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Kelly Noonan
Hope Corman
Nancy E. Reichman

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ABSTRACT

Theory suggests that adverse life events—such as unemployment or health shocks—can result in food insecurity, which has increased substantially in the U.S. over the past decade alongside the obesity epidemic. We test this proposition by estimating the effects of a specific and salient mental health event—maternal depression during the postpartum year—on child and family food insecurity. Using data from the Early Childhood Longitudinal Study—Birth Cohort, we estimate the effects of maternal depression on food insecurity using both single- and two-stage models, and explore potential buffering effects of relevant public assistance programs and supports. We find that moderate to severe maternal depression increases the likelihood that children and households experience any food insecurity—by between 50 and 80%, depending on the measure of food insecurity. We also find that maternal depression increases the likelihood of reliance on the Supplemental Nutrition Assistance Program; Supplemental Nutrition Program for Women, Infants, and Children; Medicaid; and the Temporary Assistance to Needy Families program, suggesting that these programs play a buffering role.

Kelly Noonan
Department of Economics
Rider University
2083 Lawrence Road, Room SWG 306
Lawrenceville, NJ 08648
and NBER
knoonan@rider.edu

Hope Corman
Department of Economics
Rider University
2083 Lawrenceville Road
Lawrenceville, NJ 08648
and NBER
corman@rider.edu

Nancy E. Reichman
Robert Wood Johnson Medical School
Department of Pediatrics
Child Health Institute of New Jersey
89 French St., Room 1348
New Brunswick, NJ 08903
reichmne@rwjms.rutgers.edu

Introduction

Food insecurity, which represents deprivation of an essential aspect of human well-being, has increased substantially in the U.S. over the past decade (alongside the obesity epidemic) and the reasons for this trend have not been established. In 2001, the first year that the Current Population Survey started collecting food insecurity data consistently in December of each year, 10.7% of households in the U.S. were food insecure (defined by the United States Department of Agriculture [USDA] as not having consistent access to enough food for active, healthy lives for all members) at some point in the past twelve months; that figure increased to 14.5% in 2012 (Coleman-Jensen et al., 2013). Among U.S. households with children in 2012, 10% included one or more children who experienced food insecurity (defined by the USDA as having their food intake reduced and their normal eating patterns disrupted because the household lacked money and other resources for food) in the past 12 months (Coleman-Jensen et al., 2013). Income is perhaps the strongest known correlate of food insecurity, although many poor families do not experience food insecurity and some non-poor families are food insecure (Rose, 1999; Gundersen & Gruber, 2001).

Theoretical work by Gundersen and Gruber (2001) suggests that adverse life events, such as unemployment or health shocks, may be important determinants of food insecurity. In terms of health events in particular, according to Gundersen, Kreider and Pepper (2011), "the literature on the effects of food insecurity on health outcomes has implicitly assumed that food insecurity has an influence on health outcomes, rather than the other way around. Research on the impact of health care limitations on food insecurity would be of interest, especially when the causal direction is mixed, both in terms of improved estimates of the impact of food insecurity and in terms of further delineating the causes of food insecurity (p. 298)." We address this gap by

estimating the effects of a salient and specific mental health event—maternal depression during the postpartum year—on child and family food insecurity.

Using nationally representative data from the Early Childhood Longitudinal Study—Birth Cohort, we estimate the effects of maternal depression during the postpartum year on the various measures of child and family food insecurity from the USDA Core Food Security Module (described later) using both single- and two-stage models, with the latter using severe infant health conditions and multiple births as identifiers for maternal depression. We also explore potential buffering effects of Supplemental Nutrition Assistance Program; Supplemental Nutrition Program for Women, Infants, and Children; Medicaid; and Temporary Assistance to Needy Families.

Background

Food security as a social problem

Food insecurity is an important indicator of well-being and a pressing public health issue. Because poverty can be hard to measure, it is important to look at direct measures of material hardship as indicators of well-being (Bhattacharya, Currie & Haider, 2004). Food insecurity is a hardship experienced by millions of households across the country and has been linked to current and long-term health problems. Attention to the causes and consequences of food insecurity is particularly important in light of the combined forces of the reduced safety net due to welfare reform in the 1990s, the Great Recession that began in 2008, and recent cutbacks to the Supplemental Nutrition Assistance Program.

Gundersen, Kreider, and Pepper (2011) provide an extensive review of the literature on the effects of food insecurity on health. They cite studies indicating that both children and adults living in food insecure households have greater incidence of specific health conditions such as

asthma and anemia, are more likely to have mental and behavioral problems, and have worse educational outcomes. However, few to none of the existing studies provide evidence of causal effects. That is, they do not address the possibility that there are unobserved factors associated with both food insecurity and health problems (endogeneity). Addressing this issue using data from the National Health and Nutrition Examination Survey and nonparametric bounding methods, Gundersen and Kreider (2009) found evidence that food insecurity has adverse effects on children's health status, measured as obesity and general health (excellent, very good, or good versus fair or poor). From these results, the authors inferred that previous estimates of (adverse) effects of food insecurity on health are likely downward biased. Gundersen, Kreider, and Pepper (2011) highlighted the issue of reverse causality, concluding that more rigorous research on connections between food insecurity and health is needed.

Causes of food insecurity

Poor households face serious constraints and must decide how to allocate their income in order to purchase food and other essential goods such as housing and medical care. As such, economic theory points to the importance of income as an important determinant of food security. However, according to Gundersen and Gruber (2001), it is necessary to move beyond current or average income by considering other aspects of financial wherewithal. The authors argued that unexpected negative changes to a household's budget (such as losing a job or public assistance) can make a family vulnerable to food insufficiency (a term somewhat narrower but closely related to food insecurity, as discussed by Scott & Wehler, 1998), particularly when savings are low or liquidity constraints are high. Using the 1991 and 1992 panels of the Survey of Income and Program Participation, Gundersen and Gruber found that food-insufficient households are more likely than households that are not food insufficient to experience income

shocks and that those suffering from income shocks are less likely to have liquid savings, be homeowners, and have health insurance.

Past studies of the effects of families' financial status on food insecurity and related outcomes have generally focused on the effects of job loss, income levels, assets, or income volatility, and have found that: monthly net income is associated with food security among former and current welfare recipients even when controlling for time-invariant individual-level characteristics (Corcoran, Heflin & Siefert, 2007); negative changes in monthly income from its mean increase food insufficiency, but not other hardships such as eviction and having utilities shut off (Sullivan, Turner & Danziger, 2008); negative changes in both levels and deviations in income are associated with increases in the probability of food insufficiency among non-elderly U.S. households (Leete & Bania, 2010); being sanctioned under welfare (that is, having benefits reduced or eliminated for non-compliance with work requirements or other program rules) is associated with subsequent hunger because of not being able to afford food (Reichman, Teitler & Curtis, 2005); and the macroeconomic shock of the Great Recession of 2008 did not appear to increase household hunger because of not being able to afford food (Pilkauskas, Currie & Garfinkel, 2011). Guo (2011) found that households with assets (particularly savings) are able to buffer the adverse consequences of low income with regard to food insecurity, and Gundersen and Gruber (2001) found that although income shocks and high income variance are associated with food insecurity, households with the ability to borrow can smooth their food consumption over time.

