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Transitional dynamics of household food insecurity impact children's developmental outcomes

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Abstract

Objective—To determine how transitions in and out of varying degrees of food insecurity impact children's academic competencies, executive functioning, and social skills (i.e., self-control, interpersonal skills, externalizing behaviors, and internalizing behaviors).

Method—Data come from the nationally representative kindergarten and first grade waves of the Early Childhood Longitudinal Study (2010–11); 11,958 children attending 1,289 schools are included. Statistical analyses involve using a novel framework for measuring the transitional dynamics and depth of food insecurity to predict children's developmental outcomes using hierarchal linear models, which adjust for child- and school-level confounders.

Results—Deepening food insecurity was detrimental to children's self-control (−0.208, $p<.01$), math (−0.153, $p<.01$) and working memory (−5.202, $p<.05$) scores. Remitting marginal food insecurity was associated with negative effects on children's self-control (−0.082, $p<.05$) and interpersonal skills (−0.098, $p<.01$), but not on math or working memory. Persisting marginal food insecurity negatively impacted children's self-control (−0.106, $p<.05$) and interpersonal skills (−0.115, $p<.05$). Emerging food insecurity (0.146, $p<.01$) and persisting food insecurity (0.071, $p<.05$) had detrimental effects on children's externalizing behaviors.

Conclusion—Based on a novel food insecurity transitions framework and examination of multiple developmental outcomes, this study highlights the importance of examining both depth and transitional dynamics of food insecurity. Findings indicate that deepening food insecurity and persisting marginal food insecurity may have potentially the most harmful effects on children's developmental outcomes. Clinically, findings support the need for addressing food insecurity in early childhood, even if the food insecurity challenges are marginal and just emerging.

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Keywords

food insecurity; academic skills; executive function; social skills; ECLS-K:2011

INTRODUCTION

It is well established that food insecurity affects children's learning, behavior and development. A lack of adequate nutrients can have negative and persisting impacts on children. A recent systematic review synthesized across 23 studies concluded that household food insecurity, even at marginal levels, is associated with behavioral, academic, and emotional problems from infancy to adolescence in Western industrialized countries (1). For example, food insecurity has been associated with lower reading and math scores (2, 3) and more internalizing and externalizing problem behaviors (4). While math, reading, and social skills have been well studied, there are comparatively fewer studies on the role of food insecurity in executive functioning. Executive functioning is important because it relates to overarching cognitive processes and reasoning (5). Executive functions work together to regulate and orchestrate cognition, emotion, and behavior and help a child to learn in the classroom. Some of the only research on this topic comes from a cohort study of older Puerto Rican adults in Massachusetts. Researchers found that food insecurity was associated with worse cognitive performance (6) and faster cognitive decline two years later (5).

Food Insecurity Transitions

Food insecurity is predominantly a transient phenomenon with most children moving in and out of food security throughout childhood as their family circumstances change (7). In a nationally representative sample, only 1.15% of US children were food insecure across kindergarten (1999), third grade (2002), fifth grade (2004) and eighth grade (2007), while 21% had been food insecure at a minimum of one of those checkpoints (7). In comparison to the literature that treats food insecurity as a static phenomenon in relation to children's developmental outcomes, research on how transitions in and out of food insecurity influence children's development is less established (2, 8–10). When examining a nationally representative sample of kindergarten children living at or below 300% of the poverty level who were followed into first grade, Kimbro and Denney (9) found that neither persistent food insecurity nor transitions in or out of food insecurity were associated with reading, math or science assessment scores. On the behavioral side, becoming food insecure in first grade after being food secure in kindergarten was associated with worse interpersonal skills, lower self-control, and more externalizing behaviors (e.g., bullying). Persistent food insecurity at kindergarten and first grade was associated with internalizing behaviors (e.g., sadness) (9). Across the handful of studies on food security transitions, a consistent and limiting methodological feature is the use of one dichotomous definition of food insecurity (either 3+ items [food insecure (7, 9)] or 1+ item [marginally food insecure (2, 10)] on a well-established food security scale) to create four categories of transitions: never food insecure, becoming insecure, becoming secure, and persistently insecure (2, 8, 9). When predicting child health outcomes in a cross-sectional study, other analysts created a set of three mutually exclusive food insecurity indicators: food secure (0 items on scale),

marginally food insecure (1 or 2 items) and food secure (3+), but did not capture transitions (10, 11).

The Current Investigation

Using a nationally representative sample of US children through the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011), the present study explores transitions in and out of varying degrees of food insecurity during the kindergarten and first grade years, and how the transitional dynamics and depth of food insecurity impact students' developmental outcomes. Outcomes studied include directly-assessed academic competencies in reading, math and science, two directly-assessed measures of executive functioning, and four teacher-reported measures of social skills. This paper contributes to existing literature in three regards. First, it introduces a refined operationalization of food insecurity transitions into nine categories, which combine a focus on transitional dynamics in and out of food security while gauging the intensity of the transitions. Second, it examines two measures of executive functioning, which are directly assessed and available in the ECLS-K:2011, but have not been used in previous studies of food insecurity using the ECLS (e.g., 9). Third, we control for school-level contextual factors, which have been neglected in previous studies, even though school characteristics—e.g., parental involvement (12), school location (13), and sense of safety (14)—are well-documented influences on children's academic achievement and development. Previous studies have controlled for school effects as a nuisance parameter (9) or controlled for the type of school (10), but they have not adjusted for a suite of school-level covariates as we do here. Figure 1 presents a conceptual model for our analysis. We do not propose hypotheses due to the exploratory nature of the analysis.

METHOD

Sample

Data for this study come from the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011), which is sponsored by the National Center for Education Statistics (NCES). We used data pertaining to the kindergarten and first grade waves, which were collected from direct academic assessment of the children, parents, teachers, and school administrators in fall 2010, spring 2011, fall 2011, and spring 2012. Our model included 11,958 children in 1,289 schools. Children missing one or more school-level variables were excluded from our study. The ECLS-K:2011 employed a complex, probability-based sampling design involving three stages to sample kindergarteners initially in fall 2010 (15). A sampling weight was used to adjust for differential probabilities of selection for each sampling strata (15). Table 1 provides descriptive statistics for all analyzed variables from the original dataset.

