Published in final edited form as:

Neurotoxicol Teratol. 2011 ; 33(1): 88–99. doi:10.1016/j.ntt.2010.07.003.

Early adolescent cocaine use as determined by hair analysis in a prenatal cocaine exposure cohort

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Abstract

Background—Preclinical and other research suggest that youth with prenatal cocaine exposure (PCE) may be at high risk for cocaine use due to both altered brain development and exposure to unhealthy environments.

Methods—Participants are early adolescents who were prospectively enrolled in a longitudinal study of PCE prior to or at birth. Hair samples were collected from the youth at ages 10½ and 12½ ($N=263$). Samples were analyzed for cocaine and its metabolites using ELISA screening with gas chromatography/mass spectroscopy (GC/MS) confirmation of positive samples. Statistical analyses included comparisons between the hair-positive and hair-negative groups on risk and protective factors chosen *a priori* as well as hierarchical logistical regression analyses to predict membership in the hair-positive group.

Results—Hair samples were positive for cocaine use for 14% ($n=36$) of the tested cohort. Exactly half of the hair-positive preteens had a history of PCE. Group comparisons revealed that hair-negative youth had significantly higher IQ scores at age 10½; the hair-positive youth had greater availability of cigarettes, alcohol, and other drugs in the home; caregivers with more alcohol problems and depressive symptoms; less nurturing home environments; and less positive attachment to their primary caregivers and peers. The caregivers of the hair-positive preteens reported that the youth displayed more externalizing and social problems, and the hair-positive youth endorsed more experimentation with cigarettes, alcohol, and/or other drugs. Mental health problems, peer drug use, exposure to violence, and neighborhood characteristics did not differ between the groups. Regression analyses showed that the availability of drugs in the home had the greatest predictive value for hair-positive group membership while higher IQ, more nurturing home environments, and positive attachment to caregivers or peers exerted some protective effect.

Conclusion—The results do not support a direct relationship between PCE and early adolescent experimentation with cocaine. Proximal risk and protective factors—those associated with the home environment and preteens' caregivers—were more closely related to early cocaine use than more distal factors such as neighborhood characteristics. Consistent with theories of adolescent problem behavior, the data demonstrate the complexity of predicting pre-adolescent drug use and

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Conflict of interest statement

The authors declare no conflicts of interest.

identify a number of individual and contextual factors that could serve as important foci for intervention.

Keywords

Prenatal cocaine exposure; Early adolescents; Hair; Drug testing; Substance abuse

1. Introduction

1.1. Adolescent substance use in the United States

Adolescence, considered to range broadly from 11 to 18 years, is a time of increased risk-taking behavior among humans, as well as other species [88]. Experimentation with illicit drugs is among the many unhealthy risky behaviors in which teenagers engage and represents a significant public health problem. The drugs most commonly tried by teens are tobacco, alcohol and marijuana [47,73]. The most recent data from the NIDA-funded Monitoring the Future study indicated that almost half of all high school seniors (47%) and more than a quarter of 8th graders (28%) have used some illicit drug during their lifetime [48]. The Pride Survey extended these findings downward and showed that 7% of 6th graders and 10% of 7th graders reported use of illicit drugs in the past year [73].

Although cocaine and crack use among secondary school students has generally been declining since peak rates in 1999, the lifetime prevalence rates for cocaine use among each of the three survey groups in the Monitoring the Future study – 8th, 10th, and 12th graders – have increased significantly at least once between 2004 and 2008. The most recent lifetime prevalence estimates are 3.0% for 8th graders, 4.5% for 10th graders and 7.2% for 12th graders. The annual prevalence rates for crack use specifically in the Monitoring the Future survey are the same for 8th and 10th graders at 2.0%, which is only slightly lower than for 12th graders at 2.8% [48]. Even more worrisome in the Pride Survey is the reported annual prevalence rate of 1.2% for both 6th and 7th graders [73].

Earlier experimentation with cocaine is linked to a greater likelihood of developing cocaine dependence. A study using data from the National Comorbidity Survey demonstrated that for adolescents who used cocaine at least once, the estimated cumulative probability of meeting diagnostic criteria for cocaine dependence increased seven-fold from ages 15 to 19. Additionally, the risk of developing dependence extends a decade or more after initial use, a much larger window of vulnerability compared to marijuana [93]. An increased risk of drug dependence with very early use was also demonstrated by Anthony et al. who found that a 68% risk of developing drug problems when use of illicit drugs began at less than age 13 compared to 43% for those who began at age 16 [3].

1.2. Determination of adolescent substance use

Serious substance use problems in adolescents may be underestimated because an important limitation of most studies is reliance on self-report. In a sample of pregnant adolescents, Bessa et al. [11] compared responses to drug use questions in a structured interview with analysis of hair samples and found that hair analyses detected the use of cocaine and/or marijuana in 6% of participants, none of whom had self-reported use. Studies of known adult cocaine users also have demonstrated that hair samples are far more sensitive than self-report or urine tests for detecting drug use, especially cocaine [31,67].

Hair specimens have several advantages over urine samples for detecting drug use by toxicological analyses [9,28]. The window of drug detection when using hair can be months to years depending upon the length of the hair specimens compared to 2–3 days for urine, an important advantage when attempting to identify occasional users. Hair analysis, unlike

urinalysis, is not susceptible to evasive measures on the part of the participant. Hair analysis is particularly suited for detection of cocaine use given that cocaine has the highest incorporation rate into hair compared to other common drugs of abuse due to its high lipophilicity and basicity [72].

Concerns about contamination of hair that can result from passive exposure to drugs in the environment have been addressed by sample preparation techniques and analytic methods developed and validated by more than 15 years of research. One of the most important sample preparation issues is washing the hair to remove external cocaine contaminants while leaving the internal hair structures intact. While there is no general consensus on the optimal hair washing procedure, one validated method involves an isopropanol wash followed by multiple extended phosphate buffer washes [16,83,84]. This procedure has been tested using various colors of hair (blonde, auburn, brown, and black) and both natural and chemically treated hair. These studies demonstrated that the porosity of hair, not its color, affects the rate of penetration of hair by cocaine in solution (i.e., chemically treated hair absorbs cocaine more easily than natural hair) [83]. Cocaine is less affected by cosmetic treatments than other drugs [72]. Hair that has been subjected to harsh cosmetic treatments, such as oxidative dyeing and bleaching, when appropriately washed, yields somewhat lower though still detectable levels of cocaine [20,50,98].

1.3. Adolescent vulnerability to cocaine

Preclinical studies using periadolescent rodents suggest that, compared to adults, adolescents may have an increased biological vulnerability to stimulants, including cocaine (for a review see Laviola et al. 1999[53]). This increased vulnerability may be due, in part, to greater reinforcement of novelty-seeking behavior through dopaminergic reward systems in the brain, particularly for those who are high in activity level, sensation-seeking, and/or impulsivity [90]. In addition, female adolescent rats may be at particularly high risk for cocaine dependence given that adolescents showed heightened sensitivity to cocaine compared to adults and females respond to lower doses of cocaine compared to males [99].

Youth with a history of prenatal cocaine exposure (PCE) may be at an increased risk for using cocaine due to alterations in fetal brain development as well as exposure to high-risk environments. Animal models of PCE have demonstrated both structural and functional changes in dopamine-rich brain circuits [36,37,39,56,91]. These are important findings as the dopaminergic system is linked to the rewarding properties of drugs of abuse. In well-controlled studies, significantly smaller birth head circumferences among children with PCE have been reported [5,8,22,30,58,77,86,87,100]. Head circumference, at birth and in young children, is a reliable indicator of brain volume and growth [7,57].

