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Food Insecurity and Child Development in Nebraska: The Role of Income, Home Learning Environment, and Family Socio-Demographic Factors

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FOOD INSECURITY AND CHILD DEVELOPMENT IN NEBRASKA: THE ROLE OF INCOME, HOME LEARNING ENVIRONMENT, AND FAMILY SOCIO-DEMOGRAPHIC FACTORS

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ABSTRACT

Food insecurity is a well-known risk factor for delayed child development. Still, the contribution of other factors, such as income, home learning environment (HLE), and family socio-demographic factors, remains to be determined. Therefore, the study aimed to determine the association between food insecurity and child development and assess the role of income, HLE, and family socio-demographic factors in that association. We used secondary data from the Nebraska Early Childhood Study, a cross-sectional study of caregivers of children under five years old in Omaha and Lincoln. Child development, food insecurity, and HLE were measured using a caregiver report of child development. We used multiple regression to analyze the data.

The results showed that food insecurity was negatively related to developmental outcomes (Est = -0.217, SE = 0.091, ES = -0.109, p =.018) even after adjusting for Income (Est = -0.222, SE = 0.092, ES =-0.112, p =.048). HLE was positively associated with children's developmental outcomes after controlling for income, child's age, sex, race, and ethnicity (Est = 0.376, SE = 0.092, ES = 0.198, $p < .001$). HLE did not moderate the association between food insecurity and children's developmental outcomes (Est = -0.287, SE = 0.185, ES = -0.095, p = .121). These results indicate that even if a child has access to a stimulating HLE, they may still experience developmental setbacks if they do not have enough nutritious food.

Overall, the study found that addressing food insecurity and promoting a stimulating HLE is essential in improving child developmental outcomes, especially in high-risk populations. Further research is needed to fully understand the complex factors influencing child development in food-insecure families. This study adds to the existing literature on the relationship between food insecurity, HLE, and child development and provides valuable insights for policymakers, educators, and healthcare professionals.

Keywords: food insecurity, income, child development, stimulating HLE

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1 INTRODUCTION

Food insecurity is a widespread global public health challenge, defined as insufficient access to adequate food for a healthy, active life for all household members at all times (Nord, 2010). In addition to limited food options and inadequate nutrition, food insecurity can cause shame, stigma, and isolation and trigger in-home competition for available food. This may result in parents skipping meals or reducing their food intake to ensure their children have enough to eat, ultimately leading to adverse health effects for both parents and children (Bhattacharya et al., 2004; Purdam et al., 2016; Tan, 2020). Recent reports have highlighted the increasing severity of food insecurity globally, with an estimated 720 to 811 million people experiencing hunger in 2020 and 2.4 billion people having limited access to adequate food, indicating a 15.6% increase in just one year (Chakrabarty, 2021; Kakaei et al., 2022). The COVID-19 pandemic has further exacerbated this issue. Ongoing conflicts, such as the Ukraine-Russia conflict, may further deteriorate global food security as Ukraine is among the fourth wheat exporter worldwide (Ben Hassen & El Bilali, 2022).

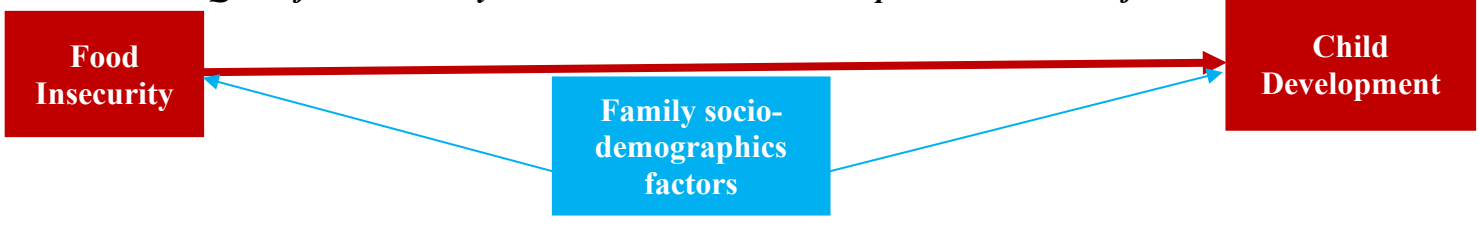
The United States (US) is not exempt from food insecurity challenges, with 10.2% of households experiencing food insecurity in 2021, affecting over 13.5 million families (Coleman-Jensen et al., 2022). The prevalence of household food insecurity in the US varies by region and demographic, with families from low-income households, racial and ethnic minority groups, and those with limited access to healthy food options and transportation being more vulnerable (Haider & Roque, 2022). Additionally, an estimated 15.9 million children lived in food-insecure households in 2021, down slightly from the previous year's estimate of 16.0 million (Coleman-Jensen et al., 2022). For children, the lack of consistent access to sufficient quality and quantity of food can lead to dietary deficiencies that may result in malnutrition and developmental issues, affecting their physical and mental health, academic performance, and long-term prospects (Allen,

2006; Hamadani et al., 2010; Malik & Marwaha, 2022). Malnutrition, in particular, is a crucial mechanism through which food insecurity affects child development, resulting in stunted growth, anemia, cognitive and behavioral issues, and other health problems (Caulfield et al., 2006; Gallegos et al., 2021).

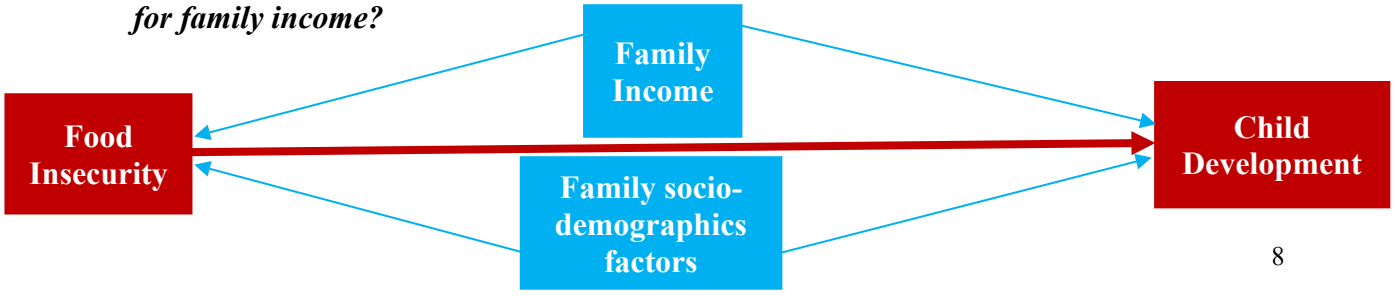
Moreover, food insecurity can also impact family dynamics, leading to stress and parenting practices that may hinder providing a supportive and nurturing environment for children's healthy development (Gee & Asim, 2018). Families facing food insecurity may have to make difficult choices between purchasing food and other necessities, further impacting their overall well-being (Masten et al., 2021). Lower family income resulting from food insecurity can lead to poor nutrition and reduced access to educational resources, exacerbating disparities in academic achievement, especially for children from racial and ethnic minority groups and those with lower-educated parents (Kendig & Bianchi, 2008; Masten et al., 2021).

Addressing food insecurity and educational equity requires a multifaceted approach that addresses socio-demographic factors and broader economic and policy-level changes. Therefore, this study addresses food insecurity among low-income families in Nebraska and its impact on child development by answering the following research questions:

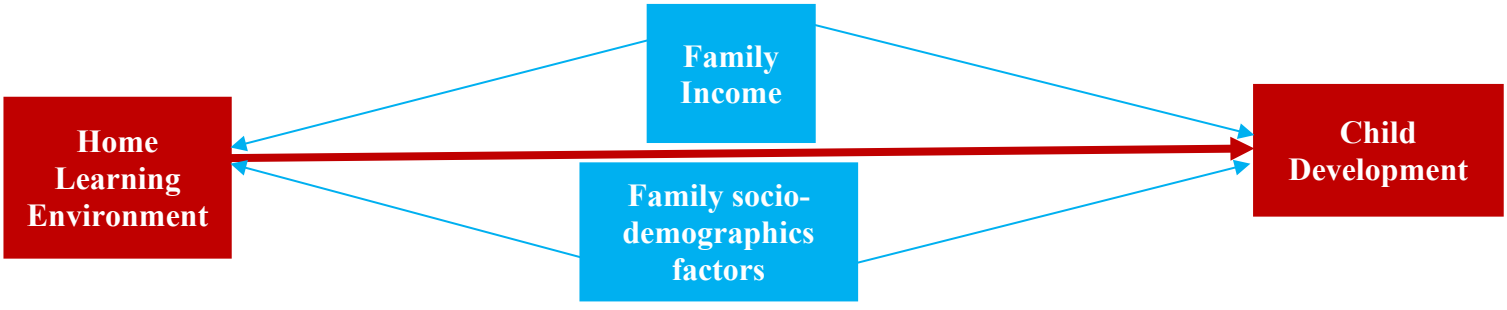
- ***RQ1: Is food insecurity associated with worse developmental outcomes for children?***



