There was a significant indirect effect between childhood exposure to violence and adolescent drinking via childhood externalizing behavior problems. All other hypothesized indirect pathways were not significant. Thus most of the early adversity measures directly predicted adolescent drinking and did not operate via childhood behavioral dysregulation characteristics. These results highlight the importance of adverse environmental exposures on pathways to adolescent drinking.

Keywords

Adolescence; Alcohol use; Prenatal exposure; Child maltreatment; Violence; Parenting

[*]Corresponding author: Program in Epidemiology, Western Psychiatric Institute and Clinic, 3811 O′Hara Street, University of Pittsburgh, Pittsburgh, PA 15213, United States, mdc1@pitt.edu (M.D. Cornelius).

Transparency document

The Transparency document associated with this article can be found, in online version.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

1. Introduction

Adolescence is a critical developmental period when alcohol use is initiated and patterns of drinking behavior are formed (Masten et al., 2008). Alcohol use in adolescence is associated with other risky adolescent behaviors including other drug use, driving under the influence, sexual risk taking, and school dropout (Zucker et al., 2008). Although multiple studies have demonstrated that drinking in adolescence is one of the strongest predictors of the development of alcohol-related problems, primary prevention efforts to reduce adolescent drinking could be enhanced by the identification of contributing risk factors from the earliest stages of development. Several studies have identified proximal risk factors that place children at higher risk for early problematic alcohol use. These environmental, personality, and sociodemographic factors have been studied extensively but usually separately, in cross-sectional analyses, or with study time frames that only span a few years. In addition, few studies have data on early development, and even fewer have data on gestational exposures. The analysis presented here was from gestation through age 16 years.

This study is guided by the developmental cascade framework, which highlights the importance of interactions and transactions from early childhood to adolescence, on the course of development across a wide variety of domains (Masten and Cicchett, 2010). Individuals with resources such as a greater parental monitoring and higher SES tend to make more successful transitions to the developmental challenges of adolescence and young adulthood (Masten et al., 2008). Children exposed to early adversity may be more vulnerable to behavioral problems, and when faced with the new developmental tasks of adolescence are more likely to develop risky behaviors such as frequent alcohol use. For example, Sitnick et al. (2014) demonstrated that one domain of development influenced additional domains in predicting alcohol, marijuana, and cigarette use. Specifically, early child externalizing behaviors and maternal depressive symptoms were indirectly related to substance use via later adolescent externalizing behaviors and parental knowledge. Rogosch et al. (2010) demonstrated an indirect path from childhood maltreatment to marijuana use via child externalizing problems using the developmental cascade model. Another study of primarily African-Americans confirmed the developmental significance of early individual characteristics in peer adjustment for substance use into young adulthood (Lynne-Landsman et al., 2010). Thus, rather than relying on ascertainment of multiple risk factors in the aggregate, this framework strives to demonstrate the developmental sequencing of risk.

1.1. Gestational environment – substance exposures

From conception through adolescence, the pace of development is rapid as the human brain undergoes remarkable development, growth, and maturation. Toxic exposures during gestation can have significant and long-lasting effects on development (Fox and Rutter, 2010; Volkow, 2013), which may manifest into later problem behaviors such as adolescent substance use. The effects of prenatal alcohol exposure (PAE) on offspring development have been identified in both the human and animal literature (Day and Richardson, 1991a; Jacobson and Jacobson, 2003; Riley, 1990). Effects have been found on offspring growth (Cornelius et al., 2002; Day et al., 1994), cognitive deficits (Richardson et al., 1995; Willford et al., 2004; 2006), and higher levels of activity and attention deficits (Leech et al.,

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

1999). Individuals with PAE are more likely to have both internalizing and externalizing behavior problems (Day et al., 2013; Sood et al., 2001).

Many of these behavioral and psychological outcomes of PAE have been shown to predict adolescent substance use (Patrick and Schulenberg, 2014). Prenatal tobacco exposure and marijuana exposure have also been linked with multiple offspring developmental outcomes including increased likelihood of tobacco (Cornelius et al., 2005) and marijuana use (Day et al., 2006) among exposed adolescent offspring. Prenatal alcohol exposure has received some attention in terms of predicting offspring drinking, but the studies have been limited. A longitudinal cohort in Seattle examined the relation between PAE and offspring alcohol use and found that PAE was more predictive of adolescent (Baer et al., 1998) and adult (Baer et al., 2003) drinking and alcohol problems than family history of use. Another cohort in Australia (Alati et al., 2008) reported a 3-fold increase in drinking at 14 years if the child had PAE. Neither of these studies considered the effects of PAE and the potential intervening role of earlier childhood outcomes associated with PAE in predicting subsequent drinking outcomes. In a recent editorial, NIDA Director, Volkow (2013), reported that certain fetal drug exposures were related to impairment of the prefrontal cortex. This change in brain function is associated with lower self-control and impulsivity (Liu et al., 2013), behaviors that predict substance use. More research is needed that considers potential intervening roles of child characteristics that are associated with PAE and that predict drinking in the adolescent years.

1.2. Childhood environmental exposures

Adverse environmental factors during childhood including exposure to maltreatment (Dube et al., 2006; Hamburger et al., 2008; Shin et al., 2012; Shin et al., 2013), violence (Pinchevsky et al., 2013; Schwab-Stone et al., 1999), maternal distress (Lamis et al., 2012), and poorer parenting behavior (Abar et al., 2015; Janssen et al., 2014; Siobhan et al., 2010) are linked to adolescent alcohol use. Quality of the home is a well-established predictor of cognitive and behavioral outcomes for children (Bradley et al., 2001; Evans, 2004; Wasik et al., 1990). In turn, satisfactory cognitive development is protective against risky behavior, including drinking (Englund and Siebenbruner, 2012; Weiland et al., 2012). Several sociodemographic characteristics are associated with adolescent alcohol use including race (Mulia et al., 2008; Polednak, 2007; SAMHSA, 2011), gender (Donovan, 2004), economic status (Hardaway and Cornelius, 2014; Hayatbakhsh et al., 2008; Humensky, 2010), and maternal age (Cornelius et al., 2006; Furstenberg et al., 1990; Jaffe et al., 2001; Sommer et al., 2000).

1.3. Childhood characteristics that predict adolescent substance use

Several of the child outcomes that are affected by early adversity are also risk factors for adolescent drinking. Psychological and behavioral dysregulation may manifest as behavior problems in childhood and present as an alcohol use disorder as the youth matures and alcohol availability increases (Clark, 2004). In a review of 15 years of research examining behavioral and personality factors that are related to adolescent drinking, extraversion, sensation-seeking and low inhibitory control (Kuntsche et al., 2006) were consistent predictors. Factors associated with adolescent drinking include externalizing problems such

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

as aggression (Englund and Siebenbruner, 2012; Kellam et al., 1982) and conduct problems (Elkins et al., 2007; Fergusson et al., 2007), as well as clinical manifestations such as conduct disorder, and oppositional defiant disorder (Larkby et al., 2006; 2011; McGue et al., 2001). Negative affect and impulsivity have also been associated with alcohol experimentation and progression to problem use (Simons et al., 2005). There have been fewer reports of a link between childhood internalizing behavior problems and adolescent drinking (Edwards et al., 2014; King et al., 2004) although there is some evidence that one may exist (Dauber et al., 2009; Kaplow et al., 2001). Thus, behavioral dysregulation during childhood may be one indirect pathway from early adverse exposures to adolescent alcohol use, and it is important to consider both internalizing and externalizing behavior problems as potential intervening pathways in the association between early adversity and adolescent drinking.

