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Effects of infant health on family food insecurity: Evidence from two U.S. birth cohort studies

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A B S T R A C T

Extremely little is known about the effects of health on food insecurity despite strong associations between the two and a theoretical basis for this avenue of inquiry. This study uses data from two national birth cohort studies in the U.S., the Early Childhood Longitudinal Study—Birth Cohort ($N = \sim 9400$) from 2001 to 2003 and the Fragile Families and Child Wellbeing Study ($N = 2458$) from 1998 to 2003, to estimate the effects of poor infant health on child and household food insecurity and explore the potential buffering effects of public programs that provide food, healthcare, and cash assistance. We address the issue of causality by defining poor infant health as an unexpected shock and conducting relevant specification tests. We find convincing evidence that poor infant health does not affect food insecurity but that it greatly increases reliance on cash assistance for low-income individuals with disabilities, which appears to be playing a buffering role.

1. Introduction

It is well known that hunger is a rampant problem in much of the developing world. However, even in many high-income countries, substantial numbers of children and families confront hardships related to food availability and the problem is worsening. In the U.S., 10.7% of households in 2001 were characterized as 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 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). In Canada, 12.2% of households experienced food insecurity in 2011, up from 11.3% in 2007–08 (PROOF, 2014), and recent data suggest similar patterns in England (Cooper, 2013) and Europe ("Europe-Fifteen Million Poor People, 2011"), where the focus is on food poverty, malnourishment, or other food deprivation-related measures as opposed to food insecurity as defined by the USDA. Food insecurity, an important indicator of deprivation of a basic human need, is strongly associated with low socioeconomic status (Rose, 1999; Gundersen and Gruber, 2001), and has become the focus of substantial public policy and research attention.

Because nutrition and diet are directly related to health, a great deal of attention has been paid in recent years to the potential effects of food insecurity on health, particularly obesity. Most studies have focused on child health, which shapes health and socioeconomic trajectories (Currie, 2009).

Gundersen et al. (2011) provide an extensive review of the literature on the effects of food insecurity on child health and show that children and adults living in food insecure households are more likely to have specific health conditions (e.g., asthma and anemia) and mental and behavioral problems. However, as the authors acknowledge, few studies provide strong evidence of causal effects (i.e., few convincingly address the potential confounding effects of unobserved factors associated with both food insecurity and health problems or the possibility that the direction of effects run from health to food insecurity). The authors point to a notable exception, Gundersen and Kreider (2009), which used nonparametric bounding methods to address these methodological challenges and found that food insecurity has adverse effects on children's obesity and general health status. From these results, both Gundersen and Kreider (2009) and Gundersen et al. (2011)

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inferred that previous estimates of (adverse) effects of food insecurity on health in the literature were biased toward zero.

Research in the opposite direction—from health to food insecurity—is almost non-existent, although theoretical work by Gundersen and Gruber (2001) suggests that the effects of health on food insecurity may be important. Gundersen et al. (2011) argued that more rigorous research on connections between food insecurity and health in both directions is needed, and that “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.” They further claimed that “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 know of no published studies that have examined the effects of health on food insecurity. However, one recent working paper presented preliminary results suggesting that maternal depression during the postpartum year increases the probability of child and household food insecurity by 50–80% and that public support programs may play a partially buffering role (Noonan et al., 2014). We know of no previous studies of the effects of physical health shocks, or health shocks to other members of the family, on food insecurity.

Economic theory suggests a number of channels through which health shocks, particularly to young children, may affect the family's food insecurity. Assuming no public support, an infant health shock could affect household food insecurity through income and/or time constraints. The time demands (e.g., to complete routine tasks such as feeding or dressing, or for more trips to healthcare providers) could lead parents to reduce their labor supply, which would reduce their labor income. Poor child health could also increase expenses (e.g., for specialized childcare or equipment), which may reduce the household budget available for other items such as nutritious foods. Increased expenses could lead to increases in parents' labor supply, in order to maintain their level of disposable income. If the labor supply effects result in a net decrease in time, parents may substitute more expensive prepared food for home-made meals or not have sufficient time for careful budgeting. Thus, even if families maintain the level of take-home income, poor child health could place them at increased risk for food insecurity.

Overall, because poor child health increases constraints in terms of both income and time, and because past studies have found that it reduces labor force participation and hours of work of mothers (Corman et al., 2005), and labor force participation of fathers (Noonan et al., 2005), we expect poor child health to increase food insecurity—unless public supports offset these costs. Given the relatively generous safety net in the U.S. for serious health problems through Supplemental Security Income (SSI), which provides cash assistance to individuals with disabilities, and of the availability of food assistance through the Supplemental Nutrition Supplement Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants and Children (WIC), we expect public supports to play a buffering role.