Individual-level Measures

Dependent Variables—The study examines measures of academic performance, executive functioning, and social skills. The three *academic performance* measures were developed using the theta scores of children's knowledge and skills ascertained through direct assessments in reading, mathematics, and science by trained professionals (15). The

two measures of *executive function* available in the ELCS-K: 2011 are for working memory and cognitive flexibility. Working memory was assessed with the Numbers Reversed test (15, 16) where children were asked to repeat increasingly long strings of orally presented numbers in reverse order. Cognitive flexibility was assessed using the two-step Dimensional Change Card Sort test (17), in which children were asked to sort a series of picture cards first by color and then by shape, and finally by color or shape, depending on whether or not the card had a black border.

For *social skills*, we used teachers' ratings of students in the domains of self-control, interpersonal skills, externalizing behaviors, and internalizing behaviors, based on the Social Skills Rating System (9) and following other studies (2, 9, 10). Teachers answered 4 or 5 questions about each child in each of the four social skills domains, and a composite score was calculated for each with higher scores mapping to more of the behavior, be it reflective of better (e.g., self-control) or worse (e.g., externalizing behaviors) social skills development (15).

Focal Independent Variables—To create our measure of food insecurity, we relied on the raw household food security scale for kindergarten and first grade provided in the ECLS (9). Household food security was measured using an eighteen-item scale from the US Department of Agriculture (18). Extending from a four-category food insecurity duration measure (8, 9) and a three category cross-sectional measure of food insecurity intensity (11), we developed a more sensitive transitional food insecurity typology that measures changes over time and includes both *marginal food insecurity*, which has been associated with worse children's developmental outcomes (2) and is gauged by affirmative responses to one or two items on the scale (1), and *food insecurity*, which is gauged by affirmative responses to three or more items on the scale. While it would be technically possible to also include *extreme food insecurity* (8 or more items on the scale), there were few cases of this in our dataset and so it was not possible to examine; only 2.6% of children scored 8 or more on the household food insecurity scale in first grade. Table 2 shows our typology, which includes nine categories of food insecurity.

Covariates: We control for a suite of other independent variables known to impact children's academic performance and social skills. In terms of parent/household characteristics, s*ingle parent household* is coded as 1=one parent or 0=two parents. *Parental nativity* is represented categorically as both parents/single parent are/is foreign born, one parent is foreign-born and one is US-born, and both parents/single parent are/is US-born. US-born parent(s) is the reference category in the statistical model. *Household size* indicates the number of children under 18 years of age in the household. *Teen mother* was constructed by recoding the mother's age categories into 1=mom was under 20 when focal child was born, or 0=mom was 20 years or older when the focal child was born. *Parental depression* was captured by asking about how often the parent felt depressed in the last week and is gauged on a Likert-type scale ranging from 1=never to 4=most of the time. *Parental health status* was also included, which is on a Likert-type scale with higher scores corresponding to better health (1=poor to 5=excellent). *Socioeconomic status* was measured using the ECLS-provided standardized family socioeconomic scale (15).

In terms of child characteristics, we used five mutually exclusive *race/ethnicity* categories, each coded 1=yes or 0=no: (i) Black or African American, non-Hispanic; (ii) Hispanic; (iii) Asian, non-Hispanic; (iv) Other (non-Hispanic), which includes the smallest racial groupings (i.e., Pacific Islander/Native Hawaiian, American Indian, Multiracial, and Unknown); and (v) White, non-Hispanic, which is used as the reference group. *Child sex* was coded as female=1 or male=0. The child's *age* in months was calculated by comparing the exact date the child completed the ECLS-K:2011 spring 2012 direct academic assessment to the child's date of birth. *Low birth weight* was coded as 1=child was 5.5 pounds or less at birth, or 0=child was more than 5.5 pounds at birth. *Disability* reflects whether or not the child had a disability diagnosed by a professional (1=yes, 0=no). Attendance in a *prekindergarten* program was noted based on if the child had attended a child care center in the year before kindergarten; it is coded 1=yes or 0=no. Finally, we controlled for the child's *kindergarten assessment scores*, using the score that corresponded with the dependent variable (e.g., we used kindergarten self-control in the model predicting first grade self-control).

School-level Measures

All school-level independent variables come from the ECLS-K:2011 school administrator survey conducted during the children's first grade year. We selected variables that were important to capturing school context (12, 14, 19), which is linked to children's school performance and social development. The school climate variables are coded so that higher scores map to better climate. *Less teacher turnover* was originally measured on a Likert-type scale from 1=serious problem to 4=not a problem; it was dichotomized due to the distribution of responses so that 1=teacher turnover is not a problem, or 0=teaching turnover is a problem. For *fewer teacher absences*, the original variable was measured on a Likert-type scale from 1=serious problem to 4=not a problem, but it was dichotomized so that 1=teacher absences are not a problem, or 0=teacher absences are a problem due to the distribution. We also use a variable that captures how often bullying happens in the school; *less bullying* is coded so higher values correspond to less bullying, and the Likert-type scale ranges from 1=happens daily to 5=never happens. A *more parent involvement* measure reflects how active parents are in school programs. The Likert-type scale ranges from 1=less active to 5=more active. The *no weapons* variable measures how often children bring weapons to school. The original Likert-type scale ranged from 1=never happens to 5=happens daily, but due to the distribution of the variable, we recoded it so that 1=weapons are never brought to school, or 0=weapons have been brought to school. For *type of school*, we recoded the composite school type variable into one variable: 1 = private school or 0=public school. We use an indicator of whether or not the school received *Title 1* funds as a measure of school socioeconomic status (1=Title 1, 0=Not Title 1). The Title 1 program provides federal financial assistance to schools serving high percentages of economically disadvantaged children to help them meet academic standards. For *school location*, we used City (1=yes, 0=no), Suburban (1=yes, 0=no), and Town or Rural (1=yes, 0=no). Suburban was used as the reference group in the model. *School enrollment* indicates total school enrollment on October 1, 2011. It was measured using five ordinal categories provided in the original data: 1=0–149 students, 2=150–299 students, 3=300–499 students, 4=500–749 students, and 5=750 or more students.