A long history of research has documented that children of parents with a substance use disorder are at higher risk for substance use problems due to both genetic and environmental influences. For example, in a study by Noble et al., a significantly higher prevalence of the A1 and B1 alleles of the D2 dopamine receptor gene was found in male cocaine addicts when compared with non-cocaine users, suggesting a genetic susceptibility to cocaine dependence and raising the possibility of genetic transmission to offspring [69]. However, the intergenerational transmission of the risk for substance abuse is thought to be only partly genetic. Parental modeling of drug use as well as a variety of interrelated psychosocial factors including maternal/caregiver psychopathology, parenting problems, family dysfunction, violent neighborhoods, and poverty are important contributors to the development of offspring substance abuse as well [25,59,63,64]. The role of fetal exposure to drugs of abuse as an additional risk factor for later substance use among children of substance abusing parents remains unclear. The reader is referred to comprehensive reviews available on this topic [35,46].

1.4. Models for understanding adolescent problem behavior including drug use

A number of theories of child and adolescent development posit that behaviors are influenced by the interaction between an individual's unique characteristics and abilities and multiple levels of his/her environment [15,54,60,70]. A common element of models of adolescent development generally, and of developmental psychopathology in particular, is a focus on social relationships in multiple contexts and settings, including families, friends, and peers in homes, schools and neighborhoods [32,70]. These models derive from a number of developmental theories (e.g., attachment, social learning and ecological–transactional theories) [6,12,19,41,79,89] which highlight the influence of relationships on social behavior and development.

Several theoretical models specific to adolescent problem behaviors propose that risk and protective factors exist at multiple levels — the individual level (including personal attributes), the contextual level (home, school, neighborhood), and the interpersonal level (parents, family, peers, other adults) [18,19,23,45,55,62,66,75,89]. For example, Dishion and colleagues have suggested that poor self esteem, depression, and skill deficits may confer a vulnerability to substance use [27]. Examining factors affecting substance use in adolescent males, Dishion et al. found interconnections among individual youth, family, and peer characteristics which led them to propose a higher order construct they call a “childhood risk structure” [25]. Similarly, Jessor's model of adolescent risk behavior includes five interrelated domains of risk and protective factors: biology/genetics, personality, behavior, the perceived environment, and the social environment [45].

Extensive empirical work based on these models has identified a number of specific risk and protective factors related to parental functioning, family functioning, peer relations, and neighborhood characteristics that affect the likelihood and extent to which adolescents will engage in alcohol and drug use as well as other risky behaviors. For example, parental affective disorders and drug use have been related to adolescent alcohol and drug use, respectively, except under conditions of high family cohesion [42]. Likewise, parental substance use has been related to age of onset of youth substance use.[27] Poor family relations also have been related to adolescent alcohol and drug use.[14] Studies have discovered specific links between interpersonal experiences with peers and the onset and escalation of risky behavior, drug use and delinquency [24,26,34]. In addition, a survey using a large population-based public school sample found that adolescents who perceived low parental caring, had difficulty talking to parents about problems, and valued the opinion of friends in making serious decisions, reported a number of behavioral and mental health problems, including substance use [2]. The perception of high neighborhood risk (e.g., gangs, fighting) by inner city minority teens predicted cigarette, alcohol and marijuana use. However, the relationship of neighborhood risk to each individual drug was qualified by psychosocial factors (e.g., negative affect, peer relations) [85].

Relatively few studies have examined the relationship between early adolescent drug use and cognitive functioning as measured by IQ. Results from the longitudinal study of African American children from the Woodlawn community in Chicago showed that higher scores on IQ and reading readiness tests in first grade predicted earlier age for first use of cigarettes, alcohol and marijuana in adolescence[33] as well as higher overall levels of alcohol and marijuana use [51]. The effect of IQ specifically on age of first use was found more often for girls than for boys [51]. These findings did not persist, however, in a follow-up study of this cohort in young adulthood (age 32) in which the first-grade reading readiness (but not IQ scores) were examined in relation to adult marijuana and cocaine use [29]. Most adolescent drug researchers have tended to use measures of school achievement or failure rather than IQ and have found that academic achievement can have a protective effect against early

drug use while school failure (which is often associated with antisocial behavior including association with deviant peers) is linked to greater drug use [40,44].

1.5. Hypotheses

Few researchers have prospectively examined the effect of very early (prenatal) risk factors (including PCE) on early adolescent use of illicit drugs while taking into account a variety of risk and protective factors that operate at the individual level and at multiple contextual levels. To explore these issues, we formulated four sets of *a priori* hypotheses. Based on the preclinical literature about structural and functional brain changes resulting from PCE as well as human studies demonstrating that children of drug abusers are at higher risk for substance use, we hypothesized first that a higher proportion of preteens with PCE would have experimented with cocaine as evidenced by cocaine-positive hair samples. Second, based on several theories of adolescent problem behavior, we hypothesized that preteens who experimented with cocaine would have higher levels of individual and contextual risk factors, and lower levels of individual and contextual protective factors than those who had not experimented with cocaine. Third, because problem behaviors tend to co-occur, we hypothesized that preteens who experimented with cocaine would demonstrate higher levels of other problem behaviors, including self-reported drug use, compared to those with no evidence of cocaine experimentation. Finally, we hypothesized that each set of risk factors would independently contribute to the prediction of membership in the group of youth with positive hair samples and that protective factors would ameliorate the effect of risk factors.

2. Methods

2.1. Procedures

Approval for this study was granted by the University of Florida institutional review board, and a federal Certificate of Confidentiality was obtained as an additional safeguard to protect the confidentiality of the data. Participants were enrolled in a prospective, longitudinal study on the developmental effects of PCE that began in 1991. Detailed information about participant recruitment and enrollment is available elsewhere [30]. Briefly, pregnant women over the age of 18 with no illicit drug use other than cocaine or marijuana and with no chronic illness that might affect pregnancy outcome or fetal development were recruited for the longitudinal study when they first entered prenatal care or, in the case of no prenatal care, at delivery. More than 2500 women were approached, and 85% consented to participate. Maternal cocaine users were identified by private, structured interviews conducted by experienced female research staff and/or by positive urine screens confirmed by GC/MS that were obtained at two unanticipated times: study enrollment and delivery. Women who admitted use or tested urine-positive for illegal drugs other than cocaine or marijuana were excluded from the study. As each cocaine-using pregnant woman was identified and enrolled, a non-cocaine using pregnant woman with similar demographic characteristics (race, parity, socioeconomic status (SES) [43] and location of prenatal care) was enrolled until a total sample of 308 was obtained.

The youth and their families have participated in repeated assessments between birth and age 13. For each new cycle of the longitudinal study, written, informed consent was given by primary caregivers, including consent to obtain hair samples; child assent was also obtained. For their study participation caregivers received a monetary stipend and the youth were given a gift card to a national retailer. At ages 10½ and 12½, the preteens were administered comprehensive neuropsychological evaluations in a mobile clinic parked outside their school or home, and their caregivers were interviewed in their homes, when possible, using standardized self-report behavioral assessments. Every six months beginning at 10½, the children also participated in private interviews, generally conducted at their

schools, which consisted of standardized self-report measures and questions adapted from the National Longitudinal Study of Adolescent Health (Add Health) [10,75].

