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Household investments in children amid rapid development: Ibo Island, Mozambique

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Household Investments in Children Amid Rapid Development:
Ibo Island, Mozambique

By

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of the

University of California, Berkeley

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Professor Ronald D. Lee, Chair
Professor Jennifer Johnson-Hanks
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Abstract

Household Investments in Children Amid Rapid Development:
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by

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Doctor of Philosophy in Demography

University of California, Berkeley

Professor Ronald D. Lee, Chair

While much of the Global South has undergone sizable fertility declines in recent decades, many Sub Saharan African countries maintain fertility rates that are among the world's highest, averaging over five children per woman. High fertility in these regions often coincides with poverty, promoting a stable steady state in which large, low-income families invest little in their children, which makes large families affordable; these "low-quality" children grow up to themselves earn low incomes and have large families. When African countries undergo economic change, growth does not always translate into higher investments in children's human capital. In a rapidly developing African community, what are the household characteristics associated with increasing investments in children over time, giving them access to the resources to ultimately make quality investments in future generations?

I use two waves of panel census data (that is, a longitudinal survey of the entire population) from Ibo Island in Northern Mozambique to investigate this question from three perspectives: household economic circumstances, farming practices, and paternal absence. I collected the second wave of data in 2012, retrospectively linking individuals and households with their data from three years prior. With child stunting rates upwards of 40%—falling above the cutoff for "very high" prevalence of malnutrition—Northern Mozambique is an ideal location in which to investigate dietary investments in children. Likewise, recent data from Ibo Island provide valuable information with which to study the effects of rapid economic development. Between 2009 and 2012, for example, the island experienced enormous changes in its living conditions (e.g. arrival of electricity, growing ubiquity of mobile phones, sizeable declines in child stunting), as it began to transition from fishing village to tourism hub. Using demographic, economic, and nutritional data, I examine circumstances and decisions that may be characteristic of household conditions in the broader Sub-Saharan African region.

I begin by investigating household economic change and children's stunting, using longitudinal census data that link individuals and households over time. Rapid economic change led to dramatic increases in the number of Ibo Island's salaried positions between 2009 and 2012. A household's livelihood transition from agriculture and/or fishing to an emerging salaried position is taken to represent improved income owing to the community's economic growth. Children in fishing and agricultural households that underwent livelihood transitions experienced above-average improvements in their height-for-age Z-scores over time, indicating that income improvements are associated with investments in nutrition. These results demonstrate potential for continued investments in children's human capital, as development proceeds and as expanded employment opportunities emerge.

Turning next to household farming practices, I investigate associations between farm composition and children's dietary outcomes. In the Global South, many food-insecure individuals have diets that rely heavily on cereals and starchy roots without nutritionally sufficient consumption of vegetables, fruits, or proteins. While the relationship between dietary diversity and health is well documented in the literature, the role for crop diversity in promoting dietary diversity is less understood. I identify a strong link between household crop diversity and children's dietary diversity, which I confirm to be a strong predictor of child height. The positive relationship between household crop diversity and child dietary diversity verifies that household-level small-farming practices have the potential to improve access to diverse foods in the absence of markets. While educational attainment is associated with reduced rates of household farming, crop composition varies meaningfully with education, and high rates of fruit production among educated farming households may explain strong links between household education, children's dietary diversity, and child height: fruit production allows households to supplement their diets with nutritious foods not widely available for purchase.

Finally, the research focuses on investments in children as a function of the presence of their biological father in the household. Father absence from the household is expected to reduce paternal investments in children, but do other household members make investments that close the gap? I investigate educational investments on Ibo, where only one third of school-aged children live with their fathers. Results demonstrate a strong relationship between schooling and presence of the biological father, with educational participation rates over 10% higher for children who live with their fathers. Dropout rates were over a third higher for children whose fathers left the home between survey waves than for children whose fathers remained in the home. A household fixed effects model identifies higher educational participation among individuals who lived with their fathers than for cohabitants (step siblings, half siblings, etc.) whose fathers were absent. The results are aligned with family structure theory (in which traditional two-parent household structure promotes positive outcomes) and kin selection theory (in which familial altruism is driven by genetic relatedness).

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Curriculum Vitae

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INTRODUCTION

While much of the Global South has undergone sizable fertility declines in recent decades, many Sub Saharan African countries maintain fertility rates that are among the world's highest, averaging over five children per woman (Central Intelligence Agency 2015). High fertility in these regions often coincides with poverty, promoting a stable steady state in which large, low-income families invest little in their children, which makes large families affordable; these "low-quality" children grow up to themselves earn low incomes and have large families (Becker, Murphy, and Tamura 1990). When African countries undergo economic change, growth does not always translate into higher investments in children's human capital. In a rapidly developing African community, what are the household characteristics associated with increasing investments in children over time, giving them access to the resources to ultimately make quality investments in future generations?

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Between 2009 and 2012, for example, the island experienced enormous changes in its living conditions (e.g. arrival of electricity, growing ubiquity of mobile phones, sizable declines in child stunting), as it began to transition from fishing village to tourism hub. Using demographic, economic, and nutritional data, I examine circumstances and decisions that may be characteristic of household conditions in the broader Sub-Saharan African region.

I begin by investigating household economic change and child stunting, using longitudinal census data that link individuals and households over time. Rapid economic change led to dramatic increases in the number of Ibo's salaried positions between 2009 and 2012. A household's livelihood transition from agriculture and/or fishing to an emerging salaried position is taken to represent improved income owing to the community's economic growth. Who benefits as the economy changes, and do those individuals pass along the higher earnings to their families through improved nutrition?

Turning next to food production, I investigate associations between farm composition and children's dietary outcomes. In the Global South, many food-insecure individuals have diets that rely heavily on cereals and starchy roots without nutritionally sufficient consumption of vegetables, fruits, or proteins. While the association between dietary diversity and health is well documented in the literature (Arimond and Ruel 2004; Cordeiro et al. 2012; Savy et al. 2005), the role for crop diversity in promoting dietary diversity is less understood, in large part because local markets can spread nutrition across a community, and connectivity to extra-community markets can spread nutrition across the broader "foodshed" (Remans et al. 2011). With its geographic isolation from the mainland and its limited market for fresh produce, Ibo provides a fascinating location in which to investigate farming strategies that allow households to overcome local limitations in dietary diversity available for purchase.

Finally, the research focuses on differences in investments in children as a function of the presence of their biological father in the household. Ibo's prevalence of non-resident fathers due to high rates of migration, divorce, and mortality makes it possible to investigate differences in investments in child quality both across and within families. I employ individual fixed effects models to explore the degree to which students drop out from school when their households undergo a father departure event, and I use household fixed effects to compare educational outcomes for cohabitating half- and step-siblings, using father presence as a predictor of school enrollment while controlling for unobserved household-level characteristics.

Theory

Although Mozambique has experienced sustained increases of 7-8% per year in real per capita GDP over the past decade (The World Bank 2015), measures of chronic childhood malnutrition have dropped only marginally, from 47% to 43%, and are still at "very high" levels (World Health Organization 1995); on a regional scale, recent changes in poverty headcount have been uncorrelated with improvements in malnutrition measures (Azzarri et al. 2012). According to Jeffrey Sachs' much-discussed and contested poverty trap theory (Banerjee and Duflo 2011; Collier 2007; Easterly 2006; Moyo 2009), this could be caused by the failure of economic prosperity to spread equally to the nation's "poorest of the poor" (Sachs 2006) and hungriest of the hungry. When poverty causes families to spend all their resources on day-to-day survival, they cannot save or invest in the future and will therefore pass the condition to their offspring as well; in a cycle that Sachs calls a "trap," economic stagnation is caused by poverty, which, coupled with population growth, is associated with sustained poverty (2006).

Easterly calls this theory into question by providing nation-level data for numerous poor countries that experienced increases in per capita incomes over time rather than the stagnant low incomes a poverty trap theorist would predict (2006); however, Banerjee and Duflo's discussion of a poverty trap operates mainly at the individual level (2011), so rising national per capita incomes do not contradict the theory if within-country inequality is also growing. A trap at this level may be caused by factors such as an individual's lack of education, his inability to buy the physical capital necessary to increase productivity, his lack of collateral necessary to take out a loan, or his poor performance in a physically demanding job due to current or previous malnourishment.

By providing their children with resources such as nutrients, shelter, breast milk, vaccinations, and help with their homework, parents are investing money and/or time in their children's well being. Not all rearing of children costs the same amount, however, because the price and quantity of investments in child quality are variable, as is the value of parents' time. Additionally, children's net cost can be reduced by their contributions to family earnings. Parents derive utility both from the number of children they have and the investments they make in their children. Since quantity and quality are both costly, parents must balance their fertility and child-investment decisions within their constrained resources (Becker 1992). In a rural African setting, it may cost relatively little to raise children due to few and low-cost quality investments, a low value of parental time, and/or high prevalence of household tasks that fall under the role of child production. However, variability in quality and quantity of children within the Ibo community is likely to exist and to vary meaningfully with household characteristics such as household economic circumstances, farm ownership, and household composition.

According to economic theory, parents make monetary and time-based investments in their children's education due to altruism, old age security, and the evolutionary drive to protect one's genetic offspring. While most parents present in a household will derive utility from their children, a non-resident parent may not, depending on the circumstance of the absence. Absent parents may feel reduced altruism toward their children as a result of reduced interactions, reduced expectations of old age support, or closer relationships with children in a new household (Cox 2007). Any of these drivers could result in reduced investments in children whose fathers are absent from the home.

Investments in child quality may be interpreted as acts of familial altruism driven by genetic closeness to one's relatives in accordance with kin selection theory (Hamilton, Cheng, and Powell 2007). According to Hamilton's rule, the altruism we show to our offspring and other family members is dictated by our degree of relatedness to the individuals because, from a standpoint of evolutionary survival, we are driven to protect our own genes. We would therefore expect to see, under the most basic assumptions, twice as much altruism towards a daughter, who shares half of an individual's genes, as towards a niece, who shares only a quarter of an individual's genes (Cox 2007).

Family structure theory, too, predicts higher levels of investment in children of two-biological-parent households, but the discrepancy is caused by the stressors facing alternative families, such as ambiguous resource allocation roles for stepparents or nonresident biological parents (Hamilton, Cheng, and Powell 2007). In an African setting in which fostering, marital separation, and remarriage to new partners are common, it is conceivable that the long history of "alternative" households has eliminated this role ambiguity, causing the family structure theory predictions to be contextually irrelevant. Even where non-parental childrearing is commonplace, however, role ambiguity and the associated feeling that resource allocation is not one's own responsibility may persist in contributing to reduced investments in non-biological children, as was observed in Sierra Leone, where ill fostered children were taken to the hospital at below-average rates (Bledsoe, Ewbank, and Isiugo-Abanihe 1988). It is also possible that low investments in children in non-traditional households are defined unambiguously within the community. If the father is seen as responsible for contributing to food production or overall communal productivity, community norms could dictate low investments in children whose fathers are not available to participate and cooperate (Hill 2002; Hrdy 2009).

In contrast to kin selection theory, some postulate that high levels of care for children are driven not by shared genes but by prospective reciprocated altruism and the payoffs resulting from familial cooperation. Under these conditions, an individual with a close proximity to or a strong, familiar relationship with his stepchildren derives utility from investments in their quality, since they, like his biological offspring, are potential providers of old-age support and security against risk (Allen-Arave, Gurven, and Hill 2008). Likewise, the same elements of a close relationship (e.g. proximity, familiarity, and trust) associated with prospective reverse altruism from child to elder could also lead an individual to feel purely altruistic to the children around him. Observed trends are likely to depend upon local sociocultural norms and individual characteristics of relationships between fathers and children, since a biological or stepfather present in the household may or may not have a close relationship with the children, and a non-resident father may or may not maintain high levels of interaction with his estranged family members.

Predicting similar patterns of investment but through a different mechanism, we may feel strong ties to the children with whom we have close contact because human physiology adapted to meet the challenges faced by hunter-gatherers, who were surrounded by children in their own kinship networks (Buss 2005) and who relied on the rewards or reciprocal generosity resulting from pro-social acts within their communities (Hrdy 2009). Consequently, we are altruistic to non-relative neighbors and feel physiological ties to children in close proximity, even when they are not our biological relatives (Buss 2005; Hamilton, Cheng, and Powell 2007).

When parents do not invest disproportionately more in biological than non-biological children, the behavior suggests that we are bonded to the children with whom we have frequent contact or strong relationships regardless of genetic ties. Domestically, researchers have investigated these topics by considering outcomes for children in adoptive and same-sex households. Average or above-average financial investments in adopted children are observed both across (Hamilton, Cheng, and Powell 2007) and within households (Gibson 2009), and outcomes for children in same-sex cohabitating households were no worse than in heterosexual married households (Rosenfeld 2010), despite children in the former group being biologically related to a maximum of one of their caretakers.

This project makes a new contribution to the literature of human capital investments in children by exploring how the level of investments operates in tandem with a rapidly changing system of economic circumstances, demographic characteristics, and agricultural practices. In his “wealth flows” theory, Caldwell describes two types of societies experiencing high and low fertility rates, respectively. In the former, individuals are members of traditional peasant households in which production occurs within the family, and net wealth flows upward from children to elder relatives due to the value of children’s labor efforts (which begin at a young age) and the low cost of child rearing. Over time, these societies transition to the latter type of society, with production shifting to wage labor outside of the household and with net wealth flowing downward from parents to children due to reduced child labor and expensive investments in their education and other forms of human capital (1978, 1980).

While Caldwell uses this framework to understand the fertility declines associated with the demographic transition—and while his claims of upward wealth flows have been questioned or discredited by empirical research using data from various peasant societies (Kaplan 1994; Lee and Kramer 2002)—his theory of increasingly downward wealth flows over time provides a useful framework within which to consider intrafamilial economic trends in a rapidly developing community. What are the predictors of human capital investments in a community in which children are becoming more expensive to raise, and economic activity is increasingly occurring outside of the household?

Local context and demography

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 to heavy foreign investment after the recent discovery of both oil and natural gas deposits, the present economic development on Ibo is owed 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 the mid-1970s. 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 experienced more than simple stagnation during Mozambique's war and postwar eras; rather, with the abrupt expulsion of Portuguese colonialists in 1974, Ibo experienced a sizable step backward in the process of economic development.

With the arrival of cash-generating activities on the island since the turn of the millennium, 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 transportation infrastructure linking 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 luxurious method of land transportation on an island of about 4 square miles (Figure 1.2) with a population that has historically traveled solely by foot and sailboat. The Ibo Foundation, founded in 2005, established a carpentry school, and the Ibo Lodge aided islanders in developing a premium Ibo Coffee brand. In early 2012, the island received electricity, a much-appreciated service after years of being told there was limited fuel to power the municipal street lamps.

Pre-tourism, Ibo was largely a community of self-employed fishermen, but the island is now home to salaried workers in its hotels, schools, bars, and hospital. However, the island's rapid economic development has occurred unevenly, and 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), bread rolls are available daily directly from the bakers, and individuals occasionally sell coconuts or other seasonal fruits from small baskets rather than storefronts. In a culture of fish, rice, and cornmeal consumption, many community members prioritize the purchase of luxury non-food goods rather than greater dietary variety. In a 2009 survey of retrospective dietary consumption, only 19% of children had consumed fruit in the previous 24 hours, and only 6% of children had consumed vegetables. A high proportion of the population's diet consists only of cereals, fats, and small portions of fish, and Ibo consequently suffers from high rates of chronic malnutrition.

Demographic composition and rates

Ibo had approximately 3500 individuals in 2009 and 4300 individuals in 2012[1] living in three neighborhoods (Table 1.1), representing population growth of approximately 6.5% per year. As Figure 1.3 demonstrates, growth in the number of

[1] Polygynous males have been double-counted, but rates of polygyny are low (approximately 3.4% of adult males, according to the 2009 census data). Since adult males are not the focus of analyses in this dissertation, I did not remove duplicated males from the dataset. Only the population-wide descriptive statistics are affected by these duplications, which are believed to be associated with no more than 30 adult males.

individuals aged 0-34 years was substantial and cannot be attributed to natural increase (high fertility and low mortality) alone.[2] Rather, the observed population increase is likely due to some combination of fertility rates that exceed mortality; immigration rates that exceed emigration; and a more exhaustive census in 2012, in which we skipped fewer homes. The design of the 2012 census instrument, in which we worked from a list of every 2009 home, made it virtually impossible to skip a home that had been visited previously. Reasons for the sex imbalance within the youngest ages group in 2009 are unknown, and a sex ratio closer to 1 was observed in the 2012 data (Figure 1.3).

Between 2009 and 2012, the census recorded 337 births, 82 deaths, 730 migrations to Ibo, and 672 migrations from Ibo. Associated rates account for approximately 41% of the observed increase in population size. The other 59% of the increase could be due to 2009 census errors (in which residents were not included in the census) or to 2012 census errors (in which persons who had been living outside of Ibo in 2009 were mistakenly identified as having always lived on the island). Females were likeliest to move away between the ages of 5 to 19 years, while males were likeliest to move away between the ages of 20 to 24 years. Migration to Ibo was most common between the ages of 15 to 19 years, accounting for the particularly high population growth rate of adolescents (9.2% per year). Migration does not account for the increase in Ibo's sex ratio (86 males per 100 females in 2009 vs. 94 males per 100 females in 2012, Figure 1.3) because males and females immigrated and emigrated in roughly equal numbers.

[2] Were the population growth due only to natural increase, individuals would be moving up through the population pyramid over time, and no bar representing a 2012 age group would be wider than the bar representing one age group younger in 2009.

High mobility within the Ibo community[3] and uncertainty regarding the completeness of the 2009 census make it difficult to estimate even rough mortality rates. In low-development contexts, mortality risks are typically highest during the first year of life and, in particular, in the first month of life. If very young infants were excluded from the 2009 census, we will not have detected their deaths between 2009 and 2012 and therefore cannot calculate an accurate life expectancy.

In the 2009 census, women were asked for complete pregnancy histories, including miscarriages and child mortality. Only 3.6 infant deaths were recorded per year for the previous five years,[4] which would represent an infant mortality rate of approximately 33 deaths per 1000; this rate is 54% lower than the national rate for Mozambique (Central Intelligence Agency 2015) and is probably inaccurately low. In the hospital's mortality registry, there is an average of less than one infant death recorded per year, so supplementing the pregnancy histories data with that from the hospital's registry does not resolve the discrepancy in infant mortality rates.

Data limitations also inhibit my ability to estimate fertility rates, since not all births are registered, and the ability to use the panel census data to count births between 2009 and 2012 is contingent upon children's survival until 2012. Although the pregnancy data could potentially provide a viable method with which to estimate the population's fertility behaviors, the data in this survey is of questionable quality. Encouraging accurate pregnancy history recall in high-fertility populations poses methodological challenges, and

[3] Approximately one quarter of individuals reportedly moved within the island between the two censuses.
[4] Children of unknown age at time of death are assumed to be infants for this measure. Children of unknown birthdate or approximated birthdate are excluded from this measure.

I am not confident that enumerators in 2009 followed a protocol that elicited women's true birth histories.

Demography of employment

Fishing is a male-dominated profession (66.7% male in 2012, Figure 1.4), while farming is female-dominated (89.0% female in 2012). Identification as an adult "dependent" is more common for females than for males (34.7% of females aged 20+ in 2012, 8.1% of males, Figure 1.4). Longitudinal trends in dependency rates are difficult to interpret, since differences in enumeration techniques may explain the observed decreases in employment for adolescent males and adult females (Figure 1.4), particularly for those employed part-time in informal sectors such as fishing (employing a high proportion of adolescent males) and bread sales (employing a high proportion of adult females).

As Chapter 3 discusses in detail, major increases were observed in employment rates in some emerging sectors associated with Ibo's economic development, such as hotels, tourism, and NGOs. On the other hand, the number of individuals who identified fishing—Ibo's most traditional livelihood—as their primary form of employment remained relatively steady over time (Figure 1.4), with, for example, 285 and 272 male fishermen in 2009 and 2012, respectively. Participation rates in resource-based employment (i.e. fishing, agriculture) varied somewhat with age. While rates of employment in fishing were around 30% for employed males of all ages in 2012, employment in agriculture was more common among older women (44.8% of employed women aged 40+) than among younger women (19.1% of employed women aged 15-39, Figure 1.4). Time will tell whether these cross-sectional differences in agricultural employment represent a move away from agricultural production, as younger generations fail to take up farming, or the continuation of agricultural production as a practice that will be upheld as young women become farmers later in life.

Tables

	0-9 years	10-17 years	18+ years	Total
2009				
Cimento	136	93	222	451 (12.8%)
Cumuamba	471	250	736	1457 (41.2%)
Rituto	513	279	834	1626 (46.0%)
Total	1120 (31.7%)	622 (17.6%)	1792 (50.7%)	3534
2012				
Cimento	164	123	304	591 (13.7%)
Cumuamba	568	327	889	1784 (41.5%)
Rituto	589	368	968	1925 (44.8%)
Total	1321 (30.7%)	818 (19.0%)	2161 (50.3%)	4300

Table 1.1. Ibo Island age and neighborhood composition, 2009 and 2012. Number of individuals living in each of Ibo's three neighborhoods, by years of age. Foreigners (emigrants from Europe and the Americas) are excluded from the table and from all analyses.

	2009			2012		
	Mean [std dev]	Range	N	Mean [std dev]	Range	N
Age (years)	22.8 [19.9]	[0, 97]	3326	21.6 [18.8]	[0, 100]	4003
Sex ratio (males: females)	0.863		3534	0.946		4300
Individuals			3534			4300
Household size	4.6 [2.5]	[1, 14]	762	4.9 [3.0]	[0, 20]	877
Asset index (2012 USD)	$609 [$782]	[$0, $3738]	707	$683 [$847]	[$0, $4519]	864
Households			762			877

Table 1.2. Ibo Island descriptive statistics, 2009 and 2012. Mean, standard deviation, range, and number of observations. Three households in 2009 and eight households in 2012 are excluded from this table and from corresponding analyses because all occupants were emigrants from Europe or the Americas; although involved in the local economy (through employment in tourism and NGOs), their characteristics are not considered to be representative of the local Ibo experience.

Figures

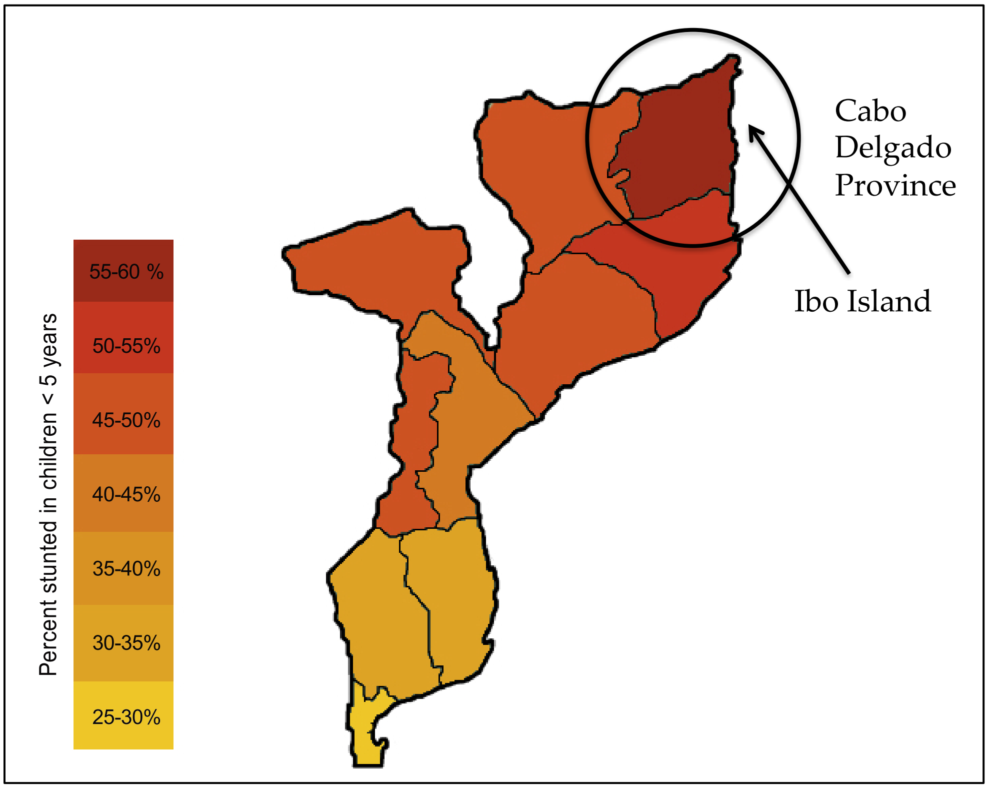

Figure 1.1. Geography of child stunting: Mozambique, 2008. Percent of child stunting (Height-for-Age Z-score <=-2 among children aged 0-4 years), by province. Mozambique's highest child stunting rates are in Cabo Delgado Province, where Ibo Island is located. Adapted from FAO data (Food and Agriculture Organization of the United Nations 2011b).