Statistical Analyses

We began with a bivariate analysis of the original data using ANOVA with Bonferroni post-hoc testing in IBM SPSS Statistics 24 to compare the eight categories of food insecurity transitions to children whose households averted food insecurity. We then used hierarchical linear modeling (HLM) to predict the developmental outcomes after employing multiple imputation (MI) to address missing values and non-response bias in the child-level dataset. MI creates multiple sets of values for missing observations by using a regression-based approach. It also avoids the bias that can occur when missing values are not missing completely at random (20). In IBM SPSS Statistics 24, ten imputed datasets were specified and 200 between-imputation iterations were used. We analyzed multiply imputed data for 11,958 children attending 1,289 different schools. HLM7 was used to analyze each of the ten individual-level datasets separately, and to calculate pooled results. When using imputed data, we analyzed the originally ordinal measures (e.g., parent depression, parent health status) as continuous predictors. This is a best practice when imputing missing data and estimating model parameters, since rounding off imputed values based on discrete categorical specifications has been shown to produce more biased parameter estimates in analysis models (20).

HLM is the most appropriate statistical technique for analyzing multi-level data (21) because when examining effects at multiple levels, traditional regression techniques may result in inaccurate parameter estimates (22, 23). HLM is appropriate for this study because our data had a multi-level structure, with children at level 1 nested within schools at level 2. All models consisted of a random intercepts and fixed slopes. Independent variables were grand mean (i.e., group mean) centered. We use a two-tailed p-value of 0.05 to define significance in our analyses.

RESULTS

Bivariate Results

All ANOVAs were significant ($p<.001$), suggesting the presence of significant differences of means for all of the outcomes based on the food insecurity categories. In terms of the post-hoc tests, having experienced any of the eight categories of food insecurity was associated ($p<.001$) with lower reading, science and math scores and worse self-control as compared to children who averted food insecurity. For cognitive flexibility and internalizing behaviors, children with persisting food insecurity had worse scores ($p<.001$) than those that had averted food insecurity. For working memory, persisting and emerging food insecurity and marginal food insecurity were associated with lower mean scores ($p<.001$) as compared to averting food insecurity. Deepening food insecurity was also associated with worse working memory ($p<.001$). Remitting marginal food insecurity was related to lower mean working memory scores ($p<.05$). All categories of food insecurity except for remitting food insecurity were associated with worse interpersonal skills ($p<.01$). Children with persisting and emerging food insecurity and marginal food insecurity had higher mean scores for externalizing behaviors as compared to those that had averted food insecurity ($p<.05$).

Multivariate Results

Results of the HLM models predicting the five directly assessed outcomes and the teacher-reported social skills are presented in Table 4. In terms of the findings for food insecurity and directly assessed outcomes, Table 4 shows that deepening food insecurity (DeepenFIS) was associated with significantly lower math scores and significantly lower working memory in first grade accounting for other child- and school-level covariates. None of the food insecurity variables were significantly related to reading, science, or cognitive flexibility scores.

Persisting marginal food insecurity (PersistMFIS) was linked to significantly worse self-control and worse interpersonal skills. Emerging food insecurity (EmergFIS) and persisting food insecurity (PersistFIS) were significantly associated with more externalizing behaviors. Deepening food insecurity (DeepenFIS) was associated with significantly worse self-control. Finally, remitting marginal food insecurity (RemMFIS) was associated with significantly worse self-control and interpersonal skills. There were no significant findings for internalizing behaviors.

Some of the school-level variables were significantly linked to our outcomes ($p<.05$, see Table 4). When teacher absences at the school were not a problem, students had significantly higher math, reading, and science scores and counterintuitively, more externalizing and internalizing behaviors. When children attended schools with more parent involvement, science scores were higher as were working memory scores. Children who attended schools with less bullying had higher cognitive flexibility scores. Students attending Title 1 schools had lower math, reading, and science scores, as well as worse working memory and worse cognitive flexibility; they also had weaker interpersonal skills, worse self-control, more internalizing behaviors and more externalizing behaviors. Children attending city schools had lower science and reading scores relative to those attending suburban schools.

DISCUSSION

Food insecurity was a relatively important predictor of most outcomes under study compared to the other child-level predictors in the multivariate models (Table 4). For math, deepening food insecurity was the third strongest predictor based on the size of the coefficient (−0.153), following kindergarten math score (0.864) and black (−0.214); Hispanic (−0.145) was the fourth strongest predictor. For working memory, deepening food insecurity was also the third strongest predictor (−5.202), with black (−6.989) and disabled (−6.252) being the strongest and Hispanic (−3.825) being the fourth strongest. For self-control, kindergarten scores (0.402) were the strongest predictor, followed by deepening food insecurity (−0.208) and female (0.126); persisting marginal food insecurity (−0.106) was the fourth strongest predictor. For interpersonal skills, the strongest predictor after kindergarten scores (0.386) and female (0.159) was persisting marginal food insecurity (−0.115), and then single parent (−0.114). For externalizing behaviors, the kindergarten score was the strongest predictor (0.531), followed by emerging food insecurity (0.145), female (−0.131), black (0.103) and then persisting marginal food insecurity (0.093).

In terms of the directly assessed academic and executive functioning outcomes, food insecurity was most closely related to math and working memory in the multivariate analyses. It was specifically deepening food insecurity that was most detrimental. The findings for working memory are relatively novel, and should be examined in future studies. Surprisingly, the ECLS executive function measures have not been used in studies of food security, but they represent an important avenue for future research. These findings for executive function are concerning, given that working memory is an important element of school success (24) and math performance specifically (25). Declining executive functioning could be related to food insecurity through stress as prefrontal cortex activity is impaired by high concentrations of dopamine and glucocorticoids (5).

