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Childhood Nutrition and Labor Market Outcomes: A Sequential Mediation Analysis

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Abstract: This paper investigates the long-term economic consequences of childhood nutrition in the Philippines, focusing on the mediating roles of cognitive development and schooling. Using longitudinal data from the Cebu Longitudinal Health and Nutrition Survey (CLHNS), we apply a sequential mediation analysis using the inverse odds ratio weighting (IORW) approach to decompose the total effect of severe stunting on adult labor market outcomes into direct effects and indirect effects through IQ and educational attainment. The results show that severe stunting significantly reduces both the likelihood of formal employment and daily earnings in early adulthood. Severely stunted children were about 28% less likely to be employed in the formal sector and earned 20% less per day compared to their non-stunted peers at age 22. Mediation analysis reveals that the indirect effect through IQ alone is modest, but the sequential pathway through IQ and college graduation accounts for about one-third of the total effect on formal employment and about 15% of the effect on daily earnings.

Keywords: Childhood nutrition, stunting, cognitive development, education, labor market outcomes, sequential mediation analysis, inverse odds ratio weighting

JEL Codes: I15, I25, J24

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1. Introduction

Childhood nutrition is critical for human capital formation, but its influence on labor market outcomes later in life remains insufficiently examined. Adequate nutrition during the formative years supports brain development, strengthens physical health, and enhances work capacity, which are all essential for productivity, employability, and improved earnings. Conversely, undernutrition can cause stunting, impair cognitive development, and increase vulnerability to illness. These adverse effects often persist into adulthood, shaping educational attainment and consequently employment opportunities.

The nutrition–labor market link is especially important in developing economies, where structural barriers restrict access to diverse, nutrient-rich diets and where public health systems struggle to provide comprehensive nutrition programs. In the Philippines, child malnutrition remains a pressing concern despite periods of economic growth, with persistently high rates of stunting and underweight among children, disproportionately affecting poorer and rural households (Ulep, et al. 2024; DOST-FNRI 2022). At the macro level, widespread undernutrition can reduce effective labor supply, slow productivity growth, and deepen poverty (Siddiqui, et al. 2020; McGovern et al. 2017).

A growing body of research shows that early-life nutritional improvements have lasting benefits for educational and labor market outcomes. Evidence from randomized trials and longitudinal studies demonstrates that children with better nutrition tend to score higher on cognitive tests, attain more years of schooling, and earn higher incomes as adults (Martorell et al. 2010; Maluccio et al. 2009; Gertler et al. 2014). The benefits often operate through two key mediators: cognitive development, commonly measured by intelligence quotient (IQ), and educational attainment.

Despite the strong theoretical and empirical basis for these linkages, important gaps remain. Much of the literature draws on contexts outside the Philippines, raising questions about the applicability of findings to a labor market characterized by a large informal sector, substantial overseas migration, and sectoral shifts toward services. Moreover, relatively few studies explicitly model the sequential mediation process, where nutrition influences IQ, IQ influences education, and education ultimately affects labor market outcomes. Without quantifying these pathways, it is difficult to identify which stages offer the highest returns to policy intervention.

Existing Philippine studies often examine the education–earnings relationship in isolation, potentially underestimating the role of early-life nutrition and cognitive development. A more integrated framework is needed to capture the cumulative effects of these factors and to understand how disadvantages in early nutrition can cascade through multiple stages of human capital formation.

This paper addresses these gaps by examining the effect of childhood nutrition on adult labor market outcomes in the Philippines, with a focus on IQ and educational attainment as sequential mediators. Using sequential mediation analysis, the study decomposes the total effect of early-life nutrition into direct effects and indirect effects operating through cognitive and educational pathways. This approach not only quantifies the relative contributions of IQ and education but also highlights the interaction between them in shaping labor market outcomes. Hence, this study makes two key contributions. First, it provides country-specific evidence on the long-term economic returns to improved child nutrition, informing policies on nutrition, education, and labor market development. Second, it advances empirical practice by explicitly modeling and quantifying sequential mediation pathways, offering a clearer understanding of how investments in early-life nutrition translate into enhanced labor market performance in adulthood.

