THE IMPACTS OF CASSAVA ON CHILD NUTRITIONAL STATUS & HOUSEHOLD FOOD SECURITY IN ZAMBIA

by

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ABSTRACT

This study utilizes data from the 1996 Living Conditions Monitoring Survey I (LCMS) conducted in Zambia to examine two important issues concerning child nutritional status. First, does adopting cassava as a primary staple contribute negatively to child nutritional status? Secondly, are household calorie and protein availability and dietary diversity pathways through which cassava influences child nutritional status?

A five-step dummy variable indicating a progressively increasing proportion of calories acquired from cassava relative to calories from all primary staples was created to measure the importance of cassava as a primary staple. Two-stage least squares, which corrects for the endogeneity of total expenditure per capita (a proxy for income), is utilized for regression analysis. All models control for socioeconomic factors such as education, household size, and the demographic composition of the household; and the regression results are corrected for the two-stage stratified sampling design.

The main findings of this study are: large amounts of calories from cassava proportional to calories from all primary staples in the household diet have 1) a negative impact on household calorie availability; 2) a negative impact on household protein availability; 3) a likely negative impact on dietary diversity; and 4) a likely negative impact on child nutritional status.

CHAPTER 1

INTRODUCTION

In sub-Saharan Africa (SSA), young children typically consume diets comprised of cereals, roots and tubers. These staples are used to prepare porridge that is relied on by many children to meet their energy needs. A reliance on such a limited diet of repeated feedings of the same porridge high in carbohydrate and low in protein may result in malnutrition. Onyango, Koski and Tucker (1998; p. 488) explain that, "Dietary quality, which is greatly enhanced by the inclusion of a variety of foods, is of critical importance to weaning age children". An adequately diverse diet includes not only the energy from starchy staples, but also the nutrients that protect against infection and disease.

In 2000, malnutrition contributed to 60% of the deaths of children under five in developing countries (WHO, 2002). Malnutrition is characterized by inadequate intake of protein, energy and micronutrients and by frequent infections and disease. A child's diet is just one of many factors that can contribute to their nutritional status. Other factors include quality of care for children and their mothers, food security, quality of the health environment, and the economic resources available to a country or community (such as per capita national income and democracy).

The question of how national income is dispersed amongst the population becomes important because household income affects the ability of the poorer households to acquire the needed variety and amount of foods to ensure proper child nutrition. Their lack of access to an adequately diverse diet (e.g. meat, oils, and vegetables) is associated with their lack of income to cultivate or purchase these nutritious foods. Without sufficient income, poor rural households have to make decisions whether to cultivate crops without inputs or change their cropping patterns.

Cassava is an important crop to consider when poor households constantly struggle with meeting their member's energy requirements, especially where soil fertility is a concern. Cassava can provide a considerable source of calories with no required fertilizer applications. In addition, cassava root can survive in the ground up to 6 months without rain. Thus, where environmental conditions are appropriate, cassava is regarded as an alternative to many grains.

According to Centro Internacional de Agricultura Tropical (CIAT, 2001), cassava is planted on about 16 million hectares around the world, with 50 percent planted in Africa, 30 percent in Asia, and 20 percent in Latin America. Its escalating attractiveness among very poor farmers has heightened the awareness of cassava as a potential food security crop. However, while cassava is known as a cheap source of carbohydrate, it has a relatively low level of protein. The protein content of cereals is considerably higher than root and tuber crops, making maize, millet, and sorghum better staples regarding protein quantity. Consumption of a starchy staple low in protein quantity may influence the quality of the household diet and contribute negatively to child nutritional status.

The general topic of this study is child nutritional status. Most of the current research on cassava tends to look at how new varieties improve production for both small and large-scale farmers. For poorer households, this may mean increased food security. However, the literature lacks research on the actual impact that cassava has on vulnerable households striving to become food secure. Household food security is defined as access to sufficient food for an active and healthy life for all household members (Maxwell and Frankenberger, 1992). It not only considers diet quantity (or energy availability) but also diet quality (dietary diversity). Motivating households to cultivate cassava without taking into account their lack of income or knowledge to supplement other nutrient rich foods may have important nutritional consequences in the future.

The general question the study asks is: does adopting cassava as a primary staple contribute negatively to child nutritional status? In addition, are household calorie and protein availability and dietary diversity pathways through which cassava influences child nutritional status? Data from the 1996 Living Conditions Monitoring Survey I conducted in Zambia is used to explore these topics. To answer the questions, community fixed-effects regression analysis (Ordinary Least Squares and Two-stage Least Squares) is utilized.

The following is the structure of the study. Chapter 2 presents the relevant literature on child nutritional status, food security, and the current cassava debate. Chapter 3 presents background information about Zambia. Chapter 4 presents the data and methods used in this study. Chapter 5 presents the empirical results. Chapter 6 will provide conclusions and policy implications.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter takes a comprehensive look into the determinants of child nutritional status and household food security. Cassava is also explored being that it is an important crop produced and consumed by rural households in Zambia.

Chapter 2 is divided into six sections: section one looks at child nutritional status; section two looks at household food security; section three explores cassava as "the food security crop"; section four looks at measurement of food security; section five looks at measurement of child nutritional status; and section six presents the limited empirical literature addressing the impact of cassava on child nutritional status.

2.1 Child Nutritional Status

In 1980, the prevalence of stunting for children in developing countries under five years of age was 47.1% and twenty years later, in 2000, the prevalence of stunting had declined to 32.5% (Administrative Committee on Coordination, Sub-Committee on Nutrition (ACC/SCN), 2000; as sited in Alderman et al., 2001). Nevertheless, in Africa, the total number of stunted children has increased (Alderman et al., 2001).

There are many factors that contribute to child nutritional status. The UNICEF conceptual framework for child growth and malnutrition (UNICEF, 1998) separates the factors into three levels: 1) immediate determinants; 2) underlying determinants; and 3) basic determinants. The immediate determinants include the dietary intake of the child and their health status. Adequate dietary intake not only necessitates the quantity but also the quality of food in a child's diet. Inadequacy of a child's diet can influence their health status, which in turn affects their appetite, absorption of nutrients and depletes the needed energy to fight off disease.

The underlying determinants involve the quality of care for the child and their mother, food security and the quality of the health environment. Care provided for the mother, during pregnancy and lactation for example, can directly affect the development of her child. A country can achieve food security at a national level, yet a household's access to available food to attain adequate nutrients for their children on a sustainable basis, may still pose a significant challenge (Smith and Haddad, 2000). The quality of the health environment includes the availability of safe water, sanitation, health care and environmental safety.

The basic determinants include the economic resources that are available to a country or community. These resources can be affected by certain political, economic, cultural and social factors that could influence how they are utilized as resources for food security, health environment and services, and care (Smith and Haddad, 2000).

The following section takes a closer look at household food security. Household food security has a direct affect on the dietary intake of a child and therefore warrants additional attention. The other determinants of child nutritional status are important, yet are not the focus of this study.

2.2 Household Food Security

Maxwell and Smith (1992) explain that there are four core concepts contained within the definition of household food security. These include 1) sufficiency of food; 2) access to food; 3) security; and 4) time. Sufficiency of food is primarily concerned with calories. Access deals with the acquisition of sufficient food by individuals or the household. Security of food entails having secure access to enough food. Food insecurity can be defined in terms of risk. Von Braun (1991) defines food insecurity as "the risk of an ongoing lack of access by people to the food they need" (as defined in Maxwell and Smith, 1992).

The last concept, time, involves the notion of having access to enough food throughout the year. Chronic (year round) versus transitory (seasonal) food insecurity matters because households who are chronically food insecure are at more risk (Maxwell and Smith, 1992).

Diets of poor households in developing countries are predominately based on starchy staples and consist of little or no animal protein, fresh fruits and vegetables (Ruel, 2002). If the majority of the household diet consists of these staple foods the quality of the diet may be inadequate. Caloric intake is a necessary but not sufficient condition for achieving food security. Therefore, households must also incorporate a diet of quality that ensures a balanced diet for all members, including children.

A high quality diet is one that meets requirements for energy and all essential nutrients or "nutrient adequacy" (Ruel, 2002). This is an important distinction when comparing diet quality to diet quantity, the latter being concerned with the availability and consumption of total food energy (kcal) (Neumann and Harris, 1999).

Diet quality can potentially be improved by increasing the number of different kinds of foods acquired by the household. Dietary diversity is the number of different foods or food groups consumed over a given time period. Poverty affects the household's ability to acquire the needed variety to ensure adequate nutrition for all members. Lack of access to certain foods primarily is because households lack the income to vary their own diets. Lack of income can directly influence which crops households cultivate and whether additional foods can be purchased that improve household nutrition. Poor households also tend to have low education levels, which hampers the attainment of knowledge that could increase nutritional awareness. This, coupled with seasonal food shortages and the fluctuating prices in staple foods that ensue, make it increasingly difficult for rural households to access food year round.

The next section takes a look at cassava as a potential food security crop. As poor households continually struggle with food security, cultivation of cassava can provide the household with a considerable amount of cheap calories. Yet diet quality becomes a significant issue.

2.3 Cassava: "The Food Security Crop"

Nearly 200 million people in SSA rely on cassava (*Manihot esculenta* Crantz) as their dietary basis. Cassava is now the fourth most important source of calories around the world. In SSA, high rates of population growth and urbanization, combined with relatively low per capita incomes and restricted economic growth, will nearly double cassava consumption to 168 million tons by 2020 (Scott, Rosegrant and Ringler, 2000). In areas where soil fertility is poor, cassava is able to grow and provide a substantial source of calories for poor households. In addition, cassava can produce acceptable yields of 8-12 tons of fresh root per hectare on plots of land that require no fertilizer. Cassava root can also survive in the ground up to 6 months without rain.

Cassava is an important crop to consider as households constantly struggle with meeting their member's energy requirements. In 1994, Prudencio and Al-Hassan explored how cassava is used as a backstop food reserve against crop failure and famine during the hungry season. Cassava assists in stabilizing food security in Africa and bridges the seasonal food gap. They identified three main objectives to the production of cassava for home consumption. The first is to bridge the food gap during the hungry season. As staple foods such as maize, sorghum, millet or rice become scarce, cassava can be used to achieve within-year food security. Second, if adverse environmental conditions exist (e.g. drought), households then rely on cassava to meet their between-year food security. The third is to maintain the starchy food supply above the minimum required when certain resources such as land decline in usable area and quality as population growth increases.

