Does rapid economic development translate into improved nutritional status for children? Data from Ibo Island, Mozambique.

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ABSTRACT: This paper investigates household asset accumulation and investments in children's nutritional capital on Ibo Island, a rapidly developing community in Northern Mozambique. Height-for-age and weight-for-age Z-scores in 2009 and 2012 are used to measure stunting and wasting, respectively. Stunting represents a sustained past period of malnutrition. Wasting reflects recent acute food shortage. Cross-sectional and individual fixed effects models investigate changes in stunting, wasting, and household asset ownership over time.

Stunting and wasting of children under 10 years old declined dramatically over the three-year study period (stunting from 45.7% to 33.5%; wasting from 16.9% to 11.0%). Stunting and wasting status exhibit different longitudinal relationships with wealth. Stunting Z-score and wealth quintile were unrelated in 2009 but strongly positively correlated in 2012; improvements in stunting Z-scores were strongly positively related to children's baseline 2009 household wealth indices. Wasting Z-score and wealth quintile were strongly positively correlated in both 2009 and 2012, but changes in wasting Z-scores were not related to baseline wealth.

The changing cross-sectional relationship between stunting and wealth status indicates that the community's relationship with nutritional investments underwent a structural change during the study period. In 2009, height-for-age Z-scores were unrelated with wealth quintile, likely because of low availability of produce and/or weak knowledge of a properly balanced diet, even among the wealthy. By 2012, after three years of economic development and nutritional outreach, height-for-age Z-scores were strongly positively correlated with cross-sectional wealth.

Stunting Z-scores indicate that, for households in the bottom quintile, asset accumulation occurs simultaneously with nutritional investments, representing a multi-faceted rise out of poverty. While children in baseline bottom quintile were least likely to experience improvements in their height Z-scores, they experienced comparatively better improvements if their households accumulated assets over the study period. Many of the bottom-quintile households maintained their disadvantaged positions over the study period, having invested in neither assets nor improved nutrition between 2009 and 2012.

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INTRODUCTION.

Northern Mozambique is among the world's most critical "hunger hotspots," with 43% of its children under five years old stunted, reflecting a sustained past period of chronic malnutrition (Azzarri et al. 2012, de Onis et al. 2012, Sanchez and Swaminathan 2005). Early health and nutritional status, especially from the fetal stage through the first five years of a child's life, are associated with cognitive development, school participation, and adult health and earnings (Almond 2006, Baird et al. 2010, Barker 1997, Case et al. 2005, Currie 2009, Field et al. 2009). High rates of childhood malnutrition may therefore be interpreted as reflections of low levels of parental investment.

This is an investigation of parental investment in children's nutritional capital for a rural African community, given household characteristics. The data are drawn from Ibo Island in northern Mozambique, where fish are plentiful, but malnutrition persists: although the majority of the island's employment is in the food production sector, the population's food insecurity remains high, and height-per-age (stunting) and weight-for-height (wasting) indicators suggest that, in many households, investments in children's nutrition are low. Given the island's remarkably rapid economic development, data from Ibo provide a community-level window into Mozambique's national experiences relating to the degree to which household wealth accumulation translates into improved nutritional status of children, a quantifiable reflection of parental investments in children's health capital.

Parents derive utility from investments in their children's quality (Becker 1960, 1992), but the size and form of investments may be dictated by parents' own consumption preferences, constraints on their time and financial resources, the price and accessibility of investments, and availability of information about the benefits of various forms of human capital. Parents face conflicting demands on their incomes, deriving utility from their own consumption, their children's consumption, investments in their children's human capital, and investments in capital goods for home or market production. These items are all expected to have positive income elasticities, such that rising incomes will lead to increased purchases of each of the items, other things equal.

In this study, household income is not observed directly and is, rather, inferred from the presence and accumulation of durable assets in the home. In the absence of income or expenditures data, asset indices are routinely used to quantify household economic status (Filmer and Scott 2012, Vyas and Kumaranayake 2006). Research in various developing countries has shown that household wealth indicators, including asset ownership and number of rooms in the home, are positively correlated with access to food (Leah et al. 2012), nutritional outcomes (Cordeiro et al. 2012, Heady 2013), and parental investments in child education (Filmer and Pritchett 2001). The positive correlations between expenditures, asset indices, and nutritional outcomes signify that with rising incomes, households can be expected to increase their spending on both assets and food. In accordance with Engel's Law, increases in household income are expected to be associated with increased food expenditures, although food expenditures typically fall as a proportion of the total household budget, and nutritional quality of the purchased food does not necessarily improve (Behrman and Deolalikar 1987, Subramanian and Deaton 1996).

Complicating the interpretation of asset accumulation as a reflection of household income, the relationship is likely to differ based upon the nature of each asset. Household incomes, for example, may be smoother than asset accumulation, especially when the purchase of an asset requires a large expenditure. Accumulation of expensive assets such as boats, motorcycles, and refrigerators may therefore be lumpy, crowding out other expenditures (either asset-based or nutritional) in the years immediately preceding or following their purchase. The joint roles of some assets as both consumer and producer durables also hinders a straightforward interpretation of the asset/income relationship. Boats are used both to visit family and to catch fish, motorcycles are used both as personal transportation and to shuttle tourists from the island's airstrip, and refrigerators are used both in the home and for selling beer or popsicles. Purchase of some household assets can therefore be associated with both income expenditure and subsequent income improvements.

Asset accumulation is understood in this study to be not just a predictor of, but also an alternative to, nutritional spending. Faced with higher incomes, a household's budget constraint allows for increased expenditures on child nutrition, assets, both, or neither. If a household allocates all its increased income to food, a child's anthropometric status could increase over time despite no change in his household wealth index. In that sense, this research takes advantage of the less than perfect correlation between asset indices and expenditures in order to investigate economic consumption preferences in the context of rapid economic change. Panel census data from Ibo Island at the individual- and household-levels allow for the investigation of drivers behind the only marginal drops in Mozambique's chronic malnutrition rates despite the country's annual growth in per capita GDP.

A poverty trap (Sachs 2005) provides one explanation for persisting malnutrition despite economic growth. In this scenario, improved incomes are affecting those Mozambicans who already had sufficient food intake, while the poorest Mozambicans have failed to benefit from economic growth and improvements. A longitudinal dataset permits me to build upon Reinbold's cross-sectional investigation of inequality in Bangladesh and Kenya, in which he identified a strong relationship between stunting and relative household wealth (2011). By following individuals and households through time, it is possible to identify the baseline economic characteristics most associated with reduced stunting or improved wealth over time.

An alternative explanation is that incomes are increasing in the homes of stunted children, but the increases are not translating into the purchase of nutrient-rich foods. This outcome could be due to a regional lack of available fresh produce, a social preference for buying larger quantities of foods from the traditional diet rather than improving nutritional variety, and/or a strong preference for non-food expenditures. If the former scenarios are occurring, height-for-age status is unlikely to be positively associated with cross-sectional wealth quintile, since community-wide low quality of diet will put individuals at risk for micronutrient malnutrition regardless of households' food expenditures. If the latter scenario is occurring, height-for-age status is expected to be positively correlated with cross-sectional wealth quintile but uncorrelated with longitudinal wealth accumulation of the poorest households: the panel data will capture a period early in the poorest households' economic development, in which they are accumulating assets before increasing food expenditures.

BACKGROUND.

Ibo Island is in northern Mozambique's Quirimbas Archipelago, where residents are 96% Muslim and 57% literate, with 65% employed in the fishing or agricultural sectors (National Institute of Statistics 2007). Although Pemba, Ibo's nearest urban neighbor, is undergoing rapid economic development due heavy foreign investment after the recent discovery of both oil and natural gas deposits, the economic development on Ibo owes itself, at least at present, to tourism rather than mineral extraction. Once one of Mozambique's most prosperous ports, Ibo's infrastructure fell into disrepair with the end of Portuguese colonialism in 1974. Its banks shut down, the interiors of its centuries-old mansions became overgrown with vegetation, and its municipal electrical plant was ransacked, resulting in the loss of electricity on the island for nearly forty years. Romantically called *the island that time forgot*, Ibo underwent more than simple stagnation during Mozambique's war and postwar eras; rather, with the abrupt expulsion of Portuguese colonialists, Ibo experienced a sizeable step backward in the economic development process.