Food insecurity has been linked to math scores in other studies (2, 26, 27). In a prior study employing a definition of food insecurity based on >1 item on the food security scale, children who were persistently food insecure in kindergarten and third grade and those who became food secure in third grade after being insecure in kindergarten had significantly lower math scores than children who had never been food insecure at either time point. The authors concluded that there may be a long lag time in the effects of food insecurity on math, since being food insecure in kindergarten mattered more for third grade math scores than did change in status over time (2). In our analysis, a status change reflecting deepening food insecurity was instead linked to math scores. We did not have any significant food security findings in the multivariate model for science scores, as was the case in another article (9). In the bivariate analyses, science scores were lower for children who had experienced any type of food insecurity as compared to those who had not. This suggests that the bivariate science findings were likely driven more by family socioeconomic circumstances and school context than by food insecurity *per se*.

Overall, social skills were more strongly related to food insecurity and food insecurity transitions than were the direct assessments of academic competencies and executive functioning in the multivariate models. This pattern was also found in another study (9) where the authors found that behavioral outcomes were more sensitive to food insecurity than longer-term, more durable outcomes like academic scores. We would have missed this finding had we relied only on the bivariate results, since all food insecurity transitions were significantly associated with lower directly assessed scores relative to averting food insecurity.

Our analyses uncovered that it is actually deepening food insecurity that was most closely associated with significantly worse self-control as compared to children who had averted food insecurity. This may have been masked in prior studies since marginally food insecure and food insecure children were not distinguished (9, 10). We also found that remitting marginal food insecurity was associated with worse self-control and interpersonal skills, although the strength of the associations were weaker than they were for deepening food insecurity in both the bivariate and multivariate models, suggesting a smaller effect. The finding suggests that the adverse effects of food insecurity may not disappear as soon as sufficient food becomes available. It may be that once children experience food insecurity, the fear that it might re-emerge persists and has negative effects. In terms of other studies looking at improvements in food security and their effects on social skills, the findings are

mixed. Some find no effects for “becoming food secure” (9) and another failed to model that effect (10). Another found that becoming food secure between kindergarten and third grade was associated with worse social skills for boys but better social skills for girls, as compared to children who were persistently food secure (2). These studies vary in how food insecurity transitions were measured, in analysis approaches, and in the treatment of school-level variables. More research is needed to assess whether there is a replicable adverse impact associated with remitting food security for children’s social skills development and to determine which contextual variables might explain such an impact if one is found.

Our findings suggest that self-control was the most sensitive to food insecurity (three significant findings), followed by interpersonal skills and externalizing behaviors (two significant findings each). Internationalizing behaviors were not sensitive to food insecurity in our analysis (no significant findings). The effects of food insecurity on social skills likely relates to a mix of unhealthy changes in diet and psychological stress (10). The findings are concerning being that limited social skills development can make it harder for children to learn in the classroom and the effects can cascade into adulthood (28). While food insecurity was not related to internalizing behaviors, persistent food insecurity and emerging food insecurity were associated with externalizing behavior. Externalizing behaviors in childhood have been shown to undermine academic competency by adolescence, which is, in turn, related to the presence of internalizing problems in young adults (28). Children engaging in externalizing behaviors can also harm their peers and themselves, diminishing their opportunities to succeed at school (29).

With its expanded food insecurity transitions framework and consideration of multiple student outcomes using a nationally-representative data set, this study highlights the vulnerable status of children who are marginally food insecure in kindergarten. For the kindergarteners in this study, a slip into food insecurity the next year was associated with lower math and working memory scores, but a move out of marginal food security was not. For self-control, children who were marginally food insecure in kindergarten were negatively affected the next year, whether they moved out of marginal food insecurity, became food insecure, or stayed marginally food insecure. For interpersonal skills, staying marginally food insecure or moving into food security were both associated with lower scores in first grade when children were marginally food insecure in kindergarten. This may suggest that marginal food insecurity in kindergarten matters more than subsequent transitions in terms of self-control (and to a lesser degree interpersonal skills) in first grade.

Kindergarten is likely a particularly sensitive time for children’s socioemotional development, as children are adjusting to a new school context with emerging social dynamics. How well children adapt to their first school experiences has long-term consequences in terms of their subsequent school performance, academic adjustment, and odds of dropping out of high school (30, 31). Marginal food insecurity may be associated with the least stable, most disrupted home lives as families struggle to grapple with emerging challenges related to poverty or health. This may lead marginal food security to have greater impacts on children’s development than deeper levels of food insecurity, since it is hypothetically possible that households who experience food insecurity and especially persisting food insecurity have better established strategies to access resources and social

services to help them cope as compared to marginally food insecure households. Others have suggested that marginal food insecurity should not be overlooked and should be treated as a serious indicator of lack of access to enough food for a healthy life (11). Our results support that conclusion.

There are several limitations associated with our analysis. Future studies should examine the intensity and duration of food security transitions over a longer time period than the two years we studied. We were limited by the available waves of ECLS data that had been released at the time of the analysis. Consideration of extreme food insecurity could theoretically be added to our transitions framework and operationalized in future analyses, but there were not enough households in that category to consider in the current analysis. While the data used were recently released by the ECLS, they pertain to 2010–2012. Since then, the US has undergone a leadership change, which may be dramatically altering economic conditions and the social service landscape, potentially affecting food insecurity in the US.

From a clinical perspective, findings offer support for the American Academy of Pediatrics recommendation that providers assess the stress of food insecurity in families by incorporating a screening tool into their practice (32). They suggest a practical two-item screening tool, which is nearly as accurate as the 18-item scale used in this manuscript (33). They also recommend that physicians familiarize themselves with community resources so that they can refer children that screen positively to relevant services (32). If children who are beginning to experience food insecurity (i.e., are marginally food insecure) are identified and enabled to return to food security, our results suggest that they may be buffered from some negative learning and behavioral outcomes.

