The Impact of Maternal Depression on Child Academic and Socioemotional Outcomes

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Abstract

This study provides a rigorous evaluation of the role of maternal depression on child classroom outcomes using a nationally-representative sample of U.S. school children. I find that children of depressed mothers have lower test scores and increased rates of problem classroom behavior. Additionally, both severity of and chronicity of maternal depression are important. These results remain after a bounding methodology is used to address the role of endogeneity, suggesting that the impacts are not simply due to unobservable characteristics associated with mothers with or without depression.

1 Introduction

Nearly one in ten Americans suffers from depression. As the rate of incidence increases, so do the direct consequences such as lost productivity. Depression costs are estimated to exceed 80 billion dollars annually, measured in terms of lost wages and health care needs, but the indirect costs are less understood. Among these indirect costs are the spillover effects on family, friends, and coworkers. Previous research has found spillovers from a person's mental health status on coworkers and spouses, manifesting as reductions in mental health status of colleagues (D'Souza et al. 2005) and spouses (Fletcher 2009; Siegel et al. 2004) of the affected. There are also labor market spillovers for spouses of those with mental health problems, such as foregone employment opportunities and lost wages (Tarricone et al. 2000; Rice and Miller 1996; Access Economics & SANE Australia 2000). However, less studied are these spillover effects on the children of the affected. This study adds to the literature of the costs of depression by examining the role of maternal depression on child outcomes.

The effect of maternal depression on child outcomes is difficult to measure due to the unclear direction of causality, or endogeneity. Depressed mothers spend less time talking and playing with their children (McLearn et al. 2006), which might result in more disruptive behavior and less interest in learning while at school. However, causality might be reversed, with the child's outcomes spurring depressive symptoms in the mother. Finally, both depression and child outcomes may be affected by unincluded environmental factors.

The research cannot tell what the outcomes would have been for a child whose mother is depressed had she not been depressed (the counterfactual). Due to the lack of strong instrumental variables, the impact of maternal depression on child outcomes cannot be fully identified. Thus, this paper will estimate the effect using complementary multivariate regression models as well as

address the role of endogeneity through a bounding method established by Altonji, Elder and Taber (2005). Maternal depression effects will be measured in terms of severity and chronicity. The former is based on the mother's score on the Center for Epidemiological Studies Depression Scale (CES-D), and the latter is defined as depression occurring in multiple time periods instead of simply the year of the child outcome being studied. The bounding approach allows the researcher to reassess what can be inferred about the effects of maternal depression on child outcomes and make inferences about the unbiased relationship between them.

Bounding is an attractive methodology given the inherent endogeneity issues present when identifying the effect of maternal depression. It relies on the role of the observable characteristics to provide information on the extent to which maternal depression might be correlated with the unobservable characteristics. This technique creates bounds, or limits, on the causal effects of maternal depression by using the differences in *observed* traits across children whose mothers have varying degrees of depression (none to severe). These differences will demonstrate the size and direction of potentially confounding *unobserved* traits.

In this study, new empirical evidence on whether maternal depression influences child outcome measures will be presented. The analysis is based on nationally-representative data from the Early Childhood Longitudinal Study- Kindergarten cohort (ECLS-K). Along with examining new outcome measures based on recent data, this study will address the methodological concern of endogeneity by using bounding techniques that have not been applied to maternal depression studies.

The paper will be organized as follows. Section 2 provides a discussion of the maternal depression literature and the relationship between maternal depression and child outcomes. The conceptual framework is explained in Section 3. The fourth section describes the data and

empirical methods in greater detail. Section 5 presents the results on how maternal depression affects child outcomes, and Section 6 will provide a discussion of the conclusions.

2 Literature Review

There is a sizable literature in child development and pediatrics documenting a relationship between maternal depression and negative child outcomes. Much of the prior work focuses on infants. A review of these studies is provided by Lovejoy et. al. (2000), whose meta-analysis of the early interactions of postpartum depressed mothers found mothers who were depressed across their infants' first 3 months of life were more irritable and hostile, less engaged, displayed less warmth and emotion, and were less likely to play with their infants.

Other work in this field has found maternal depression leads to negative reactions in infants (Cohn and Tronick, 1983) and reduced mental and motor development skills at the end of infants first year of life (Field, 1995 and Lyons-Ruth et al., 1986). Disturbances in early mother-infant interactions predict poorer infant cognitive outcomes at 18 months of age, and when mothers are not treated for depression early after its onset, the harmful effects persist as the child ages (Murray et al., 1996). Duration and severity of the disease also matter, as Campbell, Cohn and Meyers (1995) found that mothers whose depression lasted more than six months were less responsive to their infants than those mothers whose depression was shorter lived. These studies broadly focus on how depression breaks down the bonding mechanism between mother and child and how that alters a child's psychological development; less studied is its impact on how the child develops in the classroom.

Moving beyond the impact on infants, Brennan et al. (2000) established both severity and

duration of maternal depression were significant contributors in predicting behavioral problems and vocabulary scores for five-year-old children. Frank and Meara (2009) find depression leads to moderately large effects in child behavioral problems once children enter school. Others have found increased behavioral problems (Welsh-Allis and Ye, 1988; Weissman et al., 1987), augmented risks of psychopathology (Beardslee et al., 1983; Downey and Coyne, 1990; Orvaschel, 1983), and higher rates of disorder (Fendrich, Warner and Weissman, 1990).

Prior work demonstrates the impacts of maternal depression may begin during infancy and remain through adolescence. Since much of the economic success of a child is determined by non-cognitive skills (National Research Council and Institute of Medicine 2000; Heckman 2006; Cunha and Heckman 2007; Heckman 2007), maternal depression is important as it may stymie the formation of child capital. This paper builds on previous work by examining the effect of maternal depression on child outcomes by using nationally representative longitudinal data, allowing for severity, chronicity, and longer-term time trends to be studied. Additionally, previous studies have not been able to fully identify the causal link between maternal depression and child outcomes, so the use of methods proposed in Altonji, Elder and Taber (2005) are used to more thoroughly examine the role of endogeneity. Rather than relying on identifying exclusion restrictions, bounding uses observed differences between those with and without maternal depression to provide information about the size and direction of selection along the unobserved characteristics. This paper is the first to provide a thorough examination of the impact of endogeneity on estimates of maternal depression and child outcomes.