2.3.1 Cassava Production in Zambia

During the years from 1930 to 1963, cassava was regarded as a famine crop in Zambia. Colonial authorities would regulate Zambian farmers to cultivate cassava as a backup against episodic famines (Jones, 1959; as sited in Haggblade and Zulu, 2003). During the years of 1964-1981, maize was regarded as the most important crop in Zambia and substantial input subsidies and surefire markets influenced farmers everywhere to cultivate maize (Kokwe, 1997; as sited in Haggblade and Zulu, 2003). Two exotic pests appeared in Africa in the late 1970s, the cassava mealybug (CM) and the cassava green mite (CGM). Both of the pests entered into Zambian (Luapula Province) cassava fields in 1981/82. Loss under the CM infestation ranged from 60 to 100% of crop yields and losses in root production were as high as 30% with the CGM infestation (Haggblade and Zulu, 2003). Farmers that relied heavily on cassava as a staple food were significantly influenced in the northern zones of Zambia. This provoked the Zambian government to invest in cassava research for the first time.

Then in the late 1980s, the Zambian government removed most of the maize subsidies provided for farmers. This, coupled with intense research and improvement of superior local varieties of cassava, reduced the area planted to maize and increased cultivation of cassava, millet, sorghum, sweet potatoes and groundnuts (Haggblade and Zulu, 2003). Zulu et. al estimated in 2000 that the total cropped area devoted to maize had fallen from 80% in 1982 to 60% in 1999. Poor households lacked sufficient income to purchase the needed resources to cultivate maize and therefore changed to crops such as cassava that required little to no inputs.

Traditionally, cassava would take anywhere from 18-36 months to harvest. New varieties significantly decrease the harvest time to around 12 months. Cassava also requires considerably less labor per hectare than maize. The substantial canopy produced by its leaves shades out weeds and thus cuts down on the time needed to weed. Also there are virtually no costs for inputs (seed and fertilizer). This has encouraged farmers to devote on average 9% of their cropped areas to cassava (Haggblade and Zulu, 2003). The major areas that cultivate cassava in Zambia are Luapula and Northern Provinces.

2.3.2 Cassava Precautions

As environmental and economic degradation continue and the need to cultivate cassava increases, measures must be introduced where and when necessary to limit any negative effects of such an expansion (Prudencio and Al-Hassan, 1994). Such expansion could have potential negative affects on household nutrition, especially on children. Cassava has the great drawback of containing virtually nothing but carbohydrate. The Food and Agriculture Organization (FAO, 1997; p. 262) states that, "It is especially unsuitable as the main source of energy for the infant or young child because of its low protein content". Cassava contains around 1% protein compared to 10% in maize and other cereals. For example, one small dried fish weighing 150 g or 1.4 kg of maize meal contains the same quantity of protein as 6.8 kg of cassava (FAO, 1997). Children weaned on to cassava develop kwashiorkor (outcome from protein deficiency) more commonly than children weaned on to maize or millet (FAO, 1997). Cassava leaves, on the other hand, contain a substantial amount of protein, equal in value to the protein in eggs (Babaleye, 1996). When proper processing techniques (effectively removing the toxicity) are administered, combining cassava leaves with its root makes for a nutritious meal.

Adequate diets include proper quantities and qualities of food, and nutrients must be consumed in appropriate combinations for suitable absorption to take place. Households that shift their cropping patterns toward cassava may secure adequate diet quantity but compromise diet quality. If additional sources of protein are not supplemented into their diet, malnutrition is a likely result. Therefore, as households shift their cropping patterns toward cassava the impact of cassava on household nutrition, especially on that of children, becomes an important issue for study.

2.4 Measuring Food Security

One indicator commonly used to measure food security is a measure of diet quantity, specifically household calorie availability. Household calorie availability is represented by food that is acquired from purchases, own-consumption of food produced and in-kind gifts. Food composition tables are used to determine the correct content of specific nutrients in foods[1], enabling construction of the measure of diet quantity. When countries do not have their own individual tables, tables specific to certain regions are preferred (e.g. Africa (FAO) and East Africa). This is important due to the number of food composition tables and how they may significantly differ amongst regions (e.g. USDA versus Africa).

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[1] See Table 1 (Appendix) for Calorie and Protein Conversion Factors.

The food composition data usually indicate the maximum amount of nutrients available to the body from foods in their raw form. Factors that influence the nutrient content of foods such as variety, maturity, time of harvest, length of storage or exposure in the market, and processed foods are not represented in the table. Thus, the actual amount of nutrients absorbed and utilized by the body is not calculated.

Another indicator of food security is diet quality as measured by household protein availability. This measure is constructed similarly to household calorie availability, yet uses protein in its place.

Diet quality can also be represented by the measure dietary diversity. Dietary diversity is measured as the number of individual foods or groups of food (e.g. staples, fruits, meats) consumed or acquired. Food groups tend to provide more information on dietary diversity, and when a variety of foods are observed, food groups are more practical unless there is certain interest in food sources of specific nutrients (Krebs-Smith et al., 1987).

2.5 Measuring Child Nutritional Status

Certain indicators allow for the measurement of child nutritional status. These include height-for-age, weight-for-age, weight-for-height, tricep skinfolds, and mid-upper arm circumference. The first three are discussed below.

Height-for-age (or stunting) is used as a measure of chronic or long run malnutrition. Stunted growth reflects a process of failure to reach linear growth potential as a result of sub-optimal health and/or inadequate dietary intake (WHO Database).

Weight-for-height (or wasting) is used as a measure of acute or short-run malnutrition, indicating that a child has severe weight loss due to starvation or relentless disease.

Weight-for-age reflects body mass relative to chronological age. Here the height and weight of the child influences the measure, making interpretation difficult. For example, weight-for-age fails to distinguish between a short child of ample body weight and a tall, thin child.

As anthropometric measurements of individuals are compiled, comparison to a "reference" child with the same age and sex is needed in order to construct relevant scores when assessing malnutrition. This is achieved by using the National Center for Health Statistics/World Health Organization (NCHS/WHO) internal reference population. The Z-score system is used as the best system for analysis and presentation of anthropometric data. The Z-score system expresses the anthropometric value as a number of standard deviations below or above the reference mean (WHO Database).

2.6 Empirical Literature: Cassava and Child Nutritional Status

Most of the literature concerning cassava focuses on the shift toward cassava production (e.g. Haggblade, Zulu, 2003; Nweke et al., 2004) or looks at cassava as a food security crop that assists households in filling the seasonal gap of grains (e.g. Dostie et al., 2002; Prudencio, Al-Hassan, 1994). The cassava literature also recognizes cassava as a major income generator (e.g. in Nigeria) or addresses how the advances in research and development have improved many local varieties. Lastly, the literature focuses on the impact of certain characteristics of cassava (cassava toxicity and its protein inadequacy). Only one study was identified that investigated the impacts of cassava on child nutritional status. The FAO Luapula Household Food Security and Nutrition project concluded that a cassava-based food typology must be coupled with continuous consumption of animal protein to attain nutritional adequacy (as sited in McEwan, 2003). Though conclusions and associations were drawn concerning the potential impacts of cassava on child nutritional status (descriptive statistics only), no modeling to explain child malnutrition was initiated.

CHAPTER 3

BACKGROUND INFORMATION ON ZAMBIA

Chapter three provides the background information on Zambia. The chapter is divided into two sections: section one takes a look at certain issues in Zambia pertaining to agriculture, health, and child malnutrition; section two looks at a noticeable shift in cropping patterns during the 1990s.

3.1 A Brief on Zambia

Zambia is a land-locked country covering an area of 752,614 square kilometers (comparable in size to Texas). Zambia is surrounded by Angola and Namibia to its western areas; Democratic Republic of the Congo, Tanzania to its northern areas; Malawi to the east; and Mozambique, Zimbabwe, and Botswana to its southern areas (see Figure 3.1 and Figure 3.2). The country is divided into nine provinces and 72 districts. Two of the provinces are mainly urban—Lusaka and Copperbelt. The remaining provinces—Central, Eastern, Southern, Western, Northwestern, Northern and Luapula are considered rural.

Zambia lies between 8 and 18 degrees south latitude and between 20 and 35 degrees east longitude. It has a tropical climate and vegetation with three seasons: a rainy season from November to April (during which the hunger season takes place), a

Figure 3.1 Map of Africa

Figure 3.2 Map of Zambia

Source: The University of Texas at Austin:
Produced by U.S. Central Intelligence Agency

cool winter season from May to August and a hot dry season from September to October. The northern part of the country receives the highest rainfall ranging from 1,100 mm to over 1,400 mm annually. The southern and eastern parts of the country receive less rainfall ranging from 600 mm to 1,100 mm annually.

Zambia has a mixed economy consisting of an urban sector and an agricultural sector. Copper is still the number one exported commodity (55%), yet due to large declines in world copper prices and large increases in oil prices, the economy of Zambia has worsened considerably. A shift towards agriculture was initiated hoping to better the deteriorating economy. Currently tobacco, flowers and cotton, along with electricity and cobalt make up the other 45% of exported commodities (World Factbook, 2003).

The GDP per capita, in purchasing power parity dollars, is $353 (USAID, 2003; 2001 est.). GDP composition by sector is: agriculture—22%; industry—26%; and services—52% (World Factbook, 2001 est.). Eighty-six percent of the population live below the poverty line. Agriculture makes up 85% of the labor force (World Factbook). Important crops cultivated in the rural areas are maize, sorghum, rice, cassava, groundnuts, sunflower seed, vegetables, sugarcane, coffee and various animal and animal products.

The national censuses reported total populations in 1980 of 5.7 million, 1990 of 7.8 million and in 2000 of 10.2 million, with a growth rate of 2.9% per annum in 1990-2000 (USAID, 2003). The population density in 1999 was 13.5 people per square kilometer (USAID, 2003).

In 1996, fertility rates were estimated at 6.1 births per woman (USAID, 2003). Life expectancy for males was at 37 years in 1999 (USAID, 2003). In the late 1990s, overall infant mortality rates were at 109 deaths per 1,000 live births (USAID, 2003). Current infant mortality rates are 99 deaths per 1,000 live births (World Factbook, 2003).

HIV/AIDS continues to affect Zambia in all aspects of life. Current adult prevalence rates are 21.5%, with 1.2 million people living with HIV/AIDS (World Factbook, 2001 est.).

In 1996 the Zambian Demographic and Health Survey indicated that 42% of the children surveyed were classified as stunted and a further 18% were severely stunted. As children get older, prevalence of stunting increases; 24% of the children age 6-11 months were stunted and 48% were stunted by age 12-23 months. Therefore 5 out of 10 children who are two years and older are stunted. Luapula and Northern Provinces had the highest rates of stunting at 57.7 and 57.3%, respectively. These two provinces are considered to be the main cassava producers in Zambia.