In this study, we address an important gap in the literature—a dearth of studies of effects of health on food insecurity, with none focusing on physical health—by explicitly investigating the effects of an unexpected adverse physical health event—the birth of a child with a serious and potentially disabling condition—on family food insecurity. Given the importance of child health for health and socioeconomic trajectories, elucidating links between child health and hardships associated with socioeconomic status is essential for understanding, and attempting to unravel, the persistent knot between health and socioeconomic status that is apparent in the U.S., the U.K., and most other developed countries (Adler and Rehkopf, 2008; Mackenbach et al., 2008). We also explore the potential buffering effects of public programs in the U.S. that provide food (SNAP and WIC); health insurance through Medicaid or other public insurance (which in the U.S. is available to individuals who are poor and meet other eligibility criteria); and cash assistance through the Temporary Assistance to Needy Families (TANF) program (which provides cash assistance to poor families with children) and SSI.

We consider both direct measures of infant health, coded from medical records, and birthweight-related outcomes, which are more commonly used in population-based studies. We attempt to estimate causal relationships by defining poor infant health as an unexpected shock (i.e., by considering conditions that are considered by the medical community to be random in the population) and conducting relevant specification tests.

2. Data

We use data from two U.S. birth cohort studies—the Fragile Families and Child Wellbeing (FF) study and the Early Childhood Longitudinal Study—Birth Cohort (ECLS-B)—that have both overlapping and complementary strengths. The use of these datasets to examine the effects of poor child health on food insecurity has been approved by the IRBs at Rutgers—Robert Wood Johnson Medical School and Rider University.

FF follows a cohort of parents and their newborn children in large U.S. cities. Births were randomly sampled in 20 cities between 1998 and 2000. By design, approximately three quarters of the interviewed mothers were unmarried. Face-to-face interviews were conducted with 4898 mothers while they were still in the hospital after giving birth. The response rate was 86% among eligible mothers (Reichman et al., 2001). Follow-up interviews were conducted over the telephone approximately 1, 3, 5, and 9 years after the birth of the focal child. Mothers interviewed at 3 years were asked to also participate in an in-home study, which included the USDA Core Food Security Module needed to create measures of food insecurity. The 3-year in-home surveys were conducted for 3324 (68%) of the 4898 mothers in the study. Similar in-home surveys (which also included the USDA Core Food Security Module) were completed at 5 years. Data from 1 and 9 years were not used in our analyses, except for maternal reports about the child's health at 1 year that were used to augment our main measures of poor infant health.

The FF survey data are rich in measures of socioeconomic status and are linked to information from the medical records of the mother respondents and their newborns from the birth hospitalization, allowing us to create detailed measures of poor infant health. Data from the medical records were collected using a detailed instrument (available on FF website). The availability of medical record data depended, for the most part, on administrative processes of hospitals rather than decisions on the part of survey respondents to make their records available. Medical record data, which were needed for the analyses, were available for 3684 (75%) of the 4898 births in the FF sample.

All analyses using FF were limited to cases for which medical record data, which were needed to characterize infant health conditions, were available and for which a 3-year in-home survey was completed, which was needed for our measures of food insecurity. Of the 3684 mothers with medical record data, 2525 completed the 3-year in-home survey. Of the 2525 mothers, 35 observations were excluded because of missing information on covariates and another 32 observations were excluded due to missing information on program participation at 3 years, leaving 2458 analysis cases.

Comparisons (at the postpartum or “baseline” interview) between the 2458 mothers in the analysis sample to the other 2440 FF mothers indicated no significant differences by education, relationship status, prenatal nutritional status (defined later), or child sex. However, mothers in the analysis sample were more likely to be non-Hispanic black, and have publicly-insured births, had more children, and were less likely to be foreign born. Overall, there was no consistent pattern of the mothers in our analysis sample being more or less advantaged than the FF mothers not in our sample.

ECLS-B is a nationally representative panel study of >10,000 children born in the U.S. in 2001. Births were sampled from natality 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 ≥15 years old (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 2, 4, and 5 years later (5-year data were not used in our study). ECLS-B is rich in information on socioeconomic status, includes the full USDA Core Food Security Module at every wave, and includes data on maternal prenatal health in a birth certificate module. Our analyses are based on unweighted data in order to capitalize on the oversampling of very low birthweight children, as described later.