2. Literature

2.1 Effect of Nutrition on Children's Cognitive Development

Early-life nutrition has been widely recognized as a decisive factor in brain development. Adequate nutrition during this period supports synapse formation, myelination, and the growth of neural networks, all of which underpin cognitive functioning throughout life (Prado & Dewey 2014). Conversely, undernutrition can compromise these processes, leading to long-term deficits in memory, attention, and problem-solving skills.

One of the most visible markers of chronic undernutrition is stunting, defined as low height-for-age. Stunting reflects sustained nutritional deprivation and is strongly associated with lower cognitive test scores across childhood and adolescence (Glewwe and King, 2001). Victora et al. (2010) show that growth faltering most often occurs between 3 and 24 months of age, precisely when the brain is undergoing rapid development.

Deficiency in micronutrients such as iron, iodine, and vitamin A has been shown to impair cognitive development. Lozoff et al. (2006), for instance, found that infants with iron-deficiency anemia exhibited poorer cognitive and motor development at pre-school age. In the Philippines, national surveys continue to report high rates of anemia among young children (DOST-FNRI 2022), suggesting that these deficiencies may contribute to the cognitive burden of undernutrition.

2.2 Effect of Child Nutrition on Educational Outcomes

Nutritional status in early childhood also shapes later educational attainment. Well-nourished children are more likely to enroll in school on time, progress through grades without repetition, and achieve higher learning outcomes. Martorell et al. (2010), using pooled data from five low- and middle-income country (LMIC) cohorts, found that weight gain in the first two years of life was strongly predictive of both school entry age and total years of schooling. Evidence from program evaluations supports these findings. Bundy et al. (2009) reviewed school feeding programs in LMICs and found that these improved school attendance, cognition, and educational achievement, especially if complemented with other programs such as deworming and micronutrient supplementation.

In the Philippines, Glewwe, Jacoby, and King (2001) found that children with higher height-for-age scores at school entry had significantly better test scores and grade attainment. Their estimates suggested that a one-standard-deviation increase in height-for-age at school entry for the most malnourished in their sample was associated with 21 more months of schooling. Adair et al. (2021), using the same dataset, showed that early-life length-for-age (LAZ) and IQ are strong predictors of school attainment, even after accounting for household disadvantages that emerge as children grow older.

2.3 Effect of Cognitive Development on Economic Outcomes

Cognitive ability, often measured by IQ or standardized test performance, is a strong predictor of educational success. Early-life cognitive skills enhance learning efficiency, promote school readiness, and increase the likelihood of progressing through and completing higher levels of education. Ozawa et al. (2022), in a meta-analysis of the effect of different aspects of cognitive development on educational achievement, showed that across diverse country contexts, higher cognitive ability is consistently linked to better educational outcomes. For instance, a one-standard-deviation increase in executive function raises school enrollment probability by 2%–13% in Zambia and adds 8–12 months of schooling in Ghana; a similar increase in fluid intelligence boosts enrollment by 16%–24% in Burkina Faso; a one-standard-deviation rise in literacy score in China increases the likelihood of remaining in school five years later by 2.9%–8.0% and 0.20–0.30 years of additional schooling; and in Senegal, a one-standard-deviation gain in second-grade math and French scores raises the probability of completing sixth grade by about 22%.

Similarly, cross-country evidence from the Philippines, the United Kingdom, and Finland indicates that early cognitive development has a larger effect on educational attainment in the Philippine context than in higher-income settings, with estimates from the Cebu Longitudinal Health and Nutrition Survey (CLHNS) showing that a one-standard-deviation increase in cognitive scores during childhood is associated with over a year of additional schooling in adulthood (Peet et al. 2015).