3.2 A Shift in Cropping Patterns

State subsidized marketing systems had assisted Zambian farmers for many years. The government provided the marketing, extension services, and low cost inputs that encouraged agricultural production and increased incomes for rural farmers. The government retracted their subsidies in the late 1980s and hoped that private trading networks would establish themselves and provide markets to rural areas (McEwan, 2003). Unfortunately, poor road conditions and the distance most rural farmers have to travel to sell their crops hampered the networks intended to assist rural farmers.

The contribution of maize to the overall value of agricultural production declined and rural households started to diversify their cropping patterns towards sorghum, millet, cassava and sweet potatoes (McEwan, 2003). Households could no longer rely on the government subsidy programs and therefore changed their cropping patterns to obtain a cheaper supply of calories. As explained in Chapter 2, cassava does not require high quality soil or fertilizer, unlike maize. Therefore, in Northern Province a large decline in maize area was accompanied by a large increase in cassava production and in Luapula Province area under cassava increased by more than 100% (McEwan, 2003).

CHAPTER 4

DATA SET, MEASURES & METHODOLOGY

Section one of this chapter reviews the data set utilized in this study as well as the sample employed. Section two describes the measures of child nutritional status, household calorie and protein availability, and dietary diversity. Section three investigates the statistical estimation methods used. Section four looks at the independent variables used in each regression analysis and section five looks at the specification tests utilized in this study.

4.1 Data Set and Sample Selection

In 1991, Zambia designed and implemented a new Structural Adjustment Program. The effects on individuals as well as households during structural adjustment were captured in the Social Recovery Programme—Phase I in 1991. In 1995, the Social Recovery Project—Phase II was initiated. Included in the design were three components: the Microprojects Unit, the Poverty Monitoring, and the Study Fund. Within the Poverty Monitoring component, funding supported the survey design and data collection for The Living Conditions Monitoring Survey I (LCMS), which is the basis for analysis of this study. The data collection for the LCMS was carried out during August through the end of September 1996 by the Central Statistical Office, Republic of Zambia.

The 1996 population of Zambia was estimated at over nine million people (9,159,072). Administratively, Zambia is divided into nine provinces: Central, Copperbelt, Eastern, Luapula, Lusaka, Northern, Northwestern, Southern, and Western. These provinces are divided into 67[2] districts. Zambia is sparsely populated with a population density of around 12 persons per square kilometer (based on the 1996 population). Northwestern Province has the lowest population concentration and Lusaka and Copperbelt Province with the highest.

Two-stage stratified random sampling was utilized in this survey. The country was first segmented into urban and rural areas of the 67 districts located within the nine provinces mentioned above. Within the urban areas, additional stratification broke households into three housing cost groups (low, medium, and high) and within rural areas, into type of activity (small, medium, and large-scale agricultural, and non-agricultural)[3].

Within each strata, Standard Enumeration Areas (SEA) were chosen based on the 1990 Census of Population and Housing and using a combination of equal allocation and probability proportional to size. The SEAs serve as the primary sampling units. The second sampling stage was random selection of households within the SEAs. The total number of households sampled was 11,770.

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[2] There were five additional districts gazetted after this survey and are therefore not included.
[3] In order to correct for the sampling design in STATA, more than one primary sampling unit within a stratum is needed. Ninety-five of the 272 strata have only one primary sampling unit, and thus prohibiting the use of the survey command to correct for the sampling design. Therefore, this stage of stratification was not used.

4.2 Food Data Collection

Enumerators collected information on food purchased and consumed from own production or received in-kind. They visited each household once. For purchases of maize grain and maize meal the recall period was one month. For all other food items, and for maize acquired from home production or received in-kind, the recall period was two weeks. Households reported the total value of each food purchased over the recall period. When reporting home production, households indicated the quantity they consumed, the unit of measure, and the price per unit. The final number of food items used for the analysis after data cleaning is 40.

4.3 Measures of Child Nutritional Status and Food Security

4.3.1 Child Nutritional Status

The main dependent variable in this study is child nutritional status. The measure chosen in this study is height-for-age Z-score (HAZ), which measures chronic or long run malnutrition. The individual Z-score for each child is constructed by subtracting the observed value from the median value of the reference population (see Chapter 2, section 5) and then dividing by the standard deviation value of the reference population.

The sample utilized for regression analysis in this study contains children 2 to 5 years of age. This sample was chosen based on the assumption that children in Zambia tend to stop breast feeding at around two years of age. It is thus only after reaching two years old that they become dependent on food for their nutrients. The sample size is 3,920 children.

4.3.2 Food Security

In addition to investigating the determinants of child nutritional status, exploring indicators of food security will assist in providing a better understanding of the pathways through which cassava may influence child nutritional status. Household calorie and protein availability per adult equivalent and the number of food groups, a measure of dietary diversity, are the indicators of food security chosen for use in this study and constitute the other dependent variables.

It is important to establish the number of "adult equivalents" in a household to take into account the fact that people of different age and sex have differing calorie and protein needs. For example, a male weighing 60kg requires 48 grams of protein, whereas a female weighing less, say 50kg, requires 40 grams of protein. Therefore, a weight is allocated appropriately to each household member based on age, sex, and the assumption of moderate activity level, relative to that of a referenced adult male. The referenced adult male with moderate activity levels is between 30 and 60 years of age and requires 2,900 kcal per day (FAO/WHO/UNU, 1985). Children between the ages of 1 to 5 are considered to have the same consumption needs regardless of sex.

As touched on in Chapter 2, when food data are collected from households, the actual amount of foods consumed is not reported. Instead, the data reflect food *acquired* by households, which may vary much more than the actual calories or protein quantities consumed by households. This is because households can acquire large amounts of food and hold it as stock. Similarly, a household can "eat down" from food purchased prior to the survey reference period, reporting very little food acquired over the reference period itself. In the data, calorie availability per adult equivalent ranges from zero to 12,000 kcal[4]. This wide range should be taken into account by the reader when interpreting the coefficient values in Chapter 5.

Household daily calorie availability is used to explore the diet quantity measurement and household protein availability is used to explore the diet quality measurement in this study. They attempt to measure on an average day, the total energy or protein available to a household based on estimates of the energy or protein acquired from food purchases, own-consumption of food produced and in-kind gifts. When constructing these measures, deriving the metric quantities of food acquired by the household over the reference period is needed[5] and then food composition tables are utilized to compute total calories or protein acquired by the household. Household daily calorie and protein availability per adult equivalent is finally obtained by dividing the total household calories or protein by the number of days in the reference period and the number of adult equivalents.

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[4] 12,000 kcal was an upper limit set during the cleaning process. Households that reported acquiring more were dropped from the analysis.

[5] See Smith et al. 2004a for the method used to convert the raw data to metric quantities.

As explained in Chapter 2, dietary diversity can be measured as the count of individual foods or groups of food. The latter was chosen as the measurement for this study. A total of 12 food groups are used to measure dietary diversity: cereals, roots and tubers, pulses and legumes, milk and milk products, eggs, meat and offal, fish and seafood, oils and fats, sugar and honey, fruits, vegetables and miscellaneous (e.g. salt). Cassava is a member of the "roots and tubers" group.

The sample size for the food security indicator analyses is 11,496 households. The percent of households with children 2-5 years old (and thus the overlap with the child nutritional status sample) is 30%.

4.4 Statistical Methods

The major question explored in this study is: does adopting cassava as a primary staple contribute negatively to child nutritional status? In addition: are household calorie and protein availability and dietary diversity pathways through which cassava influences child nutritional status?

To answer both questions, Ordinary Least Squares (OLS) and Two-stage Least Squares (2SLS) are utilized both with and without community fixed-effects. Community fixed-effects control for such factors as geographical differences in health and sanitation infrastructure, the quality of staff and management in local clinics, soil, climate, prices, disease vectors and culture. These effects can have a strong influence on child nutritional status and food security[6].

Tests are undertaken to determine which method, OLS or 2SLS, is better for answering the above-mentioned questions. In this study, the variable total household expenditure (a proxy for income) is potentially endogenous. Household earnings decrease when households can not work because their total calorie availability is low. Alderman (2000) provides another relevant example in that household earnings decrease when a child is sick because the parent(s) must stop their income-generating activities to care for their child. Therefore, an endogeneity problem could arise between income and calorie availability or a child's well-being (reverse causality). In general, from the theoretical model (see below), it is clear that people are making decisions about how to allocate resources to income generating activities at the same time as they are making decisions about the dependent variables. Not that if no endogeneity is associated with total household expenditure, both OLS and 2SLS do a good job providing coefficient estimates, yet OLS is more efficient.

4.4.1 Regression Analysis

4.4.2 Theoretical Framework for Nutrient Demand Model

The below section is adapted from Smith and Haddad (2000; p. 7-8).

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[6] See Chapter 5, Section 2.2 and 2.3 for explanation and for 2SLS regression results comparing models with and without community-fixed effects.

In order to look at the determinants of child nutritional status, a multimember household economic model is used whereby members of the household behave as if they are maximizing a welfare function, W, made up of the utility functions of its members (U^i), indexed $i = 1,..,n$. The household members include a caregiver who is assumed to be the mother (indexed $i = M$), D other adults (indexed $i = 1,...,D$), and J children (indexed $i = 1,...,J$). Thus the welfare function looks like:

$$W\left(U_M, U_{ad}^1, ..., U_{ad}^D, U_{ch}^1, ..., U_{ch}^J; \beta\right) \text{ and } \beta = \left(\beta^M, \beta_{ad}^1, ..., \beta_{ad}^D\right), \quad (1)$$

where the β s represent each adult household member's "status". Such status affects the relative weight placed on each member's preferences in overall household decision-making, or their decision-making power. The utility functions look like:

$$U^i = U\left(N, F, X_O, T_L\right) \quad i = 1,...,n = 1 + D + J \quad (2)$$

where N, F, X_O, and T_L are $1 \times n$ vectors of the nutritional status, food and nonfood consumption, and leisure time of each household member.

Nutritional status is viewed as a household provisioning process with inputs of food, nonfood commodities and services, and care. The nutrition provisioning function for child i is as follows:

$$N_{ch}^i = N\left(F^i, C^i, X_N^i; \xi^i, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}\right) \; i = 1,...,J, \quad (3)$$

where C^i is the care received by the i^{th} child, and X_N^i represents nonfood commodities and services purchased for caregiving purposes (e.g. medicines and health services). The variable ξ^i serves as the physiological endowment of the child (his or her innate healthiness). The variable Ω_{HEnv} represents the health environment (e.g. water, sanitation, and health services in the household's community). The variable Ω_{Food} represents the availability of food in the community. Lastly, the variable Ω_{NEnv} represents the characteristics of the community's natural environment, such as agroclimatic potential, soil fertility and water stress level.