For our ECLS-B analyses, we limited the sample to cases that have 2-year follow-up data because that was the main time point at which we assessed food insecurity outcomes with this dataset. All sample sizes are rounded to the nearest 50 as required by the National Center for Education Statistics. Of the 10,500 participants in ECLS-B (all of whom had birth certificate data), 9600 completed the 2-year follow-up survey. Of those, 200 cases were dropped owing to missing data on analysis variables, leaving an analysis sample of 9400 cases. Those in our sample were less likely to be non-Hispanic black, Hispanic, Asian, foreign born, and have publicly-insured

Table 1
Characteristics of analysis samples, Fragile Families and Child Wellbeing (FF) and Early Childhood Longitudinal Study—Birth Cohort (ECLS-B).

	FF ($N = 2458$)	ECLS-B ($N = 9400$)
Food insecurity—3 years (FF); 2 years (ECLS—B)		
Child food insecurity	0.09	0.04
Household food insecurity	0.18	0.09
Poor infant health		
Severe infant health condition	0.02	N/A
Moderate or severe infant health condition	0.20	N/A
Low birthweight	0.10	0.26
Very low birthweight	0.02	0.11
Maternal characteristics		
Age, mean in years	25.04 (6.1)	27.66 (6.4)
Non-Hispanic white[a]	0.20	0.49
Non-Hispanic black	0.49	0.17
Hispanic	0.27	0.16
American Indian/Alaskan Native	N/A	0.04
Asian/Pacific Islander	N/A	0.14
Other race/ethnicity	0.04	N/A
Foreign born	0.15	0.24
<High school graduate[a]	0.35	0.19
High school graduate	0.30	0.30
Any college	0.35	0.50
Married	0.23	0.67
Cohabiting	0.38	N/A
Neither married nor cohabiting[a]	0.39	N/A
# Children in household (excluding focal child and his/her multiple birth siblings, if any), mean	1.28 (1.3)	1.08 (1.2)
Medicaid birth	0.66	0.33
Employed (*during 2-year period before the birth for FF; 1-year period before the birth for ECLS-B)*	0.80	0.72
Lived with both parents *(at age 15 for FF; age 16 for ECLS-B)*	0.41	0.59
Lives in densely populated urban area	N/A	0.12
Lives in less densely populated urban area	N/A	0.72
Lives in non-urban area[a]	N/A	0.15
Poor nutrition during pregnancy	0.05	N/A
Pre-pregnancy physical health condition	0.21	0.08
Prenatal mental illness	0.13	N/A
Other child characteristics		
Male	0.52	0.51
Multiple birth	0.02	0.17
Age when outcome was measured, mean in months	38.6 (3.3)	24.5 (1.3)
Program participation (measured same time as food insecurity)		
SNAP	0.41	0.22
WIC	0.59	0.42
SSI	0.05	0.06
Medicaid	0.62	0.35
TANF	0.22	0.08
Baseline public assistance (measured at time of the birth)		
Public assistance, welfare, or food stamps	0.38	N/A
Unemployment insurance, workmen's compensation, disability, or social security benefits	0.10	N/A

Notes: SNAP = Supplemental Nutrition Assistance Program. WIC = Supplemental Nutrition Program for Women, Infants, and Children; SSI = Supplemental Security Income; TANF = Temporary Assistance to Needy Families. All figures are proportions unless indicated otherwise; standard deviations are in parentheses. Figures are unweighted. Sample sizes for ECLS-B are rounded to the nearest 50 as required by the National Center for Education Statistics. All maternal characteristics, other than number of children in household and urban residence variables in ECLS-B, which were assessed at 9 months, pertain to before or at the time of the birth of the focal child.

[a] Reference category in regression models.

births, and more likely to be employed and to be married, than those not in our sample. Thus, our analysis sample is more socioeconomically advantaged than the overall ECLS-B sample.

FF and ECLS-B have both overlapping and complementary features for our goal of estimating the effects of infant health on food insecurity and potential buffering effects of public programs. Both are national population-based surveys that allow us to assess child and family food insecurity using the USDA Core Food Security Module, allow us to create relevant measures of infant health, are rich in socioeconomic factors, and include state indicators, which allow us to control for potentially confounding factors at the state level. ECLS-B has a large sample and (when weighted) is nationally representative, whereas FF is about half the size, is exclusively urban, and over-represents relatively disadvantaged mothers—a group at high risk for food insecurity.