2.4 Effect of Nutrition on Labor Market Outcomes

The ultimate question is whether improved early-life nutrition translates into better labor market outcomes in adulthood. Evidence from long-term cohort studies suggests that it does. Hoddinott et al. (2008), studying the Guatemalan INCAP cohort, found that nutritional supplementation in early childhood increased adult wages by 46%, largely through improvements in schooling and physical stature. McGovern et al. (2017) reviewed global evidence and estimated that each additional centimeter of adult height is associated with a 4% increase in wages for men and 6% for women. In the Philippines, Carba, Tan, and Adair (2009) found that higher length-for-age at age two was associated with a greater likelihood of formal-sector employment later in life. They found that among adults no longer in school, each one-unit increase in length-for-age Z score (LAZ) at age 2 was linked to a 40% higher likelihood of formal employment versus non-employment for males, and a 20% higher probability of formal over informal work for females.

2.5 Contribution to the literature

While the evidence is strong for each pairwise relationship, i.e., from nutrition to cognition, cognition to education, and nutrition to labor outcomes, several gaps remain, particularly in the Philippine context. First, few studies model the entire sequential pathway from early nutrition to labor market outcomes through cognitive development and educational attainment. Most focus on one or two links, making it difficult to quantify the relative importance of each mediator. Second, the distinct structure of the Philippine labor market with its high informality, substantial overseas employment, and sectoral shifts, has not been fully considered in existing analyses. These factors may influence how early-life advantages or disadvantages translate into adult economic outcomes. Third, there is limited use of formal mediation analysis techniques in Philippine studies. Such methods allow for decomposition of total effects into direct and indirect components, offering more precise policy guidance. This paper addresses these gaps by applying sequential mediation analysis to decompose the total effect of childhood nutrition on adult labor market outcomes into pathways through IQ and education, including mediated effects from IQ to education.

3. Data

This study draws on data from the Cebu Longitudinal Health and Nutrition Survey (CLHNS), a collaborative project of the Carolina Population Center at the University of North Carolina at Chapel Hill, the Nutrition Center of the Philippines in Manila, and the Office of Population Studies at the University of San Carlos in Cebu City. The CLHNS follows a cohort of women residing in Metro Cebu, the Philippines' second-largest metropolitan area by population. These women gave birth to "index children" between May 1, 1983 and April 30, 1984. Multiple follow-up surveys were conducted in 1991–1992, 1994–1995, 1998–2000, 2002, 2005, 2007, and 2009, collecting detailed information on both the mothers and their index children. For the present analysis, we use data from the 1991–1992, 1994–1995, and 2005 rounds, which provide information on maternal characteristics, the educational attainment of index children, and other individual attributes. The final sample consists of 1,425 index children. The full CLHNS dataset is open access and can be downloaded from this website: https://cebu.cpc.unc.edu/

This paper examines the mediating role of cognitive development and schooling in the relationship between childhood nutrition and labor market outcomes, specifically formal employment and daily earnings. Following Glewwe, Jacoby, and King (2001), we use height-for-age as a summary measure of nutritional history up to a given age. Height-for-age Z-scores were computed from the 1991–1992 CLHNS round, when the index children were approximately eight years old. Our binary exposure variable indicates whether the index child was severely stunted, defined as at least three standard deviations below the World Health Organization (WHO) reference standard.

Cognitive development was measured using the Philippines Nonverbal Intelligence Test, administered during the 1994–1995 CLHNS round. The test was designed specifically for the Philippines by a team of psychologists (see Guthrie, Tayag, and Jacobs 1977). We employ the standardized score from this assessment as our first mediator variable, representing general cognitive ability.

Schooling was measured using years of education completed by the index child, reported in the 2005 CLHNS round. Years of schooling range from 0 (no schooling) to 14 (college graduate). For the analysis, we also construct a binary variable indicating whether the index child completed college, which serves as our second mediator.

Labor market outcomes were captured in the 2005 CLHNS round, when index children were around 22 years old. Respondents reported the employer for their main job. An index child was classified as employed in the formal sector if he reported working for pay in a private company, a non-governmental organization (NGO), or the government. The survey also recorded daily earnings from the respondent's main job. Thus, our labor market outcomes are measured by (1) the prevalence of formal employment and (2) daily earnings.