Figure 1.2. Ibo Island: Aerial photo. Ibo is approximately 4 miles^2. Only the western portion of the island is inhabited. (Google Earth 2013).

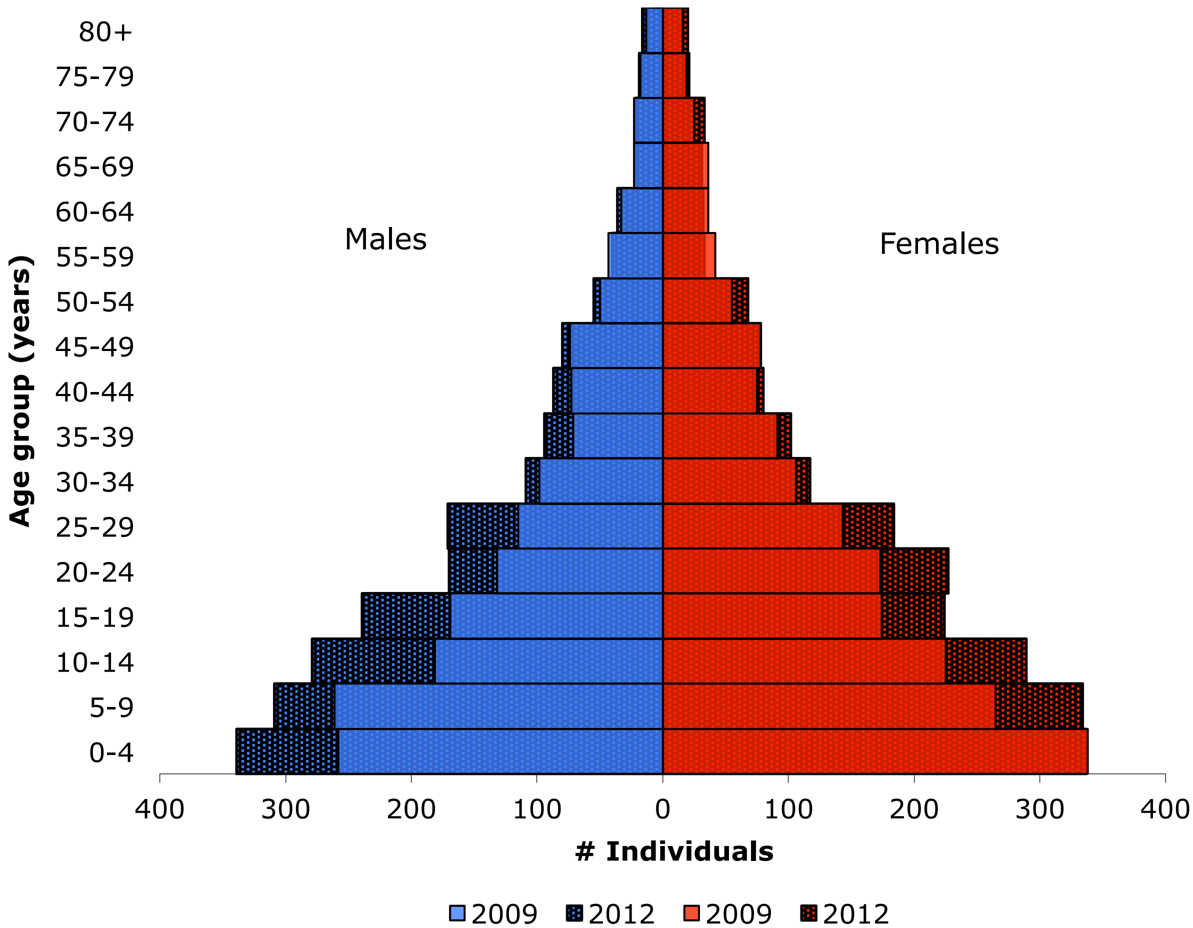

Figure 1.3. Ibo Island population pyramid: 2009 and 2012. Individuals present in the 2009 and 2012 censuses. Individuals of unknown age have been included in the pyramid within their respective sex and age category (i.e. child, adolescent, or adult), in proportion to the age composition of those with known ages.

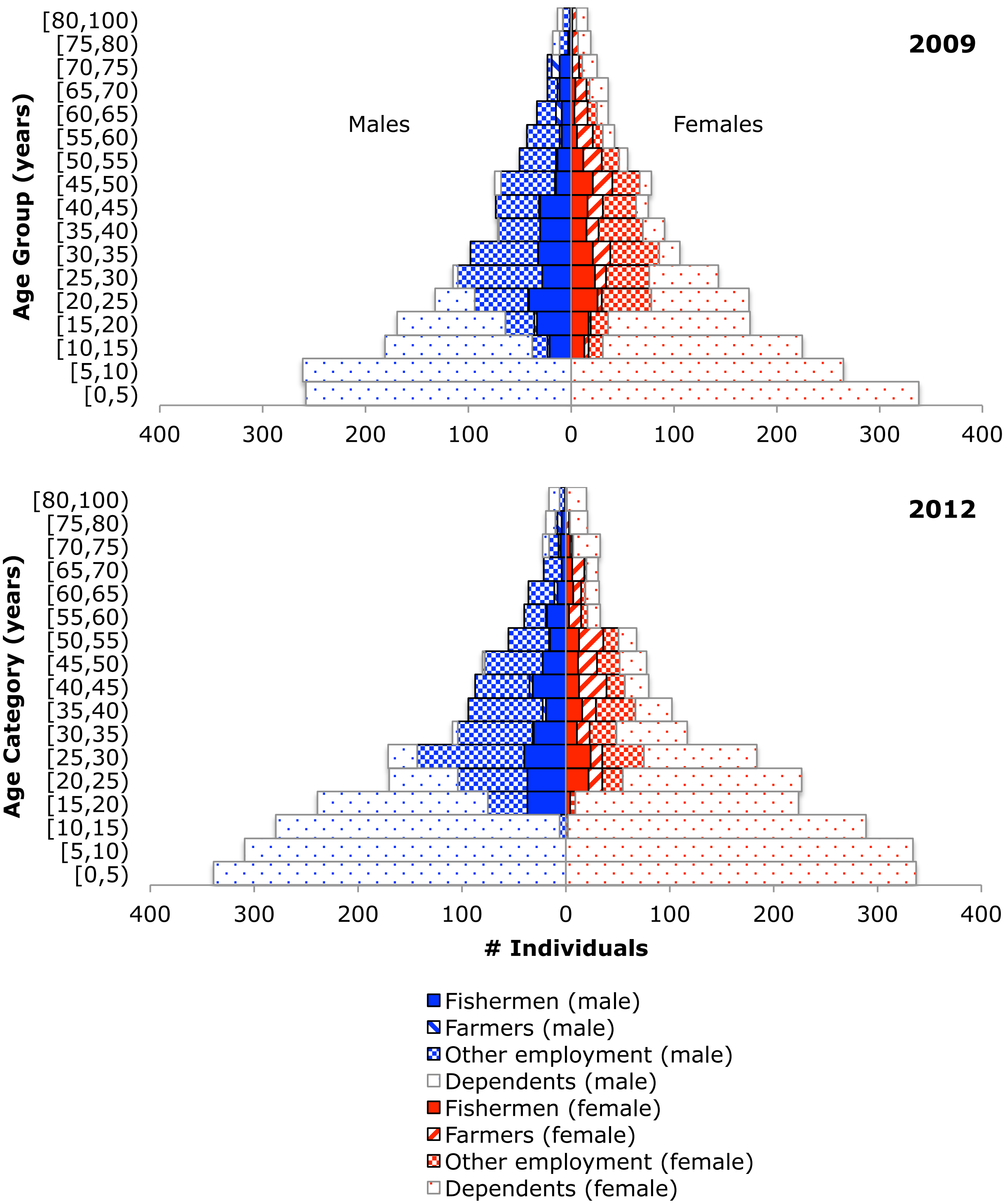

Figure 1.4. Population pyramids of employment sectors: 2009 and 2012. Individuals present in the 2009 and 2012 censuses. Individuals of unknown age have been included in the pyramid within their respective sex and age category (i.e. child, adolescent, or adult), in proportion to the age composition of those with known ages.

DATA

The data collection instruments

In 2009, the Ibo Foundation, a non-governmental philanthropic organization founded in 2005, conducted a complete census of the island, overseen by a team with expertise in nutritional, economic, and demographic research. Each house was assigned a unique House ID, each household was assigned a unique Household ID, and each resident was assigned a unique Individual ID. Since households were defined by their shared food consumption, numerous households could conceivably live within a single house, or a single household could live in numerous houses, but this was observed only on two occasions.

In 2012, I created and conducted a second-round census to calculate demographic rates and identify changes that occurred since 2009. For newly constructed homes or newly formed households, I assigned new House IDs and/or Household IDs. When possible, I used the same language from the 2009 census instrument in order to facilitate comparisons across years. Before collecting 2012 household composition data, I populated the forms with data describing the house's 2009 household members. In that way, it was possible to verify whether each person still lived in the home and, if so, to easily access their assigned Individual IDs. In order to shorten the length of household visits, I did not create 2012 forms to collect information about adults, morbidity, or pregnancy histories. Table 2.1 presents the information collected in each of the census waves.

There was at least one flawed question in the 2012 census instrument: "permanence" of moves was a difficult concept to interpret, especially because I did not include data categories for “vacation” or “seasonal migration.” When visiting a household that was vacant due to a one-month trip to a neighboring island, for instance, we classified the residents as being non-permanent emigrants, although “vacationing” would have been a more appropriate description of their status. I therefore disregarded responses to this question.

Other limitations in the data collection process related to interview protocol. In households with many children and adolescents, the census instrument was designed such that retrospective dietary information was to be collected separately for each individual, allowing for within-household comparisons (e.g. by age, by sex, by parental presence) of diet. Enumerators, however, typically asked respondents to answer the questions only one time per household. Although I tried to insist that they ask once per individual, the enumerators insisted that in the Ibo community, all individuals in the household eat the same food. Perhaps this is true, as many households serve their children meals from a single pot. In any case, I did not use the data to draw intra-household dietary conclusions.

In many ways, observing the 2012 data collection procedures caused me to question the validity of the 2009 data. I employed a very intense management style in the field in 2012, making frequent surprise visits to households where interviews were taking place in order to ensure that enumerators were following procedures. However, I heard accounts of laxer supervision efforts during 2009 and occasional cases of data fabrication. Occasional cases of data fabrication likely occurred in 2012, too.

I supervised the enumerators in Portuguese, but they conducted nearly all interviews in the local language of Kimwani, so I was unable to observe the way in which respondents’ answers were interpreted before being transcribed on the page in

Portuguese. For instance, how likely is it that—in a community in which children's birthdates and ages are not widely known without referring to one's health card—respondents for over half of children (52.3%) reported having breastfed for exactly 18 months, per the WHO recommendations? Without understanding Kimwani, it is impossible to know how appropriately the precision of the data reflects the true responses.

Data entry and cleaning

The Ibo Foundation researchers created a spreadsheet for each form type, with one row per household or individual, as applicable. While cleaning the 2009 data in March 2012, I discovered that approximately one quarter of households (N=224) were missing from the files. The Ibo Foundation gave me access to the hard copies of the 2009 census instrument, and I performed the remaining data entry myself.

In the summer of 2014, undergraduate Jane Liang assisted me with data cleaning, linking, and coding efforts. From March – July 2012 and in June 2014, we cleaned the data by ensuring that each individual, house, and household (as applicable) represented exactly one row of the applicable files: no more and no less (unless it was one of the rare cases of multiple households per house or a single household in multiple houses). In 2012, I verified that each Individual ID in the Household Composition file had a line in an individual file, and each Individual ID in an individual file corresponded to an ID in the Household Composition file. When the information was not aligned, I referenced the hard copies to guide my edits. I ensured that all Individual IDs for parents, children, and spouses linked to the IDs of individuals within the population, editing when necessary.

From January – June 2014, we verified that no codes had values falling outside of the possible range. When errors were identified, we corrected the typo or, when the correct response was unknown, we changed the response to "unknown." We checked responses for internal validity, such as verifying that no father marked as "dead" in 2009 was assigned an Individual ID.

To clean the pregnancy data, we looked for inconsistencies between the information contained in the pregnancy file and the individual files. All Individual IDs for those whose mothers lived on the island were flagged if they did not appear in the pregnancy file. In these cases, I referred to the hard copies of the 2009 census and discovered that aat least 5% of pregnancy responses (N=181) were missing from the dataset. I entered the missing data while deleting 176 duplicated responses.

For polygynous males, we used name information to link them to their other wives' House IDs. I chose a single Individual ID for each polygynous male, replacing his other IDs, so he was identified consistently across his households.

After linking individuals with their 2009 IDs, we often had information in one census wave that was unknown in another (e.g. birthdate, educational attainment, ID of a parent who was absent during one of the data collection waves). For these individuals, we compared the 2009 and 2012 data, replacing missing data with known values. When birthdates or educational attainments were different, I allowed the discrepancy to remain in the datasets.

Because cleaning the 2009 data took so much effort, I decided to input the 2012 data myself on-site, and I did so carefully. By collecting data during the day and inputting them during the evening, I was able to clean the data as they were collected and avoid cases of multiple or missing household visits.

Linking data

In November 2012, I began linking individuals who had moved within Ibo with their 2009 households and Individual IDs. Individuals who had not moved homes between census waves were automatically linked, since they were never assigned a new Individual ID. I began by making a list of all 2009 individuals who were identified as having moved within the community and all 2012 individuals who were identified as having arrived from within the island. I then looked for names that appeared on both lists, and I verified that birthdates were not conflicting. Upon identifying a match, I also looked at names of their 2009 and 2012 household members to see whether any of them had moved with them. Once I linked an individual, I replaced his 2012 Individual ID with his 2009 ID. Names and birthdates are inconsistently reported in the study population, so linking individuals was 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. Of the 3534 individuals recorded in the 2009 census, 64.1% were observed longitudinally (1874 individuals remained in the same home between census waves; 393 individuals who moved were retroactively linked).[5]

[5] 82 individuals (2.3%) reportedly died, and 132 (3.7%) had unknown whereabouts in 2012 or errors associated with their 2009 presence in the home. 672 individuals (19.0%) reportedly emigrated from Ibo between census waves. Of the 774 individuals who reportedly moved within Ibo between census waves, 393 (50.8% of these individuals, 11.1% of all 2009 individuals) were retroactively linked with the data from their 2009 residences.

In order to follow households longitudinally over time, I linked 2012 households to the Household Head's 2009 household. If, for instance, 2009 Household A divided into 2012 Households B and C, B and C will both link back to A. If 2009 Households A and B combined to form 2012 Household C, C will link back to either Household A or B, whichever was the 2009 household of Household C's Head. If the 2012 Household Head could not be linked to a 2009 Household, I linked to the 2009 Household of the oldest 2012 household member who lived on Ibo in 2009.

Coding data

In June 2014, we identified the "Household Head" in each 2009 and 2012 household based upon my understanding of household norms in the Ibo population. We did so by comparing the ages of the oldest male and oldest female in each household. When the oldest household member was a male, we coded him as the Head. When the oldest household member was a female, I manually looked at the relationship of household members. If she there were no males within the oldest female's generation, I coded her as Head; if there were males in her generation (e.g. a husband, a brother, a brother-in-law), I coded the oldest male as Head. When any household member had an unknown age, I manually looked at the relationships within the household and followed the protocol described above. When multiple individuals within the oldest generation had unknown ages, I typically chose a married male with the highest number of descendants in the home as the Head.

Tables

Year		Content	Notes
Aggregate visit *(one form per house)*			
--	--	Building type (i.e. single-family residence, multi-family residence, non-residence)	
		Construction materials of the:	
2009		Walls	*See Appendix*
2009		Roof	*See Appendix*
2009		Floor	*See Appendix*
Household composition *(one form per household)*			
2009	2012	Individual IDs residents	*A unique ID was assigned to each new resident*
2009	2012	Individual IDs of previous residents	*In 2012, 2009 data were pre-entered into the form*
2009	2012	Full name(s)	*In 2009, data were pre-entered in the form*
2009	2012	Sex(es)	*In 2009, data were pre-entered in the form*
2009	2012	Birthdate(s)	*In 2009, data were pre-entered in the form*
2009	2012	Age	
2009	2012	Relationship of each household member to the respondent	*In 2009, data were pre-entered in the form*
	2012	Whether each 2009 resident lived in the household in 2012	
	2012	Whether each 2012 resident lived in the household in 2009	
Social group *(one form per household)*			
2009	2012	Crops grown	
--	--	Dietary questions:	
2009	2012	Typical household dietary consumption	
2009	2012	Self-identified household food insecurity and seasonality	
2009		Method of home occupancy (i.e. owned, rented, borrowed, other, unknown)	
2009		Lighting type	*See Appendix*
2009		Cooking method	*See Appendix*
2009		Water source (e.g. privately owned, public well)	
2009		Toilet type	*See Appendix*
2009	2012	Household asset ownership	
2009	2012	Livestock ownership	
Non-presence *(one form per household)*			
	2012	Individual ID of each person who lived in the home in 2009 but not 2012	
	2012	Name	
	2012	Reason why the person no longer lives there (i.e.	

		moved, died, never lived there, or unknown)	
--	--	For individuals who moved:	
	2012	Destination (i.e. within the same neighborhood, within Ibo, within the Cabo Delgado Province, within Mozambique, to another country, or unknown)	
	2012	Permanence of the move	
New person *(one form per household)*			
	2012	Individual ID of each person who did not live in the home in 2009 but lived there in 2012	
	2012	Name	
	2012	Reason why the person is new to the household (i.e. moved, was born, always lived there, or unknown)	
--	--	For individuals who moved:	
	2012	Origin (i.e. within the same neighborhood, within Ibo, within the Cabo Delgado Province, within Mozambique, from another country, or unknown)	
	2012	Permanence of the move	
Work *(one form per household)*			
	2012	Individual ID of each adolescent and adult	
	2012	Name	
	2012	Household function (i.e. worker, dependent, or other)	
	2012	Whether works are self-employed	
	2012	Whether self-employed fishermen or farmers consume all their products in the household, sell all their products, or consume and sell some portion of their products	
	2012	Work code	*See Appendix*
Adult male *(one form per male aged 18+ years)*			
--	--	Individual's parents:	
2009		Individual IDs	*Typically "unknown" if the parents do not live in the household*
2009		Locations	*See Appendix*
2009		Presence in the household in the previous year (months)	
--	--	Education questions:	
2009		Educational attainment (years)	
2009		Current academic status (i.e. enrolled, not enrolled)	
2009		Principal occupation	
2009		Principal source of income	
2009		Location(s) of other house if male is a regular resident of another household	*Applicable for polygynous males*
Adult female *(one form per female aged 18+ years)*			
--	--	Individual's parents:	
2009		Individual IDs	*Typically "unknown" if the parents do not live in the household*
2009		Locations	*See Appendix*

2009		Presence in the household in the previous year (months)	
--	--	Education questions:	
2009		Educational attainment (years)	
2009		Current academic status (i.e. enrolled, not enrolled)	
2009		Principal occupation	
2009		Principal source of income	
--	--	Marriage questions:	
2009		Marital status (i.e. currently married, widowed, separated, divorced, never married)	
2009		Individual ID of current or most recent spouse	*Typically "unknown" if the couple are separated; "unknown" if the spouse is deceased*
2009		Number of times married	
2009		Age at first marriage	
2009		Wife order within most recent marriage	
--	--	Pregnancy questions:	
2009		Current pregnancy status	
2009		Number of times pregnant	
2009		Number children currently alive	
Adolescent male *(one form per male aged 10-17 years)*			
--	--	Adolescent's parents:	
2009	2012	Individual IDs	*Typically "unknown" if the parents do not live in the household*
2009	2012	Locations	*See Appendix*
2009		Presence in the household in the previous year (months)	
--	--	Education questions:	
2009	2012	Educational attainment (years)	
2009	2012	Current academic status (i.e. enrolled, not enrolled)	
--	--	Adolescent's principal caretaker:	
2009	2012	Individual ID	*Typically "unknown" if the caretaker does not live in the household*
2009	2012	Name	
2009	2012	Relationship to adolescent	*See Appendix*
2009	2012	Location	*See Appendix*
--	--	Adolescent's principal financial provider:	
2009	2012	Individual ID	*Typically "unknown" if the caretaker does not live in the household*
2009	2012	Name	
2009	2012	Relationship to the adolescent	*See Appendix*
2009	2012	Location	*See Appendix*
2009		Principal occupation	
2009		Principal source of income	
2009		Location(s) of other house if adolescent is a regular resident of another household	*Applicable for polygynous males*
--	--	Anthropometric measures:	

	2012	Weight	
	2012	Height	
2009		Number of times the adolescent was sick in the previous three months	
Adolescent female *(one form per female aged 0-17 years)*			
--	--	Adolescent’s parents:	
2009	2012	Individual IDs	*Typically “unknown” if the parents do not live in the household*
2009	2012	Locations	*See Appendix*
2009		Presence in the household in the previous year (months)	
--	--	Education questions:	
2009	2012	Educational attainment (years)	
2009	2012	Current academic status (i.e. enrolled, not enrolled)	
--	--	Adolescent’s principal caretaker:	
2009	2012	Individual ID	*Typically “unknown” if the caretaker does not live in the household*
2009	2012	Name	
	2012	Relationship to adolescent	*See Appendix*
2009	2012	Location	*See Appendix*
--	--	Adolescent’s principal financial provider:	
2009	2012	Individual ID	*Typically “unknown” if the caretaker does not live in the household*
2009	2012	Name	
	2012	Relationship to the adolescent	*See Appendix*
2009	2012	Location	*See Appendix*
2009		Principal occupation	
2009		Principal source of income	
--	--	Marriage questions:	
2009		Marital status (i.e. currently married, widowed, separated, divorced, never married)	
2009		Individual ID of current or most recent spouse	*Typically “unknown” if the couple are separated; “unknown” if the spouse is deceased*
2009		Number of times married	
2009		Age at first marriage	
2009		Wife order within most recent marriage	
--	--	Pregnancy questions:	
2009		Current pregnancy status	
2009		Number of times pregnant	
2009		Number children currently alive	
	2012	24-hour retrospective dietary consumption	
--	--	Anthropometric measures:	
	2012	Weight	
	2012	Height	
2009		Number of times the adolescent was sick in the previous three months	
Adolescent morbidity			

(one form per illness for each adolescent who has been sick within the past 3 months)			
2009		Dates of illness	
2009		Duration of illness	
2009		Individual ID of the adolescent's principal caretaker during the illness	
2009		Actions taken (e.g. took medicine, went to the hospital, went to the local healer, none) and by whom	
--	--	Name of the illness as identified by:	
2009		The household	
2009		The doctor or nurse	
2009		Presence of symptoms during the month before the census	
Child ***(one form per individual aged 0-9 years)***			
--	--	Child's parents:	
2009	2012	Individual IDs	*Typically "unknown" if the parents do not live in the household*
2009	2012	Locations	*See Appendix*
--	--	Education questions:	
2009	2012	Educational attainment (years)	
2009	2012	Current academic status (i.e. enrolled, not enrolled)	
--	--	Child's principal caretaker:	
2009	2012	Individual ID	*Typically "unknown" if the caretaker does not live in the household*
2009	2012	Name	
	2012	Relationship to child	*See Appendix*
2009	2012	Location	*See Appendix*
--	--	Child's principal financial provider:	
2009	2012	Individual ID	*Typically "unknown" if the caretaker does not live in the household*
2009	2012	Name	
	2012	Relationship to the child	*See Appendix*
2009	2012	Location	*See Appendix*
--	--	Health records:	
2009	2012	Ownership of a health card	
2009		Vaccination history	
	2012	Birth weight	
--	--	Infant feeding history:	
2009	2012	Duration of breastfeeding (months)	
2009	2012	Whether the child was ever bottle-fed	
2009	2012	Why the child stopped breastfeeding, if applicable	
	2012	Whether the child has ever received supplemented meals at the CANI Nutritional Center	
2009	2012	24-hour retrospective dietary consumption	
--	--	Anthropometric measures:	
2009	2012	Weight	
2009	2012	Height	
2009		Arm circumference	
2009		Number of times the child was sick in the previous three months	

Child morbidity *(one form per illness for each child who has been sick within the past 3 months)*		
2009	Dates of illness	
2009	Duration of illness	
2009	Individual ID of the adolescent's principal caretaker during the illness	
2009	Actions taken (e.g. took medicine, went to the hospital, went to the local healer, none) and by whom	
	Name of the illness as identified by:	
2009	The household	
2009	The doctor or nurse	
2009	Presence of symptoms during the month before the census	
Pregnancy history *(one form per pregnancy for all adult and adolescent females)*		
2009	Date of the pregnancy outcome	
2009	Location of the pregnancy outcomes (i.e. hospital on the mainland, hospital on Ibo, at home, other)	
2009	Birth parity	
2009	Whether the birth was registered	
2009	Result of the pregnancy	*See Appendix*
2009	Child's Individual ID	*Typically "unknown" if the child does not live in the household*
2009	Individual ID of the child's biological father	*Typically "unknown" if he does not live in the household*
	For children who have died	
2009	Date of death	
2009	Age at death	

Table 2.1. Content of 2009 and 2012 data collection instruments.