A key strength of FF is that we can use measures of poor infant health that capture serious health conditions that are believed to be random in the population (described later), as well as low birthweight (<2500 g), a commonly-used marker of poor infant health (Reichman, 2005). With ECLS-B, we are not able to create direct measures of poor infant health with a reasonable degree of accuracy, because the only information on infant conditions is from the infants' birth records, which are known to underreport such conditions (Kirby, 2007). However, we can investigate the associations of both low birthweight and very low birthweight (<1500 g) with food insecurity. Very low birthweight is a rare outcome (1.4% of all births in the U.S. in 2001, according to authors' calculations using natality data), but can be analyzed using ECLS-B as a result of the oversampling of very low birthweight infants in that study. Data from the medical records component of FF also allow us to create measures of maternal prenatal physical and mental illness, whereas with ECLS-B we are more limited in this regard.

Both datasets allow us to control for detailed measures of socioeconomic status at the time of the birth (before the infant's health status could have affected them), including education, marital status, and public health insurance. Although the baseline interview for ECLS-B took place 9 months after the birth of the child (versus when the mother was still in the hospital after giving birth in FF), sufficient data on timing were included to allow us to construct most covariates so that they correspond to the time of the birth. Each dataset includes a few socioeconomic measures that are not in the other, as described later.

FF allows us control for a measure of prenatal food hardship when estimating models of food insecurity and for measures of program participation at the time of the birth when estimating models of program participation (to explore potential buffering effects). As discussed later, these measures map in varying degrees to the outcomes. In ECLS-B, there is no measure of food hardship at the time of the birth and the only measure of public assistance participation at the time of the birth is public health insurance. All analysis variables are listed and summarized in Table 1 and described below.

3. Measures and sample characteristics

3.1. Food insecurity

We use the USDA Core Food Security Module, which consists of 18 questions about food hardship during the past year, to characterize food insecurity of children and households at 3 years for FF and 2 years for ECLS-B (See Appendix Table 1 for the actual questions). In supplementary models, we consider food insecurity at 5 years for FF and at 4 years for ECLS-B. Per USDA definitions, children are considered food insecure if the mother gave affirmative responses to 2+ of the 8 questions in the module that pertain to children (9% of our FF sample; 4% of our ECLS-B sample), and households are considered food insecure if the mother responded affirmatively to 3+ of any of the questions in the module (18% of our FF sample; 9% of our ECLS-B sample). Neither FF nor ECLS-B administered the Food Security Module at the time of the birth.

3.2. Poor infant health

With our goal of isolating causal effects of poor infant health on food insecurity, the ideal measure of poor infant health would: (1) characterize an unexpected outcome occurring at birth and unlikely a function of parental characteristics or behaviors (i.e., random), and (2) capture conditions strongly associated with long-term morbidity (as opposed to brief single episodes). For FF, we were able to incorporate measures meeting these criteria. We relied on coding by a pediatric consultant who was directed to classify each condition listed in the infants' medical record or reported by the mother at 1 year according to 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. Measures based on this coding have been used in several published papers (Corman et al., 2011; Curtis et al., 2010, 2013; Reichman et al., 2006; Reichman et al., 2009; Schultz et al., 2009).

We used two measures of infant health based on the consultant's coding for our FF analyses. The first—*severe infant health condition*—is whether the infant had an abnormal condition at birth that was severe, chronic, unlikely caused by parents' prenatal behavior, and in the case of 1-year maternal reports, likely present at birth (e.g., Down Syndrome, congenital heart malformations, microcephalus). This measure closely matches our criteria for a random health shock, but is rare (2% of our FF analysis sample). The second is direct, but broader—whether the child had an abnormal condition that meets the criteria for *severe infant health condition* or a less severe condition that is considered random. This measure includes conditions that may or may not have poor long-term prognoses (e.g., hydrocephalus, malformed genitalia, webbed fingers/toes). One fifth of the children in our FF analysis sample were coded as having a *moderate or severe infant health condition*. The advantages of this measure are that it consists of conditions considered random and that there are more cases of poor infant health to analyze. The disadvantage is that most of the conditions do not fall under the “severe” category.

For both FF and ECLS-B, we use *low birthweight* (<2500 g), and in ECLS-B, we also use *very low birthweight* (<1500 g) as measures of poor infant health. Low birthweight (LBW) is not a very specific measure because few moderately LBW (the majority of LBW children), those weighing 1500–2500 g, go on to have severe physical health problems (Reichman, 2005). Another disadvantage is that it is associated with poverty and prenatal behavior (e.g., cigarette smoking) (Reichman, 2005). The value of using LBW as a measure of poor infant health is that it is a widely-used marker and is comparable across studies. We use it to tie our results to the relevant population-based literature; to crosswalk the results from our two datasets, as it is the only measure of infant health in common; and to conduct specification tests (described later) that compare our results based on this measure to those based on the measures of poor infant health designed to capture random conditions. For very low birthweight (VLBW), the disadvantages are attenuated—first, because that outcome is strongly associated with severe health problems, and second because almost all VLBW infants are preterm (<37 weeks gestation) and medical science has not gotten far in identifying behavioral causes of preterm birth (Howson et al., 2012). Ten percent of the infants in FF sample and 26% of the infants in the ECLS-B sample were LBW, and 2% of the infants in FF (shown solely for comparison purposes; not included in analyses) and 11% of infants in ECLS-B were VLBW. The very high rate of LBW in ECLS-B reflects the oversampling of VLBW infants, who are by definition LBW, as well as the oversampling of twins, who are at high risk for being LBW (Crosignani et al., 2000).