Hair samples were collected from the preteens during the 10½ and 12½ assessments (average ages 10.60±0.17 years and 12.58±0.14 years). Strands of hair were cut from the scalp end at the apex of the head, taped to an index card, wrapped in aluminum foil, and stored at room temperature until transported to the lab for analysis. The Analytical Toxicology Core Laboratory at the University of Florida, under the supervision of its director (N.J.S.), analyzed the samples for cocaine and its major metabolites benzoylecgonine, ecgonine methyl ester, norcocaine, and cocaethylene.

Samples were prepared and washed according to published procedures that have been shown to be effective in removing external cocaine contamination from hair samples [16,83,84]. Prior to weighing, samples that contained hair strands longer than 9 to 10 cm were cut into 3 to 5 cm segments. The samples were extensively washed using one 15-minute isopropanol wash, followed by three 30-minute and then two 60-minute phosphate buffer (pH 6) washes. The samples were then pulverized and subjected to soft acidic hydrolysis using procedures outlined by Jurado et al. [49] Immunoassay screenings were conducted using ELISA kits from Neogen Corporation (Lexington, KY). The solid-phase extraction, derivatization, and analysis methods for the GC/MS confirmation of positive ELISA screens were based on procedures developed by Phillips et al. [71].

2.2. Participants

Of the surviving 296 children and their caregivers, 265 (90%) participated in the follow-up interviews and/or neuropsychological evaluations between ages 10½ and 12½. Hair samples were collected from 257 children at age 10½ and 252 children at age 12½. The total number of individuals who provided hair samples at one or both ages was 263.

2.3. Measures

2.3.1. Selection of measures—Measures were selected from variables available in the longitudinal data set based on the main constructs we planned to evaluate as potential risk and protective factors. To examine the role of prenatal exposure to cocaine, we chose two variables to measure the effect of PCE: maternal self-report of the frequency of cocaine use during pregnancy and birth head circumference adjusted for gestational age as a proxy for structural changes in the brain due to PCE.

To assess the role of individual factors, we chose mental health problems, namely depression and anxiety among the preteen participants, as predisposing risk factors for early drug use initiation. We also chose IQ as a measure of general cognitive functioning and an individual protective factor based on the scant literature in this area.

For contextual factors, we selected variables that could assess risk and protection at multiple levels: home environment, the caregiver, peers, and the neighborhood. Risk factors measured at each contextual level were: the availability of drugs in the home, caregiver alcohol/drug use and depression, peer drug use, and exposure to violence/negative neighborhood characteristics. Protective factors assessed were: nurturing home environments, positive caregiver attachment, positive peer attachment, and positive neighborhood characteristics.

2.3.2. Measures of the role of prenatal cocaine exposure—Maternal self-report of the frequency of her cocaine use was obtained through private, structured interviews at the end of each trimester of pregnancy and included data from the 12 weeks prior to conception

in addition to the entire pregnancy. The total number of weeks the woman used cocaine during the 12 weeks prior to conception plus her entire pregnancy were divided by the 12 weeks prior to conception plus the number of total weeks of her pregnancy to yield a frequency measure of prenatal cocaine exposure. Birth head circumference for the neonates was adjusted for gestational age to control for a statistically significant difference in the number of children born pre-term in the PCE group, even though the mean gestational age in both groups was 38 weeks [30].

2.3.3. Measures of individual risk and protective factors—Mental health problems, as individual risk factors, were assessed using three different measures. For all three measures, raw scores are converted to T-scores with separate norms provided for boys and girls. The Children's Depression Inventory (CDI)[52] was administered at ages 10½, 11½, and 12½. The CDI is a 27-item self-report measure which assesses depressive symptoms using a three-point scale (*0=absence, 1=mild symptom, 2=definite symptom*). Reported internal consistency coefficients range from 0.71 to 0.89 with concurrent validity demonstrated by strong correlations with similar measures.

Anxiety was measured using the Revised Children's Manifest Anxiety Scale (RCMAS) [76] at ages 11 and 12. The RCMAS is a 37-item yes/no self-report inventory used to measure anxiety in children. The RCMAS consists of 28 items, which constitute the Total Anxiety scale, and nine social desirability items, which constitute a Lie scale. For the standardization sample, reliability coefficients were generally >0.80 across all ages.

Mental health problems were also assessed using the Internalizing Problems scale from the Child Behavior Checklist (CBCL) and the Youth Self Report (YSR), which are, respectively, the parent-report and youth-report forms of the widely-used Achenbach System of Empirically Based Scales (ASEBA) [1]. The CBCL and YSR are designed to assess internalizing, externalizing, and other behavior problems, as well as competence in the home and school environments. The Internalizing Problems scale is comprised of three syndrome scales: Anxious/Depressed, Withdrawn/Depressed, and Somatic Complaints. The CBCL was administered to caregivers when the children were 10½ years. The YSR was collected at the age 12 interview.

Cognitive functioning as an individual protective factor was assessed using abbreviated versions of the Wechsler Intelligence Scale for Children-3rd Edition (WISC-III) [96] at age 10½ and the Wechsler Intelligence Scale for Children—4th Edition (WISC-IV) [95] at age 12½. Three subtests of the WISC-III and WISC-IV were used to estimate a Full Scale IQ score using established procedures [80,81]. For the WISC-III, the Vocabulary, Block Design, and Symbol Search subtests were used; for the WISC-IV, the Vocabulary, Block Design, and Letter–Number Sequencing subtests were used. The reliability coefficients for these particular WISC-III and WISC-IV short forms are 0.91 and 0.94, respectively.

2.3.4. Measures of contextual risk factors—Several measures were used to evaluate risk factors related to the home environment, caregiver, peers, and the neighborhood. The availability of cigarettes, alcohol, and illegal drugs in the home, which could provide the opportunity to engage in experimentation with drugs, was measured using three yes/no questions from the Add Health during private interviews with the children at ages 11 and 12½. Cronbach's alpha for the sum of the yes answers to these three questions was 0.44 at age 11 and 0.39 at age 12½.

Caregiver problems related to alcohol and drug use were assessed using interviewer ratings from the Addiction Severity Index (ASI) [65]. The ASI is a 40-minute structured interview that queries current use (last 30 days) of alcohol, cigarettes, and illicit drugs as well as

treatment for alcohol and drug problems during the past three years. It also includes sections that ask about family history of drug, alcohol or psychological problems; medical problems, employment/financial support; legal problems; family/social relationships (social support and abuse); and psychiatric problems. Based on the caregiver's responses, at the end of each section, the interviewer provides a rating for the severity of the problem (defined as "need for additional treatment") using a 10-point scale (*0=1=no real problem* to *8=9=extreme problem*). The ASI was administered to the caregivers at the age 10½ home visit. Caregiver depressive symptoms, which can affect the ability of the caregiver to provide support as well as appropriate limit-setting for a preteen, were assessed using the Center for Epidemiological Studies-Depression scale (CES-D) [74]. The CES-D scale is a 20-item self-report measure of depressive symptoms in which items are rated on a four-point scale (*1=most of the time* to *4=never*) then summed. High internal consistency and adequate test-retest reliability have been shown [21,74,97]. Validity of the CES-D for use with low-income African Americans [68] and low-income women attending primary care clinics [92] has been demonstrated. The CES-D was administered at both the 10½ and 12½ caregiver interviews.

Peer use of drugs as a contextual risk factor was assessed using three items from the Add Health at ages 11 and 12½. Specifically, questions ask: "Of your 3 best friends, how many smoke at least 1 cigarette a day?" "Of your 3 best friends, how many drink alcohol at least once a month?" and "Of your 3 best friends, how many use marijuana (weed) at least once a month?" Cronbach's alpha for the sum of these three questions was 0.54 at age 11 and 0.69 at age 12½.