To account for potential confounding, we include baseline maternal and child characteristics: (1) mother's age at first childbirth, (2) whether the mother is a college graduate, (3) whether the mother is the household head, (4) whether the mother works for pay. We also control for the sex of the index child.

We also account for household characteristics by constructing a wealth index following Filmer and Pritchett (2001). The index is based on ownership of 12 household assets, including an iron, television, VCR, refrigerator, electric fan, bicycle, car, living room set, dining room set, air conditioner, bed, and other household furniture. Household size is included separately as an additional control variable. Summary statistics for all outcome, mediator, and control variables are reported in Table 1.

In our sample, 50% of children experienced severe stunting by age eight. The mean standardized IQ score at age 11 was -0.01 (SD = 0.97). By age 22, 55% of index children were employed in the formal sector, and the average log of daily earnings was 4.99 (SD = 0.67). Males accounted for 54% of the sample. Among mothers, 8% were household heads, 5% had completed college, the average age at first birth was 20.8 years (SD = 3.6) and 74% of mothers reported working for pay. The mean household asset index was 2.79 (SD = 2.69) and the mean household size is 7.16.

Table 1. Summary statistics of variables

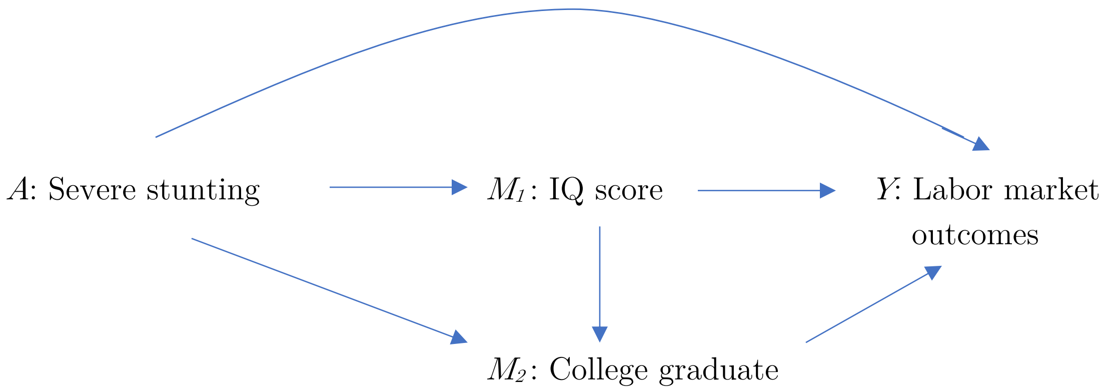
Variable	Mean	Std. dev.
Severe stunting (binary)	0.50	0.50
IQ z-score	-0.01	0.97
Formal employment at age 22 (binary)	0.55	0.50
Log of daily earnings	4.99	0.67
Index child is male (binary)	0.54	0.50
Mother is household head (binary)	0.08	0.27
Mother is college graduate (binary)	0.05	0.21
Mother's age at first birth	20.81	3.59
Mother works with pay	0.74	0.44
Asset index	2.79	2.69
Household size	7.16	2.38

4. Conceptual Framework

We examine a framework with two mediators operating in sequence. The exposure is denoted by A, the outcome by Y, and the mediators by M_1 and M_2. In this structure, A exerts direct influence on both M_1 and M_2, while M_1 also affects M_2. A set of covariates, denoted by C, may confound the relationships between the exposure, the mediators, and the outcome. These dependencies are summarized in the Directed Acyclic Graph (DAG) presented in Figure 1.

To formalize potential outcomes, let $Y\left(a, M_1(a^*), M_2\left(a^*, M_1(a^*)\right)\right)$ denote the counterfactual outcome that would be realized if the exposure A were fixed at level a, while M_1 and M_2 were set to the values they would naturally attain under an alternative exposure level a^*. Here, a and a^* represent two distinct exposure conditions (for example, $a = 1$ and $a^* = 0$).