With the arrival of cash-generating activities on the island in the past decade, Ibo has become home to shops, hotels, televisions, cellphones, motorized boats, and nightly amplified music. Even cosmetic changes to the island, such as foreigners' restoration of colonial mansions, are associated with economic changes that affect the local community, as foreign residents have brought with them US dollars, western influences, and improved transportational infrastructure to link Ibo with the Mozambican mainland.

The construction of the Ibo Lodge in 2003 (and the associated employment of approximately 100 Ibo residents for the lodge's massive renovation efforts) jumpstarted the island's transition from a barter-based fishing economy to a community that deals in cash. Generators and solar power arrived in the early- to mid-2000s, as did the island's first motorcycles, a somewhat unnecessary method of land transportation on an island of approximately 4 square miles with a population that has historically traveled locally by foot and regionally by sailboat. The Ibo Foundation, a non-governmental philanthropic organization founded in 2005, established a carpentry school, and the Ibo Lodge aided islanders in developing a premium Ibo Coffee brand to sell to tourists and serve in hotel restaurants. In early 2012, the island received electricity, a much-appreciated service after years of lacking the fuel to consistently power the municipal street lamps.

Whereas pre-tourism, Ibo was largely a community of self-employed fishermen, the island is presently home to salaried workers in its hotels, schools, bars, and hospital. The island's rapid economic development has occurred unevenly, however. While Ibo is home to numerous venders of cellphones and colognes, it lacks a store that sells fresh produce. Small shops sell dried goods (e.g. rice, cornmeal, sugar, peanuts, beans, and dried cassava), packaged goods, and homemade popsicles; bread rolls are available daily directly from the bakers; and individuals occasionally sell coconuts, papayas, and other seasonal produce from small baskets rather than storefronts.

Cereals, often prepared with small portions of fish and fats, comprise the Ibo community's nutritional staples. While the World Health Organization [WHO] recommends daily consumption of fruits and vegetables to prevent nutritional deficiencies (WHO 2003), Ibo children rarely consume fresh produce. In a 2009 Ibo Foundation survey of retrospective dietary consumption, 19% of children had consumed fruit in the previous 24 hours, and only 6% of children had consumed vegetables. Fruits and vegetables are a good source of vitamin A and iron, the dietary lack of which can cause of stunting in children (Rivera et al. 2003). Fresh produce is also the primary source of nutrients such as vitamin C in a typical diet (Keatinge et al. 2010). Poor dietary diversity is understood to be a major contributor to micronutrient malnutrition, also called "hidden hunger" (Burchi et al. 2011, Ezzati et al. 2002, Keatinge et al. 2010, Rivera et al. 2003). Food-based strategies to reduce nutrient deficiencies and stunting have been effective in other developing communities (Rivera et al. 2003, Underwood 2000), indicating that changes in a household's nutritional investments have the potential to affect children's anthropometric measures over time. If child stunting on Ibo Island is largely due to micronutrient malnutrition despite sufficient caloric intake, stunting Z-scores are likely to improve only with improved nutritional quality and not simply with increased caloric quantity.

Since 2009, the Ibo Foundation's CANI nutritional center has provided free nutritional outreach and supplemented meals to select members of the Ibo population. Children under 5 years old who are identified as undernourished (based upon their upper arm circumferences during twice-annual household visits) and pregnant women of any weight are provided with one meal daily, if they visit the Nutritional Support Center at an allotted time. Weights of the undernourished children are monitored weekly until adequate improvement is shown, at which time the children "graduate" from the program. Mothers of child-aged meal recipients are provided with a daily portion of sugared tea if they attend a nutritional lesson while their children receive the meals. Since the nutritional supplementation and outreach is available to children and pregnant women regardless of their household economic status, stunted children of all economic levels are likely to exhibit improved heights in the second wave of data collection, and the proportion of low birth weight infants is likely to decline across all wealth indices over time.

This study utilizes both stunting (height-for-age) and wasting (weight-for-height) Z-scores to understand children's changes in nutritional status over time. Since child stunting is a reflection of long-term nutrient intake, height Z-scores are likely to improve only gradually over time with improved quantity and/or quality of food. Child wasting, which reflects acute food shortage or disease, is likely to respond rapidly to changes in dietary quantity, regardless of nutritional quality. Due to the strong ties between wasting indicators and present-day diet, wasting Z-scores in the second survey wave are expected to depend less on previous nutritional status than will stunting Z-scores, allowing for the observation of changes in nutritional investments even if stunting at a young age has irreversible effects on height throughout the life course.

DATA.

In this study, I investigate children's anthropometric measurements and household asset ownership over time. In 2009, the Ibo Foundation conducted a complete census of Ibo Island. Each home was assigned a unique House ID, each social group (defined by sharing of meals) was assigned a unique Household ID, and each resident was assigned a unique Individual ID. Anthropometric measurements were recorded for children aged 0-9. For each household, information was collected relating to number of rooms in the home, ownership of 13 assets, and livestock ownership (Table 1). Surveys were conducted in Kimwani and/or Portuguese by trained enumerators in respondents' homes.

In 2012, with the Ibo Foundation's assistance, I conducted a second-round census. For each household, a form was populated with the 2009 Household Composition data to determine whether each household member still lived in the home. Those who did not were classified as having died or moved, and those who had moved were coded by type of move (intra-island or from elsewhere). We identified new household members who had entered the home since 2009; those who had entered were classified as having moved or been born, and those who had moved were coded by type of move. In addition to "died," "born," and "moved," there were codes for a "2009 census error" and for "unknown." For each new individual, we collected full name, birthdate, and gender.

To improve birthdate accuracy and collect birth weight information, we requested to see health record cards (presented for 38.1% of children). Individuals who moved within Ibo were linked retroactively (based upon name, birthdate, and family members) with their 2009 Individual IDs, while unmatched individuals were assigned new IDs. For newly constructed homes or newly formed households, new House IDs and Household IDs were assigned.

Names and birthdates are inconsistently reported in the study population, so linking individuals is challenging. When unsure, I opted not to link a person to his possible self rather than to incorrectly link him to a person of similar name and age. In total, 142 children who moved were linked with their previous IDs (representing 55.5% of 2009 children who were identified as having left for a different home within the island and 35.3% of 2012 children who were identified as having arrived from a different home within the island, Table 2). The 2012 wave utilized the first-round household-level questions to monitor accumulation of household goods and livestock since 2009. Heights were measured for all children and adolescents 13 years old or younger (those who were 10 years or younger in 2009) to compare values with their first-round measurements.

The outcome variables in this investigation are children's 2009 and 2012 height-for-age Z-scores and weight-for age Z-scores (ages 0-13 years). The Z-scores are based upon WHO standards, in comparison with a reference population of healthy children; a Z-score cut-off of less than two standard deviations below the mean is defined as moderate and severe undernutrition (WHO 2013). The independent variables are total number of rooms, livestock ownership (poultry and goats), and household assets. Livestock ownership was collected using an index from 1 to 5 (1=no animals; 2=one to five animals; 3=five to ten animals; 4=more than ten animals; 5=too many animals to count). Asset ownership data for the 13 goods presented in Table 1 were collected in a yes/no format (0=don't own; 1=own).

Household wealth was computed using Principal Components Analysis (PCA). When PCA is used with asset data and other household characteristics, the first component--that with the maximal variance--is considered to represent economic status (Filmer and Scott 2012, Vyas and Kumaranayake 2006). The eigenvector for each variable in the first component is assigned as the variable's weight, which I multiplied by the variable's scaled value (from 0 and 1) and summed to create the wealth index. PCA indicates which assets are better predictors of economic status, based upon their distributions within households. In a population in which virtually no one or everyone has an armoire, ownership of an armoire will not be a good predictor of socioeconomic status (SES), and *armoire* will receive a low weight. If an asset reflects low SES, such as a bicycle in a community in which persons prefer motor vehicles, the variable weight will be negative (Vyas and Kumaranayake 2006).