3 Conceptual Framework

Historically, economists have studied the determinants of classroom success using educational or

child quality production functions and have found human capital accumulation by children depends on a variety of inputs from the home and school (Currie 2003; Hanushek 1996; Behrman and Wolfe 1987; Currie 2001; Currie and Stabile 2003). More recent studies investigate issues of human capital investment in children by using models of skill formation (Heckman 2006; Cunha and Heckman 2007; Heckman 2007). Importantly, studies by mental health researchers suggest that maternal mental health has a direct association with parenting practices. In the economic production function framework, maternal mental health may affect both the quality and the quantity of parental time invested in children, and this is important because early life outcomes impact later well-being.

Empirical testing of the relationship between maternal depression and child outcomes is based on a time allocation model of labor supply similar to one by Cunha et al.'s 2006 and Temple's and Wilcox-Gok's (working paper, 2006) model of childhood skill formation. The former establishes the basic framework as to how depression reduces a mother's health status, which negatively impacts child development, and the latter develops the idea that the mother's capabilities and investments affect the quality of care provided by them.

The mother maximizes her utility subject to constraints on her budget and time. Utility consists of consumption (C), maternal health (M), and child development (D), and these goods are produced when time is combined with market goods and services in a production function. The mother chooses market inputs,

$$k_C, k_M, k_D$$

and time inputs,

$$t_C, t_M, t_D$$

when solving her utility maximization problem:

$$\max U = U(C, M, D)$$

Utility is subject to production constraints,

$$C = B_1(k_C, t_C, e_C)$$

$$B = B_2(k_M, t_M, e_{M,} M_0)$$

$$D = B_3(k_D, t_D, e_{D,} D_0)$$

time constraints,

$$h = T - t_C - t_M - t_D$$

and the budget constraint,

$$wh + I = p_C k_C + p_M k_M + p_D k_D$$

Note: $p_C, p_{M,}$ and p_D are the market prices; $e_C, e_{M,}$ and e_D are the mother's efficiencies in producing the three goods; w is the mother's wage rate, I is other family income; h represents hours worked, and M_0 and D_0 are the initial endowments of maternal health and child development.

Solving the maximization problem yields first order conditions equating the marginal utilities of time spent producing C, M, and D. The marginal utility per dollar spent on C, M, and

D are equal. Fully exhausting income, the net result is a reduced form expression for the mother's optimal demand for child development, which tells us that if the mother's health decreases through the onset of depression, it will lead her to increase the amount of time spent on her health production. Holding all else constant, this increase in maternal health production will result in a reduction in the production of child development.

Thus, when maternal health production is constrained by depression, the mother spends more time on her own health production and has less time to invest in child development. Following the child skills formation function of Cunha et al. (2006),

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

where M is the mother's mental health status, S is the level of skill formation, PS contains parental skill attributes, and I measures the investment in child capabilities. As in the labor supply model outlined above, maternal depression reduces the amount of time a parent has to offer to their child, so PS falls. This drop in PS then diminishes parental investment in the child's skill development. The net result is a decrease in child skill formation. This conceptual framework motivates the empirical analyses that follow that estimate the impact of maternal depression on various measures of child development. In my models, this change in child skill formation is captured by the coefficient on maternal depression.

4 Data and Methods

The Early Childhood Longitudinal Study-Kindergarten Class of 1998-1999 (ECLS-K) is used in order to examine the role of maternal depression on various child outcomes up to eighth grade.

The ECLS-K is a large, nationally representative, longitudinal study of students who entered kindergarten in the fall of 1998. The ECLS-K was sponsored by the National Center for Educational Statistics (NCES) to follow roughly 22,000 kindergartners upon entry and through completion of 8th grade. Data collection began in the fall of kindergarten (1998) and follow-up surveys were administered in the spring of kindergarten (1999), the fall of first grade (1999), the spring of first grade (2000), the spring of third grade (2002), the spring of fifth grade (2004), and the spring of eighth grade (2007). The data comes from a collection of parent, teacher, and school administrator interviews as well as child assessments. The initial sample included all kindergarteners (N= 21,409).

The estimation sample is limited to mothers of the focal child, whether that is by birth, adoption, step-parent, or legal guardian. Respondents were asked a series of questions surrounding depression in three survey rounds, when the focal child was in the spring of kindergarten, spring of third grade, and spring of eighth grade. Thus, the eighth grade sample contains of approximately 7,000 students, the third-grade sample contains nearly 12,000 students, and the kindergarten sample contains slightly more than 18,000 students. The exact sample sizes vary depending on the estimation and model specification, and Appendices A and B contain the descriptive statistics for students in each sample.

Variables

The ECLS-K measure of depression is based on the Center for Epidemiological Studies Depression Scale (CES-D). This scale was developed by Lenore Radloff (1977) and is a well-used measure of depression. Parents were surveyed about depression in three periods: spring of the child's kindergarten year, spring of the child's 3rd grade year, and spring of the child's eighth

grade year. As shown in Exhibit 1, in addition to the specific question, "how often during the past week have you felt depressed?" 11 other questions were asked to assess the respondents' emotional well-being. For all 12 questions, the respondents selected from the choice set of "never," "some of the time," "a moderate amount of time," or "most of the time."

These emotional well-being indicators compose the 12-item short version of the CES-D and are used to construct two measures of maternal depression, moderate and severe. Following the guidelines from the National Center for Education Statistics and other studies (Silverstein et al., 2005; Temple and Wilcox-Gok, 2006), moderate depression occurs when the CES-D score is greater than 9 and severe depression occurs for CES-D scores greater than 15.