ECONOMIC DEVELOPMENT BRINGS IMPROVED NUTRITIONAL STATUS FOR CHILDREN

ABSTRACT. This chapter investigates household economic change and children's stunting outcomes on Ibo Island, a rapidly developing community in Northern Mozambique. A longitudinal census (that is, a survey of the entire population) links individuals and households over time. Rapid economic change led to dramatic increases in the number of salaried positions between 2009 and 2012. A household's livelihood transition from agriculture and/or fishing to an emerging salaried position is taken to represent improved income owing to the community's economic growth. Children in fishing and agricultural households that underwent livelihood transitions experienced above-average improvements in their height-for-age Z-scores over time, indicating that income improvements are associated with increased investments in nutrition. These results demonstrate potential for continued investments in children's human capital, as development proceeds and as expanded employment opportunities emerge.

Introduction

During much of the past 60 years, Sub-Saharan Africa experienced economic stagnation, and food production failed to keep pace with increasing population sizes (Lam 2011). Recently, however, many Sub-Saharan African countries have begun to undergo rapid economic growth. Studies have suggested that economic growth is often only weakly—if at all—associated with anthropometric improvements in children at the population level (Deaton and Dréze 2009; Heltberg 2009; Subramanyam et al. 2011). This is a serious problem, as poor early health and nutritional status, especially from the fetal stage through the first five years of a child's life, are associated with reduced cognitive development, school participation, and adult health and earnings (Almond 2006; Baird et al. 2011; Barker 1997; Case, Fertig, and Paxson 2005; Currie 2008; Field, Robles, and Torero 2009).

This paper is a household-level investigation of investments in children's nutritional capital for a rural African community undergoing great economic change. The data are drawn from Ibo Island in northern Mozambique, where fish are plentiful, but malnutrition persists. 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, Blössner, and Borghi 2012; Sanchez and Swaminathan 2005). On Ibo Island, the majority of the island's employment is in the food production sector, but height-for-age (stunting) 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 window into Mozambique's national experiences regarding the translation of economic change into improved nutritional status of children, a quantifiable reflection of investments in children's health.

Parents derive utility from services resulting from investments in their children's human capital (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 regarding the benefits of various forms of human capital. Parents face conflicting demands on their incomes and derive utility from their own consumption, their children's consumption, their children's human capital, and capital goods for home or market production. These are all expected to have positive income elasticities (Subramanian and Deaton 1996), such that rising incomes will lead to increased purchases of each of these items, other things equal. Research in developing countries has shown household wealth indicators, including asset ownership and number of rooms in the home, to be positively correlated with access to food (Leah et al. 2013), nutritional outcomes (Cordeiro et al.

2012; Headey 2013), and parental investments in child education (Filmer and Pritchett 2001).

In this study, household income is not observed directly but is, rather, inferred from livelihood sector and asset ownership. Given the methodological challenges of collecting reliable consumption or expenditure data in developing countries, this inferential approach can be interpreted as an asset rather than a liability. First, I investigate changes in anthropometric outcomes of children whose household member(s) works in an emerging job sector in comparison with those whose households remain engaged exclusively in agriculture and fishing over time. The transition to an emerging occupational sector (defined here as a "livelihood transition") is taken to signify improved household economic circumstances owing to community-wide economic change. Secondly, I consider children's anthropometric measures in relation to ownership of durable assets. 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).

A poverty trap, in which improved incomes benefit those who already had sufficient nutrient intake, provides one explanation for persisting malnutrition despite economic growth. Data depicting higher economic growth among regions or occupations with better baseline economic conditions (Deaton and Dréze 2002) are consistent with this theory, revealing growing inequality concurrent with declining poverty rates. While poverty trap theory does not speak to the issue of how income affects composition of food bundles, it provides a useful framework within which to imagine that the "poorest of the poor" (Sachs 2006)—and, likewise, the hungriest of the hungry—may be unable to take advantage of the economic growth occurring around them, hindering their ability to invest in either improved caloric quantity or dietary quality.

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 nutritious food, a preference for nonnutritive foods (Behrman and Deolalikar 1987), a preference for non-food expenditures, or intra-household dietary allocations that disproportionately benefit the adults—and in particular, the adult males—in a household (Dercon and Krishnan 2000).

While livelihood transition is expected to predict nutritional investments, asset ownership is understood to be both a predictor of and a potential 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 of its increased income to asset accumulation, a child's anthropometric status could remain the same over time despite increases in his household's asset wealth. In that sense, this research takes advantage of the less than perfect correlation between asset indices and nutritional expenditures to investigate household consumption preferences in the context of rapid economic change.

Panel census data (that is, a longitudinal survey of the entire population) tracking anthropometric measures, livelihoods, and assets over time allow for a case study analysis of the drivers behind Mozambique's sluggish drops in stunting rates despite its rapid annual growth in per capita GDP. By following individuals and households through time, it is possible to identify the baseline economic characteristics most associated with reduced stunting or improved asset ownership, elucidating whether access to the higher incomes associated with economic growth is unequal across the population. If there is a regional lack of nutrient-rich foods or if households prefer nonnutritive foods, height-for-age status is unlikely to be correlated with cross-sectional asset wealth or with livelihood transition, since community-wide low quality of diet will put individuals at equal risk for micronutrient malnutrition, regardless of food expenditures. If households prefer non-food expenditures, livelihood transition will be positively correlated with asset accumulation but uncorrelated with taller heights, since improved economic circumstances will not translate into anthropometric improvement.

Background

The population of Ibo Island, in northern Mozambique's Quirimbas Archipelago, is 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 to heavy foreign investment after the recent discovery of both oil and natural gas deposits, the present economic development on Ibo is owed 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 stagnation during Mozambique's war and postwar eras: with the abrupt expulsion of Portuguese colonialists, Ibo experienced a sizable 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 transportation 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 hotel's massive renovation efforts) jumpstarted the island's transition from a barter-based fishing economy to a community that deals in cash. Privately-owned generators and solar power arrived in the early- to mid-2000s, as did the island's first motorcycles, a somewhat luxurious method of land transportation on an island of approximately four 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 municipal electricity, a much-appreciated service after years of lacking the fuel to consistently power the 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 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 (World Health Organization 2003), Ibo children rarely consume fresh produce. In a 2009 Ibo Foundation census 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 stunting in children (Rivera et al. 2003), and fresh produce is 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, Fanzo, and Frison 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 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 nutritional outreach and free 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 CANI 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 portion of sugared tea if they attend a nutritional lesson while their children receive the meals. Since the nutritional supplementation and outreach are available to children 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.

This study utilizes stunting measures to understand children's changes in nutritional status over time. Whereas wasting (weight-for-height status) is a reflection of current dietary deficiencies, stunting reflects longer-term nutrient intake. Because heights can improve over time if the quantity and/or quality of young children's food improves, stunting is the better measure with which to represent the cumulative effects of nutrient intake over time (Headey 2013). If poor fetal conditions and/or early malnutrition have caused irreversible effects on children's heights (Martorell, Khan, and Schroeder 1994), the results of the longitudinal analysis will be biased toward zero.

Data

In 2009, the Ibo Foundation conducted a complete census of Ibo Island. Each house 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 (height, weight, and arm circumference) were recorded for children aged 0-9. For each household, information was collected relating to ownership of 13 assets, goats, and poultry (Table 3.1). Censuses were conducted in Kimwani and/or Portuguese by trained enumerators in respondents' homes.

In 2012, I designed a second-round data collection instrument and conducted a census with the assistance of Ibo Foundation employees. 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 outmigration). 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 (aged 0-9 years) 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. Taking into account the 612 individuals who did not move between census waves, 84.9% of the 2009 children were linked with their 2012 values (excluding those who emigrated, died, or had an unknown outcome between 2009 and 2012). The 2012 data collection wave utilized the first-round household-level questions to monitor accumulation of household goods and livestock since 2009. In 2012, anthropometric measurements were collected for all children and adolescents 13 years old or younger.

The outcome variables in this investigation are children's 2009 and 2012 height-for-age Z-scores (HeightZ). The Z-scores are based upon WHO standards, in comparison with an international reference population of healthy children. A Z-score cut-off of less than two standard deviations below the mean is defined as "stunted," indicating moderate to severe undernutrition (World Health Organization 1995). Children are defined as those 1-4 years old (12 to 59 months of age, Table 3.2), to capture individuals who are no longer exclusively breastfeeding and who are young enough to potentially be within the window of opportunity, during which improved nutrition could impact height outcomes. For longitudinal analyses, children are between 39 and 102 months of age during the second wave of data collection (Table 3.2).

Due to the methodological challenges of collecting reliable income or expenditure data, we surveyed households about their asset ownership as a proxy for household economic status (Filmer and Scott 2012; Vyas and Kumaranayake 2006). An asset index is constructed from a household's livestock ownership (poultry and goats) and asset ownership. 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 3.1 were collected in a yes/no format (0=don't own; 1=own). For ease of interpretation, this paper employs a value-based asset index,[6,7] in which ownership of an item is multiplied by an estimated dollar value of the item in 2012 USD.

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. When calculating the asset index and throughout further analyses, I used simple imputation to replace the missing data with the population's mean value for the parameter in that census year.

Missing height-for-age Z-scores exist due to missing heights and/or missing ages. Direction of bias in missing Z-scores is unclear due to opposing relationships between missingness and wealth. Missingness of the height-for-age Z-scores was not significantly related to household asset ownership in 2009 or 2012. 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. I therefore included these children in the analysis, calculating their Z-scores using an imputed *age in months*=[12**age in years*]+6.

[6] I employ an alternative type of asset index as a robustness check.

[7] In a future version of this investigation, I will consider the merits of employing a log-based asset index to allow for a different functional form of the relationship between asset ownership and nutritional outcomes.

Missingness of birth weight data was not significantly related to height-for-age Z-scores or to asset wealth in 2009 or 2012. In models controlling for birth weight, I used simple imputation to replace the missing values with the population's mean birth weight for children in that census year.

Methods

In this paper, I analyze stunting Z-scores, changes in livelihood sector, and household asset ownership. An individual who changes careers may be inherently different from one who does not, even after controlling for education and asset wealth. Likewise, households that undergo changes in asset wealth may be inherently different in their preferences (and their preferred investments in children) than are other households. This analysis does not investigate how a household would change its nutritional investments if randomly assigned a higher income, but it does allow for observation of nutritional outcomes associated with changing economic circumstances over time.

"Livelihood transition" designation

Households engaged in "emerging" jobs are designated as those in which any member is employed in job sectors meeting the following criteria, presumed to represent high incomes owing to expanded economic opportunities in the community over time:

1. The number of employees engaged in the livelihood grew dramatically (by 50% or more) between census waves. This condition is presumed to represent a factor exogenous to the household (e.g. tourism, not-for-profit activities, creation of a

larger hospital, or arrival of electricity in the community), which caused availability of these jobs to increase between census waves.

2. The livelihood is associated with regular, salaried employment. This condition is presumed to represent an improvement in income for workers who might otherwise be employed in seasonal, subsistence-based professions or informal commerce.

The emerging livelihoods are identified in Table 3.3. The community underwent major changes in livelihood strategies between census waves (Table 3.3). The number of individuals employed in the service and tourism sectors increased dramatically, as new opportunities emerged at restaurants, bars, and hotels, and economic development on the island provided an increased role for boat transportation of both goods and tourists. Employment at the Aga Khan Foundation, the Ibo Foundation, and the Quirimbas National Park also increased. The health sector saw major growth, with both the hospital and the Ibo Foundation's CANI nutritional center hiring more employees between 2009 and 2012. The construction sector, too, saw gains in its share of employees: erecting new homes and buildings requires builders, plumbers, and contractors, and the arrival of electricity on Ibo was, not surprisingly, associated with an increase in the number of electricians. In contrast, declines in employment were observed in fishing, agriculture, and informal commerce (e.g. selling one's bread rolls, cakes, or dried fish).

Individuals engaged in salaried, non-emerging livelihoods (e.g. local government, education) are likely to have earnings similar to those employed in emerging industries. However, the stable prevalence of these jobs over time undermines the interpretation of broad change between census waves, so it cannot be argued that associated improvements in health and/or asset ownership are attributable to economic growth. Although acquiring a salaried, non-emerging livelihood is likely to be associated with an increase in a household's economic status, the results do not depict the relationship between economic growth and child outcomes. After all, since prevalence of salaried positions in the local government and schools has remained relatively stable over time, it is arguable that the individuals who entered these fields between data collection waves may also have had the opportunity to do so earlier, had they so chosen. For these reasons, a change in a household member's livelihood to a non-emerging profession is not classified as a "livelihood transition," no matter how lucrative the position may be.

This paper presumes employment in the emerging industries is associated with high wages by local standards, in part because positions in the tourism and NGO sectors were known to be sought-after within the community. Though generous, the wages are unlikely to be associated with an instant departure from poverty or with enormously higher incomes than what one had earned previously. The census enumerators for this project, for example, were paid 3000 Mz per month for full-time work (approximately $105 USD), representing enough money to buy roughly 200 pounds of fish (7 pounds per day), 1200 small bread rolls (40 per day), or one [used] television per month.

To uphold the interpretation of "livelihood transition" as an improvement in economic circumstances, I restrict the analysis to a subset of households who, in 2009, were employed exclusively in agriculture and/or fishing.[8] Since agriculture and fishing are

[8] In 2009, household employment in exclusive agriculture and/or fishing was associated with below-average household asset wealth ($466 for exclusive agriculture and fishing households, compared with $688 for all

believed to be among the lowest-paying livelihoods on Ibo, the transition to a salaried job is expected to reflect increased household income, allowing for higher investments in nutrition and/or assets. In contrast, in households with other (ostensibly more lucrative) employment during the first census wave, a "livelihood transition" to the emerging industries will be a less reliable reflection of higher income. In the broader subset including all households that weren't already engaged in an emerging industry in 2009, livelihood transition is expected to be associated with smaller improvements in height outcomes or asset accumulation.

While the total number of adolescents and adults grew by 16% between census waves, the number identified as employed declined by 11% (Table 3.3), and the proportion of employed adolescents and adults fell from 57% to 44%. These differences are likely due to inconsistencies in census enumeration among respondents with irregular employment in the informal sectors. Educational participation is unlikely to have contributed to the drop in employment, as the number of adolescents who were identified as students increased by 17% between census waves (data not shown), proportional with rates of population growth.

Models

A difference-in-differences model is employed to investigate within-individual variation over time while controlling for time-invariant unobserved characteristics, such as children's in-utero conditions, genetic endowment, and fixed parental characteristics

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other households, p=0.002) and below-average educational attainment (with the most-educated adult member of the household averaging 4.75 years in exclusive agriculture/fishing households, compared with 7.66 years for other households, p<0.001).

(arguably altruism and entrepreneurship, for instance). Model 1 relates changes in height-for-age Z-score to livelihood transition, as measured by a change in household members' livelihood between the two time periods. Model 1A is restricted to households engaged exclusively in agriculture and/or fishing in 2009—those presumed to benefit most from a livelihood transition. Model 1B includes all children, except those whose households were already employed in an emerging livelihood during the first census wave. These models incorporate eight individual- and household-level controls (child's age, birth weight, and sex; number of household members; years of educational attainment of the child's live-at-home parent or household head [whichever is highest]; whether the household owns a small farm; whether the respondent indicated that the child received nutritional intervention from CANI between the census waves; and 2009 household asset wealth).

$[1A: Ag\&Fishing\ Subset]$

$$\Delta\, HeightZ_i = \alpha + \beta(\Delta\, livelihood_h) + \delta_a age_{i2009} + \cdots + \delta_h assets_{h2009} + \varepsilon_i$$

$[1B: Broader\ Subset]$

$$\Delta\, HeightZ_i = \alpha + \beta(\Delta\, livelihood_h) + \delta_a age_{i2009} + \cdots + \delta_h assets_{h2009} + \varepsilon_i$$

To investigate within-household asset change over time, a univariate difference-in-differences model relates asset accumulation to livelihood transition. Model 2A is restricted to households that were exclusively agriculture/fishing in 2009, while Model 2B includes all households that were not engaged in emerging industries in 2009.

$$[2A: Ag\&Fishing\ Subset] \quad \Delta\ Assets_h = \alpha + \beta(\Delta\ livelihood_h) + \varepsilon_h$$

$$[2B: Broader\ Subset] \quad \Delta\ Assets_h = \alpha + \beta(\Delta\ livelihood_h) + \varepsilon_h$$

I use OLS regression to investigate the cross-sectional relationships between household asset wealth and height-for-age Z-scores. Model 3 relates 2009 height-for-age Z-scores to 2009 asset wealth, and Model 4 relates 2012 height-for-age Z-scores to 2012 asset wealth. Model 5 investigates change in each child's height over time as a function of his household's asset wealth in 2009. Model 3 incorporates the Model 1 controls, with the exception of nutritional intervention (which occurred post-2009). Models 4 and 5 incorporate all the controls from Model 1.

$$[3] \qquad HeightZ_{i2009} = \alpha + \beta assets_{h2009} + \delta_a age_{i2009} + \cdots + \delta_f farm_{h2009} + \varepsilon_i$$

$$[4] \qquad HeightZ_{i2012} = \alpha + \beta assets_{h2012} + \delta_a age_{i2009} + \cdots + \delta_g CANI_i + \varepsilon_i$$

$$[5] \qquad \Delta\ HeightZ_i = \alpha + \beta assets_{h2009} + \delta_a age_{i2012} + \cdots + \delta_g CANI_i + \varepsilon_i$$

Robustness checks

To verify robustness of the models to parameter specification, I use an alternative asset index based upon principal components analysis—or PCA (Vyas and Kumaranayake 2006)—rather than the dollar value estimates. I also perform the analyses with a somewhat older, broader age range for the children (18 to 71 months instead of 12 to 59 months).

Results

Rates of stunting

Children on Ibo aged 12 to 59 months experienced a substantial decline in stunting over time, with 43.0% stunted in 2009 vs. only 36.3% stunted in 2012 (Table 3.2, a decrease from "very high" to "high" rates (World Health Organization 1995)).

Livelihood transition

For those households engaged exclusively in agriculture and/or fishing in 2009, neither 2009 asset ownership nor household educational attainment predicted whether the household would undergo a livelihood transition into an emerging industry (p=0.742 and p=0.938, respectively, in the agriculture/fishing subset). Likewise, population-wide, 2009 asset ownership and years of education were not strong predictors of whether a household would enter an emerging industry (p=0.506 and p=0.117, respectively, in the broader dataset, in which only those households employed in emerging industries in 2009 were excluded).

These results are reassuring for two reasons. First, the results have positive implications for the Ibo community itself, indicating that asset-poor, education-poor households are not being excluded from the employment opportunities associated with economic development. Secondly, the results provide support for the basis of this investigation's model, in which I assume that livelihood transition can be interpreted as a form of economic change largely exogenous to the household.

A household's change in employment from exclusive agriculture and/or fishing—the livelihoods expected to be least lucrative—to an emerging industry was associated with substantially above-average improvements in heights (p=0.019, Model 1A in Table 3.4). Other things equal, a change in household livelihood was associated with an increase in height-for-age Z-score of more than 1 point. On the other hand, a livelihood transition was not associated with any significant improvements in heights when performing the analysis with the broader (and potentially wealthier) set that included non-agriculture/fishing households (p=0.313, Model 1B in Table 3.4).

A household's livelihood transition from exclusive agriculture and/or fishing to an emerging industry was also associated with above-average asset accumulation (p=0.044, Model 2A in Table 3.5). For these households, a livelihood transition was associated with $631 more asset accumulation than for households that remained exclusively in agriculture/fishing. On the other hand, a livelihood transition was only weakly associated with above-average asset accumulation when performing the analysis with the broader set of households, and the magnitude of the effect was smaller (p=0.059, β=$232, Model 2B in Table 3.5).

Potential for some degree of endogeneity within the livelihood transition variable arguably persists, since individuals who are good candidates for salaried positions may have unmeasured traits (e.g. reliability, punctuality, an untraditional outlook on the future of the community's economy) that explain why they—and not their peers—entered new livelihoods. If these unmeasured variables are also associated with the level of one's investments in his children's nutrition, the livelihood transition variable will capture this relationship. In that sense, the preceding results may be interpreted as indications that the types of households that participate in emerging economic sectors invest a portion of their increased incomes in improved nutrition for their children. There is no clear counterfactual with which to determine whether the households that did not undergo livelihood transitions would have invested in improved nutrition, had they received higher incomes.

Stunting & asset ownership models

While there was no cross-sectional relationship between asset wealth and height outcomes in either census year (Models 3 and 4 in Table 3.6), asset ownership in 2009 was positively correlated with children's height improvements over time. However, the relationship was relatively small in magnitude—an additional $1000 in 2009 asset wealth corresponded to approximately 0.2 additional Z-score points—and only weakly significant (p=0.069, Model 5 in Table 3.6).

As for the relationship between stunting and the control variables, there was no cross-sectional relationship between household education and height outcomes in 2009, but a significant positive relationship emerged between the census waves (p=0.046, Model 5 in Table 3.6). Birth weight data were collected only in the second census wave, so rates of known birth weights were higher in the 2012 model than in the 2009 model (59.6% and 24.1%, respectively); since mean birth weight values were imputed in case of missingness, the parameter had less explanatory value in 2009 than in 2012. Reverse causality is presumed responsible for the negative relationship between nutritional intervention and 2012 height outcomes, since underweight children were targeted to receive free meals. The high stunting rates associated with nutritional intervention are therefore the result of selection of short children as participants in the outreach program.

Robustness checks

The strong positive relationship between livelihood transition and height improvements in Model 1A was robust to the use of an older, broader age specification ($p=0.014$, $\beta=1.170$), as was the lack of relationship between livelihood transition and height change in Model 1B. The lack of relationship between asset indices and height-for-age Z-scores in Models 3 and 4 was robust to the use of an alternative (PCA-derived) asset index and to the use of the broader age specification. The weak significance of the estimated relationship between asset indices and height improvements in Model 5 was robust to the use of a broader age specification ($p=0.058$, $\beta=0.187$), but it was not robust to the use of the PCA-based asset index ($p=0.291$). Since the relationship in Model 5 is not significant at the $\alpha=0.05$ level and falls away with the use of an alternative asset index, baseline asset ownership is interpreted as lacking a clear relationship with subsequent height improvements for children.

Discussion

In just three years, the combination of economic development and nutritional outreach on Ibo Island led to great improvement in the nutritional status of the population's children. Households that benefitted from economic growth—those who underwent livelihood transitions to emerging industries—simultaneously made above-average investments in both nutrition and assets. The identification of strong links between economic growth and anthropometric outcomes is counter to the weak or nonexistent relationships identified in other research (Deaton and Dréze 2009; Heltberg 2009; Subramanyam et al. 2011) and may be due to this study's investigation of economic growth at the household—rather than the population—level. A population can simultaneously experience increased per capita incomes and increased inequality, interfering with researchers' ability to relate anthropometric improvements to economic growth, so observation of individual households over time provides a clearer dataset with which to understand the routes through which development may translate into increased investments in children's human capital.