The Supplemental Nutrition Assistance Program (food stamps) was designed to alleviate the problem of hunger and food insecurity. However, studies have found that food stamp recipients are more, not less, likely than non-recipients to be food insecure (Gundersen &

Oliveira, 2001). Gundersen and Oliveira pointed to the need for employing newer methodological techniques to address (likely adverse) selection into program participation. Bartfeld and Dunifon (2006) found that states with easier access to food assistance programs have lower levels of food insecurity. Studies by Borjas (2004), Van Hook and Balistreri (2006), and Nord and Prell (2011) exploited natural experiments, such as changes in program eligibility for immigrants or temporary increases in benefits, to estimate effects of food stamps and other transfer programs on food insecurity. Collectively, this research led Gundersen, Kreider, and Pepper (2011) to conclude that food stamps do reduce (but certainly do not eliminate) food insecurity. Overall, the literature suggests that food stamps and other programs are partial buffers against food insecurity, although endogeneity and measurement error continue to present estimation challenges (Gundersen & Kreider, 2008; Gundersen & Ribar, 2011).

The importance of mental health

The prevalence of mental health problems makes investigation of their effects particularly important. According to data from the 2009 Behavioral Risk Factor Surveillance System, about one-third of individuals answered at least "one" to the question, "…Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" (CDC, 2010). In addition, more than one in thirteen individuals in the U.S. aged 12 years and older experienced depression in the past two weeks (measured in 2007–2010) , with women more likely to experience depression than men and working-aged adults more likely to experience depression than children or senior citizens (Pratt, 2008). While untreated mental health problems can severely compromise the quality of life of those afflicted and potentially their families and

communities, there are effective treatments for many types of mental illness, particularly depression (Farr et al., 2011).

According to Almlund et al. (2011), non-cognitive traits are as important as cognitive ability in determining economic success, and according to Layard (2013), mental health is an understudied form of human capital despite evidence that it is a major factor affecting productivity and well-being. While several methodologically rigorous studies have investigated the effects of mental health on labor market outcomes (and by inference, income), few have investigated effects of mental health problems on household production and decision-making.

Four studies using the National Comorbidity Survey found that mental health disorders, including depression, reduce the likelihood that women are in the labor force and that they are employed—Banerjee et al. (2013), using a structural modeling approach; Chatterji et al. (2011), bivariate probit models; Marcotte, Wilcox-Gok and Redmon (2000), instrumental variables models; and Ettner, Frank, and Kessler (1997), a latent variable approach. These findings are consistent with other studies, all of which used instrumental variables techniques, by Frijters, Johnston, and Shields (2010) using Australian Household Labour Dynamics data; Ojeda et al. (2010), the National Household Survey of Drug Use and Health; and Teftt (2012), Behavioral Risk Factor Surveillance System data. Nelson and Kim (2011), using a propensity score matching technique with Medical Expenditure Panel Survey data, found that employed individuals with mental illness are more likely to lose their jobs. Marcotte, Wilcox-Gok, and Redmon (2000) and Marcotte and Wilcox-Gok (2003) also found, using data from the National Comorbidity Study and an instrumental variables approach, that women with depression have lower earnings and that the earnings penalty from depression is greater for those with lower incomes. However, using data from the National Longitudinal Survey of Youth and estimating

fixed-effects models, Cseh (2008) found that although depressed individuals have lower wages than non-depressed peers, a change in depression status did not correspond to a wage change. Berndt et al. (1998), using data from a clinical trial, found improvements in self- perceived productivity as a depressive symptoms were reduced, suggesting that depression negatively affects productivity on the job.

Mental health and food insecurity

Siefert et al. (2000), Carter et al. (2011), Heflin, Siefert and Williams (2005), Casey et al. (2004) and others all found positive associations between mental health problems and food insecurity. Unlike the recent literature on mental health and labor market outcomes described above, these studies did not attempt to model causality or address potential endogeneity. An exception, a study by Heflin and Ziliak (2008), used a fixed effects approach with two waves of the Panel Survey of Income Dynamics. The fixed effect approach allows the authors to address potential sample heterogeneity, but does not necessarily address the potential for reverse causality. These authors found some evidence that food insufficiency causes emotional distress. However, as argued by Casey et al. (2004) and others, it is difficult to establish causal relationships (and their direction) in this literature.

In a very recent study, Dahal and Fertig (2013) used data from the Panel Study of Income Dynamics to estimate effects of mental illness on spending behavior, addressing the potential endogeneity of mental illness by estimating two-stage and fixed-effects models. They found that women with mental health problems spend more on a variety of consumer goods, but less on investments such as education. They attributed this pattern of spending to a hypothesized process of "retail therapy" akin to self-medication. For low income women, this phenomenon might translate to poorer budget management and not being able to afford food at some point in their

budget cycle.

As far as we know, no previous studies have attempted to estimate the causal effects of mental illness, or depression in particular, on food insecurity, despite evidence that the two are correlated, that depression reduces labor force participation (and, by inference, earned income), that depression appears to lower productivity on the job (and, by extension, potentially in the household), and that mental illness affects women's spending patterns. We address this gap in the literature by estimating the effects of a salient and specific mental health event—maternal depression during the postpartum year—on child and family food insecurity. Postpartum depression, which is generally defined as moderate to severe depression in a woman after she has given birth, is experienced by 10–20% of all childbearing women within 6 months of delivery (Miller, 2002). Symptoms include despondent mood, changes in sleeping and eating patterns, feelings of inadequacy as a parent, and impaired concentration (Miller, 2002). Postpartum depression has at least some random component according to the medical community (O'Hara & Swain, 1996) and often has lingering effects well beyond the 6 month period (Vliegen, Casalin & Luyten, 2014). This particular health event—to mothers of very young children—has been causally linked to parents' relationship dissolution (Reichman, Corman & Noonan, 2014), as well as to homelessness and housing problems that are often precursors to homelessness (Curtis et al., 2013). Homelessness has been linked to food insecurity with some evidence of a causal link from the former to the latter (Gundersen et al., 2003).

Theoretical framework

Following Gundersen and Gruber (2001), we consider a household utility-maximization model, wherein utility is a function of food and other goods (Eq. 1), subject to budget constraints based on current assets (Eq. 2) and current income (Eq. 3):

(1) $U_t = U(F_t, OGt)$

(2) $A_t = A_{t-1} + Y_{t-1} - p_{Ft-1}F_{t-1} - p_{OGt-1}OG_t - _1$

(3) $Y_t = w_tL_t + Y_{ot} + Y_{TRt}$

Assets in the current period (A_t) are a function of the past period's assets (A_{t-1}), the past period's income (Y_{t-1}), the past period's food expenditures (the price times the quantity of food), and the past period's expenditures on other goods (the price times the quantity of other goods). Income can have three sources: own earnings based on the wage (w) and the number of hours worked (L), other income (Y_{ot}), and transfer income (Y_{TRt}). Food insecurity occurs when income and assets are insufficient for obtaining adequate food plus other needed or desired goods, and the household allocates its resources such that adequate food intake is not achieved. Based on this model, Gundersen and Gruber considered a number of factors that may affect a household's propensity to experience food insufficiency (which, as mentioned earlier, is related to food insecurity)—low average income, negative income shocks such as loss of employment or earnings, having a spouse leave, moving, lack of savings, and access to borrowing. Gundersen and Oliveira (2001) noted another (generally unobserved) factor—the householders' skills at budgeting. This specific form of human capital may be correlated with education, but there could be variation in budgeting skills even holding education constant.