3.3. Covariates

The measures used as control variables, which were very similar (but not identical) across the two datasets, included maternal age, race/ethnicity (categories are different in the two datasets, as a result of the oversampling in ECLS-B of American Indian/Alaskan Natives and Asian/Pacific Islanders), nativity, education, marital status, number of children in household (at baseline for FF; 9 months for ECLS-B) excluding the focal child and his/her multiple birth siblings (if any), public health insurance for the birth (Medicaid), employment prior to the birth (within past 2 years for FF; within past 1 year for ECLS-B), and household structure growing up (lived with both of her biological parents—at age 15 for FF; 16 for ECLS-B).

For FF analyses, we also include whether the mother was cohabiting (but not married to) the biological father of the focal child, plus several measures from the mother's prenatal medical records: A baseline measure of food hardship (any mention, from a specific response choice in a check box or in progress notes, of “nutritional inadequacy” during pregnancy; 5% of FF sample), a measure of pre-pregnancy physical health (any documentation of a pre-existing physical health condition, such as chronic lung disease, cardiac problems, diabetes, or hypertension; 21% of FF sample), and a measure of prenatal mental illness (any documentation of a pre-existing diagnosed mental illness including depression, anxiety, bipolar disorder, schizophrenia, or anorexia; 13%). For ECLS-B analyses, we include a measure of the mother's prenatal physical health, but no measures of her prenatal food hardship or mental health are available; we also include measures of whether the mother lived in a densely populated urban area and whether she lived in a less densely populated urban area (both compared to living in a non-urban area), as classified by ECLS-B based on U.S. Census categories.

Overall, maternal characteristics, other than the number of children and urban residence variables in ECLS-B, which were assessed at 9 months, pertain to before or at the time of the birth of the focal child. All models control for multiple birth as well as the child's sex and age (in months) at the time the outcome was measured. Finally, indicators for the mother's state of residence at baseline were included in most models to control for policies or other potentially confounding state-level factors. For each dataset, states with <75 observations were combined into a single category.

Maternal and child characteristics are quite different across the two analysis samples, reflecting the different populations the studies represented, the oversampling in each of the studies according to specific characteristics, and the timing of the follow-up interviews.

3.4. Program participation

We estimate the effects of poor infant health on participation in the following programs (measured at 3 years for FF, 2 years for ECLS-B) during the past 12 months: SNAP, WIC, Medicaid, SSI, and TANF. All models of program participation include the same covariates as in the food insecurity models, but for FF we also include controls for receipt of “public assistance, welfare or food stamps” and “unemployment insurance, workmen's compensation, disability or social security benefits” in the past year, assessed at the time of the birth (classifications in quotations are taken verbatim from the mother's baseline questionnaire). Although the baseline measures of program participation do not correspond perfectly to the relevant 3-year measures, the two are highly correlated (e.g., ~2/3 of mothers on TANF and about 60% of those on SNAP at 3 years were on “public assistance, welfare or food stamps” at baseline; not shown in tables). Finding positive associations (i.e., that poor infant health appears to increase participation in a given program) would suggest that the programs are mitigating, at least to some extent, adverse effects of poor infant health on food insecurity.

Table 2
Multivariate probit estimates of the effects of poor infant health on child and household food insecurity, Fragile Families and Child Wellbeing (FF) and Early Childhood Longitudinal study—Birth Cohort (ECLS-B).

	Food insecurity—child	Food insecurity—household
	Coefficient (SE) [ME]	Coefficient (SE) [ME]
FF ($N = 2458$)		
Severe infant health condition	0.006 (0.225) [0.001]	0.150 (0.227) [0.040]
Moderate or severe infant health condition	−0.052 (0.081) [-0.007]	−0.014 (0.057) [-0.003]
Low birthweight	−0.051 (0.098) [−0.007]	−0.003 (0.081) [−0.001]
ECLS-B ($N = 9400$)		
Very low birthweight	−0.015 (0.081) [−0.001]	0.033 (0.063) [0.004]
Low birthweight	0.029 (0.058) [0.002]	0.018 (0.047) [0.004]

Notes: Sample sizes for ECLS-B are rounded to the nearest 50 as required by the National Center for Education Statistics. Each cell shows estimates from a separate probit model. SE = Standard error. ME = Marginal effect. Models include all maternal and child characteristics (other than the other measures of infant health) from Table 1 plus state indicators. Outcomes are measured at 3 years (FF) or 2 years (ECLS-B) and pertain to past 12 months. Estimates are unweighted.