Neighborhood risk factors were assessed using Things I've Seen and Heard (TISH) [78] and the Neighborhood Survey from the Add Health. The TISH is a 20-item, NIMH-developed questionnaire that assesses exposure to violence both in the community and the home. The frequency of exposure to items is rated on a five-point scale (*0=no times* to *4=many times*). The TISH was administered during the age 11½ youth interviews. For this study, the three positively worded items as well as two items that were endorsed infrequently ("Somebody threatened to kill me" and "I've seen a dead body outside") were eliminated. The endorsed items from the resulting 15-item scale were summed and had a Cronbach's alpha of 0.71. The Neighborhood Survey from the Add Health, administered at age 12, consists of 31 true/false items that assess both positive and negative characteristics of the local community. The 13 negative items were grouped into one scale and a score was derived by summing the endorsed items ($\alpha=0.75$). One reverse-scored item, which the preteens seemed to have difficulty comprehending, was omitted.

2.3.5. Measures of contextual protective factors—Several measures were used to assess contextual factors that could confer protection (buffer against the risks) of early drug use initiation. Specifically, we included measures of the quality of the home environment, positive attachment with primary caregivers and peers, and positive neighborhood characteristics. The Home Observation for Measurement of the Environment Inventory (HOME) [17] is an interviewer-completed measure that assesses characteristics related to nurturance and stimulation in a child's home environment based on observations as well as interview questions. The Early Adolescent version of the HOME is designed for use when youth are between 10 and 15 years old [13]. The total score is based on all 60 yes/no items. The HOME has demonstrated good inter-observer agreement and has been shown to correlate with measures of adolescent development across different ethnic groups, including African Americans. HOME measures were collected at both the 10½ and 12½ caregiver interview visits.

The preteens' perceptions of the positive and negative dimensions of relationships with their primary caregiver and close friends were assessed at age 12½ using the Inventory of Parent and Peer Attachment (IPPA) [4]. The IPPA is a 25-item self-report measure designed to assess three broad dimensions for relationships with mother, father, and peers: degree of mutual trust, quality of communication, and extent of anger and alienation. Items are rated on a five-point scale (*0=almost never or never true to 4=almost always or always true*). An attachment score is obtained by reverse-scoring negatively worded statements and adding all the items. Cronbach's alpha has been reported as 0.87 for mother attachment and 0.92 for peer attachment [38].

Positive neighborhood characteristics, such as the availability of community resources (e.g., playground, recreation center, and library) and positive adults (e.g., “adults one could talk to about important things” and “neighbors [who] notice when I'm good and encourage me to do my best”), were assessed using items from the Add Health Neighborhood Survey. The 17 positive items (yes=1, no=0) were used to create a single scale; the sum of these items had a Cronbach's alpha of 0.74.

2.3.6. Measures of problem behaviors—Behavior problems, which generally co-occur with early drug use initiation, were assessed using scales from the Add Health, CBCL and YSR. In addition, self-report of drug use was obtained using questions adapted from the Add Health. At age 10½, questions from the Add Health assessed the frequency during the previous 12 months of the youth's engagement in 10 risky behaviors using a three-point scale (*1=never, 2=once or twice, 3=sometimes*). Included is a wide range of behaviors such as “ride a bike or skateboard without a helmet,” “break a rule that your parents set just for the thrill of seeing whether you could get away with it,” and “played with/used a gun.” A single scale was constructed from the sum of the 10 items ($\alpha=0.64$). The Add Health Delinquency Scale, administered at age 11½, contains 20 items assessing the frequency during the previous 12 months of behaviors such as damaging property, stealing, and carrying a weapon to school using a four-point scale (*0=never to 5=5 or more times*). A total score is derived from the sum of the 20 items ($\alpha=0.79$).

The CBCL and YSR Externalizing Problems scale, which is comprised of the Rule-Breaking Behavior and Aggressive Behavior syndrome scales was used to assess acting-out behaviors. Raw scores were converted to T-scores for analyses. The Social Problems scale of the CBCL and YSR was used to assess problems with peer relations. Per manual recommendations, raw scores for the Social Problem scale were used for analyses [1].

Questions adapted from the Add Health were also used to obtain self-report of drug use at ages 11 and 12½. Included were questions about experimentation, regular use, and lifetime use of cigarettes, chewing tobacco, alcohol, marijuana, cocaine, inhalants, other illegal drugs including the use of prescription drugs for non-prescribed purposes. Since very few of the preteens endorsed use of illicit drugs, only the percentages endorsing experimentation with cigarette smoking, alcohol, and any substance use are reported.

2.4. Statistical analyses

SAS 8.2 (Cary, NC) was used to conduct data screening and all statistical analyses. With the exception of the demographic information and the drug use self-report results, missing values, which comprised less than 1% of the data, were imputed using the Markov chain Monte Carlo method for deriving maximum likelihood estimates [82]. Group comparisons were made using Fisher's exact test for categorical data and the Wilcoxon rank sum test for continuous data. Hierarchical logistical regression was used to evaluate our fourth hypothesis about the unique contribution of categories of risk and protective factors. The criterion for significance tests was set at $\alpha = 0.05$, two-tailed.

3. Results

There were a total of 263 participants from whom hair samples were obtained at either 10½, 12½, or both. Analyses of the 257 hair samples obtained at age 10½ yielded 14 (5.4%) that were positive for cocaine. Of these 14 positive samples, nine were from youth with PCE, 12 were from girls, and 13 were from African Americans. Analysis of the 252 hair samples obtained at 12½ yielded 25 (9.9%) that were cocaine-positive. Of these 25 positive samples, 11 were from youth with PCE, 13 were from girls, and 24 were from African Americans. Three participants had cocaine-positive hair samples at both time-points. Thus, a total of 36 different individuals (13.7% of the cohort tested) were identified with cocaine-positive hair samples at age 10½, 12½, or both.

Attrition analyses were conducted comparing the 263 study participants with the 33 surviving non-participants on the three study enrollment match variables (race, parity, and SES), prenatal drug exposures (tobacco, alcohol, marijuana, and cocaine) and three child birth characteristics (gestational age, birth weight, and head circumference). Results revealed no significant group differences on any variables (all p 's > 0.05, data not shown).

Descriptive data for the participants by both hair status (hair-positive $n=36$, hair-negative $n=227$) and PCE status (PCE $n=129$, non-exposed $n=134$) are shown in Table 1. Comparisons between the two hair groups (cocaine-positive vs. cocaine-negative) revealed no significant differences for any maternal characteristics at birth. The majority of the mothers in the sample were African American, multiparous, and poor. On average, the mothers were in their mid-20s at the time of their pregnancy and had less than a 12th grade education. Maternal use of tobacco, alcohol, marijuana, and cocaine during pregnancy did not differ. Comparisons between the two prenatal exposure groups (PCE vs. non-exposed) yielded differences on maternal characteristics that paralleled those previously reported for the entire cohort: PCE mothers were older and reported more use of tobacco, alcohol, and marijuana than the non-cocaine using mothers.

For child characteristics at birth, the hair-positive group did not differ significantly from the hair-negative group for PCE, gender composition, gestational age, birth weight, adjusted birth head circumference, or SES. Both groups were on average full-term and of average size with persistently low SES. Only one significant between-groups difference was found: the proportion in each group for whom the biological mother was the primary caregiver at age 10½. A larger percentage of hair-positive preteens were cared for by their biological mothers (81%) compared to the hair-negative group (61%) ($p=0.03$).