The child's care, C^i, is itself treated as a child-specific, household-provisioned service with the time input of the child's mother, T_c^i. The mother's decision-making process in caregiving is assumed to be governed by the following functions:

$$C^i = C\left(T_c^i, N^M; E^M, \Omega_c\right) \quad i = 1,\ldots,J, \text{ and} \tag{4}$$

$$N^M = N\left(F^M, C^M, X_N^M; \xi^M, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}, \beta^M\right). \tag{5}$$

In equation (4) E^M is the mother's educational level (assumed to be contemporaneously exogenous), which affects her knowledge and beliefs. The term Ω_c represents cultural factors affecting caring practices. N^M is the mother's own nutritional status, symbolizing the status of her physical and mental health. In addition to the variables entering into the child nutrition provisioning function, the mother's nutritional status may be determined by β^M, symbolizing her status relative to other adult members.

The maximization of (1) subject to (2), (3), (4), and (5) along with household members' time and income constraints lead to the following reduced-form equation[7] for the i^{th} child's nutritional status in any given year:

$$N_{ch}^{i^*} = \left(\beta, \xi^1, \ldots, \xi^J, \xi^M, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}, \Omega_c, E^M, P, I\right) \quad i = 1, \ldots, J, \tag{6}$$

where P is a vector of prices of $X_O, X_N, F,$ and I is the household's total (exogenous) income.

In order to look at the determinants of calorie and protein availability and dietary diversity, the same utility function supplied above is maintained. The specified nutrition provisioning function for household member i is (adapted from Smith et al., 2004b):

$$N^i = N\left(Z_1^i, \ldots, Z_P^i, C^i, X_N^i; \xi^i, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}\right), \quad i = 1, \ldots, n,$$

where

$$Z_p(F), \quad p = 1, \ldots, P.$$

Here the $Z_p, \quad p = 1, \ldots, P$ are nutrients such as calories, protein and fat (the macronutrients) or vitamin A, Zinc and Iron (micronutrients), all of which are derived from foods. The reduced-form nutrient demand function takes the form:

$$Z_P^*\left(\beta, \xi^1, \ldots, \xi^n, \Omega_{HEnv}, \Omega_{Food}, \Omega_{NEnv}, \Omega_c, E^A, P, I\right), \quad p = 1, \ldots, P,$$

where E^A is adult educational level.

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[7] A reduced-form model contains only exogenous (predetermined) variables on the right-hand side and are easier to estimate than properly modeled production functions (Alderman, 2000).

The framework incorporates both diet quantity and dietary quality. Diet quantity can be expressed as the sum of the calorie values of foods consumed, thus focuses only on one of the nutrients (Z_1, for example). This is also true with protein. Dietary quality, by contrast, is characterized by all of the nutrients needed for nutritional health $(Z_1,\ldots,Z_P)$.

4.4.3 Econometric Model

The theoretical foundation of the reduced-form equations for child nutritional status, calorie and protein availability, and dietary diversity has been established above. Child nutritional status, calorie and protein availability or dietary diversity (Y) are hypothesized to be explained by K explanatory variables, denoted X_k according to the following empirical arrangement:

$$Y_{ic} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,ic} + \mu_c + \upsilon_{ic}, \upsilon_{ic} \sim N(0,\sigma^2), \quad i = 1,\ldots,\mathrm{I} \quad c = 1,\ldots,\mathrm{C},$$

where i denotes households, c denotes communities, α is a scalar, β is a $K \times 1$ vector of parameters, and υ is an error term. The μ_c are unobserved community-specific, household-invariant effects, and the υ_{ic} are stochastic.

If total household expenditure is not endogenous, then OLS results would provide unbiased and consistent estimates of the β_k. Testing for endogeneity becomes important because of the usage of total, rather than exogenous income in the regressions. Instead of there being no correlation between one of the X_k and υ_{ic}, i.e.,

$E[\upsilon_{ic} \mid X_k] = 0$, as assumed in OLS, the endogenous variable, total expenditure per capita, now provides information about the expectations of the disturbances. A set of variables Z_k (called "identifying instruments"), such that Z_k is correlated with X_k but not with υ_{ic} needs to be found to achieve consistent estimates of β_k. Utilization of the method of instrumental variable estimation, which relies on the relationship between Z_k, X_k, and υ_{ic}, is needed.

Using possession of households' assets as instruments, the Durban-Wu-Hausman test for a jointly significant difference between uninstrumented and instrumented parameter estimates is employed. Household assets (in the LCMS, 10 different household assets were identified such as bicycle, motorcycle, television, video player) are used because they are a good proxy of household income and are adequately correlated with total expenditure per capita. These assets are measured by using a dummy variable indicating whether a household owns a particular asset.

Two tests are needed to determine which instruments are appropriate. The first, the relevance test, establishes whether the chosen instruments actually explain variation in the prospectively endogenous variable to be instrumented. The second, the overidentification test, establishes whether the contending instruments directly affect the dependent variable (child nutritional status, calorie or protein availability or dietary diversity) other than through the prospectively endogenous variable, total expenditure per capita.

Given endogeneity, OLS cannot provide unbiased, but more importantly consistent estimates. Therefore, 2SLS method is employed and consists of two stages: *Stage1,* calculating the predicted residuals from the regression of total expenditure per capita on the instruments Z_k and all the exogenous X s in the system; and *Stage2,* regressing the dependent variable on all of the independent variables plus on the predicted values from *Stage1*.

4.5 Independent Variables

This section describes the independent variables used in this study. The variables included in the model of child nutritional status are total expenditure per capita, mother's education, the age and sex of the child, whether the household is female headed, whether the household is urban, age of household head, household size, and household age-sex composition. In addition, dummy variables indicating the levels of calories from cassava proportional to calories from all primary staples acquired by the household have been included in order to determine the impact of cassava on child nutritional status. The variables included in the models of calorie and protein availability and dietary diversity include the above variables except for the child variables (age and sex), and mother's education is replaced by adult education. Also, the variable indicating whether the household is urban is not included in the models that include community fixed-effects. This is because in community fixed-effects regression analysis, the urban dummy variable does not vary over the cluster (primary sampling unit) (Alderman et. al, 2001).

Prices are not explicitly included as independent variables, yet price heterogeneity across communities is captured by the community fixed-effects terms.

Measure of Levels at Which Households Acquire Cassava

The construction of the cassava variable was attained by taking the calories from cassava acquired by the household and then dividing it by the calories from all staples (maize, millet, sorghum, rice and cassava) acquired by the household. Thus the calories from cassava proportional to calories from all primary staples was created. Further, a 5-step dummy variable was developed that ranges from zero (no cassava acquired by the household) to a high proportion of staples calories from cassava, greater than or equal to 0.70 (see Table 2). This allows for the detection of threshold effects as cassava acquisition moves from none through the four other groups.

Table 2. Levels At Which Households Acquire Cassava

Step	Definition of Cassava Acquisition Five-step Dummy Variable*	Title	Number of Children in CNS Model**	Number of Households in FS Model***
1	Equal to zero	"No cassava acquired"	3114 (79.4%)	9114 (79.3%)
2	Greater than zero and less than 0.10	"Small amount of cassava acquired"	428 (10.9%)	1103 (9.6%)
3	Greater than or equal to 0.10 and less than 0.30	"Medium amount of cassava acquired"	151 (3.9%)	507 (4.4%)
4	Greater than or equal to 0.30 and less than 0.70	"Large amount of cassava acquired"	96 (2.4%)	319 (2.8%)
5	Greater than or equal to 0.70	"Cassava as a primary staple"	131 (3.3%)	453 (3.9%)

*Each group is defined by a differing proportion of calories from cassava relative to calories from all staples.

**Child Nutritional Status Model (3,920 children from 3,425 households in total).
Note: Households may have more than one child.

***Food Security Indicator Models (11,496 households in total).

Measure of Total Expenditure Per Capita

Total expenditure is the value of all the acquisitions for food and nonfood items by the household. This includes cash purchases, the value of gifts received by the household and the value of items consumed from home production. Total expenditures are divided by the number of household members to obtain the total expenditures per capita.

Measure of Mother's Education

Mother's education is measured using two dummy variables representing whether or not she has primary education and whether or not she has secondary education. Education should be positively correlated with child nutritional status as it serves to increase the mother's awareness of the need to ensure adequate consumption of proper foods and provide sufficient health care.

Measure of Adult Education

Adult education is measured using dummy variables representing whether any adult member (>18 years) has primary education and whether any adult has secondary education. Calorie and protein availability and dietary diversity could be positively correlated with education, as education may serve to increase adult household members' awareness of the need to ensure adequate consumption of calories and protein or diversify the diet. On the other hand, calorie and protein availability and dietary diversity could be negatively correlated with education, as education may serve to increase adult household members' awareness of the need to decrease consumption of certain foods (e.g. fats) to avoid obesity, heart disease, etc.

Measure of Household Demographic Characteristics

Household age-sex composition, household size, as well as the age of the head of the household measure possible scale effects and demographic structure of the household. A dummy variable accounting for whether the household is headed by a female and a dummy variable indicating whether the household is urban are also included. The age and the sex of the child are included, but only in the model determining child nutritional status.

4.6 Specification Tests

Tests for heteroskedasticity, omitted variables bias and multicollinearity are carried out for all four models[8].

Heteroskedasticity becomes an issue in multivariate regression models when the variance of the disturbance terms, conditional on the chosen values of the explanatory variables, is not constant. For instance, the conditional variances of the disturbance terms may increase as the values of the explanatory variables increase. The heteroskedasticity test used in this study is the Cook-Weisberg test using fitted values of the dependent variables. If heteroskedasticity is not corrected, the estimates of the parameters will not be efficient.

Correction for heteroskedasticity is easily achieved by minimizing a weighted sum of residual squares, whereby the weight assigned to each observation is inversely proportional to its variance—meaning that observations with large variances get smaller weights and those with small variances get larger weights.

Upon correction for heteroskedasticity, robust standard errors are provided that are efficient. This will have a direct influence on the confidence intervals and could significantly improve the t-statistic.

Testing for omitted variable bias in the model becomes important because if certain variables are excluded from the model, the parameter estimates of the included

[8] Testing for heteroskedasticity, omitted variables bias, and multicollinearity is not possible in STATA when accounting for the survey design. Thus tests were performed using standard regression models (see Chapter 5, section 2.4 and Appendix, Tables 13-16).

variables could be biased. The included variables receive the credit for the influence that may be attributable to an excluded variable.

Looking at economic theory and the empirical literature before constructing a model can assist with variable selection. This can provide the needed knowledge of which variables to include and therefore lessen the probability of excluding relevant variables.

The test for omitted variables is the Ramsey-Reset test using powers of the fitted values of the dependent variables. Unfortunately this test does not provide assistance in choosing an alternative model or which variables to include.

