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THE EFFECT OF MATERNAL DEPRESSION AND SUBSTANCE ABUSE ON CHILD HUMAN CAPITAL DEVELOPMENT

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ABSTRACT

Recent models of human capital formation represent a synthesis of the human capital approach and a life cycle view of human development that is grounded in neuroscience (Heckman 2007). This model of human development, the stability of the home and parental mental health can have notable impacts on skill development in children that may affect the stock of human capital in adults (Knudsen, Heckman et al. 2006; Heckman 2007). We study effects of maternal depression and substance abuse on children born to mothers in the initial cohort of the 1979 National Longitudinal Survey of Youth (NLSY), a national household survey of high school students aged 14-22 in 1979. We follow 1587 children aged 1-5 in 1987, observing them throughout childhood and into high school. We employ a variety of methods to identify the effect of maternal depression and substance abuse on child behavioral, cognitive, and educational related outcomes. We find no evidence that maternal symptoms of depression affect contemporaneous cognitive scores in children. However, maternal depression symptoms have a moderately large effect on child behavioral problems. These findings suggest that the social benefits of effective behavioral health interventions may be understated. Based on evidence linking early life outcomes to later well-being, efforts to prevent and/or treat mental and addictive disorders in mothers and other women of childbearing age have the potential to improve outcomes of their children not only early in life, but throughout the life cycle.

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1. Introduction

New approaches to modeling the formation of human capital represent a synthesis of the human capital approach and a life cycle view of human development that is grounded in neuroscience (Heckman 2007). That literature highlights the importance of the household environment on the development of children and the compelling evidence that a child's relationship with his or her care giver is important in determining the development of the brain. Based on this model of human development, the stability of the home and parental mental health can have notable impacts on skill development in children that may affect the stock of human capital in adults (Knudsen, Heckman et al. 2006; Heckman 2007).

There is a well developed literature that links mental illness in adults to lower levels of employment, reduced productivity, lower earnings and early exits from the labor force (Currie and Madrian 1999; Frank and Koss 2005).[1] Empirical analysis of the causal links between mental illness and labor market outcomes reveals evidence of intergenerational effects of mental disorders on labor market outcomes. That is, working age adults with parents that suffered from mental disorders had relative odds of working that were 5 to 10 percent lower than otherwise similar adults that reported no mental illness in their parents (Ettner, Frank and Kessler 1997). Similarly, parental mental illness reduces earnings and hours worked in working adults, holding constant other factors affecting labor supply. That research and other studies (Currie and Stabile 2008) also suggest that the effect is due in part to an increased likelihood of experiencing a mental illness if one's parents had such illnesses (relative odds of 1.12 to 1.24). Understanding how parental mental disorders can affect skill accumulation and adult human capital is

[1] When we refer to mental illnesses we include substance use and abuse disorders.

especially important given that there are cost-effective treatments for the most prevalent mental illnesses that have been tested in women of child bearing ages at various income levels (U.S. Department of Health and Human Services 1999; Miranda, Chung et al. 2003). Thus, ameliorating parental mental health problems offers the potential to efficiently bolster the development of human capital at an early age.

In this paper we examine the impact of maternal depression and substance abuse on the cognitive and behavioral development of children during their early school years. We make use of data from the National Longitudinal Survey of Youth (NLSY), 1979 cohort, to estimate the impact of maternal mental health on a set of cognitive and behavioral outcomes in grammar school aged children. Our results show that, after controlling for the mother's early life circumstances, symptoms of maternal depression or alcohol abuse/dependence primarily influence behavioral outcomes in children rather than cognitive outcomes. As shown in recent work (National Research Council and Institute of Medicine 2000; Heckman 2006; Cunha and Heckman 2007; Heckman 2007), non-cognitive skills and attributes are important determinants of economic success that have been under appreciated in policy circles.

The paper is organized into five remaining sections. Section 2 summarizes background literature on child development and maternal depression, including a discussion of conceptual models relevant to our research. In section 3, we describe our data and the empirical strategy in detail. The fourth section provides the results on how maternal behavioral health influences maternal investments in children and child outcomes. Section 5 presents factor analyses and Section 6 presents mother-fixed effect

models as robustness checks of our main results. Section 7 offers a discussion of our conclusions and some policy implications.

2. Background and Theoretical Considerations

Research in neurobiology and child development shows that stress in the home environment can have important effects for the healthy development of children (National Research Council and Institute of Medicine 2000; National Scientific Council on the Developing Child 2005). This research also shows that early influences (positive or negative) on emotional development in children can have lasting effects into adulthood. The quality of maternal care early in life is known to be important in animals and humans (McEwan and Seeman 1999). Stable and supportive care-giving environments have been linked to an enhanced ability to cope with stress that reduces the likelihood of mental health problems in children and with lasting effects into adulthood.

Maternal depression and substance abuse is thought to disrupt the care giving environment (U.S. Department of Health and Human Services 1999; Kim-Cohen, Moffit et al. 2005). Earlier literature on maternal depression established evidence that there are important and lasting effects of maternal depression on child development (Cogill, Caplan et al. 1986). Cogill and colleagues (1986) showed that maternal depression early in a child's life (1st year) has a negative and significant effect on cognitive skills measured at age 4. A meta-analysis published in 1999 reviewed 33 studies of the relationship between maternal depression and child behavior (Beck 1999). That review showed a consistent relationship between maternal depression and child behavior. The

results showed that behavior problems occurred both in the pre-school period and among school aged children.

Two more recent studies are consistent with those from the 1980s and 1990s. In one, (Petterson and Albers 2001), the authors analyzed the National Maternal and Infant Follow Back Survey data to examine the impacts of maternal depression and poverty on child development. They found that mothers with likely depression as measured by a CESD score of 16 to 30 and 30 and above had young children that scored lower on cognitive and motor skills development tests. They also found that higher income levels appear to attenuate but do not eliminate the effects of maternal depression. A British study examined the link between maternal depression and antisocial behavior in children (Kim-Cohen, Moffit et al. 2005). Using data on twins, the authors examined the impact of maternal depression that occurred during the first 5 years of the children's life on antisocial behavior measured at age 7. They also examined the incremental effects of maternal depression that occurred when the children were aged 5 to 7 years. The results indicated a significant impact on antisocial behavior at age 7 of both early life maternal depression and more recent depression.

The presence of mental health problems in school aged children has been linked to long term reduction in the accumulation of human capital (Currie and Stabile 2008). Currie and Stabile (2008) use the NLSY to examine the impact of mental disorders on children and their subsequent academic achievement. They show that Attention Deficiet and Hyperactivity Disorder and conduct disorders both have negative and significant impacts on achievement test scores and levels of educational attainment. Together these

results suggest that maternal depression and substance abuse, treatable mental disorders, may affect the accumulation of human capital early in life.

A Comment on Gene-environment interactions

An emerging literature on the role of gene-environment interactions as predictors of depression and substance abuse offers a final piece of background that is relevant for framing our study. Both depression and addictive disorders have a large heritable component, with estimates based on twin studies in the range of .4 to .5 as the share of depression and alcohol disorders that are heritable (Sullivan et al. 2000; Caspi et al. 2008). Research has long struggled with understanding how and when genes lead to psychiatric disorders. After a number of unsuccessful attempts to isolate particular genes that "cause" specific illnesses, researchers have instead identified gene environment interactions that likely cause depression and substance use (Heath and Nelson 2002; Kendler, Garnder et al. 2002; Caspi and Moffit 2006).

For example, stressful life events are common predictors of depression, but the presence of symptoms and diagnoses of depression following stressful life events were much more common among individuals exhibiting a particular polymorphism in one region of the serotonin transporter (5-HTT) gene (Caspi and Moffit 2006). Similarly, alcoholism often runs in families, but it is unclear precisely how much of this relates to familial environment compared with genetics. Evidence suggests that highly traumatic events such as sexual abuse as a child, interact with elevated genetic risk of alcoholism to raise the chance that individuals become alcoholics (Heath and Nelson 2002; Kendler, Garnder et al. 2002; Caspi and Moffit 2006). Taken together, this evidence suggests that an attempt to isolate the effect of maternal depression or substance abuse on children

requires rich information about the mother's background. In addition, such evidence suggests that a model of child development of human capital cannot treat all genetic influence as fixed, as a model with child fixed effects might.

Theoretical Considerations

Cunha and colleagues (Cunha, Heckman et al. 2006; Cunha and Heckman 2007) have developed a model that links skills or capability (education, cognitive, emotional and behavioral attributes that underlie economic success) formation in children to parental capabilities and parental investments in child development. The model developed by Cunha et al. (2006) also recognizes that there are multiple stages in child development. The findings from the neuroscience literature (National Research Council and Institute of Medicine 2000) indicate that parental capabilities and investments have different impacts on child development at different stages of development. The model of Cunha et al. (2006) yields several implications. First, cognitive, behavioral, physical and other capabilities are interdependent. That is, cognitive skills obtained today depend on investments in health and emotional development among other factors (possibly made at an earlier point in time). Second, parental capacities to invest in child capabilities are important and have varying impacts at different points in a child's development. Third, past investments affect the impact of current investments in child development.