Figure 1. Hypothesized causal pathways illustrated in a DAG



Note: Confounders C are not shown for brevity

In our setting, the exposure A represents severe stunting in childhood ($a = 1$) versus no severe stunting ($a^* = 0$). The sequential mediators are cognitive development (M_1, measured by IQ score) and schooling (M_2, measured by college graduation), while the outcome Y reflects labor market performance in terms of formal employment and daily earnings. We define the counterfactuals as follows. First, $M_1(a^*)$ corresponds to the level of cognitive development the child would have attained if he or she had not been severely stunted. Second, $M_2(a^*, M_1(a^*))$ represents the likelihood of completing college under the joint scenario where the child was not severely stunted and had achieved the level of cognitive development associated with that condition. Building on these, the counterfactual outcome $Y\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right)$ refers to the labor market outcomes that would have been observed if the child had in fact been severely stunted, but both cognitive development and schooling had been fixed to the levels they would have attained in the absence of stunting. Finally, $Y\left(a, M_1(a), M_2(a^*, M_1(a))\right)$ represents the labor market outcomes that would have been observed if the child had been severely stunted and developed the level of cognitive ability consistent with stunting, but college completion had been fixed at the level that would have occurred without stunting, conditional on cognitive development remaining at the stunted level.

The total effect of A on Y can be decomposed into contributions from the joint mediators (M_1, M_2), conditional on a set of baseline confounders C at the population level via Equation (1):

$$
\begin{aligned}
& g\{E[Y\left(a, M_1(a), M_2(a, M_1(a))\right) | C = c]\} - g\{E[Y\left(a^*, M_1(a^*), M_2(a^*, M_1(a^*))\right) | C = c]\} \\
= \; & g\{E[Y\left(a, M_1(a), M_2(a, M_1(a))\right) | C = c]\} - g\{E[Y\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right) | C = c]\} \\
+ \; & g\{E[Y\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right) | C = c]\} - g\{E[Y\left(a^*, M_1(a^*), M_2(a^*, M_1(a^*))\right) | C = c]\}
\end{aligned}
$$

The link function $g\{\cdot\}$ specifies the scale of the effect. On a linear scale, $g\{\cdot\}$ is the identity function, so the total effect equals the sum of the natural direct and natural indirect effects. On a multiplicative scale, such as the odds ratio, $g\{\cdot\}$ is the logit function, and the total effect equals the product of the two effects.

The left-hand side of Equation (1) is the *conditional total effect* which measures how much the outcome changes (on the chosen scale) when the exposure shifts from a^* to a, holding constant the confounders. The first term on the right-hand side is the *conditional natural indirect effect* measures how much the outcome changes when the exposure is held at a, but the mediators shift from the (natural) levels they would take under a^* to those they would take under a. This effect therefore captures the part of the exposure's influence that operates through the mediators jointly. The second term on the right-hand side is the *conditional natural direct effect* which measures how much the outcome changes when the exposure is set to a instead of a^*, while both mediators remain fixed at the levels they would naturally take under a^*. This captures the portion of the exposure's effect that does not operate through the mediators.

In this study, the conditional total effect measures how much labor market outcomes (i.e., formal employment and daily earnings) would differ between two hypothetical scenarios: one in which all children were severely stunted in early childhood and one in which none were stunted. The conditional natural direct effect measures how much these labor market outcomes would differ if children were severely stunted versus not stunted, while both cognitive development (IQ) and schooling (college completion) were fixed at the levels they would naturally have taken in the absence of stunting. In contrast, the conditional natural indirect effect measures how much labor market outcomes would differ if all children were stunted but both cognitive development and schooling were shifted from the levels they would have taken without stunting to the levels they would have taken with stunting.