Following the Gundersen/Gruber model, we posit that a household's propensity for experiencing food insecurity is a function of past savings/assets, current income, prices of food and other goods, the householder's budgeting efficiency (BEt), and the household's access to credit (CRt).

(4) $FI_t = g(A_{t-1}, Y_t, p_{F,} p_{OG}; BE_t, CR_t)$

We would expect the mother's depression to have a negative effect on her income based

on the literature, discussed above, demonstrating that depression and mental health problems more generally reduce women's employment and productivity, and recent findings that depression during the postpartum year in particular leads to relationship dissolution (which likely has negative income ramifications) and risk for homelessness (which has been related to food insecurity). Depression could also result in a depreciation of one's budgeting efficiency to the extent that it compromises mental processing (see Berndt et al. 1998) or induces retail therapy (see Dahal & Fertig, 2013).

Gundersen and Oliveira (2001) modeled the decision to participate in the food stamps program as a function of earned and other income, expected benefits from the program (which is a function of income and family size), and the cost of participation in the program. In this framework, which can be applied to other form of public assistance, Gundersen and Oliveira considered as costs the potential stigma of participating in the program, which may particularly acute for food stamps; search for information on how and where to apply for benefits; and burdens associated with enrollment and maintenance of eligibility. Holding constant earned and other income, we would expect participation to increase overall income and therefore reduce food insecurity—as long as the benefits of the increased income outweigh the relevant costs.

Data

The Early Childhood Longitudinal Study—Birth Cohort (ECLS-B) is a nationally representative panel study of over 10,000 children born in the United States in 2001. Births were sampled from Vital Statistics records and consist of children born in 2001 who were alive at 9 months, had not been placed for adoption, and were born to mothers aged 15 years or older (Bethel et al. 2005). Twins, low birthweight infants, and American Indian/Alaskan Natives and Asian/Pacific Islanders were oversampled. The initial (baseline) survey was conducted when the

child was 9 months old, and follow-up surveys were completed at 2, 4, and 5 years (the 4 and 5 year follow-up data are not used in our study). Additionally, the ECLS-B includes detailed data on maternal and infant health from the infants' birth records (as recorded in the Standard Certificate of Live Birth). Data can be weighted to produce nationally representative results, although the analyses we present in this paper are based on unweighted data in order to capitalize on the oversampling of multiple births as described below.

We investigate the effects of the mother's depression (assessed when the child was 9 months old) on various measures of child and household food insecurity at the 2-year follow-up using the USDA Core Food Security Module (see Coleman-Jensen et al. 2013 for a full description of the module and measures), which was embedded in the mother's 2 year interview. We thus limit the sample to cases for which we have 2-year follow-up data. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality. Of the 10,500 participants in the ECLS-B (all of whom had birth certificate data), 9,600 completed the 2-year follow-up survey. Of those, 1,500 respondents were dropped from the analyses owing to missing data on maternal depression, which was assessed in a separate self-administered questionnaire, and another 200 cases were dropped owing to missing data on other analysis variables, leaving an analysis sample of 7,900 cases. Those in our analysis sample were less likely to be non-Hispanic black, less likely to be Hispanic, less likely to be Asian, less likely to be foreign born, less likely to have a birth covered by Medicaid or other public insurance, more likely to have been employed, and more likely to be married than those not in our sample. The selection into our sample of those who are less disadvantaged, and therefore at decreased risk for experiencing food insecurity, may lead to downward biased estimated effects of maternal depression on food insecurity. That is, because more disadvantaged

women are closer to the margin for experiencing food insecurity, this additional health event may push them "over the edge." We test this hypothesis in supplemental models described later.

The ECLS-B is highly appropriate for studying the effects of maternal depression during the postpartum year on child and household food insecurity because it: (1) is a nationally representative, panel data set with a large sample size; (2) includes information on maternal depression and household food insecurity collected using widely-used and accepted standardized instruments; (3) allows us to measure both maternal depression and food insecurity at relevant time points; (4) includes a rich set of relevant control variables, including the mother's own mother's history of depression; (5) includes state indicators, allowing us to control for potentially confounding factors at the state level; and (6) oversampled multiple births (normally a relatively rare event), allowing us to use multiple birth as an identifier for maternal depression, as described below.

Methodological Approach

In modeling the impact of maternal depression in the postpartum period on subsequent food insecurity, we estimate a reduced form version of Eq. 4, generalized as follows:

(5) $FI_t = h(M_{t-1}, C_{t-1}, S_{t-1}, D_{t-1})$.

Food insecurity in the current period is a function of the mother's (M) and child's (C) characteristics before experiencing the depression, prices and program environments (proxied by a state indicator, S_{t-1}), and whether the mother experienced depression during the postpartum year (D_{t-1}). The estimated effect of D in this specification will be unbiased as long as maternal depression is an exogenous shock, or a random event. However, it is difficult to operationalize mental illness as a shock. Indeed, as discussed earlier, few existing studies have isolated causal relationships between physical or mental health and food insecurity, in either direction, precisely

because identification opportunities are scarce. We take an important step in addressing this gap by exploiting a mental health event—maternal depression during the postpartum year—which is thought to have at least some random component according to the medical community, and observing its effects on subsequent food insecurity. According to O'Hara and Swain (1996), postpartum depression (which is related to—but not one and the same as—depression during the postpartum year, as discussed below under "Measures") is unrelated to many sociodemographic characteristics, but strongly associated with having a history of psychopathology. We explore the extent to which this is the case in our sample, include the maternal grandmother's history of depression in our models in addition to detailed sociodemographic characteristics, and estimate two-stage models to address the potential endogeneity of maternal depression.

In the first set of analyses, we estimate multivariate probit models of the effects of maternal depression (assessed at 9 months) on various measures of food insecurity at 2 years, controlling for a host of potentially confounding variables (Eq. 5). Although the ECLS-B includes the USDA Core Food Security Module in every wave, we focus on food insecurity at 2 years in order to be confident that the depression precedes the food insecurity (which would not be the case if we focused on food insecurity at 9 months) but not by so much time that effects, if any, may be missed (which could be the case if we focused on food insecurity at 4 or 5 years). We consider a number of different model specifications in order to assess robustness of our results and explore patterns in our estimates.

In the next set of analyses, we estimate 2-stage models that use whether the birth was a multiple and whether the infant had a serious health condition as identifiers for depression during the postpartum year and conduct relevant statistical tests. In prior research, we identified infant health conditions that are potentially associated with long-term morbidity, but are unlikely

related to maternal behaviors (see, e.g., Curtis et al. 2013). We relied on the coding of specific health conditions by an outside pediatric consultant who was directed to classify each condition listed in infants' medical records vis-à-vis degree of severity (in terms of expected significant long-term morbidity) and likelihood, according to the medical community, of having been caused by parental behavior. The goal was to capture severe conditions that are for the most part random (e.g., Down Syndrome, congenital heart malformations), given that the pregnancy resulted in a live birth. We applied this coding to information contained in the birth certificate module of the ECLS-B to create a measure of "moderate or severe health condition" as described in Appendix Table 1.