The empirical work presented in this paper takes these ideas as a point of departure. Consider the skills formation function of Cunha et al. (2006)

(1) $S_{t+1} = F(PS, S_t, I_t; M_t)$

Where S is the level of skill formation, PS is parental skill attributes (education, cognitive abilities, etc.), I is the investment in child capabilities at time t, and M is mother's mental health status at time t. We focus on mother's mental health status because of the mother's central role as a care giver and the existing clinical evidence of a link between mother's mental health and child skills acquisition. We focus on depression and substance abuse because they are relatively common behavioral health problems in women of child bearing age and because they can disrupt care giving. We observe the impact of depression and substance use and abuse on measures of cognitive and behavioral skills formation early in a child's academic career (grades 1-5 and again in grades 6-9). In our conception, maternal depression and substance abuse can affect skill formation in children by reducing the effective level of parent skills (PS) and by reducing the productivity of parental investments in child skills development (I). The literature on the impact of mental disorders on human capital formation shows that mental and substance abuse problems affect productivity, conditioning on human capital attributes (Frank and Koss, 2005).

The empirical implications of these ideas are that models aimed at estimating the impact of depression and substance use and abuse on child development should condition on parental skill levels. Our empirical analysis tries to account for the mother's stock of human capital at the time of the child's early schooling. We then estimate the impact of proximate mental health shocks (maternal depression, substance abuse) on the parents' level and effectiveness of investment in skill acquisition for their children. We adopt an empirical strategy that directly examines the effect of symptoms of maternal depression and substance abuse on indicators of maternal investments in child development,

essentially comparing maternal investments and child outcomes across groups of mothers with and without significant symptoms of depression and/or substance abuse. To strengthen this comparison, we combine the detailed information about the mother's family of origin with early measures of the mother's behavioral health and substance use to match mothers based on their risk of having significant symptoms of depression using propensity score methods (Rosenbaum and Rubin 1983). We condition out mother's measured human capital, family endowments, risk of mental health problems, and other capabilities (Currie and Thomas 1999). This ensures that we are comparing mothers who are similar with respect to observed characteristics that are associated with a high likelihood of depression. Using these methods, we find consistent evidence that symptoms of maternal depression, and to a lesser extent, symptoms of maternal alcohol abuse/dependence have a significant and moderate sized adverse effect on child behavior. These effects are also present in maternal fixed effect models that compare siblings with and without exposure to maternal behavioral health symptoms in primary school.

3. Data and Empirical Strategy

The 1979 National Longitudinal Survey of Youth

We used the 1979 cohort of the NLSY (Bureau of Labor Statistics 2005) to follow a cohort of women and their children through grade nine of the child's schooling. The NLSY conducted in-person interviews with individuals aged 14-22 in 1979, re-interviewing them annually through 1994 and every 2 years since then. Blacks, Hispanics, and economically disadvantaged non-black/non-Hispanic youths were over-sampled. Until 1989, interviews were conducted using pencil and paper before

converting to Computer Assisted Personal Interviews in 1990. About 4,000 women were interviewed over the period from 1979 through 2004. Initial response rates were high, 87 percent, and retention rates were about 90 percent through 1994. In the years since, retention rates have ranged from 77 to 85 percent. The data set contains information on demographics, household structure (both in the household of origin, and in new living arrangements as respondents mature), education, income, cognitive ability, symptoms of depression, substance use and symptoms use and dependence.

Beginning in 1986, the NLSY collected information on all children of interviewed females, through maternal reports, but also from direct assessments of children. For a subset of questions, children age 10 and older were interviewed biennially regarding family, school, and delinquent behavior. For our analyses, we selected all female respondents with a preschool aged child (ages 0-4) in 1986. From this sample of 2,421 unique female NLSY respondents and their 3,333 children, we dropped 1327 children missing one or more cognitive assessments. From the remaining 2006 children, we dropped 116 children due to missing information on key variables such as maternal depression and substance use, abuse, and dependence symptoms. We also dropped 303 children due to missing information on other covariates such as education and income. This left us with a sample of 1587 children of female NLSY respondents. Each mother was interviewed, 18 times, on average (from 1979 through 2004).

Below we describe the behavioral and cognitive variables of interest. Because the longitudinal nature of the NLSY implies some complexity regarding the timing of different measures used, we display the timing of our most important measures, maternal depression and substance use/abuse and child outcome measures in Figures 1 and 2 and

the means of our dependent and independent variables of interest are shown in Tables 1 and 2.

Maternal investments in children – the HOME scales

To understand how maternal depression and problem substance use might influence children, we first examine measures of investments in children made in the home. The NLSY asked detailed questions regarding parental involvement with children using the Home Observation for Measurement of the Environment-Short Form, adapted from the HOME inventory (Caldwell and Bradley 1984). The NLSY public use data set includes two separate summary scales: a cognitive stimulation scale and an emotional stimulation scale. Examples of cognitive stimulation scale questions include, "How many children's books does your child have?" and emotional questions like, "If your child got so angry that he/she hit you, what would you do?" Questions differ based on relevance for the child's age. We used the continuous measures of these scales contained in the NLSY as measures reflecting maternal inputs. Table 1 summarizes the scales we use in analyses of maternal inputs. The total HOMES scale measure averages 985 with a standard deviation of about 150. The cognitive stimulation score has a similar mean and variance. The emotional stimulation score averages about 48, but with a standard deviation close to 30.

Child outcomes

We examine both the cognitive and behavioral outcomes of children. The cognitive outcome measures were scores on the Peabody Individual Achievement Test (PIAT) in Math and Reading Comprehension. We include two PIAT assessments for each child, the first took place when the child was between the ages of 7 and 10, and the

second occurred when the child was between ages 11 and 14. In a separate assessment of child behavior, mothers were asked multiple items regarding child behavior, the Behavior Problem Index (BPI), which was adapted from Achenbach's Child Behavior Check List (Achenbach and Edlebroch 1978; Achenbach and Edlebroch 1979). As with the cognitive measures, we include two measurements of the BPI , assessments between ages 7 and 10, and between ages 11 and 14. In addition, children aged 10 and older answered 9 items related to delinquency which were combined by NLSY staff to form a delinquency scale (see the Appendix for details). For all children, we examine whether the child has ever been suspended or expelled from school at any point during the schooling years.

Table 1 summarizes the child outcomes of interest for the 1587 children in our sample. The cognitive measures are all standardized to have an average near 100 with standard deviations in the range of 12 to 15. The behavior problems indices are similarly standardized, although the variance is modestly higher for these (with standard deviations ranging from 15-17). The delinquency scale is standardized to have a mean of zero with higher numbers indicating increasing delinquent behavior. In this group of children born to relatively young mothers, the average score on the scale is slightly positive, .055. Finally, a sizeable minority of children in our sample, 22.4 percent, have experienced suspension or expulsion from school.

Maternal mental health and substance abuse

The empirical analysis described below, seeks to estimate the separate effects of episodic symptoms of depression on investments in children and on cognitive and behavioral outcomes of children. We chose this focus because there are many successful

psychotherapeutic and pharmacological treatments available for individuals with mild and moderate depression. Similarly, there are many effective treatments available for individuals with substance abuse or dependence. As a result, the variables of interest include maternal symptoms of depression, symptoms of alcohol abuse or dependence, and heavy use of marijuana (which we use as a proxy for substance abuse or dependence).

The NLSY includes several direct and indirect measures of maternal mental health based on interviews with the study participant.[2] As part of our attempt to focus on proximate symptoms of depression that occurred during a child's primary school years, we want to compare women at similar risk for having significant symptoms of depression thus we take account of indicators of early depression in mothers before the child was born. We also did this to account for the most recalcitrant cases of depression that might be less amenable to treatment. In 1980 and 1987, the ten item Rosenberg scale of self-esteem (Rosenberg 1965) was administered to mothers. Although this scale was not designed to measure depression directly, in another data set, the Longitudinal Study of Generations, measures of the Rosenberg and the commonly used 20 item CES-D, or Center for Epidemiological Studies – Depression Scale (Radloff 1977) are quite highly correlated, with a correlation coefficient of .56 to .64.[3] We created our proxy indicator of depression in 1980 using the standard cutoffs for low self esteem, a score below 10 on the 30 point Rosenberg scale. We then used these in our procedure for balancing risk of

[2] In the case of depression and substance abuse or dependence, diagnosis of these disorders relied heavily on self-reported symptoms of the patient.

[3] We verified the correlation among female respondents in the National Longitudinal Survey of Generations (Bengston 1997), a survey of California health maintenance organization enrollees age-matched to the same cohort as the NLSY. In this survey, measures of the CES-D and the Rottenberg scale were significantly ($p<.0001$) positively correlated with ρ ranging from .56 to .64 during years in which both measures were available (1988, 1991, 1994, and 1997).

depression in mother with and without depression during children's primary school years. Our approach is described more fully later in this section.