5. Method for sequential mediation analysis

We apply the *inverse odds ratio weighting (IORW)* approach to multiple mediation analysis, developed by Tchetgen Tchetgen (2013) and Nguyen et al. (2015). The central idea of IORW is to construct inverse odds ratio weights that break the association between the exposure and the mediators, thereby deactivating indirect pathways (see Zugna et al. 2022). By reweighting the observed data, the distribution of the mediators within each level of A and C is transformed to mimic the distribution they would have taken under the counterfactual scenario. Formally, the counterfactual expression in Equation (1) earlier:

$$g\{E[Y\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right)|C = c]\}$$

can be rewritten as:

$$g\left\{E\left[\frac{P(M_1 = m_{01}, M_2 = m_{02}|A = a, \quad C = c)}{P(M_1 = m_{01}, M_2 = m_{02}|A = a^*, \quad C = c)}Y\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right)|C = c\right]\right\}$$

$$= \{E[WY\left(a, M_1(a^*), M_2(a^*, M_1(a^*))\right)|C = c]\}$$

where $P(M_1 = m_1, M_2 = m_2|A = a, \quad C = c)$ is the joint conditional probability of the two mediators given the exposure and covariates, and m_{01}, m_{02} are reference values of the mediators. By the invariance property of the odds ratio, the weight W can be equivalently expressed as:

$$W = \frac{P(A = a^*|M_1 = m_1, M_2 = m_2, \quad C = c)P(A = a|M_1 = m_{01}, M_2 = m_{02}, \quad C = c)}{P(A = a|M_1 = m_1, M_2 = m_2, \quad C = c)P(A = a^*|M_1 = m_{01}, M_2 = m_{02}, \quad C = c)}$$

where $P(A = a|M_1 = m_1, M_2 = m_2, \quad C = c)$ is the conditional probability of the exposure given the mediators and covariates. Intuitively, the numerator upweights individuals whose mediators are more likely under the counterfactual exposure a^*, while the denominator downweights those whose mediators are more likely under the observed exposure a. In combination, this ratio ensures that, after weighting, the mediator distribution in the exposed group $(A = a)$ resembles what it would have been under the alternative exposure $(A = a^*)$. In this way, applying W effectively "turns off" the pathways from A to the mediators, allowing us to identify the outcome distribution under counterfactual mediator values.

Following Zugna et al. (2022), we implemented IORW in three steps. First, we modeled the exposure by fitting a logistic regression of A on the mediators (M_1, M_2) and covariates C. Predicted probabilities from this model were used to calculate the inverse odds ratio weights, reweighting individuals so that the mediator distribution matched that of the alternative exposure scenario.[1] Second, we estimated the conditional total effect of A on Y

[1] In our estimation we stabilized the weights which include the marginal probability of exposure given baseline covariates in the numerator. This reduces variability and prevents extreme weights while leaving the estimand unchanged (Robins, Hernán, and Brumback 2000).

by regressing the outcome Y on A and C. Third, we obtained the conditional direct effect by re-estimating the outcome model using the IORW weights for exposed subjects (i.e., severely stunted index children) and the weights equal to 1 for unexposed subjects (i.e., those who are not severely stunted). As discussed, this blocks the pathways through the mediators. The indirect effect was then computed as the difference (under an additive scale) or the ratio (under a multiplicative scale) between the total and direct effects. Confidence intervals were constructed using bias-corrected and accelerated (BCa) bootstrapping.

6. Results and Discussion

Using the inverse odds ratio weighting approach, we find that severe stunting substantially reduces the likelihood of formal employment at age 22. The total effect in Table 2 shows that stunted children are about 28.4% less likely to be formally employed compared to their non-stunted peers (PR = 0.716, 95% CI: 0.590–0.869). When considering cognitive development alone, the direct effect corresponds to a 23.8% lower prevalence of formal work (PR = 0.762, 95% CI: 0.622–0.930), while the indirect effect through IQ alone accounts for a 6.0% reduction (PR = 0.940, 95% CI: 0.865–0.990). When IQ and college graduation are examined jointly as sequential mediators, the indirect effect becomes slightly stronger, corresponding to a 7.7% reduction in formal work (PR = 0.923, 95% CI: 0.854–0.983). The direct effect in this specification remains large, with stunted children being 22.4% less likely to hold formal employment (PR = 0.776, 95% CI: 0.642–0.951). Together, the sequential pathway through IQ and schooling explains about one-third of the total effect of stunting on formal employment, highlighting its substantive role alongside the direct effect.