Pooling the 2009 and 2012 data, all variable weights were positive. The most important variables were *mattress*, *phone*, and *sink*; the variables with the lowest weight were *sewing machine*, *goats*, and *wheelbarrow* (Table 1). I assigned households to wealth quintiles based on the wealth index cutoffs in both 2009 and 2012. A comparison of a household's baseline wealth quintile vs. its 2012 quintile represents a change in relative wealth within the community. A comparison of a household's baseline wealth quintile vs. its 2012 quintile with 2009 cutoffs represents changes in actual wealth, since asset and/or livestock ownership must have changed in order to fall into a different quintile using the existing cutoffs.

Missing data.

A comparison of the mean 2009 height-for-age Z-scores for missing vs. non-missing data suggests that missingness of asset data is not significantly related to height-for-age Z-score in either 2009 or 2012 (Appendix 1). When using PCA to calculate the wealth index and throughout further analyses, I used simple imputation to replace the missing data with the variable's mean value in that survey year. Missing height-for-age Z-scores exist due to missing heights and/or missing ages.[1] Direction of bias in missing Z-scores is unclear due to opposing relationships between missingness and wealth, and missingness of the height-for-age Z-scores was not significantly related to household wealth in 2009 or 2012 (Appendix 1). I excluded missing Z-score observations and performed Complete Case Analysis, using children only of known ages and heights. Height-for-age Z-scores are calculated using a child's age in months. For those individuals with known years of age, missing birthdate was unrelated to household wealth (Appendix 1). I therefore included these children in the analysis, calculating their Z-scores using an imputed *age in months*=[12**age in years*]+6.[2] Missingness of birth weight data was not significantly related to height-for-age Z-scores or household wealth in 2009 or 2012 (Appendix 1). In models controlling for birth weight, I used simple imputation to replace the missing values with the population's mean birth weight.

In 2012, the children observed longitudinally were in significantly wealthier households and had significantly higher height-for-age Z-scores than did the unlinked children of comparable ages (Appendix 2; children born since 2009 excluded from analysis). The differences in wealth between panel and non-panel children can largely be explained by the negative relationship between household wealth and moving within Ibo (Appendix 2): staying in the same home was associated with higher 2009 and 2012 household wealth. There also exists a negative correlation between 2012 wealth and a child's unknown whereabouts in 2009 (Appendix 2), indicating that skipping children during the 2009 census may have occurred more often in poorer households. Children who moved within Ibo and were linked had somewhat higher 2009 height-for-age Z-scores and significantly higher 2012 height-for-age Z-scores than unlinked children who moved

[1] Heights could not be measured for children who were absent from the island during the survey period. Since Ibo has a secondary school, children under 14 years of age are not expected to be off of the island due to school participation; however, in both 2009 and 2012, children with missing heights were from significantly wealthier households (Appendix 1) than children with height data. Although missingness of age data was not significantly related to household wealth (Appendix 1), the missing values are likely to be non-randomly associated with lower wealth, since they indicate the absence of a hospital-issued health card and could reflect low numeracy or parental attention.
[2] If over- and underreporting of years of age were equally likely for children with unknown birthdates, estimating months of age with the above formula will lead to equal proportions of over- and underestimated Z-scores, biasing results toward zero.

within the island (Appendix 2). Missing data may therefore limit the ability to draw longitudinal conclusions about some of the population's most economically and nutritionally vulnerable children.

Alternative wealth index.

As a robustness check for the PCA-based wealth index, I also repeat the analyses using a value-based wealth index (in which approximate dollar values are assigned to each asset and summed).

METHODS.

In this paper, I analyze long-term and recent nutritional investments in children (as reflected by stunting and wasting Z-scores, respectively) and household asset ownership. Accumulation of assets is endogenous to the household, and households that undergo changes in wealth may be inherently different in their preferences (and their preferred investments in children) than other households. The analysis therefore allows us to observe the changes in child nutritional outcomes associated with household wealth characteristics over time.[3]

In this analysis, I use ordinary least squares (OLS) to investigate the effect of 2009 household wealth on: height-for-age Z-scores in 2009 (Model 1), height-for-age Z-scores in 2012 (Model 2), and changes in height-for-age Z-scores over time (Model 3). Model 4 relates 2012 household wealth to 2012 height-for-age Z-scores. Model 1 incorporates six individual- and household-level controls (child's age, child's birth weight, number of household members, Cimento neighborhood, Cumuamba neighborhood, and whether the child was observed longitudinally in the panel dataset. Ibo has three neighborhood classifications; baseline children live in Rituto

[3] I expect reverse causality (in which presence of an ill child reduces household wealth accumulation) to be uncommon in this study. Low rates of female labor force participation and high rates of childcare by siblings likely contribute to low opportunity costs in caring for an unhealthy child.

neighborhood). Models 2-3 incorporate four additional individual-level controls (baseline stunting Z-score, baseline wasting Z-score, whether the survey respondent indicated that the child received nutritional intervention from CANI in the previous 3 years, and whether the child was age-eligible to receive nutritional intervention; by design, children included in Models 2 and 3 are in the panel dataset.) Model 4 incorporates the controls from Model 1 and two additional individual-level controls (whether the respondent indicated that the child received nutritional intervention from CANI in the previous 3 years and whether the child was age-eligible to receive nutritional intervention).

[1] $$heightZ_{i2009} = \alpha_1 + \beta_1(Wealth\ score_{i2009}) + \delta_{a1}age_i + \cdots + \delta_{f1}panel_i + v_i$$

[2] $$heightZ_{i2012} = \alpha_2 + \beta_2(Wealth\ score_{i2009}) + \delta_{a2}age_i + \cdots + \delta_{i2}eligible_i + v_i$$

[3] $$heightZ_{i2012} - heightZ_{i2009} = \alpha_3 + \beta_3(Wealth\ score_{i2009}) + \delta_{a3}age_i + \cdots + \delta_{i3}eligible_i + v_i$$

[4] $$heightZ_{i2012} = \alpha_4 + \beta_4(Wealth\ score_{i2012}) + \delta_{a4}age_i + \cdots + \delta_{h4}eligible_i + v_i$$

In analyzing a child's nutritional status vs. household wealth, ordinary least squares (OLS) cannot control for individual-level unobservables, such as children's in-utero conditions and genetic endowment. An individual-level fixed effects model is therefore an appealing choice because it controls for fixed unobserved characteristics and investigates within-individual variation over time. Model [5] relates changes in height-for-age Z-score to asset accumulation, as measured by the deviation of a child's household wealth score at time *t* from his household's mean score for the two time periods.

[5] $$heightZ_{it} - \overline{heightZ_i} = \alpha_5 + \beta_5\left(Wealth\ score_{it} - \overline{Wealth\ score_i}\right) + v_{it} - \bar{v}_i$$

To investigate the relationship between household wealth and children's wasting, Models 6-10 have the same components as Models 1-5 described above, using weight-for-height Z-score as the outcome variable of interest.

[6] $$weightZ_{i2009} = \alpha_1 + \beta_1(Wealth\ score_{i2009}) + \delta_{a1}age_i + \cdots + \delta_{f1}panel_i + v_i$$

[7] $$weightZ_{i2012} = \alpha_2 + \beta_2(Wealth\ score_{i2009}) + \delta_{a2}age_i + \cdots + \delta_{i2}eligible_i + v_i$$

[8] $$weightZ_{i2012} - weightZ_{i2009} = \alpha_3 + \beta_3(Wealth\ score_{i2009}) + \delta_{a3}age_i + \cdots + \delta_{i3}eligible_i + v_i$$

[9] $$weightZ_{i2012} = \alpha_4 + \beta_4(Wealth\ score_{i2012}) + \delta_{a4}age_i + \cdots + \delta_{h4}eligible_i + v_i$$

[10] $$weightZ_{it} - \overline{weightZ_i} = \alpha_5 + \beta_5\left(Wealth\ score_{it} - \overline{Wealth\ score_i}\right) + v_{it} - \bar{v}_i$$

Since some children will have changed households or experienced a change in his household composition during the study, accumulation of an asset does not mean with certainty that the child's baseline household purchased the asset within the three-year period; rather, it could indicate that a child moved to a household that already owned the asset, or new members who already owned the asset entered the household. While this complicates our ability to be sure that asset accumulation represents a household's decision to purchase that item during the timeframe of interest, it does not interfere with our interpretation of changing asset ownership as a reflection of a child's changing household economic conditions. Interpretation of livestock accumulation is additionally complicated, since an increase in the number of animals owned could represent either purchase of animals or the natural procreation of existing animals. I therefore include livestock ownership when calculating wealth scores but not in subsequent considerations of asset accumulation or deaccumulation.