In 1992, respondents completed the 20 item CES-D, or Center for Epidemiological Studies – Depression Scale (Radloff 1977). Respondents answer questions regarding their mood, energy level, feelings of worth, and related questions. Generally, a score of 16 or higher on a scale from 0 to 60 indicates a cluster of symptoms consistent with a high likelihood of a diagnosis of depression. Respondents also responded to an abbreviated seven item CES-D in 1994[4], and again in the first interview after age 40. Respondents answered a nine item CES-D scale when taking the age 40 assessment in 1998 and later. We coded women as having symptoms of depression if they scored 16 or higher (1992 CES-D) and if they scored more than one standard deviation above the mean on later CES-D scales.[5] For the bulk of our analyses, we categorize a mother as depressed (during a child's schooling years) if she had a CES-D score at or above the cutoff in both 1992 and 1994. We do this to minimize the measurement error natural in population based measures of depressive symptoms. In models that examine within-mother outcomes of multiple children, we use a single measure of depression (1992, 1994, or age 40) closest to the child's 7-10 year old assessment.

Substance use, abuse, and dependence measures

The NLSY asked respondents extensive questions regarding use of alcohol and illicit drugs, and in selected years, respondents were asked to report a wide array of

[4] The seven item CES-D is highly correlated with the 20 item scale (r=.90 according to David Dooley and JoAnn Prause Social costs of underemployment)

[5] The cutoff for depression was 8 on a scale from 0 to 21 on seven item scales, and 9 on a scale from 0 to 27 on 9 item scales.

symptoms associated with alcohol abuse or dependence. To target alcohol use associated with functional impairment, we used questions from the 1985, 1989, and 1994 surveys to code individuals with 2 or more symptoms of alcohol abuse or dependence (See the appendix for a list of the questions used to identify symptoms.) Very few mothers reported use of illicit drugs other than marijuana, so we focused on measures of heavy marijuana use based on the 1984, 1992, and 1998 surveys. Marijuana use was considered heavy for individuals that had used marijuana more than 5 times in the last 30 days (1984), or at least 1-2 times per week in the last 30 days (1992 and 1998). Unlike the NLSY questions on alcohol use, the survey provides no information regarding symptoms related to marijuana use, and heavy use of marijuana in itself does not necessarily imply that mothers were impaired by marijuana use.

Table 2 summarizes the maternal characteristics of interest, the rate of mothers likely to have depression, alcohol abuse/dependence symptoms, and heavy marijuana use; it also summarizes the set of covariates employed in each analysis. As teenagers and young adults, based on Rosenberg scores, the mothers had rates of depression of 18.6 percent. This rate is in line with epidemiological evidence from the National Co-morbidity Study Replication, or NCS (Kessler, Berglund et al. 2005). The NCS collected information on US adults aged 18 to 54. In this study, 11.6 percent of women report any mood disorder in the past year (8.6 percent for depression), and 23.4 percent experienced an anxiety disorder, and over 30 percent are estimated to have a diagnosis of any mental or substance disorder in the course of the year (Kessler, Berglund et al. 2005). Just over 3 percent had symptoms of alcohol abuse and/or dependence, similar to national numbers on the 12 month prevalence of alcohol abuse.

Overview of Empirical Approach

Our analysis of the influence of maternal depression and substance use or abuse on child outcomes faces several common methodological challenges due to potential reverse causation and omitted variables that may be correlated with both measures of interest (maternal depression and substance use and abuse) and the child outcomes. Reverse causation could occur if children who have poor behavior or low cognitive skills cause stress for mothers that might trigger symptoms of depression, alcohol abuse, or lead to heavier use of marijuana. The second potential threat to our analysis is that unobserved variables could influence both maternal behavioral health and child outcomes. For example, if mothers with lower cognitive skills also are at higher risk of poor mental health, and if maternal cognitive skills affect the way in which mothers invest in children, we might erroneously attribute child outcomes to maternal depression when in fact the mother's low cognitive endowment causes both poor mental health and poor child outcomes. We take multiple steps to address these threats to inference.

Addressing the Potential for Reverse Causation

The longitudinal nature of the NLSY helps to ensure that we identify symptoms of depression and/or substance abuse that precede child assessments of behavior and cognitive outcomes. We experimented with alternative specifications regarding the measurement of a mother's mental health and the measurement of child outcomes. In each case, the relationship between maternal depression and child outcomes were as strong in models where depression measures preceded measures of childhood outcomes as they were in models where depression may have been measured at the same time or after child outcomes. For example, most of the child outcomes at age 11 to 14 were a

function of maternal depression measured in 1992 and 1994, before the outcomes were measured (see Figure 2), but these results are equally strong compared with outcomes measured when children were ages 7-10, but using the same depression measure.

One might still worry about reverse causation in the event that the birth of a difficult child launched a series of depressive episodes in the mother. However, we can test the robustness of our findings to such a threat by estimating mother-fixed effect models that examine siblings who were and were not exposed to maternal depression symptoms at the time of age 7 to 10 assessments. Because these observations will necessarily be after the birth of both children, women for whom a difficult child launches repeated or chronic depression would have symptoms throughout the schooling years of all the children we observe in the NLSY, and thus such mothers would be dropped from any mother-fixed effect analysis.

Addressing Omitted Variables

The rich data in the NLSY minimize the potential threat of unobserved variables because we can control for an expansive set of covariates. They will help us address three of the most serious threats to inference a) that maternal ability is correlated with her behavioral health and her inputs to children; b) that the permanent income of the mother's family of origin or her family as an adult makes it difficult to invest in child human capital and also contributes to poor behavioral health; or c) that the genetic endowment of the mother, including her propensity to have poor behavioral health and or her ability to invest in education might affect child-rearing independently of behavioral health problems. The measures included in the NLSY make it possible to better address such threats than does the typical household surveys. For example, for each NLSY

respondent, we have a measure of IQ based on her 1980 percentile on the Armed Forces Qualification Test. We also know details regarding the mother's household of origin during her high school years, so we can control for household structure, a measure of average annual income in the mother's household of origin (measured over the period from 1979-84) and educational attainment of the mother's parents.

A unique feature in the NLSY is that respondents report depression and/or anxiety of their parents, as well as whether a mother or father had problematic drinking behavior. Throughout the paper, we refer to the mother's parents as grandparents, since we are focused on child outcomes. Also, due to the structure of the NLSY sample frame, many mothers have siblings in the NLSY; we have measures of depression and substance use/abuse among siblings too. We use these family measures of parent and sibling behavioral health to control for family-level factors such as genetic predisposition to have behavioral health problems. Such variables help us to control for genetic factors passed on through family members that would not be affected by treatment of behavioral health symptoms. Third, we combine the detailed information about the mother's family of origin with early measures of the mother's behavioral health and substance use to match mothers based on their risk of having significant symptoms of depression using propensity score methods. This ensures that we are comparing mothers who are similar with respect to observed characteristics that are associated with a high likelihood of depression. Finally, as described above, we test the robustness of our main findings among a sample of mothers with more than one child, using fixed effect specifications to measure within-mother differences in child outcomes related to contemporaneous symptoms of depression and/or alcohol abuse. This last approach is similar to the

approach taken in a study of substance use and children (Chatterji and Markowitz 2001) in the NLSY.[6]

Propensity Score Models

We employ propensity score methods to achieve two empirical goals of our analysis. First, we wish to account for the impact of the characteristics of the mother's family of origin, including parental and sibling measures of behavioral health, a measure of income, and the household structure. Also, as mentioned before, to focus on symptoms of depression or substance abuse that are episodic, rather than a chronic and severe mental disorder that is less amenable to treatment, we control for measures of depression, alcohol abuse, and marijuana use of the mother before the child was born. Second, we wish to balance observed characteristics that are predictive of maternal depression to ensure that we are comparing women with similar tendencies to be depressed. Thus, we balance our data so that the women in our sample share common attributes during their youth that are associated with depression (whether or not they actually display symptoms). The advantage of the propensity score weighting approach we describe below (or any propensity score approach) over simple regression-based adjustment is that we will compare those women who, on the basis of observed characteristics, appear very similar. This prevents us from attributing child outcome effects to depression when the distribution of observed characteristics of depressed mothers (those with an indicator for depression based on 1992 and 1994 CESD measures) differs dramatically from that of mothers who are not depressed.

[6] We employ multiple measures of maternal depression symptoms, and we examine alcohol abuse whereas Chatterji and Markowitz (2001) estimate the effect of substance use. Our narrower definition captures women who are impaired by drinking behavior, and we incorporate the effect of maternal depression on primary school outcomes for children.