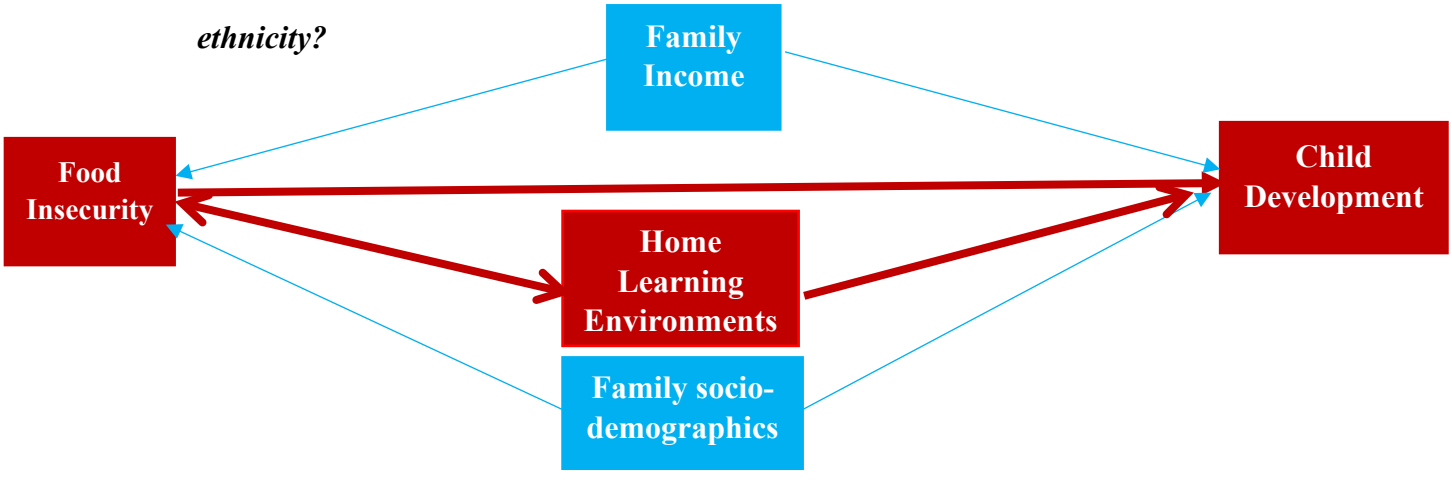
- ***RQ2: Does food insecurity predict worse developmental outcomes even after adjusting for family income?***



- ***RQ3: Are children's developmental outcomes positively associated with a stimulating HLE, controlling for income, child's age, sex, race, and ethnicity?***



- ***RQ4: Does a stimulating HLE moderate the association between food insecurity and children's developmental outcomes, controlling for income, child's age, sex, race, and ethnicity?***



2 BACKGROUND AND LITERATURE REVIEW

2.1 Child Development

Early childhood development (ECD) refers to the physical, cognitive, social, and emotional growth and changes that occur in children from birth to approximately age 8 (Fernald et al., 2017). This period is critical for laying the foundation for a child's future health and well-being, as their experiences can significantly impact their development throughout their lives (Fernald et al., 2017). The functions of ECD can be broadly classified into three categories (Fernald et al., 2017): (1) physical development, which includes gross and fine motor skills, sensory development,

physical health, changes in size, strength, and coordination; (2) cognitive development, which includes language, communication skills, problem-solving, and critical thinking, creativity; and memory skills (3) social-emotional development, which includes developing social skills, emotional regulation, and a sense of self-identity.

The determinants of ECD can be environmental or biological factors (Likhar et al., 2022). Environmental determinants include the quality of the physical environment, availability of resources, and social support networks. Biological determinants include genetics, maternal health during pregnancy, and early childhood nutrition. Addressing these determinants through supportive policies, programs, and interventions can promote healthy ECD and improve outcomes for children and families (Fernald et al., 2017).

There are several measurement tools used to assess child development across different domains. Some commonly used tools include Ages and Stages Questionnaires (Squires et al., 2009), Devereux Early Childhood Assessment (LeBuffe, 1999), Bayley Scales of Infant and Toddler Development (Bayley, 2006), Child Behavior Checklist (Achenbach & Edelbrock, 1991), etc. These traditional ECD measurement tools only provide a child's developmental status at the individual level through direct observation, resulting in lengthy and costly assessments. However, this study used a population-level ECD measurement tool called the Kidsight instrument (Raikes et al., 2021). This population-level ECD measurement tool is inexpensive and easy to administer because it relies on caregiver reports. It results in faster data collection at a large scale, which is beneficial to inform policies and large-scale programs (Raikes et al., 2021).

2.2 Food Insecurity and Child Development

Household food insecurity has been shown to significantly negatively affect early childhood development (ECD) (De Oliveira et al., 2020; Gallegos et al., 2021). Children in households experiencing food insecurity are at a higher risk for poor nutrition, stunted growth,

cognitive and academic difficulties, behavioral and emotional problems, and poor health (De Oliveira et al., 2020; Gallegos et al., 2021). Moreover, food insecurity can have long-lasting consequences, such as an increased risk for obesity and chronic health conditions.

The literature on this topic indicates that children living in food-insecure households experience various adverse outcomes. Huang et al. (2018) found that children in food-insecure households had lower reading skills and poorer health status than those in food-secure households. Hernandez & Jacknowitz (2009) reported that toddlers living with temporarily food-insecure adults had immediate adverse effects on their cognitive and motor development. Jackson & Vaughn (2017) found that household food insecurity during childhood was linked to greater involvement in adolescent misconduct, especially among males. Perez-Escamilla & de Toledo Vianna (2012) demonstrated that household food insecurity had a strong and long-lasting psychosocial and emotional impact on children.

Furthermore, Alaimo et al. (2001) reported that family-level food insufficiency in the United States was associated with adverse academic and psychosocial outcomes. In Ghana, Aurino et al. (2020) found that household food insecurity had measurable effects on children's early development, particularly academic and cognitive skills. In Brazil, De Oliveira et al. (2021) suggested that household food insecurity was associated with a higher risk of developmental delays among children under two years of age. Finally, Saha et al. (2010) reported that household food security was positively related to subsequent language development among rural children in Bangladesh.

Despite the vast amount of literature on the subject, Byrd et al. (2021) found that food insecurity was not directly associated with any developmental outcome. However, the diversity of results in the literature underscores the need to investigate whether food insecurity is associated

with poorer developmental outcomes for children in our sample before examining the role of income, HLE, and family socio-demographic factors in that association.

2.3 Child Development and Income

Research consistently reveals a robust association between income and child developmental outcomes (Berger et al., 2009; Blau, 1999). Specifically, children from low-income families are at a higher risk of experiencing unfavorable physical health, cognitive abilities, academic achievement, and social-emotional developmental outcomes (Berger et al., 2009). This correlation can be attributed significantly to the quality of the home environment, which is often inadequate in low-income households (Berger et al., 2009). Living in substandard housing exposes children to environmental toxins, which can compromise their physical health. In addition, a lack of access to high-quality educational and recreational resources can negatively impact cognitive development and academic achievement (Berger et al., 2009).

Furthermore, chronic stressors such as financial insecurity, housing instability, and food insecurity often afflict low-income families and can adversely affect their children's social-emotional development and behavior (Masten et al., 2021). Food insecurity is more prevalent in low-income families due to limited financial resources, which can limit access to affordable and nutritious food options (Masten et al., 2021). Multiple studies (Alaimo et al., 2001; Berger et al., 2009; Cook et al., 2008; Rose-Jacobs et al., 2008 & Slopen et al., 2010) have underscored the significance of considering income while studying the association between household food insecurity and child development.

Thus, assessing the role of income in our study is crucial in comprehending the factors contributing to disparities in child outcomes and developing effective interventions to enhance child well-being.

2.4 Child Development and HLE

HLE refers to the conditions and experiences within a child's home that facilitate their cognitive and socio-emotional development (Yu & Daraganova, 2015). A stimulating HLE encompasses a range of learning opportunities, including age-appropriate books, toys, technology, and media, engagement in conversations and activities with parents or caregivers, and exposure to novel experiences and environments (Lamb & Bornstein, 1987; Yu & Daraganova, 2015). These family care practices are critical for healthy growth and brain development, particularly during the first five years of a child's life (Lamb & Bornstein, 1987).

The HLE plays a vital role in child development, with research indicating that children who grow up in a stimulating and supportive HLE exhibit superior academic achievement, cognitive abilities, and social-emotional development compared to those who do not (Hamadani et al., 2010; Ho et al., 2022; Li et al., 2023). For example, parents who engage in frequent conversations with their children, read books together, and provide opportunities for play and exploration can help promote their children's language development, problem-solving skills, and curiosity (Hamadani et al., 2010; Ho et al., 2022; Li et al., 2023). Conversely, children who grow up in homes with limited resources and little parental involvement in learning activities may experience developmental delays and academic struggles (Hamadani et al., 2010; Ho et al., 2022; Li et al., 2023).

In a recent study, Jasińska et al. (2022) found that a more stimulating HLE, including access to learning materials, reading, and educational activities with parents, was associated with better executive function development and literacy skills in children. Additionally, better nutritional status was linked to better performance on these measures (Jasińska et al., 2022). This study suggests that interventions to enhance children's cognitive and literacy skills should consider HLE and nutritional status, with parent-child interactions and access to learning materials particularly

effective (Jasińska et al., 2022). Furthermore, when children experience food insecurity in a stimulating HLE, the adverse effects of food insecurity on developmental outcomes can be mitigated (Jasińska et al., 2022). This is because a stimulating HLE can buffer the negative impact of food insecurity on child development by providing additional resources, opportunities for learning and exploration, and emotional support (Jasińska et al., 2022).