Table 2. Estimates of total, direct, and indirect effects of severe stunting on the incidence of formal work with IQ and college graduation as mediators.

	Through IQ		
		95% Confidence Interval	
Conditional effect: IOR approach	Prevalence Ratio	Lower Bound	Upper Bound
Direct effect	0.762	0.622	0.930
Indirect effect	0.940	0.865	0.990
Total effect	0.716	0.590	0.869
	Through IQ and College graduation		
		95% Confidence Interval	
Conditional effect: IOR approach	Prevalence Ratio	Lower Bound	Upper Bound
Direct effect	0.776	0.642	0.951
Indirect effect	0.923	0.854	0.983
Total effect	0.716	0.590	0.869

Note: Confidence intervals are computed using BCa bootstrapping

Table 3 presents the estimated effects of severe stunting on daily earnings at age 22, with IQ and college graduation as potential mediators. The total effect indicates that severely stunted children earn about 19.9% less per day than their non-stunted peers (Ratio = 0.801, 95% CI: 0.727–0.888). When mediation is considered through cognitive development alone, the natural direct effect shows a substantial reduction in earnings (Ratio = 0.810, 95% CI: 0.732–0.900), while the indirect effect through IQ is very small and statistically insignificant (Ratio = 0.989, 95% CI: 0.957–1.023). When IQ and college graduation are modeled sequentially, the direct effect remains strong (Ratio = 0.820, 95% CI: 0.739–0.910), and the indirect effect through this combined pathway suggests a 2–3% reduction in earnings that is marginally significant (Ratio = 0.977, 95% CI: 0.939–1.007). This indirect pathway accounts for roughly 15% of the total effect, suggesting that while the dominant channel is direct, cognitive development and schooling together explain a non-negligible share of the impact of stunting on earnings.

Table 3. Estimates of total, direct, and indirect effects of severe stunting on daily earnings with IQ and college graduation as mediators.

	Through IQ		
		95% Confidence Interval	
Conditional effect: IOR approach	Ratio Scale	Lower Bound	Upper Bound
Direct effect	0.810	0.732	0.900
Indirect effect	0.989	0.957	1.023
Total effect	0.801	0.727	0.888
	Through IQ and College graduation		
		95% Confidence Interval	
Conditional effect: IOR approach	Ratio Scale	Lower Bound	Upper Bound
Direct effect	0.820	0.739	0.910
Indirect effect	0.977	0.939	1.007
Total effect	0.801	0.727	0.888

Note: Confidence intervals are computed using BCa bootstrapping

Our findings contribute to the literature on the long-term economic consequences of childhood nutrition. Consistent with evidence from global longitudinal cohorts (Martorell et al. 2010; Hoddinott et al. 2008; McGovern et al. 2017), we show that severe stunting in early life significantly reduces both the likelihood of formal employment and daily earnings in adulthood. These results are also in line with Philippine-specific evidence from Carba, Tan, and Adair (2009), who found that higher length-for-age at age two was associated with better labor market outcomes, underscoring that early nutritional deficits can constrain economic opportunities well into adulthood.

Our mediation analysis provides further insight into the mechanisms behind these effects. In line with studies emphasizing the role of early nutrition in shaping cognitive development (Prado & Dewey 2014; Glewwe & King 2001), we find that part of the effect of stunting operates through cognitive ability. However, the indirect effect through IQ alone is relatively modest, suggesting that cognitive development has its strongest influence when coupled with educational attainment. The sequential pathway through IQ and college graduation accounts for about one-third of the total effect of stunting on formal employment, consistent with evidence that cognitive skills enhance learning efficiency and increase the likelihood of progressing to higher education (Peet et al. 2015).