When comparing the PCE vs. non-exposed groups, again the pattern of differences paralleled those found in the original cohort. Differences were found for gestational age, birth weight, adjusted birth head circumference, and the proportion of children cared for primarily by their biological mothers, all of which favored the non-exposed children. The groups were statistically similar in terms of gender composition and average SES at age 10½.

To evaluate our first hypothesis, Fisher's exact test was used to compare the proportion of preteens with PCE in the hair-positive and hair-negative groups. Contrary to expectations, youth with PCE constituted about 50% of both groups (Table 1).

To evaluate our hypotheses related to individual and contextual risk and protective factors, the means for each variable were compared for the hair-positive and hair-negative groups using the Wilcoxon rank sum test (Table 2). Given that the original longitudinal study was designed to evaluate the effects of PCE, results of group comparisons for the PCE vs. non-exposed groups are also shown although we did not have specific hypotheses related to PCE

status. There were no significant differences by PCE status on any of the measures examined.

In terms of individual risk factors, group comparisons by hair status yielded no significant results on measures of mental health problems. The average total T-scores ($M=50$, $SD=10$) for the hair-positive and hair-negative groups were similar on the Children's Depression Inventory measured at yearly intervals between 10½ and 12½ and on the Revised Children's Manifest Anxiety Scale measured at ages 11 and 12. Internalizing problems as assessed by caregiver report using the CBCL at age 10½ and youth report using the YSR at age 12 were not significantly different between the hair-positive and hair-negative groups.

Group comparisons for cognitive functioning, an individual protective factor, revealed a significantly higher estimated Full Scale IQ score for the hair-negative group at age 10½ as assessed using the WISC-III. The group difference was not found, however, during repeated assessment using the WISC-IV at age 12½, although the hair-negative group had somewhat higher scores than the hair-positive group.

For contextual risk factors, the hair-positive youth reported significantly greater availability of cigarettes, alcohol, and illegal drugs in the home at age 11 ($p=0.02$) and at age 12½ ($p=0.03$). The hair-positive group also had caregivers with significantly higher interviewer ratings at 10½ for ASI alcohol problems ($p=0.01$) but not for drug problems ($p=0.56$). The caregivers of the hair-positive group reported significantly more symptoms of depression on the CES-D at both 10½ ($p=0.0003$) and 12½ ($p=0.02$). The groups did not differ, however, on self-report of cigarette, alcohol, or marijuana use among their friends at ages 11 and 12½, exposure to violence as measured by the TISH at age 11, or negative neighborhood characteristics as measured by the Neighborhood Survey at age 12.

For contextual protective factors, the hair-negative group had significantly higher HOME scores at both 10½ and 12½ ($p's=0.0003$) and significantly higher (more positive) attachment to both their primary caregivers ($p=0.02$) and their peers at 12½ ($p=0.01$). Mean scores did not differ between the two groups for positive neighborhood characteristics as measured by the Neighborhood Survey at age 12.

Table 3 shows the results of analyses related to our third set of hypotheses involving problem behaviors. Again, results are shown for group comparisons between the PCE and non-exposed groups, and there were no significant differences on any of the measures. For the hair groups, engagement in problem behaviors as determined by the preteens' self-report did not differ significantly between the groups for the Add Health risky behaviors, Add Health Delinquency, YSR Externalizing Problems, or YSR Social Problems scales. Caregivers of the hair-positive youth reported significantly more Externalizing Problems ($p=0.005$) and Social Problems ($p=0.04$) compared to the caregivers of the hair-negative youth. At age 11, no significant group differences were found for youth self-report of drug use with very few preteens in either group endorsing experimentation with cigarettes, alcohol, or any other drugs. By age 12½, however, significant differences were found for all of the drug use variables with the hair-positive preteens admitting to more experimentation with cigarettes, alcohol, and use of any drug (cigarettes, alcohol, marijuana, cocaine, or inhalants). Only one preteen (a hair-positive boy) endorsed having tried cocaine at age 12½.

Three sets of hierarchical logistic regression analyses were conducted to examine the relative effect of risk and protective factors in predicting membership in the hair-positive group. The first set of models evaluated the effect of the individual risk and protective factors (Table 4 top half). The second set of models then evaluated the additive effect of the contextual risk factors (Table 4 bottom half). The third set of models (Table 5) was used to examine the potential for contextual protective factors to buffer against the contextual risk

factors after controlling for the individual risk and protective factors. To minimize the number of models evaluated, only risk and protective factors that were significant in the bivariate group comparisons were entered into the analyses. Variables designed to measure the same construct (e.g., caregiver problems, home environment) were entered simultaneously. An average score was created for variables that were measured at more than one time point (e.g., availability of drugs in the home, CES-D, HOME). After entry into a model, all variables, whether significant or not, were retained as new variables were added to subsequent models.

For the baseline model (Model 1) predicting hair-positive status, we entered PCE (maternal report of % weeks of cocaine use during pregnancy, range 0 to 1) and birth head circumference adjusted for gestational age, consistent with the hypothesis that preteens with PCE could be vulnerable to early cocaine use by virtue of altered brain development. We also entered child gender into the baseline model to assess the possibility that PCE might have a differential effect by gender. This model was not significant. For the second model, we entered the age 10½ estimated FSIQ, the individual protective factor which differed between the two groups. Model 2 was significant and indicated that a higher estimated FSIQ was associated with a lower odds ratio for hair-positive status (OR=0.97, 95% CI=0.95 to 0.99) and that female gender was associated with a higher odds ratio for hair-positive status (OR=2.18, 95% CI=1.01 to 4.72). In Model 3, we added the first contextual risk factor — an average of the preteens' report of the availability of drugs in the home at ages 11 and 12½. Model 3 was significant with both FSIQ and drugs in the home as significant predictors. The availability of drugs in the home more than doubled the odds that a preteen would be classified as hair-positive (OR=2.33, 95% CI=1.31 to 4.14). In Model 4, we entered the two variables reflecting caregiver problems: ASI alcohol problems at 10½ and an average of the CES-D scores obtained at ages 10½ and 12½. Model 4 was significant with caregiver depression (CES-D score), but not alcohol problems, as a significant predictor in addition to the preteens' FSIQ and the availability of drugs in the home. As expected, caregiver depression was associated with a greater likelihood that a preteen would be in the hair-positive group (OR=1.06, 95% CI=1.01 to 1.10).

The results of the logistic regression analyses for contextual protective factors are summarized in Table 5. In Model 5, we added an average for the HOME total scores obtained at ages 10½ and 12½. This model was significant. The HOME measure was associated with a lower likelihood of hair-positive membership (OR=0.91, 95% CI=0.87 to 0.98) and caused the protective effect associated with a higher FSIQ to fall just below significance ($p=0.07$). In Model 6, we entered the caregiver IPPA, a measure of the preteen's self-reported attachment to his/her primary caregiver. This model was significant with the caregiver IPPA as a significant predictor along with the HOME measure and the availability of drugs in the home. As expected, higher scores on the IPPA (more positive caregiver attachment) were associated with a slightly lower likelihood of hair-positive membership (OR=0.97, 95% CI=0.95 to 0.99). After including caregiver attachment, preteen cognitive functioning (FSIQ) reemerged as a protective factor ($p=0.04$) and caregiver depression dropped out as a significant risk factor ($p=0.053$). In the last model (Model 7), we substituted the peer IPPA, a measure of the preteen's self-reported positive attachment to peers, for the caregiver IPPA. Both attachment measures could not be entered into the same model due to a problem with multicollinearity ($r=0.52$, $p<0.0001$). Model 7 was significant and very similar to Model 6: peer IPPA was a significant predictor along with the HOME measure and the availability of drugs in the home. The magnitude of the protective effect of positive attachment to peers was the same as that of positive caregiver attachment (OR=0.97, 95% CI=0.95 to 0.99).