However, the precise nature of this relationship may depend on several factors, such as the severity and duration of household food insecurity (Jasińska et al., 2022; Milner et al., 2018), the quality of the stimulating HLE (Hamadani et al., 2010), and the age and developmental stage of the child (Lehrl et al., 2020). Thus, it is essential, on the one hand, to investigate the relationship between positive child developmental outcomes and a stimulating HLE and, on the other hand, to examine the modifying effect of the stimulating HLE on the association between food insecurity and child developmental outcomes.

2.5 The Present Study

Food insecurity is a significant public health concern associated with various adverse health outcomes, particularly among children. Studies have shown that children who experience household food insecurity are at increased risk for poor physical and mental health outcomes and academic difficulties (De Oliveira et al., 2020; Gallegos et al., 2021). While the adverse effects of food insecurity on child development are well-established, less is known about the factors that may moderate this association.

The present study investigates the relationship between food insecurity and child development while assessing the unique contributions of income, HLE, and family socio-demographic factors to this association among Nebraskan families. Income is a well-established predictor of food insecurity, so examining whether income explains the association between food insecurity and child development is essential. The HLE encompasses the quality and quantity of

learning experiences and educational materials in the home, a significant predictor of child development (Bradley & Corwyn, 2005). Therefore, examining whether it moderates the relationship between food insecurity and child outcomes is essential. Finally, family socio-demographic factors, such as parental education and race/ethnicity, may also be significant predictors of child development. Therefore, it is essential to control for these factors in the analysis. This is why the specific objectives of the study are to:

- Determine the association between food insecurity and worse developmental outcomes for children.
- Assess the unique contribution of income to the association between food insecurity and child development.
- Investigate the relationship between positive children's developmental outcomes with stimulating HLE, controlling for income, child's age, sex, race, and ethnicity.
- Examine the modification effect of the stimulating HLE on the association between food insecurity and children's developmental outcomes, controlling for income, child's age, sex, race, and ethnicity.

This study will contribute to our understanding of the complex relationship between food insecurity and child development. It will provide valuable information for policymakers and healthcare providers working to address this critical public health issue. By better understanding how food insecurity interacts with HLEs to predict child development, this study will provide essential insights into the most effective strategies for addressing food insecurity and promoting optimal child development.

3 METHODOLOGY

3.1 Participants

This study utilized a secondary data set obtained from the Nebraska Early Childhood Study Dataset, an extensive investigation of children's development from birth to six years in the Lincoln and Omaha metropolitan areas of Nebraska, USA (Raikes et al., 2021). The Nebraska Early Childhood Study comprised various survey items from multiple sources. Specifically, the survey items used to assess family demographics, childcare, and parent mental health were extracted directly from the existing survey battery for the National Survey of Children's Health (NSCH).

Data were collected from caregivers through an online survey that typically required 20-30 minutes to complete. The online survey was administered between October 2020 and January 2021 to caregivers recruited from healthcare providers, parenting support programs, childcare facilities, and social media platforms. Priority was given to underrepresented, high-risk groups to ensure inclusiveness and representativeness. Caregivers could access the online questionnaire using their mobile phone, tablet, or computer through a hyperlink containing questions about family demographics, the child's adverse childhood experiences, development, health, and stimulating home learning environment (Raikes et al., 2021). In exchange for their participation, caregivers received $20 gift cards during the first two months of recruitment and $40 gift cards during the subsequent three months. The increase in payment was intended to attract more respondents and ensure sample diversity (Raikes et al., 2021).

Initially, 2,400 individuals responded to some survey questions, but only data from 486 caregivers were included in the analyses, adhering to specific inclusion and exclusion criteria. Specifically, the data were only included if the respondent had completed at least half of the survey, had a child aged birth to 60 months, and had provided information on family food insecurity status,

as only half of the sample had been queried on this variable. Furthermore, the respondents were required to reside in Douglas, Lancaster, or Sarpy County (Raikes et al., 2021).

3.2 Child Development

The outcome variable child's development was measured using the Kidsight score (Raikes et al., 2021). This instrument was used for children from 12 to 60 months. The items used to generate children's scores are caregiver-report items that index normative child development, covering language, physical, cognitive, and social/emotional development. For the survey, items are placed into age bins so that respondents receive an age-appropriate set of items based on children's ages. The form included questions like: Can your child jump with both feet leaving the ground? How high can this child count correctly? (Development summary score). This instrument used the items from Global Scale for Early Development (GSED) Short Form and the National Outcome Measure (NOM). This form included 139 items from the GSED and 62 items from the NOM. However, caregivers did not have to respond to all the items. These items were like: "If an object falls to the ground out of view, does your child look for it?". "Can your child correctly ask questions using the words 'what,' 'which,' 'where,' or 'who?

3.3 Food Insecurity

Data on household food insecurity were collected using items from the National Survey of Children's Health (NSCH) (Jackson & Testa, 2021). The primary caregivers were asked: "Which of these statements best describes the food situation in your household in the past 12 months?"

The response included four options: (1) We could always afford to eat good nutritious meals; (2) We could always afford enough to eat, but not always the kinds of food we should eat; (3) Sometimes, we could not afford enough to eat; (4) Often, we could not afford enough to eat.

Respondents who reported that they could sometimes or often not afford enough to eat were designated as experiencing moderate-to-severe food insecurity (Jackson & Testa, 2021).

Respondents who said they could always afford enough to eat, but could not always afford to purchase nutritious foods, were selected as experiencing mild food insecurity (Jackson & Testa, 2021). Lastly, respondents who reported being consistently able to afford good, nutritious meals were defined as being food secure (Jackson & Testa, 2021). Food insecurity was coded to a binary variable (i.e., 0- "mild and moderate-to-severe food insecurity"; 1- "food security").

3.4 Home Learning Environment

The family care indicator (FCI) instrument assessed the HLE dimensions. This instrument was developed by the United Nations Children's Fund (UNICEF) to measure young children's HLE in developing countries in large population surveys, emphasizing items likely to be related to cognitive and language development (Frongillo et al., 2003).

The FCI questionnaire was indexed using two content areas: home learning activities and home learning materials. Home learning activities were indexed by caregivers' reports of whether someone in the house over age 15 had engaged in ten different activities with the child in the past three days, for example, book reading; painting or drawing; counting; and taking the child out of the house. Home learning materials were indexed by caregivers' reports of whether the child plays with a range of toys and other materials. We used a sum score of home learning materials and activities to determine HLE, with higher scores indicating more stimulation in the HLE.

3.5 Income

Caregivers were asked to estimate their total household income in 2020 using language from the National Survey of Children's Health question: "Think about your combined family income. What is the projected amount for 2020 before taxes?" (Raikes et al., 2021).

3.6 Socio-demographic Characteristics

These characteristics are for the child: age, sex, race, and ethnicity. For the caregiver: age, sex, race and ethnicity, education, and marital status. Caregivers reported demographic and geographic information as follows:

- Age: The child's age was given in days.
- Sex: the child's sex was coded to a binary variable (i.e., 0- "Male"; 1- "Female").
- Race and Ethnicity: Following procedures in the National Survey of Children's Health, caregivers were asked to report on the 15 racial categories (Native Hawaiian or other Pacific Islander, American Indian or Alaskan Native; Asian; Black or African American, and White (Ingram et al., 2003) and a separate question focused on identification as Hispanic or Latino descent. Race was coded to a binary variable (i.e., 0- "Not white"; 1- "white"). The same coding was done for ethnicity (i.e., 0- "Hispanic"; 1- "non-Hispanic").

3.7 Statistical analysis

Four multiple regression models were used to answer the research questions. We used IBM SPSS Statistics Version 28.0.1.1 (IBM Corp., Armonk, NY, USA) to perform all analyses, and significance testing occurred at the $\alpha = 0.05$ level.

3.7.1 Model 1

The first model (Model 1) addressed RQ1: Is food insecurity associated with worse developmental outcomes for children?

$$y_i = \beta_0 + \beta_1 \mathrm{FI}_i + x_i\gamma + \epsilon_i \quad (1)$$

where $\boldsymbol{x}_i$ contains information on the child's age, sex, race, and ethnicity and i indexes children.

In this model 1, the coefficient of interest is β_1, which represents the effect of food insecurity (FI) on children's developmental outcomes. It quantifies the change in the outcome variable y_i associated with a one-unit increase in food insecurity, holding all other variables in x_i

(child's age, sex, race, and ethnicity) constant. The error term ϵ_i captures the random variation in the outcome variable that the model cannot explain. Thus, by estimating the value of β_1, after controlling for other relevant factors, the model can provide insights into whether food insecurity is associated with worse developmental outcomes for children. If the coefficient β_2 is statistically significant and negative, it suggests that food insecurity directly affects developmental outcomes, even after controlling for a child's age, sex, race, and ethnicity.

3.7.2 Model 2

The second model (Model 2) addressed the RQ2: Does food insecurity predict worse developmental outcomes even after adjusting for family income?

$$y_i = \beta_0 + \beta_1 \mathrm{FI}_i + \beta_2 \mathrm{FINC}_i + x_i\gamma + \epsilon_i \quad (2)$$

In Model 2, the coefficient of interest is β_1, which represents the effect of food insecurity (FI) on developmental outcomes while controlling for family income (FINC). Including the FINC variable allows us to examine whether food insecurity predicts developmental outcomes above and beyond a standardized level of family income. By estimating the value of β_1 in Model 2, we can determine whether food insecurity predicts worse developmental outcomes even after adjusting for family income and other relevant control variables. If the coefficient β_2 is statistically significant and negative, it suggests that food insecurity directly affects developmental outcomes, even after controlling for family income and other factors.