The relationship between livelihood transition and height improvements fell away when the broader population of children was included in the regression (Model 1B), likely because of the smaller economic impact of livelihood transition on non-subsistence households due to higher baseline incomes. It is also possible that the exclusively agricultural/fishing households in the subset had above-average access to nutrient-rich foods, in which case, improved economic circumstances allowed them to invest in better nutrition, while non-farming households were limited to the less nutritious foods sold in local shops. This interpretation may be somewhat substantiated by the weakly significant relationship between farm ownership and height improvement in Model 1B ($p=0.069$, $\beta=0.417$, Table 3.4). However, farm ownership could also be a reflection of some other aspect of household wealth that the asset index failed to capture.

An individual who opts to leave the fishing and agricultural sectors to work in an emerging industry may have unobserved characteristics (e.g. entrepreneurship, determination) that differentiate him from individuals in other households. Likewise, an individual who holds employment over time in an emerging sector is likely to have other unique unobserved characteristics (e.g. dependability, adaptability). If individuals employed in emerging industries have unusually strong preferences for nutritional investments (or unusually low preferences for non-food expenditures), the results of this analysis may overstate the effect of livelihood transition. We might therefore expect to observe fewer nutritional improvements among the next wave of children whose households enter the emerging industries. However, fixed effects methodology reduces at least some of this endogeneity, since the unobserved traits and preferences of individuals arguably remain fixed over time.

If the whole population had lacked access to or knowledge of good nutrition, we would not have observed height improvements with livelihood transition in the population subset. These results therefore suggest that the lack of cross-sectional relationship between asset ownership and height outcomes in 2012 is not caused by a population-wide lack of nutritious foods or by a population-wide lack of knowledge relating to nutritious foods.

A meaningful relationship emerged between educational attainment and height outcomes over time. Whereas in 2009, there was no discernable relationship between education and stunting, by 2012, a child whose parent or household head had 10 years of education underwent a Z-score improvement of 0.6 more points since 2009 than a peer whose household members had no formal education. It is possible that returns to education rose between 2009 and 2012, so better educated individuals experienced disproportionately high increases in their incomes over time, allowing them to make above-average investments in their children's nutrition. This is seen as unlikely, however, because livelihood transition and education were unrelated at the household level. (If returns to education had risen between 2009 and 2012, 2009 educational attainment would likely have been a strong predictor of livelihood transition, indicating that well-educated individuals were uniquely able to enter the community's emerging lucrative positions.) Rather, I expect that household members with higher educational attainment were especially responsive to nutritional outreach and growing western influences, thereby developing stronger preferences for nutrition than did their less educated peers. Further research to understand the characteristics associated with uptake of health-promoting behaviors in a community facing rapidly changing influences could elucidate the increasingly important role that education plays in households' nutrition investment decisions.

As improved infrastructure and expanded employment opportunities continue to transform Africa's rural areas, this research suggests that economic growth has the potential to benefit children directly because their households will invest a portion of their higher incomes in nutritional improvements. The lack of association between educational attainment or baseline asset wealth and a subsequent livelihood transition is promising for households with low human or physical capital, indicating that a poverty trap does not appear to prevent these households from taking advantage of emerging economic opportunities. Small farming and nutritional outreach may play an important role in translating economic growth into nutritional improvements because access to and preference for nutritious foods are necessary precursors of the movement away from nonnutritive dietary staples.

Tables

	Estimated value	2009 % household ownership	2009 N	2012 % household ownership	2012 N	% change
Armoire	$200	33.7%	754	28.9%	865	-14%
Bike	$100	17.4%	754	12.5%	866	-28%
Boat	$2,000	9.9%	718	11.2%	866	13%
Fridge	$333	7.8%	756	13.0%	866	67%
Mattress	$100	68.5%	753	66.4%	866	-3%
Motorcycle	$600	10.2%	755	13.0%	866	28%
Phone	$33	43.8%	756	64.3%	866	47%
Sewing machine	$117	6.0%	755	5.8%	866	-3%
Sink	$20	57.4%	756	76.3%	866	33%
Tape deck	$40	54.9%	754	55.9%	866	2%
Television	$100	13.5%	756	34.2%	866	153%
Wheelbarrow	$83	2.6%	717	3.8%	866	44%
Wooden furniture	$100	69.4%	755	68.5%	866	-1%
Poultry index [1-5]	[1]=$0 [2]=$12 [3]=$37 [4]=$70 [5]=$93	1.49 [0.81]	715	1.82 [1.09]	866	22%
Goat index [1-5]	[1]=$0 [2]=$75 [3]=$240 [4]=$450 [5]=$600	1.23 [0.63]	717	1.16 [0.48]	865	-6%
Asset index, NAs omitted		$609 [$782]	707	$683 [$847]	864	12%
Asset index, imputed means		$613 [$765]	759	$685 [$849]	866	12%
Households			759		866	

Table 3.1. Household asset wealth characteristics, 2009 and 2012. Estimated asset value used to calculate the wealth index. Percent asset ownership within households; number of households for which asset ownership data are available. Poultry, goat, and asset indices display mean household index by year, with standard deviations in brackets. All monetary values displayed in 2012 USD.

	2009	2009	2012	2012	2012
12-59 months	X	X	X		
12-102 months					
39-102 months				X	X
Longitudinally linked		X			X
Age (months)	36.1	36.1	36.7	70.7	72.7
	N=471	N=324	N=494	N=718	N=324
Birth weight (kilos)	3.00	3.00	2.91	2.98	3.00
	N=222	N=114	N=294	N=262	N=114
Height-for-age Z-score	-1.22	-1.18	-1.04	-0.94	-0.79
	N=468	N=321	N=485	N=699	N=314
% Stunted	43%	39%	36%	29%	22%
	N=468	N=321	N=485	N=699	N=314
Asset index[A]	$661	$730	$691	$759	$863
	N=471	N=324	N=494	N=718	N=324
Children (N)	471	324	494	718	324

Table 3.2. Child characteristics, 2009 and 2012. Descriptive data for children aged 12-59 months, children of appropriate ages to be considered in longitudinal models (including those who were not observed longitudinally), and children present in the longitudinal dataset. [A] Value imputed in case of missingness.

	Growing	Salaried	Emerging	# Workers [% workforce]	
				2009	2012
Fishing and Agriculture				657 [44%]	564 [43%]
Fishing				468	388
Agriculture				187	174
Other (rancher, beekeeper, etc.)				2	2
Construction and Industry				171 [12%]	189 [14%]
Construction					
Builder				34	49
Electrician	Yes	Yes	Yes	0	10
Carpenter		?		32	37
Other (plumber, contractor, etc.)	Yes			19	31
Artisanal activities					
Tailor				17	20
Other (silver, ebony, florist, etc.)				35	38
Other (difficult to classify)				34	4
Commerce, Services, and Tourism				453 [31%]	309 [23%]
Commerce					
Small shops		?		37	25
Informal commerce (bread, dried fish, etc.)				309	147
Service					
Restaurant, bar, tea house	Yes	Yes	Yes	11	25
Boat transport (of goods)	Yes			12	34
Other (barber, maid, etc.)	Yes	?		5	11
Tourism					
Hotel	Yes	Yes	Yes	31	54
Boat transport (of tourists)	Yes			0	11
Other (guide, cultural activities, etc.)				6	5
Other (difficult to classify)				44	5
Public Administration, Social Assistance				200 [14%]	227 [17%]
Education					
Teacher		Yes		46	45
Other school employee		Yes		11	12
Health					
Hospital	Yes	Yes	Yes	10	27
Nutritional center	Yes	Yes	Yes	1	10
Other (local healer, etc.)				6	3
Foundations and Organizations					
Aga Khan Foundation, Ibo Foundation	Yes	Yes	Yes	28	52
National Park	Yes	Yes	Yes	9	15
Other				5	1
Police and Local Government		Yes		38	32
Other (maritime, other difficult to classify)		?		46	30
Other (difficult to classify)				0 [0%]	26 [2%]
Total employees [% of adolescents & adults]				1481 [57%]	1315 [44%]
Total individuals > 9 years old				2577	2981

Table 3.3. Employment by sector & designation of "emerging" livelihoods. Number of adolescents or adults (> 9 years old) who identified each job as his or her primary livelihood. "Yes" identifies the components of the "emerging livelihood" classification. "?" identifies livelihood categories that may include both salaried and self-employed workers.

	Model 1A (Ag/fishing subset)		Model 1B (Broader set of households)	
	Dependent Variable: Δ Height Z-score (2012-2009)			
Δ Household Livelihood	1.047	*	-0.272	
Std error (robust)	0.432		0.269	
Constant	3.097		-0.423	
Std error (robust)	1.906		1.084	
Individual-level Controls				
Age, 2009 (months)	-0.015		-0.002	
Sex (0=Female, 1=Male)	0.104		0.199	
Birth weight (kg)[A]	-0.894		0.066	
Household-level Controls				
# Household members, 2009	0.048		0.017	
Education of parent/HH head	-0.135	~	0.047	
Nutritional intervention	0.913		0.123	
Small farm, 2009[A]	-0.108		0.417	~
2009 Asset Index (thousands)	0.380		0.187	~
N (individuals)	73		296	

Table 3.4. Height change and livelihood transition. Models 1A and 1B are OLS difference-in-differences models with change in livelihood as the independent variable. Model 1A includes only those children whose 2009 households were exclusively engaged in fishing and/or agricultural activities. Model 1B includes all children whose households were not engaged in emerging industries in 2009. Models are clustered at the household level. Asset index values are in thousands of 2012 USD. [A] Value imputed in case of missingness. ~ Indicates significant at the α=0.10 level; * significant at the α=0.05 level; ** significant at the α=0.01 level; *** significant at the α=0.001 level.

	Model 2A (Ag/fishing subset)		Model 2B (Broader set of households)	
	Dependent Variable: Δ Asset index (2012-2009) 2012 USD, thousands			
Δ Household Livelihood	0.631	*	0.232	~
Std error	0.310		0.123	
Constant	0.111		0.056	
Std error	0.078		0.042	
N (households)	112		443	

Table 3.5. Asset accumulation and livelihood transition. Models 2A and 2B are OLS difference-in-differences models with change in livelihood as the independent variable. Model 2A includes only those households who in 2009 were exclusively engaged in fishing and/or agricultural activities. Model 2B includes all households that were not engaged in emerging industries in 2009. Asset index values are in thousands of 2012 USD. ~ Indicates significant at the α=0.10 level; * significant at the α=0.05 level; ** significant at the α=0.01 level; *** significant at the α=0.001 level.

	Model 3	Model 4	Model 5
	Dependent Variable: Height Z-score		
	2009 Height Z-Score	2012 Height Z-Score	Δ Height Z-Score
2009 Asset Index (2012 USD, thousands)	-0.138		0.200 ~
Std error	0.087		0.110
2012 Asset Index (2012 USD, thousands)		0.033	
Std error		0.074	
Constant	-0.550	-2.610 ***	-0.624
Std error	1.045	0.495	1.051
Individual-level Controls			
Age (months)B	0.000	0.006	-0.002
Sex (0=Female, 1=Male)	-0.194	-0.118	0.176
Birth weight (kg)[A]	-0.026	0.458 **	0.010
Household-level Controls			
# Household members[B]	-0.044	-0.021	0.017
Education of parent/HH head	-0.016	0.052 *	0.060 *
Nutritional intervention		-0.439 **	0.169
Small farm[AB]	-0.212	-0.021	0.430 ~
N	468	485	311

Table 3.6. Asset wealth and stunting. Models 3 and 4 are cross-sectional OLS models for height-for-age Z-score as a function of asset wealth score in 2009 (Model 3) and 2012 (Model 4). Model 5 is an OLS model for change in height-for-age Z-score (2012-2009) as a function of 2009 asset wealth scores. All models are clustered at the household level. Asset index values are in 2012 USD. [A] Value imputed in case of missingness. [B] 2009 data used as control for Models 3 and 5; 2012 data used as control for Model 4. ~ Indicates significant at the α=0.10 level; * significant at the α=0.05 level; ** significant at the α=0.01 level; *** significant at the α=0.001 level.

EAT WHAT YOU GROW: POSITIVE LINKS BETWEEN CROP AND DIETARY DIVERSITY IN A FOOD-LIMITED COMMUNITY

ABSTRACT. In the Global South, many food-insecure individuals have diets that rely heavily on cereals and starchy roots without sufficient vegetables, fruits, or proteins. Poor dietary diversity is a major contributor to micronutrient malnutrition, which can have detrimental effects on later-life outcomes. While the relationship between dietary diversity and health is well documented in the literature, the role for crop diversity in promoting dietary diversity is less understood. In this research, I use data from Ibo Island, Mozambique, which has a limited year-round market in which fresh produce is sold. Although household crop diversity does not predict children's heights, I identify a strong link between household crop diversity and children's dietary diversity, which I confirm to be a strong predictor of child height. The positive relationship between household crop diversity and child dietary diversity verifies that household-level small-farming practices have the potential to improve access to diverse foods in the absence of markets. While educational attainment is associated with reduced rates of household farming, crop composition varies meaningfully with education, and high rates of fruit production among educated farming households may explain strong links between household education, children's dietary diversity, and child height: fruit production allows households to supplement their diets with nutritious foods not widely available for purchase. Grid plots and star plots are used to visualize dietary and crop composition, allowing for a better understanding of the structure underlying numerical dietary and crop diversity indices.

Introduction

In the Global South, many food-insecure individuals—those who lack reliable access to affordable foods of adequate caloric quantity and nutritional quality (World Food Summit 1996)—have diets that rely heavily on starchy staples without sufficient vegetables, fruits, or proteins (Arimond and Ruel 2004). Poor dietary diversity is understood to be a major contributor to micronutrient malnutrition, or "hidden hunger" (Burchi, Fanzo, and Frison 2011; Ezzati et al. 2002; Keatinge et al. 2010; Rivera et al. 2003), which can have lasting detrimental effects on development, school participation (Alderman, Hoddinott, and Kinsey 2006), and adult health and earnings (Victora et al. 2008). For this reason, outreach and policy in poor countries often prioritize early childhood nutrition as central for development (The World Bank 2006). With child stunting rates exceeding 40% (Food and Agriculture Organization of the United Nations 2011b), Northern Mozambique is an excellent location in which to study the factors associated with consumption of a well-balanced diet in a community where many households suffer from chronic food insecurity.

While the association between dietary diversity and health outcomes is well established in the literature (Arimond and Ruel 2004; Cordeiro et al. 2012; Savy et al. 2005), the relationship between crop and dietary diversity is less well understood. International development organizations routinely recommend incorporation of dietary objectives in guidelines for agricultural intervention policy (Herforth 2012), but evidence in support of linkages between agriculture and nutrition remains limited (Girard et al. 2012). There are various routes through which agricultural production can affect nutritional consumption, and researchers have alternatively identified household-level associations (Kabunga, Ghosh, and Griffiths 2014) and lack of associations (Remans et al. 2011) between foods produced and foods consumed. Existence of indirect pathways between home production and consumption (e.g. production-for-income, female empowerment (The World Bank 2007)) weakens the direct pathway from crops to diet, and the sale of produce to neighbors diffuses a crop's nutritional benefits throughout a community (Remans et al. 2011).

In this study, I use dietary consumption data from Ibo Island, Mozambique to investigate the relationship between dietary diversity and small-farming activities, hypothesizing that the direct pathway between home production and consumption will dominate due to the low availability of fresh produce for sale. I explore the characteristics of household farm ownership and diverse farm ownership to better understand the pathways through which high dietary diversity is achieved in a community that lacks a year-round market in which to buy fresh produce. While high crop diversity may not be a prescription for increasing nutrition among households with a low preference for dietary diversity, since such households may rather sell than consume their produce, high crop diversity is expected to be one route through which dietary diversity can be achieved.

Recent meta-analyses of nutrition-agriculture linkages limited their investigations to experimental studies in which households were randomly selected for participation in an agricultural intervention project (Girard et al. 2012; Masset et al. 2012). Although experimental research reduces the endogeneity of crop production decisions, the results of such studies must still be interpreted cautiously due to the ability of experimental design to unexpectedly influence greater community conditions. For instance, if an agricultural intervention to promote sweet potato cultivation targets 5% of farmers, those individuals may be likelier to engage in production-for-income than if the intervention targets 50% of farmers, which could saturate the market, reducing the price of sweet potatoes by increasing their supply. There remains a role for an understanding of the associations between agriculture and diet in non-experimental settings, where individuals have self-selected into farming and nutritional practices, and market conditions are in a pre-intervention state. Observation of farming behavior in such settings provides insight into the characteristics associated with adoption of nutrition-promoting farming practices on a household's own accord, in the absence of targeted agricultural intervention.

Background

The data for this project are from Ibo Island in northern Mozambique, where stunting rates are high, although the majority of the island's employment is in the food production sector. Ibo is located hours by boat and road from the nearest year-round marketplace in which produce is sold. Small shops sell dried goods (e.g. rice, cornmeal, sugar, peanuts, beans, and dried cassava) daily, and individuals occasionally sell homegrown produce from small baskets on porches. The lack of a consistent year-round market in which to buy fresh produce suggests that one of the best ways for an Ibo household to increase its access to diverse foods is to grow them.

Cereals and starches, typically prepared with small portions of fish and fats, comprise the Ibo community's nutritional staples. The World Health Organization recommends daily consumption of fruits and vegetables to prevent nutritional deficiencies (World Health Organization 2003), but Ibo's children rarely consume fresh produce. In a 2009 survey of retrospective dietary consumption on Ibo, 19% of children had consumed fruit in the previous 24 hours, and only 6% had consumed vegetables. Fruits and vegetables are a good source of vitamin A and iron, the dietary lack of which can cause stunting in children (Rivera et al. 2003), and fresh produce is the primary source of nutrients such as vitamin C in a typical diet (Keatinge et al. 2010).

The Ibo Foundation, a non-governmental philanthropic organization, established a nutritional center (Centro do Apoio Nutricional de Ibo, CANI) in 2009 to provide free nutritional outreach and 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 lunch daily if they visit the CANI center at an allotted time. Weights of the undernourished children are monitored weekly until adequate improvement is shown, at which time the children are "graduated" from the program. As additional incentive to participate, mothers of child-aged meal recipients are provided with a cup of sugared tea if they attend a nutritional lesson while their children receive the meal. In 2011, the Ibo Foundation hired an agricultural coordinator, who established a teaching farm near the CANI center. The coordinator and her local employees provided agricultural advice and seeds to members of the population who sought their services, but the outreach was not targeted to any particular individuals or households.

Data

In collaboration with the Ibo Foundation, I conducted a complete census on Ibo Island over a 7-week period (866 households, surveyed from August 13 through October 1, 2012). Surveys were conducted in Kimwani and/or Portuguese by four trained enumerators in respondents' homes.

Individual-level data: heights and dietary diversity.

We collected full name, birthdate, and gender information for each individual who resides in the community. To improve birthdate accuracy and collect birth weight information, we requested to see health record cards (presented for 38.1% of children). Heights were measured for children up to age 13 years and used to calculate height-for-age Z-scores based upon WHO standards, in comparison with a reference population of healthy children. A Z-score that falls more than two standard deviations below the mean is defined as "stunted," indicating moderate to severe undernutrition (De Onis and Blössner 1997).

Retrospective dietary data—in which the respondent indicated whether a child had eaten foods from ten food classifications (see Index 1) in the past 24 hours—were collected for all children. I construct a dietary diversity index (DDI) for children aged 2-9 years based on their reported food consumption in the previous 24 hours. The DDI is a count-based index in which children receive 1 point for responses of "yes" (consumed)[9] and 0 points for responses of "no" (did not consume), with a maximum possible value of 10 points for a child who consumed all ten food types in the previous 24 hours:

<u>Index 1</u>

$$DDI_i = Cereals_i + Dairy_i + Eggs_i + Fats_i + Fish_i + Legumes_i + Meat_i + Fruits_i + Tubers_i + Vegetables_i$$

In the absence of the data necessary to construct a dietary quality index (Drescher, Thiele, and Mensink 2007; Drewnowski et al. 1997), dietary diversity indices (DDIs), which quantify the foods consumed from various food groups, can serve as proxies for more complex measures of dietary quality (Kant et al. 1993; Michels and Wolk 2002; Remans et al. 2011) and are often positively correlated with anthropometric outcomes in developing communities (Arimond and Ruel 2004; Savy et al. 2005).

The DDI employed in this project differs from the recommendations of the FAO (Food and Agriculture Organization of the United Nations 2011a) because of limitations in

[9] The data collection instrument asks whether the children "consumed" the food in the previous 24 hours. I interpret affirmative responses to mean that the children were served (i.e. had access to) the foods. In other words, if a child were served vegetables but refused to eat them, I expect that the response would be "yes: consumed."

the survey instrument (e.g. lack of differentiation between vitamin-A-rich fruits and vegetables, dark green leafy vegetables, and other types of fruits and vegetables; lack of differentiation between vitamin-A-rich tubers and white tubers; lack of differentiation between organ meat and other meats). While these differences prohibit comparisons between this population's DDIs and those from other studies, within-population comparisons of DDI are still presumed to be useful. By relating DDI to anthropometry, Model 1 serves to verify that the DDI used here is a meaningful representation of micro and/or macronutrient consumption.

Household-level data: crop diversity

The CDI is a count-based index in which households receive 1 point for responses of "yes" (grew one of the seven crop classifications during the past 12 months) and 0 points for responses of "no" (did not grow). One additional point was added for farm ownership (1=yes, 0=no) to differentiate farmers who did not grow any of the surveyed crops from non-farming households. The maximum possible CDI is 8 points.

Index 2

$$CDI_h = (cassava_h + corn_h + fruit_h + legumes_h + peanuts_h + potatoes_h + sweetpotatoes_h) + farm_h$$

Due to the nature of the indices, the CDI and DDI are not expected to have a one-to-one relationship, even if all households ate exclusively what they grew. While there are components of the CDI that impact a single component of the dietary diversity index (e.g. fruit production may impact only fruit consumption), there are other cases in which multiple components of the CDI impact one component of the dietary diversity index. For instance, cassava, potatoes, and sweet potatoes are each designated a point on the CDI, but the tuber category is worth just one point on the DDI. The categories are generally broader in the CDI than the DDI, and small-farming households were not asked about their production of some commonly eaten vegetables (e.g. onions) or fat-rich crops (e.g. coconuts). These features of the indices will drive the magnitude of the relationship between crops and diet to be less than one-to-one. On the other hand, some of the components of the CDI have the potential to impact more than one component of the DDI. For instance, cassava roots are tubers, and cassava leaves are vegetables. In this sense, cultivation of a single crop (e.g. cassavas, peanuts) could increase the DDI by more than one point.

Controls

Educational attainment information was collected in 2009 by a team of researchers for the Ibo Foundation. Since formal education was largely unavailable to non-Portuguese Ibo residents prior to Mozambique's independence in the 1970s, the household head's educational attainment is constrained by his or her age. Therefore, I created a maximum educational attainment variable for each child's live-at-home parents and/or household head, selecting whichever value was highest. For household-level analyses, a "household maximum" educational variable was created to reflect the years of education of the most educated household member.

Asset ownership data were collected relating to ownership of 13 assets, goats, and poultry. A value-based asset index was created for each household based upon the estimated values of each asset type in 2012 USD (Table 3.1). Household asset indices ranged from $0 to $4420 (Table 4.1).

A variable representing the percent of employed persons in the household who identify themselves as farmers is used as a control to differentiate households that rely heavily on farming from those that use farming as only a secondary source of food or income.

Due to endogeneity concerns, receipt of supplemented meals at the CANI nutritional center is not included as a control. Selection for nutritional outreach during the previous three years is potentially due to both prior anthropometric measures and prior dietary diversity.

Excluded and missing data

Data collected from August 13-21, 2012 are excluded from analysis due to the potential impact of Ramadan (a fasting period) and Eid (a feasting holiday) on dietary patterns (Food and Agriculture Organization of the United Nations 2011a). Mean dietary diversity indices were lowest (4.02) for children who were visited during Ramadan and highest (5.90) for children who were visited in the three days following Eid, compared with a mean dietary diversity value of 4.26 for the children who were visited later in the season (Table 4.2). Height data reinforce the interpretation that Ramadan—and not the geography of survey enumeration—is responsible for the dietary differences between children visited in mid-August and those visited later. If households with low dietary diversity year-round happened to be visited during Ramadan due to dietary clustering within neighborhoods, the children in those households would be expected to exhibit below-average heights, but their heights were indistinguishable from those of other children (Table 4.2). Therefore, it does not appear that the children excluded from analysis represent a dietarily unique subset of the population.