The child outcomes used in this study are measured in the spring of each year (kindergarten, third grade, and eighth grade) and appear in the child component of the survey. Math and reading scores from item response theory (IRT) exams provide measures of cognitive ability. In addition to academic performance outcomes, non-cognitive socioemotional child outcomes were examined for the same years as the test scores. These measures are based on the ECLS-K teacher survey that asked teachers to assess each child's ability in five different areas, ranking them from "seldom" to "always," which created continuous scales ranging from 1 to 4. The survey stopped collecting these measures after the fifth grade period, so they are only available during the kindergarten and third grade waves in my study. Exhibit 2 provides detailed descriptions of each of the five measures.

Included in the regression analysis are covariates that control for child, family, and school characteristics. Child controls are age, race/ethnicity, birth weight, disability status, English as a second language, and gender; family characteristics include a parental involvement index, amount of story-telling and books read to the child, marital status, if the mother was a teenager at birth,

number of nights the family eats dinner together, mother employment, father employment, socioeconomic status, mother's education, and father's education; school characteristics are US Census region of the school, urban/rural status, teacher turnover, crowding problems in the school, share of students receiving free lunch, public/private school, and a series of school neighborhood quality measures such as crime, presence of gangs, tension, and drugs.

Summary Statistics

Exhibits 3 and 4 present estimates of the differences in mean outcomes between children with and without depressed mothers for each survey period (full descriptive statistics found in Appendices A and B). It is evident that children whose mothers are either moderately (Table 3) or severely (Table 4) depressed have lower mean test scores than those whose mothers are not depressed, and the magnitudes of these effects are similar for both moderate and severe levels of depression.

The mean values of the five measures of socio-emotional child outcomes also demonstrate that children of depressed mothers have lower average scores in ability to benefit from the learning environment, exhibit self-control, and demonstrating interpersonal skills. When comparing the incidence of externalizing problem behavior (arguing and fighting) and internalizing problem behavior (anxiety and loneliness), there is no statistically significant difference between children of depressed mothers and non-depressed mothers.

Methods

The general research question is, "What is the impact of maternal depression on child outcomes?" To answer this question, several different models were estimated. First, linear cross-sectional regressions were estimated in each time period, and the endogeneity problem inherent with this

methodology was addressed using a bounding estimation procedure. Next, inverse probability models were estimated to address the concern about the non-randomness associated with which group each child belonged to (depressed or non-depressed mother). Both the linear-cross sectional regression with the bounding correction and the inverse probability models answer the question, "What was the contemporaneous effect of maternal depression on child outcomes?"

In addition to estimating the contemporaneous effect of maternal depression, fixed effects models examined how changes in maternal depression over time impact children. These models corrected for omitted variable bias by allowing time-invariant unobservable individual and school measures to be differenced out in the estimation process. However, this methodology answers a slightly different research question, which is, "What is the impact on an a child when a mother becomes depressed?"

While each methodology will be discussed in further detail below, the following equation demonstrates the *general* relationship of interest:

$$Y_{ijt} = \alpha + \beta D_{it} + \delta X_{it} + \omega_i + \gamma_j + \varepsilon_{ijt} \qquad (1)$$

where Y_{ijt} is the child outcome of individual i at school j in time t, D_{it} is a dummy representing whether or not the mother of child i in time period t is depressed, X_{it} is a set of other explanatory variables, ω_i are unobserved individual effects that are constant over time, γ_j are the school effects that are constant over time, ε_{ijt} is an error term uncorrelated with D_{it} and X_{it}, and α, β, and δ are the parameters to estimate.

The impact of maternal depression on child outcomes is measured by the coefficient, β. Of concern is that depression is also correlated with unobservable characteristics that might also

influence test scores and behavioral measures. Thus, estimating equation (1) using OLS leads to biased estimates of β, which is why inverse probability weighting, fixed effects, and a bounding methodology were implemented.

Bounding addresses the endogeneity surrounding maternal depression and child outcomes. This approach provides information on the extent to which maternal depression might be correlated with unobservables that could potentially bias the effects of depression. Altonji, Elder and Taber (2005) argue that one can assume that the selection on observables reflects the degree to which selection on unobservables exists. In other words, this method will allow me to see how much section on unobservables there must be, relative to selection on observables, to account for the association between maternal depression and child outcomes. The method by Altonji et al. (hereafter AET) is advantageous since it does not rely on identifying variables like instruments that might be weak in explanatory power. Instead, the identification comes from the restriction on the coefficient of correlation between the error terms of an equation that estimates maternal depression and one that estimates the various child outcomes.

AET methodology uses information on selection into maternal depression and child outcomes based on observed factors to acquire information about the degree of selection along the unobserved characteristics. Despite not knowing the exact degree of selection on unobservables, bounding can gauge how sensitive estimates are to the various assumptions about the degree of selection on unobserved variables. Bias arises from the unobserved covariates (the error terms) of the following equations:

$$Outcome_i = \propto (D_i) + \delta X_i + c_i \qquad (2)$$

$$D_i = \beta_i + \mu_i \qquad (3)$$

In an ideal setting, equations (2) and (3) would be estimated with at least one additional source of identifying variation that predicts maternal depression (*Di*) but is not correlated with the outcomes. However, in many nonexperimental (and quasi-experimental) cases, no appropriate instruments are available to use as a source of identification. Instead, I estimate the two simultaneous equations of interest using a Heckman selection model, which will identify them *without* requiring an instrument and provide information about the bounds.

The first step estimates the effect of maternal depression on child outcomes using a selection model in which the correlation between the unobserved variables is fixed at various levels. This allows me to see how sensitive the estimates of the effect of maternal depression are to the problem of correlated unobservables. The analysis provides a threshold of selection on unobservables, or the point at which maternal depression no longer has a statistically significant effect on child outcomes. The correlation coefficient, ρ, is constrained to be -0.5, and then incrementally increased to -0.3, -0.1, 0.0, 0.1, 0.3, and 0.5. This method allows the model to incorporate increasingly greater amounts of correlations among the unobservables.