Multicollinearity refers to the existence of more than one exact linear relationship between explanatory variables. If high multicollinearity exists, the estimates have large variances and covariances that make precise estimation difficult.

To test for multicollinearity, variance inflation factors (VIF) are used. The VIF shows how the variance of an estimator is inflated by the presence of multicollinearity. As the coefficient of correlation between two variables increases to one, the VIF approaches infinity. The criteria for the VIF in this study are based on the following: multicollinearity is present if the largest VIF is greater than 10 or the mean VIF is considerably greater than 1 (StataCorp 2001).

CHAPTER 5

RESULTS

Chapter 5 presents the empirical results. First, descriptive statistics for the dependent variables—child nutritional status, calorie and protein availability per adult equivalent, and dietary diversity—are reported. The descriptive statistics for the independent variables are supplied as well. Second, the different tests to determine which method to utilize, OLS or 2SLS, for answering the key questions are reported. Following are the regression results as well as a look at the specification tests. The last section supplies the answers to the two main questions asked in Chapter 1: Does adopting cassava as a primary staple contribute negatively to child nutritional status? Are household calorie and protein availability and dietary diversity pathways through which cassava influences child nutritional status?

5.1 Descriptive Statistics

Table 3 presents the descriptive statistics for the main dependent variable, child nutritional status, as well as the independent variables used in the child nutritional status regression analysis. The mean height-for-age Z-score (HAZ) for children 2 to 5 years of age is –2.067. For reference, the WHO Global Database on Child Growth and Malnutrition (WHO 2003) uses a cutoff point of HAZ <–1 as mild stunting HAZ <–2 as moderate stunting and HAZ <–3 as severe stunting.

Table 3. Descriptive Statistics for Variables Used in the Child Nutritional Status Model (Children ages 2-5 years)

Variable	Mean	Standard Deviation	Minimum	Maximum
Dependent Variable				
Height-for-age Z-score (HAZ)	-2.068	1.615	-5.99	5.7
Independent Variables				
Calories from cassava/calories from all staples:				
No calories from cassava	0.77	0.40	0	1
Greater than .0 and less than .10	0.11	0.31	0	1
Greater than or equal to .10 and less than .30	0.05	0.19	0	1
Greater than or equal to .30 and less than .70	0.03	0.15	0	1
Greater than or equal to .70	0.05	0.18	0	1
Total expenditure per capita (Zambian Kwacha)	682.86	1175.44	19.6	36244.4
Mother's Education: any primary	0.58	0.50	0	1
Mother's Education: any secondary	0.20	0.45	0	1
Age of child (months)	40.80	9.68	25	59
Sex of child (female= 1)	0.48	0.50	0	1
Whether female headed household	0.16	0.36	0	1
Whether household is urban	0.37	0.49	0	1
Household size	6.71	3.55	2	41
Age of household head (years)	39.12	11.44	17	90
Percent females 16-30 (years)	15.07	12.19	0	75
Percent females over 30 (years)	8.73	9.17	0	50
Percent males 0-16 (years)	27.73	16.59	0	75
Percent males 16-30 (years)	9.20	11.77	0	71.4
Percent males over 30 (years)	10.93	8.70	0	60
Number of Observations	3920			

Note: Means are adjusted for survey design (weighted means).
Currency in Zambian Kwacha (in January, 1996, US $1.00 = ZK1,207.90).

As mentioned in Chapter 4, a five-step dummy variable was created that indicates the levels of calories from cassava proportional to calories from all primary staples acquired by the household. The proportion of households who acquire no cassava is 0.77. The proportion of households who acquire cassava as a primary staple, greater than or equal to 0.70, is 0.05. The majority, around 70%, of the households from this group are from Luapula and Northern Provinces.

A two-sample t test with equal variance was employed to determine whether there is a difference between the mean HAZ for households who acquire cassava and households who do not acquire cassava. The mean HAZ for households who acquire cassava is –2.1942 and the mean HAZ for households who do not acquire cassava is –1.8595. The difference between these two means is 0.3347 Z-scores and is significant at the one percent level (p=0.000). This is a substantial difference that merits further investigation of the affects of cassava on child nutritional status.

The mean HAZs across the groups of households who acquire different levels of calories from cassava are provided in Figure 5.1. Note the monotonic decline in HAZ as the level of calories from cassava increase in the household diet.

Figure 5.1
Mean Height-for-age Z-score for Households Acquiring Different Levels of Cassava

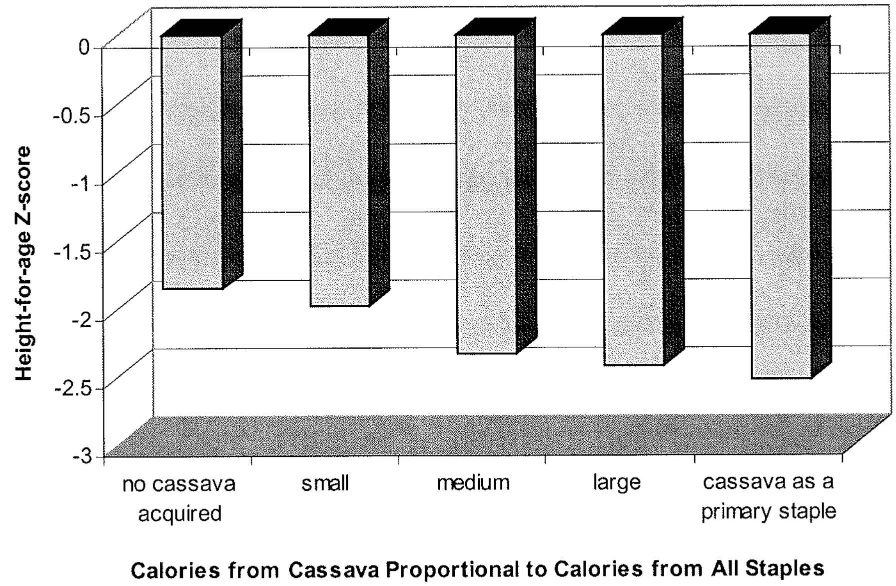


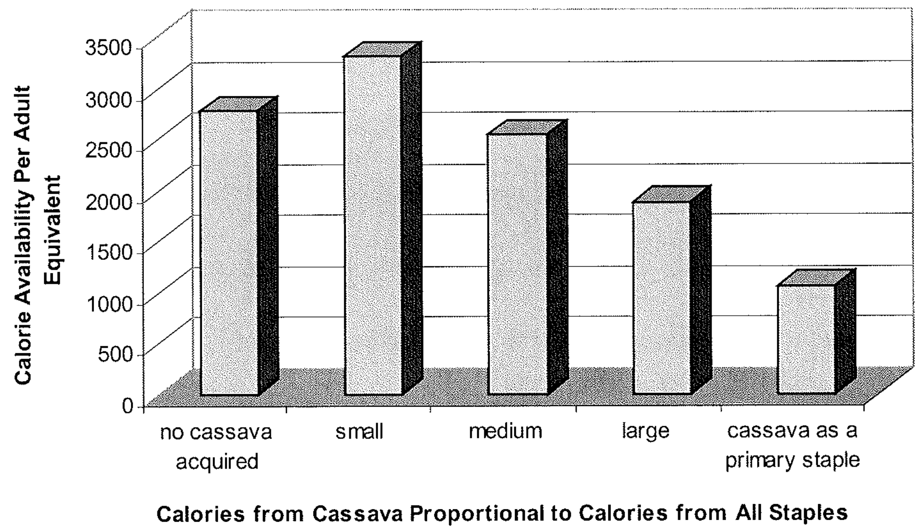
Table 4 presents the descriptive statistics for the other three dependent variables, calorie and protein availability per adult equivalent, and dietary diversity, as well as the independent variables used in their regression analysis. The mean of the variable measuring diet quantity (calorie availability per adult equivalent) is 2683 calories. The recommended caloric intake of the adult equivalent reference, a male 30-60 years, is 2,900 calories. The mean calorie availability per adult equivalent for households acquiring different levels of cassava is provided in Figure 5.2. Note as the proportion of calories from cassava relative to staples calories increases calorie availability declines.

Table 4. Descriptive Statistics for Variables Used in the Food Security Models

Variable	Mean	Standard Deviation	Minimum	Maximum
Dependent Variables				
Calorie availability per adult equivalent (kcal)	2683.1	1851.9	0	11989.6
Protein availability per adult equivalent (grams)	72.3	50.4	0	340.1
Number of food groups	7.5	2.5	1	12
Independent Variables				
Calories from cassava/calories from all staples:				
No calories from cassava	0.76	0.41	0	1
Greater than .0 and less than .10	0.10	0.29	0	1
Greater than or equal to .10 and less than .30	0.05	0.21	0	1
Greater than or equal to .30 and less than .70	0.03	0.16	0	1
Greater than or equal to .70	0.05	0.19	0	1
Total expenditure per capita (Zambian Kwacha)	930.80	1951.75	10.2	65222.2
Adult Education: any primary	0.46	0.48	0	1
Adult Education: any secondary	0.45	0.50	0	1
Whether female headed households	0.24	0.41	0	1
Whether household is urban	0.35	0.50	0	1
Household size	5.03	3.00	1	41
Age of household head (years)	41.73	13.78	13	90
Percent females 0-16 (years)	15.64	17.61	0	100
Percent females 16-30 (years)	14.89	18.74	0	100
Percent males 0-16 (years)	19.81	18.44	0	83
Percent males 16-30 (years)	14.56	21.12	0	100
Percent males over 30 (years)	14.60	18.89	0	100
Number of Observations	11496			

Note: Means are adjusted for survey design (weighted means)
Currency in Zambian Kwacha (in January, 1996, US $1.00 = ZK1,207.90)

Figure 5.2
Mean Calorie Availability Per Adult Equivalent for Households Acquiring Different Levels of Cassava



The mean of the first variable measuring diet quality, protein availability per adult equivalent, is 72 grams. The protein recommended dietary/daily allowance (RDA) for a male 25 years or older is around 60 grams per day. In North America, people usually consume 3 to 5 times more protein than is needed. This pattern of excessive protein intake is not the same in rural Africa. Most rural households consume much less than the recommended intake levels suggest. However, the mean for protein availability per adult equivalent is quite high for this sample. The data were collected right after the harvest season and most households had sufficient food or money from the sale of their cash or food crops which perhaps enabled them to supplement more foods rich in protein (e.g. meat). The mean of the other variable measuring diet quality (dietary diversity) is 7.5 food groups.

The mean protein availability per adult equivalent and the mean number of food groups for households acquiring different levels of cassava are provided in Figure 5.3 and Figure 5.4, respectively. Once again a similar trend is noticed. As households increase their intake of cassava, household protein availability and dietary diversity decline.