Although nutritious diet is complementary with breastfeeding for children aged 6-23 months (Arimond and Ruel 2004), children under age two are excluded from analysis because of uncertainty as to whether respondents differentiated between consumption of cow's milk and breast milk when describing young children's retrospective "dairy" consumption. The resulting population size is 887 children aged 2-9 years (Table 4.1), surveyed over the course of 5.5 weeks. The short time frame during which children were surveyed is expected to minimize seasonal differences in the availability of foods.

Height-for-age Z-scores are calculated using a child's age in months. For those children with known years of age but unknown birthdate, I calculated Z-scores using an imputed

$$\boxed{age\ in\ months_i = (12 * age\ in\ years) + 6}$$

Children with unknown heights were excluded from analyses of height-for-age Z-scores. In models controlling for birth weight, I used simple imputation to replace the missing value with the population-wide mean. For households with unknown asset information, the missing value for each asset is replaced with the community-wide average rate of asset ownership (i.e. since 28.9% of households reportedly own armoires, 0=does not own an armoire, 1=owns an armoire, and 0.289=household is missing armoire information). In models controlling for education of the live-at-home parent or household head, I replaced missing values with 0 years of education because outcome variables for children with missing educational data were most similar to those from no-education households (Table 4.2). I excluded children with missing Z-score, DDI, and CDI data from associated analyses.

Methods

In this study, I use ordinary least squares (OLS) regression to investigate children's height-for-age Z-scores as a function of dietary diversity or crop diversity categories (low, middle, and high diversity, Model 1) and children's dietary diversity as a function of household crop diversity categories (Model 2). Model 1 incorporates six individual- and household-level controls (child's age in years, child's sex, child's birth weight, number of household members, years of education of the child's live-at-home parent or household head [whichever is highest], and the household's value-based asset ownership score). Model 2 incorporates the above controls with the exception of child's birth weight. Model 3 uses logistic regression to relate farm ownership to household characteristics. Model 4 uses OLS to relate crop diversity to household characteristics among the subset of households that own farms.

In performing Model 2—in which I investigate individuals' Dietary Diversity Indices as a function of their households' Crop Diversity Indices—I am motivated by the expectation that a diverse household farm increases individuals' access to a diverse diet. A positive association between the two measures does not necessarily lend itself to this interpretation, however, since a household's preference for dietary diversity could drive its members to grow a diverse array of crops. In either case, a strong association between crop and dietary diversity will confirm the household-level role for agricultural production in providing access to healthful foods in a location with limited local markets for perishable fruits and vegetables.

The data for this project lack the detail necessary to incorporate ecological functional diversity or nutrient traits (Remans et al. 2011) in the CDI, so some crops are assigned one point each despite being highly similar in their nutritional composition and contribution to the diet (e.g. potatoes and cassava). The data do not describe small farm size, the quantity of food consumed, or the quantity of crops grown, sold or bartered. Interpretation of the DDI and CDI outcomes therefore relates more to households' broad preferences, behaviors, and outcomes (i.e. the *types of households* with diverse farms, the *types of children* who eat diverse diets) than to the benefits of growing or consuming specific foods or specific numbers of foods. In Models 1 and 2, I therefore found it useful to create CDI categories of low (CDI=1 or 2), middle (CDI=3, 4, or 5), and high (CDI=6 or 7), rather than fitting a possibly non-linear relationship to a linear model.

Results

Stunting, dietary diversity, and crop diversity models

Rates of stunting in the population are "high" (World Health Organization 1995), with 32.0% of children's height-for-age Z-scores at or below -2 (Table 4.1). The median DDI is 4, representing consumption from four of the ten food groups of interest in the previous 24 hours (Table 4.1). The most typical foods consumed were cereals (e.g. corn, rice, and bread) and fats, followed by fish and tubers (Figures 4.1-4.2).

Dietary diversity index is positively associated with child height (p=0.006 in the univariate model, p=0.055 in the multivariate model with controls, Table 4.3), verifying that the DDI employed in this project serves as an effective proxy for dietary quality. Likewise, the results demonstrate a strong positive association between a child's dietary diversity and his or her household crop diversity, controlling for other significant characteristics including educational attainment and household asset wealth (p=0.013, Table 4.4). Mean dietary diversity levels were, on average, approximately 0.5 points higher for children in high-diversity farming households than for children in non-farming households (Table 4.2).

In a model directly relating child height to crop diversity, no significant relationship is found between the variables (p=0.477 and p=0.608 in the univariate and multivariate models, respectively, Table 4.3). This lack of relationship could be due to the weakly negative relationship between farm ownership and child height (Table 4.2).

Household characteristics

After fishing, farming is the second most common occupation on Ibo Island, and 172 respondents (13.1% of employed individuals) identify farming as their primary profession (Figure 4.3). Ibo's agricultural sector is predominantly female (Table 4.5, Figure 4.3), and each additional adult female in the household increases the odds ratio of farm ownership by a factor of 1.53 (Table 4.5). However, an increased number of females in the household is associated with a reduction in the crop diversity of the household farm (Table 4.5).

Educational attainment is negatively associated with both farming and crop diversity, although the relationship with crop diversity is not significant (Table 4.5). A peculiarity of the data collection design is likely responsible for the strong negative association between unknown educational attainment and farm ownership (Table 4.5):

since educational data were collected in 2009 (three years before the 2012 census), the data are only available for those individuals who were present on the island during both census waves. Lack of linkage with 2009 data could indicate that the individuals with unknown education levels had not lived in their homes long enough to establish farms or are uniquely mobile individuals who never establish farms. Therefore, it is likely the individuals' lack of presence in 2009—and not some characteristic associated with their educational attainment—that underlies the strong negative association with farming practices.

Index components

Since dietary diversity indices are based upon the sum of food types consumed (Drewnowski et al. 1997; Kant et al. 1993; Michels and Wolk 2002), the values do not differentiate between an individual who consumed, for example, dairy and cereals and another who consumed vegetables and tubers. To allow for a transparent understanding of the nutritional components represented by the numerical values, I have plotted the food types eaten by each child as a grid plot (Figure 4.1) and, by subsets of the population, as star plots (Figure 4.2). In a star plot depicting the traits of a population, each trait is given an axis radiating from the origin. If 100% of the population exhibit a trait, the star's point on that axis has a distance of 1 from the center; if 0% of the population exhibit the trait, there is no point on that axis because the distance from the center is equal to 0.

One third of children had dietary diversity values of 4, indicating that they had consumed foods from four of the ten categories in the previous 24 hours. The grid and star plots (Figures 4.1-4.2) elucidate the uniformity with which children of all dietary diversity levels consumed cereals, fats, and fish. These foods were consistently consumed even by higher dietary diversity children, demonstrating that additional food types augment—rather than substitute—the typical foods from the low-diversity diet. Nearly all low-DDI children consumed cereals prepared with fats and, in 56% of cases, fish; beyond this, foods from virtually no other categories had been consumed (Figures 4.1-4.2). It was effectively only the children with above-average dietary diversity (DDI > 4) who had consumed any fruits or vegetables the prior day. This visualization of dietary consumption data highlights avenues for improved dietary diversity among close to two thirds of Ibo's children, as their DDI values would improve with the regular consumption of produce, legumes, and/or animal products beyond fish.

Although education and DDI are strongly positively associated (Tables 4.2 and 4.4), there is no clear relationship between education and CDI among farming households (Table 4.5). A grid plot reveals interesting patterns pertaining to education that underlie the additive crop diversity index. By definition, farms with CDIs of 6 or greater—observed less commonly among highly educated households—grow all or nearly all surveyed crops, including fruit. Among households growing five or fewer crop types, however, crop composition varies meaningfully with education. In the subset of low- and mid-diversity farms, fruit is grown by only 10% of farming households with educational attainment of 5th grade or below, while it is grown by 33% of households with educational attainment of 6th grade or higher (Figure 4.4).

The strong relationship between household educational attainment and children's dietary diversity (Table 4.4) is driven by the positive association between years of education and the consumption of fruits, vegetables, and milk products (p=0.001, p=0.046, and p=0.032, respectively,[10] Figure 4.5). Since there is an inverse relationship between household education and farm ownership, many of the children in high-education households who reportedly ate fruits and vegetables in the previous 24 hours live in non-farming households (Figure 4.5).

Discussion

This paper provides evidence that household-level small-scale agricultural activities may impact nutritional behaviors and/or dietary access. The linkages between crop diversity, dietary diversity, and child heights in this community are consistent with the proposal that local, sustainable, biodiverse agriculture is a potential solution to undernutrition in developing communities (Blasbalg, Wispelwey, and Deckelbaum 2011). The lack of reliable markets in the Ibo community likely plays a key role in the household-level relationship between farming and dietary diversity. Whereas markets in other study communities can distribute crops across a foodshed, thus smoothing regional dietary consumption patterns (Remans et al. 2011), produce grown on Ibo appears to remain largely within the producing household.

The small magnitude of the relationship identified between crop diversity and dietary diversity (in which approximately six or seven crops grown are associated with six tenths more food types eaten) may be related to seasonality and the temporal scales of the survey questions, since DDI is 24-hour retrospective, while CDI reflects crops grown in the

[10] These p-values are the results of univariate logistic regressions (not shown) modeling children's consumption of each dietary component as a function of maximum years of educational attainment within the household, excluding those households with unknown educational attainment. Standard errors are clustered at the household level. No other dietary components were significantly associated with educational attainment at the $\alpha = 0.05$ level.

past year. The small size of a typical farm in this community could also play a role, since farming may not produce enough food to be reflected in a household's daily consumption. If a child eats vegetables once per week, for instance, the expected value of his DDI on any given day of data collection is only one seventh of a point higher than if he never ate vegetables at all. That the model identifies a significant relationship between crop diversity and diet, regardless of seasonality and consideration of farm size, demonstrates the great degree to which household production and diet operate in tandem in this community, either through production influencing diet or through adoption of diverse farming practices due to a preference for dietary diversity. In either case, the relationship is consistent with a theorized link between farming practices, nutritional practices, and good health.

Though significant, the magnitudes of the relationships between wealth, household education, and child outcomes are also modest in size. For instance, 12 additional years of education—the maximum possible spread in the population—are associated with two thirds of an additional food group consumed and Z-scores approximately one third of a point higher (Tables 4.1, 4.3, 4.4). An additional $2600 in assets (over three times more than average ownership levels) corresponds to one additional food group consumed (Table 4.1 and 4.4). These magnitudes demonstrate that in the Ibo community, wealth, education, and crop diversity are associated with improved child outcomes, but they are not the only routes through which above-average heights and dietary diversity are achieved.

On average, highly educated parents feed their children more diverse diets, but educational attainment is negatively associated with farm ownership, indicating that some educated households diversify their diets through market purchases rather than home production. However, data from highly educated farming households provide further support for the "eat what you grow" interpretation of this community's livelihood strategy. Educated farming households do not have above-average crop diversity indices (Table 4.5), but they do grow fruits—a food that is particularly difficult to consistently purchase in the community—at substantially higher rates than do their less educated peers with equally low-crop-diversity farms (Figure 4.4). The household grid plot reveals differences in underlying crop composition that were otherwise masked by the additive crop diversity index: educated households appear to use home production to meet the dietary demands that local markets cannot. In future studies employing additive dietary diversity indices, grid and star plots could surely provide a useful way to visualize patterns of the underlying components' compositions.

These data demonstrate the ability of household-level crop diversity and crop composition to meet a household's demand for dietary quality. However, crop specialization could also theoretically support dietary diversity if it allowed households to trade with a neighbor who specialized in a different crop. In that sense, these results are in support of a community's crop diversification, achieved either at the level of the household farm or the community in general. The results contribute to the growing call for metrics with which to monitor small-farmers' sales and barters in order to document the pathway from diverse production to diverse consumption. With such data, it will be better possible to discern the ability of small-farming practices to fill a gap between the quantity of fresh produce demanded and supplied in an isolated community.

Tables

	Mean [Std Dev]	Range	N
Age (years)	5.54 [2.25]	(2, 9)	887
Birth weight (kg)	2.92 [0.53]	(1, 4.5)	315
Education of HH head or parent (years)+	4.46 [3.25]	(0, 13)	504
Height-for-Age Z-score	-0.99 [1.10]	(-3, 3)	865
Household asset wealth (2012 USD)	$717 [$876]	($0, $4420)	887
# Household members	7.36 [3.26]	(2, 20)	887
Dietary Diversity Index	4.26 [1.41]	(0, 9)	886
Crop Diversity Index	1.43 [2.34]	(0, 7)	882
Stunted (%)	32.0%		865
Male (%)	47.4%		887

Table 4.1. Children's descriptive statistics. Mean, standard deviation, range, and number observations provided for all continuous variables pertaining to children in the population aged 2-9; percentage of individuals and number observations provided for categorical variables. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest).

	Ramadan *(excluded from analysis)*	Post-Eid *(excluded from analysis)*	Not Ramadan or Eid *(included in analysis)*	Total
Height-for-age Z-score	-1.00 [0.96]	-0.81 [1.19]	-0.99 [1.10]	-0.98 [1.10]
N	47	62	865	974
Sig (p < 0.05)	A	A	A	
Dietary Diversity Index	4.02 [0.95]	5.90 [1.81]	4.26 [1.41]	4.36 [1.48]
N	49	67	886	1002
Sig (p < 0.05)	B	A	B	

	No farm ownership (CDI=0)	Low crop diversity (0 < CDI < 6)	High crop diversity (CDI >= 6)	Total
Height-for-age Z-score	-0.96 [1.06]	-1.08 [1.19]	-0.96 [1.11]	-0.99 [1.10]
N	554	214	92	860
Sig (p < 0.05)	A	A	A	
Dietary Diversity Index	4.16 [1.38]	4.36 [1.32]	4.68 [1.62]	4.26 [1.40]
N	575	214	92	881
Sig (p < 0.05)	B	AB	A	

	Unknown household education[+]	No household education[+] (educ = 0 yrs)	Low household education[+] (0 < educ < 6 yrs)	High household education[+] (educ ≥ 6 yrs)	Total
Height-for-age Z-score	-1.15 [1.13]	-0.90 [1.13]	-0.86 [1.09]	-0.85 [1.01]	-0.99 [1.10]
N	371	91	228	175	865
Sig (p < 0.05)	B	AB	A	A	
Dietary Diversity Index	4.13 [1.34]	4.13 [1.14]	4.30 [1.38]	4.59 [1.64]	4.26 [1.41]
N	383	94	227	182	886
Sig (p < 0.05)	B	AB	AB	A	

Table 4.2. Children's mean height-for-age Z-scores and dietary diversity indices by crop diversity and household education. Mean, standard deviation, and number observations of children's height-for-age Z-scores and dietary diversity indices (DDIs), by household crop diversity index (CDI) and household education. [+]Household education reflects years of educational attainment by household head or parent who lives in the household (whichever is highest). Different letters indicate statistical differences ($p < 0.05$, Bonferroni method) within rows between column categories.

	Height-for-age Z-score (Model 1)							
Dietary diversity index (DDI)	0.081	**	0.061	‘				
Std error (robust)	0.029		0.032					
Low crop diversity index (CDI: 1 or 2)					0.052		0.035	
Std error (robust)					0.156		0.151	
Middle crop diversity index (CDI: 3, 4, or 5)					-0.214	‘	-0.193	
Std error (robust)					0.123		0.128	
High crop diversity index (CDI: 6 or 7)					-0.001		0.021	
Std error (robust)					0.130		0.126	
Constant	-1.327	***	-2.236	***	-0.955	***	-1.988	***
Std error (robust)	0.132		0.373		0.050		0.352	
Individual controls								
Age (years)			0.017				0.018	
Sex (Female=0, Male=1)			-0.049				-0.047	
Birth weight^			0.302	**			0.300	**
Household controls								
# Household members			-0.006				-0.004	
Education of HH head or parent (years)+			0.026	*			0.030	*
Household asset wealth (2012 USD, thousands)^			0.028				0.043	
N			864				860	

Table 4.3. Children's stunting, dietary diversity, and household crop diversity. OLS models of children's height-for-age Z-scores as a function of dietary diversity index (DDI) or crop diversity index (CDI); standard errors clustered at the household level (469 households). Crop diversity is divided into categories representing low, mid, and high diversity; baseline values are for non-farming households (CDI=0). ^Mean values imputed in case of missingness. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest); 0 value imputed in case of missingness. ‘ Indicates significance at the α=0.10 level; * indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

	Dietary Diversity Index (Model 2)			
Low crop diversity (CDI 1 or 2)	0.274		0.234	
Std error (robust)	0.244		0.258	
Middle crop diversity (CDI 3, 4, or 5)	0.174		0.324	‘
Std error (robust)	0.228		0.170	
High crop diversity (CDI 6 or 7)	0.474	‘	0.613	*
Std error (robust)	0.274		0.270	
Constant	4.157	***	3.486	***
Std error (robust)	0.087		0.258	
Individual controls				
Age (years)			0.030	
Sex (Female=0, Male=1)			-0.017	
Household controls				
# Household members			-0.045	‘
Education of HH head or parent (years)+			0.098	***
Household asset wealth (2012 USD, thousands) ^			0.388	***
N			881	

Table 4.4. Crop and children's dietary diversity. OLS models of children's dietary diversity index (DDI) as a function of household crop diversity index (CDI); standard errors clustered at the household level (473 households). Crop diversity is divided into categories representing low, mid, and high diversity; baseline values are for non-farming households (CDI=0). +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest); 0 value imputed in case of missingness. ^Mean value imputed in case of missingness. Asset wealth in thousands of 2012 USD. ‘ Indicates significance at the α=0.10 level; * indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

	Farm ownership (Model 3) *Odds ratios*		CDI among farming HHs (Model 4)	
# Adult females	1.526	***	-0.332	*
Std error	0.152		0.137	
# Adult males	1.164		0.163	
Std error	0.110		0.133	
Years of education (HH maximum) +	0.919	**	-0.050	
Std error	0.029		0.045	
Education unknown (0 = false, 1 = true)	0.221	***	-0.628	‘
Std error	0.059		0.377	
Household asset wealth (2012 USD, thousands) ^	0.956		-0.022	
Std error	0.090		0.143	
% HH employment in farming			0.002	
Std error			0.003	
Constant	0.450	***	4.868	***
Std error	0.111		0.390	
N	872		243	

Table 4.5. Demographics of farm ownership and crop diversity (Models 3 and 4). Logit model of household farm ownership as a function of household characteristics (column 1) and OLS model of farm CDI as a function of household characteristics, given farm ownership (column 2). + 0 value imputed in case of missingness. ^ Mean value imputed in case of missingness. ‘ Indicates significance at the α=0.10 level; * indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

Figures

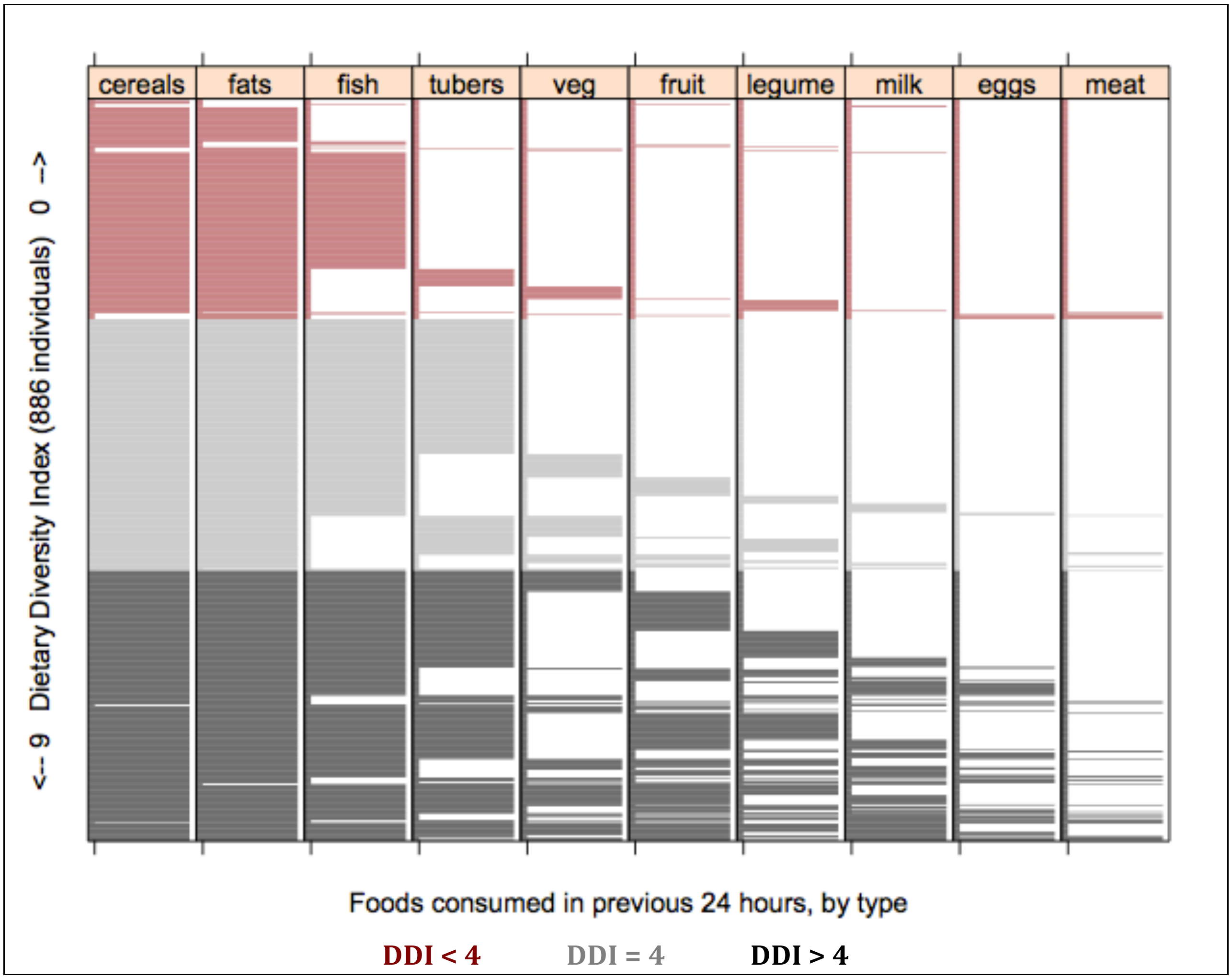

Figure 4.1. Grid plot depicting individuals' dietary composition by Dietary Diversity Index (DDI). Plot contains one row for each of 886 children, sorted by DDI. Foods consumed are represented with long bars of filled color.

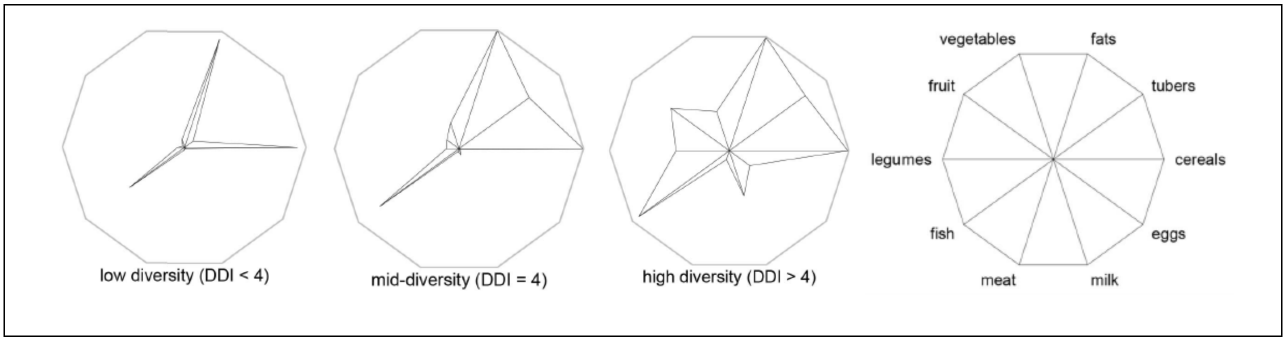

Figure 4.2. Star plots depicting dietary composition by Dietary Diversity Index (DDI). Each plot represents a subset of the population (DDI less than 4 [N=263], equal to 4 [N=300], or greater than 4 [N=323]). Within each subset, if 100% of children consumed the food type, the radius on that axis has a length of 1. If 0% of children consumed the food type, the radius on that axis has a length of 0.