Previous research has focused on proximal influences on adolescent drinking. Our data, representing two large longitudinal cohorts, contain measures from much earlier in development, beginning with prospective data from pregnancy and delivery. These well-characterized birth cohorts represent the youth with adverse gestational and environmental exposures, who we hypothesize have a greater risk of drinking during adolescence. The mothers from these cohorts are a unique, high-risk group of women with enough gestational substance use to permit analyses tracing pathways from gestational exposures and early adversity to childhood behavioral dysregulation and adolescent drinking. In addition, we have measures from several points during childhood and adolescence, which we consider in our developmental pathway model. Though multiple studies have examined one or more of these factors, none has considered all of them using prospective data starting with gestation. We hypothesized that early adversity risk factors, including gestational substance exposure, will predict greater adolescent drinking. In addition, we hypothesize that childhood behavioral characteristics will indirectly link early adversity exposures with adolescent drinking. We test separate models for internalizing and externalizing problems to determine if there are separate pathways from early adversity exposures to adolescent drinking via childhood behavior problems.

2. Materials and methods

2.1. Procedures

This report is from the Maternal Health Practices and Child Development Project (MHPCD). Mothers were interviewed prenatally, and with their offspring at delivery, 6, 10, 14, and 16 years. Standardized protocols were used to assess the psychological, environmental, and alcohol use characteristics of the mothers and their offspring. The data from gestation and the 6-, 10-, 14- and 16-year follow-up phases were used for this analysis.

Data were from cohorts in the MHPCD that had comparable measures of maternal and child development, psychological status, and environmental characteristics. The combined cohort had 917 mother/offspring dyads and was comprised of three studies: two were combined studies of prenatal alcohol and marijuana use among adult mothers (Adult Mothers Cohort; AA06390, DA03874: PI N. Day), and one was from a study of gestational substance use among teenage mothers (Teen Mothers Cohort; DA09275: PI M. Cornelius). Adult Cohort

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

mothers were 18–42 years old at recruitment and Teen Cohort mothers were 12–18 years old.

For the Adult Cohort study, women who were at least 18 years of age were enrolled at their fourth prenatal month clinic visit. Eighty-five percent of the women who were approached agreed to participate. There were no differences in age, income, or race between those who participated and those who refused. Two cohorts were selected from the total sample of adult women: 1) pregnant adult women who drank 3 or more alcoholic drinks per week and a random sample of women who drank less often or not at all were selected for a study of prenatal alcohol use, and 2) pregnant adult women who used marijuana at the rate of 2 or more joints per month and a random sample of women who used cannabis less often or not at all were chosen for a study of the effects of cannabis use during pregnancy.

For the Teen Mother Cohort, pregnant adolescents were enrolled at their fourth prenatal month clinic visit. All adolescents attending the prenatal clinic who were in their fourth month of pregnancy and who were under 19 years of age were eligible. Ninety-nine percent of the women who were approached agreed to participate.

A combined dataset of the Teen and Adult Mother cohorts was created for an integrative data analysis (Curran and Hussong, 2009). We avoided potential sources of between-subject heterogeneity common to integrative data analysis because: all participants were drawn from the same prenatal clinic; we had the same follow-up time periods; and the same measures and personnel were used in all birth cohorts. The Institutional Review Boards of the Magee-Womens Hospital and the University of Pittsburgh approved each of these studies. Certificates of Confidentiality were obtained from the National Institutes of Health for all phases of the studies.

Participants: The median age of the women in the combined cohorts in the fourth month of pregnancy was 20 years (range: 12–42) and 79% were unmarried at delivery. Fifty-eight percent drank alcohol during the first trimester, 50% smoked cigarettes, and 32% used marijuana. The average daily number of drinks among first trimester drinkers was 0.84 (range: 0.002–19.6). Detailed descriptions of alcohol and other substance use measures have been published (Cornelius et al., 1994; 1995; Day et al., 1989; 1991b).

At birth, the combined sample size was 1176 live singleton infants. By the 16-year follow-up, 103 offspring were lost to follow-up, 67 refused participation, 13 children died, 15 were adopted or in foster care, and 52 had moved out of the area. Nine offspring did not complete the drug and alcohol assessment, which resulted in a sample of 917 (78% of the birth sample). Offspring who did not participate at the 16-year phase ($N = 259$) compared to those who participated in the original studies ($N = 917$) were more likely to be White (54% and 40%, respectively; $p < 0.05$) and male (57% and 49%, respectively; $p < 0.05$). There were no differences in maternal age, marital status, prenatal alcohol, marijuana, or tobacco exposure.

2.2. Measures

2.2.1. Gestational exposure—Prenatal Alcohol Exposure (PAE) was assessed for each trimester of pregnancy using the usual, maximum, and minimum frequency and quantity of

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

each alcoholic beverage (wine, beer, liquor, and beer and wine coolers). The average daily number of drinks was calculated from these data. The distribution of average daily number of drinks was positively skewed, so log linear transformations were used to reduce skewness. Cigarette smoking was measured as average cigarettes/day. Marijuana use was assessed as the quantity and frequency of the usual, maximum, and minimum use, parallel to alcohol. Marijuana, hashish, and sinsemilla use were transformed into average daily joints: a blunt of marijuana was converted to four joints, and a hashish cigarette or bowl was counted as three joints based on the relative amount of Δ-9-THC in each (Gold, 1989). Other illicit drug use was rare during pregnancy and at the follow-up phases, and was not considered in our analyses. Because substance use declined beyond the first trimester, we used first trimester exposures in our analyses. At all phases of testing, the participants were interviewed in a private setting by interviewers who were comfortable discussing alcohol and drug use, trained to use the instrument reliably, accurately identify the drugs used, and assess the amount of use.

2.2.2. Childhood environmental exposures—*Home environment* was measured at 6 years with the Home Observation for Measurement of the Environment-Short Form (HOME-SF) (Caldwell and Bradley, 1984) (Teen cohort) and the Home Screening Questionnaire (HSQ) (Frankenburg and Coons, 1986) (Adult cohort). The HSQ correlates well with the HOME (Frankenburg and Coons, 1986). Both instruments measure the quality and quantity of support available to the child for cognitive, social, and emotional development. The HSQ and HOME-SF scores were transformed to *z*-scores and combined for the analyses.

Maternal Depression and *Hostility* were assessed at all phases. For this study, these measures from the 6-year assessment were used to ensure that none of the children had begun to drink. Maternal depressive symptoms were assessed using the CES-D (Radloff, 1977). Maternal hostility was measured using the Spielberger State-Trait Anxiety Inventory (Spielberger et al., 1983).