Figure 5.3
Mean Protein Availability Per Adult Equivalent for Households Acquiring Different Levels of Cassava

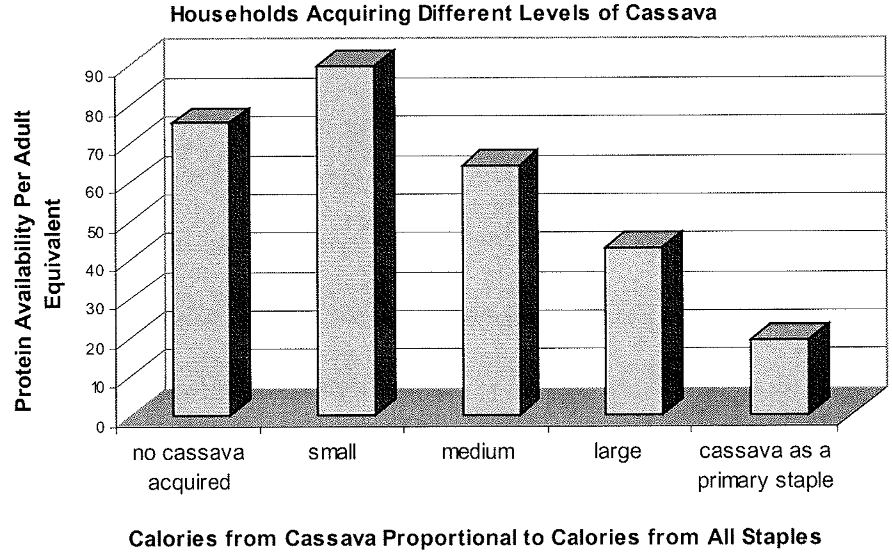


Figure 5.4
Mean Number of Food Groups for
Households Acquiring Different Levels of Cassava

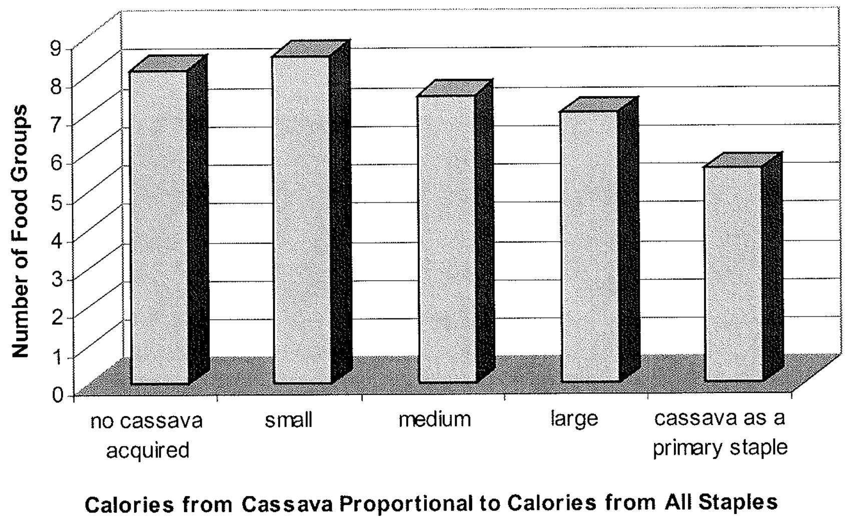
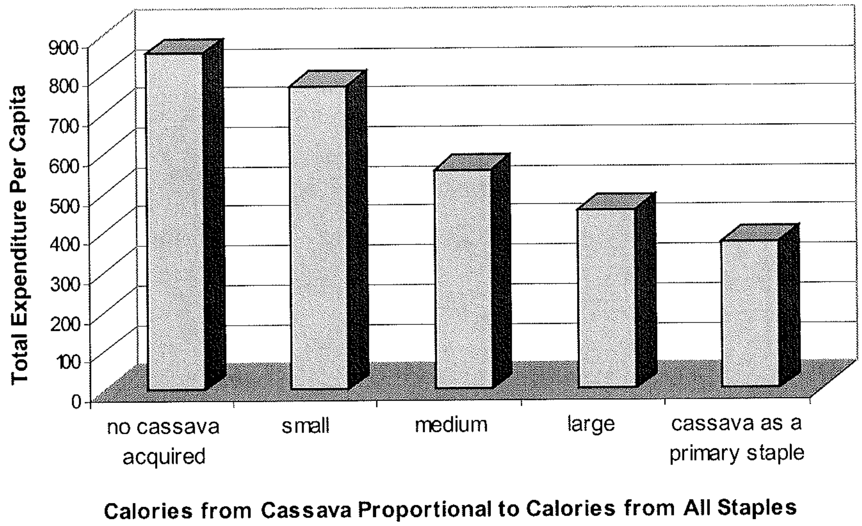


Figure 5.5 shows the importance of controlling for income in order to isolate the effect of cassava on child nutritional status and food security measures. Households that acquire a larger proportion of calories from cassava are also households that have low incomes. As explained in Chapter 2, the empirical literature suggests that a lack of income seems to be the underlying reason why households adopt cassava as their primary staple.

Figure 5.5
Mean Total Expenditure Per Capita for Households Acquiring Different Levels of Cassava



5.2 Regression Analysis

5.2.1 Which Method, OLS or 2SLS?

5.2.1.1 Relevance Test

If the endogeneity problem does not exist, then OLS results would provide unbiased and consistent estimates of the parameters. Testing for endogeneity becomes important because of the usage of total, rather than exogenous income in the regressions. Solving this problem requires the usage of an instrumental variable set. To determine which set of instruments to use, the relevance test must be employed. This establishes whether the instrument set used truly explains variation in the endogenous variable, total expenditure per capita. The null hypothesis is: the instruments are not jointly significant in a regression of total expenditure per capita on the instrument set and all exogenous variables. The hypothesis is rejected if the p-value is less than 0.1, in which case the instruments are "relevant"[9].

The test results for the child nutritional status model with and without community fixed-effects (using as assets the ownership of a video player and a radio) are an F-value of 7.90 and 25.46, respectively, and a significance level for both of one percent (p=0.000). The test results for the calorie and protein availability per adult equivalent and the number of food groups models with and without community fixed-effects (using as assets motorcycle and motor vehicle) are an F-value of 7.83 and 37.06 respectively, and a significance level for both of one percent (p=0.000) for all three dependent variables. The conclusion is that the null hypothesis is rejected, and all instrument sets are relevant.

5.2.1.2 Overidentification Test

The overidentification test determines whether the instrument set affects the dependent variable other than through total expenditure per capita. The joint null hypothesis is: 1) instruments are uncorrelated with the errors and 2) the model is correctly specified. The hypothesis is rejected if the test p-value is less than 0.1.

The p-value results for the child nutritional status model with and without community-fixed effects are 0.38 and 0.58, respectively. For calorie and protein

[9] The large sample sizes make it hard not to reject the null hypothesis.

availability per adult equivalent and the number of food groups the p-value results for these models that include community-fixed effects are 0.14, 0.13, 0.12, respectively. The p-value results for these models that do not include community-fixed effects are 0.58, 0.73, and 0.95, respectively. Therefore the null hypothesis is not rejected for all dependent variables, indicating that overidentification is not a problem and the instrument sets chosen are valid for use when performing the Durban-Wu-Hausman test.

5.2.1.3 The Durban-Wu-Hausman Test

The Durban-Wu-Hausman test determines whether 2SLS or OLS is the best estimator of the parameters. The null hypothesis is: total expenditure is not endogenous. If the coefficient on the residuals that were predicted in the first stage is statistically significant ($p<0.1$) when the dependent variable is regressed on all the independent variables (including the residuals), then the null hypothesis is rejected and total expenditure is endogenous, and 2SLS is the correct method to utilize.

The p-value results for the child nutritional status model with and without community-fixed effects are both significant at the one percent level. The test rejects the null hypothesis indicating that 2SLS is the preferred method of choice. For calorie and protein availability per adult equivalent and the number of food groups the p-value results for these models that include community-fixed effects are 0.07, 0.003, and 0.000, respectively. The p-value results for these models that do not include community-fixed effects are 0.07, 0.004, and 0.000, respectively. The test rejects the null hypothesis indicating that 2SLS is the preferred method of choice.

5.2.2 The Determinants of Child Nutritional Status

Regression results for 2SLS with and without community-fixed effects are reported in Table 5[10]. When community-fixed effects are included in the 2SLS regression analysis, the coefficients on the cassava dummy variables lose significance and magnitude. The probable explanation is that cassava production in the rural areas (and therefore consumption) is correlated with location-specific factors such as soil type and climate. Community-fixed effects account for these same location-specific factors, and when included in the model "drown out" the statistical association of the cassava terms with child nutritional status. Therefore, results without community-fixed effects will be focussed on in the subsequent discussion.

When coefficients of both groups representing the highest proportions of calories from cassava are compared to the reference category, no cassava acquired, a negative and significant association with child nutritional status is observed in this sample. If households acquire calories from cassava proportional to calories from all staples ranging from 0.3 to less than 0.70 there is a decrease in HAZ by –0.4208 Z-scores. This coefficient is significant at the five percent level. If the proportion is

[10] Regression results for OLS with and without community-fixed effects are reported in Table 9 (see Appendix).

Table 5. 2SLS Regression Results for Child Nutritional Status (Children ages 2-5years)

	Child Nutritional Status (HAZ)			
	2SLS without community-fixed effects		2SLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	-0.1299	-1.3	-0.0226	-0.2
Greater than or equal to .10 and less than .30	-0.1862	-1.3	-0.0298	-0.1
Greater than or equal to .30 and less than .70	-0.4208	-2.2 **	-0.0348	-0.1
Greater than or equal to .70	-0.3730	-2.1 **	0.0010	0.0
Total expenditure per capita (Zambian Kwacha)	0.0008	4.1 ***	0.0009	2.6 ***
Mother's Education: any primary	-0.1184	-1.3	-0.0110	-0.1
Mother's Education: any secondary	-0.0723	-0.6	-0.0311	-0.3
Age of child (months)	-0.0109	-3.2 ***	-0.0080	-2.3 **
Sex of child (female= 1)	0.2449	3.2 ***	0.2443	3.2 ***
Whether female headed household	-0.0518	-0.4	-0.1393	-1.1
Household size	0.0278	1.8 *	0.0253	1.2
Age of household head (years)	-0.0015	-0.4	0.0053	1.3
Percent females 16-30 (years)	-0.0085	-2.2 **	-0.0056	-1.4
Percent females over 30 (years)	0.0050	1.0	0.0003	0.1
Percent males 0-16 (years)	0.0003	0.1	-0.0007	-0.3
Percent males 16-30 (years)	-0.0077	-1.9 *	-0.0080	-2.0 **
Percent males over 30 (years)	-0.0025	-0.4	-0.0066	-1.0
Whether household is urban	-0.0647	-0.5		
R-squared	.		0.1764	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	2.3	0.0564	0.01	0.9998
Test for joint significance of community-fixed effects			328.4	0.000
Specification Tests				
Instrument Relevance	25.5	0.000	7.9	0.0004
Overidentification		0.587		0.38
Durban-Wu-Hausman		0.000		0.000
Number of Clusters			575	
Number of Observations	3920		3920	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

greater than or equal to 0.70, there is a decrease in HAZ by –0.3730, also significant at the five percent level.