Using an adaptation of weighting methods initially proposed by Hirano and Imbens (2001), but modified as described in Li, Zaslavsky and Landrum (2007), we use the extensive information available in the NLSY on the mother's youth to predict her likelihood of depression (Hirano and Imbens 2001; Li, Zaslavsky et al. 2007). The propensity score model takes the following form:

(2) $\log[\Pr(\text{DEPRESSED})/(1-\Pr(\text{DEPRESSED})] = \beta_0 + \beta_1 X_{ijYOUTH} + \beta_2 Z_{ijYOUTH}$

where X is a vector of early life characteristics of the mother and Z captures characteristics of the mother's family and household of origin. The X vector of mother's characteristics when she was a youth includes: a measure of depression using the 1980 Rosenberg scale, whether the mother had 2 or more symptoms of alcohol abuse or dependence in 1985, whether the mother used marijuana 6 times or more in the 30 days prior to the 1984 survey, whether the mother was an oldest child, the mother's race and ethnicity, immigrant status, and her 1980-81 AFQT percentile. The Z vector includes: whether the mother reports that either of her parents (the maternal grandparents) had alcohol problems, whether either maternal grandparent had anxiety or depression, whether the maternal grandparents were married in 1979, the mother's mean real family income 1979-1984, the mother's number of siblings in 1979, two indicators for whether the maternal grandmother completed high school or some college, indicators for whether the mother had a sibling NLSY participant who was depressed in 1980, had symptoms of alcohol abuse in 1985, or used marijuana heavily in 1984. We then used the estimated parameters from (1) to construct a propensity score, $\hat{p}_i = \hat{\beta}_1 X_{iYOUTH} + \hat{\beta}_2 Z_{iYOUTH}$. The propensity score formed the basis of person-level weights that balanced the observed characteristics (from equation 1) of depressed and non-depressed mothers, giving more weight to the overlapping portion of the distribution of

propensity scores. Specifically $\omega_i = \hat{p}_i$, if the mother was not depressed in 1992 and 1994, and $\omega_i = 1 - \hat{p}_i$, if the mother was depressed in 1992 and 1994. This propensity score weighting approach, described briefly in Li, Zaslavsky, and Landrum (2007), like more commonly discussed inverse probability weighting techniques (Hirano & Imbens, 2001), balances observed characteristics across treatment and control groups. However, in this case, characteristics are balanced to resemble those among overlapping portions of the treatment and control distributions of observed characteristics. This adapted technique obtains average treatment effects, over the distribution of covariates in the population where the treatment and control groups overlap, as opposed to the entire population. This approach also minimizes the variance of our estimates, which can be excessively large in inverse probability weighting techniques when individuals have a very low propensity score. By construction, this propensity score weighting technique forces the distribution of observed characteristics in the propensity model to be identical across the two groups.[7] All estimates in the paper weight each observation with the propensity-score-based weight.

Table 2 displays a summary of variables used to predict maternal depression in the propensity score models. One surprising statistic is the high rate of problem drinking women report among their parents, 20 percent. This measure is admittedly crude, but we would expect it to be considerably higher than the mother's own alcohol abuse or dependence both because of the measure (which likely includes drinking that does not cause functional impairment) and because this variable reflects the perceived drinking behavior of both parents, rather than a single individual. In fact, this number is close to

[7] For an application in health services research, see McWilliams et al. (2003).

national estimates of the share of adults reporting that they lived with an alcoholic parent any time before age 18. In a topical supplement to the 1988 National Health Interview Survey, 18.6 percent of the adult, non-institutionalized population (19.6 percent of females) reported that they lived with an alcoholic parent during their childhood (Schoenborn 1991). In contrast, mothers report very low rates of anxiety and/or depression among their parents, less than 4 percent, in contrast to national estimates which are substantially higher.[8] To address the potential for under-reporting of depression and anxiety and possible over-reporting of problem drinking, where available, we used sibling reports to increase the specificity of problem drinking questions and to increase the sensitivity of questions regarding anxiety and depression among maternal grandparents.

A second factor that may seem surprising at first is the difference between sibling rates of depression (based on the 1980 Rosenberg scale) compared to mothers, and the differences between mothers and siblings on measures of alcohol abuse/dependence and marijuana use. Note that mother's siblings may include both male and female siblings. These numbers in fact line up well with estimates of the differential prevalence of depression and substance use disorders by sex. Women are nearly twice as likely to report depression symptoms than men. In contrast, women are only one half to one third as likely to report symptoms of alcohol abuse or dependence (Kessler et al. 2005).

Outcome models

[8] Given epidemiological evidence on rates of depression (over 6%) and anxiety (18%) in the adult population, these adult children clearly are not aware of symptoms their parents may have experienced. This is consistent with anecdotal evidence suggesting that even significant life struggles, such as those overcome by immigrants to the U.S., are not shared with children (Kirk Semple, "Family Stories as Secret Text for Immigrants," The New York Times, March 16, 2009, p. A16).

To examine how maternal depression and substance use/abuse affect children, we estimate models of both maternal inputs (the HOMES scales) and continuous child outcomes. We estimate models of the following form:

(3) $$Y_i = \alpha + \beta_1 * DEPRESSED + \beta_2 * ALCOHOL + \beta_3 * MARIJUANA + \delta_k + \Gamma X_i$$

Where the measures of depression, symptoms of alcohol abuse or dependence, and heavy marijuana use are the main variables of interest, and are coded as described above. The model includes a set of age dummies to reflect the age of the child at the time the outcome Y was measured in relation to a reference age, the modal age at which an assessment occurred. This is important because child cognitive and behavior scores vary widely with the age of the child. The vector X includes individual characteristics of the child, the child's mother, and the household at the time the outcome was measured. These variables (defined in table 2) include: child sex, whether child is the oldest, number of child's siblings, whether the child was born to a teenage mother, mother's marital status, mother's years of education, and a measure of permanent income (average annual household income 1986-2004). Table 2 clearly demonstrates that the mothers in this sample are atypical, because they are younger, on average, than all mothers (related to our desire to follow child outcomes over a long period of time which required following a sample of young mothers), and due to the oversampling of disadvantaged populations in the NLSY. One third of the mothers are black, just over one fifth are white, and the remaining mothers are Hispanic in origin (of any race). The mothers average just over 12 years of education (at the time of the child assessments), and about 60 percent of mothers were married at the time that child assessments occurred. Finally, the mothers fall relatively low in the distribution of AFQT scores. These characteristics may affect how

one generalizes results, but they are of interest because currently in the U.S., disadvantaged Hispanic and black women are disproportionately represented among mothers due to higher fertility rates.

In addition to the OLS models described earlier, we have one binary outcome for children, suspension/expulsion from school at any point during the schooling years. We estimate logit models of the same variables in (2), but the dependent variable is a dichotomous indicator of ever being expelled or suspended. For all of the models above, we re-estimated (2) adding in the covariates from the propensity score model in (2) to verify that our results would be doubly robust to errors that could arise from any misspecification in the propensity score model. Variance estimates may be reduced by the addition of the covariates from the propensity score model to outcome models as in 2. In our case, the estimates of parameters on maternal depression, alcohol abuse, and marijuana use were very similar, so for parsimony, we present only estimates with the covariates described for equation (3).

Because we balance depressed and non-depressed mothers based on an extensive set of early life characteristics, including behavioral health of mother and her family members, we interpret the estimated β coefficients as the effect of proximate symptoms of depression, alcohol abuse, and heavy marijuana use on maternal inputs and child outcomes. By specifying the model in this way, we hope to isolate symptoms of depression, for example, that are most amenable to treatment. We also aim to obtain evidence on the nature of the mechanism linking depression and substance abuse to child human capital formation by studying how these factors relate to maternal emotional and cognitive inputs.

4. Main Results

Maternal Inputs:

Table 3 displays results for our first set of outcome models, those estimating how maternal emotional and cognitive stimulation varies with maternal depression and maternal substance use or abuse. Two patterns emerge from this table. First, maternal depression is estimated to have a significant influence on the supply of maternal emotional stimulation measures to school aged children in both primary and middle school years. The emotional stimulation sub-component of the HOMES falls by about 6 points (or one fifth of a standard deviation) if a mother has symptoms of depression. Second, the magnitude of this adverse effect of depression is large, especially if one compares it to the magnitude of other indicators that we think are likely to be important, like household income. For example, the 6 point drop in the emotional sub-scale is larger than the drop that occurs with an increase of one in the log of household income. Third, the effect of maternal depression on the emotional stimulation scale does not hold for the cognitive stimulation scale. Recall that the cognitive scale averages over 990, with a standard deviation of nearly 150. Thus, the statistically insignificant 7 point drop in the cognitive stimulation scale for mothers who are likely to be depressed versus those that aren't depressed is small. Finally, the table reveals a similar lack of influence of symptoms of alcohol abuse or dependence among mothers on the cognitive stimulation provided by mothers. In contrast, symptoms of alcohol abuse and/or dependence have moderately large, and statistically significant, effects on the emotional stimulation subscale measured when children were age 11 to 14. Together, our results imply that behavioral health symptoms among mothers may have moderate effects on inputs that

influence a child's emotional development and behavior, but have few measureable effects on our measure of mother's cognitive input.