While few studies have investigated the effects of newborn characteristics on mother's depression, a previous study using the ECLS-B found that multiple birth is associated with depression during the postpartum year (Choi, Bishai & Minkovitz, 2009) and another found that mothers of high risk very low birthweight infants (those diagnosed with bronchopulmonary dysplasia) reported more psychological distress (based on the Brief Symptom Inventory Scale) than mothers of term infants at 1 month and 2 years postpartum (Singer et al., 1999). These findings provide some support for our use of multiple birth and poor child health as identifiers. Of course, we will test for the predictive strength of these variables, as well as the necessary exclusion restrictions (that is, whether the variables being used as identifiers are associated with food insecurity only through maternal depression) and whether the error term in the maternal depression equation is uncorrelated with the error term in the food insecurity equation.

Finally, we explore the potential buffering effects of the Supplemental Nutrition Assistance Program (SNAP); Supplemental Nutrition Program for Women, Infants, and Children (WIC); Medicaid; and the Temporary Assistance to Needy Families (TANF) program by

modeling participation in each program (at 2 years) using the same right-hand-side variables as in Eq. 5. That is, we explore whether maternal depression during the postpartum year is associated with participation in the various programs at 2 years. Finding positive associations (that maternal depression appears to increase participation in a given program) would suggest that the programs are mitigating, at least to some extent, adverse effects of maternal depression on food insecurity. This set of analyses is considered preliminary and descriptive because we do not address the endogeneity of maternal depression in the models of program participation.

Measures and descriptive analysis

The means for all analysis variables other than the mother's state of residence are shown in Table 1, both for the sample as a whole and by one of two measures of maternal depression during the postpartum year (described later) that we use. Below we discuss the overall characteristics of the sample and then the differences in those characteristics by whether the mother had depression.

Food insecurity

We use the USDA Core Food Security Module, which consists of 18 different questions about food hardship during the past year, to create measures of food insecurity of children and of households at 2 years. Per USDA definitions, children are considered to have very low food security if the mother gave affirmative responses to 5 or more of the 8 questions pertaining to children, and low food security if the mother gave affirmative responses to 2, 3 or 4 of the 8 questions. Owing to small sample sizes, we combine very low and low food insecurity, which together, apply to 3.9% of the children in our sample, in our multivariate analyses.

Also per USDA definitions, households are considered to have: (1) very low food security if the mother responded affirmatively to 8 or more of the 18 questions in the Core Food

Security Module, (2) low food security if she responded affirmatively to 3 to 7 of the questions, and (3) marginal food security if she responded affirmatively to 1 or 2 questions. In our sample, 1.7% of the households experienced very low food security, 6.8% experienced low food security, and 8.0% experienced marginal food security during the year preceding the 2-year interview. These figures are lower than the national figures from Nord, Andrews and Carlson (2004), who reported that, about 17% of households with children in 2003 were low or very low food insecure. However, according to Snow et al. (2009), households with very young children (as in the ECLS-B) have lower levels of food insecurity than households with older children. In our models, we use two measures of household food insecurity—the first combines very low and low household food security as defined above, and the second combines all three categories (very low, low and marginal household food insecurity).

Maternal depression during the postpartum year

Maternal depression was assessed at 9 months using an abbreviated form of the Center for Epidemiological Studies Depression (CES-D) Scale that assesses depressed affect, positive affect, somatic symptoms, psychomotor retardation, and interpersonal activity (Radloff 1977). The instrument contains 12 items with each item coded on a 4-point scale between 0 and 3, with each of the symptoms occurring never (a score of zero), 1–2 days (score of 1), 3–4 days (score of 2), or 5–7 days (score of 3), with the range of total scores being 0 to 36. Using cutoff scores provided by the ECLS-B, a score of 15 or more suggests severe depression and a score of at least 10 suggests moderate or severe depression. Approximately 7% of the mothers in our sample are characterized as experiencing severe depression during the week preceding the 9-month interview and approximately 18% of the mothers are characterized as experiencing moderate or severe depression. We use the latter as our main measure of maternal depression, but perform

supplementary analyses using the more stringent measure.

It is important to point out that the measures of maternal depression based on the CES-D do not capture postpartum depression per se (which is generally based on the first 6 months after childbirth) or an actual diagnosis. Rather, these measures characterize maternal depression at a specific point during the postpartum year (when the focal child was 9 months old) based on one of a number of different instruments that are used in the literature to assess postpartum depression from surveys. According to a very recent review article about the course of postpartum depression, the 0 to 6 month time interval typically used to assess postpartum depression may be overly rigid, as 30–50% of mothers with postpartum depression continue to have major depression during their child's first year of life and even beyond (Vliegen, Casalin & Luyten, 2014). As such, our measures of maternal depression during the postpartum year likely capture many cases of conventionally-defined postpartum depression, which is an unexpected event for many mothers (O'Hara and Swain, 1996). However, because our measure does not conform to the 0–6 month period after childbirth, we refrain from referring to our CES-D-based measures as postpartum depression. Rather, we refer to these measures as "maternal depression," "depression during the postpartum year," or "maternal depression during the postpartum year."

Other analysis variables

Multivariate models include a basic set of sociodemographic characteristics of the mother—age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian or Pacific Islander, Native American), nativity (foreign born), education (less than high school, high school graduate, any college), marital birth, whether the birth was covered by Medicaid or other public insurance (proxy for poverty), whether the mother was employed during the 12 month preceding the child's birth, whether the mother lived with both of her own parents at age 16 (proxy for family structure and hardship growing up), and urbanicity (densely populated urban area, less

densely populated urban area, non-urban area, as classified by the ECLS-B based on U.S. Census categories). We also include number of children under 18 in the mother's household at the time of the birth, proxied by a measure of the number of other children in the household at 9 months minus 1 or more for the focal child and his/her multiple birth siblings. Most models also include indicators for the mother's state of residence at the time of the birth in order to control for state policies or other potentially confounding state-level factors (states with fewer than 100 observations are grouped together in a single indicator). All models include the child's sex.

Mothers were about 28 years old, on average, at the time the focal child was born. Over half (53%) of the mothers were non-Hispanic white, 16% were non-Hispanic black, 14% were Hispanic, 12% were Asian or Pacific Islander, and 5% were American Indian. Over half of the mothers had attended at least some college. Over two-thirds (68%) of the mothers were married at the time of the birth, and there was about one other child the household on average. About one third of births were covered by Medicaid or other public insurance. The majority of mothers (73%) worked within the 1-year period preceding the child's birth. Only 58% of mothers lived with both of their parents when they were 16 years old. Most mothers lived in urban areas (71% in densely populated urban areas and 13 percent in less densely populated urban areas).

Because mental illness is often associated with physical illness and the directionality is not always clear (Prince et al., 2007), we include a measure of the mother's physical health at the time of the birth—whether the mother had any prenatal medical risk factors (such as cardiac disease) as reported on the birth certificate. Eight percent of the mothers in the sample had a prenatal medical risk factor.

Finally, in certain models we include a measure of the mental health history of the mother's own mother (the child's maternal grandmother). Mothers were asked the following

question at the 2-year survey, "Now thinking about your relatives, whether they live with you or not, have you or any of your blood relatives ever had …Major Depression?" If the answer to this question was yes, the mother was asked which relative had the given condition. Seven percent of the mothers in the sample had mothers with a history of major depression. This measure is intended to capture the mother's family-related (genetic or environmental) predisposition for depression. It is possible that depression during the postpartum year is less of a shock for mothers, whose own mothers had a history of depressive symptoms, making this measure an important control variable. However, if the mother's depression and her mothers' history of depressive symptoms are highly correlated, including the measures of the mother's parents' depressive symptoms might lead to underestimated effects of the mother's depression. As such, we include these measures in some models and not others and interpret our findings accordingly.