The next step uses the degree of selection on observed characteristics to fix the degree of selection on the unobserved characteristics at a level that is considered conservative. It computes the amount of sorting into maternal depression and the outcomes on observed variables, and then obtains estimates of the effect of maternal depression under the assumption that the degree of sorting on the unobservables is equal to the degree of sorting on the observed. Altonji et al. argue that if the observable determinants of an outcome are just a random subset of the complete set of

determinants, then selection on the observable characteristics must be equal to selection on the unobservables. The portion of the outcome variable associated with observed variables has the same relationship with maternal depression as the portion related to the unmeasured factors. Thus, the maximum (minimum) value of ρ is:

$$\frac{Cov(X'\beta, X'\delta)}{Var(X'\delta)} \geq \rho \geq 0 \qquad (4)$$

For this to be the maximum (minimum) possible correlation, three conditions must hold:

1. The observable covariates, X, are randomly chosen from the full set of factors determining the outcome, Y;

2. There are a large number of both observable and unobservable factors, and 3. The part of the outcome variable related to the observables has the same relationship with the endogenous variable as the part of the outcome related to the unobservables.

Equation (4) provides one end of the bound, either the lower limit (if the negative effect of maternal depression on outcomes induces a positive bias and overestimates the negative effect of maternal depression), or upper limit (if it creates a negative bias and underestimates the effect). Empirically, this procedure is done by estimating a Heckman selection model using (2) and (3) in two ways. First, the effect of maternal depression on outcomes is estimated without controls (or the unadjusted mean differences) as well as with controls for student, school, and family demographics. Second, the direction of bias based on observed variables will be calculated by comparing the maternal depression effect of the equation without controls to the equation with controls. If the magnitude of the maternal depression effect with controls is larger than the one without, then the bias is downward, meaning the effect of depression is bigger in the unadjusted mean differences in the particular outcome between the treatment and control groups. Step three finds the effect of maternal depression on child outcomes assuming ρ is restricted to fixed,

imposed values, and step four does the same using the maximum (minimum) ρ value. Lastly, these estimates from steps three and four will be compared to the original unadjusted mean. If the values using the restricted values of ρ are less than half of the unadjusted mean differences, then the effect of selection on unobservables is small.

The next technique used to examine contemporaneous effects of maternal depression, inverse probability weighted estimators, is outlined by Hurano, Imbens, and Ridder (2000). A concern with the data is that there are unobservable variables that influence maternal depression, and the selection into that group is not random. Inverse probability weighting (IPW) is a tool to use with the data that we do have, the observed parameters, which allows adjustment for preexisting observed differences among groups (i.e. selection bias). When estimating the effect of maternal depression on child outcomes, we would like to measure the causal effect of depression, or the change in an outcome between the child with a depressed mother and what his outcome would have been if she were not depressed.

Let $d \in 0, 1$ index depressed ($d = 1$) or not ($d = 0$). There are two potential outcomes, $Y(1)$ and $Y(0)$ and the causal effect of depression on an outcome is thus $Y(1) - Y(0)$, where the average causal effect across the population is $E[Y(1) - Y(0)]$. In linear form this is:

$$E[Y(1) - Y(0)] = b_0 + b_1 d \quad (5)$$

The average causal effect of receiving the "treatment" (being depressed) is measured by b_1. This measures the change in d from 0 to 1. Equation 5 represents the potential outcomes, not observed outcomes. Therefore, we only see one of the outcomes, depressed or not, and cannot observe the counterfactual. If a child's mother was depressed, the counterfactual is what the child's outcome would have been in the absence of maternal depression. Inverse propensity weighting draws

inference about a population using the observed characteristics of the members of the subpopulation. It creates a reweighted data set that better resembles a randomized experiment. Individuals are assigned smaller (larger) weights if their observed treatment status is overrepresented (underrepresented), given their covariates. I first estimate a logit model to predict the probability of being depressed, p, controlling for child, family, and school characteristics, and weighted each unit by 1/p. This method is advantageous over the more common propensity score matching estimation, which requires quite a bit of overlap of observed characteristics between the treatment and control groups, as it requires fewer distributional assumptions about the underlying data and produces unbiased and efficient estimates (Wooldridge, 2007).

Lastly, fixed-effects estimation uses children as their own control and takes advantage of the variation that arises from changes in maternal depression over time, but within the same individuals:

$$Y_{ijt} - \overline{Y_{ij}} = \beta(D_{it} - \overline{D_i}) + \delta(X_{it} - \overline{X_i}) + \varepsilon_{ijt} \qquad (6)$$

By subtracting the mean values of each variable over time, Equation (6) generates unbiased estimates of the effect of maternal depression on child outcomes, as the time-invariant characteristics drop out of the model and identification hinges on the within-child variation of having a mother with depression or not.

5 Results

Contemporaneous impacts of maternal depression

Exhibits 5-9 present the results from the linear cross-sectional models, AET bounding, and the inverse probability weighting. The linear cross-sectional models (Exhibit 5) suggest that moderate

maternal depression negatively impacts kindergarten and third grade cognitive and socioemotional outcomes, with magnitudes being relatively larger for third graders. Additionally, these results suggest that as severity increases, so do the negative effects on children. Eighth grade students showed no statistically significant differences in test scores for either moderate or severe maternal depression.

As mentioned, one potential problem with estimates from these cross-sectional models is that the results might be driven by unobserved covariates. Thus, AET bounds were estimated (Exhibit 6, Exhibit 7, and Exhibit 8) to place limits on the magnitude of the selection on unobservables. Although this methodology has been applied to correct for selection in other studies (Dee et al., 2006/2007), it has not been applied to maternal depression estimates. The first row in the bounding tables, "Maternal depression without controls," shows the simple unadjusted mean differences in the outcomes between those children with and without depressed mothers. As more covariates enter the model, the magnitudes of these estimates get smaller. According to Altonji et al., this suggests that the bias from the unobserved covariates might move in the same direction. "Implied direction of bias," indicates the direction of the bias that results from controlling for the unobserved characteristics—when the bias is downwards (upwards), the maximum ρ is negative (positive).