4. Analysis

We attempted to isolate causal effects by using the two measures of poor infant health, described earlier, that include conditions considered by the medical community to be random and that have been demonstrated in past research to be unrelated to parents' characteristics—thus greatly minimizing the potential confounding effects of unobserved factors. To the extent that there is residual confounding, we would expect our models to overestimate the effects of poor infant health on food insecurity. Common sense dictates that unobserved characteristics that would make the mother more prone to having a child with a health problem would also be more likely to cause her to experience food insecurity—e.g., mothers who tend to “live for today” would be both less likely to invest in their child's health and less able to garner sufficient resources to purchase sufficient high-quality food.

We capitalize as much as possible on the fact that our datasets follow families over time, which allows us to establish that the infant health shock preceded the food insecurity or program participation—reducing concerns about reverse causality. However, this strategy is only as good as our baseline controls corresponding to the outcomes. To the extent that our measures of poor infant health coded from medical records are truly random, this strategy becomes less important. We therefore devote a lot of attention to exploring this issue. We investigate the associations between poor infant health and maternal baseline characteristics and, when relevant, conduct "placebo" tests wherein we predict the baseline value of the outcome as a function of poor infant health. If our measures of poor infant health are indeed random, they should be unassociated with anything that occurred before the child was born. We also use LBW—which is definitely not random—as a counterfactual in these analyses.

Comparing mothers with and without infants in poor health (separately, for each of the two coded measures), we found no significant differences by race/ethnicity, nativity, education, employment, or relationship status. Maternal age was slightly higher for those with infants in poor health. In contrast and as expected, LBW was significantly associated with maternal characteristics. Mothers with LBW infants were less likely to be foreign born and more likely to be non-Hispanic black, have publicly-insured births, and be unmarried than mothers with normal-birthweight infants (not shown). This evidence supports our assertion that the measures of poor infant health coded from the medical records are picking up random conditions, while LBW is strongly associated with low socioeconomic status.

Table 2 summarizes results from multivariate probit regression models of the effects of each relevant measure of poor infant health on child and household food insecurity using each of the two datasets—for a total of 10 different specifications. Models include all maternal and child characteristics (other than the other measures of infant health) from Table 1 plus state indicators.

Results are robust; we find no evidence that poor infant health, measured four different ways and using two different datasets, is associated with either child or household food insecurity. In all cases, standard errors exceed the associated coefficients. Full regression results for the models using LBW—the only measure of poor infant health that the two datasets have in common—are presented in Appendix Table 2 (full results for the other models summarized in Table 2 are available upon request).

Overall, we consistently find that having an infant in poor health is not associated with subsequent food insecurity, even when using the measures based on coded conditions that are arguably random. However, these null associations do not preclude the possibility that poor infant health is placing families at risk for food insecurity but that public supports are protecting those families from experiencing that hardship. We consider the potential buffering effect of programs that specifically focus on food availability (SNAP, WIC), provide healthcare (Medicaid), provide cash assistance to poor families with children (TANF), and provide cash assistance to individuals with disabilities (SSI). Reichman et al. (2006) used FF to estimate the effects of poor infant health on program participation at 1 year, focusing on TANF. Their preferred measure of poor infant health, which they called "abnormal newborn condition," was defined as having either a serious health condition (similar to the measure used here) or being VLBW. At the time of that study, medical record data were available for <40% of their analysis sample. They found that "abnormal newborn condition" was positively associated with participation in SSI and Medicaid, but not TANF or SNAP. They cautioned the reader that the 1-year period may be too brief for poor infant health to affect program participation, and suggested that future research should consider a longer time horizon.

Table 3 presents estimated effects of poor infant health on participation in each of the programs in the past 12 months when the child was 3 years old (FF) or 2 years old (ECLS-B). Each cell presents results from a different regression model that includes all maternal characteristics, child characteristics (other than the other measures of infant health), and baseline program participation measures from Table 1 (for FF) plus state indicators. As with Table 2, we place greater reliance on the coded measures of poor infant health (from FF), since these measures capture conditions considered random by the medical community that are uncorrelated with important observed maternal characteristics. Full regression results for the models using LBW—the only measure of poor infant health the two datasets have in common—are presented in Appendix Tables 3 and 4 (full results for the other models summarized in Table 3 are available upon request).