FINDINGS.

Children on Ibo under 10 years old experienced a substantial decline in stunting over time, with 45.7% stunted in 2009 vs. only 33.5% stunted in 2012 (Table 3, a decrease from "very high" to "high" rates [WHO 2013]). 64.5% of stunted children in 2009 were no longer stunted in 2012 (Table 4), while 19.0% of children who were non-stunted in 2009 were stunted in 2012 (data not shown). Children under 10 years old also experienced a decline in wasting over time, from 16.9% wasted in 2009 to 11.0% wasted in 2012 (Table 3, a decrease from "very high" to "high" rates [WHO 2013]).

The 2012 wealth quintile cutoffs indicate moderate levels of mobility in children's household relative wealth, with 59% of children from the poorest quintile in 2009 rising to a higher quintile by 2012 and 38% of children from the wealthiest quintile in 2009 falling to a lower quintile (Table 5). There were substantial increases in asset ownership between 2009 and 2012: only 26% of children in the lowest wealth quintile in 2009 would fall in that same quintile based upon 2012 ownership, according to the 2009 cutoffs (Table 5). Children in the lowest 2009 quintiles experienced the greatest mean gains in wealth scores during the three-year period (Table 4).

Stunting

Model 1 demonstrated no significant relationship between wealth score and children's height-for-age Z-scores in 2009 (Table 6).[4] 2009 stunting rates were lowest (39.4%) for children in the second wealth quintile and highest (51.0%) for children in the third wealth quintile (N=1076 children from the 2009 dataset; data not shown). However, 2009 wealth score was strongly predictive of children's 2012 height-for-age Z-scores (Model 2 in Table 6), indicating a positive relationship between baseline conditions and subsequent health outcomes. Likewise, 2009 wealth score was positively correlated with changes in height Z-scores (Figure 1 and Model 3 in Table 6), indicating that better wealth status in 2009 was associated with more nutritional improvements

[4] All OLS results (significance and direction of coefficient) for Models 1-4 were robust to use of Complete Case Analysis, in which wealth scores relying upon imputed values due to missingness were omitted (data not shown).

over time. Only 37.5% of stunted children in the lowest 2009 wealth quintile were non-stunted three years later, compared with a population-wide rate of change of 62.3% for stunted children (Table 4).

Although same-year wealth and Z-scores were unrelated in 2009, they were positively correlated in 2012 (Model 4 in Table 6). This marks a major change in the population's socioeconomic conditions. Nutritional investments in children transitioned from being uniformly low regardless of household wealth to being lowest in the poorest households and highest in the wealthiest households.

The fixed effects model indicates that no significant relationship exists between change in height-for-age Z-score and change in wealth index over time (Model 5 in Table 6).[5] Figure 2 serves to explain this lack of significance by demonstrating the differing relationship between asset accumulation and stunting changes based upon children's baseline level of household wealth. The figure segments children along the x-axis by their 2009 household wealth quintile and, further, by their household asset accumulation patterns.

Figure 2 groups children by their households' asset accumulation patterns between 2009 and 2012: households experience either deaccumulation (decrease of more than one asset in total number of assets owned), no change in number of assets owned, or accumulation (increase of more than one asset in total number of assets owned). Because of the population's increasing asset ownership during the study period, accumulation was more common than deaccumulation. By design, zero children in Quintile 1 households experienced deaccumulation of > 1 asset during the study period, since no Quintile 1 households owned more than one asset in 2009. For children in Quintile 5, accumulation of > 1 asset was uncommon during the study period. The average Quintile 5 child's household owned 8.0 of 13 possible assets in 2009.

[5] Fixed effects findings for Model 5 were robust to the use of Complete Case Analysis (data not shown).

The y-axes of Figure 1 and Figure 2 display the mean change in height-for-age Z-scores for children in each quintile and asset accumulation group. Mean changes in height-for-age by quintile rise from virtually no change for children in baseline Quintile 1 to a change of greater than a half of a Z-score in baseline Quintile 5. This trend is in accordance with the positive correlation observed between 2009 wealth score and changes in height Z-scores (Model 3 in Table 6).

Bar widths in Figure 1 and Figure 2 are scaled by the number of children falling into each group. Quintiles are split at the household level, and children are somewhat likelier to fall into the richest baseline wealth quintile than the poorest (246 vs. 206 children, respectively), explaining the slightly wider bar widths on the figure's right side. This positive relationship between wealth and children may be due to financial constraints of young adults, since an individual may delay marriage and childbearing until he or she has means with which to support offspring. Low asset ownership among the elderly may also explain the trend. Accumulation of many of this study's assets of interest (especially electronic devices, such as a mobile phone, a television, or a refrigerator) may be more common among working-aged persons who place high value on new assets and have the incomes with which to buy them. It is these working-aged persons who are of prime ages to have children under 10 years old in the home.

Stunting declined dramatically in the Ibo population between 2009 and 2012, and nearly all wealth quintiles and asset accumulation groups experienced mean improvements in heights during the study period. In the 1st quintile, however, maintaining low asset ownership (indicating an increase of no more than one asset) was associated with negative height-for-age outcomes for children over time (Figure 2). In the 1st and 2nd quintiles, children whose households accumulated assets experienced above-average improvements in their Z-scores in comparison with other children in their quintile. In the 3rd through 5th quintiles, children whose households accumulated assets experienced below-average Z-score improvements in comparison with other children in their quintile. Asset accumulation was therefore positively associated with height improvements for the population's poorest children and negatively associated with height improvement for those who were less poor.

Wasting

Models 6 and 9 demonstrated a significant positive relationship between wealth score and children's weight-for-height Z-scores in both 2009 and 2012 (Table 7).[6] Unlike the relationship between 2009 wealth and 2012 height-for-age scores, 2009 wealth did not predict children's weight-for-height Z-scores in 2012 (Model 7 in Table 7), indicating no relationship between baseline conditions and subsequent wasting outcomes. Likewise, 2009 wealth score was unrelated to changes in weight-for-height Z-scores (Model 8 in Table 7). The fixed effects model indicates that no significant relationship exists between change in weight-for-height Z-score and change in wealth index over time (Model 10 in Table 7).[7] While the lack of correlation between wealth and longitudinal wasting trends limits the ability to interpret household investment tradeoffs or the baseline conditions associated with nutritional investments over time, the wasting results confirm our expectation of a strong cross-sectional relationship between poverty and low caloric consumption during both survey periods.

Alternative wealth index.

Results of the analyses were confirmed when using a value-based wealth index (in which approximate dollar values are assigned to each asset and summed) in place of the PCA wealth index. Significance and direction of coefficients for Models 1-10 remained the same.[8]

DISCUSSION.

[6] All OLS results (significance and direction of coefficient) for Models 6-9 were robust to use of Complete Case Analysis, in which wealth scores relying upon imputed values due to missingness were omitted (data not shown).
[7] Fixed effects findings for Model 10 were robust to the use of Complete Case Analysis (data not shown).
[8] I have performed these analyses but haven't yet created the tables to include in the appendix.

In just three years, the combination of economic development and nutritional outreach on Ibo Island has led to enormous improvements in the population's nutritional status and major changes in the relationship between wealth and nutritional investments in children. In 2009, amid the commencement of Ibo's rapid development and before the opening of the Ibo Nutritional Support Center (CANI), wealth scores were uncorrelated with height-for-age Z-scores. By 2012, there existed a strong positive relationship between same-year height Z-scores and wealth scores (Table 3), indicating that wealthier households have begun to invest in foods that contribute to better nutrition. This changing cross-sectional relationship indicates that, within the study period, the community experienced a structural change in its relationship between household economic status and nutritional investments in children.