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References

1. Shankar P, Chung R, Frank DA. Association of Food Insecurity with Children’s Behavioral, Emotional, and Academic Outcomes: A Systematic Review. Journal of Developmental and Behavioral Pediatrics. 2017; 38:1–16. [PubMed: 27902544]
2. Jyoti DF, Frongillo EA, Jones SJ. Food insecurity affects school children’s academic performance, weight gain, and social skills. The Journal of Nutrition. 2005; 135(12):2831–9. [PubMed: 16317128]
3. Alaimo K, Olson CM, Frongillo EAJ. Food insufficiency and American school-aged children’s cognitive, academic, and psychosocial development. Pediatrics. 2001; 108:44–53. [PubMed: 11433053]
4. Slopen N, Fitzmaurice G, Williams DR, Gilman SE. Poverty, Food Insecurity, and the Behavior for Childhood Internalizing and Externalizing Disorders. Journal of the American Academcy of Child & Adolescent Psychiatry. 2010; 49(5):444–52.
5. Wong JC, Scott T, Wilde P, Li Y-G, Tucker LK, Gao X. Food Insecurity Is Associated with Subsequent Cognitive Decline in the Boston Puerto Rican Health Study. Journal of Nutrition. 2016; 146(9):174–1745.

6. Gao X, Scott T, Falcon LM, Wilde PE, Tucker KL. Food insecurity and cognitive function in Puerto Rican adults. The American Journal of Clinical Nutrition. 2009; 89(4):1197–203. [PubMed: 19225117]
7. Ryu J-H, Bartfeld JS. Household Food Insecurity During Childhood and Subsequent Health Status: The Early Childhood Longitudinal Study—Kindergarten Cohort. American Journal of Public Health. 2012; 102(11):e50–e5. [PubMed: 22994255]
8. Hernandez DC, Jacknowitz A. Transient, but not persistent, adult food insecurity influences toddler development. Journal of Nutrition. 2009; 139(8):1517– 24. [PubMed: 19535426]
9. Kimbro RT, Denney JT. Transitions into food insecurity associated with behavioral problems and worse overall health among children. Health Affairs. 2015; 34(11):1949–55. [PubMed: 26526254]
10. Howard LL. Transitions between food insecurity and food security predict children's social skill development during elementary school. British Journal of Nutrition. 2011; 5:1852–60.
11. Cook JT, Black M, Chilton M, Cutts D, Cuba SEd, Heeren TC, et al. Are Food Insecurity's Health Impacts Underestimated in the US Population? Marginal Food Security Also Predicts Adverse Health Outcomes in Young US Children and Mothers. Advances in Nutrition. 2013; 4(1):51–61. [PubMed: 23319123]
12. Ma X, Klinger DA. Hierarchical Linear Modelling of Student and School Effects on Academic Achievement. Canadian Journal of Education. 2000; 25(1):41–55.
13. Stewart EB. School structural characteristics, student effort, peer associations, and parental involvement: The influence of school-and individual-level factors on academic achievement. Education and Urban Society. 2008; 40(2):179–204.
14. Berkowitz R, Moore H, Astor RA, Benbenishty R. A Research Synthesis of the Associations Between Socioeconomic Background, Inequality, School Climate, and Academic Achievement. Review of Educational Research. 2016; 87(2):425–69.
15. Tourangeau K, Nord C, Lê T, Sorongon AG, Hagedorn MC, Daly P. , et al. Statistics NCfE. Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) User's Manual for the ECLS-K:2011 Kindergarten Data File and Electronic Codebook, Public Version. Washington DC: US Department of Education; 2015.
16. Mather N, Woodcock RW. Examiner's Manual: Woodcock-Johnson III Tests of Achievement. Itasca, IL: Riverside Publishing; 2001.
17. Zelazo PD. The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. Nature Protocols. 2006; 1(1):297–301. [PubMed: 17406248]
18. Bickel G, Nord M, Price C, Hamilton W, Cook J. Guide to measuring household food security: revised. Alexandria, VA: Department of Agriculture, Food and Nutrition Service; 2000.
19. Lowenstein AE, Wolf S, Gershoff ET, Sexton HR, Raver CC, Aber JL. The stability of elementary school contexts from kindergarten to third grade. Journal of School Psychology. 2015; 53:323–35. [PubMed: 26270276]
20. Enders CK. Applied Missing Data Analysis. New York: Guilford Press; 2010.
21. Raudenbush SW, Bryk AS. Hierarchical linear models: Applications and data analysis methods. Thousand Oaks: Sage; 2002.
22. Hahs-Vaughn DL, Onwuegbuzie AJ. Estimating and using propensity score analysis with complex samples. The Journal of Experimental Education. 2006; 75(1):31–65.
23. Thomas SL, Heck RH. Analysis of large-scale secondary data in higher education research: Potential perils associated with complex sampling designs. Research in Higher Education. 2001; 42(5):517–40.
24. Alloway TP, Alloway RG. Investigating the predictive roles of working memory and IQ in academic attainment. Journal of Experimental Child Psychology. 2010; 106(1):20–9. [PubMed: 20018296]
25. Raghubar KP, Barnes MA, Hecht SA. Working memory and mathematics: A review of developmental, individual difference, and cognitive approaches. Learning and Individual Differences. 2010; 20(2):110–22.
26. Reid LL. Joint Center for Poverty Research Working Paper 137. Tallahasse, FL: Florida State University; 2000. The consequences of food insecurity for child well-being: An analysis of children's school achievement, psychological well-being, and health; 16

27. Winicki J, Jemison K. Food insecurity and hunger in the kindergarten classroom: its effect on learning and growth. Contemporary Economic Policy. 2003; 21:145–7.

28. Masten AS, Roisman GI, Long JD, Burt KB, Obradović J, Riley JR, et al. Developmental cascades: linking academic achievement and externalizing and internalizing symptoms over 20 years. Developmental Psychology. 2005; 41:733–46. [PubMed: 16173871]

29. Glew GM, Fan MY, Katon W, Rivara FP, Kernic MA. Bullying, psychosocial adjustment, and academic performance in elementary school. Archives of Pediatrics & Adolescent Medicine. 2005; 159(11):1026–31. [PubMed: 16275791]

30. Alexander KL, Entwisle DR, Horsey CS. From first grade forward: Early foundations of high school dropout. Sociology of Education. 1997; 70:87–107.