4. Discussion

This report was designed to assess individual and contextual risk and protective factors for early experimentation with cocaine, using data from a longitudinal cohort of youth who were prospectively enrolled in a study on the developmental effects of PCE at birth. The participants are a group of non-urban preteens (assessed between the ages of 10½ and 12½) who might be considered at high risk of early drug experimentation due to maternal use of cocaine and other drugs during pregnancy and their disadvantaged socioeconomic status. An innovative feature of the study is the use of toxicological analysis of hair samples to determine cocaine use among the preteens. Analytic techniques that included six separate washes to eliminate external contaminants from the hair samples and the use of immunoassay screenings and GC/MS confirmation of positive samples lend confidence that the preteens identified as hair-positive had indeed ingested cocaine.

Hair samples identified cocaine use for 36 participants (14% of those tested) with three of the preteens testing positive at both age 10½ and 12½. The number of participants in the current sample with cocaine-positive hair specimens (5.4% at age 10½ and 9.9% at age 12½) was considerably higher than expected. There is no national survey we are aware of that reports cocaine use among youth who are as young as our participants. The rates we found are comparable to self-reported use of *any illicit drug in the past year* (not just cocaine in the past several months) among 6th graders (7%) and 7th graders (10%) in the Pride Survey [73]. However, none of our participants admitted to cocaine use during private interviews at 10½ and only one participant (a hair-positive boy) admitted to cocaine use at age 12½, underscoring the importance of obtaining biologic specimens and not relying on self-report of cocaine use.

Contrary to expectations, the hair-positive group did not differ from the hair-negative group in the proportion with PCE (or amount of exposure to any of the other three study-eligible drugs — cigarettes, alcohol, and marijuana). Exactly half of the 36 hair-positive children had PCE. This result seems at odds with preclinical studies that suggest a greater risk of cocaine addiction in animals with PCE [61]. Considering that the majority of the hair-positive group (33 of 36) had positive specimens at only one of the two timepoints when samples were collected, it appears that the cocaine use detected among the preteens in this study represents experimentation rather than regular use. Given the young age of our participants, only a longitudinal design can determine if the hair-positive preteens will go on to develop cocaine abuse or dependence.

We examined how a number of risk and protective factors both individual and contextual differed between the hair-positive and hair-negative groups. Mental health problems, as an individual risk factor, were measured using standardized scales for depression and anxiety completed by the youth and their caregivers at different intervals. There were no significant differences between the hair-positive and hair-negative groups on any of the measures. Both groups obtained average scores that were within the normal range and slightly below the normative mean for all measures. These results suggest that symptoms of anxiety and depression were not associated with early cocaine experimentation in this sample. On the other hand, cognitive functioning, conceptualized as an individual protective factor was found to differ between the groups. The hair-negative group had a significantly higher estimated FSIQ at 10½ but not 12½. The lack of a difference at the later age could be due to a change in the assessment instrument (from WISC-III and WISC-IV). Additionally, further examination of the role of cognitive functioning as a potential protective factor against early drug use is warranted using measures that are more specific than IQ, e.g., measures of problem-solving and other domains of executive functioning that could put the early cocaine-experimenters at risk for poor outcomes in school and other areas.

In terms of contextual risk factors evaluated in the study, the availability of drugs in the home, caregiver problem alcohol use, and caregiver depression were all significantly higher, on average, for the hair-positive preteens. Peer drug use, exposure to violence, and negative neighborhood characteristics were contextual risk factors that did not, however, differ between the groups. Among the contextual protective factors, the quality of the home environment and positive attachment to both primary caregivers and peers were higher for the hair-negative group. A positive neighborhood did not seem to exert a protective effect. Given the young age of our sample, it is not surprising that more statistically significant effects were found for more proximal factors such as primary caregivers and the home environment as compared to more distal factors like peers and neighborhoods. As the preteens progress through adolescence, it is expected that distal factors may play a more salient role.

Engagement in other problem behaviors, which commonly co-occur with early drug use, was also assessed. On self-report measures of risky behaviors, delinquency, externalizing problems and social problems completed by the preteens, no significant differences were found. However, the primary caregivers of the hair-positive group reported significantly higher scores for externalizing problems and social problems. The differences by informant could reflect a true difference in aggressive, impulsive, and sensation-seeking behaviors associated with cocaine use as has been demonstrated among periadolescent animals [90]. Alternatively, caregiver report of youth behavior problems can be affected by caregiver problems, particularly depressive symptoms [94], which were higher on average for the caregivers of hair-positive youth. Post-hoc analysis of the correlation between the 10½ caregiver CES-D total score and the 10½ CBCL Externalizing Problems scale was $r=0.34$ for the hair-positive group but only $r=0.17$ for the hair-negative group (both $p's < 0.05$). Although the hair-positive preteens did not endorse externalizing behaviors, they did seem to be willing to report experimentation with cigarettes and alcohol and other drugs by age 12½. There were no differences between the groups at age 11, but by age 12½ the hair-positive group endorsed higher rates of drug experimentation.

Building on the results from the group comparisons, hierarchical logistic regression analyses were used to assess the relative effect of various risk factors as well as the potential of protective factors to buffer against the effects of risk factors. Results indicated that cognitive ability (estimated IQ) was a significant individual protective factor, which lowered the likelihood of membership in the hair-positive group. This effect, while small ($OR=0.97$, 95% $CI=0.95$ to 0.99), remained constant even after the inclusion of contextual risk factors. The effect of gender as a predictor of hair-positive status remains unclear given it only emerged as a significant predictor in one model (Model 2). Among the two sets of contextual risk factors examined, the availability of drugs in the home and caregiver depression, but not alcohol problems, contributed uniquely to the prediction of early cocaine use. The availability of drugs in the home had a much larger effect, almost doubling the likelihood that a preteen would be in the hair-positive vs. the hair-negative group. When all risk variables were included in the final model, each remained significant although the effects were small (all $OR < 2.0$). Overall, the results of these analyses showed that higher cognitive ability could serve as a protective factor; however, each set of contextual risk variables uniquely added to the prediction of hair-positive status.

Results of models testing the relative effect of contextual protective factors when added to the final model of risk factors yielded some interesting results. Both the quality of home environment and positive caregiver attachment were significant predictors that decreased the likelihood that a preteen would be in the hair-positive group. While these effects were generally small, it is noteworthy that both were significant in the same model and that caregiver attachment had a slightly larger effect than a positive home environment

(OR=0.97 and 0.92, respectively). Finally, in a separate model that evaluated the effect of positive peer attachment, we found that the overall model was significant and that the magnitude of the effect for positive peer attachment was the same as that for positive caregiver attachment (both ORs=0.97).

The current study has several limitations. First, we could not take a developmental approach to analyzing the data given that: (1) the individual and contextual risk and protective factors were collected within the same time frame as the hair samples, and (2) the primary outcome measure (hair-positive status) was collapsed across two ages (10½ and 12½). The risk and protective factors are best thought of as correlates rather than predictors of early cocaine experimentation, although many of the factors we considered have likely existed for some time (IQ, caregiver alcohol problems, home and neighborhood environments). A second limitation is the use of narrow-band predictors over broader constructs based on aggregate measures. The small size of our subsample of interest (hair-positive youth, $n=36$) as well as our desire to measure a range of individual and contextual factors necessitated a simpler analytical approach. Even with the logistic regression analyses, we chose to average repeated measures since the short interval for the data collection rendered modeling of effects over time impractical.