Childhood maltreatment was measured by the Childhood Trauma Questionnaire (CTQ) (Bernstein and Fink, 1998), a well-validated self-report instrument that measures lifetime exposure to physical and emotional abuse and neglect and sexual abuse. It was scored as the cumulative total of all subscales for which the score was above the cut-point for “moderate to severe abuse.” The data from the 16-year follow-up captured lifetime exposure and were examined as an ordinal variable to assess the total maltreatment exposure to five types of abuse and neglect.

The Screen for Adolescent Violence Exposure (SAVE; Hastings and Kelley, 1997) assessed child’s exposure to violence over his/her lifetime. The SAVE is a self-report scale for assessing community violence exposure. We adapted the SAVE for our study, changing the Likert-scale ratings into dichotomous (yes/no) responses. For these analyses, lifetime history of violence exposure collected during the 16-year follow-up phase was the sum of personal victimization incidents such as having been shot or shot at, beaten, and hurt/stabbed by a knife.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Parenting practices were measured by the My Parents instrument (Steinberg et al., 1992) and collected at the 16-year follow-up phase. This is an assessment of parenting practices as reported by adolescents. This measure has three scales: acceptance/involvement, strictness/supervision, and psychological autonomy granting scale.

2.2.3. Childhood behavioral measures—The Child Behavior Checklist (CBCL; Achenbach, 1991) has 118 problem items reported by the mother. Child internalizing and externalizing scales at age 6 were considered as potential intervening variables for this study because this age precedes the age of alcohol initiation. The CBCL has adequate reliability; test-retest scores for all of the problem scales were between 0.8 and 0.9.

The SNAP is a 25-item rating scale completed by mothers (Pelham and Bender, 1982) to assess child activity level, attention span, impulsivity, and peer interactions. The subscales of activity, attention and impulsivity from age 6 were used in the analyses.

2.3. Drinking outcome measures

Questions for *adolescent Alcohol Use* were developed by Donovan (1994). Measures included quantity, frequency of beer, liquor, wine, and wine and beer coolers. Offspring drinking was measured at ages 10, 14, and 16 years. The key outcome for this analysis was past year frequency and quantity of alcoholic beverages at mid-adolescence using the 16-year phase. Adolescents who had had their first full drink were asked: “During the past year, on the days that you drank (specific beverage), how many (specific containers) did you usually drink?” Next, they were asked: “How often did you drink this amount?” Responses included: every day; almost every day; 3–4 times a week; 1–2 times a week, 2–3 times a month; once a month; 6–11 times a year; 1–5 times a year. From these quantity and frequency items, average daily number of drinks was calculated. Questions were repeated for beer, wine liquor, wine coolers and beer coolers. For the analyses, level of alcohol use was based on average daily drinks and was categorized into 0, <1 drink/week, and ≥1 drinks per week.

2.3.1. Sociodemographic covariates—The *sociodemographic* covariates included race (dichotomous), child age, child gender (dichotomous), maternal education (years of education), and economic hardship. *Maternal age* at recruitment at the fourth gestational month was used as a continuous variable. *Economic hardship* was constructed as a latent variable from three measures: monthly family income, ability to handle bills, and financial strain (Hardaway and Cornelius, 2014). Financial strain was constructed from three questions in the maternal interview that inquired how often mothers were short of money at the end of the month, could not buy essential things for their child, and could not do extra things for their child.

2.3.2. Statistical analysis—The main outcome variable was offspring alcohol use at age 16. The independent variables consisted of the early adversity variables: prenatal alcohol, tobacco, and marijuana exposure, abuse/neglect, and exposure to violence. The intervening variables considered included CBCL externalizing and internalizing behavior problems, and SNAP impulsivity, attention, and activity behavior problems. Covariates considered for

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

inclusion were maternal age at delivery, race, economic hardship, depression and hostility, marital status, education, parenting, home environment, child's gender, and child's age at the 16-year assessment.

The analysis proceeded in steps. In the first step, we tested which childhood characteristics were directly related to 16-year drinking using ordinal polytomous logistic regression and retained only those that were significantly related to drinking for further analyses. The ordinal model applied is also known as the proportional odds model (POM). POM is the most commonly used method since it requires a single coefficient for each predictor assuming parallelism of curves for different logits. In the second step, the relations between the covariates and childhood characteristics were tested, and the significant relations were retained to obtain the most parsimonious model. In the last step, structural equation modeling (SEM) was applied to simultaneously estimate the relations between early adversity variables, childhood behavioral characteristics, and drinking at 16 while controlling for significant covariates. All the significant covariates of offspring drinking were retained in the final model. Indirect effects were tested based on the product of the coefficients using M+ statistical package. In addition to early adversity variables, we also tested the indirect effects of maternal psychosocial characteristics on offspring drinking. All significance levels were one-sided.

To adjust for sample loss, the analyses were repeated with sample weights to reflect the differential loss by gender and race. The weights were calculated as the inverse of the probability of response for each gender and racial group. The results with the weights were similar to those of the original data. We have presented the unweighted data for ease of interpretation.

3. Results

3.1. Descriptive analyses

At the 16-year phase, the offspring were, on average, 16.8 years old with a range from 15.9 to 19.5. Sixty percent were Black and 49% were males. Seventeen percent were not under maternal custody. At the 16-year follow up, the family's average monthly income was $2219 (range = $0–$18,000), caregivers mean education was 12.4 years (range = 6–18), and 35% were married.

At the 16-year follow-up phase, 47% of the adolescents drank over the past year; 27% drank less than a drink per week, 14% reported drinking at least one drink/week but less than a drink/day, and 6% reported drinking one or more drinks/day. Since the high frequency alcohol use group was small, it was combined with the weekly user group for the analyses. Forty-three percent of the offspring initiated drinking between ages 13 and 16.9 years, and 22% started drinking before 14 years. Thirty-nine percent had ever smoked cigarettes and 51% had used marijuana by the 16-year follow-up phase.

Fifty-eight percent of the mothers reported drinking during first trimester of pregnancy. The average daily volume among drinkers was 0.82 with a range of 0.002 to 12 drinks/day. This variable was log transformed to reduce skewness. Forty-nine percent of the offspring were

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

exposed to violence, 33% reported exposure to one act of violence, and the remainder were exposed to more than one act of violence. Eleven percent of the adolescents reported none to minimal lifetime abuse or neglect, 19% reported abuse and neglect above the moderate/severe cut-points, and the remaining reported some abuse and neglect, but not reaching the moderate/severe cut-point. The average scores of the gestational and childhood factors across offspring drinking level are provided in Table 1.

3.2. Predictors of adolescent drinking: direct effects

In the bivariate analyses, White race, less economic hardship, older maternal and offspring age were significantly associated with a higher level of adolescent drinking. Environmental variables from the gestational and childhood periods that significantly predicted a higher level of drinking were PAE and prenatal tobacco exposure, less parental strictness, less parental involvement, greater maternal hostility during childhood, and greater exposure to child maltreatment and violence (Table 1). Variables that were significant at the bivariate level were added to the ordinal logistic regression analyses.