31. Fitzpatrick C, Pagani LS. Task-Oriented Kindergarten Behavior Pays Off in Later Childhood. Journal of Developmental & Behavioral Pediatrics. 2013; 34:94–101. [PubMed: 23369956]

32. American Academy of Pediatrics. Promoting Food Security for All Children: Policy Statement. Pediatrics. 2015; 136(5):e1431–e8. [PubMed: 26498462]

33. Hager ER, Quigg AM, Black MM, Coleman SM, Heeren T, Rose-Jacobs R, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. Pediatrics. 2010; 126(1):e26–e32. [PubMed: 20595453]

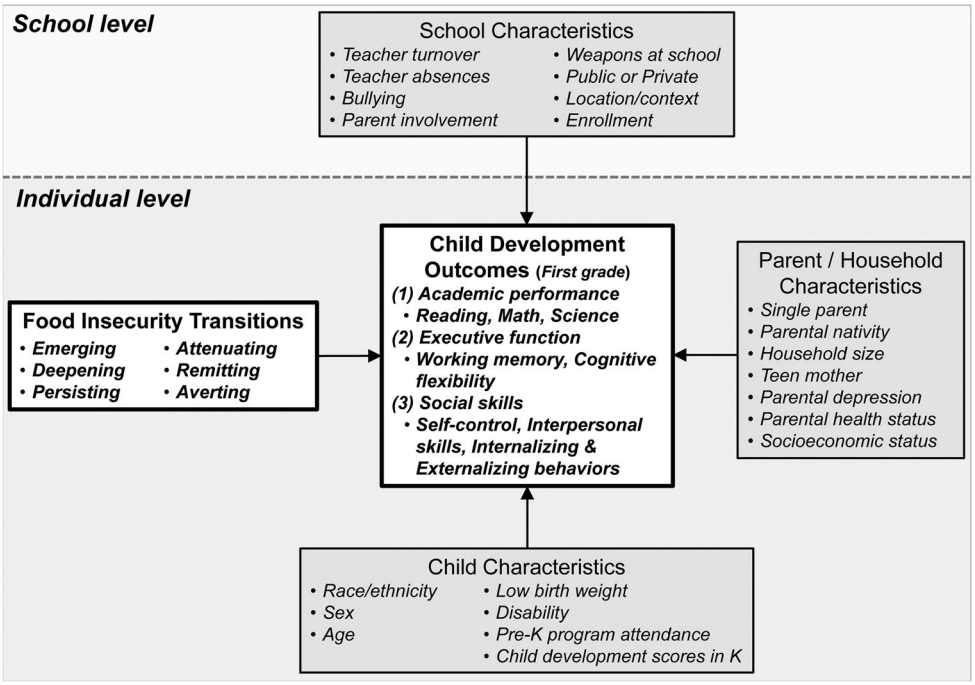

Figure 1.

Conceptual model of the influence of food insecurity transitions on child development outcomes, including other school- and individual-level factors

Table 1

Descriptive statistics for original data, n=1,289 schools and 11,958 first grade students

VARIABLE	ECLS Variable Name	N	Mean	Standard Deviation	Min	Max	Yes (Valid %)	No (Valid %)	Missing N (%)
Independent Variables									
School-Level									
Fewer teacher absences	S4 C8D	1289			0	1	698 (54.2%)	591 (45.8%)	0 (0%)
Less teacher turnover	S4 C8E	1289			0	1	1059 (82.2%)	230 (17.8%)	0 (0%)
City school *(ref: suburb)*	X4LOCALE	1289			0	1	487 (37.8%)	802 (62.2%)	0 (0%)
Rural/town school *(ref: suburb)*	X4LOCALE	1289			0	1	298 (23.1%)	991 (76.9%)	
No weapons	S4 C6A	1289			0	1	721 (55.9%)	568 (44.1%)	0 (0%)
Private *(ref: public)*	X4SCTYP	1289			0	1	21 (1.6%)	1268 (98.4%)	0 (0%)
Title 1	S4 F1	1289			0	1	929 (72.1%)	360 (27.9%)	0 (0%)
School enrollment	X4ENRLS	1289	3.87	1.54	1	6			0 (0%)
Less bullying	S4 C6G	1289	3.45	0.87	1	5			0 (0%)
More parental involvement	S4 C4A	1289	3.96	0.98	1	5			0 (0%)
Individual-Level[1]									
Food Insecurity Transitions[2] (*ref: AvertFIS*)	X2FSRAW2, X4FSRAW2	7721							4237 (35.4%)
PersistFIS							498 (6.5%)	7223 (93.6%)	
PersistMFIS							204 (2.7%)	7517 (97.4%)	
EmergFIS							210 (2.7%)	7511 (97.3%)	
EmergMFIS							341 (4.4%)	7380 (95.6%)	
DeepenFIS							177 (2.3%)	7544 (97.7%)	
RemFIS							331 (4.3%)	7390 (95.7%)	
RemMFIS							476 (6.2%)	7245 (93.8%)	
AttenFIS							178 (2.3%)	7534 (97.7%)	
Parent/Household Characteristics									
Single Parent	X4IDP1	9646					2201 (22.8%)	7455 (77.2%)	2312 (19.3%)
Parental Nativity[3]	P2PARCT1, P2PARCT2								2768 (23.1%)
Foreign-born Parent(s)		9190					1680 (18.3%)	7510 (81.7%)	
One US-born and 1 Foreign born Parent	P2PARCT1, P2PARCT2	9205					698 (7.6%)	8507 (92.0%)	
Household Size	X4LESS18	9604	2.606	1.155	1	14			2439 (20.4%)