3.7.3 Model 3

The third model (Model 3) will be used to address the RQ3: Are children's developmental outcomes positively associated with a stimulating HLE, controlling for income, child's age, sex, race, and ethnicity?

$$y_i = \beta_0 + \beta_1 \mathrm{FCI}_i + \beta_2 \mathrm{FINC}_i + x_i\gamma + \epsilon_i \quad (3)$$

In Model 3, the coefficient of interest is β_1, which represents the effect of a stimulating HLE (FCI) on developmental outcomes while controlling for family income (FINC) and other relevant factors such as age, sex, race, and ethnicity. The FCI variable captures how much children can access stimulating learning materials, experiences, and interactions at home. By estimating the value of β_1 in Model 3, we can determine whether a positive association exists between stimulating HLE and developmental outcomes after controlling for family income and other relevant factors. Suppose the coefficient β_1 is statistically significant and positive. In that case, it suggests that an HLE is positively associated with better developmental outcomes for children, even after adjusting for family income and other relevant factors.

3.7.4 Model 4

The last model (Model 4) will be used to address the RQ4: Does a stimulating HLE moderate the association between food insecurity and children's developmental outcomes, controlling for income, child's age, sex, race, and ethnicity?

$$y_i = \beta_0 + \beta_1 \mathrm{FCI}_i + \beta_2 \mathrm{FI}_i + + \beta_3\ \mathrm{FINC}_i + \beta_4(\mathrm{FCI}_i \times \mathrm{FI}_i) + \ x_i\gamma\ + \epsilon_i \qquad (4)$$

In Model 4, the coefficient of interest is β_4, which represents the interaction effect between a stimulating HLE (FCI) and food insecurity (FI) on developmental outcomes while controlling for family income (FINC) and other relevant factors such as age, sex, race, and ethnicity. The coefficient β_1 represents the effect of a stimulating HLE on developmental outcomes while β_2 represents the effect of food insecurity on developmental outcomes. The interaction term β_4 captures the extent to which the association between food insecurity and developmental outcomes varies depending on the level of a stimulating HLE. By estimating the value of β_4 in Model 4, we can determine whether a stimulating HLE moderates the relationship between food insecurity and developmental outcomes. A significant positive coefficient for the interaction term suggests that

the positive effect of a stimulating HLE can help buffer the adverse effects of food insecurity on developmental outcomes.

3.8 Human Subjects

Our institutional review board reviewed our study as we used secondary data from the Nebraska Early Childhood Pilot Study (Raikes et al., 2021). It determined it to be non-human subject research.

4 RESULTS

4.1 Study Population and Descriptive Data

This study includes a final sample of 486 children. Tables 1 and 2 provide descriptive statistics on the sample of children and caregivers. Of the children in the sample, 68.3% were white and non-Hispanic (83.5%), with a median age of 36 months, and 50.6% were male.

The majority of primary caregivers were white (71.8%), non-Hispanic (86.8%), female (85.3%), married (80.2%), and had at least a high school diploma (94.4%). The mean age of primary caregivers was 31.7 years. Compared to national estimates reported by the US Census Bureau (2021), the sample of caregivers in this study was more educated (45.5% said having a bachelor's degree, versus 32.1% nationally) and less likely to identify as Black (11.7% in the sample versus 13.4% nationally) or Hispanic (13.2% in the sample versus 18.5% nationally).

The sample's median income in 2019 was $58,372, nearly $10,000 below the national median income (Semega et al., 2021). A substantial proportion of caregivers reported enrollment in federal services (54.5%), with Medicaid enrollment (40.3%) and financial and nutrition aid being the most commonly reported (36.8%).

Regarding food insecurity, 65% of children (n=316) were not exposed. In comparison, 28.6% (n=139) were exposed to mild food insecurity, 5.4% were exposed to moderate food insecurity (n=26), and 1.0% were exposed to severe food insecurity (n=5).

4.2 Bivariate Analysis

Based on key socio-demographic factors associated with delay in child development in previous research (Kofke et al., 2022; Sánchez-Vincitore & Castro, 2022; Solanke et al., 2019), we reported bivariate analyses on the following variables: child and caregiver's race/ ethnicity; caregiver and child sex; caregiver and child age; college education vs. non-college educated; income; HLE and association with child development and food insecurity (See Table 3). Within our sample, HLE and income were all positively and significantly related to child development and between each other. However, income, child development, and HLE were negatively and significantly associated with food insecurity.

4.3 Multivariate Analyses

We conducted multiple linear regression analyses to understand the underlying reasons for the relationship between demographic group differences (race/ethnicity, child gender, caregiver's receipt of college, income, and HLE) and the association between child development and food insecurity.

4.3.1 Association between Food Insecurity and Child Development

Table 4 displays the regression coefficient estimates for Model 1 corresponding to RQ1 (i.e., "Is food insecurity associated with worse developmental outcomes for children?"). We found a negative association between food insecurity and children's developmental outcomes (Est = -0.217, SE = 0.091, ES = -0.109, p = .018), controlling for the child's age, sex, race, and ethnicity.

4.3.2 Association between Food Insecurity, Child Development, and Income

Table 4 displays the regression coefficient estimates for Model 2 corresponding to RQ2 (i.e., "Does food insecurity predict worse developmental outcomes even after adjusting for family income?"). We found a negative association between food insecurity and children's developmental outcomes even after adjusting for family income (Est = -0.189, SE = 0.095, ES = -0.095, p = .048).

4.3.3 Association between Child Development and Stimulating HLE and Income

Table 4 displays the regression coefficient estimates for Model 3 corresponding to RQ3 (i.e., "Are children's developmental outcomes positively associated with a stimulating HLE, controlling for income, child's age, sex, race, and ethnicity"). We found that HLE is positively associated with children's developmental outcomes, even after controlling for income, child's age, sex, race, and ethnicity (Est = 0.376, SE = 0.092, ES = 0.198, p <.001).

4.3.4 Association between Child Development, Food Insecurity, and Stimulating HLE

Table 4 displays the regression coefficient estimates for Model 4 corresponding to RQ4 (i.e., "Does a stimulating HLE moderate the association between food insecurity and children's developmental outcomes, controlling for income, child's age, sex, race, and ethnicity"). We failed to find sufficient evidence that HLE moderated the association between food insecurity and children's developmental outcomes after controlling for income, child's age, sex, race, and ethnicity (Est = -0.287, SE = 0.185, ES = -0.095, p = .121).

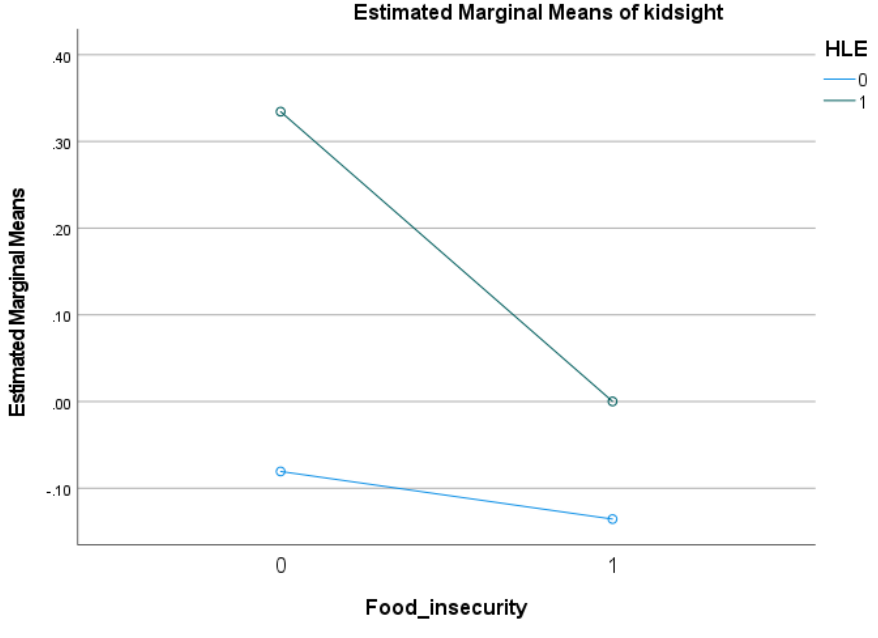


Figure 1: Interaction Plot between Family HLE and Food Insecurity

The graph shows that the change (difference) in the development of children living in a low HLE with food insecurity, represented by the blue line, is lower than the change (difference) in the development of children living in an HLE without no food insecurity, represented by the green line. Since these two changes are not significantly different, there is no interaction.

This means that the presence of a stimulating HLE did not weaken the negative relationship between food insecurity and developmental outcomes in children. Therefore, the results suggest that interventions targeting HLE may be beneficial for children's developmental outcomes. Still, they may not be enough to counteract the negative impact of food insecurity on child development.

5 DISCUSSION

5.1 Summary

This study examined the association between food insecurity and child development and assessed the unique contribution of family income, stimulating HLE, and family socio-demographic factors to that association. Four research questions were examined: first, whether food insecurity is associated with worse developmental outcomes for children; second, whether food insecurity predicts worse developmental outcomes even after adjusting for family income; third, whether children's developmental outcomes are positively associated with a stimulating HLE, controlling for income, child's age, sex, race, and ethnicity; and finally, whether stimulating HLE moderates the association between food insecurity and children's developmental outcomes, controlling for income, child's age, sex, race, and ethnicity.

