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

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ABSTRACT. In the Global South, many food-insecure individuals have diets that rely heavily on starchy staples 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. In this research, I use data from Ibo Island, Mozambique, which lacks a year-round market in which to buy fresh produce. 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, and recent research identified a relationship only at the village-level. This paper is unique in its identification of strong household-level links between crop diversity and child dietary diversity, which I verify is a strong predictor of child height. The findings paint an optimistic outlook for this and other remote Sub-Saharan African communities, where localized small-farming practices has the potential to improve household-level access to diverse foods.

Introduction. Northern Mozambique is among the world's most critical "hunger hotspots," where chronic food insecurity and sustained past periods of malnutrition have caused over 40% of children to exhibit stunted growth (Azzarri et al. 2012, de Onis et al. 2012, Sanchez and Swaminathan 2005). 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 et al. 2011, Ezzati et al. 2002, Keatinge et al. 2010, Rivera et al. 2003), the repercussions of which can have lasting detrimental effects on development, school participation (Alderman et al. 2006), and adult health and earnings (Victora et al. 2008). Outreach and policy in poor countries often prioritize early childhood nutrition as central for development (The World Bank 2006).

In this study, I use dietary consumption data from Mozambique to investigate the relationship between dietary diversity and small-farming activities in a remote community with no year-round market in which to buy fresh produce. I hypothesize that local small-farming practices play a major role in improving children's diets within small-farming households because growing diverse crops increases the household's access to a diverse diet. The link between dietary diversity and child health outcomes is well established in the literature (Arimond and Ruel 2004, Savy et al. 2005), but the relationship between crop and dietary diversity is less investigated. In Remans et al.'s analysis of crop diversity in three African villages, associations between crops grown and household dietary diversity are found to be significant at the village--but not the household--level, perhaps owing to the sale of household crops to neighbors (2010). In contrast, my results identify a significant positive relationship between diversity of household small-farming activities and diversity of household children's diets, demonstrating linkages between foods produced and consumed even after the dilution of the relationship by selling produce to other "foodshed" households.

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) and are often positively correlated with anthropometric outcomes in developing communities (Arimond and Ruel 2004, Savy et al. 2005). In addition to modeling the relationship between crop production, diet, and anthropometric outcomes, the full paper uses novel graphical strategies to visualize dietary diversity, allowing for a better understanding of the nutritional components represented by dietary count indices.

Background. The data for this project are drawn from Ibo Island in northern Mozambique, where stunting rates are "high" to "very high" (WHO 2014) 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 home-grown produce from small baskets on porches. The lack of a year-round market in which to buy fresh produce means that one of the only ways for a household to increase its access to diverse foods for home consumption is to grow them.

Cereals and starches, typically prepared with small portions of fish and fats, comprise the community's nutritional staples. The World Health Organization recommends daily consumption of fruits and vegetables to prevent nutritional deficiencies (WHO 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.

Methods. In this study, I construct a dietary diversity index (DDI) for children aged 2-9 years[i] 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) 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:

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

[i] Although dietary diversity is complementary with breastfeeding for children aged 6-23 months, children under age 2 are excluded from analysis because of their unique dietary patterns, owing to the large role of breast milk consumption.

DDI values are modeled in relation to the household's crop diversity index (CDI). Like the DDI, the CDI is a count-based index in which households receive 1 point for responses of "yes" (grew in the past 12 months) and 0 points for responses of "no" (did not grow), with a maximum possible CDI of 8 points:[ii]

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

I collected data from all of the approximately 850 households on Ibo over a 7-week period[iii] in 2012 in collaboration with the Ibo Foundation, a local NGO.

Preliminary Results. As expected, dietary diversity index is strongly positively associated with child height (Table 1), verifying that an additive dietary diversity index can serve as an effective proxy for dietary quality. This research is unique in its demonstration of a strong positive association between a child's dietary diversity and his household's crop diversity, controlling for other significant characteristics including educational attainment of the household head and household asset wealth (Table 2). The small magnitude of the relationship may be related to the temporal scales of the survey questions, since DDI is 24-hour retrospective, while CDI reflects crops grown in the past year. These findings suggest the potential of diverse multicropping systems to meet demand for a diverse diet.

The findings are consistent with the proposal that local, sustainable, biodiverse agriculture is a strong solution to undernutrition in developing communities (Blasbalg et al. 2011). While a more detailed understanding of food consumption (broken down by amount of each food consumed) would elucidate the role of diverse farm production in improving the true quality of children's diets, these results provide evidence in support of the role of local small-scale agricultural activities in impacting nutritional behaviors. As I continue to investigate this research topic, I plan to incorporate additional demographic characteristics to model whether, for instance, household age composition appears to play a role in a household's preference for a well-balanced (albeit untraditional) diet.

[ii] One point was also added for small farm ownership, to capture those small-farmers who did not grow any of the surveyed crops.

[iii] Data collected during and immediately following Ramadan have been excluded from analysis due to the fasting and feasting activities.

	Height-for-age Z-score			
Dietary diversity index (DDI)	0.076	*	0.067	*
Std error (robust)	0.030		0.032	
Constant	-1.302	***	-2.160	***
Std error (robust)	0.135		0.387	
Individual controls				
Age (years)			0.012	
Sex (Female=0, Male=1)			-0.050	
Nutritional outreach			-0.409	***
Birth weight^			0.266	*
Household controls				
# Household members			0.000	
Education of HH head or parent^+			0.020	
Household asset wealth (2012 USD, thousands)			0.027	
N				812

Table 1. Dietary diversity and stunting. OLS models of children's height-for-age Z-scores as a function of dietary diversity index (DDI); standard errors clustered at the household level. ^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). 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.

	Dietary Diversity Index (DDI)			
Crop diversity index (CDI)	0.056		0.085	*
Std error (robust)	0.037		0.033	
Constant	4.204	***	3.545	***
Std error (robust)	0.088		0.270	
Individual controls				
Age (years)			0.03	
Sex (Female=0, Male=1)			0.012	
Nutritional outreach			0.151	
Household controls				
# Household members			-0.053	
Education of HH head or parent^+			0.100	***
Household asset wealth (2012 USD, thousands)			0.428	***
N				826

Table 1. Crop and 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. ^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). 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.