VARIABLE	ECLS Variable Name	N	Mean	Standard Deviation	Min	Max	Yes (Valid %)	No (Valid %)	Missing N (%)
Teen Mother	P1OLDMOM	8813					2373 (26.9%)	6440 (73.1%)	3145 (26.3%)
Parental Depression	P2DEPRES	8618	1.270	0.600	1	4			3456 (28.9%)
Parental Health Status	P2HEALTH	8653	3.789	0.980	1	5			3400 (28.4%)
SES	X4SESL_I	9646	−0.155	0.758	−2.33	2.37			2392 (20.0%)
Child Characteristics									
Race/Ethnicity	X_RACETH_R								14 (.1%)
Black *(ref: white)*		11944					1584 (13.3%)	10360 (86.7%)	
Hispanic *(ref: white)*		11944					3010 (25.2%)	8934 (74.8%)	
Asian *(ref: white)*		11944					522 (4.4%)	11422 (95.6%)	
Other *(ref: white)*		11944					652 (5.5%)	11262 (94.5%)	
Female	X_CHSEX_R	11935					5779 (48.4%)	6156 (51.6%)	23 (0.2%)
Age in Months	X4AGE	11661	85.454	4.429	63.88	109.40			4771 (4.0%)
Low Birth Weight	P1WEIGH5	8486					838 (9.9%)	7648 (90.1%)	3472 (29.0%)
Disability	X4DISABL2	9229					1388 (15.0%)	7841 (85.0%)	2729 (22.8%)
Prekindergarten	P1CNUMPK	8739					5846 (66.9%)	2893 (33.1%)	3219 (26.9%)
Kinder Reading	X2RTHETK2	11583	0.478	0.752	−2.9616	2.9779			410 (3.4%)
Kinder Science	X2STHETK2	11422	0.032	0.891	−2.392	1.8895			570 (4.8%)
Kinder Math	X2MTHETK2	11551	0.460	0.746	−5.812	2.8824			439 (3.7%)
Kinder Working Memory	X2NRWABL	11559	450.621	30.309	393	572			433 (3.6%)
Kinder Cognitive Flexibility	X2DCCSTO	11559	15.181	2.783	0	18			432 (3.6%)
Kinder Self-Control	X2KTCHCON	10888	3.200	0.626	1.00	4.00			1355 (11.3%)
Kinder Interpersonal	X2KTCHPER	10897	3.161	0.641	1.00	4.00			1351 (11.4%)
Kinder Internalizing	X2KTCHINT	10945	1.500	0.479	1.00	4.00			1315 (11.0%)
Kinder Externalizing	X2KTCHEXT	10966	1.619	0.620	1.00	4.00			1283 (10.7%)
Dependent Variables									
1st Grade Reading	X4RTHETK2	11650	1.611	0.738	−1.8809	3.8839			490 (4.1%)
1st Grade Science	X4STHETK2	11631	0.907	0.975	−2.3383	3.8880			505 (4.2%)
1st Grade Math	X4MTHETK2	11641	1.670	0.831	−1.8763	4.7308			494 (4.1%)
1st Grade Working Memory	X4NRWABL	11644	469.606	24.969	403	572			491 (4.1%)
1st Grade Cognitive Flexibility	X4DCCSTO	11646	16.050	2.404	0	18			489 (4.1%)
1st Grade Self-Control	X4KTCHCON	10700	3.219	0.617	1.00	4.00			1917 (16.0%)

VARIABLE	ECLS Variable Name	N	Mean	Standard Deviation	Min	Max	Yes (Valid %)	No (Valid %)	Missing N (%)
1st Grade Interpersonal	X4KTCHPER	10794	3.151	0.647	1.00	4.00			1853 (15.5%)
1st Grade Internalizing	X4KTCHINT	10792	1.539	0.505	1.00	4.00			1842 (15.4%)
1st Grade Externalizing	X4KTCHEXT	10877	1.719	0.604	1.00	4.00			1770 (14.8%)

[1]The child-level descriptive statistics are weighted using W6CS6P_6T0a.

[2]The key for the abbreviations is presented in the last column of Table 2.

[3]Reference is US-born parent(s)

Table 2

An expanded typology of food security transitions

Transition name	Description of the food security transitions	Raw food insecurity score in kinder	Raw food insecurity score in first	Abbreviated variable name used in paper
Persisting food insecurity	Food insecure in both kindergarten and first grade	3+	3+	PersistFIS
Persisting marginal food insecurity	Marginally food insecure in both kindergarten and first grade	1 or 2	1 or 2	PersistMFIS
Emerging food insecurity	Moved from food secure in kindergarten to food insecure in first grade	0	3+	EmergFIS
Emerging marginal food insecurity	Move from food secure in kindergarten to marginally food insecure in first grade	0	1 or 2	EmergMFIS
Deepening food insecurity	Move from marginally food insecure in kindergarten to food insecure in first grade	1 or 2	3	DeepenFIS
Remitting food insecurity	Move from food insecure in kindergarten to food secure in first grade	3+	0	RemFIS
Remitting marginal food insecurity	Move from marginally food insecure in kindergarten to food secure in first grade	1 or 2	0	RemMFIS
Attenuating food insecurity	Move from food insecure in kindergarten to marginally food secure in first grade	3	1 or 2	AttenFIS
Averting food insecurity	Food secure in kindergarten and first grade	0	0	AvertFIS

Table 3

Results of ANOVA with post-hoc Bonferroni tests comparing mean outcome scores for children in each food insecurity transitions category with those who have averted food insecurity

Outcome	F	PersistFIS[1]	PersistMFIS[1]	EmergFIS[1]	EmergMFI[1]	DeepenFIS[1]	RemFIS[1]	RemMFIS[1]	AttenFIS[1]
Reading	37.00***	0.353***	0.330***	0.339***	0.304***	0.300***	0.270***	0.215***	0.365***
Science	44.02***	0.458***	0.466***	0.440***	0.375***	0.561***	0.423***	0.356***	0.553***
Math	35.68***	0.349***	0.380***	0.394***	0.393***	0.391***	0.277***	0.249***	0.347***
Working Memory	20.76***	8.103***	10.528***	10.695***	5.663**	12.548***	3.858	4.265*	5.765
Cognitive Flexibility	7.13***	0.613***	0.255	0.121	0.487*	0.523	0.073	0.366*	0.358
Self-Control	20.61***	0.130***	0.211***	0.206***	0.233***	0.373***	0.09***	0.160***	0.206**
Interpersonal Skills	15.45***	0.142**	0.221***	0.175**	0.202***	0.284***	0.063	0.171***	0.192**
Internalizing Behaviors	4.06***	−0.101**	−0.018	−0.108	−0.066	0.001	−0.051	−0.051	−0.068
Externalizing Behaviors	12.75***	−0.145***	−0.158*	−0.194***	−0.223***	−0.131	−0.015	−0.108**	−0.121

Note: The model uses the sampling weight W6CS6P_6T0a.