The AET bounding methodology imposes restrictions on ρ, or the correlation among the unobserved covariates, reruns the models with these restrictions in place, and produces new estimates of maternal depression. Although there is relatively high selection on observables for maternal depression, the range of estimates are shown in the bottom rows of these exhibits (6-8). For example, focusing on column one in Exhibit 6 (differences in math scores for kindergartners), bounding suggests that when unobservable characteristics are accounted for, moderate maternal

depression reduces math scores by roughly one point, which is smaller than the unadjusted mean difference of 3.8 points. In general, this pattern exists for all ages and levels of maternal depression—accounting for the selection on the unobserved characteristics, the magnitude of the impact of maternal depression on child outcomes decreases.

Inverse probability weighting reweights the sample to address the issue of non-random selection into treatment (depressed or not). In general, the same pattern emerges with these results (Exhibit 9) as with the linear cross sectional models (Exhibits 5-8), although the magnitudes are different. For kindergartners, the effect of moderate maternal depression reduces math scores by less than one point and has negative impacts on socioemotional outcomes (reduced ability to learn in the environment, reduced self-control, and increased rates of internal and external problem behavior). IPW resulted in larger impacts of moderate maternal depression on third grade math and reading scores (roughly five points) and very large reductions (fourteen points) were seen in eighth grade reading scores when mothers were severely depressed.

Time impacts of maternal depression

Fixed-effects models were estimated to take advantage of the panel set-up of the EKLS-K data. By following the same children over a nine year period, one can measure the effect of a change in maternal depression between one period and the next on the same student. Since the time-invariant characteristics that could potentially bias the estimates drop out of the model, these results hinge on the within-student variation. As shown in Exhibit 10, the impact of a mother moving from not depressed when her child was in kindergarten to moderately depressed in third grade leads to reductions in all outcomes. For these children, math and reading scores fell over

one point and socioemotional outcomes were negatively impacted. Children whose mothers moved from not depressed to severely depressed were much more likely to exhibit problem behaviors; these estimates were double those of the moderately depressed column. Similar patterns emerged between third and eighth grade, although with this group there were more significant differences when mothers were severely depressed. Again, the magnitudes increased as severity increased.

Chronicity

Linear cross-sectional models were estimated to examine the role of persistence of depression. Due to sample size, these models were restricted to mothers with *moderate* depression in two (or more) periods. While the data cannot distinguish whether or not these mothers moved in and out of depression between the waves, it is assumed that if the mother was moderately depressed in periods one (e.g. kindergarten) and two (e.g. 3rd grade), she experienced some levels of depression in the years between (e.g. 1st and 2nd grade). If a mother reported moderate depression when her child was in kindergarten and 3rd grade, her child scored 3 points lower than his/her counterpart whose mother did not report any depression in those two time periods. Similarly, children with these mothers were likely to experience reductions in ability to learn in the environment, reductions in self-control in the classroom, reductions in interpersonal skills, and increases in behavioral problems. Similar effects were not found between waves two (3rd grade) and three (8th grade). Persistence of depression in all three periods was also not predictive of changes in test scores for eighth graders.

6 Discussion

In the existing literature on the consequences of depression in the family, depression of a parent has been shown to be associated with a number of adverse outcomes for family members. Researchers focusing specifically on the impact of maternal depression on infants and children report evidence from dozens of studies in the consequences for child well-being. However, the adverse outcomes reported for maternal depression represent causal impacts only if all relevant confounding variables are included in the analysis. This reliance on the assumption of selection on observables is a concern due to the possibility that unincluded factors affecting both maternal depression and child outcomes may exist.

This study employs several estimation methods in an attempt to obtain causal estimates of the effects of maternal depression on the test scores and noncognitive skills of school-aged children. The main focus is on the use of a bounding method, as it addresses the issue of endogeneity and places limits on the estimates based on selection of characteristics that are observed. Results for inverse probability weighted models and student fixed effects models augment the analysis and support the results found using OLS models with AET bounds.

I find the presence of any maternal depression leads to lower math and reading scores for Kindergartners and third graders, and the magnitude increases as severity of depression increases. Importantly, there were also several negative effects observed in the scores of noncognitive skills, particularly for third graders, suggesting that it is not just the academic performance of the child that might suffer if their mother is depressed. These results motivate a role for health and education policy, as policy efforts require information on causal relationships. Efforts to identify and provide assistance to mothers of school-aged children can have an effect on children's educational success.

Exhibits

Appendices

Exhibit 1: Emotional well-being variables

Variable Name	Description (all measures reference the previous week)
Bothered	Felt that you were bothered by things that don't usually bother you?
Appetite	Felt that you did not feel like eating, that your appetite was poor?
Blue	Felt that you could not shake off the blues even with help from your family and friends?
Focus	Felt that you had trouble keeping your mind on what you were doing?
Depress	Felt depressed?
Effort	Felt that everything you did was an effort?
Fearful	Felt fearful?
Restless	Felt that your sleep was restless?
Less talk	Felt that you talked less than usual?
Lonely	Felt lonely?
Felt sad	Felt sad?
Not go	Did not go somewhere you should have?

Source: ECLS-K Codebook

Exhibit 2: Child socioemotional outcomes

Variable Name	Description
Learn	Six-item scale that rate the child's attentiveness, task persistence, eagerness to learn, learning independence, flexibility, and organization. This measures the ease with which children benefit from the learning environment.
Control	Four-item scale that includes the child's ability to control behavior by respecting the property rights of others, controling temper, accepting peer ideas for group activities, and responding appropriately to pressure from peers.
Interpersonal Skills	Five-item scale measuring a child's skill in forming and maintaining friendships, getting along with people who are different, comforting or helping other children, expressing feelings, ideas and opinions in positive ways, and showing sensitivity to the feelings of others.
Externalizing Problem Behavior	Five-item scale measuring the frequency with which a child argues, fights, gets angry, acts impulsively, and disturbs ongoing activities.
Internalizing Problem Behavior	Four-item scale measuring loneliness, sadness, low self-esteem, and anxiety.