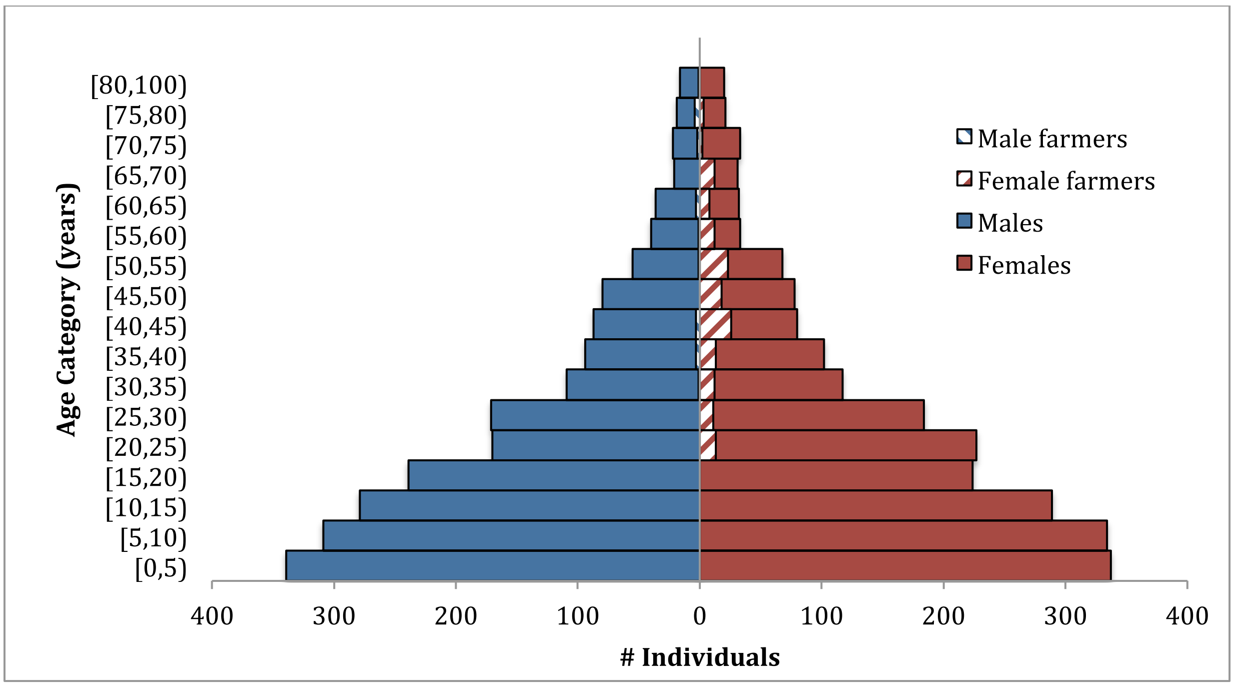

Figure 4.3. Population pyramid: the composition of Ibo's farmers. In 2012, Ibo Island had 4296 residents (48.6% male, 51.4% female). Farming is the second most common profession on the island, with 172 respondents (19 males, 153 females) identifying farming as their primary occupation. The most common occupation on the island is fishing (408 individuals: 272 males, 136 females). 147 individuals are employed in informal commerce (e.g. bread, dried fish), making it the third most common occupation on the island.

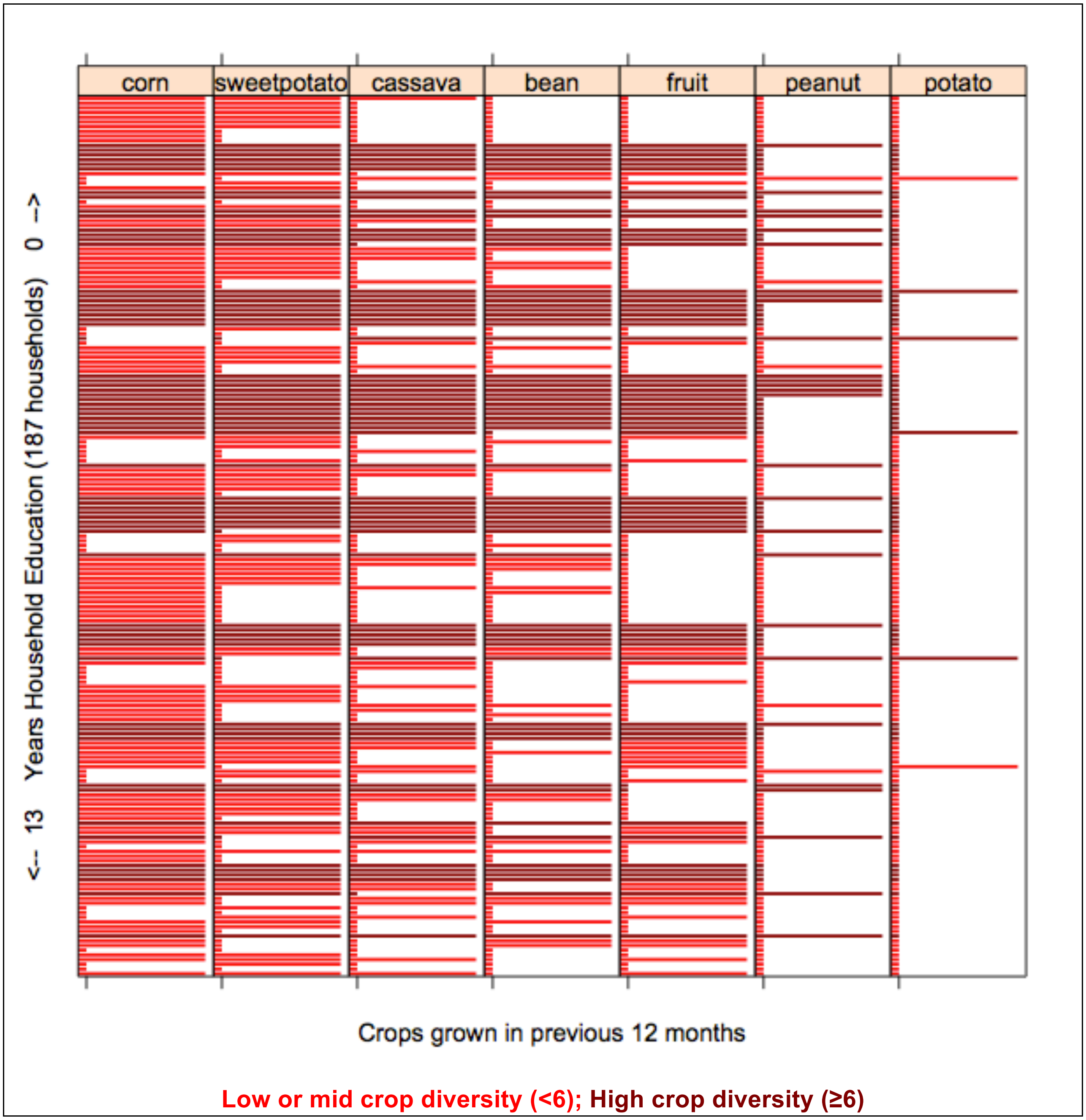

Figure 4.4. Grid plot depicting crop composition by household educational attainment. Plot contains one row for each of 187 households with known educational attainment, sorted by each household's maximum years of education. Crops grown are represented with long colored bars. Bright red shading identifies households who grow fewer than six of the surveyed crops; dark red shading identifies households who grow six or more of the surveyed crops. Crop diversity is negatively associated with educational attainment. Among low- or mid-diversity farms, fruit was grown in 10% of households with low educational attainment and in 33% of households with high education.

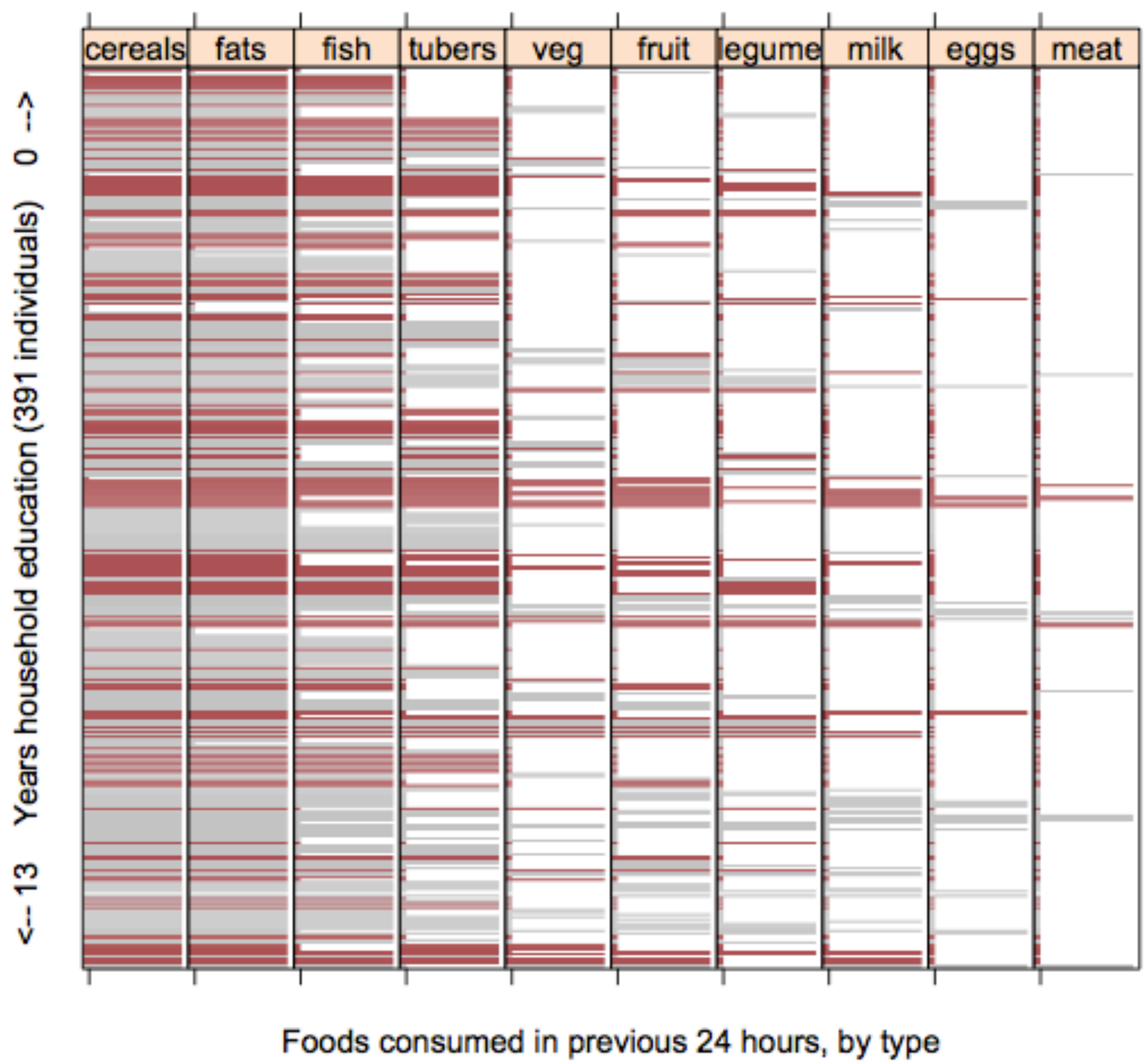

Figure 4.5. Grid plot depicting dietary composition by household educational attainment and farm ownership. Plot contains one row for each of 391 children with known household-level educational attainment, sorted by maximum years of education. Foods grown are represented with long colored bars. Gray shading identifies children in non-farming households; dark red shading identifies children in farming households. Dietary diversity is strongly positively associated with household educational attainment. The association is driven by significantly higher rates of consumption of vegetables, fruits, and milk.

THE FATHER'S ROLE IN HIS CHILDREN'S SCHOOL PARTICIPATION

ABSTRACT. Father absence from the household is expected to reduce paternal investments in children. Do other household members fill that gap? This paper uses longitudinal data to investigate absence of the biological father and children's educational participation on Ibo Island, Mozambique, where only 34.0% of school-aged children live with their biological fathers. Results demonstrate a strong relationship between schooling and father presence, with educational participation rates over 10% higher for children who live with their fathers. Dropout rates were over a third higher (14.3%) for children whose fathers left the home between survey waves than for children whose fathers remained in the home (10.4% dropout rate). Father departure was associated with greater dropout rates among adolescents than younger children, perhaps due to perceptions that returns to education would increase over time due to the community's rapid economic development. Economic development trends may also explain higher rates of educational participation among females, even within households. A fixed effects model identified higher educational participation among individuals who lived with their biological fathers than for housemates (step siblings, half siblings, etc.) whose fathers were absent. The results provide support for family structure theory (in which the structure of a traditional two-parent household promotes positive outcomes) and kin selection theory (in which familial altruism is driven by genetic relatedness).

Introduction

Parents make monetary and time-based investments in their children's education for a wide range of reasons, including altruism, old age security, and the evolutionary drive to protect one's genetic offspring. While most parents sharing a household with their children will derive utility from them, a non-resident parent may not, depending on the circumstance of the absence. Absent parents may feel reduced altruism to their children as a result of reduced interactions, reduced expectations of old age support, or a closer relationship with children in a new household (Cox 2007). Any of these drivers could result in reduced investments in children whose fathers are absent from the home.

Investments in child quality may be interpreted as acts of familial altruism driven by genetic closeness to one's relatives in accordance with kin selection theory (Hamilton, Cheng, and Powell 2007). According to Hamilton's rule, the altruism we show to our offspring and other family members is dictated by our degree of relatedness to the individuals because, from a standpoint of evolutionary survival, we are driven to protect our own genes. We would therefore expect to see, under the most basic assumptions, twice as much altruism towards a daughter, who shares half of an individual's genes, as towards a niece, who shares only a quarter of an individual's genes (Cox 2007). According to this rule, a biological father (even a non-resident biological father) would be driven to make more investments in his children than would a stepfather, who shares no genes with his wife's offspring (Hamilton, Cheng, and Powell 2007). While a mother of half-siblings would, all things being equal, like to invest in her biological children equally regardless of paternity, she may lack the bargaining power in her present relationship to heavily invest in those of her children whose fathers are deceased or divorced (Akashi-Ronquest 2009).

Family structure theory, too, predicts higher levels of investment in children of two-biological-parent households, but the discrepancy is caused by the stressors facing alternative families, such as ambiguous resource allocation roles for stepparents or nonresident biological parents (Hamilton, Cheng, and Powell 2007). In an African setting in which fostering, marital separation, and remarriage to new partners are common, it is conceivable that the long history of "alternative" households has eliminated this role ambiguity, causing the family structure theory predictions to be contextually irrelevant. Even where non-parental childrearing is commonplace, however, role ambiguity and the associated feeling that resource allocation is not one's own responsibility may persist in contributing to reduced investments in non-biological children, such the low hospital admission rates observed among ill fostered children in Sierra Leone (Bledsoe, Ewbank, and Isiugo-Abanihe 1988). It is also possible that low investments in children in non-traditional households are defined unambiguously within the community. If the father is seen as responsible for contributing to food production or overall communal productivity, community norms could dictate low investments in children whose fathers are not available to participate and cooperate (Hill 2002; Hrdy 2009).

In contrast to kin selection theory, some postulate that nepotism is driven not by shared genes but by prospective reciprocated altruism and the payoffs resulting from familial cooperation. Under these conditions, an individual with a close proximity to or a strong, familiar relationship with his stepchildren derives utility from investments in their quality, since they, like his biological offspring, are potential providers of old-age support and security against risk (Allen-Arave, Gurven, and Hill 2008). Likewise, the same elements of a close relationship (e.g. proximity, familiarity, and trust) associated with prospective reverse altruism from child to elder could also lead an individual to feel purely altruistic to the children around him.

While these theories are supported by data in which fathers in New Mexico invested more in the children of their current than previous mates (Anderson, Kaplan, and Lancaster 1999), the trend is likely to depend upon local sociocultural norms and individual characteristics of relationships between fathers and children, since a biological or stepfather present in the household may or may not have a close relationship with the children, and a non-resident father may or may not maintain high levels of interaction with his estranged family members. Father absence has many causes (e.g. death, divorce, or labor migration) with varying implications for paternal relationship and investment. For instance, research from Mexico identified more social and financial interaction with children by fathers who were absent due to migration than divorce (Nobles 2011).

Predicting similar patterns of investment but through a different mechanism, we may feel strong ties to the children with whom we have close contact because human physiology adapted to meet the challenges faced by hunter-gatherers, who were surrounded by children in their own kinship networks (Buss 2005) and who relied on the rewards or reciprocal generosity resulting from pro-social, cooperative acts within their communities (Hrdy 2009). Consequently, we are altruistic to non-relative neighbors and feel physiological ties to children in close proximity, even when they are not our biological relatives (Buss 2005; Hamilton, Cheng, and Powell 2007).

When parents do not invest disproportionately more in biological than non-biological children, the behavior suggests that we are bonded to the children with whom we have frequent contact or strong relationships regardless of genetic ties. Domestically, researchers have investigated this theory by considering outcomes for children in adoptive and same-sex households. Average or above-average financial investments in adopted children are observed both across (Hamilton, Cheng, and Powell 2007) and within households (Gibson 2009), and in an investigation of grade level for age, in which normal progression through primary school may be interpreted as an indicator of parental investments in the form of time (e.g. helping with homework) or money (e.g. tutoring), no difference was identified in outcomes for children in same-sex cohabitating households than in heterosexual married households (Rosenfeld 2010), despite children in the former group being biologically related to a maximum of one of their homosexual caretakers.[11]

In this paper, I aim to address the applicability of the aforementioned topics (i.e. bioevolutionary demographic theory, the treatment of non-biological children in the household, and the effect of immigration on left-behind children) in the African context by taking advantage of educational enrollment data from a community with high rates of divorce, widowhood, separation, and remarriage. Children who do not live with their biological fathers are expected to experience reduced educational investments because their fathers are not present to advocate for them when the household makes financial decisions; however, the level of household investments is hypothesized to vary meaningfully with the cause of paternal absence. I explore the relationship between absence and investment in rural Mozambique, using panel data to compare trends in educational participation for children who experience a father absence event (due to separation, mortality, or migration) with those whose biological fathers remain in the household over time. Throughout this paper, I will use the term "father" to signify a child's biological father; other types of fathers (e.g. stepfathers, adoptive fathers) will be called by their specific roles.

Above-average rates of disruptions in educational participation are expected for children who experience the death of a father between survey waves. A father's migration event, however, is anticipated to have a less predictable relationship with investments in his children. While a father who moves within a community may maintain his school

[11] A child could be related to both his homosexual caretakers in the case of a consanguineous homosexual partnership.

payments due to continued contact with and altruistic feelings toward his child, a father who leaves the community in search of improved economic opportunities may send remittances that benefit the children he left behind. The data do not allow for interpretation of whether the father has remarried or whether his move is temporary in nature. However, the data do provide insight into conditions surrounding the nature of the move by distinguishing between absent "non-provider" fathers, who are not identified in the survey as a child's primary provider, and absent "provider" fathers, who continue to be the primary provider for a child, presumably through remittances or—if they remain in the Ibo community—through some other method of child support. Even then, interpretation is challenging, since it is unclear whether an absent provider father's remittances are the result of labor migration undergone to support the household or permanent spousal separation but continued connection to the child.

It is possible that longitudinal data monitoring the dropout behavior of children over time does not fully capture the effect of father departure event. A father who died between 2009 and 2012 may have already been sick during the first survey wave, and a couple who separated between survey waves may already have been having problems in 2009. According to this reasoning, the 2009 school enrollment rates may already be low for children whose fathers are about to leave the home, and the longitudinal models will underestimate the role of the father in a child's school enrollment. Likewise, it is possible that a characteristic other than father departure, such as financial hardship, led to both the father departure and the child's withdraw from school, making causal interpretations inappropriate. Although I am unable to control for all possible avenues of endogeneity and reverse causality in the data, I investigate the degree to which select conditions in 2009—

father presence, child's school enrollment, and household asset wealth—predict subsequent father absence.

As an alternative approach, I use intra-household fixed effects to compare educational participation rates for co-resident children (e.g. stepsiblings, half-siblings, cousins, or unrelated children) who experience differences in paternal presence within the home. The fixed effects model controls for household-level unobservable characteristics, taking advantage of the population's high rates of remarriage and fertility outcomes from multiple men per woman. Educational participation outcomes are compared with those of children who are presumably exposed to the same household-level constraints, differing only in individual-level characteristics such as age, sex, and paternal presence.

Data

The data for this project are drawn from Ibo Island in northern Mozambique, where approximately 76% of school-aged children (defined here as ages 6-17) were identified as "students" in 2012 (Table 5.1).

In 2009, the Ibo Foundation, a non-governmental philanthropic organization, 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. For each child (aged 0-9 years) and adolescent (aged 10-17 years), data were collected to identify the location of the child's mother and father. Children's current educational participation was recorded, as was their highest level of educational attainment. Censuses were conducted in Kimwani or Portuguese by trained enumerators in respondents' homes.

In 2012, the Ibo Foundation gave me access to their 2009 data instrument, which I used to design a second-round data collection instrument with which I retrospectively linked individuals and households with their prior responses. In addition to collecting information regarding the location of the father and mother, I also recorded the location of each individual's principal financial provider.

In order to track intra- and extra-community migration movements between the data collection waves, I populated a form for each household with the 2009 Household Composition data. Individuals who were identified as no longer living in the home were classified as having died or moved, and those who had moved were coded by type of move (intra-island or outmigration). New household members who had entered the home since 2009 were classified as having moved or been born, and those who had moved were coded by type of move. To allow for the possibility of inaccuracy and uncertainty, we also allowed enumerators to identify "2009 census error" and "unknown" destinations of former residents.

For each new individual, we collected full name, birthdate, and gender. Because birthdates are not well known within the population, we requested to see health record cards (presented for 38.1% of children). When I was unable to match an individual retrospectively with his previous residence, I assigned him or her a new ID. Because names and birthdates are inconsistently reported in the study population, linking individuals is challenging. I erred on the side of caution when performing the retrospective links of internal migrants, preferring to fail to link a person to his possible self rather than to incorrectly link him to a person of similar name and age. Five individuals whose reported ages increased by less than one year or more than five years during the three-year period between census waves were dropped from analysis due to concerns that the linked child was actually two different people.

In total, 104 school-aged children and adolescents who moved were linked with their previous IDs. This value represents 58.8% of 2009 individuals who were identified as having moved to a different home within the island and 33.3% of 2012 individuals who were identified as having arrived from a different home within the island. I attribute the discrepancy in rates to more exhaustive enumeration efforts in the second census wave, leading to fewer skipped individuals. Taking into account the linkage of those individuals who did not move between the waves, it was possible to link 88.2% of the children who were school-aged during the 2009 survey with their 2012 values (excluding those who emigrated, died, or had an unknown outcome between 2009 and 2012).

Since formal education was largely unavailable to the Ibo population prior to colonial independence in the 1970s, educational attainment of the household head is constrained by the household head's age. In other words, if I were to control for educational attainment of the household head, many multi-generational households would receive values of 0, despite there being educated individuals in the household. Since I expect that the educational attainment of a parent—not necessarily the child's oldest live-at-home relative—can influence educational investments in a child, I created an educational attainment control for each child's live-at-home parent or household head, whichever value was highest. Adults' educational attainment data were collected only in 2009, so 2012 values were based upon 2009 data from household members who were linked between survey waves.

In 2009 and 2012, asset ownership data were collected relating to ownership of 13 assets, goats, and poultry. A value-based asset index was created for each household based upon the estimated values of each asset type in 2012 USD (Table 3.1). Household asset ownership increased dramatically between census waves, with maximum observed values of $3738 and $4519 in 2009 and 2012, respectively (Table 5.1).

The outcome variables in this investigation are school-aged individuals' 2009 and 2012 educational participation (currently "enrolled" in school or "not enrolled"). For cross-sectional analyses, "school-aged" was defined as being 6-17 years of age; I selected six as the lower age bound because of the dramatic increase in enrollment rates between ages five and six (from 29.4% to 67.3% in 2009, Table 5.3). The upper bound of 18 years was chosen to represent adulthood and, potentially, less reliance on parental investments.

Ibo offers education through the 10th grade, after which individuals who continue their studies must move to Pemba or Mocimboa da Praia on the Mozambican mainland, situated eight-plus hours away by boat and road. Since the most educated members of the population move away—temporarily or permanently—to pursue more education, the individuals who remain on Ibo represent a less educated subset of the population. Therefore, cross-sectional investigations of educational enrollment by age (Table 5.3, Figure 5.1) may give the impression of students dropping out of school in their late teens, when they have actually self-selected out of the population in order to continue their studies. In 2009, only 4.3% of 16- and 17-year-olds were enrolled in 10th grade, demonstrating that individuals rarely advance past tenth grade before age 18 (Table 5.3).