In the regression analyses, White race, older maternal age, PAE, less parental strictness, and greater exposure to maltreatment and violence during childhood remained significantly associated with adolescent level of use (Table 2). Each drink per day increase in maternal drinking during pregnancy increased the odds of being in a higher level of the drinking group by 1.7 times. For each unit of difference in less parental strictness, the odds of being in a higher level of drinking were increased by 1.2 times. Prenatal exposure to tobacco, maternal hostility, economic hardship, and parental involvement were no longer significant after controlling for the other covariates. The Score test examining the proportional odds model assumption of parallelism was not significant ($\chi^2_7 = 5.9$, $p = 0.56$) indicating the adequacy of the fitted model.

At age 6, only externalizing and internalizing behavior problems were significantly related to drinking at age 16. The mean CBCL externalizing scores (Achenbach, 1991) were 51.9, 53.9, 54.8 ($\chi^2 = 13.2$, $p = 0.003$) for the None, <1 drink/week, and 1+ drinks/week groups, respectively. The average CBCL internalizing scores for the three groups were 49.4, 50.3, and 51.1 ($\chi = 4.7$, $p = 0.03$), respectively. Age 6 attention, activity, and impulsivity were not significant predictors of alcohol use at 16.

3.3. Testing indirect effects via childhood behavior

Separate SEM models were applied to assess indirect effects through externalizing and internalizing behaviors at age 6. The comprehensive indirect effects model with the externalizing scores is presented in Fig. 1. The weighted least square estimator of the coefficients, standardized coefficients of each pathway, and the decomposition of total effects of early adversity variables on offspring drinking is presented in Table 3. The normed comparative fit index (CFI) for the overall model fit was 1.0 indicating a very good fit. The indirect effects of PAE and child maltreatment on offspring drinking via externalizing behavior were not significant. However, the indirect effect reached statistical significance for exposure to violence. The proportion of this effect relative to the total effect was 8% (0.009/0.11). Maternal depression and hostility at age 6 were only indirectly related to

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

offspring drinking at 16 via childhood externalizing behavior problems, the direct effects of maternal psychological problems on adolescent alcohol use were not significant. The internalizing behavior problem scores at 6 were not related to drinking once we controlled for race, and hence indirect effects via this variable were non-significant for all considered early adversity variables.

4. Discussion

The goal of this study was to examine whether the early adversity variables were directly related to offspring alcohol drinking at 16 or whether there were indirect effects of early adversity via childhood behavioral characteristics. This is the first study to demonstrate separate pathways from exposures to early environmental adversity to adolescent drinking in a combined set of large birth cohorts. We investigated not only important demographic characteristics, but also gestational exposures to alcohol, tobacco, and marijuana, as well as maternal psychological problems. We examined data from cohorts of mothers capturing a wide age span of reproductive age, including enough women who engaged in prenatal substance use to statistically model long-term direct and indirect effects. We identified factors that significantly predicted adolescent drinking from the gestational and childhood periods, consistent with a developmental cascades framework. Importantly, we also identified those variables that did not. Heavier drinking during adolescence was directly predicted by PAE, White race, parental strictness (less), mother's age (older), and greater maltreatment and violence exposure. Some early adversity risk factors that were significant at the bivariate level (e.g., maternal hostility, prenatal tobacco exposure, family economic hardship, and parental involvement) were not significant at the multivariate level.

These findings are in general agreement with several reports that have assessed predictors of adolescent drinking. However, this is the first study to link PAE to adolescent drinking using longitudinal data and considering multiple other early adversity risk factors. PAE was a significant direct predictor of adolescent drinking. This finding could reflect a common familial association between mothers who drink during pregnancy and offspring use. This is consistent with two other studies from the literature on alcohol use in adolescents with PAE (Alati et al., 2008; Baer et al., 1998). Animal studies suggest that in utero ethanol exposure causes embryological changes resulting in oxytocin system changes (McMurray et al., 2008) and neurobehavioral deficits (Shea et al., 2012). Such changes may result in increased preferential intake of alcohol among exposed offspring (Honey et al., 2003). However, in our analyses, behavioral characteristics from earlier in childhood did not indirectly link PAE with adolescent drinking. The PAE effects were direct, suggesting that the familial explanation is stronger, and/or that the fetal changes may have resulted in unmeasured neurobehavioral effects that, in turn, affected drinking behavior. It is also the case that women who drank during pregnancy were more likely to be drinkers across their offspring's lifespan, and this may also influence adolescent use due to parental modeling, access to alcohol in the home, and perceived parental acceptability of alcohol use.

Our composite model revealed separate direct and indirect paths between childhood exposure to violence and maltreatment and alcohol use at age 16. Exposure to childhood maltreatment was directly associated with adolescent drinking, as reported by others

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

(Hamburger et al., 2008; Shin et al., 2012; 2013), but not indirectly related. The only early adversity factor that had both direct and indirect effects on adolescent drinking was childhood exposure to community violence. Exposure to violence is common among U.S. children. In a nationally representative sample, 53% of children experienced assault in the past year (Finkelhor et al., 2005). Childhood externalizing problems were indirectly related to violence exposure and adolescent drinking. Other studies have examined relations between violence exposure during childhood and substance use in later adolescence and have also found direct effects on adolescent drinking in both cross-sectional (Vermeiren et al., 2003) and longitudinal (Taylor and Kliewer, 2006) studies. This is the first study to demonstrate direct effects of childhood exposure to violence on adolescent alcohol use while controlling for other early adversity risk factors, including prenatal exposure to alcohol.

Race (White) was a significant sociodemographic predictor of higher levels of drinking by age 16, which is consistent with national data (SAMHSA, 2011). Children of older mothers in this study also used alcohol earlier and at higher levels than the children of younger mothers. These results may be an artifact of the oversampling of alcohol use that occurred in the Adult Mother Cohort or they could reflect a genuinely higher risk of PAE in individuals with older mothers. A report from Detroit has demonstrated that the effects of PAE are more pronounced in offspring of older mothers (Jacobson et al., 2004). Our findings also match the results of recent studies indicating that older mothers are more likely to drink while pregnant (Kitsantas et al., 2014; Meschke et al., 2013). Thus, the children of the oldest mothers may be more vulnerable to drinking due to greater gestational exposure.

This study utilizes two rich datasets with excellent retention rates that include a wide range of maternal ages and extensive information on adversity, maternal and child substance use measured at multiple time points across a 17-year span. Rates of prenatal substance use were higher in our sample than rates reported in national datasets (SAMSHA, 2013; Tong et al., 2009). Although this yielded enough maternal substance use data to statistically trace pathways to adolescent use, our results may not generalize to populations with lower prenatal substance exposures. The sample also represents a low SES group, 43% White and 57% Black, with a large proportion who were not married at delivery. Therefore, these results may not extend to families from middle and higher SES, or to families from other racial ethnic groups, or families with married parents. It is also possible that some women might misreport their substance use when asked during their pregnancy. We did not use biological measures of maternal substance use, as they do not allow an accurate assessment of alcohol use over a longer period, such as a trimester. However, to increase the accuracy of the data that were reported, we constructed detailed questions, carefully selected interviewers, and extensively trained our staff in interviewing techniques. One of our follow-up phases occurred 6 years after the prior phase. It is possible that child environmental factors, which could not be measured during this period, were not captured and therefore could not be considered in our analyses. Finally, the goal of this study was to consider direct and indirect effects of gestational and environmental exposures on adolescent drinking. Future research will consider models that take into consideration the potential moderating effects of these variables on adolescent drinking. Finally, it should be noted that measures of childhood maltreatment exposure and violence exposure were assessed at age 16 and reflect lifetime (or the past 16 year) exposures. Therefore, it is impossible to determine actual

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

timing of these childhood exposure events, thus we caution that our findings cannot be considered causal.