In 2009, rates of child stunting were high in all wealth quintiles, indicating that even the community's richest households were not making strong nutritional investments in their children. High stunting rates across economic groups is likely a reflection of uniformly poor nutritional diversity due to low regional availability of produce in 2009 and/or a population-wide lack of knowledge regarding a properly balanced diet. By 2012, after three years of nutritional outreach by the CANI educators, height-for-age Z-scores were strongly positively correlated with cross-sectional wealth. Nutritional outreach may have effectively increased all households' desire to consume vitamin-rich foods, leading Ibo's small farmers to produce more produce or a higher proportion of their produce to sell, as opposed to consuming in the home.[9] If the produce became more widely available for purchase post-2009, wealthier households would have been more financially capable of obtaining it, leading to improvements in their children's anthropometric statuses. As a complementary theory, it is possible that CANI's provision of information relating to the importance of consuming fruits and vegetables disproportionately benefitted the wealthier

[9] I am currently investigating the relationship between small farm ownership, produce consumption, and self-identified food security in another paper.

households, since they may be better educated and, thus, better able to process the importance of the information.

Although the nutritional supplements and education appear to have benefitted some children greatly, and although all wealth groups had equal access to the nutritional support, nutritional status of children in wealthier households improved the most. 2009 wealth scores were strong predictors of improvements in stunting Z-scores between 2009 and 2012, indicating that children in households with higher baseline wealth were likelier than poorer children to benefit from the island's combination of economic development and nutritional outreach (Figure 1). Children in the poorest quintile experienced a virtual lack of nutritional improvement (from 36.4% to 36.1%, Table 4, Figure 1), despite the availability of free nutritional supplements to undernourished children of all wealth statuses.

Due to the extreme poverty of the population's poorest households, it is possible that they substituted away from the at-home food consumption of their children who received food supplements. CANI used weekly weigh-ins to monitor the recipients' weights, and some households were targeted for repeated meetings to discuss the necessity of providing a dinner at home to a child whose weight was dropping in spite of his supervised consumption of fortified lunches. Given household-wide hardships and complex intra-household negotiations relating to the distribution of scarce food resources, it is not surprising that some households may have viewed the free food supplements as substitutes rather than augmentations of children's diets. Since it is probable that food scarcities were greater in the poorest households, the relatively wealthier households may have been likelier to benefit from the supplements as intended, continuing to provide daily meals to all household members.

It is also possible that children in poorer households benefitted less from the nutritional outreach due to higher time constraints within the household. Visiting the CANI nutritional center each day as a pregnant woman to receive a nutritious lunch, or taking one's undernourished child to the center, may require a time commitment beyond what some poor households can afford, if the women have heavy responsibilities in the home. If this is the case, birth weights and height statuses may be least likely to improve in poorer households, despite the availability of free meals.

A household's chosen balance between nutritional investments and asset investments differs based upon its position in time within the wealth distribution. While I hypothesized that a strong preference for non-food expenditures would be associated with asset accumulation before increased food expenditures among the poorest households, an opposing picture is emerging. Bottom-quintile households that are investing in assets are, on average, investing simultaneously in nutrition (Figure 2). When early in the wealth distribution, Ibo residents place high priority upon nutritional investments within the constraints of their incomes. For households with higher wealth, some substitution may be occurring away from nutritional investments, perhaps because parents are already observing anthropometric improvements in their children. Households in upper quintiles are, on average, investing in improved nutrition regardless of asset accumulation behavior, and the mean height improvements in these quintiles are sizeable. However, the height improvements of children in these quintiles appear to be somewhat lower if their households have recently accumulated assets (Figure 2).

Within the bottom 2009 wealth quintile, a household's failure to accumulate assets boded poorly for children's nutritional outcomes (Figure 2), and these children fell anthropometrically behind their peers. A "poverty trap," in which the poorest community members have failed to benefit from economic growth and improvements, appears to be occurring within this segment of the Ibo population: approximately half of children in the poorest quintile were in households that invested in neither assets nor, on average, improved nutrition during the study period. In this sense, it appears that recent economic development has occurred unequally across the population, creating a gap between the nutritional outcomes of the island's poorest children and those whose families have higher asset ownership. Also demonstrating unequal outcomes across the population, mean height-for-age Z-score improvements are substantially higher for children in the wealthier quintiles than for those in the lowest (Figure 1). The dramatic reductions in population-wide stunting rates are indications, however, that the combination of economic development and nutritional outreach is benefitting many. Continued development in the population will hopefully position even its poorest members to improve household nutritional consumption, representing an inter-generational rise out of poverty as present-day children with high human capital become healthy working-aged adults.

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TABLES.

	2009		2012		% change	Eigenvector [PC1], imputed means
	% household ownership	N	% household ownership	N		
Rooms	2.65	756	2.84	866	7%	0.178
Armoire	33.7%	754	28.9%	865	-14%	0.279
Bike	17.4%	754	12.5%	866	-28%	0.177
Boat	9.9%	718	11.2%	866	13%	0.184
Fridge	7.8%	756	13.0%	866	67%	0.241
Mattress	68.5%	753	66.4%	866	-3%	0.343
Motorcycle	10.2%	755	13.0%	866	27%	0.230
Phone	43.8%	756	64.3%	866	47%	0.340
Sewing machine	6.0%	755	5.8%	866	-3%	0.106
Sink	57.4%	756	76.3%	866	33%	0.340
Tape deck	54.9%	754	55.9%	866	2%	0.303
Television	13.5%	756	34.2%	866	153%	0.324
Wheelbarrow	2.6%	717	3.8%	866	46%	0.140
Wooden furniture	69.4%	755	68.5%	866	-1%	0.311
Bird index	1.49 [0.81]	715	1.82 [1.09]	866	22%	0.169
Goat index	1.23 [0.63]	717	1.16 [0.48]	865	-6%	0.119
Wealth index, NAs omitted	2.07 [0.89]	707	2.35 [0.92]	864	14%	
Wealth index, Imputed means	2.07 [0.88]	758	2.34 [0.92]	866	13%	
Households		758		866	14%	

Table 1. Household wealth characteristics, 2009 and 2012. Mean values imputed for missing values in PCA and calculation of Count Index score. Eigenvectors from the first principal component used to calculate Weighted Wealth index by multiplying by scaled (0:1) household value.

2009					
Same home	Moved			Died	Unknown
612	469			4	34
	Within Ibo		Elsewhere		
	256		213		
	Matched	Unmatched			
	142	114			
Panel dataset		2009 only			
754		364			
Total					
1118					
2012					
Same home	Moved			Born	Unknown
612	669			378	48
	Within Ibo		Elsewhere		
	402		267		
	Matched	Unmatched			
	142	260			
Panel dataset		2012 only			
754		953			
Total					
1707					
2009 & 2012					
Total					
2071					

Table 2. Children's population and population dynamics between 2009 and 2012. Number (N) children observed in each year. Data exist for 2071 children, 1117 of whom were present in 2009 and 1708 of whom were present in 2012. 754 children remained in the same home between the two survey waves or were retroactively linked with their previous individual IDs.

	2009	2009	2012	2012	2012	2012
Ages 0-9	X	X	X			
Ages 0-13				X		
Ages 3-13					X	X
Longitudinal only		X				X
Age (years)	4.37 N=1100 (98%)	4.39 N=750 (99%)	4.40 N=1292 (100%)	5.95 N=1673 (98%)	7.40 N=1299 (98%)	7.43 N=751 (99.6%)
Birth weight (kilos)	3.01 N=223 (20%)	3.01 N=223 (30%)	2.91 N=601 (47%)	2.92 N=650 (38%)	2.97 N=380 (29%)	3.01 N=223 {30%}
Height Z-score (Stunting)	-1.31 N=1076 (96%)	-1.26 N=727 (96%)	-1.00 N=1257 (97%)	-1.06 N=1614 (95%)	-1.03 N=1247 (94%)	-.89 N=718 (95%)
Stunted (Z-score <= -2)	45.7% N=1076 (96%)	42.6% N=727 (96%)	33.5% N=1257 (97%)	35.3% N=1614 (95%)	32.7% N=1247 (94%)	25.8% N=718 (95%)
Weight Z-score (Wasting)	-0.20 N=1012 (91%)	-0.27 N=680 (90%)	-0.19 N=1204 (93%)	-0.29 N=1561 (91%)	-0.44 N=1222 (92%)	-0.54 N=709 (94%)
Wasted (Z-score <= -2)	16.9% N=1012 (91%)	18.7% N=680 (90%)	11.0% N=1204 (93%)	12.0% N=1561 (91%)	12.8% N=1222 (92%)	15.0% N=709 (94%)
Wealth Score	1.32 N=1118 (100%)	1.35 N=754 (100%)	1.56 N=1292 (100%)	1.58 N=1707 (100%)	1.60 N=1329 (100%)	1.65 N=754 (100%)
Children (N)	1118	754	1292	1707	1329	754

Table 3. Child characteristics, 2009 and 2012. Comparing data for all children present in 2009, 2009 data for all children in the longitudinal dataset, data for children aged 0-9 in 2012, data for all children present in 2012, data for children aged 3-13 in 2012, and 2012 data for all children in the longitudinal dataset.