Few adolescents (not more than ten individuals[12] of more than 100 adolescents aged 16 or 17) leave Ibo each year to continue their studies, so their absence from the dataset is not expected to substantially influence the results of this analysis.

To capture dropout events, only children enrolled in school in 2009 are included in the longitudinal model; here, I widen the lower age bound to five years (including children aged 5-15 and 7-17 years during the first and second waves of data collection, respectively) to increase the number of observations. While low rates of school participation motivated the exclusion of 5-year-olds from cross-sectional models, timing of school entry is less important in the longitudinal model, since observations are constrained to children who were already enrolled in school during the first data collection wave. Advanced students who left Ibo in their late teens to continue their studies are not included in longitudinal models because they were not Ibo residents during the second census wave. However, the impact of the data's inability to capture educational investments for this subset of students is expected to be minimal, due to the low frequency of educational migration during adolescence.[13]

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[12] In total, 25 children under 16 years of age were enrolled in 8th grade or higher in 2009 (Table 5.3), indicating that they may have been eligible for adolescent-aged educational emigration from Ibo before the 2012 census. Of these 25 individuals, in 2012: 20% were adolescents enrolled in school on Ibo (N=5); 32% were Ibo adults of unknown educational enrollment status (N=8); 40% had left Ibo, possibly to continue their education elsewhere in the Cabo Delgado district (N=10); and 8% had unknown location or were unlinked with their previous data after an intra-island move (N=2).

[13] As discussed in the ***Methods*** below, only children and adolescents who were enrolled in school in 2009 and who lived with their fathers in 2009 are included in the longitudinal analysis of father departure impacts. Of the ten students who may have left Ibo as adolescents to further their studies between census waves, only three would have been eligible for inclusion in the longitudinal model based on their 2009 father presence status. Failure to capture the changes in educational investments of these individuals decreases the N by only 1.2%, from 238 to 235 individuals.

Missing data

Children and adolescents of unknown age (61 and 39 individuals in 2009 and 2012, respectively) are dropped from analysis. For households with unknown asset information, the missing value for each asset is replaced with the community-wide average rate of asset ownership (i.e. since 28.9% of households reportedly own armoires, 0=does not own an armoire, 1=owns an armoire, and 0.289=household is missing armoire information). In models controlling for education of the live-at-home parent or household head, I replaced missing values with 0 because educational outcome variables for children and adolescents with missing household education data were most similar to those from no-education households (data not shown).

Methods

In this paper, I analyze educational participation and father absence status cross-sectionally and over time. The island's high rates of divorce, mortality, and remarriage provide the opportunity to investigate within- and across-household differences for children with differing classifications of absent fathers. The longitudinal data allow for the observation of changes in individuals' educational participation and father presence over time.

Predictors of father presence

To determine the degree to which father departure events can be predicted by prior individual- and household-level conditions (such as the possibility that fathers with underperforming children may be more likely to leave), I use logistic regression to relate father presence in 2012 to father presence in 2009, individual's educational enrollment in 2009, household-level asset wealth in 2009, and father's years of educational attainment. The model uses data from both census waves (individuals aged 5-15 years in 2009 and 7-17 years in 2012). Since the analysis of characteristics predicting father departure is longitudinal in nature, only those individuals who were observed in both census waves are included.

Models

I use three models to evaluate the relationship between father presence and current or subsequent educational outcomes. Model 1 uses logistic regression to relate cross-sectional educational enrollment to father presence. Using data from both census waves, the model incorporates a 2012 year dummy, individual-level controls (mother presence, age dummies, and sex), and three household-level controls (number of household members, education of the household head or at-home parent, and value-based asset ownership score). Standard errors are clustered at the household level.

Model 2 uses logistic regression to investigate the impact of father departure as a shock on a child's educational enrollment by modeling school enrollment longitudinally over time. To capture the influence of a father departure on dropout behavior, only children who were enrolled in school and living with their fathers in 2009 are considered. The model incorporates individual-level controls (2012 mother presence, 2012 age dummy, and sex) and three household-level controls (2012 number of household members, education of the household head or at-home parent, and 2012 value-based asset ownership score). Standard errors are clustered at the household level.

Model 3 uses fixed effects to investigate differences in school enrollment status between cohabitating children who are experiencing different father absence statuses during a single census year. Data are pooled from 2009 and 2012, with a year*father interaction term to determine whether the relationship between father presence and school enrollment changed over time.

Results

Descriptive results

In both census years, the mean household size for school-aged children and adolescents was approximately seven individuals per household (Table 5.1). Mother absence was common (rates of 40.1% and 45.8% in 2009 and 2012, respectively) but less common than father absence (62.9% and 66.0% in 2009 and 2012, Table 5.1). Despite their high rates of absence, biological fathers were the most frequently identified source of financial provision, supporting 39.3% of school-aged children and adolescents in 2012 (Table 5.1).

Over half of households contained at least one school-aged individual in each census year (Table 5.2). Among those households with two or more school-aged individuals, relatively high heterogeneity was observed in children's father presence status and educational participation. More than one in four households contained school-aged individuals with different father presence statuses (i.e. one or more child whose father lives in the home and one or more child whose father does not live in the home, Table 5.2) or different educational enrollment statuses (i.e. one or more child who is enrolled in school and one or more child who is not enrolled in school, Table 5.2). School enrollment rates were somewhat higher for girls than boys, particularly among young children (Figure 5.1).

Educational enrollment dropped by 6.3 percentage points between 2009 and 2012 (Table 5.1, p=0.001, regression not shown), but the difference was not significant once individuals' characteristics—including sex, age, and parental presence—were controlled for (Table 5.4). Likewise, rates of parental absence were higher in 2012 than in 2009 (a difference of 3.1 percentage points for fathers and 5.7 percentage points for mothers, Table 5.1), but the changes over time were not significant (p=0.126 and p=0.068 for fathers and mothers, respectively, data not shown).

Predictors of father absence

Father presence in 2012 did not vary meaningfully with a child's prior educational enrollment, the household's prior asset wealth, or the father's educational attainment (Table 5.5). Not surprisingly, 2012 father presence was strongly associated with 2009 father presence (Table 5.5), confirming that death, divorce, and probably some labor migration movements are permanent in nature. Father migration events are surely reactions to unobserved characteristics of the individual and the household. However, these results confirm that low educational participation, household asset wealth, and father's education are not strong predictors of subsequent paternal absence due to migration or death.

Model 1: Cross-sectional relationship between father presence and education

In both census waves, father presence in the home was a strong predictor of a child's educational enrollment, although the relationship between the two variables was lower in 2012 (Table 5.4). School-aged children's enrollment was higher by 12.7% and 10.7% in 2009 and 2012, respectively, when the father lived at home than when fathers were absent, corresponding with an increase of 2.1 in the log odds of enrollment (Tables 5.4 and 5.6). The strong positive association between father presence and school enrollment remained even after controlling for other significant characteristics including age, sex, household educational attainment, and household asset wealth. Unlike father presence, the presence of one's mother in the home was not related to school enrollment, and there was no significant interaction between father and mother presence (Table 5.4).

Model 2: Longitudinal relationship between father departure and dropping out

School dropout rates were about one-third higher for children whose fathers left between census waves (14.3%) than for those whose fathers remained in the home (10.4%,Table 5.6), but the relationship in the univariate specification of Model 2 was not significant (Table 5.7, p=0.587). Meaningful relationships emerge within the classifications of father absence, such as dropout rates nearly twice as high for children whose fathers died between survey waves (22.2%) as for those whose fathers moved away (12.1%, Table 5.6). Among children whose fathers moved away, dropping out was more common if the children or adolescents continued to count on their fathers as their principal financial providers (15.4%) than if they had a different provider (10.0%, Table 5.6). However, these differences were not significant (data not shown).

While dropout rates were uniform across age groups for children whose fathers remained in the home (10.3% for children aged 7-10 years in 2012 vs. 10.4% for children aged 11-17 years, Table 5.6), father departure had a much more disruptive effect upon educational enrollment for individuals older than 10 years of age. In fact, when an interaction term between father departure and child's age group was added to the model, the relationship between father departure and dropping out of school was strongly negative for the baseline group of children aged 7-10 years ($p<0.001$), reducing the dropout probability to 0, while it was strongly positive for adolescents aged 11-17 ($p<0.001$, Table 5.7), with dropout rates of 16.7% (Table 5.6). It is worth noting, however, that the associated sample sizes are very small (10 school-aged children and 32 adolescents). Had a single dropout event been observed for a child whose father left the home, the difference in dropout rates would not be nearly as dramatic. Therefore, the high significance and large magnitude of these coefficients should be interpreted cautiously.

High educational attainment of one's at-home parents or household head was a strong positive predictor of school enrollment (Table 5.4) and of remaining in school over time (Table 5.7). Although household-level asset wealth was positively associated with school enrollment in the cross-sectional models (Table 5.4), it exhibited little relationship with enrollment behavior over time (Table 5.7) and therefore does not appear to serve as a buffer against dropping out of school.

Model 3: Intra-household relationship between father presence and school enrollment

This intra-household comparison of schooling as a function of parental presence determines whether educational participation rates are significantly higher for school-aged individuals who live at home with a parent than for school-aged individuals within the same home—perhaps step siblings, half siblings, cousins, or unrelated individuals—whose parent does not live in the same home. Given the population's high frequency of divorce, separation, spousal mortality, and remarriage and the regularity with which children are raised by aunts, uncles, cousins, and grandparents, intra-household variation in parental status is common (observed in 75 and 106 households in 2009 and 2012, respectively, Table 5.2). Of the 665 households with two or more school-aged individuals, 218 contained individuals with differing educational enrollment statuses and were therefore included in the household fixed effects model (Table 5.2).

In the univariate model, no relationship was identified between educational participation and differing father presence among school-aged individuals in the same home and census year (p=0.078, Table 5.8). There was also no relationship between educational participation and differing mother presence (p=0.081, Table 5.8). However, once individual-level controls were added to the model, intra-household differences in father presence were meaningful predictors of educational enrollment, with significantly higher educational participation among children whose fathers lived in the home than their housemates whose mothers did not (Table 5.8). Sex of the child or adolescent was a major predictor of educational enrollment, with close to a 50% reduction in the log odds of enrollment if the school-aged individual was male in comparison with the females with whom he shared a household. The interaction term between father and mother presence is negative (although not significantly so), indicating that presence of one biological parent reduces the importance of the other parent's presence. In total, the results of Model 3 demonstrate that, for children in households that are making unequal investments in their school-aged children, it is strongly advantageous to live with one's biological father.

Discussion

As economic development continues to occur throughout Mozambique, returns to education are likely to increase. Between 2009 and 2012 alone, the number of Ibo Island households participating in the tourism or NGO sectors increased by 476% (Table 3.3). Unlike more traditional livelihood sectors (e.g. fishing, agriculture), which do not require formal education, emerging jobs across the region require verbal—if not written—knowledge of the Portuguese language. The longitudinal nature of this dataset provides an exciting opportunity to observe both population-wide and individual-level educational participation trends over time.

Somewhat surprisingly, educational enrollment rates on Ibo went down during the three-year period of observation. With only two waves of data collection, it is difficult to discern whether the observed declines in parental presence and educational participation (Table 5.1) represent a trend (in which parental absence is becoming increasingly common, while educational participation becomes rarer), improved data collection techniques in 2012 (which would have resulted in better inclusion of all individuals in the dataset), or an influx of immigrants who had below-average education and parental presence characteristics.

Further investigation provides evidence in support of the second and third explanations for the observed declines. Among school-aged individuals who were linked between survey waves, rates of school participation dropped marginally and insignificantly over time (from 83.6% in 2009 to 81.4% in 2012, p=0.269, analysis not shown). However, among individuals who reported having moved within Ibo but were unlinked between survey waves, school participation is observed to have dropped dramatically over time (from 81.1% in 2009 to 67.4% in 2012, p<0.001, analysis not shown). There are two potential explanations for these unlinked internal migrants: either the child actually immigrated from elsewhere (providing evidence in support of immigration as a driver of declining educational rates), or the child was skipped in one of the survey waves (providing evidence in support of more exhaustive enumeration as a driver of the declines).

Educational enrollment rates in 2012 were substantially lower for individuals who moved to Ibo between census waves than for those who were identified as having lived there since 2009 (66.9% vs. 78.2%, p<0.001, analysis not shown). Similarly, rates of 2012 father presence were over 50% lower for immigrants than non-migrants (16.5% father presence for children who moved to Ibo between census waves vs. 36.7% for children who remained on the island, p<0.001, analysis not shown). Rather than representing a decline in educational participation in recent years, the decreasing cross-sectional rates appear to represent some combination of more exhaustive enumeration techniques and a change in community composition, with a different type of children and adolescents—those with below-average educational participation and paternal presence—entering the population over time.

This paper's results are largely aligned with kin selection theory, in which a child raised by his biological parents is shown more altruism than a child raised by more distant relatives or non-relatives, and family structure theory, in which higher investments are observed among children who live with their biological parents because they do not face the stressors of alternative families. The results are largely counter to theories predicting pure altruism or prospective reciprocated altruism resulting from scenarios of familial cooperation because a discernable pattern between parental presence and educational investments is observed. The cross-sectional models (Model 1 and 3), for instance, identify a strong significant relationships between father presence and educational participation during both census waves (Table 5.4, Table 5.8), indicating that biological fathers in the home appear to dictate educational investments in their children above what other relatives or non-relatives would have invested in the children in the fathers' absence. In households in which men live with both biological and non-biological children, the fathers appear to invest disproportionately in their own biological children.

In other respects, kin selection theory is less well supported by the results. Under Hamilton's Rule, we would expect—all other things equal—to observe comparable investments in one's biological children regardless of a father's proximity. In this population, however, children whose fathers continue to serve as their principal providers after leaving the home drop out from school at rates approximately 50% higher than their peers whose fathers remain in the home (Table 5.6), although the number of observations is small (N=13 children whose fathers support the household after moving), and the difference is not significant (p=0.654, analysis not shown).

It is also possible that the high rates of dropout behavior among children left behind by remittance-sending fathers is driven not by the inadequacy of the remittances but by the psychological stress of having an absent father. Similarly, low educational participation rates among children who do not live with their fathers could be the result of a dropout event resulting from the shock of a household disruption, after which they did not re-enroll.

That possibility limits interpretation of the cross-sectional results, making the educational outcome look like the result of current living conditions when it is actually the result of a previous, one-time shock.

The longitudinal model uses individual fixed effects to control for this possibility, examining only children who lived with their fathers and were enrolled in school during the first census wave. Although the analysis of dropping out and father departure did not yield significant results (Table 5.5), the direction and magnitude of the relationship—with school dropout rates over a third higher among children whose fathers left home during the preceding three years (Table 5.6)—serves to explain at least some aspects of the observed cross-sectional patterns. Since a father departure event is associated with reduced educational investments in his children over time, it logically follows that children who do not live with their fathers will have lower rates of school enrollment, having likely experienced a father departure shock at a prior point in their lifetimes.

Other explanations for the cross-sectional relationship between father presence and educational participation also exist, however, relating mainly to the endogeneity of the variables. Although reverse causality is possible (e.g. a difficult child—as evidenced by his lack of ability to succeed in school—drives his father to leave the home), the existence of unobserved conditions impacting both educational participation and father presence seems to be a more plausible driver of the observed patterns.[14] Financial hardship, for example, could lead to both father absence and low educational investments if father migration or mortality rates are higher among the poor. An investigation of father presence

[14] In a future version of this chapter, I will explore the possibility of using excluded predictors of father's departure as instruments in a "Heckit" approach.

in 2012 as a function of child's educational enrollment and household asset wealth in 2009 did not identify any significant relationship between these variables (Table 5.5), but it is conceivable that educational enrollment is not a good reflection of a child's ability to impact father presence, and household asset wealth does not capture the aspects of poverty that impact mortality rates and migration decisions. In this sense, the results of the investigation are limited in their ability to demonstrate the degree to which father absence or departure directly impacts educational investments. Father absence may therefore be a reflection—rather than a cause—of conditions associated with low school participation. A fixed effects model can control for those conditions that remained fixed over time (e.g. poverty, a lack of emotional attachment to a child) but not for time-variant conditions (e.g. the loss of a job, a changing relationship with a child after a father marries a new wife).

While being 11 or more years old was not associated with low rates of school enrollment (Table 5.4), it was strongly associated with high likelihood of dropping out of school when the individual experienced a father departure event (Table 5.5 and 5.6). Younger children tended to remain in school when their fathers left the home, while adolescents whose fathers left the home withdrew from school at above-average rates. One plausible explanation for this trend is that when a father leaves the home, adolescents are tasked with entering the labor force in order to contribute financially to their households. However, an investigation of the employment statuses of the six adolescents who dropped out of school when their fathers left due to migration or mortality (Table 5.6) indicated that all six of them were "dependents" in 2012 (data not shown) and had not entered the workforce. Sample sizes of school dropout and father departure events are too small to reject the possibility that the workforce is a draw to Mozambican adolescents whose fathers leave home, but in the Ibo Island population in this study's time frame, this scenario was not observed. Rather, these adolescents appear to have dropped out for other, unknown reasons (e.g. lack of school fees, psychological stress of a father departure event).

Another explanation for the above-average dropout rates of older students who experience a father departure shock relates to the community's economic development, in which literacy and language skills may contribute to an individual's ability to participate in the lucrative emerging job sectors of tourism and non-profit foundations. With higher returns to education anticipated in the future, it would be more important to keep young kids in school because they will ostensibly benefit more from continued education than will older school-aged individuals, who are entering a less-developed labor market. While this explanation does not account for the positive relationship between father departure and continued education among younger students (Table 5.5), the uniform outcomes among the small number of observed individuals in this scenario are arguably responsible for the coefficient's very large magnitude.

The changing nature of the local economy may also serve to explain why educational participation rates are substantially lower for males than for females, both in the greater population (Table 5.4) and within households (Table 5.8). If traditionally male-dominated professions not requiring formal education (e.g. fishing, carpentry) continue to exist on Ibo while a new class of professions that increase returns to education emerges, a rational household may decide to allocate educational funds only to females. Such a division of resources would allow males to earn money within traditional job sectors, while females—who otherwise may have stayed at home—will enter job sectors requiring some formal education.

Further support for the importance of the biological father in the home comes from the household-level fixed effects model, since father presence was again found to be positively associated with school participation (Table 5.8), as kin selection and family structure theories would predict. These results indicate that an individual who lives with his or her father has a greater likelihood of being enrolled in school than does a school-aged individual in the same household (e.g. a step sibling, a half sibling, a cousin, or an unrelated cohabitant) whose father does not live in the home. The same is not true of maternal presence: though the relationship between maternal presence and educational enrollment is positive, the association is much weaker (Table 5.8). A lack of significant relationship between mother presence and educational participation across all models is not interpreted as inconsistent with theories of biological nepotism or the importance of traditional family structure. Rather, mothers in this population are rarely the principal earners of their households (Table 5.1), and they may lack the bargaining power to dictate investments in their children that would reflect their own preferences. The step-fathers, uncles, or unrelated males who are present in the household may make household expenditure decisions that disproportionately benefit their own biological children, while a mother's presence in the home is not associated with her ability to negotiate equal investment in her own children's education.

The household-level fixed effects model—which compares educational outcomes only among cohabitating individuals—is an excellent way to control for unobserved characteristics operating at the household level, such as financial resources, altruism, and the degree to which the household members who control the purse strings value educational investments in children. The approach does have some drawbacks, however, which limit the degree to which the results can be interpreted as representative of the greater Ibo population. Since households with uniform education enrollment statuses are dropped from analysis, the results are limited to representing a minority of households (Table 5.2), in which at least one school-aged individual attends school and at least one does not. Therefore, among households that vary in their educational investments in children and adolescents, father presence predicts better educational outcomes, as would be predicted under kin selection or family structure theory. However, the majority of households do not vary in this respect. Within most households, investments in school-aged individuals are being made uniformly, regardless of the child's genetic relatedness or sex, demonstrating altruism that could be driven by close proximity of the individuals within the household.

This study confirms the importance of father presence in dictating educational investments in school-aged individuals. While the models cannot control for the possibility of time-variant shocks with repercussions impacting both father presence and educational enrollment, individual- and household-level fixed effects confirm that household conditions associated with father departure have negative consequences for biological offspring, who drop out from school at above-average rates and are enrolled in school at lower rates than their housemates whose fathers live in the home. Although the number of observations of school-aged individuals is large (N=2346), small sizes of population subsets (e.g. individuals who experienced a father departure event between survey waves) contribute to large standard errors and limited ability to draw conclusions with statistical certainty. Future research incorporating a third wave of data collection would be an exciting way to add observations to the dataset and follow the population through time as economic development continues to alter the perceived returns to educational investments.

Tables

	Mean [Std Dev]	Range	N
2009			
Age (years)	10.80 [3.37]	(6, 17)	1030
Education of HH head or parent (years)+	4.43 [3.47]	(0, 13)	885
Household asset wealth (2012 USD)	718 [892]	(0, 3738)	918
# Household members	6.52 [2.44]	(1, 14)	1030
Enrolled in school	82.4%	(0, 1)	1022
Mother absent (%)	40.1%	(0, 1)	1030
Mother absent: Deceased (%)	4.6%	(0, 1)	1030
Mother absent: Lives on Ibo (%)	8.0%	(0, 1)	1030
Mother absent: Lives elsewhere (%)	27.3%	(0, 1)	1030
Father absent (%)	62.9%	(0, 1)	1030
Father absent: Deceased (%)	11.0%	(0, 1)	1030
Father absent: Lives on Ibo (%)	13.7%	(0, 1)	1030
Father absent: Lives elsewhere (%)	38.0%	(0, 1)	1030
Male (%)	48.7%	(0, 1)	1030
2012			
Age (years)	10.99 [3.38]	(6, 17)	1316
Education of HH head or parent (years)+	4.50 [3.00]	(0, 13)	676
Household asset wealth (2012 USD)	842 [955]	(0, 4519)	1311
# Household members	7.37 [3.15]	(1, 20)	1316
Enrolled in school	76.1%	(0, 1)	1316
Mother absent (%)	45.8%	(0, 1)	1316
Mother absent: Deceased (%)	3.7%	(0, 1)	1316
Mother absent: Lives on Ibo (%)	23.5%	(0, 1)	1316
Mother absent: Lives elsewhere (%)	16.2%	(0, 1)	1316
Father absent (%)	66.0%	(0, 1)	1316
Father absent: Deceased (%)	5.6%	(0, 1)	1316
Father absent: Lives on Ibo (%)	38.0%	(0, 1)	1316
Father absent: Lives elsewhere (%)	22.1%	(0, 1)	1316
Male (%)	49.1%	(0, 1)	1316
Primary financial provider: mother (%)	11.9%	(0, 1)	1316
Primary financial provider: father (%)	39.3%	(0, 1)	1316
Primary financial provider: absent father (%)	8.8%	(0, 1)	1316
Primary financial provider: grandparent (%)	10.4%	(0, 1)	1316

Table 5.1. School-aged children's descriptive statistics, 2009 and 2012. Mean, standard deviation, range, and number of observations provided for all continuous variables pertaining to children and adolescents in the population with known ages from 6-17; percentage of individuals and number of observations provided for categorical variables. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest). Financial provider data were not collected in 2009.

	2009	2012
Households	893	875
# school-aged individuals per household		
0	402 (45.0%)	305 (34.9%)
1	196 (21.9%)	200 (22.9%)
2+	295 (33.0%)	370 (42.3%)
# father presence statuses (i.e. present, not present) in households with 2+ school-aged individuals		
1	220 (74.6%)	264 (71.4%)
2	75 (25.4%)	106 (28.6%)
# educational enrollment statuses (i.e. enrolled, not enrolled) in households with 2+ school-aged individuals		
1	208 (70.5%)	239 (64.6%)
2	87 (29.5%)	131 (35.4%)
Individuals	3779	4301
School-aged individuals	1030	1316
# school-aged individuals who live…		
with school-aged cohabitants	196 (19.0%)	200 (15.2%)
without school-aged cohabitants	834 (81.0%)	1116 (84.8%)

Table 5.2. Household descriptive statistics, 2009 and 2012. Numbers of individuals and households, categorized by composition and educational participation. In total, 1030 and 1316 school-aged individuals (children and adolescents aged 6-17 years) were observed in 491 and 570 households in 2009 and 2012, respectively. In 2009 and 2012, there were 295 and 370 households with two or more school-aged individuals, making them eligible for inclusion in the household fixed effects model (Model 3); since households with invariate observations in the outcome variable will be dropped from fixed effects, only the 87 and 131 households with multiple educational enrollment statuses were included in the model.