5. Conclusions

Our findings have several important implications for public health. These results highlight the importance of reaching young women in the prenatal clinic and reducing alcohol use during pregnancy. Early exposures to factors such as PAE, maltreatment and violence, and less parental strictness may be early markers of risk for adolescent drinking. Children with higher exposure to violence may become more aggressive in childhood and this externalizing behavior predicts more involvement with drinking in mid-adolescence. These findings highlight the need for intervention programs in communities with high exposure to violence and identifying those young children with more externalizing tendencies. Identifying these individuals in schools and clinics from such communities could lead to more efficient programs that target those most at risk for increased alcohol use in the adolescent years.

Acknowledgments

This study was supported by the following grants: AA08284, DA009275, AA022473 (PI: M. Cornelius); AA06390, HD36890, DA03874 (PI: N. Day); DA19482, AA00312 (PI: C. Larkby). The authors wish to thank the young women and children who made this study possible by contributing their time and sharing their experiences with our interviewers and field staff.

References

Abar C, Jackson K, Colby S, Barnett N. Parent-child discrepancies in reports of parental monitoring and their relationship to adolescent related behaviors. J Youth Adolesc. 2015; 44:1688–1701. [PubMed: 24964878]

Substance Abuse and Mental Health Services Administration. Results From the 2010 National Survey on Drug Use and Health: Summary of National Findings. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2011. NSDUH Series H-41, HHS Publication No. (SMA) 11-4658

Substance Abuse and Mental Health Services Administration. Results From the 2012 National Survey on Drug Use and Health: Summary of National Findings. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2013. NSDUH Series H-46, HHS Publication No. (SMA) 13-4795

Achenbach, T. Manual for the Child Behavior Checklist 4–18 and 1991 Profile. University of Vermont Department of Psychiatry; Burlington, VT: 1991.

Alati R, Calvarias A, Najman J, O'Callaghan M, Bor W, Al Mamun A, Williams G. The developmental origin of adolescent alcohol use: findings from the Mater University study of pregnancy and its outcomes. Drug Alcohol Depend. 2008; 98:136–143. [PubMed: 18639392]

Baer J, Barr H, Bookstein F, Sampson P, Streissguth A. Prenatal alcohol exposure and family history of alcoholism in the etiology of adolescent alcohol problems. J Stud Alcohol. 1998; 59:533–543. [PubMed: 9718105]

Baer J, Sampson P, Barr H, Connor P, Streissguth A. A 21-year longitudinal analysis of the effects of prenatal alcohol exposure on young adult drinking. Arch Gen Psychiatry. 2003; 60:377–385. [PubMed: 12695315]

Bernstein, DP.; Fink, L. Childhood trauma questionnaire: a retrospective self-report manual. The Psychological Corporation; San Antonia, TX: 1998.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Bradley RH, Convyn RF, Burchinal M, McAdoo HP, Coll CG. The home environments of children in the United States part II: relations with behavioral development through age thirteen. Child Dev. 2001; 72:1868–1886. [PubMed: 11768150]

Caldwell, B.; Bradley, R. Home Observation for Measurement of the Environment (HOME) - Revised Edition. University of Arkansas; Little Rock: 1984.

Clark D. The natural history of alcohol use disorders. Addiction. 2004; 99:5–22. [PubMed: 15488102]

Cornelius M, Richardson G, Day N, Cornelius J, Geva D, Taylor P. A comparison of prenatal drinking in two recent samples of adolescents and adults. J Stud Alcohol. 1994; 55:412–419. [PubMed: 7934048]

Cornelius M, Taylor P, Geva D, Day N. Prenatal tobacco and marijuana use in adolescents: effects on offspring gestational age, growth and morphology. Pediatrics. 1995; 95:738–743. [PubMed: 7724314]

Cornelius M, Goldschmidt L, Day N, Larkby C. Prenatal substance use among pregnant teenagers: A six-year follow-up of effects on offspring growth. Neurotoxicol Teratol. 2002; 24:703–710. [PubMed: 12460652]

Cornelius M, Leech S, Goldschmidt L, Day N. Is prenatal tobacco exposure a risk factor for early adolescent smoking? A follow-up study Neurotoxicol Teratol. 2005; 27:667–678. [PubMed: 16014324]

Cornelius M, Goldschmidt L, Willford J, Leech S, Larkby C, Day N. Body size and intelligence in 6-year-olds: are offspring of teenage mothers at risk? Matern Child Health J. 2006; 13:847–856. [PubMed: 18683038]

Curran P, Hussong A. Integrative data analysis: the simultaneous analysis of multiple data sets. Psychol Methods. 2009; 14:81–100. [PubMed: 19485623]

Dauber S, Hogue A, Paulson J, Leiferman J. Typologies of alcohol use in white and African American adolescent girls. Subst Use Misuse. 2009; 44:1121–1141. [PubMed: 19544150]

Day, N.; Richardson, G.; Creasy, R.; Warshaw, J. Alcohol exposure during pregnancy: a continuum of effects Seminars in Perinatology. Vol. 15. WB Saunders; Philadelphia: 1991a. p. 271-279.

Day N, Jasperse D, Richardson G, Robles N, Sambamoorthi U, Taylor P, Scher M, Stoffer D, Cornelius M. Prenatal exposure to alcohol: effect on infant growth and morphologic characteristics. Pediatrics. 1989; 84:536–541. [PubMed: 2771556]

Day N, Sambamoorthi U, Taylor P, Richardson G, Robles N, Jhon Y, Scher M, Stoffer D, Cornelius M, Jasperse D. Prenatal marijuana use and neonatal outcome. Neurotoxicol Teratol. 1991b; 13:329–334. [PubMed: 1886543]

Day N, Richardson G, Geva D, Robles N. Alcohol, marijuana, and tobacco: effects of prenatal exposure on offspring growth and morphology at age six. Alcohol Clin Exp Res. 1994; 18:786–794. [PubMed: 7526725]

Day N, Goldschmidt L, Thomas C. Prenatal marijuana exposure contributes to the prediction of marijuana use at age 14. Addiction. 2006; 101:1313–1322. [PubMed: 16911731]

Day N, Helsel A, Sonon K, Goldschmidt L. The association between prenatal alcohol exposure and behavior at 22 years of age. Alcohol Clin Exp Res. 2013; 37:1171–1178. [PubMed: 23442183]

Donovan, J. Drinking and Drug Use Interview. Pittsburgh Adolescent Research Center; Pittsburgh, PA: 1994.