Table 4 shows models of child math and reading comprehension scores on the PIAT. The main message from these models is that maternal depression (after controlling for early life circumstances of the mother) has little or no measureable effect on cognitive outcomes for their children. For young adolescents, age 11 to 14, having a mother with symptoms of alcohol abuse is estimated to lower math test scores. Finally, there is no discernable effect of contemporaneous maternal marijuana use on cognitive outcomes among children.

Table 5 reports the results for similar models of child behavior outcomes. Strikingly, scores on the BPI are 7 points higher (indicating more behavior problems) among children with mothers who are depressed. These results are consistent with the decrement to emotional stimulation among these depressed mothers based on the HOMES scale. As in the earlier results on emotional stimulation, these effects are sizeable, especially in comparison to other measures such as household income. However, it is difficult to link maternal depression to either delinquency of 10-14 year olds, or suspension/expulsion, since these parameter estimates are small and not precisely estimated. The estimated effects of maternal alcohol abuse on child behavior are mixed. For younger children, alcohol abuse is associated with worse (higher) BPI measures. For older children, this is not the case. Surprisingly, children with mothers who have symptoms of alcohol abuse are significantly less likely to be suspended or expelled. The mechanism for this is unclear, although the literature on children of alcoholics suggests that some children respond to parental alcoholism by acting as parents and becoming

overachievers during school years, rather behaving less responsibly (American Academy of Child & Adolescent Psychiatry 2002).[9] Another surprising effect is that children of mothers who are heavy marijuana users tend to engage in less delinquent behavior than other children. In the case of marijuana, this may reflect our relatively crude measure of use since use does not necessarily coincide with any functional impairment.

5. Factor Models

As described earlier we examine several indicators of cognitive development (PIAT reading and math scores) and several behavioral measures (BPI, reports of suspension/expulsion, delinquency). Because few studies have assessed more moderate effects of depression and substance use on cognitive and behavioral outcomes during the school years, there is little guidance to indicate which behavioral measure or which cognitive measure might be most important among children who have mothers with behavioral health problems. Also, given the large number of outcomes we examine, we want to reduce the dimensionality of our analysis to avoid problems of multiple comparisons (the notion that with many outcomes, our variables of interest will randomly predict our outcomes of interest with significance in at least some cases). Because these measures seek in part to measure fundamental phenomena related to cognitive development, learning, and social and emotional development, we develop summary measures of cognitive development and behavior. This approach has the added advantage of allowing us to combine very concrete measures, such as suspension/expulsion and the delinquency scale, with more impressionistic indicators such as the BPI that might be influenced by symptoms of depression in mothers.

[9] Such children do not escape negative consequences of growing up with alcoholics, however, as they remain at elevated risk for alcoholism later in life, and they suffer from other behavioral health issues.

We create our factor measures by estimating a factor model. A factor that combines our multiple outcome measures will increase the variation available compared with any single measure. Also, because the factor analysis will use only information that pertains to a single concept, the underlying factor in the analysis, to the extent that this factor reflects cognitive or behavioral outcomes, the factor analysis will increase the signal to noise ratio compared to the signal from any one measure alone. Thus, we expect that the use of factors will increase our statistical power to estimate the effect of depressive symptoms and substance abuse on child cognitive and behavioral outcomes. Our approach follows previous work (Fryer, Heaton et al. 2006). We estimate these models in two steps. First, we conduct the factor analysis from which we construct our cognitive and behavior outcome measures. We follow Fryer et al. (2006) and focus on a single factor with the greatest explanatory power if it explains more than 50% of the variance in the proxy measures. In these data, the cognitive factor accounts for over 67% of the variation in the proxies, while the behavioral factor accounts for 53% of the variation in those proxies (see Table 6).

Results of Factor Analyses

Table 6 displays results of the factor analysis. It shows that, as we suspected, the cognitive measures capture related constructs and they contribute relatively equal weights to the first factor. Similarly, the behavioral measures contribute comparable weight to the underlying behavior factor. As noted earlier, the first factor accounts for more than half the variation in both sets of proxy variables.

Table 7 displays the results of analyses using our constructed behavior and cognitive indices as the outcomes of interest. This table confirms the results of the earlier

analyses. Maternal depression has relatively little effect on cognitive outcomes among children in primary and middle school years. In contrast, it has a moderately large negative effect on child behavior (about one third of a standard deviation). Heavy marijuana use by mothers is estimated to have a negative effect on the cognitive score that is significantly different from zero at conventional levels. Surprisingly maternal alcohol abuse and dependence is estimated to have a positive and significant effect on the cognitive factor for the 7-11 year olds. This puzzling result is stable to changes in specification.

6. Fixed Effect Models

Our preferred models are those presented in tables 3 through 6 because they allow us to capture the influence of contemporaneous maternal behavioral health at different points in time for children in primary and middle school years. We deliberately chose not to look "within child" at the effect of maternal depression because depression might matter differently for children at different ages and we did not want to assume that the effect of behavioral health problems should be the same at different ages. However, most women in our sample have more than one child, allowing us to examine the impact of maternal behavioral health for different children, measured at similar ages. Thus, for an expanded sample of NLSY women with multiple children (not just the mothers of our 1587), we estimated age 7-10 outcomes as a function of maternal depression symptoms, controlling for mother-specific fixed effects. With the inclusion of fixed effects, it was no longer necessary to use the propensity score weighting. However, we did control for the time varying covariates used in the rest of our child outcome models. The results of

these within mother models for 2653 women with 2 or more children are shown in Table 9.

As in our previous results, maternal depression seems to be exerting the most important effect on child behavior measures but not for child cognitive measures. The BPI is 3.3 points higher for children who are assessed during a period shortly before, during, or after an interview in which the mother had symptoms of depression according to her responses on the CESD. Given that the measures of depression do not necessarily match up to child assessments as well as in the earlier models, and considering the variation absorbed by the maternal fixed effects, we view this result as strong confirmation of our main finding, that maternal depression interferes with child behavior.[10] Our results from the HOMES scales suggest that this negative influence of maternal depression operates mainly through decrements in emotional stimulation at home, rather than through lowered opportunities for cognitive stimulation.

7. Conclusions and Implications

The analysis reported here shows that symptoms consistent with a high likelihood of depression in mothers of young school age children interfere with measures of social and emotional development. This result is robust to a variety of empirical specifications. We uncover evidence suggesting that the mechanism through which depression affects the social and emotional development of grammar school aged children is through the disruption of parenting activity that manages anger, misbehavior and other emotions of

[10] We also estimated models of behavior using sub-scale for internalizing mental health problems (anxiety and depression) and externalizing behavior (conduct disorder). The results indicate that a high likelihood maternal depression affects both types of behavior problems. Detailed results are available from the authors upon request.

young children. At the same time we do not find any evidence that maternal depression has a meaningful effect on measures of cognitive development (reading and math).

To put the magnitude of the effects in context we use the parameter estimates from our models of the BPI for young children (7-11) to consider the increase in household income that would compensate for the impact of maternal depression. We estimate that an increase in household income of about $63,000, assessed at the sample mean, would produce an increase in BPI sufficient of offset the impact of mother's depression.

The results for indicators of maternal alcohol abuse and dependence are somewhat mixed. We find some evidence that alcohol abuse/dependence affects both cognitive and social and emotional development. The estimates are less consistent across models than were those for depression. We did find evidence suggesting that alcohol abuse/dependence indicators interfere with mother's activities aimed at emotional support. We are therefore more tentative in our view about the impacts of mother's substance abuse on human capital formation in young children. More investigation of the mechanism and the impact on outcome of substance abuse problems in mothers is warranted.

Heckman and coauthors have produced evidence showing the importance of investment in the social and emotional development of children to economic successes later in life (Heckman, Stixrud et al. 2006). Our results highlight the role of maternal behavioral health as an input into the social and emotional development of young children. Specifically, we find that maternal depression can be especially disruptive of child social and emotional development

There are a number of effective strategies for the treatment of depression. They can include psychotherapies, antidepressant medications and combinations of these inputs. A number of these approaches have been tested on low income mothers of young children and have been found to be highly effective (Miranda, Chung et al. 2003). This means that recognizing and treating depression in mother's of young children may constitute an effective investment in human capital formation. Given the modest costs of treating most cases of depression ($1200-$2000), and the potentially significant and lasting effects that interruptions in social and emotional development can have of human capital formation, greater attention to screening and treatment of at risk women (e.g. Head Start mothers) with young children may be warranted.

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APPENDIX

Table A1 displays the questions used to construct an indicator variable for maternal alcohol abuse or dependence. The variable was equal to one if the mother had two or more of the following symptoms.