Results from the top panel of Table 3 (for FF) indicate that families with an infant in poor health are significantly more likely to participate in the SSI program. Effect sizes are particularly large

Table 3
Multivariate probit estimates of the effects of poor infant health on program participation at three years, Fragile Families and Child Wellbeing (FF) and Early Childhood Longitudinal Study—Birth Cohort (ECLS-B).

	SNAP	WIC	Medicaid	SSI	TANF
	Coefficient (SE) [ME]	Coefficient (SE) [ME]	Coefficient (SE) [ME]	Coefficient (SE) [ME]	Coefficient (SE) [ME]
FF ($N = 2458$)					
Severe infant health condition	−0.302 (0.233) [−0.108]	0.063 (0.232) [0.024]	0.423* (0.246) [0.143]	1.517*** (0.276) [0.278]	−0.442 (0.332) [−0.082]
Moderate or severe infant health condition	−0.048 (0.090) [−0.018]	0.010 (0.057) [0.004]	0.017 (0.072) [0.006]	0.559*** (0.128) [0.042]	−0.070 (0.082) [−0.016]
Low birthweight	−0.002 (0.091) [−0.001]	0.013 (0.094) [0.005]	0.197** (0.094) [0.071]	0.697*** (0.148) [0.065]	0.015 (0.083) [0.004]
ECLS-B ($N = 9400$)					
Very low birthweight	−0.049 (0.056) [−0.010]	0.188*** (0.051) [0.073]	0.386*** (0.056) [0.141]	1.140*** (0.055) [0.186]	0.071 (0.069) [0.005]
Low birthweight	0.084** (0.042) [0.018]	0.125*** (0.038) [0.048]	0.305*** (0.041) [0.108]	0.790*** (0.048) [0.091]	0.092* (0.053) [0.007]

Notes: ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$. SNAP = Supplemental Nutrition Assistance Program. WIC = Supplemental Nutrition Program for Women, Infants, and Children; SSI = Supplemental Security Income; TANF = Temporary Assistance to Needy Families. Sample sizes for ECLS-B are rounded to the nearest 50 as required by the National Center for Education Statistics. Each cell shows estimates from a separate probit model. SE = Standard error. ME = Marginal effect. Models include all maternal characteristics, child characteristics (other than the other measures of infant health), and baseline program participation measures from Table 1 plus state indicators. Outcomes are measured at 3 years (FF) or 2 years (ECLS-B) and pertain to past 12 months. Estimates are unweighted.

when considering severe conditions. The estimated effect of *severe health condition* on SSI participation is almost 28 percentage points compared to a mean of 5%. The effect for moderate or severe health condition is much smaller, but the 4 percentage point marginal effect still represents an increase of 80% compared to the relevant mean. The results for SSI are similar for ECLS-B, with effect sizes that are larger for the more severe outcome (VLBW). The large estimated effects on SSI are not surprising, as we are focusing on infants with severe impairments (or at high risk for such) and the SSI program provides substantial financial benefits to disabled individuals. Wiseman and Wamhoff (2005) found that, for a poor family receiving TANF in 2003, transferring a child from TANF to SSI increased monthly income by almost $500, while allowing the rest of the family members to continue to receive some benefits from TANF and other public programs.

Poor infant health also increases the likelihood that members of the household are covered by public health insurance, although the magnitude of the effects is highly variable. The FF analyses, which control for our best available measures of baseline program participation, reveal no evidence that poor infant health significantly affects participation in SNAP, WIC, or TANF. The ECLS-B analyses, which do not control for public assistance at the time of the birth (other than Medicaid) or use our preferred measures of infant health, are consistent with those from FF, but show stronger estimated effects for Medicaid and WIC and small positive associations between LBW and both SNAP and TANF. However, these results should be interpreted with caution, given that they do not hold up in the FF analyses. Although the FF measures of baseline program participation do not correspond perfectly with the relevant outcomes, they are very strong predictors of future program participation, as indicated earlier and can be seen in Appendix Table 3.

Overall, Table 3 provides robust and strong evidence that having an infant in poor health increases reliance on SSI, suggesting that this relatively generous program could be preventing families with poor infant health from experiencing material hardships such as food insecurity.

