

Household Food Insecurity and Children's Development: A Longitudinal GEE Analysis

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1 Background and Research Question

Student' academic achievements have long been linked to teaching quality, school resources, and community education levels. However, one critical yet often overlooked factor is household food insecurity. The U.S. Economic Research Service [1] defines food insecurity as having reduced quality, variety, or desirability of food, or experiencing disrupted eating patterns due to limited resources. Food insecurity could undermine children's academic and socioemotional development in the early school years. Previous longitudinal work focuses on both transition and persistence instead of the static status of food insecurity. Jyoti et al [2] showed that food insecurity in kindergarten is associated with slower growth in the math score, specifically for girls. Gallegos et al. [3] summarized four longitudinal studies and found consistent evidence that persistent or increasing food insecurity harms students' academic and cognitive outcomes. They also linked transitions into insecurity to poorer reading and math scores. Although existing longitudinal studies have examined changes and persistence in food insecurity, few have explored the underlying mechanisms that explain these effects. The teacher-child relationship, a likely classroom pathway (mediator), has not yet been directly researched in early elementary samples.

Research Question: How do changes in household food security status from kindergarten to first grade predict growth of academic achievement (reading and mathematics) and development of socioemotional skills from kindergarten through second grade? In addition, do these associations vary by family socioeconomic status? This study extends previous work by centering changes in food security during the foundational early elementary period and testing the teacher-child relationship as a mediator of these associations.

2 Data and Variables

We will use data from the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011), a large national dataset that follows about 18,000 children from kindergarten through elementary school [1]. It includes direct assessments of children's academic skills, teacher and parent reports on social-emotional development, and repeated measures of household food security using the 18-item USDA scale. This information is suitable for studying how changes in food insecurity relate to children's growth in the early school years.

Our sample will include first-time kindergarteners with at least two valid food security waves and one outcome measure. We will exclude multiple births (e.g., twins) to ensure independent observations. According to previous studies, we would expect approximately 12,000–14,000 children with repeated measures across six different timestamps (fall/spring in kindergarten to fall/spring to second grade). These periods capture important early dynamics in family and school environments.

Outcome Variable: Our study will focus on either (1) reading and math Item Response Theory (IRT) scores or (2) teach-rated social-emotional skills (such as self-control, learning approaches, behavior patterns). If possible, we will extend the analysis to include both sets of outcomes, applying multiple-comparison adjustments as needed.

Primary Predictor: Household food security is our primary predictor, and it measures both continuously (total score on the USDA 18-item scale) and categorically (high/marginal, low, very low). To capture change, we will create a difference score ($FS_CHANGE = \text{current} - \text{baseline}$) and a cumulative

exposure variable about how many waves a child experienced low food security.

Other Covariates: We will adjust for key child, family, and school characteristics, including sex, race/ethnicity, age, socioeconomic status (SES) composite score, family structure, home language, parent education, school type, and urbanicity. To produce nationally representative estimates and accurate standard errors, we will apply the sampling and replicate weights provided by NCES.

3 Analysis Plan

3.1 Data Preparation

We will restructure the ECLS-K:2011 data from the wide format (one row record per child) to long format (multiple row records per child, one for each wave), resulting a person-period dataset suitable for longitudinal analysis. We will create derived food security variables (FS_CHANGE, cumulative exposure) and examine patterns of data missingness across waves. Missing data will be addressed using Full Information Maximum Likelihood (FIML) estimation, which uses all available data to produce unbiased estimates under the missing at random (MAR) assumption.

3.2 Primary GEE Models

We will employ Generalized Estimating Equations (GEE) as our primary analytical framework to model longitudinal trajectories of child development from kindergarten through second grade. GEE is particularly well-suited for this research question as it provides population-averaged estimates that are directly interpretable for policy implications. It also handles missing data efficiently by utilizing all available observations at each wave. In addition, it produces valid inference through robust sandwich estimators even when the correlation structure is not perfectly specified.

We will begin with unconditional growth models to establish the functional form of developmental trajectories (testing linear versus quadratic time effects) and to compare alternative working correlation structures, including independence, exchangeable, autoregressive AR(1), and unstructured patterns. Model selection will be guided by AIC/BIC/QIC criteria. We anticipate AR(1) correlation is the most appropriate given that adjacent time points should be more highly correlated than distant ones.

The main effect models will regress each outcome on time (linear and quadratic), time-varying food security, baseline food security, their interactions with time, and all control covariates listed above, incorporating wave-specific sampling weights to maintain national representativeness. Specifically, the model takes the form:

$$E(Y_{it}) = \beta_0 + \beta_1(\text{TIME}) + \beta_2(\text{FOOD_SEC}_{it}) + \beta_3(\text{TIME} \times \text{FOOD_SEC}_{it}) \\ + \beta_4(\text{FS_BASELINE}_i) + \beta_5(\text{TIME} \times \text{FS_BASELINE}_i) + \sum \beta(\text{CONTROLS}) \quad (1)$$

where β_2 estimates the within-individual effect of contemporaneous food security changes, β_3 tests whether food security affects growth rates, and β_4 captures between-individudal differences in baseline status.

3.3 Moderation and Sensitivity

To examine whether food insecurity effects vary by socioeconomic status, we will test three-way interactions ($\text{TIME} \times \text{FOOD_SECURITY} \times \text{SES_QUARTILE}$) and calculate simple slopes at each SES level, with the hypothesis that effects will be strongest among the lowest SES quartile. We will conduct the sensitivity analysis to test the robustness of finding: comparing results across different working correlation structures (exchangeable, AR(1), unstructured) to ensure conclusions are not sensitive to model assumptions.

References

- [1] Economic Research Service. (2025a, January 8). *Key statistics and graphics on food security in the U.S.* U.S. Department of Agriculture. Retrieved from <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics>
- [2] Jyoti, D. F., Frongillo, E. A., and Jones, S. J. Food insecurity affects school children's academic performance, weight gain, and social skills. *Journal of Nutrition*, 135(12), 2005, 2831–2839. doi: 10.1093/jn/135.12.2831.
- [3] Gallegos, D., Eivers, A., Sondergeld, P., and Pattinson, C. Food Insecurity and Child Development: A State-of-the-Art Review. *International Journal of Environmental Research and Public Health*, 18(17), 2021, Article 8990. doi: 10.3390/ijerph18178990.
- [4] Kimbro, R. T., and Denney, J. T. Transitions Into Food Insecurity Associated With Behavioral Problems And Worse Overall Health Among Children. *Health Affairs*, 34(11), 2015, 1949–1955. doi: 10.1377/hlthaff.2015.0626.