We found that, first, food insecurity was associated with worse developmental outcomes for children. Second, food insecurity predicted worse developmental outcomes for children, even after adjusting for family income. Third, stimulating HLE was positively associated with children's developmental outcomes, even when controlling for income, age, sex, race, and

ethnicity. Finally, stimulating HLE through HLE did not moderate the association between food insecurity and children's developmental outcomes, even after controlling for income, age, sex, race, and ethnicity.

5.2 Key results

5.2.1 Food insecurity was associated with worse developmental outcomes for children

The present study supports the negative association between food insecurity and child developmental outcomes, in line with previous literature reporting similar findings, including reduced cognitive development, academic achievement, and behavioral problems (de Oliveira et al., 2020). A systematic review including 22 studies across 14 countries highlights that children from food-insecure households exhibit lower cognitive and language development scores and a higher risk of developmental delays than those from food-secure families (de Oliveira et al., 2020).

However, our findings contrast with those of Byrd et al. (2021), who reported no direct association between food insecurity and any developmental outcomes among preschool children. This discrepancy may be attributed to the different methodological approaches employed. Byrd et al. (2021) utilized three individual-level instruments to assess child developmental outcomes and two USDA Annual Food Security Survey questions to measure food insecurity. In contrast, we employed one population-level instrument to measure all early childhood development functions and collected data on food insecurity via the NSCH. There is no one-size-fits-all approach to measuring early childhood development, and the best method depends on the context and purpose of the measurement. A combination of instruments is recommended to capture the multidimensional construct of ECD, while population-level instruments are valuable for policy and planning purposes (de Oliveira et al., 2020).

Future research using both population- and individual-level assessments can provide a more comprehensive evaluation of a child's development. However, our methodological approach aligns with our research questions and study goals.

5.2.2 Food insecurity predicted worse developmental outcomes even after adjusting for family income

The present study found a significant negative association between food insecurity and child developmental outcomes, even after controlling for family income. This finding suggests that the relationship between food insecurity and child development remains relatively stable when income is standardized, emphasizing the adverse effect of food insecurity on child developmental outcomes after accounting for other variables in the model. While our results confirm that food insecurity significantly predicts child developmental outcomes, the precise mechanism through which income impacts this relationship remains unclear.

Previous studies have indicated that income positively correlates with children's developmental outcomes (Berger et al., 2009; Slopen et al., 2010). For example, Berger et al. (2009) found that a child's development is strongly influenced by family income, with lower-income families having difficulty providing the resources and support necessary for healthy growth. However, the authors argued that this relationship is complex and may be mediated by other factors such as parenting practices, education, and healthcare. Similarly, Slopen et al. (2010) reported that income partially mediated the relationship between food insecurity and child behavioral and emotional problems, indicating that income-related factors play a crucial role in this relationship.

These findings from the literature highlight the importance of considering income as a critical factor when studying child development and food insecurity (Alaimo et al., 2001; Cook et al., 2008; Rose-Jacobs et al., 2008). Further research using mediation analysis may provide

additional insights into the role of income in the relationship between food insecurity and child development.

5.2.3 Children's developmental outcomes were positively associated with a stimulating HLE

The analysis found that providing a stimulating HLE was positively associated with child development. Our results are consistent with the literature (Kariger et al., 2012; Tamis-LeMonda et al., 2019; Vanbecelaere et al., 2021). For instance, Tamis-LeMonda et al. (2019) found that the quality of the HLE at an early age predicts children's academic skills in 5th grade, even after controlling for family income, maternal education, and children's cognitive ability at 14 months. Another study by Vanbecelaere et al. (2021) found that a stimulating HLE, including parental support and access to learning materials, is positively associated with children's early cognitive and non-cognitive outcomes in math and reading. Additionally, they found that parental support in math activities has a stronger relationship with math outcomes than parental support in reading activities (Vanbecelaere et al., 2021).

These results emphasize the importance of engaging in HLE. Indeed, nurturing HLE can give children a solid foundation for academic success, emotional well-being, and lifelong learning. A stimulating HLE can help children reach their full potential and thrive by promoting cognitive, language, social-emotional, and physical development.

5.2.4 Stimulating HLE did not moderate the association between food insecurity and children's developmental outcomes

Our findings suggest that a stimulating HLE does not significantly moderate the association between food insecurity and developmental outcomes. In other words, even if a child has access to books, educational resources, and other enriching activities at home, they may still experience developmental setbacks if they do not have enough nutritious food.

Jasińska et al. (2022) showed that stimulating HLE and good nutrition were crucial factors for children's cognitive and literacy development. Children with a more stimulating HLE and better nutrition status performed better on measures of executive function and literacy skills. The study highlighted the importance of providing children with access to learning materials and educational activities with parents to promote a stimulating HLE. Adequate nutrition is also essential for cognitive development, and addressing food insecurity can improve children's nutritional status, positively impacting their cognitive and literacy outcomes. Therefore, interventions to improve children's cognitive and literacy skills should consider both HLE and nutritional status as essential factors.

Although the study did not directly explore the role of HLE in the relationship between food insecurity and child development, it suggested that a stimulating HLE could promote healthy child development regardless of food insecurity status. However, addressing food insecurity and improving the HLE should also be a priority in promoting healthy child development.

5.3 Strengths and Limitations

The current study has several strengths. Firstly, it establishes a negative association between food insecurity and child development, indicating that reducing food insecurity may improve developmental outcomes for children. Secondly, the study highlights the essential role of both stimulating HLE and food security in predicting children's developmental outcomes, underlining the need for interventions that address both nutritional status and HLE. Such interventions could facilitate access to healthy food options and provide resources and educational opportunities for parents and caregivers to promote healthy cognitive and literacy development, particularly in low-income communities where food insecurity is more prevalent.

Despite these strengths, several limitations of the study should be considered. Firstly, the cross-sectional design limits the ability to infer causality, and longitudinal studies would be

necessary to establish causal relationships. Secondly, the study's sample may not be representative of the broader population in Nebraska as participants were recruited through specific channels, potentially biasing the results towards those more engaged with social services or healthcare. Thirdly, self-reported food insecurity and income measures used in the study may be subject to social desirability bias and inaccurate reporting. Finally, the low explanatory power of the models used in the study suggests that other unmeasured factors may contribute to the observed relationships, indicating the need for further research to fully understand the complex associations between HLE and child development in food-insecure families.

5.4 Future Directions

Based on the strengths and limitations of this study, several recommendations for future research are suggested. First, the study's small sample size of only 486 children may limit the generalizability of the findings. Future studies could address this issue by recruiting a larger sample size to increase the statistical power of the analysis and improve the representativeness of the study. Second, the study sample was predominantly white and non-Hispanic, indicating the need for more diverse participants to explore the relationship between food insecurity and child development in different demographic groups.

Third, the study used a single question with four response options to measure food insecurity. Future studies could use measures like the Household Food Insecurity Access Scale or the Food Security Survey Module to assess food insecurity more accurately. Fourth, the study was cross-sectional, limiting the ability to establish causality. Future studies could use longitudinal designs to examine the relationship between food insecurity and child development.

Fifth, the study did not control for confounding variables like maternal depression, stress, or parental support. Future studies could include additional variables to control for potential confounding factors affecting the relationship between food insecurity and child development.

Lastly, future research could evaluate the effectiveness of food assistance programs, early childhood education, and parenting support programs in improving child outcomes. Addressing these recommendations will help to advance the knowledge on food insecurity and child development and inform policies and interventions that promote healthy child development.

5.5 Policy Recommendations

Based on the findings of this study, we can recommend implementing policies that aim to alleviate food insecurity among low-income families and provide support for HLE:

- Increase access to federal food assistance programs: Given the significant impact of food insecurity on child development, policymakers should consider expanding access to food assistance programs such as SNAP (Supplemental Nutrition Assistance Program) and WIC (Women, Infants, And Children) to help low-income families meet their basic food needs.
- Increase investment in early childhood education: The study highlights the importance of stimulating HLE in promoting child development. Policymakers should consider increasing investment in early childhood education programs that provide families with resources and support to create an HLE that supports child learning and development.
- Address structural factors contributing to poverty: Poverty and low income are key predictors of food insecurity and poor developmental outcomes for children. Policymakers should consider addressing structural factors contributing to poverty, such as improving access to affordable housing, increasing the minimum wage, and providing affordable healthcare.
- Increase funding for research on food insecurity and child development: While this study provides important insights into the relationship between food insecurity and child development, the sample size and scope of the study are limited. Policymakers should consider increasing funding for research on food insecurity and child development to

understand better the complex factors contributing to poor developmental outcomes in low-income families and identify effective interventions.

6 CONCLUSION

This study demonstrates the adverse impact of food insecurity on child development and underscores the role of income and a stimulating home learning environment (HLE) in promoting positive developmental outcomes. Our findings suggest that access to a stimulating HLE is linked to better child development outcomes. While a stimulating HLE alone does not eliminate the negative effect of food insecurity on child development, addressing and promoting a stimulating HLE are crucial to improving child developmental outcomes, particularly in populations at high risk of food insecurity. This study highlights the need for further research to comprehensively understand the complex factors that affect child development in food-insecure families. It also contributes to the growing body of literature on the relationship between food insecurity, HLE, and child development. It provides valuable insights for policymakers, educators, and healthcare professionals who aim to improve young children's and their families' lives.