Appendix table A1: Common Questions in both the 1989 and 1994 NLSY surveys – used to construct measure of symptoms of alcohol abuse or dependence

1. Continued to drink alcohol although threat to health
2. Cut down on activities with friends in order to drink
3. Drinking could have caused someone else to be injured
4. Drinking has hurt chances for job promotion
5. Drove a care after having too much to drink
6. Ended up drinking much more than intended to
7. Found it difficult to stop drinking once started
8. Frequency got into physical fights during/after drinking
9. Hangover interfered with things supposed to be doing
10. Heard/seen things not really there after drinking
11. Kept drinking although caused emotional problems
12. Kept drinking although caused problems at home/work
13. Lost ties to family member/friend because of drinking
14. Need to drink more to get same effect
15. Drank for longer period of time than intended to
16. Heavy sweating/shaking after drinking/morning after
17. Same amount of alcohol having less effect than before
18. Taking a drink to stop shaking after drinking
19. Sick or vomited after drinking or the morning after
20. Spent a lot of time drinking or getting over effects
21. Spouse/someone else threatened to leave due to drinking
22. Stayed away from work/gone to work late because drinking
23. Tried to stop drinking but could not do it

In 1985, there were fewer questions regarding symptoms of alcohol abuse. Table A2 displays the six questions we used to construct symptoms of alcohol abuse or dependence.

Table A2: Questions in the 1985 NLSY surveys used to construct 1985 measure of symptoms of alcohol abuse or dependence

1. Once you started drinking, was it difficult for you to stop before you became completely intoxicated?
2. During the past year have you often taken a drink the first thing when you got up in the morning?
3. Have you stayed away from work because of a hangover?
4. Has drinking hurt your chances for promotion or raises or a better job?
5. During the past year have you gotten into a fight while drinking?
6. Once you started drinking, was it difficult for you to stop before you became completely intoxicated.

Delinquency scale (used for children aged 10 to 14)

Below are the nine questions asked to create the delinquency scale for children aged 10 to 14. Children aged 10 and older were asked, Have you ever:

1. stayed out later than your parents said;
2. hurt someone bad enough to need a doctor;
3. lied to parents about something important;
4. taken something without paying for it;
5. damaged school property on purpose;
6. gotten drunk;
7. did wrong at school so that parent had to come pick them up;
8. skipped a day of school without permission;
9. stayed out one night without permission;

Table A3 below displays the regression coefficients from the propensity score model predicting mother's depression in 1992 and 1994

Table A3: Regressions Predicting Maternal Depression, 1992 & 1994	**Coefficient (SE)**
Depression & SA	
Poor Mental Health 1980 (Rosenberg Score<10)	0.161 (0.264)
Alcohol Abuse/Dependence[1] 1985	0.53 (0.504)
Heavy Marijuana Smoker[2] 1984	0.002 (0.560)
Mother's Sibling Depression & SA	
Poor Mental Health 1980 (Rosenberg Score<10)	-0.617 (0.328)
Alcohol Abuse/Dependence[1] 1985	0.009 (0.341)
Heavy Marijuana Smoker[2] 1984	-0.506 (0.312)
Maternal Grandparent Depression/Anxiety & Alcohol	
Maternal grandparent had anxiety or depression Dx	0.564* (0.241)
One or both of mother's parents had problems with alcohol	-1.393 (0.932)
AFQT percentile score (1980)	-0.031** (0.005)
Log of Mean household income 1979-1984	0.092 (0.063)
Maternal Grandmother Education	
High school graduate	-0.685* (0.275)
Some college	-0.307 (0.469)
Parents married at baseline interview (1979)	0.174 (0.222)
# of siblings (1979)	-0.016 (0.042)
Mother is Oldest child	-0.027

	(0.277)
Mother's Race-Ethnicity	
African-American	-0.134
	(0.253)
Hispanic	-0.110
	(0.275)
Mother is Foreign Born	-0.741
	(0.560)
Constant	-1.842**
	(0.711)
Number of Observations	1,587

Note: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$; Regressions estimated using logistic models; All observations weighted based on 1979 sample weight.

Figure 1: Timeline of Mother's Early Life Measures of Depression, Marijuana, and Symptoms of Alcohol Abuse/Dependence

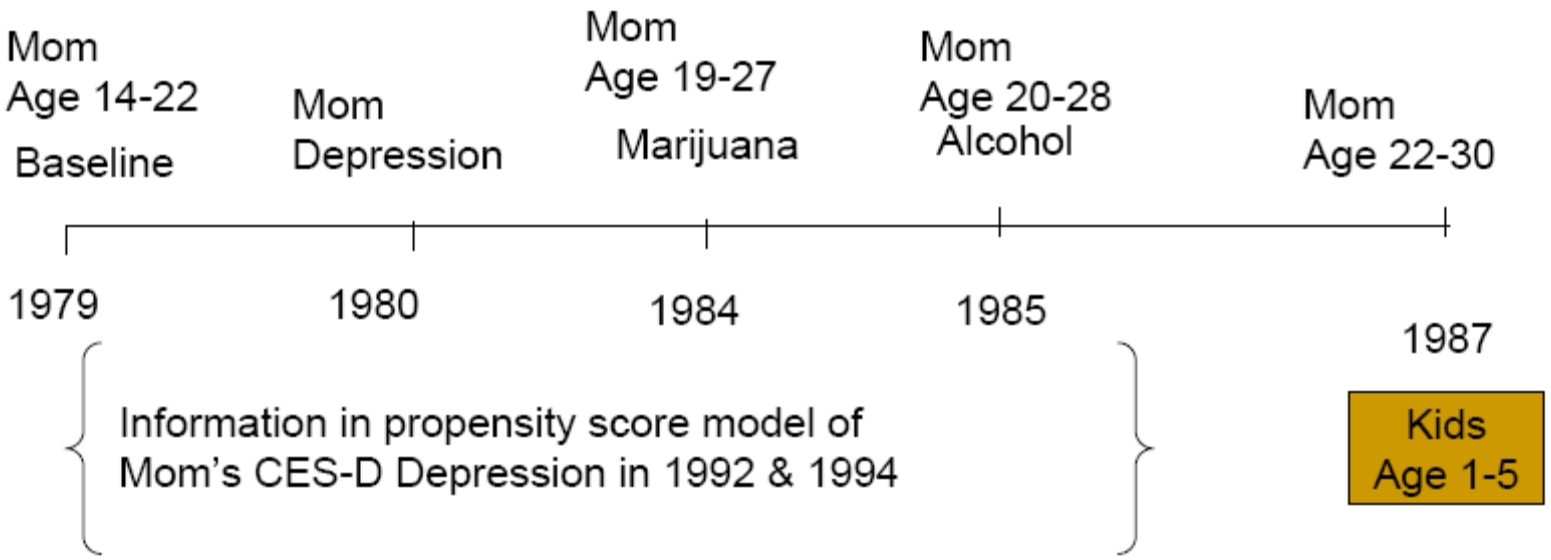

Figure 2: Timeline of Child Outcome Measures and Maternal Measures of Depression, Marijuana, and Symptoms of Alcohol Abuse/Dependence for Child Outcome Models