4.1. Supplementary analyses

We conducted a number of auxiliary analyses (results available on request). First, we further validated our assumption that poor infant health is an unexpected shock. The lack of significant differences in sociodemographic characteristics by poor infant health using FF, discussed earlier, supports this assumption. We also conducted "placebo tests" for the models of program participation. The logic was that a shock that takes place at birth cannot possibly affect the mother's pre-birth program participation, and finding significant associations would indicate spurious correlation. We do not conduct corresponding tests for food insecurity, because we found no effects of poor infant health. With FF, we estimated each measure of baseline program participation as a function of each measure of poor infant health, both unadjusted and adjusting for the maternal characteristics in Table 1. With ECLS-B, we estimated baseline Medicaid (the only available measure of public assistance at the time of the birth) as a function of both LBW and VLBW, both with and without covariates. The bottom line is that whether or not we include covariates, there is no evidence that our preferred measures of poor infant health are associated with any type of baseline public assistance. In contrast, LBW is positively associated with baseline program participation. When we include covariates, it is no longer significantly associated with "TANF or SNAP" or "other public assistance" at baseline but does predict a Medicaid birth. Overall, these results provide further evidence that our preferred measures of poor infant health are indeed capturing unexpected health events, and also that the covariates help reduce bias in models relating program participation to LBW.

Second, given the very strong effects of poor infant health on SSI, we used FF to explore whether another family health event – maternal depression during the postpartum year – has similar effects. In auxiliary analyses (results not shown but available upon request), we found no associations between maternal depression and subsequent SSI, which is not surprising given that SSI is for severe disability and presumably easier to qualify for based on physical impairments than for mental impairments.

Third, we attempted to include program participation in models of food insecurity, as our current approach does not directly assess the buffering effects of public assistance. Specifically, we estimated supplementary models of the effects of poor infant health on food insecurity controlling for current household income and program participation (measured at 3 years for FF, 2 years for ECLS-B). Poor infant health was never a significant predictor of food insecurity, and household income was uniformly, negatively, and significantly associated with food insecurity. However, public assistance participation was *positively* associated with food insecurity. Thus, like much of the previous literature (see Gundersen et al., 2011), we were not able to construct models to estimate the buffering effects of public assistance that produced plausible results. We therefore continue to rely on the more cautious approach of estimating the effects of poor infant health on both food insecurity and program participation using infant health measures based on conditions that are considered random, exploring patterns of estimates across measures of infant health and the different programs, and inferring the potential buffering effects of the programs.

Finally, we conducted a few additional specification checks. We estimated the effects of poor infant health on food insecurity and on program participation at 5 years (FF) and 4 years (ECLS-B), instead of 3 and 2 years, respectively, to explore the possibility that poor infant health could take longer than 2–3 years to have effects. We found that poor infant health, regardless of how measured and which dataset used, had no significant impact on subsequent food insecurity. We continue to find strong and significant effects of poor infant health on SSI participation, suggesting that the effects on participation in that program are not short-lived. We also estimated models that excluded the state indicators and that excluded all observations with small state samples (instead of combining them); in both cases, the estimated effects of poor infant health on food insecurity were substantively unchanged from those in Table 2.

5. Conclusion

This study addressed an important gap in the growing literature on food insecurity and health—the almost complete lack of studies of the effects of health on food insecurity—by explicitly investigating the effects of a family health event, the birth of an infant with a serious and potentially disabling health condition, on family food insecurity. We attempted to estimate causal relationships by defining poor infant health as an unexpected shock. We explored the potential buffering effects of public programs that provide food, healthcare, and cash assistance. We used data from two national birth cohort studies, one of which is representative of births in the U.S. (and for which our analysis sample was selectively advantaged in terms of socioeconomic status compared to the full sample) and the other of which represents a relatively disadvantaged population (urban mothers having non-marital births).

We found robust and convincing evidence that infant health does not affect food insecurity, but that cash assistance to individuals with disabilities may play a buffering role. We were in a good position to detect effects on food insecurity, should they exist, given our two datasets with overlapping and complementary strengths and our rich array of measures of infant health. The fact that we did not find associations between any measure of poor infant health and later food insecurity is an important contribution to the literature on the effects of food insecurity on child health, which struggles with issues surrounding causality. Our findings also suggest that public supports play a potentially instrumental and enduring buffering role. Specifically, we found very strong effects of serious infant health conditions on receipt of benefits from the relatively generous SSI program, but not on food or more temporary cash assistance.

Overall, our results contribute to the growing literature on food insecurity and health by providing an important first test of whether physical health affects family food insecurity, pointing to a specific situation in which the child health safety net in the U.S. appears to be effective, and providing some reassurance to those studying the effects of food insecurity on child health that reverse pathways do not appear to be a concern.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2014.10.041.

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