For earnings, the direct effect of stunting is more pronounced, while the indirect effect through IQ and schooling is smaller, only marginally significant, and explains about 15%

of the total effect. This weaker mediation channel for earnings contrasts with the stronger mediation observed for formal employment, suggesting that early-life nutrition influences access to the type of employment more strongly than wage levels within jobs. One possible explanation is that our measure of earnings was collected when respondents were around 22 years old, at the start of their careers. Unfortunately, later rounds of the CLHNS did not collect earnings information, preventing us from assessing whether the earnings gap between stunted and non-stunted children widens or persists over time.

7. Conclusion

This study examined the long-run effects of childhood nutrition on adult labor market outcomes in the Philippines, using data from the Cebu Longitudinal Health and Nutrition Survey (CLHNS). By applying the inverse odds ratio weighting (IORW) approach in joint mediation analysis, we decomposed the total effect of severe stunting on labor outcomes into direct effects and indirect effects operating through cognitive development and educational attainment. Our results show that severe stunting has substantial and lasting consequences: stunted children at age eight were about 28% less likely to be formally employed and earned about 20% less per day by age 22 compared to their non-stunted peers. Mediation analysis reveals that the indirect effect of stunting through IQ alone is modest, but the sequential pathway through IQ and college graduation is more important, explaining about one-third of the total effect on formal employment and about 15% of the total effect on daily earnings.

The study makes three key contributions to the literature. First, it provides rigorous empirical evidence that severe stunting reduces both employment opportunities and earnings in adulthood, strengthening the case that early-life nutrition is central to long-term human capital formation. This complements international evidence and adds important country-specific evidence for the Philippines, where undernutrition remains widespread and the labor market is characterized by high informality. Second, the study explicitly quantifies the sequential mediation process, showing that the impact of nutrition on labor outcomes operates partly through cognitive development and, more strongly, through the combined channel of cognition and schooling. While IQ alone accounts for a relatively small share of the effect, cognitive development plays a critical enabling role in supporting educational attainment, which in turn shapes access to formal work. Third, the study contributes methodologically by demonstrating the application of the IORW approach in a multiple-mediator setting. This method allows for a transparent decomposition of total effects into direct and indirect components without requiring explicit modeling of the joint distribution of mediators, providing a template for future research in similar contexts.

Our study also has several limitations. First, the labor market outcomes are measured when respondents were around 22 years old, a relatively early stage in their careers. Earnings at this point may not fully capture lifetime income trajectories, and the indirect effects of education may grow stronger later in life. Unfortunately, later rounds of the CLHNS did not collect earnings information, limiting our ability to track these dynamics. Second, the measure of nutrition (i.e., HAZ at around eight years old) may understate the effects of nutritional deficits in the critical 0 to 2-year window when growth faltering is most severe. This implies that our results may represent conservative estimates of the true effects of early-life nutrition. Third, while we control for several maternal and child characteristics, residual confounding remains possible. Household income shocks, parental aspirations, or variations in school quality may influence both nutrition and later labor market outcomes in ways not fully captured in our data. Finally, the CLHNS is geographically limited to Metro Cebu. Although it provides high-quality longitudinal data, its representativeness for rural or other urban labor markets in the Philippines may be limited.

Despite these limitations, this paper still provides evidence that investments in early childhood nutrition yield long-term economic dividends, enhancing employability and earnings potential. In terms of policy, enacting nutritional programs targeting both mother (e.g. micronutrient supplementation) and child (e.g. breastfeeding promotions) should be prioritized. Our results underscore the importance of linking nutrition and education policy. This suggests that nutrition programs in school (e.g. feeding programs) as well as policies to enhance quality learning (e.g. remedial classes) and increase the probability of finishing college (e.g. through school voucher or conditional cash transfer programs) can help translate early cognitive gains into labor market advantages.

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