The coefficient representing total expenditure per capita is positive and statistically significant at the one percent level for child nutritional status[11]. Income assists the household in accessing food, providing health care for the child and a healthy environment for the child to grow suitably.

Whether a mother has any primary education or whether she has any secondary education does not seem to determine child nutritional status in this study. There is a negative and strongly significant association between the age of the child and child nutritional status as seen in previous studies (e.g. Smith et al., 2003).

Child nutritional status shows evidence of bias toward girls. This is relatively consistent with the empirical findings that in Africa, the nutritional status of a girl is similar or even better than that of a boy (Svedberg, 1990).

The coefficient of the dummy variable representing whether the household is female headed was negative, yet non-significant in explaining child nutritional status. Whether the household is urban has no association with child nutritional status.

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[11] 2SLS regression analysis without community-fixed effects was also carried out using total expenditure per capita squared to see if there would be any change in the cassava terms. No substantial change was observed in the cassava terms in the child nutritional status as well as the food security models.

Larger household size has a positive association with child nutritional status and the coefficient was statistically significant at the ten percent level. The age of the household head seems to have no association with child nutritional status.

5.2.3 The Determinants of Food Security

Regression results for 2SLS with and without community-fixed effects, for all three food security models, are reported in Table 6 through Table 8[12]. When community-fixed effects are included in the 2SLS regression analysis, the coefficients on the cassava dummy variables lose significance and magnitude, yet remain statistically significant for all three models (except for one cassava dummy variable in the dietary diversity model). In staying consistent with the results provided for the determinants of child nutritional status, results for the food security models without community-fixed effects will be used in the subsequent discussion.

5.2.3.1 Diet Quantity

When all coefficient values of the dummy variables that represent the calories from cassava proportional to calories from all staples are compared to the reference category, no cassava acquired, a statistically significant association with diet quantity is observed. Households who acquire small amounts of cassava increase their total calorie

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[12] Regression results for OLS with and without community-fixed effects, for all three food security models, are reported in Table 10 through Table 12 (see Appendix).

availability. However, as households increase the amount of cassava they acquire relative to other staples their total energy acquisition decreases.

The coefficient of the dummy variable for the largest proportion of calories from cassava, greater than or equal to 0.70, is –1,749 calories. Households who acquire cassava as a primary staple come mostly from rural areas (91% of the households from this group are rural). These households may be concentrating solely on cassava in order to secure food and unable to supplement the loss of calories from increased cassava production.

Total expenditure per capita has a positive association with diet quantity, and the coefficient of total expenditure per capita is significant at the one percent level. Income enables households to cultivate or purchase foods that assist them in meeting their caloric needs.

Whether any adult member (>18 years) has any primary education or any secondary education does not seem to influence diet quantity. Whether the household is female headed is not a determinant of diet quantity in this sample.

Whether the household is urban does seem to negatively influence diet quantity. In general, urban households tend to eat less calorie-dense starchy staples and are less physically active than their rural counterparts.

Larger household size has a negative association with diet quantity, and the coefficient representing household size is statistically significant at the one percent level. The age of the household head has a negative association with diet quantity.

Table 6. 2SLS Regression Results for Calorie Availability Per Adult Equivalent

Variables	Calorie Availability Per Adult Equivalent			
	2SLS without community-fixed effects		2SLS with community-fixed effects	
	Coeff.	t-stat	Coeff.	t-stat
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	568.98	6.4 ***	505.99	6.5 ***
Greater than or equal to .10 and less than .30	-346.93	-2.6 ***	-305.27	-2.6 ***
Greater than or equal to .30 and less than .70	-925.08	-7.3 ***	-906.90	-6.5 ***
Greater than or equal to .70	-1749.94	-18.6 ***	-1993.88	-12.7 ***
Total expenditure per capita (Zambian Kwacha)	0.34	5.3 ***	0.40	3.3 ***
Adult Education: any primary	-68.61	-0.7	22.67	0.3
Adult Education: any secondary	-31.29	-0.3	65.25	0.6
Whether female headed household	-21.76	-0.3	-8.51	-0.1
Household size	-141.88	-11.3 ***	-140.24	-8.9 ***
Age of household head (years)	-4.10	-1.9 *	-3.49	-1.6 *
Percent females 16-30 (years)	5.53	3.1 ***	4.86	2.7 ***
Percent females over 30 (years)	8.76	3.9 ***	9.28	4.2 ***
Percent males 0-16 (years)	-4.67	-3.0 ***	-4.92	-3.7 ***
Percent males 16-30 (years)	-3.38	-2.0 **	-3.95	-2.1 **
Percent males over 30 (years)	2.96	1.3	1.05	0.5
Whether household is urban	-343.55	-4.3 ***		
R-squared	0.1922		0.3587	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	109	0.000	62.2	0.000
Test for joint significance of community-fixed effects			202.3	0.000
Specification Tests				
Instrument Relevance	37.1	0.000	7.8	0.0004
Overidentification		0.58		0.14
Durban-Wu-Hausman		0.07		0.07
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

5.2.3.2 Diet Quality

Protein Availability Per Adult Equivalent

When all coefficients of the dummy variables that represent the calories from cassava proportional to calories from all staples are compared to the reference category, no cassava acquired, a statistically significant association with the diet quality measure, protein availability per adult equivalent, is observed. Households who acquire small amounts of cassava increase their total protein availability. However, as households increase the amount of cassava they acquire, their total protein decreases. The coefficient for the largest proportion of calories from cassava, greater than or equal to 0.70, has a value of –59.6 grams of protein.

Similar to diet quantity, larger proportions of calories from cassava are associated with a decline in the total protein in the household diet. This is not surprising because we would expect a reduction in protein to accompany a substantial reduction in calories. In addition, cassava contains very little protein relative to other staples. Therefore, as households increase their calories from cassava and consequently decrease their consumption of other staple foods higher in protein, we would expect the protein content of the diet to be further reduced.

The coefficient of total expenditure per capita is statistically significant at the one percent level for this measure of diet quality. Income contributes positively toward increasing the amount of protein a household acquires (e.g. the purchase of meat).

Table 7. 2SLS Regression Results for Protein Availability Per Adult Equivalent

	Protein Availability Per Adult Equivalent			
	2SLS without community-fixed effects		2SLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	15.44	6.4 ***	11.73	5.4 ***
Greater than or equal to .10 and less than .30	-14.77	-4.5 ***	-13.91	-4.3 ***
Greater than or equal to .30 and less than .70	-33.54	-12.4 ***	-32.87	-9.4 ***
Greater than or equal to .70	-59.64	-28.5 ***	-61.42	-15.1 ***
Total expenditure per capita (Zambian Kwacha)	0.01	5.7 ***	0.01	3.6 ***
Adult Education: any primary	-1.49	-0.5	1.15	0.5
Adult Education: any secondary	-2.23	-0.7	0.72	0.2
Whether female headed household	-1.71	-0.9	-1.39	-0.8
Household size	-3.77	-10.9 ***	-3.43	-6.8 ***
Age of household head (years)	-0.08	-1.4	-0.06	-1.0
Percent females 16-30 (years)	0.12	2.5 ***	0.11	2.1 **
Percent females over 30 (years)	0.22	3.6 ***	0.24	3.8 ***
Percent males 0-16 (years)	-0.13	-3.2 ***	-0.14	-3.6 ***
Percent males 16-30 (years)	-0.13	-2.7 ***	-0.14	-2.6 ***
Percent males over 30 (years)	0.02	0.3	-0.02	-0.4
Whether household is urban	-12.55	-5.4 ***		
R-squared	0.1951		0.3253	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	236.9	0.000	73.8	0.000
Test for joint significance of community-fixed effects			237.7	0.000
Specification Tests				
Instrument Relevance	37.1	0.000	7.8	0.0004
Overidentification		0.73		0.13
Durban-Wu-Hausman		0.004		0.003
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

Whether any adult member (>18 years) has any primary education or any secondary education does not seem to influence diet quality. Whether the household is female headed has a negative but non-significant association with diet quality.

Whether the household is urban does seem to negatively influence diet quality. This is possibly due to a price effect. Larger household size negatively affects protein acquisition. Age of the household head is not a significant determinant.

Dietary Diversity

Recall that dietary diversity is measured by using the number of food groups out of 12[13]. One of the food groups is "roots and tubers", which consists of cassava, Irish potatoes, and sweet potatoes. Regardless of whether a household acquires one, two, or three of these foods, the measure of dietary diversity recognizes them as belonging only to one food group. Given this, when households begin to acquire cassava, they increase the number of food groups acquired by one if they did not previously acquire another root or tuber. In this case, if the coefficient on the dummy variables representing calories from cassava proportional to calories from all staples is equal to one, then cassava has no additional effect on dietary diversity beyond increasing the count of food groups. If the coefficient is less than one or negative, then calories from cassava has a negative effect on dietary diversity.

[13] As dietary diversity is measured by using the number of food groups out of 12, it could also be analyzed using a count regression model in future studies.

Table 8. 2SLS Regression Results for Number of Food Groups

	Number of Food Groups			
	2SLS without community-fixed effects		2SLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	0.9258	10.5 ***	1.1154	13.0 ***
Greater than or equal to .10 and less than .30	0.5403	4.5 ***	0.9560	7.2 ***
Greater than or equal to .30 and less than .70	0.2877	2.3 **	0.7205	5.5 ***
Greater than or equal to .70	-0.7416	-5.0 ***	-0.1187	-0.9
Total expenditure per capita (Zambian Kwacha)	0.0008	6.1 ***	0.0009	3.6 ***
Adult Education: any primary	0.7096	5.0 ***	0.4396	4.2 ***
Adult Education: any secondary	1.4145	8.9 ***	0.8632	6.6 ***
Whether female headed household	-0.3895	-3.7 ***	-0.4408	-4.3 ***
Household size	0.1702	10.7 ***	0.1671	6.0 ***
Age of household head (years)	-0.0157	-5.5 ***	-0.0128	-4.3 ***
Percent females 16-30 (years)	-0.0010	-0.4	-0.0022	-0.9
Percent females over 30 (years)	-0.0048	-1.9 *	-0.0058	-2.1 **
Percent males 0-16 (years)	-0.0028	-1.4	-0.0036	-1.9 *
Percent males 16-30 (years)	-0.0071	-2.9 ***	-0.0102	-3.6 ***
Percent males over 30 (years)	-0.0136	-4.7 ***	-0.0185	-5.4 ***
Whether household is urban	1.3657	9.6 ***		
R-squared	0.2606		0.4169	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	55.4	0.000	51.7	0.000
Test for joint significance of community-fixed effects			1245.2	0.000
Specification Tests				
Instrument Relevance	37.1	0.000	7.8	0.0004
Overidentification		0.95		0.12
Durban-Wu-Hausman		0.000		0.000
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

As can be seen from Table 8, all of the coefficients on the cassava dummy variables are less than one, and that for the "greater than or equal to 0.70" dummy is negative. All coefficients are statistically significant at the five percent level or lower. While not all sample households acquiring cassava have cassava as their only root or tuber[14], these results suggest that cassava acquisition has a likely negative effect on dietary diversity in this sample, especially when cassava is a primary staple.