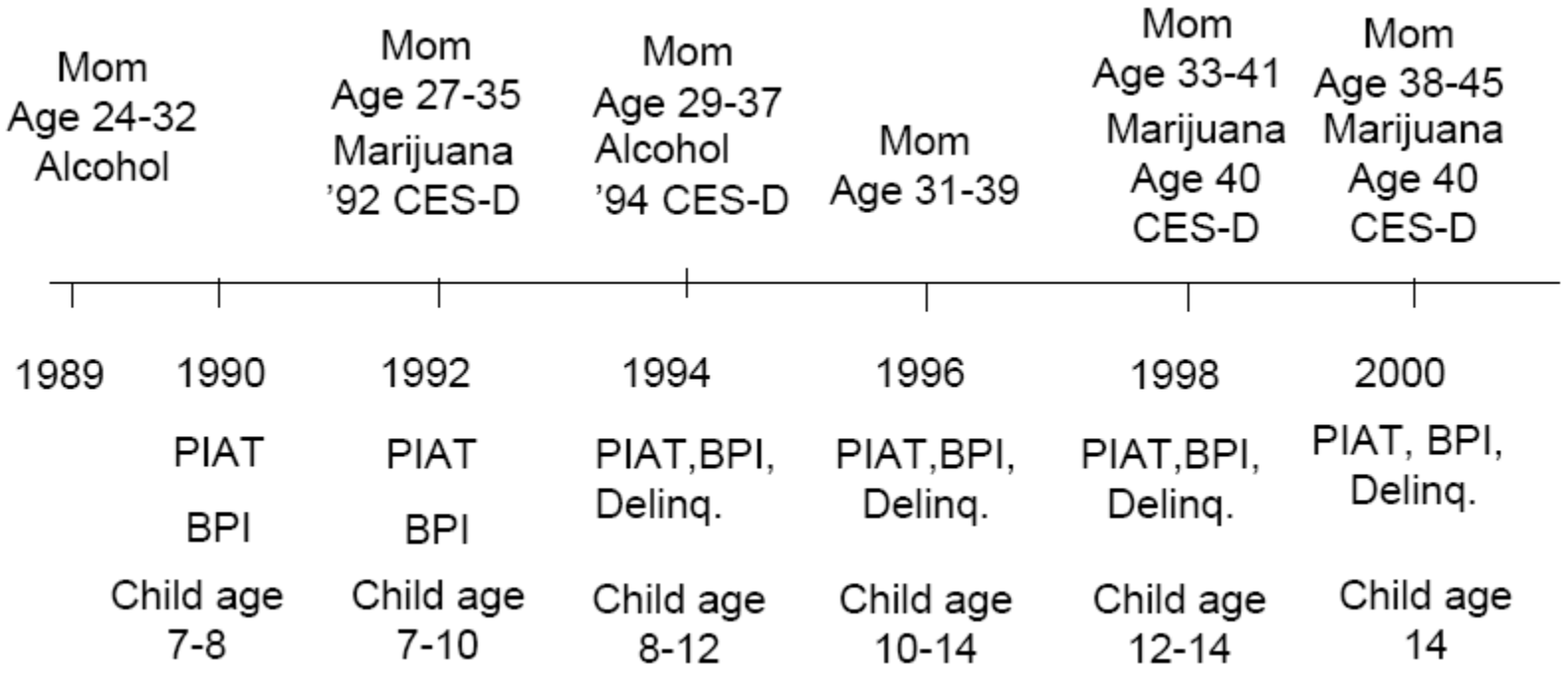

Table 1. Child Outcomes for 1587 Children of NLSY79 women		
	Age 7-10	Age 11-14
	Mean (SD)	Mean (SD)
COGNITIVE		
Piat Math Standardized Score	99.74 (12.79)	99.15 (13.85)
Piat Reading Standardized Score	102.1 (13.89)	96.35 (13.45)
Cognitive factor score		0.037 (1.012)
BEHAVIOR		
Behavior Problems Index Total	106.8 (14.93)	107.64 (15.22)
Internalizing behavior subscale	--	103.63 (17.50)
Externalizing behavior subscale	--	105.88 (16.39)
Anxiety/Depression subscale	104.1 (13.12)	105.4 (12.95)
Child Delinquency Scale Standardized	--	0.055 (0.643)
Behavior factor score	--	-0.023 (1.006)
Ever Suspended or Expelled (all ages)		22.37%
INTERMEDIATE OUTCOMES – Measures of Maternal Involvement		
Cognitive stimulation score	991.5 (148.3)	990.7 (149.1)
Emotional stimulation score	48.91 (29.43)	48.38 (30.02)
Total stimulation score	985.3 (147.3)	984.3 (151.7)
Mother reads to child 3+ times per week (age 7-10)	49.45%	

Table 2. Characteristics of 1587 NLSY79 Women & Their Families	
Characteristics of mother & her family at baseline	**% or Mean (SD)**
Grandparent Alcoholic	21.36
Grandparent Anxiety/Depression	4.158
Mother Depressed 1980 (Rosenberg scale)	18.65
Mother's Sibling Depressed 1980 (Rosenberg scale)	14.85
Mother Symptoms of Alcohol Abuse/Dependence 1985	3.019
Mother's Sibling Symptoms of Alcohol Abuse/Dependence 1985	7.763
Mother Heavy Marijuana User 1984	4.806
Mother's Sibling Heavy Marijuana User 1984	9.452
Mother Oldest Child	20.16
Maternal Grandmother Education	
Did not graduate from high school	54.95
High school graduate	35.17
At least some college	9.890
Mother's Parents Married 1979	64.27
Mother's Mean Real Family Income 1979-1984 (in 2006 $)	34,521 (22,884)
Mother Mean Number of Siblings 1979	4.395 (2.804)
Race-Ethnicity	
Black	32.88
Hispanic	22.18
White	45.05
AFQT Percentile 1980-1981	34.71 (26.97)
Covariates in models of child outcomes	%
Gender of child	
Male	47.57
Female	52.36

Table 2, ctd.

Oldest Child	44.23
# of Siblings	1.82
Teen Mother	9.10
Mother Marital Status when child took ages 7-10 tests	
Never married	13.86
Married	61.06
Divorced, Separated or Widowed	24.95
Mother Marital Status when child took age 11-14 tests	
Never married	11.97
Married	59.86
Divorced, Separated or Widowed	28.05
Mother Immigrant	6.11
Mother Poor Mental health 1992 and 1994 (CES-D score of 16+)	11.34
Mother Heavy Marijuana Smoker	
1992	4.10
1998	2.46
Mother Symptoms of Alcohol Abuse/Dependence	
1989	9.64
1994	11.03
Mother Years of Education at Child's Age 7-10 Test	12.35 (1.66)
Mother Years of Education at Child's Age 11-14 Test	12.55 (2.02)
Average Annual Household Income 1986-2004 ($2006)	48,833 (43,145)

Table 3: Regressions of the Impact of Maternal Mental Health on home cognitive and emotional stimulation – weighted on 1992/94 depression

	Home Stimulation Emotional Sub-Scale Score		Home Stimulation Cognitive Sub-Scale Score		Mom Reads to Child 3x/week
	Age 7-10	**Age 11-14**	**Age 7-10**	**Age 11-14**	**Age 7-10**
Mother's Depression & SA					
Mother Depressed 1992 & 1994	-6.136**	-5.472**	-2.888	-7.274	-0.082
	(2.432)	(2.558)	(13.15)	(12.99)	(0.236)
Alcohol Abuse/Dependence[1]	1.572	-7.012**	-7.583	-11.66	0.126
	(3.929)	(3.568)	(20.26)	(18.16)	(0.361)
Heavy Marijuana Smoker[2]	-3.015	-1.390	-42.584	14.236	-0.613
	(6.310)	(4.871)	(37.736)	(47.051)	(0.614)
Age at test (reference = 8/14)					
7/11	24.60**	13.57**	17.61	6.969	2.172
	(10.80)	(6.846)	(113.4)	(37.86)	(1.497)
9/12	13.89	0.122	-7.500	-61.820**	0.129
	(8.960)	(5.419)	(92.13)	(31.02)	(1.067)
10/13	19.00**	3.739	-29.34	-13.02	-0.301
	(9.036)	(5.477)	(91.98)	(30.50)	(1.071)
Region (reference=North East)					
North Central	5.789	1.851	6.604	3.012	-0.008
	(3.931)	(4.797)	(22.10)	(25.75)	(0.370)
South	1.502	-4.246	-8.222	-33.81	0.323
	(3.666)	(4.303)	(20.48)	(24.87)	(0.336)
West	3.886	3.774	-40.53*	-39.59	-0.015
	(3.842)	(4.545)	(23.19)	(26.55)	(0.380)
# of Adults in Household (reference=1)					
2	15.284***	2.692	24.79	-6.107	-0.175
	(3.278)	(2.615)	(19.71)	(17.80)	(0.318)
3 or more	1.850	1.762	3.902	6.658	-1.142***
	(3.946)	(4.161)	(30.39)	(22.45)	(0.429)
Child is female	4.604**	-0.926	34.08***	45.91***	-0.056
	-2.214	-2.32	-12.75	-12.777	-0.213
Oldest child	1.578	3.322	47.56***	32.75**	0.926***
	-2.402	-2.368	-13.56	-14.69	(0.224)
# of siblings	-2.255***	-1.776**	-5.785	-9.024*	0.145*

	-0.781	-0.791	-4.761	-5.591	-0.088
Ln (Annual Household Income)	3.981**	4.889**	61.94***	58.25***	0.167
	(1.921)	(2.257)	(10.67)	(11.864)	(0.192)
Mother's education (yrs) at time of assessment	-1.043	-1.645**	8.779**	13.70***	0.082
	(0.740)	(0.828)	(3.61)	(4.125)	(0.075)
Mother was a teenage mother	-0.590	-1.152	5.793	11.69	-0.159
	(3.571)	(4.594)	(23.35)	(21.80)	(0.340)
Mother's Marital Status at test (reference=never married)					
Married	11.013**	20.067***	26.57	2.347	0.116
	(4.335)	(4.156)	(24.93)	(23.18)	(0.385)
Divorced , Separated, Widowed, Other	-6.162	-1.494	13.62	-19.76	0.021
	(4.167)	(3.457)	(25.16)	(21.678)	(0.371)
Constant	-19.12	4.621	146.2	178.6	-4.104
	(20.12)	(21.61)	(141.2)	(128.8)	(2.162)
R^2	0.325	0.284	0.248	0.266	

note: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$; Regressions 1-4 are estimated using OLS regression 5 is estimated with logistic regression;

[1] 1989 for age 7-10 outcomes and 1994 for age 11-14 outcomes; [2] 1992 for age 7-10 outcomes and 1998 for age 11-14 outcomes. All observations weighted based on propensity scores from models of maternal depression in 1992 and 1994.