DEDICATION

To my God, Lord, and Savior, the Alpha and Omega of my life

To my parents, Marcel and Colette, I cannot thank you enough for your sacrifices to allow me to study. Despite the distance separating us, you have always been a constant source of encouragement and support, keeping me connected to my roots. Your support, guidance, prayers, and love have helped me navigate the challenges of living in a foreign country. Even when we could not physically be together during family holidays, funerals, and birthdays, your presence and support were always felt.

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APPENDIX

Assumptions for Regression Analysis

The assumptions of a simple linear regression model are independence, linearity, equal variances, and normality. Independence means that response values are independent. It can be assessed by knowing the details of the study design. Based on the current study design, the sample of children and caregivers are random. Therefore, we can assume that independence holds.

Linearity means the response (Y) values for various covariate (X) values fall on a straight line. This assumption can be checked using a scatterplot to visualize the relationship between the predictor and response variables. The scatter plot of the response versus the predictors should be randomly scattered, with no apparent patterns, about the residual value of 0. Figure 2 shows that the cloud of points is approximately linear without any nonlinearity; thus, the linearity assumption holds.

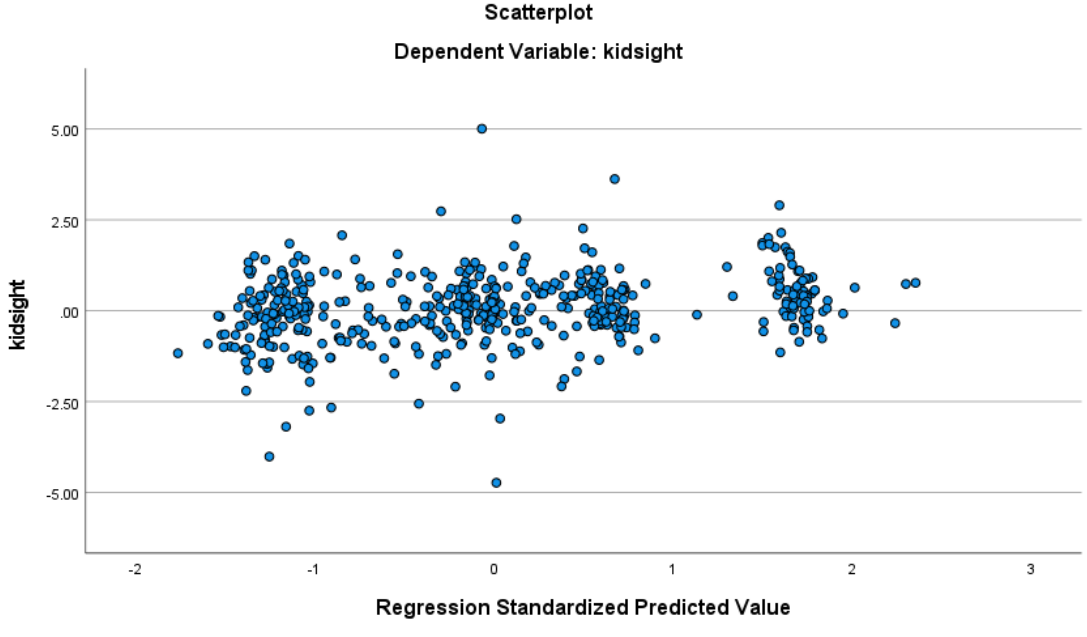

Figure 2: Scatterplot

Normality means that for each particular value of the covariates (X), the corresponding response values (Y) are normally distributed. The plot of the percentiles of the residuals against

the percentiles of the standard normal distribution should look linear. We can use a histogram and a normal Q-Q or P-P plot to check whether the residuals are normally distributed. Figures 3-6 show that all the residuals are normally distributed. Income was skewed to the left (figure 4), and we transformed this variable into the log of income (figure 5) to meet the normality assumption; thus, the normality assumption holds.