Most of the covariates—maternal age, race/ethnicity, nativity, education, marital status and prenatal physical health condition, state of residence, and the child's sex—are measured from birth certificate module to ensure that these characteristics preceded the birth and therefore the maternal depression if that occurred. Whether the mother was employed 12 months prior to birth, whether her prenatal care was financed through Medicaid, and whether she lived with both of her parents at age 16 were measured retrospectively at 9 months, but apply to the period preceding the birth. Whether the mother lived in a densely populated urban area, a less-densely populated urban area, or a non-urban area and the number of children in the household were measured at 9 months. The grandmother's history of depression were all assessed at 2 years, but in many—if not most—cases these measures would be the same if they had been collected at the time of the birth (i.e if the grandmother did not have a first episode of depression between the birth and the 2-year interview). By definition, the child's age at the time of food security

assessment was measured at time of the 2-year survey. As mentioned earlier, we use two additional variables in bivariate probit models as identifiers for maternal depression—multiple birth and moderate or severe infant health condition, which was based on data from the birth certificate module as described earlier.

Differences in sample characteristics by maternal depression

There are clear differences in characteristics between mothers who had depression during the postpartum year and those who did not. Those who had depression were younger, less likely to be non-Hispanic white, more likely to be non-Hispanic black, less likely to be foreign born, less educated, less likely to be married at the birth, more likely to have births covered by Medicaid or other public insurance, and less likely to have lived with both parents at age 16. This result is at odds with the findings by O'Hara and Swain (1996) that postpartum depression (as more typically measured) is unrelated to many socioeconomic characteristics. This systematic pattern of less advantaged mothers being more likely to experience depression during the postpartum year underscores the importance of addressing the potential endogeneity of maternal depression through means other than statistical adjustment, such as two-stage models. As expected based on O'Hara and Swain and many others, the maternal grandmother's history of depression is strongly associated with the mother's depression during the postpartum year, pointing to this measure as an important control variable.

Multivariate Analysis

Single equation models

Table 2 presents probit estimates of the effects of maternal depression on the probability of child and household food insecurity at 2 years. For each of the three food insecurity outcomes and each of the two measures of maternal depression (moderate or severe depression and severe

depression, as described earlier), we present the estimated effects of maternal depression from four different probit models (altogether, from 24 different models). Model 1 includes no covariates. Model 2 includes child's characteristics plus all of the maternal characteristics in Table 1 other than the maternal grandmother's history of depression. Model 3 includes all of the variables in Model 2 plus the grandmother's history of depression, which we argued earlier is conceptually an important control variable, but due to its strong correlation with the mother's depression, could potentially pick up some of the effects of the mother's depression. Model 4 includes all of the variables in Model 3 plus state indicators. Each cell contains the probit coefficient, the standard error which is corrected for state clustering of observations using the Huber-White method (in parentheses), and the marginal effect [in brackets].

In all models, maternal depression significantly increases the likelihood of food insecurity. The marginal effect size generally declines as more covariates are added, with the biggest declines between Models 1 and 2 (when adding all control variables other than grandmother's history of depression and state indicators). That is, once the large set of control variables, most of which are sociodemographic, are included, the strong association between maternal grandmother's history of depression and the mother's depression during the postpartum year for the most part disappears (alleviating our concerns about potentially over-controlling), and the state indicators also do not affect the estimates. For both child and household low or very low food insecurity, the estimates are uniformly higher when using the more stringent measure of maternal depression, suggesting a dose-response relation.

The effect sizes are very large—e.g., in the most adjusted model (Model 4), moderate or severe maternal depression increases the likelihood that the children and families will be food insecure by 76% and 65% (relative to the relevant sample means), respectively. The effect size is

somewhat smaller when using the broader measure of household food insecurity (53%). In additional analyses (results not shown, but available on request), we tested our hypothesis, stated earlier, that the effects of maternal depression on food insecurity are stronger for more disadvantaged women. Specifically, we estimated the effects of moderate or severe maternal depression on the three food insecurity outcomes from Table 2 along three dimensions of socioeconomic disadvantage—marital status, health insurance for the birth, and education. Specifically, we estimated and compared the effects of maternal depression on food insecurity for subsamples of mothers who were married versus unmarried, who had Medicaid or other publicly insured births versus privately insured births, and who had any college education versus a high school education or less For all three outcomes, we found that the effects of maternal depression on food insecurity were stronger for the more disadvantaged group (unmarried, Medicaid or other public insurance, high school education or less) than for the comparison group, providing support for our hypothesis.

Table 3 presents the full probit results for Model 4 from Table 2, using the measure of moderate or severe depression, for all three measures of food insecurity (corresponding results from all other models in Table 2 are available from the authors upon request). Estimates for the state identifiers are not presented. Racial and ethnic differences are usually significant, and lower education and poverty (proxied by Medicaid-financed birth) and additional children in the household strongly and significantly increase the likelihood of food insecurity, while having lived with both parents at age 16 decrease the risk of food insecurity. It is notable that all of the health variables are significant predictors of household food insecurity. Not only does maternal depression during the postpartum year have strong associations with food insecurity, but a prenatal physical health condition increases the likelihood of household food insecurity and the

maternal grandmother's history of depression is a strong independent predictor of both child and household food insecurity.

Two-stage models

The accuracy of the estimates presented thus far, from single-equation models, depends on the degree to which maternal depression during the postpartum year is an exogenous shock. Our results in Table 1 suggest that this may not be the case even with our extensive control variables, which substantially reduced the estimated effects of maternal depression on food insecurity. To further investigate the potential endogeneity of maternal depression, we estimate 2-stage (bivariate probit) models that use multiple birth and moderate or severe infant health conditions as identifiers for depression during the postpartum year. Both of these infant-related factors are significantly associated with maternal depression, as we saw in Table 1.

We explored the appropriateness of the two identifiers in several different ways. First, we relied on previous research, discussed earlier, to confirm that these two variables have been linked to mother's subsequent mental health. Second, we ran supplementary models of the effects of moderate or severe depression on the three measures of food insecurity that corresponded to Model 4 from Table 2 but also included the two identifiers, and found that multiple birth and poor infant health were not independently associated with food insecurity. Third, we estimated the same models just described but that excluded mothers with moderate or severe depression and found no direct associations between the two identifiers and food insecurity in this mentally healthy cohort. These results provide further evidence that the two child-related identifiers are related to food insecurity only through maternal depression.

Results from the bivariate probit models, which estimate maternal depression in the postpartum year (using the moderate or severe measure) in the first stage and household food

insecurity in the second stage, are presented in Appendix Table 2, for all three measures of food insecurity. These results indicate that: (1) the two identifiers are jointly significant predictors of maternal depression (chi-square joint significance tests), (2) the two identifiers are excludable from each outcome equation (exclusion tests), and (3) the error term in the maternal depression equation is not significantly correlated with the error term in the outcome equation, for either outcome (Wald test of Rho=0), suggesting that our fully-adjusted single-equation estimates of the effects of maternal depression on food insecurity are not biased (that is, that they account for all relevant confounding factors).