2009 Wealth Quintile		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	All Quintiles
Wealth Score	2009	.18 [.16]	.72 [.20]	1.26 [.14]	1.74 [.12]	2.45 [.34]	1.35 [.83]
	2012	.99 [.74]	1.35 [.55]	1.57 [.65]	1.76 [.75]	2.35 [.61]	1.65 [.81]
	Mean change	.81 [.73]	.63 [.54]	.29 [.66]	.02 [.71]	-.10 [.54]	.30 [.73]
# Assets owned (of 13)	2009	.48 [.50]	2.15 [.69]	3.94 [.62]	5.46 [.52]	8.03 [1.50]	4.15 [2.80]
	2012	2.92 [2.41]	4.05 [1.77]	4.66 [2.11]	5.49 [2.51]	7.62 [2.38]	5.12 [2.79]
	Mean change	2.35 [2.32]	1.88 [1.79]	.83 [2.00]	-.02 [2.46]	-.55 [1.93]	.78 [2.39]
% stunted (<=-2 Z)	2009	36.1%	34.3%	50.4%	45.2%	46.7%	42.6%
	2012	36.4%	22.7%	25.0%	24.3%	22.0%	25.8%
	0['12]|1['09]	39.1%	68.8%	64.5%	70.6%	72.0%	64.5%
Rooms	2009	2.57 [.86]	2.48 [.80]	2.88 [.88]	2.91 [.76]	2.87 [.63]	2.75 [.80]
	2012	2.73 [.68]	2.83 [.81]	2.94 [.76]	3.06 [1.17]	3.29 [1.00]	2.99 [.94]
Armoire	2009	0.7%	7.0%	25.2%	50.3%	77.9%	35.5%
	1['12]|0['09]	14.2%	28.6%	10.9%	18.8%	10.0%	18.0%
Bike	2009	0.7%	6.9%	20.3%	32.9%	52.5%	24.7%
	1['12]|0['09]	3.7%	7.4%	11.2%	18.5%	23.3%	11.7%
Boat	2009	2.3%	0.0%	10.3%	9.6%	40.7%	14.1%
	1['12]|0['09]	6.2%	3.8%	6.7%	13.4%	7.8%	7.7%
Fridge	2009	0.0%	11.0%	4.9%	5.0%	27.6%	10.7%
	1['12]|0['09]	5.9%	5.4%	8.5%	14.4%	32.8%	13.5%
Mattress	2009	5.1%	48.9%	78.9%	96.9%	99.4%	68.6%
	1['12]|0['09]	39.5%	65.3%	76.9%	0.0%	100.0%	51.1%
Motorcycle	2009	0.0%	7.6%	4.9%	3.1%	40.3%	12.7%
	1['12]|0['09]	2.9%	4.5%	11.1%	11.5%	14.8%	8.8%
Phone	2009	1.5%	13.1%	46.3%	55.3%	98.3%	46.2%
	1['12]|0['09]	43.3%	49.2%	48.5%	72.2%	100.0%	51.6%
Sewing machine	2009	0.0%	1.4%	13.0%	9.9%	13.3%	7.8%
	1['12]|0['09]	7.4%	8.4%	2.8%	2.8%	2.5%	4.8%
Sink	2009	4.4%	29.0%	62.6%	93.2%	96.7%	60.3%
	1['12]|0['09]	59.2%	72.8%	84.8%	81.8%	100.0%	69.6%
Tape deck	2009	9.6%	33.8%	47.2%	90.7%	92.2%	58.0%
	1['12]|0['09]	44.7%	47.9%	53.8%	66.7%	100.0%	51.1%
Television	2009	0.0%	0.0%	1.6%	6.8%	60.8%	16.5%
	1['12]|0['09]	13.2%	29.7%	39.7%	46.7%	59.2%	35.5%
Wheelbarrow	2009	0.0%	0.0%	1.7%	1.3%	11.6%	3.4%
	1['12]|0['09]	0.0%	0.0%	0.9%	10.3%	9.2%	4.5%
Wooden furniture	2009	22.1%	51.0%	77.2%	92.5%	96.7%	70.1%
	1['12]|0['09]	38.7%	59.2%	67.9%	91.7%	100.0%	53.4%
Poultry	2009	18.2%	52.7%	49.6%	42.2%	61.6%	45.6%
	1['12]|0['09]	63.9%	43.5%	36.8%	66.3%	45.5%	53.9%
Goat(s)	2009	2.3%	22.9%	20.7%	18.5%	34.3%	20.5%
	1['12]|0['09]	10.9%	14.9%	14.1%	15.6%	19.5%	14.9%
Children (N)		136	145	131	161	181	754
% Children in quintile		18%	19%	17%	21%	24%	100%

Table 4. 2009 stunting and asset ownership by 2009 wealth quintile, with conditional change in stunting status and conditional asset accumulation. Data only for children in the panel dataset. Change in Wealth Score represents (mean(2012 score-2009 score)) for members of each 2009 quintile. Conditional change in stunting represents % non-stunted children in 2012 conditional on being stunted in 2009 for members of each 2009 quintile. Conditional change in asset ownership represents % children in households owning asset in 2012 conditional on non-ownership in 2009 for members of each 2009 quintile.

	2009 Wealth Quintile				
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Lower Quintile, 2009 cutoffs	NA	8%	18%	37%	21%
Same Quintile, 2009 cutoffs	26%	16%	26%	11%	79%
Higher Quintile, 2009 cutoffs	74%	77%	55%	52%	NA
Lower Quintile, 2012 cutoffs	NA	10%	28%	43%	38%
Same Quintile, 2012 cutoffs	41%	34%	28%	20%	62%
Higher Quintile, 2012 cutoffs	59%	56%	44%	37%	NA

Table 5. Wealth quintile mobility, 2009 to 2012. Comparison of 2009 vs. 2012 quintile using 2009 cutoffs tabulates % of children in each 2009 quintile who would fall in a lower, higher, or the same quintile in 2009 based upon their 2012 asset ownership. Comparison of 2009 vs. 2012 quintile using 2012 cutoffs represents relative wealth mobility within the community, tabulating the % of children in each 2009 quintile who were in a lower, higher, or the same quintile in 2012.

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Dependent Variable: Height-for-age Z-score									
	2009 Z-Score		2012 Z-Score		Δ Z-Score (2012-2009)		2012 Z-Score		Δ Z-Score (2012-2009)	
2009 Wealth Index	-0.096		0.192	**	0.192	**				
Std error	0.054		0.046		0.046					
2012 Wealth Index							0.087	*		
Std error							0.038			
Δ Wealth Index (2012-2009)									-0.078	
Std error									0.079	
Constant	-1.611	**	-1.141	*	-1.264	**	-2.375	**	0.383	**
Std error	0.567		0.494		0.462		0.311		0.063	
Individual & Household Controls										
Age, 2009	0.035	*			-0.009					
Age, 2012			-0.017				-0.020			
Birthweight	0.106		0.093		0.096		0.320	**		
Household members, 2009	-0.019		-0.009		-0.009					
Household members, 2012							-0.002			
Cimento neighborhood, 2009	-0.269		0.259	*	0.26	*				
Cimento neighborhood, 2012							0.149			
Cumuamba neighborhood, 2009	0.031		0.153		0.151					
Cumuamba neighborhood, 2012							0.069			
Child is in panel dataset	0.164						0.363	**		
Height Z-score, 2009			0.220	**	-0.778	**				
Weight-for-Height Z-score, 2009			0.058	*	0.062	*				
Received nutrition intervention			-0.092		-0.083		-0.328	**		
Age-eligible for nut. intervention			0.190		0.230		0.250	*		
N	1076		647		647		1614		694	

Table 6. Wealth & Stunting Models. OLS Models (Models 1-4) modeling 2009 height-for-age Z-scores (Model 1), 2012 height-for-age Z-scores (Models 2 and 4), and changes in height-for-age Z-scores (Model 3) as a function of 2009 and 2012 wealth score (Models 1-3 and Model 4, respectively). Model 5 is a deviation from means fixed effects model with height-for-age Z-score as the dependent variable. OLS Models control for birth weight (using simple imputation for missing values), # household members, neighborhood dummies (baseline is Rituto neighborhood), whether the child is in the longitudinal dataset, 2009 height-for-age Z-score, 2009 weight-for-height Z-score, whether the child was identified as having received nutritional intervention from CANI between 2009 and 2012, and whether the child was eligible for CANI intervention based on his/her age. * indicates significant at the $\alpha=0.05$ level; ** indicates significant at the $\alpha=0.01$ level.