Age (years)	Typical grade in school (mode)	Students enrolled in 8th grade or higher	Students enrolled in 10th grade	Students enrolled in school	N
4	preschool	0	0	22 (16.8%)	131
5	preschool	0	0	30 (29.4%)	102
6	1st	0	0	70 (67.3%)	104
7	2nd	0	0	113(85.6%)	132
8	2nd	0	0	60 (74.1%)	81
9	2nd	0	0	80 (83.3%)	96
10	3rd	0	0	87 (89.7%)	97
11	3rd	2 (2.2%)	0	82 (91.1%)	90
12	4th	2 (2.4%)	0	70 (85.4%)	82
13	5th	4 (5.2%)	0	65 (84.4%)	77
14	6th	4 (6.3%)	0	54 (85.7%)	63
15	6th	13 (15.5%)	0	65 (77.4%)	84
16	6th	20 (29.9%)	2 (3.0%)	55 (82.1%)	67
17	8th	21 (49.9%)	3 (6.1%)	41 (83.7%)	49

Table 5.3. Grade in school by age, 2009. 935 children and adolescents of known ages 4-17 were enrolled in preschool through 10th grade.

	Educational enrollment (Model 1)			
	Year dummy		Year dummy & controls	
Father present	2.116	***	2.033	*
Std error (robust)	0.447		0.733	
Mother present			0.879	
Std error (robust)			0.206	
Constant	3.693	***	3.135	***
Std error (robust)	0.423		0.742	
Individual & household-level controls				
Year dummy: 2012	0.747	*	0.851	
Age dummy: 6 years old			0.308	***
Age dummy: 7 years old			0.755	
Age dummy: 11 years or older			1.134	
Male			0.595	***
# Household members'			0.987	
Education of HH head or parent, years+			1.183	***
Asset wealth (2012 $, thousands)^			1.347	***
Interaction terms				
Father present * 2012	0.743		0.586	
Mother present * 2012			1.165	
Father present * mother present			1.127	
N			2338	

Table 5.4. Log odds of educational enrollment as a function of father presence. Logit models of children's educational enrollment (1=enrolled) as a function of father presence (1=present); standard errors clustered at the household level. Analysis limited to children aged 6-17 years. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest); 0 years imputed in case of missingness. ^Asset wealth in thousands of 2012 USD; mean values imputed in case of missingness. * Indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

	Father presence, 2012	
Father presence (2009)	110.4	***
Std error (robust)	51.9	
Child's educational enrollment (2009)	0.516	
Std error (robust)	0.210	
Father's educational attainment, years (2009)+	1.058	
Std error (robust)	0.083	
Asset wealth (2009 [2012 $, thousands])^	1.151	
Std error (robust)	0.265	
Constant	0.057	***
Std error (robust)	0.030	
N	608	

Table 5.5. Log odds of father presence (2012) as a function of 2009 father presence, child's educational participation, father's education, and household wealth. Logit model of father presence (1=present) in 2012 as a function of 2009 father presence, 2009 child's educational enrollment (1=enrolled), and 2009 household asset wealth; standard errors clustered at the household level. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest); 0 years imputed in case of missingness.^Mean values imputed in case of missingness. Asset wealth in thousands of 2012 USD. * Indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

	Father location in 2012 (*For children who attended school in 2009 and whose fathers lived at home in 2009)*		Total
	Father still at home	Father left	
Child still enrolled	173 (89.6%)	36 (85.7%)	209 (88.9%)
Child dropped out	20 (10.4%)	6 (14.3%)	26 (11.1%)
Total	193	42	235

	Father still at home	Father moved	Father died	Total
Child still enrolled	173 (89.6%)	29 (87.9%)	7 (77.8%)	209 (88.9%)
Child dropped out	20 (10.4%)	4 (12.1%)	2 (22.2%)	26 (11.1%)
Total	193	33	9	235

	Father still at home	Father moved		Father died	Total
		Absent father is not principal supporter	Absent father is principal supporter		
Child still enrolled	173 (89.6%)	18 (90.0%)	11 (84.6%)	7 (77.8%)	209 (88.9%)
Child dropped out	20 (10.4%)	2 (10.0%)	2 (15.4%)	2 (22.2%)	26 (11.1%)
Total	193	20	13	9	235

	Father still at home		Father moved		Father died		Total
	Child < 11 years	Child ≥ 11 years	Child < 11 years	Child ≥ 11 years	Child < 11 years	Child ≥ 11 years	
Child still enrolled	61 (89.7%)	112 (89.6%)	9 (100.0%)	20 (83.3%)	1 (100.0%)	6 (75.%)	209 (88.9%)
Child dropped out	7 (10.3%)	13 (10.4%)	0 (0.0%)	4 (16.7%)	0 (0.0%)	2 (25.%)	26 (11.1%)
Total	68	125	9	24	1	8	235

Table 5.6. Dropping out of school, given father presence classifications. Table includes the 235 school-aged children who were enrolled in school and whose fathers lived at home during the 2009 census wave.

	Dropping out of school (Model 2)		
	Univariate model	Controls	Controls & interaction term
Father departure	1.442	1.480	8.5e-7 ***
Std error (robust)	0.971	0.957	5.6e-7
Constant	0.116 ***	0.229	0.270
Std error (robust)	0.030	0.301	0.356
Individual controls			
Age dummy: 11 years or older (2012)		1.288	1.015
Male		1.018	0.972
Mother presence (2012)		1.043	1.090
Household controls			
# Household members (2012)		0.992	0.989
Education of HH head or parent, years (2012)+		0.745 **	0.753 **
Household asset wealth (2012 $, thousands)^		1.000	1.000
Interaction term			
Father departure * 11 years or older			2.3e6 ***
N			235

Table 5.7. Log odds of dropping out of school between 2009 and 2012 as a function of father departure from the home. Logit models of children's rates of dropping out of school (1=dropped out) as a function of a father departure event (1=left home); standard errors clustered at the household level. Dropping out and a father departure event represent a change between 2009 and 2012 characteristics. +Education reflects years of attainment by household head or parent who lives in the household (whichever is highest); 0 years imputed in case of missingness. ^Asset wealth in thousands of 2012 USD; mean values imputed in case of missingness. * Indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level. Other interaction terms (father presence*male, father presence*mother presence) were not significant, data not shown.

	Educational participation, household fixed effects (Model 3) *2009 and 2012 pooled data*			
	Father presence w/ year dummy	Mother presence w/ year dummy	Year dummy & controls	Year dummy, controls, & interaction term
Father presence	2.148		2.874 *	5.976 *
Std error (robust)	0.933		1.460	4.226
Mother presence		2.051	1.653	1.975
Std error (robust)		0.844	0.746	0.930
Individual controls				
Age dummy: 6 years old			0.234 ***	0.225 ***
Age dummy: 7 years old			0.506 *	0.486 *
Age dummy: 11+ years old			1.049	1.028
Male			0.545 ***	0.526 ***
Interaction terms				
Father presence * 2012	0.487		0.327	0.312
Mother presence * 2012		0.665	1.022	1.020
Father presence * Mother presence				0.378
N				711

Table 5.8. Log odds of educational participation as a function of father presence, co-resident fixed effects. Logit models of educational enrollment (1=enrolled) as a function of father presence (1=present); household-level and year-level fixed effects. 711 children observed within 218 households with >1 school-aged child (257 individuals in 2009; 454 individuals in 2012; 87 households in 2009; 131 households in 2012). Analysis limited to children aged 6-17 years. * Indicates significance at the α=0.05 level; ** indicates significance at the α=0.01 level; *** indicates significance at the α=0.001 level.

Figures

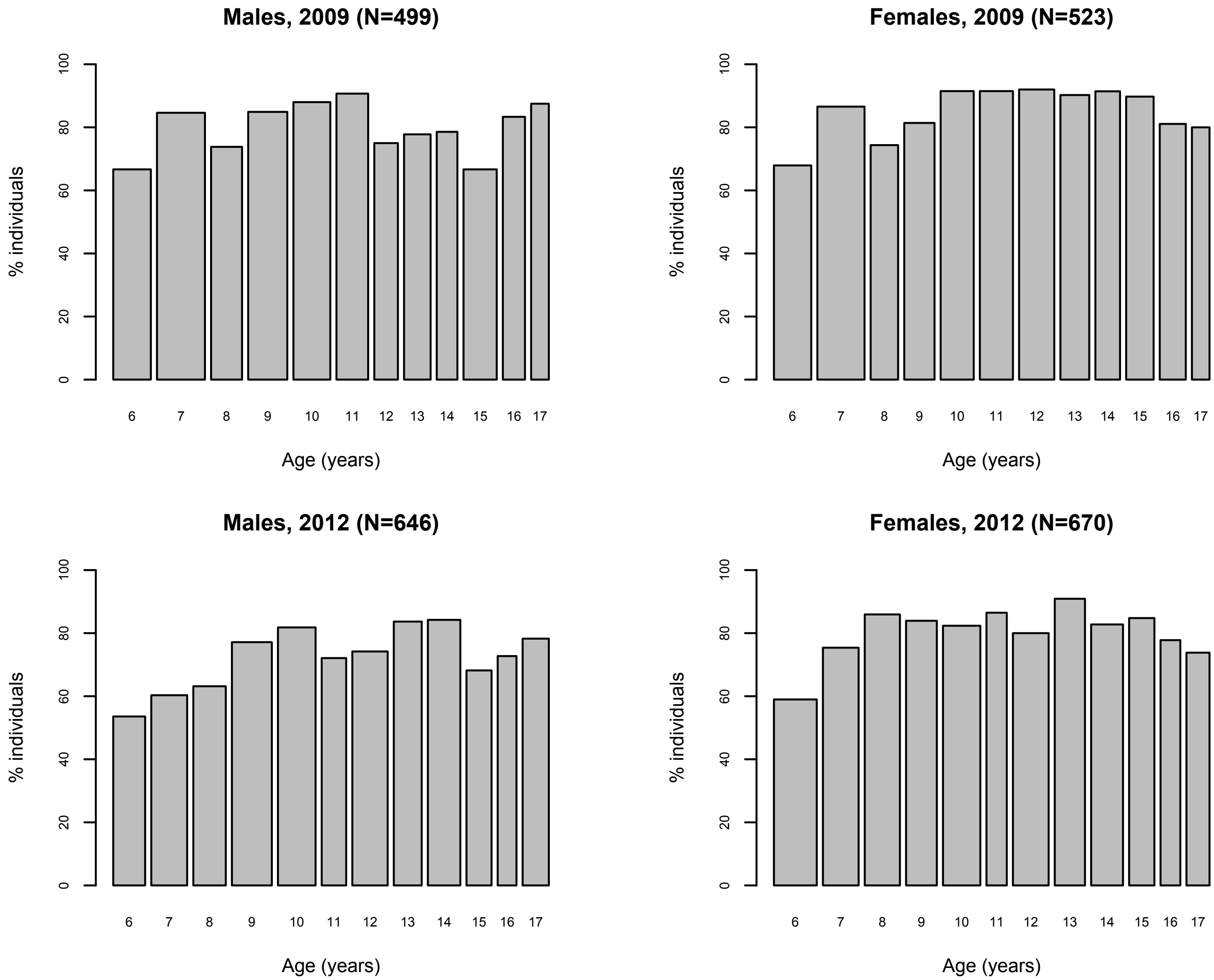

Figure 5.1. Educational participation by age and sex, 2009 and 2012. Percent of individuals aged 6-17 years who were enrolled in school during the census year. Rates of school enrollment were somewhat higher in 2009 than 2012 and, within census years, were somewhat higher for females than males. Bar width is scaled to the number of observations within each group.

CONCLUSION

Amid the growing prominence of tourism and local NGOs, the population of Ibo Island has experienced major recent changes in its health and economy. In just three years, the community's combination of economic development and nutritional outreach led to great improvements in the nutritional status of the population's children, with child stunting rates falling from 43% to 36% (Table 3.2)—a highly impressive decline, since nutritional improvements experienced outside of the "window of opportunity" of very early childhood typically have little effect on height. Despite the role of economic growth in dictating nutritional outcomes, however, the island's isolation from markets in which fresh produce is widely available continues to limit the availability of healthful foods for sale, and home agricultural production remains a primary route through which dietary diversity, a presumed proxy for dietary quality, is achieved. As the island's economic climate changes, sustained associations between household composition and investments in children continue to be observed over time, with presence of the biological father remaining one of the strongest predictors of a child's school enrollment in both 2009 and 2012 (Table 5.4).

Economic circumstances

Households that benefitted from economic growth—those who underwent livelihood transitions to emerging industries—simultaneously made above-average investments in both nutrition and assets. The identification of strong links between economic growth and anthropometric outcomes are counter to the weak or nonexistent relationships identified in other research (Deaton and Dréze 2009; Heltberg 2009;

Subramanyam et al. 2011) and may be due to this study's investigation of economic growth at the household—rather than the population—level. While a population can simultaneously experience increased per capita incomes and increased inequality, interfering with researchers' ability to link anthropometric improvements to economic growth, observation of individual households over time provides a clearer dataset with which to understand the routes through which development may transfer into increased investments in children's health.

If the whole population had lacked access to or knowledge of good nutrition, we would not have observed height improvements with livelihood transition in the population subset. These results therefore suggest that the lack of cross-sectional relationship between asset ownership and height outcomes in 2012 is not caused by a population-wide lack of nutritious foods or by a population-wide lack of knowledge relating to nutritious foods.

A meaningful relationship emerged between educational attainment and height outcomes over time. Whereas in 2009, there was no discernable relationship between education and stunting, by 2012, a child whose parent or household head had 10 years of education underwent a Z-score improvement of 0.6 more points over time than a peer whose household members had no formal education. Household members with higher educational attainment may have been especially responsive to nutritional outreach and growing western influences, thereby developing stronger preferences for nutrition than did their less educated peers.

Farm production

This research provides evidence in support of a household-level role for small-scale agricultural activities in impacting nutritional behaviors and/or dietary access, and the lack of reliable markets in the Ibo community likely plays a key role in the household-level relationship between farming and dietary diversity. Whereas markets in other study communities can distribute crops across a foodshed, thus smoothing regional dietary consumption patterns (Remans et al. 2011), produce grown on Ibo appears to remain largely within the producing household. That the model identifies a significant relationship between crop diversity and diet, regardless of seasonality and consideration of farm size, demonstrates the great degree to which household production and diet operate in tandem in this community, either through production influencing diet or through adoption of diverse farming practices due to a preference for dietary diversity. In either case, the relationship is consistent with a theorized link between farming practices, nutritional practices, and good health.

On average, highly educated parents feed their children more diverse diets, but educational attainment is negatively associated with farm ownership, indicating that some educated households diversify their diets through market purchases rather than home production. However, data from high-education farming households provide further support for the "eat what you grow" interpretation of this community's livelihood strategy. Educated farming households do not have above-average crop diversity indices (Table 4.5), but they do grow fruits—a food that is particularly difficult to consistently purchase in the community—at substantially higher rates than do their less educated peers with equally low-crop-diversity farms (Figure 4.4). Educated households appear to use home production to meet the dietary demands that local markets cannot.

Father presence

The results of this research are largely aligned with kin selection theory, in which a child raised by his biological parents is shown more altruism than a child raised by more distant relatives or non-relatives. In a cross-sectional model, for instance, I identify a strongly significant relationship between father presence and educational participation in both 2009 and 2012 (Table 5.4). In other respects, however, kin selection theory is less well supported by the results. Under Hamilton's Rule, we would expect—all other things equal—to observe comparable investments in one's biological children regardless of a father's proximity. In this population, however, children whose fathers continue to serve as their principal providers after leaving the home drop out from school at higher rates than their peers whose fathers remain in the home (Table 5.6, small sample size, results not significant).

The results are largely counter to theories predicting altruism or prospective reciprocated altruism resulting from scenarios of familial cooperation, in which we would see no discernable pattern between parental presence and educational investments. In fact, having one's principal financial provider live outside of the Ibo community showed no discernable association with educational participation in either census year, indicating that proximity to the household one supports is not a strong predictor of resulting investments.

It is possible that the low educational participation rates among children who do not live with their fathers are the result of a dropout event resulting from the shock of a household disruption, after which they did not re-enroll. That possibility limits interpretation of the cross-sectional results, making the educational outcome look like the result of current living conditions when it is actually the result of a previous, one-time shock. The longitudinal model uses individual fixed effects to control for this possibility, examining only children who lived with their fathers and were enrolled in school during the first census wave. Although the analysis of dropping out and father departure did not yield significant results (Table 5.5), the direction and magnitude of the relationship—with school dropout rates over a third higher among children whose fathers left home during the preceding three years (Table 5.6)—serves to explain at least some aspect of the observed cross-sectional patterns. Since a father departure event is associated with reduced educational investments in children over time, it logically follows that children who do not live with their fathers will have lower rates of school enrollment, having likely experienced a father departure shock at a prior point in their lifetimes. Other explanations for the cross-sectional relationship between father presence and educational participation also exist, however, relating mainly to the endogeneity of the variables.

While adolescence was not associated with low rates of school enrollment (Table 5.4), it was strongly associated with high likelihood of dropping out of school when the individual experiences a father departure event (Table 5.5 and 5.6). Younger children tended to remain in school when their fathers left the home, while adolescents whose fathers left the home withdrew from school at above-average rates. One plausible explanation for this trend is that when a father leaves the home, adolescents are tasked with entering the labor force in order to contribute financially to their households. However, an investigation of the employment statuses of the six adolescents who dropped out of school when their fathers left due to migration or mortality indicated that none of them had entered the workforce between census waves. Sample sizes of school dropout and father departure events are too small to reject the possibility that the workforce is a draw to Mozambican adolescents whose fathers leave home, but in the Ibo Island population in this study's time frame, this scenario was not observed. Rather, these adolescents appear to have dropped out for other, unknown reasons (e.g. lack of school fees, psychological stress of a father departure event).

Another explanation for the above-average dropout rates of older students who experience a father departure shock relates to the community's economic development, in which literacy and language skills may contribute to an individual's ability to participate in the lucrative emerging job sectors of tourism and non-profit foundations. With higher anticipated returns to education over time, it would be more important to keep young kids in school because they will ostensibly benefit more from continued education than will older school-aged individuals, who are entering a less-developed labor market. While this explanation does not account for the positive relationship between father departure and continued education among younger students (Table 5.5), the uniform outcomes among the small number of observed individuals in this scenario are arguably responsible for the coefficient's very large magnitude.

Further support for the importance of the biological father in the home comes from the household-level fixed effects model, since father presence was again found to be positively associated with school participation (Table 5.8), as kin selection and family structure theories would predict. These results indicate that an individual who lives with his or her father has a greater likelihood of being enrolled in school than does a school-aged individual in the same household (e.g. a step sibling, a half sibling, a cousin, or an unrelated cohabitant) whose father does not live in the home. The same is not true of maternal presence: though the relationship between maternal presence and educational enrollment is positive, the association is much weaker (Table 5.8). A lack of significant relationship between mother presence and educational participation across all models is not interpreted as inconsistent with theories of biological nepotism or the importance of traditional family structure. Rather, mothers in this population are rarely the principal earner of a household (Table 5.1), and they may lack the bargaining power to dictate investments in their children that would reflect their own preferences.

Conclusion

As improved infrastructure and expanded employment opportunities continue to transform Africa's rural areas, this research suggests that economic growth has the potential to benefit children directly because their households will invest a portion of their higher incomes in nutritional improvements. The lack of association between educational attainment or baseline asset wealth and a subsequent livelihood transition is promising for households with low human or physical capital, indicating that a household-level poverty trap does not appear to prevent these households from taking advantage of emerging economic opportunities. Small farming and nutritional outreach may play an important role in translating economic growth into nutritional improvements because access to and preference for nutritious foods are necessary precursors of the movement away from nonnutritive dietary staples.

With continued economic development throughout Mozambique, returns to education are likely to increase over time. Unlike more traditional livelihood sectors (e.g. fishing, agriculture), which do not require formal education, emerging jobs across the region require verbal—if not written—knowledge of the Portuguese language. The growth of these job sectors may serve to explain why educational participation rates are substantially lower for males than for females, both in the greater population (Table 5.4) and within households (Table 5.8). If traditionally male-dominated professions not requiring formal education continue to exist on Ibo while a new class of professions that increase returns to education emerge, a household's decision to allocate educational funds to females would be rational. Such a division of resources would allow males to earn money within traditional job sectors, while females who otherwise may have stayed at home will enter job sectors that require formal education.

For isolated communities with low levels of market connectivity for purchase of perishable foods, this research demonstrates the ability of household-level crop diversity to meet a household's demand for dietary quality. However, crop specialization could also theoretically support dietary diversity if it allowed households to trade with a neighbor who specialized in a different crop. In that sense, the results are in support of a community's crop diversification, achieved either at the level of the household farm or the community in general. The results contribute to the growing call for metrics with which to monitor small-farmers' sales and barters in order to document the pathway from diverse production to diverse consumption. With such data, it will be better possible to discern the ability of small-farming practices to fill a gap between the quantity of fresh produce demanded and supplied in an isolated community.

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APPENDIX: DATA CODES

Construction materials: Walls.

1. Palm fronds
2. Earth
3. Wood
4. Cement, brick, or stone
5. Sheets of zinc or other metal
6. Stick and mud
7. Recycled or improvised materials
8. Other

Construction materials: Roof.

1. Palm fronds
2. Tile
3. Cement, brick, or stone
4. Sheets of zinc or other metal
5. Plastic or sheets of another synthetic material
6. Other

Construction materials: Floor.

1. Earth or clay
2. Wood boards
3. Cement or brick
4. Parquet or polished wood
5. Tile
6. Other
7. It’s not possible to see the floor

Household lighting.

1. Municipal electricity
2. Generator
3. Municipal electricity and generator

4. Gas lamp or lantern
5. Candle
6. Solar panels
7. Other
8. Unknown

Cooking method.

1. Firewood
2. Coal
3. Oil
4. Gas
5. Electricity
6. Other
7. Unknown

Toilet.

1. Toilet connected to a sewer pipe
2. Toilet not connected to a sewer pipe
3. Traditional pit
4. Don't own (use the bush or the beach)
5. Other
6. Unknown

Location codes.

1. In the same home
2. In the same neighborhood
3. On Ibo
4. In Cabo Delgado Province
5. Elsewhere in Mozambique
6. In another country
7. Dead
8. Unknown

Relationship codes.

1. Mother
2. Father
3. Grandparent
4. Aunt or uncle
5. Other

Pregnancy outcome codes.

1. Live birth
2. Miscarriage or abortion (< 28 weeks)
3. Stillborn (28 or more weeks)
4. Multiple live births
5. Multiple stillborns
6. Multiples, with some stillborn

Work codes.

Fishing and Agriculture
--- Fisherman
    111. of fish
    112. of octopus
    113. of crab
    114. of lobster
    115. other type of fisherman
--- Farmer
    121. of a small farm/kitchen garden
    122. of coffee
    123. other type of agriculture
13. Livestock caretaker (goats, chickens, cows)
14. Beekeeper
19. Other fish or agriculture

Industry and Construction
--- Construction
    211. Builder
    212. Electrician
    213. Plumber
    214. Master builder
    215. Painter

216. Carpenter
217. Other construction work

--- Artisanal activities

221. Silversmith
222. Florist
223. Seamstress
224. Ebony
229. Other artisanal activity

29. Other industry or construction

Services, Commerce, and Tourism

--- Commerce

311. Bodega
312. Bread (i.e. making, selling)
313. Other commerce

--- Service

321. Restaurant
322. Bar or tea house
323. Nightclub
324. Hair salon
325. Boat transport
329. Other service

--- Tourism

331. Hotel or campsite
332. Boat transport
333. Guide
334. Cultural activities (e.g. dance, music)
339. Other tourism

39. Other service, commerce, or tourism

Public Administration and Assistance Activities

--- Education

411. Teacher
419. Other education employment

--- Health

421. Hospital
422. CANI Nutritional Center
423. Healer
429. Other health employment

--- Foundation or non-governmental organization

431. Aga Khan Foundation
432. Ibo Foundation
433. National Park of the Quirimbas
439. Other foundation or non-governmental organization

44. Sailor

45. Administration and police
49. Other public administration or assistance activity

51. Other employment (difficult to classify)