Potential buffering effects of food and cash assistance programs

Given the literature reviewed earlier, there are good reasons to believe that women with maternal depression are more likely than those without depression to have gaps in income due to reduced labor force activity. This would increase their need for, and possibly make them qualified for, a range of public support programs. However, as discussed earlier in the context of the theoretical model, depression may reduce women's ability to apply and maintain eligibility. Thus, it is unclear whether maternal depression would increase, reduce, or have no net effect on program participation. For the programs to buffer the effects of maternal depression on food insecurity, maternal depression would have to increase program participation; we explore this question as a first step in trying to understand the potential roles that the programs play in buffering the effects of maternal depression on child and household food insecurity.

We consider the potential effects of maternal depression during the postpartum year on food assistance through the Supplemental Nutrition Assistance Program (SNAP, or food stamps) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program; health care coverage through Medicaid; and cash assistance through the Temporary

Assistance to Needy Families (TANF) programs. In Table 4, we present estimated effects of maternal depression during the postpartum year—for the full sample, for the subsample of mothers at or below 185% of poverty at 9 months, and for the subsample of mothers at or below poverty at 2 years—on participation in each of the four programs from models that include the same set of covariates as in Table 3. Covariates estimates for the full sample are presented in the Appendix Table 3. Because we do not explicitly address the potential endogeneity of maternal depression in these analyses, the results should be interpreted with caution vis-à-vis causal inferences.

We find that maternal depression is significantly and positively related to participation in all four programs for the full sample, implying that increased need for support among depressed mothers outweighs a possible reduced ability to navigate the system. Effect sizes are similar for all four programs, varying from 17% for WIC to 25% for Medicaid (considering the marginal effects relative to the relevant sample program participation means). When limiting the sample to poor women, we find that the estimated effects of depression on SNAP and TANF participation (17 to 19%) are similar to those for the full sample, but that depression is no longer associated with WIC participation and is much less associated with Medicaid participation that it was in the full sample (effect size declines to about 10%). We infer from the estimates in Table 4 that families with depressed mothers would have had worse food security outcomes in the absence of public support programs, and that the SNAP and TANF programs appear to be particularly important in buffering food insecurity effects of depression among poor mothers. The covariate estimates are consistent with expectations in terms of directionality and relative magnitudes, both against other covariates and across program participation outcomes.

Conclusion

Using nationally representative data from the Early Childhood Longitudinal Study—Birth Cohort, we found robust evidence that a health shock in the family—maternal depression during the postpartum year—is strongly associated with child and household food insecurity approximately 3–15 months later. The effects are stronger for more disadvantaged women, who are at greater risk for food insecurity to begin with. As far as we know, this study represents the first strong test of the Gundersen and Gruber model as applied to a health shock. While we know from much past literature that food insecurity affects health, the findings from this study demonstrate that health can also affect food insecurity and that, more generally, health and socioeconomic status are intertwined into an intricate knot and cannot be characterized as a "one way street." We found less direct—and therefore suggestive—evidence that maternal depression increases the likelihood of participation in SNAP, WIC, Medicaid, and TANF, and therefore that these programs appear to buffer the effects of health shocks on food hardship.

Future research is needed to complement the findings of this study by investigating the effects of other types of health shocks, as well as the importance of timing of those shocks, on individuals' and family members' food-related hardship at various stages of the lifecourse. Rigorous research is also needed to obtain better estimates of the buffering effects of the various public support programs in the context of maternal depression on food insecurity among children and households, as well as vis-à-vis other health shocks and contexts (e.g., a mental health shock to a child on his/her siblings; a physical health shock to a middle-aged individual on the food insecurity of his/her elderly parents).

From a policy perspective, the findings have implications for the targeting of programmatic interventions and underscore the importance of communication and coordination

between healthcare providers, social service agencies, and public support programs. For example, maternal depression screening by pediatricians in the perinatal and postpartum is currently recommended by the American Academy of Pediatrics' Bright Futures Initiative and Task Force on Mental Health. Such family-centered practices, along with cooperation and referrals between pediatricians, maternal healthcare providers, and public support programs that provide food, healthcare, and cash assistance, have the potential to improve both health and household food security in the United States.

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Table 1: Sample Characteristics

	Full Analysis Sample (N = 7,900)	Had Maternal Depression at 9 Months (N = 1,400)	Did Not Have Maternal Depression (N = 6,500)
Food Insecurity (measured at 2 years)			
Low food security—children	.04***	.08	.03
Very low food security—children	<.01**	<.01	<.01
Low food security—household	.07***	.12	.06
Very low food security—household	.02***	.04	.01
Marginal food security—household	.08***	.11	.07
Maternal Characteristics			
Age, in years	27.6***	26.1	27.9
	(6.3)	(6.4)	(6.2)
Non-Hispanic white *(reference category in regression models)*	.53***	.48	.54
Non-Hispanic black	.16***	.24	.14
Hispanic	.14**	.12	.14
Asian or Pacific Islander	.12**	.11	.13
American Indian	.05**	.06	.05
Foreign born	.20***	.16	.21
< High school graduate	.17***	.24	.16
High school graduate	.30***	.38	.29
Any college	.52***	.37	.56
Marital birth	.68***	.53	.71
Number of other children in the household	1.06***	1.17	1.03

Medicaid birth	.33***	.49	.29
Employed at all during year prior to the birth	.73***	.68	.74
Lived with both parents at age 16	.58***	.48	.60
Lives in less densely populated urban area	.13	.13	.13
Lives in densely populated urban area	.71*	.69	.71
Lives in non-urban area *(reference category in regression models)*	.16*	.18	.16
Prenatal physical health condition	.08	.08	.08
Own mother had history of depression	.07***	.11	.06
Child Characteristics			
Male child	.51	.51	.51
Child's age, in months, when outcome was measured	24.5	24.5	24.5
	(1.3)	(1.4)	(1.3)
Identifiers (used only in 2-stage models):			
Multiple birth	.17**	.19	.17
Infant health condition	.10***	.13	.09
Program participation (measured at 2 years)			
SNAP	.21***	.35	.18
WIC	.41***	.55	.37
Medicaid	.34***	.51	.30
TANF	.08***	.13	.06

Notes: All figures are proportions unless indicated otherwise. *** p <0.01; ** p <0.05; * p <0.10 for significant differences between mothers with and without depression. Figures are unweighted. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality. SNAP = Supplemental Nutrition Assistance Program. WIC = Supplemental Nutrition Program for Women, Infants, and Children; TANF = Temporary Assistance to Needy Families.

Table 2: Effects of Maternal Depression on Food Insecurity at 2 Years Using Alternative Measures and Model Specifications (N = 7,900)

	No Covariates (1)	Basic Covariates (2)	Basic Covariates + Grandmother's Depression (3)	Basic Covariates + Grandmother's Depression + State Indicators (4)
	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]
Moderate or Severe Maternal Depression (at 9 months)				
Low or Very Low Food Security—Child	.520*** (.057) [.057]	.430*** (.060) [.036]	.422*** (.060) [.035]	.425*** (.062) [.031]
Low or Very Low Food Security—Household	.524*** (.046) [.098]	.390*** (.049) [.060]	.380*** (.049) [.058]	.391*** (.050) [.055]
Low, Very Low, or Marginal Food Security—Household	.494*** (.040) [.139]	.362*** (.043) [.090]	.352*** (.043) [.087]	.362*** (.044) [.087]
Severe Maternal Depression (at 9 months)				
Low or Very Low Food Security—Child	.681*** (.074) [.092]	.560*** (.076) [.057]	.547*** (.076) [.055]	.553*** (.078) [.049]
Low or Very Low Food Security—Household	.673*** (.064) [.146]	.534*** (.067) [.094]	.519*** (.067) [.091]	.527*** (.069) [.086]
Low, Very Low, or Marginal Food Security—Household	.521*** (.059) [.155]	.366*** (.062) [.095]	.351*** (.062) [.091]	.354*** (.064) [.089]

Notes: *** p <0.01; ** p <0.05; * p <0.10. SE = Standard Error. ME = Marginal Effect. Basic Covariates include all Maternal Characteristics from Table 1 other than maternal grandmother's depression, plus the focal child's sex and age at the time of the 2-year interview. Estimates are unweighted. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality.