	Model 6	Model 7	Model 8	Model 9	Model 10
	Dependent Variable: Weight-for-height Z-score				
	2009 Z-Score	2012 Z-Score	Δ Z-Score (2012-2009)	2012 Z-Score	Δ Z-Score (2012-2009)
2009 Wealth Index	0.128 *	0.075	0.075		
Std error	0.054	0.049	0.049		
2012 Wealth Index				0.091 **	
Std error				0.035	
Δ Wealth Index (2012-2009)					0.052
Std error					0.089
Constant	-0.635	-0.347	-0.530	-0.099	-0.308 **
Std error	0.592	0.531	0.497	0.289	0.070
Individual & Household Controls					
Age, 2009	-0.132 **		-0.042		
Age, 2012		-0.046		-0.092 **	
Birthweight	0.406 *	0.095	0.099	0.181 *	
Household members, 2009	-0.008	-0.014	-0.015		
Household members, 2012				0.001	
Cimento neighborhood, 2009	0.023	-0.029	-0.018		
Cimento neighborhood, 2012				-0.004	
Cumuamba neighborhood, 2009	-0.273 **	0.066	0.056		
Cumuamba neighborhood, 2012				-0.003	
Child is in panel dataset	-0.240 *			-0.286 **	
Height Z-score, 2009		0.059	0.060		
Weight-for-Height Z-score, 2009		0.134 **	-0.864 **		
Received nutrition intervention		-0.125	-0.115	-0.373 **	
Age-eligible for nut. intervention		-0.044	-0.019	-0.190	
N	1012	638	638	1561	638

Table 7. Wealth & Wasting Models. OLS Models (Models 6-9) modeling 2009 weight-for-height Z-scores (Model 6), 2012 weight-for-height Z-scores (Models 7 and 9), and changes in weight-for-height Z-scores (Model 8) as a function of 2009 and 2012 wealth score (Models 5-8 and Model 9, respectively). Model 10 is a deviation from means fixed effects model with weight-for-height Z-score as the dependent variable. OLS Models control for birth weight (using simple imputation for missing values), # household members, neighborhood dummies (baseline is Rituto neighborhood), whether the child is in the longitudinal dataset, 2009 height-for-age Z-score, 2009 weight-for-height Z-score, whether the child was identified as having received nutritional intervention from CANI between 2009 and 2012, and whether the child was eligible for CANI intervention based on his/her age. * indicates significant at the $\alpha=0.05$ level; ** indicates significant at the $\alpha=0.01$ level.

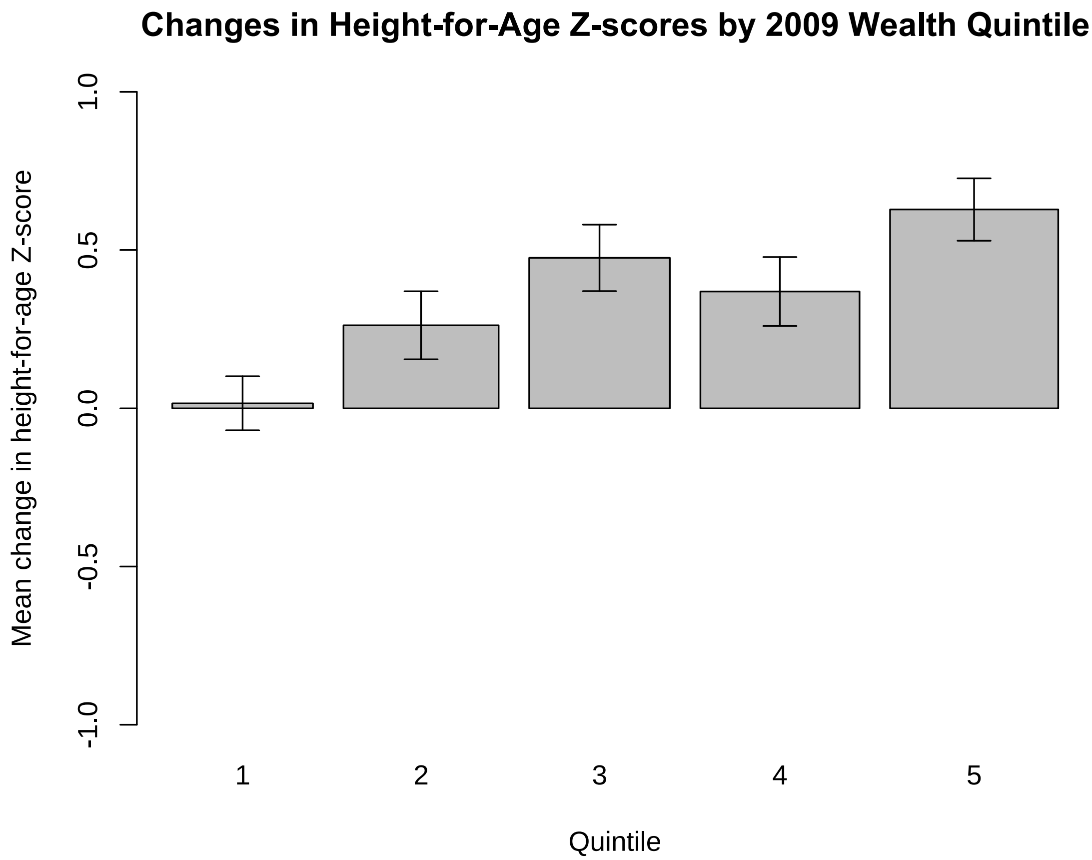

Figure 1. Mean changes in height-for-age Z-scores by 2009 wealth quintile. Error bars represent standard errors. Bar width is scaled to number of children in each group.