In summary, the results do not support a direct relationship between PCE and early adolescent experimentation with cocaine. In our sample, the preteens experimenting with cocaine had lower levels for the one individual protective factor examined (cognitive functioning), higher levels of contextual risk factors (availability of drugs in the home, caregiver alcohol problems, and caregiver depression) and lower levels of contextual protective factors (positive home environment, positive caregiver attachment, and positive peer attachment). Mental health problems, as individual risk factors, did not distinguish experimenters from non-experimenters. In addition, neighborhood characteristics, whether positive or negative, did not seem to exert much influence on early cocaine experimentation. These data suggest that for preteens, drug prevention/intervention efforts should focus on improving caregiver functioning and parent–child relationship quality, which will likely, in turn, result in a more positive home environment. Consistent with theories of adolescent problem behavior, the data demonstrate the complexity of predicting early adolescent drug use.

Acknowledgments

Research support provided by NIDA grant R01 DA05854 (F.D.E. and M.L.B.). The funding agency played no role in the study design; collection, analysis and interpretation of the data; the writing of the manuscript; or the decision to submit the manuscript for publication. The authors would like express their gratitude to our dedicated research staff and the children and their families who made this research possible.

We dedicate this portion of our work to Dr. Vince Smeriglio — as grateful beneficiaries of his competence and professionalism, dedication to strong and significant science, and willingness to advise and support the research efforts of our team, as he has many others. Dr. Smeriglio's encouragement and enthusiasm often went beyond the call of duty. With great wisdom he relayed the scientific importance of supporting and appreciating research on the effects of prenatal drug exposure to our various institutions. His encouraging words maintained the enthusiasm and good efforts of many hardworking project teams. On a personal level, Dr. Smeriglio's sensitivity, warmth, gentle humor, and gracious manner have endeared him to a large cadre of prenatal drug researchers, and he will be long remembered by his colleagues and mentees.

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Table 1

Sample descriptive statistics by hair and prenatal cocaine exposure (PCE) status.^a

Characteristic	Hair-positive (n=36)	Hair-negative (n=227)	PCE (n=129)	Non-exposed (n=134)	p value
<i>Biological mother</i>					
Race, n (% African American) ^b	33 (92%)	182 (80%)	104 (81%)	111 (83%)	0.75
Parity, n (% multiparous) ^b	31 (86%)	200 (88%)	110 (85%)	121 (90%)	0.26
Socio-economic status at birth ^{b, c}	4.8±0.4	4.7±0.6	4.7±0.6	4.7±0.5	0.56
Age at delivery (years)	24.6±5.0	26.2±5.6	28.0±4.8	24.1±5.6	<0.0001
Education (years)	11.3±1.3	11.3±1.3	11.3±1.5	11.3±1.1	0.66
Cigarettes during pregnancy (no./day)	4.2±6.9	5.6±8.5	8.7±9.0	2.2±6.1	<0.0001
Alcohol during pregnancy (oz. absolute/day)	0.10±0.18	0.12±0.32	0.23±0.41	0.01±0.05	<0.0001
Marijuana during pregnancy (joints/day)	0.03±0.11	0.05±0.29	0.09±0.36	0.01±0.12	<0.0001
Cocaine during pregnancy (% weeks used)	0.21±0.27	0.23±0.31	0.21±0.27	—	—
<i>Child</i>					
Prenatal cocaine exposure, n (% exposed)	18 (50%)	111 (49%)	—	—	—
Gender, n (% female)	22 (61%)	102 (45%)	65 (50%)	59 (44%)	0.32
Gestational age (wks)	38.7±2.1	38.9±1.9	38.6±2.1	39.1±1.8	0.02
Birth weight (g)	3149±668	3152±590	3046±603	3253±582	0.005
Adjusted birth head circumference (cm)	33.9±1.6	34.1±1.5	33.9±1.4	34.3±1.5	0.02
With biological mother at age 10½ (% yes)	29 (81%)	137 (61%)	50 (39%)	116 (87%)	<0.0001
Socio-economic status at age 10½ ^c	4.1±0.9	3.9±1.0	3.9±1.0	3.9±0.9	0.56

^aValues are frequency (percent) or means±standard deviation. P values were calculated using Fisher's Exact Test for categorical variables and the Wilcoxon Rank Sum Test for continuous variables.

^bRace, parity and socio-economic status were match variables for PCE and non-exposed participants at study enrollment.

^cBased on Hollingshead scale where 1=highest, 5=lowest category.

Table 2

Individual and contextual factors by hair and prenatal cocaine exposure (PCE) status.

Measures (youth age at assessment)	Hair-positive		Hair-negative		PCE		Non-exposed		p value
	Mean±SD		Mean±SD		Mean±SD		Mean±SD		
	n=36	n=227	n=129	n=134					
Individual risk factors									
Mental health problems									
CDI total T-score (10½)	46.3±8.3	44.8±7.2	45.7±8.6	44.3±5.8	0.26	0.65			
CDI total T-score (11½)	43.2±8.3	42.5±6.4	43.3±7.7	42.0±5.5	0.93	0.69			
CDI total T-score (12½)	43.5±7.0	41.8±6.2	42.3±6.8	41.8±5.9	0.13	0.89			
RCMAS total T-score (11)	45.6±11.0	47.1±10.6	47.8±11.3	46.0±10.0	0.57	0.20			
RCMAS total T-score (12)	45.0±11.8	44.0±10.7	44.1±11.0	44.1±10.7	0.81	0.90			
CBCL Internalizing Problems T-score (10½)	49.9±8.8	49.1±10.1	49.0±10.4	49.4±9.4	0.52	0.58			
YSR Internalizing Problems T-score (12)	49.6±8.8	47.7±9.5	47.8±9.7	48.2±9.2	0.24	0.66			
Individual protective factor									
Cognitive functioning									
WISC-III Estimated Full Scale IQ (10½)	82.1±19.3	90.1±16.0	88.9±16.9	89.2±16.6	0.03	0.72			
WISC-IV Estimated Full Scale IQ (12½)	88.7±13.5	93.3±12.1	92.2±13.2	93.1±11.5	0.07	0.86			
Contextual risk factors									
Home environment									
Cigarettes, alcohol and illegal drugs in home (11)	0.6±0.8	0.3±0.6	0.4±0.7	0.3±0.7	0.02	0.21			
Cigarettes, alcohol and illegal drugs in home (12½)	0.8±0.9	0.4±0.7	0.5±0.7	0.5±0.8	0.03	0.91			
Caregiver problems									
Caregiver ASI Alcohol Problems (10½)	0.6±1.6	0.2±0.9	0.3±1.1	0.3±1.0	0.01	0.40			
Caregiver ASI Drug Problems (10½)	0.1±0.5	0.2±1.0	0.2±1.0	0.2±0.9	0.56	0.27			
Caregiver CES-D total score (10½)	24.6±10.3	17.5±11.0	17.8±11.4	19.0±10.8	0.0003	0.27			
Caregiver CES-D total score (12½)	22.6±9.7	18.6±11.2	18.8±11.1	19.5±11.1	0.02	0.57			
Peers									
Cigarette, alcohol and marijuana use by 3 best friends (11)	0.2±0.6	0.3±0.8	0.2±0.7	0.3±0.7	0.50	0.78			
Cigarette, alcohol and marijuana use by 3 best friends (12½)	0.4±1.1	0.3±0.8	0.3±1.0	0.2±0.7	0.52	0.77			
Neighborhood									