Table 3: Effects of Moderate or Severe Maternal Depression on Child and Household Food Insecurity (N = 7,900)

	Low or Very Low Food Security—Child	Low or Very Low Food Security—Household	Low, Very Low, or Marginal Food Security—Household
	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]
Moderate or severe depression (9 months)	.425*** (.062) [.031]	.391*** (.050) [.055]	.362*** (.044) [.087]
Mother's age, in years	.008*** (.006) [.000]	-.002 (.004) [-.000]	-.008 (.004) [-.002]
Non-Hispanic black	.251*** (.084) [.016]	.155** (.068) [.020]	.183*** (.058) [.042]
Hispanic	.344*** (.100) [.024]	.089 (.080) [.011]	.129** (.066) [.029]
Asian or Pacific Islander	-.177 (.149) [-.008]	-.310*** (.112) [-.020]	-.300*** (.086) [-.056]
American Indian	.230** (.116) [.015]	.153 (.097) [.020]	.179** (.082) [.042]
Foreign born	.157 (.098) [.009]	.168* (.078) [.021]	.265*** (.063) [.062]
High school graduate	-.095 (.074) [-.005]	-.072 (.061) [-.008]	-.086* (.051) [-.018]
Any college	-.369*** (.090) [-.021]	-.223*** (.072) [-.026]	-.365*** (.060) [-.079]
Marital birth	.052 (.074) [.003]	-.012 (.058) [-.001]	-.080* (.048) [-.017]

Number of other children in the household	.120*** (.020) [.007]	.080*** (.018) [.009]	.092*** (.015) [.020]
Medicaid birth	.349*** (.072) [.022]	.532*** (.058) [.072]	.375*** (.047) [.086]
Employed at all during year prior to the birth	.044 (.063) [.002]	.026 (.050) [.003]	.045 (.042) [.009]
Mother lived with both parents at age 16	-.118** (.060) [-.007]	-.156*** (.048) [-.019]	-.144*** (.039) [-.031]
Lives in less densely populated urban area	.153 (.099) [.009]	.122 (.078) [.015]	.111* (.066) [.025]
Lives in densely populated urban area	.029 (.084) [.002]	-.019 (.066) [-.002]	-.018 (.056) [-.004]
Prenatal physical health condition	.118 (.094) [.007]	.165** (.076) [.021]	.131** (.065) [.030]
Own mother had history of depression	.188* (.101) [.012]	.207*** (.079) [.028]	.185*** (.068) [.043]
Male child	.067 (.055) [.004]	.080* (.044) [.009]	.079** (.036) [.017]
Child's age, in months, when outcome was measured	-.001 (.021) [-.000]	-.006 (.016) [-.001]	-.003 (.013) [-.001]

Notes: *** p <0.01; ** p <0.05; * p <0.10. SE = Standard Error. ME = Marginal Effect. Estimates are unweighted. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality. All models include state indicators (estimates not shown).

Table 4: Estimated Effects of Moderate or Severe Maternal Depression on Program Participation at 2 years for various sub-samples

	SNAP	**WIC**	**Medicaid**	**TANF**
	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]
Full Sample (N=7900)				
Moderate or severe depression (at 9 months)	.231*** (.047) [.051]	.176*** (.045) [.068]	.243*** (.048) [.085]	.200*** (.057) [.015]
185% of Poverty at 9 months (N=3700)				
Moderate or severe depression (at 9 months)	0.175*** (0.053) [0.068]	0.044 (0.054) [0.015]	0.153*** (0.057) [0.056]	0.152** (0.063) [0.027]
185% of Poverty at 2 years (N=3500)				
Moderate or severe depression (at 9 months)	0.208*** (0.054) [0.082]	0.087 (0.056) [0.028]	0.201*** (0.059) [0.070]	0.185*** (0.062) [0.037]

Appendix Table 1: Coding of Poor Infant Health

The coding of health conditions was designed to characterize conditions that are at least moderately severe, unlikely caused by prenatal behavior, have a relatively poor long term prognosis, and are present at birth. The coding was originally developed and used for the Fragile Families and Child Wellbeing (FFCWB) Study, wherein a pediatric consultant was directed to glean information from the infants' medical records (augmented with 1-year maternal reports) and to assign all infant conditions a number between 1 and 16 according to the grid below. After giving the consultant the grid and clear instructions, the investigators had no further input into how particular conditions were coded. If a child had multiple conditions, each condition was assigned a separate number.

For this paper, we applied the FFCWB coding methodology to the ECLSB, using information on newborn conditions and congenital anomalies from the birth certificate module and assigning the same codes to conditions that were assigned in the FFCWB.

Moderate or Severe Infant Health Condition was coded as a one (yes) if the child had a condition in either cell #1 or cell #2. Examples of conditions in cell #1 are renal agenesis, microcephalus, and Down Syndrome. Examples of conditions in cell #2, which are considered random at birth but may or may not have long-term health consequences, are, hydrocephalus, cleft palate, and heart malformations.

Examples of high severity conditions considered possibly related to parents behavior are seizures (cell 5) and likely related to prenatal behavior are fetal alcohol syndrome (cell 9). These conditions are not coded as ones in the above measures.

	Severity			
	High	Medium	Low	Unknown
Not Behavior Related	1	2	3	4
Possibly Behavior Related	5	6	7	8
Likely Behavior Related	9	10	11	12
Not Enough Information To Determine if Behavior Related	13	14	15	16

Appendix Table 2: Bivariate Probit Estimates of Effects of Moderate or Severe Maternal Depression on Food Insecurity at 2-Years (N = 7,900)

	Moderate or severe depression (at 9 months)	**Low or Very Low Food Security—Child**	**Moderate or severe depression (at 9 months)**	**Low or Very Low Food Security—Household**	**Moderate or severe depression (at 9 months)**	**Low, Very Low, or Marginal Food Security—Household**
	Coefficient (SE)	Coefficient (SE) [ME]	Coefficient (SE)	Coefficient (SE) [ME]	Coefficient (SE)	Coefficient (SE) [ME]
Moderate or severe depression (at 9 months)		.292 (.578) [.019]		.005 (.419) [.001]		.053 (.314) [.012]
Mother's age, in years	.002 (.004)	.008 (.006) [.000]	.001 (.004)	-.001 (.004) [-.000]	.001 (.004)	-.008** (.004) [-.002]
Non-Hispanic black	.155*** (.055)	.257*** (.087) [.017]	.155*** (.055)	.172*** (.069) [.022]	.155*** (.055)	.196*** (.058) [.045]
Hispanic	-.117* (.067)	.338*** (.106) [.024]	-.114* (.067)	.072 (.083) [.009]	-.116* (.067)	.116* (.067) [.026]
Asian or Pacific Islander	.302*** (.075)	-.168 (.155) [-.008]	.304*** (.075)	-.278** (.118) [-.028]	.302*** (.075)	-.277*** (.090) [-.053]
American Indian	.084 (.083)	.232** (.116) [.016]	.087 (.082)	.158* (.096) [.021]	.085 (.082)	.182** (.081) [.043]