Source: ECLS-K Codebook

Exhibit 3: Differences in mean outcomes between children with and without depressed (moderately or severely) mothers

	Kindergarten	3rd Grade	8th Grade
Cognitive Outcomes			
Math score	-4.92 ***	-9.66 ***	-7.29 **
Reading Score	-4.62 ***	-12.34 ***	-10.45 ***
Socioemotional Outcomes			
Approaches to learning	-0.24 ***	-0.18 ***	n/a
Self-control	-0.19 ***	-0.11 ***	n/a
Interpersonal skills	-0.22 ***	-0.15 ***	n/a
Externalizing problems	0.02 ***	0.09 **	n/a
Internalizing problems	0.12 ***	0.12 ***	n/a

*** p< 0.01, ** p< 0.05, * p< 0.1

Exhibit 4: Differences in mean outcomes between children with and without severely depressed mothers

	Kindergarten	3rd Grade	8th Grade
Cognitive Outcomes			
Math score	-5.328 ***	10.29 ***	-7.99 ***
Reading Score	-5.089 ***	-13.09 ***	-11.48 ***
Socioemotional Outcomes			
Approaches to learning	-0.258 ***	-0.19 ***	n/a
Self-control	-0.202 ***	-0.12 ***	n/a
Interpersonal skills	-0.233 ***	-0.16 ***	n/a
Externalizing problems	0.172 ***	0.10 ***	n/a
Internalizing problems	0.126 ***	0.13 ***	n/a

*** p< 0.01, ** p< 0.05, * p< 0.1

Exhibit 5: Regression adjusted results (OLS)

	Kindergarten		Third Grade		Eighth Grade	
	Any	Severe	Any	Severe	Any	Severe
Cognitive Outcomes						
Math score	-0.718 **	-1.736 ***	-2.839 ***	-3.417 *	0.237	0.191
Reading Score	-0.731 **	-0.677	-3.054 **	-6.146 ***	-1.174	-2.478
Socioemotional Outcomes						
Approaches to learning	-0.062 ***	-0.116 ***	-0.103 ***	-0.121 **		
Self-control	-0.052 **	-0.058	-0.110 ***	-0.059		
Interpersonal skills	-0.044 *	-0.099 ***	-0.131 ***	-0.118 *		
Externalizing problems	0.045 *	0.074 *	0.098 ***	0.060		
Internalizing problems	0.055 ***	0.096 ***	0.120 ***	0.139 **		

Note: Sample sizes vary by model. Any depression: N~13,000 (Kindergarten); N~7,500 (3rd); N= 7,800 (8th). Severe depression: N~ 12,300 (Kindergarten); N~6,800 (3rd); N~6,400 (8th).

Models control for school characteristics (percent minority, neighborhood problems with crime, drugs, tension, or gangs, teacher turnover, crowdedness, percent receiving free lunch, urban/rural, and school type), student characteristics (race, gender, age, birthweight, exercise, disability, and if Engligh is a second language), and family characteristics (parental involvement, education, and employment, socioemotional status, number of nights dinner is eaten together, number of children in the family, region, mother's age at child's birth, frequency of stories told and books read in the house, number of books in the house, and receipt of WIC).

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Exhibit 6: Sensitivity of maternal depression estimates to various assumptions regarding the degree of selection on unobservables for kindergartners

	Any Depression						
Assumption	Math Score	Reading Score	Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problems	Internalizing Problems
Maternal depression estimate without controls	-3.775 (0.261)	-4.002 (0.295)	-0.173 (0.0173)	-0.134 (0.0159)	-0.151 (0.0163)	0.123 (0.0169)	0.0814 (0.0137)
Maternal depression estimate controled for detailed set of student, family, and school	-0.718 (0.312)	-0.731 (0.371)	-0.062 -0.021	-0.052 (0.021)	-0.044 (0.021)	0.045 (0.021)	0.055 (0.017)
Implied direction of bias	downward	downward	downward	downward	downward	downward	downward
R2 from regression of outcome on all covariates	0.266	0.180	0.140	0.088	0.088	0.107	0.037
Maternal Depression estimate assuming:							
p= -.5	-1.003 -0.225	-0.799 -0.285	-0.0584 -0.014	-0.0553 (0.0132)	-0.0581 (0.0136)	0.0614 (0.0136)	0.034 (0.0113)
p= -.3	-0.998 -0.225	-0.788 (0.284)	-0.0586 (0.0140)	-0.0553 -0.0133	-0.0582 (0.0137)	0.0609 (0.0135)	0.0334 (0.0113)
p= 0	-0.998 (0.225)	-0.768 (0.284)	-0.0585 (0.0140)	-0.0551 (0.0133)	-0.0581 (0.0137)	0.0608 (0.0135)	0.0334 (0.0112)
p= .3	-1.002 (0.225)	-0.746 (0.284)	-0.0584 (0.0140)	-0.0551 (0.0133)	-0.0579 (0.0137)	0.0609 (0.0135)	0.0334 (0.0112)
p = .5	-1.005 (0.225)	-0.729 (0.283)	-0.0583 (0.0141)	-0.0554 (0.0133)	-0.0578 (0.0137)	0.0609 (0.0134)	0.0329 (0.0111)
p set so that selection on observables= selection on unobservables	-0.998 (0.225)	-0.769 (0.284)	-0.0586 (0.0140)	-0.0553 (0.0133)	-0.0582 (0.0137)	0.0609 (0.0135)	0.0273 (0.0105)
Number of observations	13,614	13,369	13,390	13,347	13,300	13,362	13,344

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exhibit 6 (continued): Sensitivity of maternal depression estimates to various assumptions regarding the degree of selection on unobservables for kindergartners