Measures (youth age at assessment)	Hair-positive <i>n</i> =36		Hair-negative <i>n</i> =227		PCE <i>n</i> =129		Non-exposed <i>n</i> =134		<i>p</i> value
	Mean±SD		Mean±SD		Mean±SD		Mean±SD		
Things I've Seen and Heard total (11½)	9.2±6.3		8.5±6.5		8.5±6.5		8.7±6.5		0.78
Neighborhood Survey negative items (12)	2.9±2.5		2.7±2.4		3.0±2.7		2.4±2.1		0.16
<i>Contextual protective factors</i>									
Home environment									
HOME Total score (10½)	36.9±9.0		42.8±8.0		42.6±7.9		41.5±8.8		0.43
HOME Total score (12½)	39.7±8.3		45.2±7.6		44.6±7.6		44.3±8.2		0.95
Caregiver attachment									
IPPA Primary Caregiver Attachment (12½)	67.7±17.5		74.6±14.4		74.2±14.1		73.1±15.8		0.71
Peer attachment									
IPPA Peer Attachment (12½)	56.0±18.1		64.0±14.1		62.8±15.3		62.9±14.7		0.97
Neighborhood									
Neighborhood Survey positive items (12)	10.1±3.2		10.1±2.8		9.9±3.2		10.2±2.5		0.95

ASI = Addiction Severity Index, CBCL = Child Behavior Checklist, CDI = Children's Depression Inventory, CES-D = Center for Epidemiological Studies-Depression scale, HOME = Home Observation for Measurement of the Environment, IPPA = Inventory of Parent and Peer Attachment, RCMAS = Revised Children's Manifest Anxiety Scale, WISC-III/WISC-IV = Wechsler Individual Scale for Children-3rd and 4th Ed., YSR = Youth Self Report.

Table 3

Problem behaviors by hair and prenatal cocaine exposure (PCE) status.^a

Measures (youth age at assessment)	Hair-positive <i>n</i> =36	Hair-negative <i>n</i> =227	PCE <i>n</i> =129	Non-exposed <i>n</i> =134	<i>p</i> value
Other problem behaviors					
Add Health Risky Behaviors (10½)	6.5±2.7	6.5±3.2	6.6±3.0	6.4±3.3	0.70
Add Health Delinquency Scale (11½)	5.2±6.2	5.1±6.4	5.0±6.4	5.2±6.3	0.98
YSR Externalizing Problems T-score (12)	47.2±8.9	44.8±10.0	45.8±9.7	44.6±10.0	0.44
YSR Social Problems raw score (12)	3.2±3.1	2.8±2.8	3.0±2.9	2.8±2.7	0.47
CBCL Externalizing Problems T-score (10½)	57.7±10.1	52.5±10.8	54.1±11.3	52.5±10.4	0.26
CBCL Social Problems raw score (10½)	3.6±2.1	3.0±2.7	3.3±3.0	2.9±2.3	0.61
Drug use self-report at age 11	<i>n</i> =36	<i>n</i> =226	<i>n</i> =128	<i>n</i> =134	
Tried cigarettes, <i>n</i> (%)	3 (8%)	16 (7%)	9 (7%)	10 (7%)	1.00
Drank alcohol >2 times, <i>n</i> (%)	3 (8%)	10 (4%)	4 (3%)	9 (7%)	0.26
Drank alcohol not with family, <i>n</i> (%)	0 (0%)	2 (1%)	1 (1%)	1 (1%)	1.00
Tried cigarettes, alcohol or any drug, <i>n</i> (%)	6 (17%)	23 (10%)	12 (9%)	17 (13%)	0.43
Drug use self-report at age 12½	<i>n</i> =35	<i>n</i> =221	<i>n</i> =125	<i>n</i> =131	
Tried cigarettes, <i>n</i> (%)	7 (20%)	15 (7%)	10 (8%)	12 (9%)	0.83
Drank alcohol >2 times, <i>n</i> (%)	5 (14%)	6 (3%)	6 (5%)	5 (4%)	0.76
Drank alcohol not with family, <i>n</i> (%)	4 (11%)	4 (2%)	6 (5%)	2 (2%)	0.16
Tried cigarettes, alcohol or any drug, <i>n</i> (%)	8 (22%)	18 (8%)	11 (9%)	15 (11%)	0.54

CBCL = Child Behavior Checklist; YSR = Youth Self Report.

^aValues are frequency (percent) or means±standard deviation. *P* values were calculated using Fisher's Exact Test for categorical variables and the Wilcoxon Rank Sum Test for continuous variables.

Table 4

Hierarchical logistic regression analyses for predicting hair-positive status using individual factors and contextual risk factors.

	Model 1			Model 2			Model 3			Model 4		
	B	SE	B	B	SE	B	B	SE	B	B	SE	B
Individual risk variables												
Prenatal cocaine exposure	-0.24	0.63	0.79	-0.25	0.63	0.78	-0.28	0.65	0.76	-0.35	0.68	0.71
Adjusted BHC	-0.05	0.13	0.96	0.01	0.13	1.01	0.01	0.14	1.01	-0.01	0.14	0.99
Child gender	0.63	0.38	1.88	0.78	0.39	2.18*	0.73	0.41	2.07	0.53	0.41	1.69
Individual contextual variable												
Age 10½ estimated FSIQ			-0.03	0.01	0.97**	-0.03	0.01	0.97**	-0.03	0.01	0.97**	0.97**
Contextual risk variables												
Drugs in home (average)						0.85*	0.29	2.33**	0.68	0.31	1.97*	1.97*
Caregiver ASI alcohol problems									0.25	0.14	1.29	1.29
Caregiver CES-D (average)									0.05	0.02	1.06*	1.06*
χ^2	3.61, NS			11.78*			20.01**			28.96***		
df	3			4			5			7		

ASI = Addiction Severity Index, BHC = birth head circumference, CES-D = Center for Epidemiological Studies-Depression scale, FSIQ = Full Scale IQ, NS = non-significant.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 5

Hierarchical logistic regression analyses for predicting hair-positive status with addition of contextual protective factors.

	Model 5			Model 6			Model 7		
	B	SE B	β	B	SE B	β	B	SE B	β
Individual risk variables									
Prenatal cocaine exposure	-0.23	0.69	0.79	-0.08	0.71	0.92	-0.27	0.71	0.76
Adjusted BHC	0.02	0.15	1.02	-0.02	0.15	0.98	0.007	0.15	1.00
Child gender	0.69	0.43	2.00	0.60	0.44	1.82	0.81	0.44	2.24
Individual risk variable									
Age 10½ estimated FSIQ	-0.02	0.01	0.98	-0.03	0.01	0.97*	-0.02	0.01	0.98
Contextual risk variables									
Drugs in home (average)	0.65	0.31	1.91*	0.66	0.32	1.94*	0.65	0.32	1.91*
Caregiver ASI alcohol problems	0.11	0.15	1.12	0.17	0.16	1.19	0.16	0.16	1.18
Caregiver CES-D (average)	0.05	0.02	1.05*	0.05	0.02	1.05	0.04	0.02	1.04
Contextual protective variables									
HOME Total (average)	-0.09	0.03	0.91**	-0.08	0.03	0.92**	-0.08	0.03	0.93*
Caregiver IPPA				-0.03	0.01	0.97*			
Peer IPPA							-0.03	0.01	0.97*
X^2		37.27****			43.38****			41.25****	
df	8	9	9						

ASI = Addiction Severity Index, BHC = birth head circumference, CES-D = Center for Epidemiological Studies-Depression scale, FSIQ = Full Scale IQ, HOME = Home Observation for Measurement of the Environment, IPPA = Inventory of Parent and Peer Attachment.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.0001$.