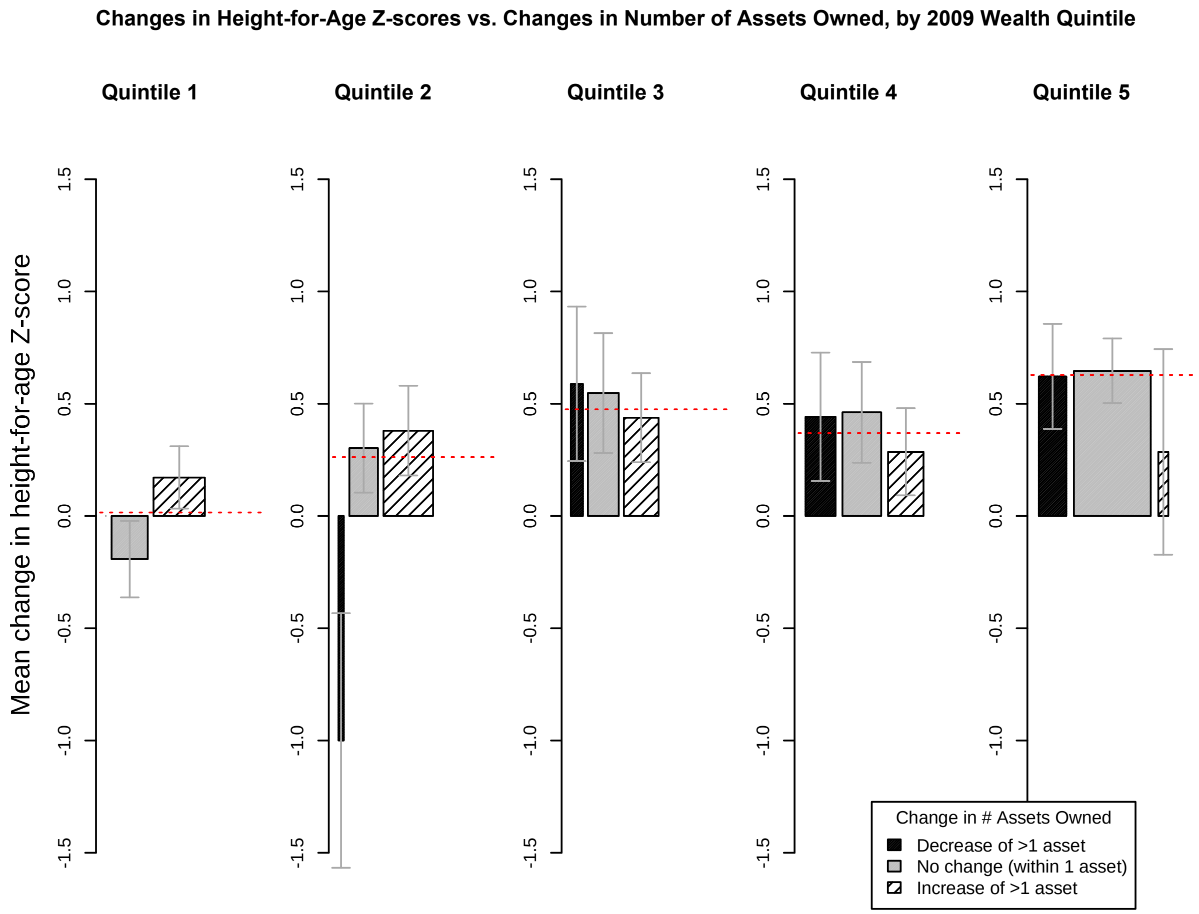

Figure 2. Changes in height-for-age Z-scores vs. changes in number of assets owned, by 2009 wealth quintile. Black bars represent changes for children whose households deaccumulated net assets over time. Gray bars represent changes for children whose households maintained ownership net asset over time (within one asset). Hatched bars represent changes for children whose households accumulated net assets over time. Error bars represent standard errors. Bar width is scaled to number of children in each group. Dashed red lines depict mean changes in height-for-age Z-scores for each 2009 wealth quintile.

APPENDIX.

	2009 data vs. 2009 height-for-age Z-score				2012 data vs. 2012 height-for-age Z-score			
	Non-missing	Missing	Sig	N=1076	Non-missing	Missing	Sig	N=1614
Rooms	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Armoire	-1.31 [1.43]	-1.4 [0.84]	p=.84	1066	-1.06 [1.21]	-2.33 [0.58]	p=.07	1611
Bike	-1.31 [1.43]	-1.56 [0.88]	p=.60	1067				1614
Boat	-1.31 [1.44]	-1.27 [1.24]	p=.82	1009				1614
Fridge	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Mattress	-1.30 [1.43]	-2 [1.04]	p=.07	1062				1614
Motorcycle	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Phone	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Sewing machine	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Sink	-1.31 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Tape deck	-1.31 [1.43]	-1.56 [0.88]	p=.60	1067				1614
Television	-1.30 [1.43]	-1.5 [0.93]	p=.70	1068				1614
Wheelbarrow	-1.31 [1.44]	-1.27 [1.24]	p=.82	1009				1614
Wood furniture	-1.31 [1.44]	-1.5 [0.93]	p=.70	1068				1614
Bird(s)	-1.31 [1.44]	-1.26 [1.33]	p=.79	1004				1614
Goat(s)	-1.31 [1.44]	-1.27 [1.24]	p=.82	1009	-1.06 [1.21]	-0.50 [0.71]	p=.51	1612
Birth weight	-1.29 [1.58]	-1.31 [1.39]	p=.80	217	-0.99 [1.32]	-1.10 [1.13]	p=.06	631
	2009 data vs. Wealth Index 2009				2012 data vs. Wealth Index 2012			
	Non-missing	Missing	Sig	N=1118	Non-missing	Missing	Sig	N=1707
Height	1.31 [0.82]	1.91 [0.60]	p=.04	1110	1.57 [0.79]	1.87 [.85]	p<.01	1649
Age (years)	1.32 [0.82]	1.00 [0.72]	p=.10	1100	1.59 [0.80]	1.38 [0.62]	p=.13	1673
Height z-score	1.31 [0.82]	1.47 [0.87]	p=.22	1076	1.58 [0.80]	1.68 [0.80]	p=.22	1614
Birthdate	1.32 [0.82]	1.30 [0.83]	p=.86	1069	1.58 [0.79]	1.60 [0.80]	p=.53	1315
Birth weight	1.38 [0.85]	1.30 [0.81]	p=.22	223	1.56 [0.77]	1.60 [0.81]	p=.34	650

Appendix 1. Missing vs. non-missing data. Mean values of Z-score and wealth indices, with SD in brackets. Missing asset data vs. stunting Z-scores and missing individual-level data vs. Count Index score, by year. No Z-scores were significantly different for individuals with missing vs. non-missing asset variables. Count Index scores were significantly higher for children with missing height data in 2012 (p=0.04).

Panel children vs. 2009 data					
IN PANEL DATASET	Linked	N	Unlinked	N	Sig
Wealth score	1.35 [0.83]	754	1.25 [0.79]	364	p=.07
Height z-score	-1.26 [1.39]	727	-1.41 [1.51]	349	p=.10
DIED/UNKNOWN 2012 LOCATION	Known 2012 location	N	Died or unknown	N	Sig
Wealth score	1.33 [0.82]	1081	1.11 [0.76]	37	p=.11
Height z-score	-1.29 [1.43]	1039	-1.68 [1.42]	37	p=.11
LEFT IBO	Ibo in 2012	N	Left Ibo	N	Sig
Wealth score	1.32 [0.83]	868	1.34 [0.80]	213	p=.81
Height z-score	-1.26 [1.41]	832	-1.43 [1.50]	207	p=.14
MOVED WITHIN IBO	Same Home in 2012	N	Moved within Ibo	N	Sig
Wealth score	1.38 [0.84]	612	1.20 [0.78]	256	p<.01
Height z-score	-1.30 [1.34]	586	-1.10 [1.55]	246	p=.29
LINKED AFTER WITHIN-IBO MOVE	Moved, linked	N	Moved, unlinked	N	Sig
Wealth score	1.24 [.78]	142	1.14 [.78]	114	p=.34
Height z-score	-1.10 [1.56]	141	-1.30 [1.54]	105	p=.33
Panel children vs. 2012 data [aged 3-13]					
IN PANEL DATASET	Linked	N	Unlinked	N	Sig
Wealth score	1.65 [0.81]	754	1.54 [0.78]	575	p=.01
Height z-score	-0.89 [0.99]	718	-1.22 [1.19]	529	p<.01
UNKNOWN 2009 LOCATION	Known 2009 location	N	Unknown origin	N	Sig
Wealth score	1.62 [0.79]	1281	1.20 [0.85]	48	p<.01
Height z-score	-1.03 [1.10]	1199	-1.13 [0.96]	48	p=.53
ARRIVED FROM OUTSIDE IBO	Ibo in 2009	N	Moved to Ibo	N	Sig
Wealth score	1.60 [0.81]	1014	1.67 [0.75]	267	p=.17
Height z-score	-1.02 [1.06]	954	-1.06 [1.24]	245	p=.61
MOVED WITHIN IBO	Same Home in 2009	N	Moved within Ibo	N	Sig
Wealth score	1.66 [0.80]	612	1.50 [0.80]	402	p<.01
Height z-score	-.87 [0.99]	584	-1.25 [1.11]	370	p<.01
LINKED AFTER WITHIN-IBO MOVE	Moved, linked	N	Moved, unlinked	N	Sig
Wealth score	1.57 [0.83]	142	1.46 [0.78]	260	p=.21
Height z-score	-1.00 [0.98]	134	-1.40 [1.16]	236	p<.01

Appendix 2. Missing vs. non-missing children. A comparison of 2009 and 2012 wealth scores and height-for-age Z-scores for children who were and were not a part of the panel dataset. Those who were not a part of the panel dataset were not included in one of the sample years due to an unknown location, a location outside of the Ibo population, or the inability to link the children who moved within the Ibo population.