	Severe Depression						
Assumption	Math Score	Reading Score	Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problems	Internalizing Problems
Maternal depression estimate without controls	-5.328 (0.406)	-5.089 (0.509)	-0.258 (0.0305)	-0.202 (0.0290)	-0.233 (0.0273)	0.172 (0.0286)	0.126 (0.0241)
Maternal depression estimate controlled for detailed set of student, family, and	-1.736 (0.500)	-0.677 (0.676)	-0.116 (0.038)	-0.058 (0.042)	-0.099 (0.037)	0.074 (0.036)	0.096 (0.034)
Implied direction of bias	downward	downward	downward	downward	downward	downward	downward
R2 from regression of outcome on all covariates	0.265	0.176	0.135	0.087	0.086	0.106	0.038
Maternal Depression estimate assuming:							
p= -.5	-1.237 (0.376)	-0.714 (0.474)	-0.106 (0.0234)	-0.0838 (0.0222)	-0.105 (0.0229)	0.0788 (0.0228)	0.0582 (0.0190)
p= -.3	-1.236 (0.375)	-0.688 (0.474)	-0.105 (0.0235)	-0.0831 (0.0223)	-0.104 (0.0230)	0.0793 (0.0227)	0.0572 (0.0189)
p= 0	-1.237 -0.375	-0.658 (0.474)	-0.105 (0.0235)	-0.0827 (0.0223)	-0.103 (0.0230)	0.0794 (0.0226)	0.0571 (0.0189)
p= .3	-1.243 (0.375)	-0.636 (0.473)	-0.105 (0.0235)	-0.0828 (0.0223)	-0.103 (0.0230)	0.0798 (0.0226)	0.057 (0.0189)
p = .5	-1.248 (0.375)	-0.622 (0.472)	-0.106 (0.0235)	-0.0833 (0.0223)	-0.103 (0.0230)	0.0804 (0.0225)	0.0563 (0.0187)
p set so that selection on observables= selection on unobservables	-1.237 (0.375)	-0.658 (0.474)	-0.105 (0.0235)	-0.0828 (0.0223)	-0.104 (0.0230)	0.0795 (0.0226)	0.0567 (0.0188)
Number of observations	12,569	12,351	12,377	12,337	12,297	12,352	12,337

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exhibit 7: Sensitivity of maternal depression estimates to various assumptions regarding the degree of selection on unobservables for third graders

	Any Depression						
Assumption	Math Score	Reading Score	Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problems	Internalizing Problems
Maternal depression estimate without controls	-8.187	-10.18	-0.154	-0.13	-0.134	0.126	0.111
	(0.915)	(1.049)	(0.0278)	(0.0254)	(0.0273)	(0.0261)	(0.0242)
Maternal depression estimate controlled for detailed set of student, family, and school variables	-2.839	-3.054	-0.103	-0.11	-0.131	0.098	0.12
	(1.034)	(1.193)	(0.034)	(0.035)	(0.038)	(0.035)	(0.033)
Implied direction of bias	downward	downward	downward	downward	downward	downward	downward
R2 from regression of outcome on all covariates	0.275	0.295	0.138	0.086	0.089	0.101	0.055
Maternal Depression estimate assuming:							
p= -.5	-1.475	-2.291	-0.0817	-0.07	-0.0902	0.0856	0.0749
	(0.619)	(0.691)	(0.0205)	(0.0191)	(0.0204)	(0.0187)	(0.0173)
p= -.3	-1.462	-2.278	-0.0816	-0.0707	-0.0904	0.0839	0.0738
	(0.619)	(0.693)	(0.0205)	(0.0192)	(0.0205)	(0.0186)	(0.0172)
p= 0	-1.451	-2.265	-0.0812	-0.0706	-0.0901	0.0836	0.074
	(0.620)	(0.693)	(0.0206)	(0.0193)	(0.0205)	(0.0185)	(0.0172)
p= .3	-1.433	-2.253	-0.0807	-0.0702	-0.0899	0.084	0.0737
	-0.62	(0.693)	(0.0206)	(0.0193)	(0.0205)	(0.0185)	(0.0171)
p = .5	-1.41	-2.248	-0.0801	-0.0705	-0.0904	0.0835	0.0719
	(0.619)	(0.693)	(0.0206)	(0.0193)	(0.0205)	(0.0183)	(0.0169)
p set so that selection on observables= selection on unobservables	-1.451	-2.265	-0.0815	-0.0707	-0.0904	0.084	0.0735
	(0.620)	(0.693)	(0.0206)	(0.0192)	(0.0205)	(0.0185)	(0.0171)
Number of observations	7,794	7,781	7,383	7,348	7,332	7,375	7,355

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exhibit 7 (continued): Sensitivity of maternal depression estimates to various assumptions regarding the degree of selection on unobservables for third graders

	Severe Depression						
Assumption	Math Score	Reading Score	Approaches to Learning	Self-Control	Interpersonal Skills	Externalizing Problems	Internalizing Problems
Maternal depression estimate without controls	-10.29 (1.281)	-13.09 (1.445)	-0.191 (0.0393)	-0.124 (0.0375)	-0.164 (0.0384)	0.103 (0.0411)	0.129 (0.0386)
Maternal depression estimate controlled for detailed set of student, family, and school	-3.417 (1.685)	-6.146 (2.111)	-0.121 (0.058)	-0.059 (0.059)	-0.118 (0.063)	0.060 (0.068)	0.139 (0.064)
Implied direction of bias	downward	downward	downward	downward	downward	downward	downward
R2 from regression of outcome on all covariates	0.287	0.297	0.144	0.098	0.095	0.106	0.054
Maternal Depression estimate assuming:							
p= -.5	-1.946 (0.939)	-2.353 (1.050)	-0.0749 (0.0318)	-0.0370 (0.0299)	0.0631 (0.0292)	0.0858 (0.0270)	-0.0754 (0.0318)
p= -.3	-1.934 (0.941)	-2.361 (1.052)	-0.0747 (0.0320)	-0.0367 (0.0301)	0.0605 (0.0290)	0.0845 (0.0269)	-0.0748 (0.0320)
p= 0	-1.911 (0.941)	-2.337 (1.052)	-0.0742 (0.0321)	-0.0359 (0.0302)	0.0597 (0.0290)	0.0849 (0.0269)	-0.074 (0.0321)
p= .3	-1.878 (0.941)	-2.313 (1.052)	-0.0738 (0.0320)	-0.0361 (0.0302)	0.0606 (0.0289)	0.0842 (0.0268)	-0.0739 (0.0320)
p = .5	-1.84 (0.941)	-2.314 (1.051)	-0.0736 (0.0320)	-0.0378 (0.0302)	0.061 (0.0286)	0.0813 (0.0264)	-0.0748 (0.0320)
p set so that selection on observables= selection on unobservables	-1.912 (0.941)	-2.338 (1.052)	-0.0744 (0.0321)	-0.0362 (0.0302)	0.0599 (0.0290)	0.0849 (0.0268)	-0.0742 (0.0321)
Number of observations	8,103	8,090	7,721	7,688	7,674	7,714	7,695