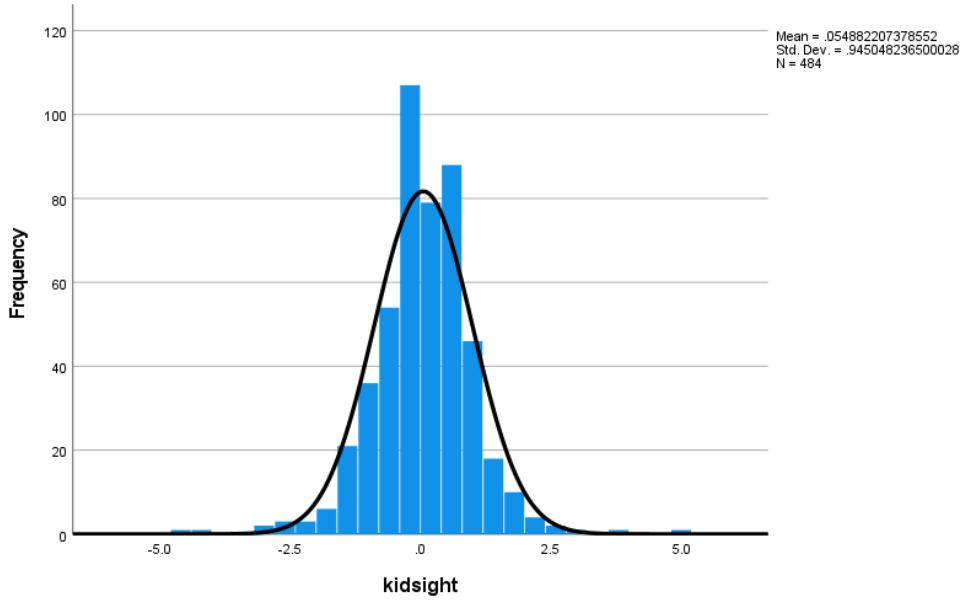

Figure 3: Distribution of Child Development

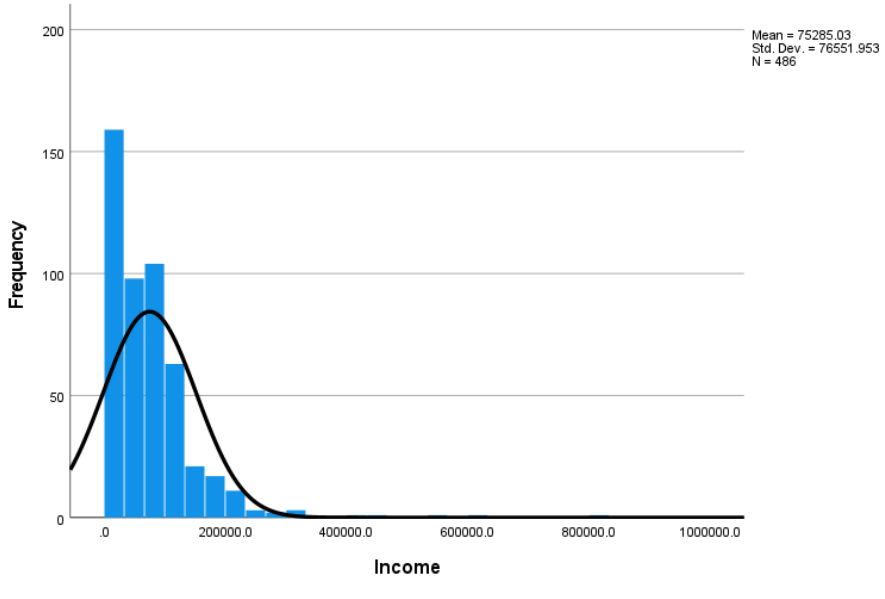

Figure 4: Distribution of Income

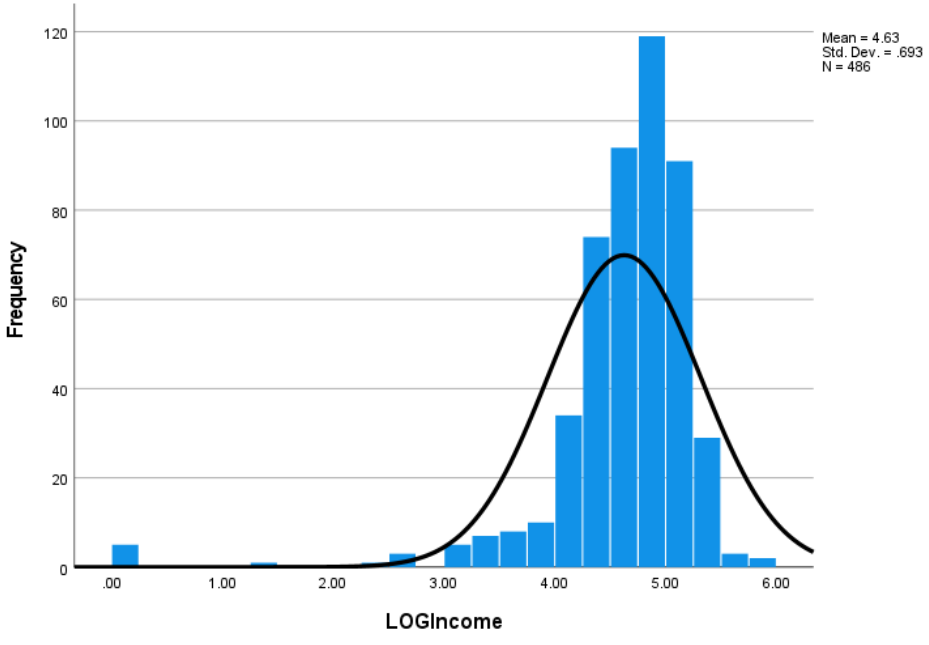

Figure 5: Distribution of Log-Transform Income

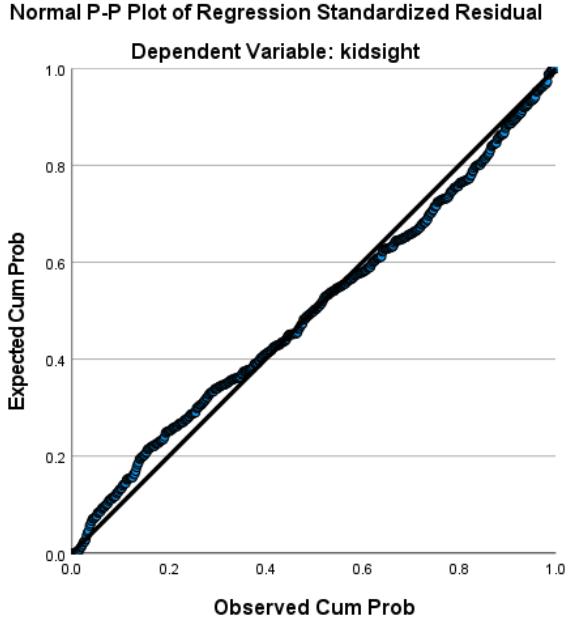

Figure 6: Normal P-P Plot of Regression Standardized Residual

Equal Variances (Homoscedasticity) mean for different values of the covariate (X), the variability in their response values (Y) is the same. The variability in the response variable should look constant for all predictor values. Based on Figure 7-11, we can see that the variances of the

residuals are similar across the groups, which indicates that the assumption of homoscedasticity has been met.