*** $p \leq .001$,

** $p \leq .01$,

* $p \leq .05$

[1] Mean difference in scores as compared to “AvertFIS”.

Table 4

Predicting directly assessed academic and teacher-reported social skills outcomes using food insecurity categories and control variables at the child- and school-level

	Reading	Science	Math	Working Memory	Cognitive Flexibility	Self-Control	Interper-sonal	Internal-izing	External-izing
	Coeff.	*Coeff.*	*Coeff.*	*Coeff.*	*Coeff.*	*Coeff.*	*Coeff.*	*Coeff.*	*Coeff.*
School-Level Variables									
Fewer teacher absences	0.113*	0.093*	0.107*	1.114	0.141	−0.025	−0.007	0.044*	0.055*
Less teacher turnover	−0.028	−0.026	−0.037	−1.22	0.013	0.001	−0.028	−0.003	−0.058*
Less bullying	−0.004	0.019	−0.028	0.492	−0.137*	0.001	0.008	<−.001	0.004
More parental involvement	0.021	0.092***	0.023	1.344*	0.071	0.015	0.001	−0.004	0.004
No weapons	0.055	0.053	0.085	0.772	0.109	−0.013	−0.006	−0.021	−0.013
Private *(ref: public)*	−0.127	−0.143	−0.143	0.309	−0.184	−0.229	−0.204	0.165	0.198
Title 1	−0.238***	−0.302***	−0.288***	−4.476***	−0.28*	−0.105***	−0.093**	0.085***	0.095***
School Enrollment	0.012	−0.019	0.018	−0.532	0.003	0.004	0.007	0.008	−0.007
City *(ref :suburb)*	−0.104*	−0.117*	−0.061	−0.39	0.02	−0.041	−0.032	0.024	0.021
Town/Rural *(ref: suburb)*	0.065	0.09	0.048	0.856	0.077	−0.008	−0.008	0.021	0.032
Individual-Level Variables:									
Food Insecurity Transitions (*ref: AvertFIS*)									
PersistFIS	−0.048	−0.012	−0.052	−1.245	−0.182	−0.059	−0.065	0.056	0.07*
PersistMFIS	−0.034	−0.034	0.053	−2.433	−0.018	−0.106*	−0.115*	−0.041	0.093
EmergFIS	−0.011	0.066	−0.003	−3.955	0.224	−0.113	−0.106	0.058	0.145**
EmergMFIS	0.008	0.013	−0.03	1.4	−0.221	−0.088	−0.066	−0.001	0.077
DeepenFIS	0.013	−0.127	−0.153*	−5.202*	−0.126	−0.208**	−0.146	−0.016	0.021
RemFIS	−0.008	−0.014	0.001	0.352	0.25	−0.017	0.021	0.034	−0.023
RemMFIS	−0.038	−0.015	−0.015	−0.059	<.001	−0.082*	−0.098**	0.019	0.051
AttenFIS	−0.018	−0.025	−0.007	−0.507	−0.29	−0.087	−0.031	0.03	0.055
Parent/Household Characteristics									
Single Parent	−0.028	−0.085***	−0.024	−0.416	0.175	−0.073**	−0.114***	0.082***	0.071***

	Reading	Science	Math	Working Memory	Cognitive Flexibility	Self-Control	Interper-sonal	Internal-izing	External-izing
	Coeff.	***Coeff.***	***Coeff.***	***Coeff.***	***Coeff.***	***Coeff.***	***Coeff.***	***Coeff.***	***Coeff.***
Foreign-born parent(s) *(ref: US born parent(s))*	0.084***	−0.125**	−0.01	0.034	0.01	0.08**	0.016	−0.074**	−0.09***
One US-born and 1 foreign born parent (*ref: US born parent(s)*)	0.015	−0.008	−0.041	−0.528	−0.163	0.05	−0.036	−0.011	0.001
Household size	<−.001	−0.026**	−0.01	−0.246	0.057	0.01	0.004	−0.012	−0.014
Teen mother	−0.01	−0.042	−0.011	−0.339	−0.24**	−0.049*	−0.059*	0.033	0.055**
Parental depression	0.005	0.009	<.001	−0.245	0.085	0.003	−0.003	−0.012	0.018
Parental health status	0.009	0.012	−0.002	0.35	−0.006	0.016	0.015	−0.018	0.004
SES	0.059***	0.101***	0.046***	2.092***	0.29***	0.049***	0.058***	−0.027*	−0.021
Child Characteristics									
Black *(ref: white)*	−0.05	−0.239***	−0.214***	−6.989***	−0.784***	−0.104**	−0.11**	−0.011	0.103***
Hispanic *(ref: white)*	−0.058*	−0.189***	−0.145***	−3.825***	−0.306**	−0.001	0.032	−0.045	−0.024
Asian *(ref: white)*	−0.027	0.036	−0.019	2.778	−0.153	0.017	0.046	−0.078*	−0.015
Other *(ref: white)*	−0.009	−0.001	−0.094*	−0.74	−0.078	−0.001	0.034	−0.028	0.006
Female *(ref: male)*	0.03*	−0.073***	−0.088***	−0.09	0.037	0.126***	0.159***	−0.009	−0.131***
Age	−0.003*	0.008***	−0.003	0.025	0.02	−0.001	−0.001	<.001	−0.001
Low birthweight	−0.037	−0.06	−0.023	−1.854	−0.488**	0.013	−0.001	0.02	−0.006
Disability	−0.092***	−0.122***	−0.09***	−6.252***	−0.47***	−0.09***	−0.095***	0.145***	0.094***
Prekindergarten	0.012	−0.015	0.021	1.863**	0.139	−0.026	−0.04*	−0.009	0.014
Kindergarten Score	0.755***	0.695***	0.864***	0.362***	0.149***	0.402***	0.386***	0.27***	0.53***

Note: The model uses the sampling weight W6CS6P_6T0a.

*** $p \leq .001$,

** $p \leq .01$,

* $p \leq .05$