Donovan J. Adolescent alcohol initiation: A review of psychosocial risk factors. J Adolesc Health. 2004; 25:529.e7–529.e18. [PubMed: 15581536]

Dube S, Miller J, Brown D, Giles W, Fellitti V, Dong M, Anda R. Adverse childhood experiences and the association with ever using alcohol and initiating alcohol use during adolescence. J Adolesc Health. 2006; 38:444e1–444e10. [PubMed: 16549308]

Edwards AC, Latendresse SJ, Heron J, Cho S, Hickman M, Lewis G, Dick D, Kendler K. Childhood internalizing symptoms are negatively associated with early adolescent alcohol use. Alcohol Clin Exp Res. 2014; 38:1680–1688. [PubMed: 24848214]

Elkins IJ, McGue M, Iacono WG. Prospective effects of attention-deficit/hyperactivity disorder, conduct disorder, and sex on adolescent substance use and abuse. Arch Gen Psychiatry. 2007; 64:1145–1152. [PubMed: 17909126]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Englund ME, Siebenbruner J. Developmental pathways linking externalizing symptoms, internalizing symptoms, and academic competence to adolescent substance use. J Adolesc. 2012; 35:1123–1140. [PubMed: 22465287]

Evans GW. The environment of childhood poverty. Am Psychoanal. 2004; 59:77–92.

Fergusson D, Horwood L, Ridder E. Conduct and attentional problems in childhood and adolescence and later substance use, abuse, and dependence: results of a 25-year longitudinal study. Drug Alcohol Depend. 2007; 88:S14–S26. [PubMed: 17292565]

Finkelhor D, Ormrod R, Turner H, Hamby S. The victimization of children and youth: a comprehensive national survey. Child Maltreat. 2005; 10:5–25. [PubMed: 15611323]

Fox N, Rutter M. Introduction to the special section on the effects of early experience on development. Child Dev. 2010; 81:23–27. [PubMed: 20331652]

Frankenburg W, Coons C. The home screening questionnaire: its validity in assessing home environment. J Pediatr. 1986; 108:624–626. [PubMed: 3958839]

Furstenberg F, Levine J, Brooks-Gunn J. The children of teenage mothers: patterns of early childbearing in two generations. Fam Plan Perspect. 1990; 22:54–61.

Gold, M. Marijuana. Plenum; New York: 1989.

Hamburger M, Leeb R, Swahn M. Childhood maltreatment and early alcohol use in high-risk adolescents. J Stud Alcohol Drugs. 2008; 69:291–295. [PubMed: 18299771]

Hardaway C, Cornelius M. Economic hardship, family processes, and problem drinking in low-income adolescents. J Youth Adolesc. 2014; 43:1191–1202. [PubMed: 24248327]

Hastings T, Kelly M. Development and validation of the Screen for Adolescent Violence Exposure (SAVE). J Abnorm Child Psychol. 1997; 25:511–520. [PubMed: 9468111]

Hayatbakhsh M, Mamun A, Najman J, O'Callaghan M, Bor W, Alati R. Early childhood predictors of early substance use and substance use disorders: prospective study. Aust N Z J Psychiatry. 2008; 42:720–731. [PubMed: 18622780]

Honey P, Galef B. Ethanol consumption by rat dams during gestation, lactation, and weaning increases ethanol consumption by their adolescent young. Dev Psychobiol. 2003; 42:252–260. [PubMed: 12621651]

Humensky J. Are adolescents with high socioeconomic status more likely to engage in alcohol and illicit drug use in early adulthood? Subst Abuse Treat Prev Policy. 2010; 5:19. [PubMed: 20687935]

Jacobson J, Jacobson S. Effects of prenatal alcohol exposure on child development. Alcohol Res Health. 2003; 27:282–286.

Jacobson S, Jacobson J, Sokol R, Chiodo L, Corobana R. Maternal age, alcohol abuse history, and quality of parenting as moderators of the effects of prenatal alcohol exposure on 7.5-year intellectual function. Alcohol Clin Exp Res. 2004; 28:1732–1745. [PubMed: 15547461]

Jaffe S, Caspi A, Moffitt T. Why are children born to teen mothers at risk for adverse outcomes in young adulthood? Results from a 20-year longitudinal study. Dev Psychopathol. 2001; 12:377–379.

Janssen, T.; Larsen, H.; Pronk, T.; Vollerbergh, W.; Wiers, R. Interactions between parental alcohol-specific rules and risk personalities in the prediction of adolescent alcohol use. Alcohol Alcohol. 2014. http://dx.doi.org/10.1093/alcalc/agu039

Kaplow J, Curran P, Angold A, Costello E. The prospective relation between dimensions of anxiety and the initiation of adolescent alcohol use. J Clin Child Psychol. 2001; 30:316–326. [PubMed: 11501249]

Kellam S, Brown C, Fleming J. Social adaptation to first grade and teenage drug, alcohol, and cigarette use. J Sch Health. 1982; 52:301–306. [PubMed: 6919707]

King SM, Iacono WG, McGue M. Childhood externalizing and internalizing psychopathology in the prediction of early substance use. Addiction. 2004; 99:1548–1559. [PubMed: 15585046]

Kitsantas P, Gaffney K, Wu H. Identifying high-risk subgroups for alcohol consumption among younger and older pregnant women. J Perinat Med. 2014; 43:43–52. [PubMed: 24791820]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Kuntsche E, Knibbe R, Gmel G, Engels R. Who drinks and why? A review of socio-demographic, personality, and contextual issues behind the drinking motives in young people. Addict Behav. 2006; 31:1844–1857. [PubMed: 16460883]

Lamis D, Malone P, Lansford J, Lochman J. Maternal depressive symptoms as a predictor of alcohol use onset and heavy episodic drinking. J Consult Clin Psychol. 2012; 80:886–896.

Larkby C, Goldschmidt L, Day NL. Prenatal alcohol exposure and DSM-IV disorders in offspring at age 16. Alcohol Clin Exp Res. 2006; 30(6, Supplement):56A.

Larkby C, Goldschmidt L, Hanusa B, Day N. Prenatal alcohol exposure is associated with conduct disorder in adolescence: findings from a birth cohort. J Am Acad Child Adolesc Psychiatry. 2011; 50:262–271. [PubMed: 21334566]

Leech S, Richardson G, Goldschmidt L, Day N. Prenatal substance exposure: effects on attention and impulsivity of six-year-olds. Neurotoxicol Teratol. 1999; 21:109–118. [PubMed: 10192271]

Liu J, Lester B, Neyzi N. Regional brain morphometry and impulsivity in adolescents following prenatal exposure to cocaine and tobacco. JAMA Pediatrics. 2013; 167:348–354. [PubMed: 23400239]

Lynne-Landsman S, Bradshaw C, Ialongo N. Testing a developmental cascade model of adolescent substance use trajectories and young adult adjustment. Dev Pscyhopathol. 2010; 22:933–948.