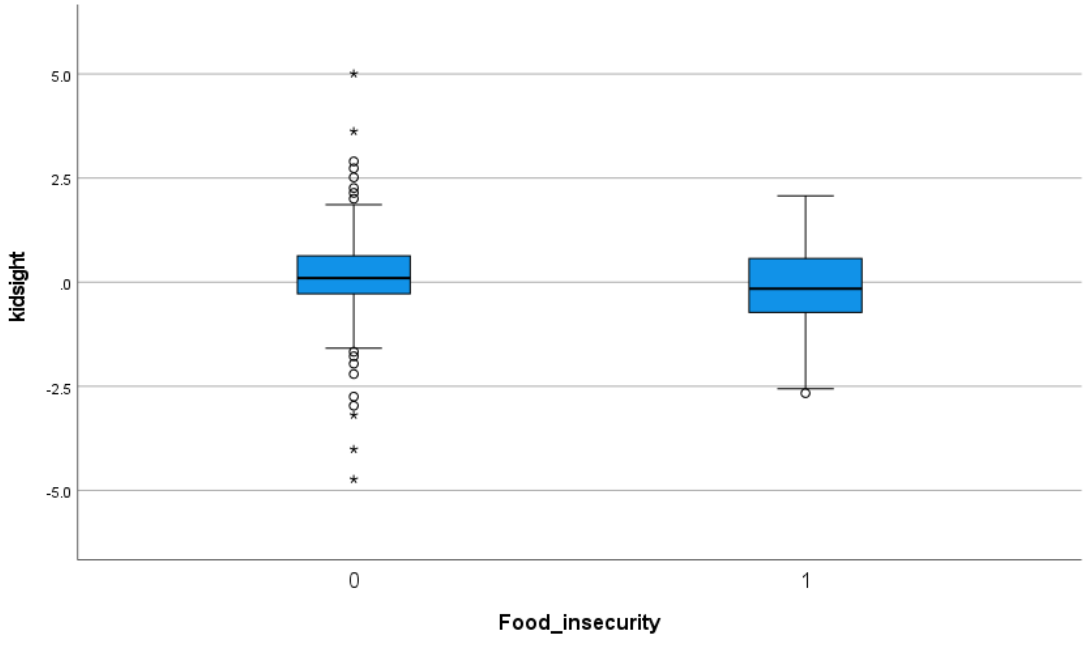

Figure 7: Side-by-Side Box Plot between Child Development and Food Insecurity

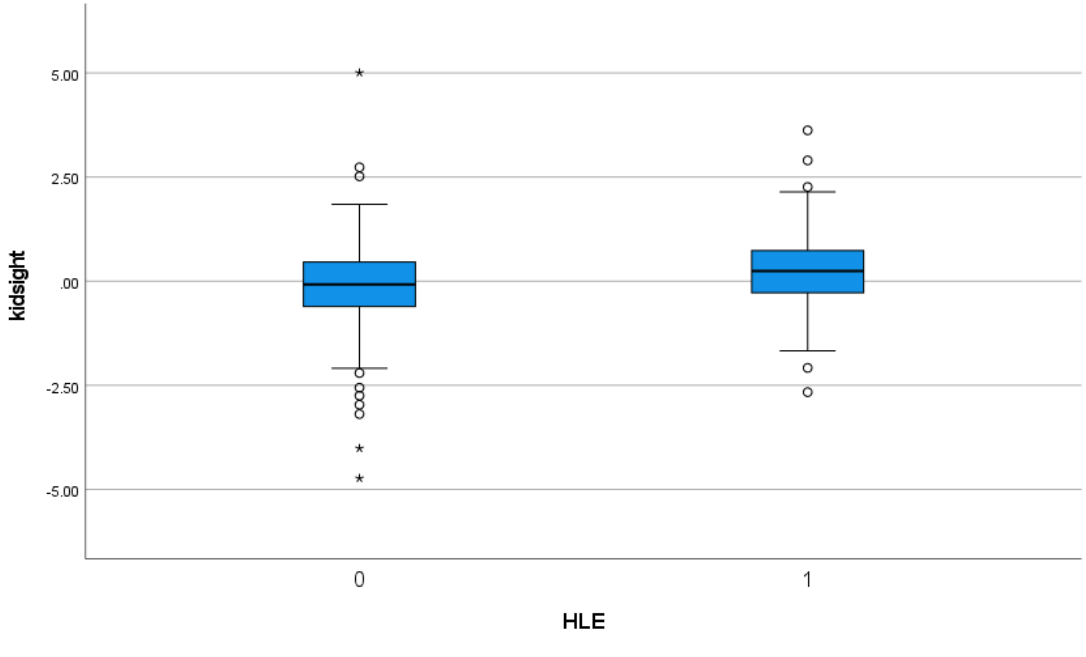

Figure 8: Side-by-Side Box Plot between Child Development and Family HLE

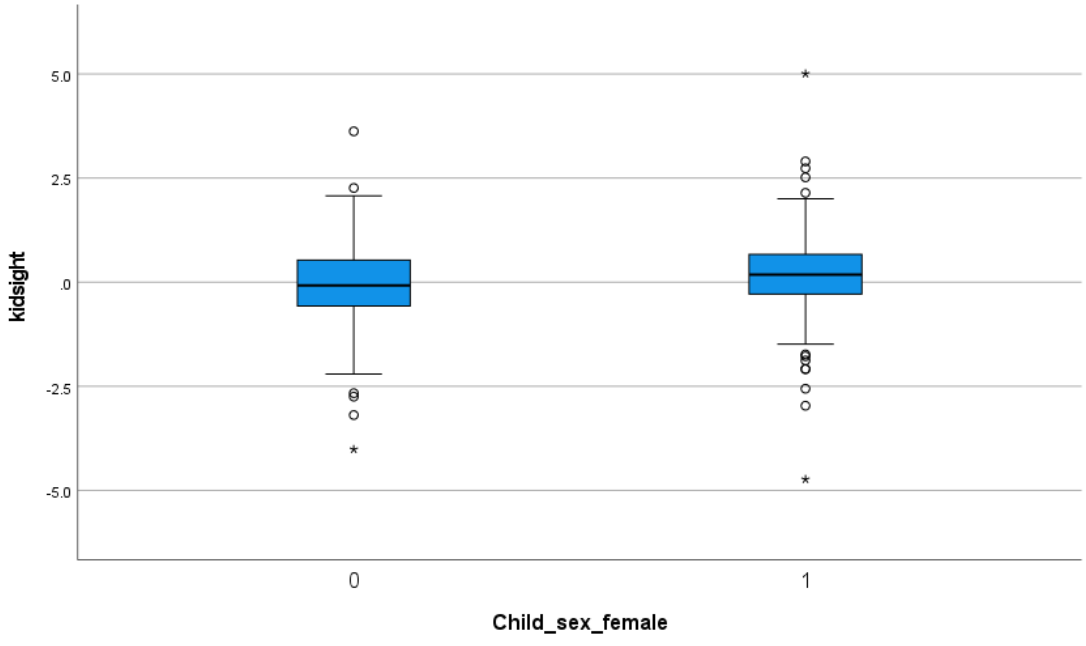

Figure 9: Side-by-Side Box Plot between Child Development and Child's Sex

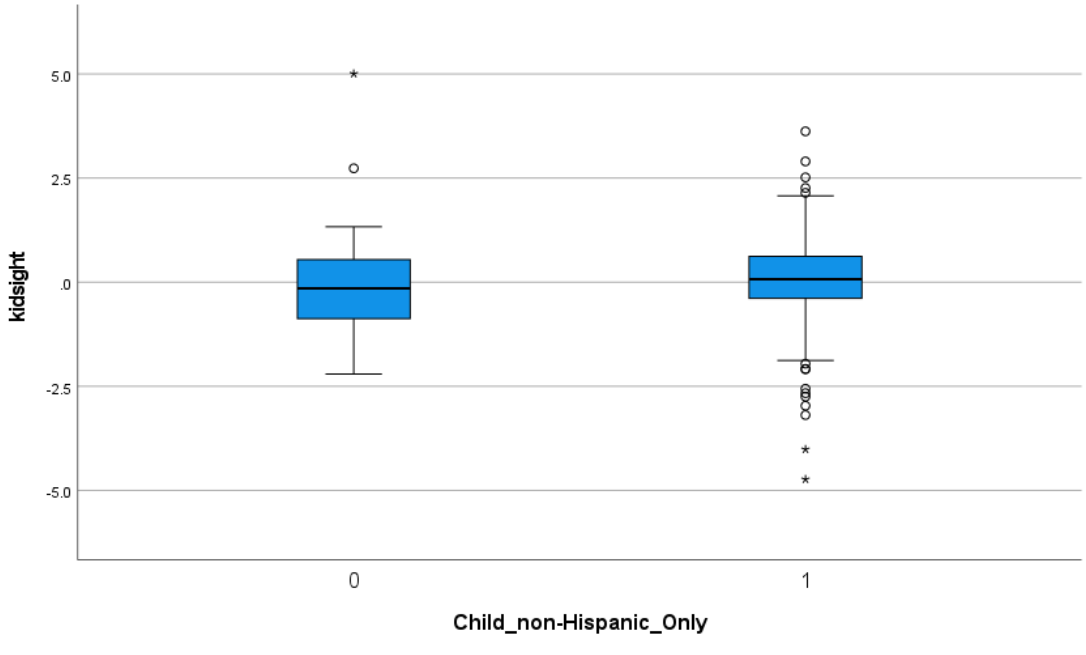

Figure 10: Side-by-Side Box Plot between Child Development and Child's Ethnicity

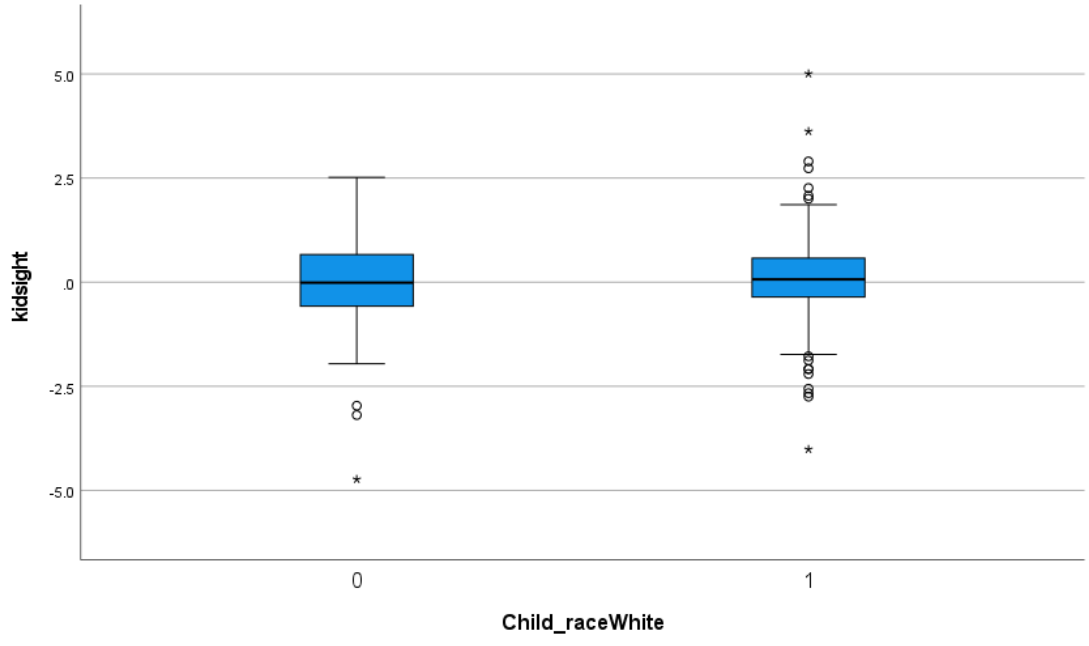

Figure 11: Side-by-Side Box Plot between Child Development and Child's Race

Table 1: Caregiver's Descriptive Statistics (N=486)

	Variables	***Total count***	***Percentage***
Sex	Female	415	85.4%
	Male	71	14.6%
Race	White	349	71.8%
	Black	57	11.7%
	Asian	35	7.2%
	Native Hawaiian and Other Pacific Islander	29	6.0%
	American Indian or Alaska Native	16	3.3%
Ethnicity	Non-Hispanic	422	86.8%
	Hispanic	64	13.3%
Education	Bachelor's degree	221	45.5%
	Associate Degree	144	29.6%
	High School Diploma	94	19.3%
	Non-High School Diploma	27	5.6%
Marital Status	Not Married	96	19.8%
	Married	390	80.3%
Age Category in years	Younger than 21	12	2.5%
	21-29	160	32.9%
	29-39	267	54.9%
	More than 39	47	9.7%

Table 2: Child's Descriptive Statistics (N=486)

	Variables	*Total count*	*Percentage*
Sex	Male	246	50.6%
	Female	240	49.4%
Race	White	332	68.3%
	Black	76	15.6%
	Asian	40	8.2%
	Native Hawaiian and Other Pacific Islander	24	4.9%
	American Indian or Alaska Native	14	2.9%
Ethnicity	Non-Hispanic	406	83.5%
	Hispanic	80	16.5
Age Category in months	6-11	110	22.6%
	12-23	99	20.4%
	24-35	98	20.2%
	36-47	79	16.3%
	48-59	63	13.0%
	59-71	37	7.6%
Food insecurity	No Food Insecurity	316	65.0%
	Mild	139	28.6%
	Moderate	26	5.4%
	Severe	5	1.0%

Table 3: Bivariate Analysis

	1	2	3	4	5	5	6	7	8	9	10	11	12	13
Child Development	--													
Food Insecurity	-0.115*	--												
HLE	0.188**	-0.196**	--											
Income	0.095*	-0.332**	0.184**	--										
Caregiver is College Grad	0.100*	-0.375**	0.206**	0.502**	--									
Caregiver is Married	-0.022	-0.210**	0.038	0.318**	0.329**	--								
Caregiver is white	0.026	-0.173**	0.266**	0.356**	0.398**	0.206**	--							
Caregiver is non-Hispanic	0.061	-0.070	0.140**	0.148**	0.138**	0.045	0.178**	--						
Caregiver's age	-0.049	-0.095*	0.140**	0.255**	0.226**	0.131**	0.160**	0.090*	--					
Caregiver is female	0.071	0.022	-0.040	-0.001	-0.008	-0.088	0.000	-0.011	-0.057	--				
Child's age in months	0.025	-0.012	0.306**	0.031	0.040	-0.077	0.078	-0.031	0.164**	-0.091*	--			
Child is non-Hispanic	0.045	-0.033	0.116*	0.142**	0.136**	0.082	0.202**	0.828**	0.086	0.028	-0.064	--		
Child is female	0.131**	0.000	-0.022	0.020	0.082	0.066	-0.021	-0.039	-0.012	0.176**	-0.074	0.020	--	
Child is white	0.041	-0.224**	0.235**	0.380**	0.409**	0.251**	0.831**	0.091*	0.155**	-0.044	0.037	0.101*	-0.044	--

Notes: ***p<.001, **p<.01, *p<.05

Table 4: Regression Models Evaluating Associations between Child Development, Food Insecurity, Income, and HLE

	M1	M2	M3	M4
(Constant)	-.0177	-0.061	-0.142	-0.037
	(0.168)	(0.326)	(0.313)	(0.323)
Food insecurity	-0.217*	-0.222*		-0.061
	(0.091)	(0.092)		(0.115)
	[-0.109]	[-0.112]		[-0.031]
Child's age	0.002	0.002	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
	[0.036]	[0.037]	[-0.024]	[-0.022]
Child is non-Hispanic	0.110	0.113	0.052	0.050
	(0.126)	(0.127)	(0.126)	(0.126)
	[0.039]	[0.041]	[.019]	[0.018]
Child is female	0.253**	0.253**	0.253**	0.254**
	(0.085)	(0.085)	(0.084)	(0.084)
	[0.134]	[0.134]	[0.134]	[0.134]
Child is white	0.034	0.049	0.010	-0.016
	(0.094)	(0.101)	(0.100)	(0.100)
	[0.017]	[0.024]	[0.005]	[-0.008]
Log Income		-0.028	-0.023	-0.037
		(0.067)	(0.066)	(0.066)
		[-0.020]	[-0.017]	[-0.027]
HLE			0.376***	0.443***
			(0.092)	(0.111)
			[0.198]	[0.233]
Interaction between HLE and Food Insecurity				-0.287
				(0.185)
				[-.0095]

Notes: ***p<.001, **p<.01, *p<.05