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exhibit 8: Sensitivity of maternal depression estimates to various assumptions regarding the degree of selection on unobservables for eighth graders

	Any Depression		Severe Depression	
Assumption	Math Score	Reading Score	Math Score	Reading Score
Maternal depression estimate without controls	-7.108 (1.404)	-10.320 (1.626)	-7.993 (2.472)	-11.48 (2.611)
Maternal depression estimate controlled for detailed set of student, family, and	0.237 (1.212)	-1.174 (1.415)	0.191 (1.887)	-2.478 (2.614)
Implied direction of bias	downward	downward	downward	downward
R2 from regression of outcome on all covariates	0.311	0.341	0.303	0.332
Maternal Depression estimate assuming:				
p= -.5	-1.660 (0.678)	-2.109 (0.831)	-2.255 (1.131)	-3.056 (1.394)
p= -.3	-1.645 (0.679)	-2.052 (0.834)	-2.256 (1.136)	-2.985 (1.402)
p= 0	-1.631 (0.680)	-2.017 (0.835)	-2.24 (1.138)	-2.931 (1.404)
p= .3	-1.634 (0.681)	-2.02 (0.836)	-2.212 (1.139)	-2.922 (1.404)
p = .5	-1.651 (0.683)	-2.039 (0.839)	-2.183 (1.142)	-2.95 (1.408)
p set so that selection on observables= selection on unobservables	-1.631 (0.680)	-2.017 (0.835)	-2.24 (1.138)	-2.931 (1.404)
Number of observations	6,807	6,778	6,434	6,407

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exhibit 9: Regression adjusted results (inverse probability weighting)

	Kindergarten		Third Grade		Eighth Grade	
	Any	Severe	Any	Severe	Any	Severe
Cognitive Outcomes						
Math score	-0.669 *	-1.122	-4.763 **	-4.729 **	-0.301	-9.016 *
Reading Score	-0.613	-0.326	-5.412 *	-5.565 **	-0.901	-13.834 *
Socioemotional Outcomes						
Approaches to learning	-0.047 **	-0.041	-0.089	-0.098 *		
Self-control	-0.043 **	-0.005	-0.040	-0.049		
Interpersonal skills	-0.032	-0.03	-0.079	-0.085		
Externalizing problems	0.039 *	0.055	0.056	0.06		
Internalizing problems	0.055 ***	0.063 **	0.137 **	0.146 **		

Note: Sample sizes vary by model. N~13,000 (Kindergarten); N~7,500 (3rd); N= 7,800 (8th)

Models control for school characteristics (percent minority, neighborhood problems with crime, drugs, tension, or gangs, teacher turnover, crowdedness, percent receiving free lunch, urban/rural, and school type), student characteristics (race, gender, age, birthweight, exercise, disability, and if Engligh is a second language), and family characteristics (parental involvement, education, and employment, socioemotional status, number of nights dinner is eaten together, number of children in the family, region, mother's age at child's birth, frequency of stories told and books read in the house, number of books in the house, and receipt of WIC).

*** p< 0.01, ** p< 0.05, * p< 0.1

Exhibit 10: Regression adjusted results (fixed effects)

	Kindergarten-Third Grade		Third-Eighth Grade	
	Any	Severe	Any	Severe
Cognitive Outcomes				
Math score	-1.397 **	-1.665 *	5.214	8.199
Reading Score	-1.289 *	-1.585	5.614	-3.761
Socioemotional Outcomes				
Approaches to learning	-0.048 **	-0.037	-0.135	-0.313 **
Self-control	-0.072 ***	-0.009	0.225 *	-0.360 ***
Interpersonal skills	0.056 **	0.135 ***	-0.476 ***	-0.476 ***
Externalizing problems	0.063 ***	0.123 ***	0.201 *	0.642 ***
Internalizing problems	-0.046 *	-0.056	-0.117 **	0.662 ***

Note: Sample sizes vary by model. N~10,500 (Kindergarten-3rd); N~900 (3rd-8th)

Models control for covariates that might change from one period to the next (teacher turnover, small school, socioeconomic status, parental involvement, overcrowding in school, neighborhood characteristics such as crime, drugs, gangs, and tension, parental employment, disability, percent receiving a free lunch, amount of exercise per week, family structure, age, number of nights the family has dinner together, number of children in teh family, and living in an urban location).

*** p< 0.01, ** p< 0.05, * p< 0.1

Exhibit 11: Regression adjusted results of the impact of chronic maternal depression on child outcomes (OLS)

	Depression: Kindergarten and 3rd grade **Outcome: 3rd grade**	Depression: 3rd and 8th grade **Outcome: 8th grade**	Depression: Kindegarten, 3rd, and 8th grade **Outcome: 8th grade**
Cognitive Outcomes			
Math score	-3.315 *	1.955	0.491
Reading Score	-3.032	2.912	1.785
Socioemotional Outcomes			
Approaches to learning	-0.175 ***	n/a	n/a
Self-control	-0.149 ***	n/a	n/a
Interpersonal skills	-0.185 ***	n/a	n/a
Externalizing problems	0.148 **	n/a	n/a
Internalizing problems	0.147 ***	n/a	n/a
Number of observations	Range: 8,016-8,494	Range: 6,810-6,840	Range: 6,810-6,840

Models control for school characteristics (percent minority, neighborhood problems with crime, drugs, tension, or gangs, teacher turnover, crowdedness, percent receiving free lunch, urban/rural, and school type), student characteristics (race, gender, age, birthweight, exercise, disability, and if Engligh is a second language), and family characteristics (parental involvement, education, and employment, socioemotional status, number of nights dinner is eaten together, number of children in the family, region, mother's age at child's birth, frequency of stories told and books read in the house, number of books in the house, and receipt of WIC).

*** p< 0.01, ** p< 0.05, * p< 0.1

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