Masten A, Cicchett D. Editorial: developmental cascades. Developmental cascades [Special Issue, Part 1]. Dev Psychopathol. 2010; 22:491–495. [PubMed: 20576173]

Masten A, Faden V, Zucker R, Spear L. Underage drinking: a developmental framework. Pediatrics. 2008; 121:S235–S251. [PubMed: 18381492]

McGue M, Iacono W, Legrand L. Origins and consequences of age at first drink. I. Associations with substance-use disorders, disinhibitory behavior and psychopathology, and P3 amplitude. Alcohol Clin Exp Res. 2001; 25:1156–1165. [PubMed: 11505047]

McMurray M, Williams S, Jarrett T, Cox E, Fay D, Overstreet D, Walker C, Johns J. Gestational ethanol and nicotine exposure: effects on maternal behavior, oxytocin, and offspring ethanol intake in the rat. Neurotoxicol Teratol. 2008; 30:475–486. [PubMed: 18664381]

Meschke L, Holl J, Messelt S. Older not wiser: risk of prenatal alcohol use by maternal age. Matern Child Health J. 2013; 17:147–155. [PubMed: 22307728]

Mulia N, Yu Y, Semore S, Greenfield T. Social disadvantage, stress, and alcohol use among black, Hispanic, and white Americans: findings from the 2005 U.S. National Survey. J Stud Alcohol Drugs. 2008; 69:824–833. [PubMed: 18925340]

Patrick M, Schulenberg J. Prevalence and predictors of adolescent alcohol use and binge drinking in the United States. Alcohol Res. 2014; 35:193–200. [PubMed: 24881328]

Pelham W, Bender M. Peer relationships in hyperactive children. Adv Learning Beh Dis. 1982; 1:365–436.

Pinchevsky G, Gillian M, Wright EM, Fagan AA. Gender differences in the effects of exposure to violence on adolescent substance use. Violence Vict. 2013; 28:122–144. [PubMed: 23520836]

Polednak A. Secular trends in US black-white disparities in selected alcohol-related cancer incidence rates. Alcohol Alcohol. 2007; 41:125–130. [PubMed: 17255152]

Radloff L. The center for Epidemiological Scale–Depressions (CES-D): a self-report depression scale for research in the general population. Appl Psychol Meas. 1977; 1:385–401.

Richardson G, Day N, Goldschmidt L. Prenatal alcohol, marijuana, and tobacco use: infant mental and motor development. Neurotoxicol Teratol. 1995; 17:479–487. [PubMed: 7565494]

Riley E. Long-term behavioral effects of prenatal alcohol exposure in rats. Alcohol Clin Exp Res. 1990; 14:670–673. [PubMed: 2264595]

Rogosch F, Oshri A, Cicchetti D. From child maltreatment to adolescent cannabis abuse and dependence: a developmental cascade model. Dev Psychopathol. 2010; 22:883–897. [PubMed: 20883588]

Schwab-Stone M, Chen C, Greenberger E, Silver D, Lichtman J, Voyce C. No safe haven II: the effects of violence exposure on urban youth. J Am Acad Child Adolesc Psychiatry. 1999; 38:359–367. [PubMed: 10199106]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Shea K, Hewitt A, Olmstead M, Brien J, Reynolds J. Maternal ethanol consumption by pregnant guinea pigs causes neurobehavioral deficits and increases ethanol preference in offspring. Behav Pharmacol. 2012; 23:105–112. [PubMed: 22157142]

Shin S, Hong H, Wills T. An examination of pathways from childhood maltreatment to adolescent binge drinking. Am J Addict. 2012; 21:202–209. [PubMed: 22494222]

Shin S, Miller D, Teicher M. Exposure to childhood neglect and physical abuse and developmental trajectories of heavy episodic drinking from early adolescence into young adulthood. Drug Alcohol Depend. 2013; 127:31–38. [PubMed: 22749563]

Simons J, Gaher R, Correia C, Hansen C, Christopher M. An affective-motivational model of marijuana and alcohol problems among college students. Psychol Addict Behav. 2005; 19:326–334. [PubMed: 16187813]

Siobhan R, Jorm A, Lubman D. Parenting factors associated with reduced adolescent alcohol use: a systematic review of longitudinal studies. Aust NZ J Psychiat. 2010; 44:774–783.

Sitnick S, Shaw D, Hyde L. Precursors of adolescent substance use from early childhood and early adolescence: testing a developmental cascade model. Dev Psychopathol. 2014; 26:124–140.

Sommer K, Whitman Y, Borkowski J, Gondoli D, Burke J, Maxwell S, Weed K. Prenatal maternal predictors of cognitive and emotional delays in children of adolescent mothers. Adolescence. 2000; 35:88–112.

Sood B, Delaney-Black V, Covington C, Nordstrom-Klee B, Ager J, Templin T, Janisse J, Martier S, Sokol R. Prenatal alcohol exposure and childhood behavior at age 6 to 7 years: I. Dose-response effect. Am Acad Pediatr. 2001; 108:1–9.

Spielberger, CD.; Gorsuch, RL.; Lushene, R.; Vagg, PR.; Jacobs, GA. Manual for the State-Trait Anxiety Inventory. Consulting Psychologists Press; Palo Alto, CA: 1983.

Steinberg L, Lamborn S, Dornbusch S, Darlin N. Impact of parenting practices on adolescent achievement: authoritative parenting, school-involvement and encouragement to success. Child Dev. 1992; 63:1266–1281. [PubMed: 1446552]

Taylor K, Kliewer W. Violence exposure and early adolescent alcohol use: an exploratory study of family risk and protective factors. J Child Fam Stud. 2006; 15:207–221.

Tong V, Jones J, Dietz P, D'Angelo D, Bombard J. Trends in Smoking Before, During, and After Pregnancy — Pregnancy Risk Assessment Monitoring System (PRAMS), United States, 31 Sites, 2000–2005. MMWR Surveill Summ. 2009; 58(SS04):1–29.

Vermeiren R, Schwab-Stone M, Deboutte D, Leckman P, Ruchkin V. Violence exposure and substance use in adolescents: findings from three countries. Pediatrics. 2003; 111:535–540. [PubMed: 12612233]

Volkow N. Impact of fetal drug exposures on the adolescent brain. JAMA Ped. 2013; 167:390–391.

Wasik BH, Ramey CT, Bryant DM, Sparling JJ. A longitudinal study of two early intervention strategies: Project CARE. Child Dev. 1990; 61:1682–1696. [PubMed: 2083492]

Weiland B, Nigg J, Welsh R, Yau W, Zubieta J, Zucker R, Heitzeg M. Resiliency in adolescents at high risk for substance abuse: flexible adaptation via subthalamic nucleus and linkage to drinking and drug use in early adulthood. Alcohol Clin Exp Res. 2012; 36:1355–1364. [PubMed: 22587751]

Willford J, Richardson G, Leech S, Day N. Verbal and visuo-spatial learning and memory function in children with moderate prenatal alcohol exposure. Alcohol Clin Exp Res. 2004; 28:497–507. [PubMed: 15084908]

Willford J, Leech S, Day N. Moderate prenatal alcohol exposure and cognitive status of children at age 10. Alcohol Clin Exp Res. 2006; 30:1051–1059. [PubMed: 16737465]

Zucker R, Donovan J, Masten A, Mattson M, Moss H. Early developmental processes and the continuity of risk for underage drinking and problem drinking. Pediatrics. 2008; 121:S252–S272. [PubMed: 18381493]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