Table 4: Regressions of the Impact of Maternal Mental Health and Substance Use/Abuse on Individual Cognitive Outcomes – weighted on depression

	PIAT Math Scores		PIAT Reading Scores	
	Age 7-10	**Age 11-14**	**Age 7-10**	**Age 11-14**
Mother's Depression & SA				
Mother Depressed 1992 & 1994	-0.186	0.715	-0.074	0.870
	(0.960)	(1.028)	(1.053)	(0.979)
Alcohol Abuse/Dependence[1]	-0.580	-4.359***	0.090	-0.417
	(1.606)	(1.407)	(1.827)	(1.376)
Heavy Marijuana Smoker[2]	2.939	1.668	1.386	-0.475
	(1.931)	(2.616)	(2.105)	(2.781)
Age at test (reference = 8/14)				
7/11	6.510**	-0.725	0.512	-1.449
	(3.150)	(2.674)	(2.259)	(2.060)
9/12	-1.064	2.948*	-3.603***	1.676
	(0.953)	(1.778)	(1.080)	(2.064)
10/13	4.582	0.155	-6.002**	0.269
	(3.087)	(1.007)	(2.678)	(0.993)
Region (reference=North East)				
North Central	0.293	3.139*	0.798	-0.131
	(1.732)	(1.929)	(1.956)	(1.949)
South	-3.212**	-1.369	-4.607***	-4.068**
	(1.528)	(1.657)	(1.710)	(1.673)
West	-3.789**	-0.993	-4.238**	-2.727
	(1.685)	(1.809)	(1.987)	(1.732)
# of Adults in Household (reference=1)				
2	1.062	-1.689	0.646	-0.216
	(1.514)	(1.108)	(1.475)	(1.048)
3 or more	-2.686	-0.742	-2.108	0.114
	(1.903)	(1.370)	(2.179)	(1.483)
# of siblings	-0.747**	-1.051**	-1.097***	-0.837**
	(0.367)	(0.408)	(0.409)	(0.388)
Child is female	-0.334	-2.470**	1.400	-0.489
	(0.945)	(0.972)	(1.046)	(0.929)
Oldest child	-0.076	0.134	1.453	1.822
	(1.157)	(1.201)	(1.202)	(1.152)
Ln (Mean Household Income)	4.079***	4.166***	5.608***	4.558***
	(0.987)	(1.097)	(1.086)	(0.963)
Mother's education (yrs) at time of test	1.203***	0.632**	0.817***	0.805***

	(0.251)	(0.314)	(0.296)	(0.244)
Mother was a teenage mother	0.729	2.291	0.921	2.345
	(1.353)	(1.646)	(1.611)	(1.527)
Mother's Marital Status at time of test (reference=never married)				
Married	0.371	4.428***	0.943	5.057***
	(1.732)	(1.679)	(1.832)	(1.665)
Divorced , Separated, Widowed, Other	3.433**	2.285	3.394**	4.175***
	(1.476)	(1.453)	(1.484)	(1.385)
Constant	37.68 ***	49.23	-0.074	36.43
	(9.334)	(10.20)	(1.053)	(9.426)
R^2	0.178	.186	0.225	0.219

note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; Regressions are estimated using OLS; All observations weighted based on propensity scores from models of maternal depression in 1992 and 1994.

[1] 1989 for age 8 outcomes and 1994 for age 14 outcomes; [2] 1992 for age 8 outcomes and 1998 for age 14 outcomes

Table 5: Regressions of the Impact of Maternal Mental Health and Substance Use/Abuse on Individual Behavioral Outcomes – weighted on 1992/94 depression

	Behavior Problems Index Total Score		Delinq. Scale	Ever suspended or expelled
	Age 7-10	**Age 11-14**	**Age 11-14**	**Any age**
Mother's Depression & SA				
Mother Depressed 1992 & 1994	6.816***	7.106***	0.008	0.029
	(1.150)	(1.190)	(0.053)	(0.199)
Alcohol Abuse/Dependence[1]	4.259**	-0.229	0.092	-0.843**
	(1.968)	(2.085)	(0.083)	(0.327)
Heavy Marijuana Smoker[2]	1.634	1.319	-0.176*	0.700
	(2.669)	(3.332)	(0.096)	(0.605)
Age at test (reference = 8/14)				
7/11	-0.342	0.034	-0.029	-0.177
	(4.231)	(2.164)	(0.163)	(0.550)
9/12	-0.001	-1.924	-0.150*	-0.536
	(1.170)	(2.321)	(0.078)	(0.402)
10/13	-7.75***	-0.320	-0.097*	-0.338
	(2.609)	(1.353)	(0.059)	(0.220)
Region (reference=North East)				
North Central	2.752	-0.569	-0.003	0.209
	(2.017)	(1.895)	(0.109)	(0.397)
South	0.502	-2.776	-0.082	0.231
	(1.728)	(1.750)	(0.103)	(0.372)
West	0.851	-1.730	-0.082	0.182
	(1.850)	(1.976)	(0.099)	(0.416)
# of Adults in Household (reference=1)				
2	-0.499	-0.025	0.109*	0.325
	(1.523)	(1.514)	(0.062)	(0.238)
3 or more	0.986	4.010*	-0.019	0.885***
	(2.355)	(2.144)	(0.085)	(0.333)
# of siblings	-0.751	-0.953*	0.016	0.070
	(0.514)	(0.527)	(0.024)	(0.070)
Child is female	-3.363***	-2.150*	-0.120**	-0.577***
	(1.113)	(1.198)	(0.054)	(0.205)
Oldest child	1.871	0.533	-0.164***	0.159

	(1.349)	(1.335)	(0.060)	(0.229)
Ln (Annual Household Income)	-4.887***	-5.983***	-0.021	-0.976***
	(1.067)	(1.025)	(0.052)	(0.178)
Mother's education (yrs) at time of assessment	-0.597	0.249	-0.022	0.104**
	(0.315)	(0.330)	(0.016)	(0.051)
Mother was a teenage mother	-2.386	0.730	0.062	0.401
	(1.992)	(2.153)	(0.105)	(0.286)
Mother's Marital Status at test (reference=never married)				
Married	4.966**	1.995	-0.240**	-0.905***
	(1.947)	(2.326)	(0.096)	(0.296)
Divorced , Separated, Widowed, Other	5.063***	2.381	0.006	-0.464*
	(1.797)	(2.201)	(0.087)	(0.270)
Constant	159.9***	171.4***	0.941	8.668***
	(10.50)	(10.3)	(.556)	(1.793)
R^2	0.155	0.138	0.081	

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; Regressions 1-3 are estimated using OLS; Regression 4 is estimated using a logit. All observations weighted based on propensity scores from models of maternal depression in 1992 and 1994.

[1] 1989 for age 7-10 outcomes and 1994 for age 11-14 outcomes; [2] 1992 for age 7-10 outcomes and 1998 for age 11-14 outcomes

Table 6: Factor Loadings for Cognitive and Behavior Measures

	Factor Loading
Cognitive Ability Measures	
Piat Math Score Age 7-10	0.823
Piat Reading Score Age 7-10	0.816
Piat Math Score Age 11-14	0.832
Piat Reading Score Age 11-14	0.833
Share of variation explained by factor	0.675
Behavior Measures	
Child Delinquency Scale	0.712
Behavior Problems Index	0.726
Ever Suspended or Expelled	0.751
Share of variation explained by factor	0.531

Table 7: Regressions of the Impact of Maternal Mental Health and Substance Use/Abuse on Cognitive and Behavioral Factor Indices

	Cognitive Index Score Age 7-14	**Behavioral Index Scores Age 11-14**
Mother's Depression & SA		
Mother Depressed 1992 and 1994	0.016	0.229***
	(0.071)	(0.081)
Alcohol Abuse/Dependence 1994	0.090	-0.055
	(0.117)	(0.111)
Heavy Marijuana Smoker 1998	-0.290**	0.012
	(0.113)	(0.206)
Alcohol Abuse/Dependence 1998	0.294**	---
	(0.136)	
Heavy Marijuana Smoker 1992	-0.088	---
	(0.162)	

note: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$; Regressions are estimated using OLS. Regressions are estimated using OLS; All observations weighted based on propensity scores from models of maternal depression in 1992 and 1994.Cognitive index model includes covariates from both age 7-10 models and age 11-14 models, as in Table 3. Behavior index model includes covariates from age 11-14 models shown in Table 3.

Table 8: Fixed Effect Model Predicting Cognitive and Behavioral Outcomes

	Piat Math	Piat Reading	Behavior Problem Index	Ever Repeat Grade
Mother depressed	-0.439	-0.312	3.297***	-0.065
	(1.213)	(1.268)	(1.289)	(0.037)
Symptoms of alcohol	1.754	1.057	0.019	-0.023
Abuse or dependence	(1.783)	(1.863)	(1.894)	(0.054
Heavy Marijuana use	3.796	1.545	-1.716	0.139
	(2.734)	(2.857)	(2.905)	(0.083)
Includes covariates?	Yes	Yes	Yes	Yes
Number of observations	2,653	2,653	2,653	2,653
R2	0.020	0.054	0.063	0.031

note: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$