Foreign born	-.112** (.062)	.153 (.101) [.009]	-.124** (.062)	.151* (.080) [.019]	-.121* (.062)	.253*** (.065) [.059]
High school graduate	.027 (.051)	-.094 (.074) [-.005]	.027 (.051)	-.070 (.060) [-.008]	.025 (.051)	-.084* (.051) [-.018]
Any college	-.190*** (.058)	-.376*** (.095) [-.021]	-.191*** (.058)	-.242*** (.074) [-.029]	-.193*** (.058)	-.379*** (.061) [-.082]
Marital birth	-.215*** (.046)	.043 (.084) [.002]	-.214*** (.045)	-.036 (.066) [-.004]	-.215*** (.045)	-.098* (.052) [-.021]
Number of other children in the household	.014 (.015)	.120*** (.020) [.007]	.014 (.015)	.080*** (.017) [.010]	.014 (.015)	.092*** (.015) [.020]
Medicaid birth	.294*** (.045)	.361*** (.088) [.023]	.293*** (.045)	.560*** (.062) [.079]	.292*** (.045)	.399*** (.052) [.092]
Employed at all during year prior to the birth	-.118*** (.040)	.039 (.067) [.002]	-.118*** (.040)	.012 (.053) [.001]	-.118*** (.040)	.034 (.044) [.007]
Prenatal physical health condition	-.011 (.064)	.117 (.094) [.007]	-.011 (.064)	.161** (.076) [.021]	-.011 (.064)	.128** (.065) [.029]
Mother lived with both parents at age 16	-.088** (.037)	-.121** (.061) [-.007]	-.087** (.037)	-.164*** (.048) [-.020]	-.089** (.037)	-.151*** (.039) [-.033]

Lives in less densely populated urban area	-.018 (.065)	.152 (.099) [.009]	-.015 (.065)	.117 (.078) [.015]	-.016 (.065)	.108 (.066) [.024]
Lives in densely populated urban area	.041 (.052)	.031 (.084) [.002]	.042 (.015)	-.013 (.066) [-.002]	.041 (.052)	-0.14 (.056) [-.003]
Own mother had history of depression	.404*** (.063)	.205 (.126) [.013]	.405*** (.063)	.254*** (.092) [.036]	.405*** (.063)	.222*** (.077) [.053]
Male child	.017 (.034)	.067 (.055) [.004]	.015 (.034)	.081* (.043) [.010]	.014 (.034)	.080** (.036) [.017]
Child's age, in months, when outcome was measured	.011 (.013)	-.000 (.021) [-.000]	.011 (.013)	-.005 (.016) [-.001]	.011 (.013)	-.003 (.013) [-.001]
Identifiers						
Multiple birth	.177*** (.047)		.178*** (.045)		.178*** (.045)	
Infant health condition	.126** (.055)		.122** (.056)		.123** (.055)	
Rho	.077		.224		.178	
Test Results (p-values)						

Wald Test of rho = 0	.817		.371		.326	
Chi-square joint significance test of identifiers	.000		.000		.000	
Exclusion tests (p-values):						
Multiple birth		.692		.626		.713
Infant health condition		.948		.593		.850

Notes: *** p <0.01; ** p <0.05; * p <0.10. SE = Standard Error. ME = Marginal Effect. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality. All models include state indicators (estimates not shown).

Appendix Table 3: Estimated Effects of Moderate or Severe Maternal Depression on Program Participation at 2 years (N = 7,900)

	SNAP	WIC	Medicaid	TANF
	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]	Probit Coefficient (SE) [ME]
Moderate or severe depression (at 9 months)	.231*** (.047) [.051]	.176*** (.045) [.068]	.243*** (.048) [.085]	.200*** (.057) [.015]
Mother's age, in years	-.008** (.004) [-.002]	-.022*** (.003) [-.008]	-.025*** (.004) [-.008]	-.001 (.005) [-.000]
Non-Hispanic black	.647*** (.058) [.165]	.470*** (.055) [.184]	.376*** (.058) [.135]	.639*** (.073) [.063]
Hispanic	.121 (.074) [.026]	.501*** (.059) [.196]	.051 (.068) [.017]	.244** (.095) [.019]
Asian or Pacific Islander	-.062 (.106) [-.012]	-.162** (.072) [-.060]	-.197** (.084) [-.063]	0.218* (.132) [.017]
American Indian	.184** (.085) [.041]	.255*** (.082) [.099]	-.054 (.088) [-.018]	.209* (.109) [.016]
Foreign born	-.321*** (.076) [-.058]	.356*** (.057) [.138]	.150** (.065) [.052]	-.471*** (.104) [-.024]
High school graduate	-.194*** (.053) [-.038]	-.104* (.053) [-.039]	-.168*** (.055) [-.055]	-.267*** (.063) [-.016]
Any college	-.642*** (.062) [-.133]	-.570*** (.056) [-.214]	-.533*** (.059) [-.180]	-.584*** (.083) [-.040]
Marital birth	-.377*** (.048) [-.083]	-.342*** (.043) [-.131]	-.551*** (.045) [-.194]	-.475*** (.064) [-.037]

Number of other children in the household	.100*** (.017) [.020]	.093*** (.016) [.035]	0.076*** (.017) [.026]	.058*** (.021) [.004]
Medicaid birth	.925*** (.047) [.224]	0.786*** (0.042) [0.301]	1.131*** (0.042) [0.401]	.617*** (.064) [.051]
Employed at all during year prior to the birth	-.075* (.045) [-.016]	-.002 (.040) [-.001]	-.178*** (.043) [-.061]	-.106* (.057) [-.007]
Mother lived with both parents at age 16	-.187*** (.041) [-.039]	-.055** (.036) [-.021]	-.079** (.039) [-.027]	-.132** (.054) [-.009]
Lives in less densely populated urban area	.113* (.068) [.024]	-.149** (.051) [-.143]	-.003 (.066) [-.001]	.099 (.095) [.007]
Lives in densely populated urban area	-.012 (.059) [-.002]	-.372*** (.051) [-.143]	-.138** (.055) [-.047]	.188** (.081) [.011]
Prenatal physical health condition	.103 (.069) [.022]	.132** (.063) [.051]	.131* (.068) [.045]	.079 (.085) [.005]
Own mother had history of depression	.198*** (.071) [.044]	.022 (.065) [.008]	.079 (.071) [.027]	.394*** (.086) [.035]
Male child	-.035 (.039) [-.007]	-.031 (.033) [-.012]	.043 (.036) [.014]	.019 (.049) [.001]
Child's age, in months, when outcome was measured	-.020 (.015) [-.004]	-.035** (.013) [-.013]	-.017 (.014) [-.006]	-.023 (.020) [-.001]

Notes: *** p <0.01; ** p <0.05; * p <0.10. SE = Standard Error. ME = Marginal Effect. SNAP = Supplemental Nutrition Assistance Program. WIC = Supplemental Nutrition Program for Women, Infants, and Children; TANF = Temporary Assistance to Needy Families. Estimates are unweighted. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics to protect subject confidentiality. All models include state indicators (estimates not shown).