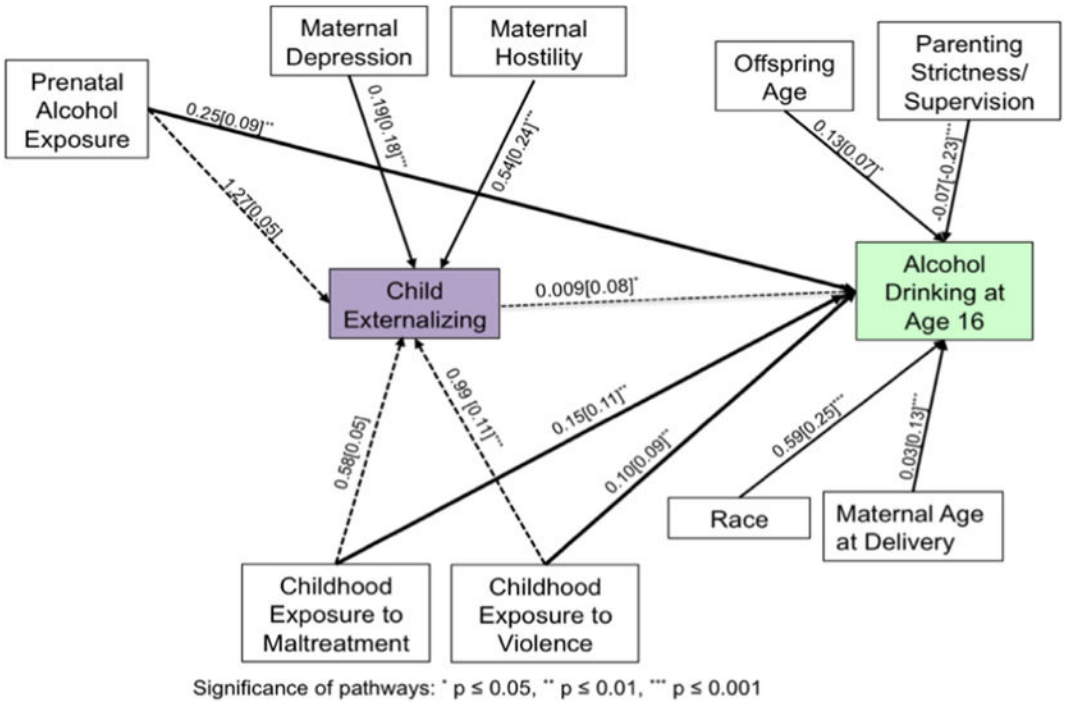

Fig. 1.

Direct and indirect effects of early adverse exposures to adolescent drinking.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1

Bivariate relations between demographic/environmental factors and offspring level of drinking.

Variable	Offspring drinking level			*P* value[a]
	None *N* = 484	<1 drink per week *n* = 247	≥1 drink per week *n* = 186	
	Mean, SD	Mean, SD	Mean, SD	
Demographic				
Race (% White)	28.1	45.7	61.8	<0.001
Offspring gender (% male)	49.8	44.9	52.2	NS
Economic hardship	12.8 (3.0)	12.3 (3.0)	12.1 (3.0)	<0.01
Maternal age (at recruitment)	19.9 (4.5)	21.2 (4.4)	21.3 (4.4)	<0.001
Offspring age	16.7 (0.68)	16.8 (0.66)	17.0 (0.81)	<0.001
Gestational and childhood factors				
Prenatal alcohol exposure (1st trimester)	0.22 (0.4)	0.29 (0.4)	0.36 (0.5)	<0.001
Prenatal tobacco exposure (1st trimester)	5.2 (8.6)	7.2 (10.8)	9.9 (11.6)	<0.001
Prenatal marijuana exposure (1st trim.)	0.32 (0.9)	0.29 (0.9)	0.30 (0.9)	NS
Home environment (age 6)	−0.05 (1.0)	−0.03 (0.9)	0.09 (1.0)	NS
Maternal depression (age 6)	37.5 (9.8)	38.3 (9.5)	38.1 (9.4)	NS
Maternal hostility (age 6)	16.2 (4.8)	16.4 (4.1)	17.3 (4.7)	<0.05
Parental strictness (age 16)	20.1 (3.8)	18.3 (3.9)	17.1 (3.9)	<0.001
Parental involvement (age 16)	30.8 (4.1)	29.6 (4.2)	29.0 (4.9)	<0.001
Pubertal status (age 16)	2.9 (0.8)	2.9 (0.9)	2.7 (0.9)	<0.05
Childhood maltreatment exposure (age 16 – covering childhood)	2.0 (0.8)	2.3 (0.8)	2.4 (0.9)	<0.001
Exposure to violence (age 16 – covering childhood)	0.69 (1.0)	0.78 (1.0)	1.0 (1.3)	<0.01

SD = Standard deviation, NS = Not significant.

[a]Based on ordinal logistic regression.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Significant demographic/environmental predictors of offspring drinking level: multivariate analyses[a].

Variable	Coefficient	Cumulative OR	*P* value
Race	1.21	3.30	<0.001
Maternal age	0.06	1.10	<0.001
Prenatal alcohol exposure	0.52	1.70	<0.010
Parental strictness	−0.15	0.86	<0.001
Childhood maltreatment exposure	0.25	1.34	<0.010
Exposure to violence	0.09	1.10	<0.001

[a]McFadden's pseudo R^2 was 0.12.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Summary of model pathways and direct and indirect effects of early adversity variables on offspring drinking at 16.

Variable	Estimated coeff. [standardized coeff.]	Coeff./S.E.	One-tailed *p*-value
Pathways to drinking at 16			
Race	0.59 [0.25]	6.4	<0.001
Parental strictness	−0.07 [−0.23]	−5.8	<0.001
Maternal age	0.03 [0.13]	3.6	<0.001
Childhood maltreatment exposure	0.15 [0.11]	2.6	<0.01
Prenatal alcohol exposure	0.25 [0.09]	2.4	<0.01
Exposure to violence	0.10 [0.09]	2.4	<0.01
CBCL Externalizing behavior	0.009 [0.08]	2.0	<0.05
Offspring age at 16 assessment	0.13 [0.07]	1.9	<0.05
Pathways to CBCL externalizing			
Maternal hostility	0.54 [0.24]	7.3	<0.001
Maternal depression	0.19 [0.18]	4.9	<0.001
Childhood exposure to violence	0.99 [0.11]	3.1	<0.001
Prenatal alcohol exposure	1.27 [0.05]	1.5	NS
Childhood maltreatment exposure	0.58 [0.05]	1.4	NS
Decomposition of direct and indirect effects of early adversity variables on offspring drinking			
PAE			
Indirect	0.011 [0.004]	1.19	0.12
Direct	0.252 [0.093]	2.38	0.01
Total	0.263 [0.097]	2.50	0.005
Childhood maltreatment exposure			
Indirect	0.005 [0.004]	1.11	0.14
Direct	0.153 [0.108]	2.65	0.004
Total	0.158 [0.112]	2.75	0.003
Childhood violence exposure			
Indirect	0.009 [0.008]	1.65	0.05
Direct	0.101 [0.095]	2.43	0.01
Total	0.110 [0.103]	2.63	0.005