Total expenditure per capita has a positive association with dietary diversity. Increased income enables households to cultivate or purchase more foods and therefore increase the number of food groups they acquire.

The coefficients for the dummy variables representing whether any adult has primary education or any secondary education are positive for dietary diversity and significant at the one percent level. As educational levels of adult members in the household improve, so too does their awareness of the benefits of diversifying their diets.

Whether the household is female headed has a negative association with dietary diversity. Perhaps female headed households are concentrating primarily on the staple food (due to their domestic obligations) and therefore have less time to cultivate alternative foods or cash crops.

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[14] Around 50% of households in the greater than zero and less than 0.10 group only acquire cassava as their root or tuber; around 54% of households in the greater than or equal to 0.10 and less than 0.30 group; around 56% of households in the greater than or equal to 0.30 and less than 0.70 group; and around 60% of households in the greater than or equal to 0.70 group.

Whether the household is urban has a positive association with dietary diversity. Urban households may have better access to different foods that may allow them to increase their overall dietary diversity.

Household size has a positive association with dietary diversity. As households increase in size, so too does the diversity of their diet. The age of the head of the household seems to negatively affect the number of food groups the household acquires.

5.2.4 Specification Tests

The specification tests described in Chapter 4 could not be performed in STATA when at the same time accounting for the survey design. Therefore, testing for heteroskedasticity, omitted variable bias, and multicollinearity was performed using standard regression models without community-fixed effects that do not account for the survey design.

A strong presence of heteroskedasticity was detected in all four models. The Cook-Weisberg tests are provided in Table 13 through Table 16 and robust standard errors are reported using weighted least squares (see Appendix). Correcting for heteroskedasticity does not appreciably influence the t-statistics of the coefficients in the child nutritional status model. Correcting for heteroskedasticity in the diet quantity and diet quality models does not substantially change the magnitude of the t-statistics except for the coefficient representing income. For example, the t-statistic of the coefficient of total expenditure per capita changes from 21 to 6.8 in the diet quantity model. This suggests that income may be the source of the heteroskedasticity. Lastly, all coefficients that were significant in the standard models without correcting for heteroskedasticity remain significant in the models correcting for heteroskedasticity.

When testing for multicollinearity, all four models met the following criteria established in Chapter 4 (StataCorp 2001): none of the largest VIF are greater than 10 and the mean VIF in all four models are not considerably greater than 1. The Ramsey-Reset test (StataCorp 2001) revealed possible omitted variable bias in all three food security models, yet was not a problem in the child nutritional status model.

5.3 Answers To The Research Questions

5.3.1 Child Nutritional Status

Does adopting cassava as a primary staple contribute negatively to child nutritional status? This study does find a negative association between cassava acquisition and child nutritional status when community-fixed effects are not included in the child nutritional status model. On the other hand, when community-fixed effects are included, there is no statistical association between cassava acquisition and child nutritional status. This is possibly due to a strong correlation between cassava production (and thus acquisition) and location-specific factors such as soil type and climate, rather than the absence of an association in reality. Furthermore, since food security has a direct influence on child nutritional status, and cassava has a negative association with food security regardless of which model is used (with or without community-fixed effects), there is a strong possibility that cassava has a negative impact on child nutritional status.

5.3.2 Diet Quantity

Is household calorie availability a pathway through which cassava influences child nutritional status? Cassava is a significant determinant of diet quantity in Zambia. The coefficients on the dummy variables representing calories from cassava proportional to calories from all staples were substantial in size, and as the proportions of calories from cassava increase, the magnitudes of the negative coefficients become increasingly large. As households increase their consumption of cassava and decrease their consumption of other staple foods, less total calories are available for the household. A decrease in total calories for the household likely reduces the calories provided for the child and could potentially result in child malnutrition.

5.3.3 Diet Quality

Is household protein availability a pathway through which cassava influences child nutritional status? The potentially harmful characteristic of cassava is its lack of protein. Households that supplement cassava in small proportion appear to increase their total calories and protein. However, as the proportions of staples calories from cassava increases, the total protein availability in the household diet decreases monotonically. Protein is an extremely important nutrient that young children require to develop. If households increase their proportion of calories from cassava and are unable to access protein from other sources, child nutritional status will likely be compromised.

Is dietary diversity a pathway through which cassava influences child nutritional status? In this sample, cassava acquisition has a likely negative effect on dietary diversity. As children develop and no longer depend entirely on their mother's breast for nutrient intake, diversity in foods across and within food groups becomes imperative, as shown by Arimond and Ruel (2002), who found a strong statistically significant association between food-group diversity measures and children's height-for-age Z-scores. If a household acquires a large proportion of calories from cassava and cannot supplement the diet with diverse foods that can assist in providing proper nutrition to their children, child nutritional status will likely be negatively effected.

CHAPTER 6

CONCLUSIONS & POLICY IMPLICATIONS

Does adopting cassava as a primary staple contribute negatively to child nutritional status? Are household calorie and protein availability and dietary diversity pathways through which cassava influences child nutritional status? This study has attempted to answer these questions using data on children's nutritional status and food acquisition from Zambia.

6.1 Conclusions

2SLS regression analysis has revealed that in Zambia increases in cassava consumption, as measured by the calories acquired from cassava proportional to calories acquired from all primary staples, have 1) a negative impact on household calorie availability; 2) a negative impact on household protein availability; 3) a likely negative impact on dietary diversity; and 4) a likely negative impact on child nutritional status.

Poor rural households in Zambia are constantly struggling with food insecurity and a lack of resources to cultivate superior staple foods. Cassava is an alternative to resource dependent staple foods (such as maize) that provides the household with a source of cheap calories. If cassava makes up a large proportion of staples calories a household acquires, total energy availability is negatively impacted. Along these same lines, total protein availability is also negatively impacted, partly because of the considerably lower protein content of cassava compared to other staples. Further, the diversity of the household's diet is likely reduced, signaling a reduction in the quality of the household's diet.

Does adopting cassava as a primary staple contribute negatively to child nutritional status? Given that (a) the above mentioned indicators of food security are negatively impacted by cassava; (b) food security is a pathway which directly influences the dietary intake of a child; and (c) the empirical results of this study indicate a negative association between cassava acquisition and children's' long-run nutritional status, then cassava likely has a negative impact on the nutritional status of children ages 2 to 5 years, who are dependent on food for their nutritional well-being.

6.2 Policy Implications

Should agricultural policy support the current shift toward cassava by poor rural households striving to become food secure? Will agricultural policy that supports the promotion of cassava varieties provide households with a means of securing adequate and nutritious food?

The June 2003 monthly report for Zambia provided by the Famine Early Warning Systems Network (FEWS NET) showed an increase by 15% country wide in the production of cassava during the 2002/03 production season. This included the nontraditional cassava growing areas. In some regions, increases in production of cassava by over 180 and 200% were witnessed compared to the previous year. These increases were a direct result of the government's distribution of early maturing cassava varieties to small-scale farmers for the past three years by its Food Security Pack Program (FEWS NET, 2003).

Programs that emphasize a particular strategy for poor rural households who are food insecure are multifaceted. They must address not only issues of production, but also how certain crops impact markets, nutrition, and poverty alleviation. Also, programs need to address issues concerning where best to target their strategy, who benefits the most from certain strategies and what the spillover effects within the general population are. This research has shown that policy makers promoting cassava as a food security crop must consider the nutritional tradeoffs of its net impact. Cassava is an attractive crop for households that are poor. Cassava production seems to be a plausible solution for a household's transitory food security problem. However, the results in this study show that adopting cassava as a primary staple negatively impacts the household diet.

If programs intended to increase total food availability by encouraging the cultivation of cassava by poor households are implemented, they need to also 1) incorporate nutritional awareness programs—when promoting cassava as a food security crop a more synergistic approach would include nutritional awareness programs to better inform households about the potential negative effects of a cassava-based food typology; 2) promote the production of crops such as legumes to improve the household diet—programs that encourage households to cultivate food crops high in nutrient quality and combine them with their cassava-based meals could substantially improve household nutrition; and 3) .promote income generating activities for poor households that could provide them with the needed income to supplement foods high in nutrient quality.

APPENDIX

Table.1 Calorie and Protein Conversion Factors

Foodname	kcals_100g	protein_100g	Edible Percentage
Cassava	149	1.2	74
Millet	346	8.9	100
Sorghum	345	10.7	100
Rice	353	7	100
Sweet potatoes	121	1.6	79
Irish potatoes	82	1.7	86
Groundnuts	549	23	100
Beans	347.8	22	100
Eggs	140	12	88
Milk (fresh)	79	3.8	100
Sugar	387	0	100
Salt	0	0	100
Cooking oil	884	0	100
Non-alcoholic beverage	39	0.05	100
Alcoholic beverage	90.25	0.6	100
Maize grain	357	9.4	100
Breakfast mealie meal	353	8	100
Roller mealie meal	353	10	100
Hammermilled meal	353	10	100
Kapenta	233.5	44	100
Bream	224.75	18.4	88
Misc. Fish	229.125	18.8	94
Chicken	146	20	67
Goat	168	18	74
Pork	418	12	82
Misc. meat	223	18	77.25
Tomatoes	21	1	96
Onions	41	1.2	94
Cabbage	26	1.7	80
Leaves	25	2.76	80
Misc. vegetables	38.8	1.665	87.6
Bread	261	7.7	100
Bun/roll	261	7.7	100
Fritter	227	4.7	100
Misc. bread	261	7.7	100
Lemons	29	0.6	64
Bananas	88	1.5	68
Oranges	49	0.6	72
Papaya	32	0.4	74
Misc. fruits	60.9	0.775	70.22

Table 9. OLS Regression Results for Child Nutritional Status (Children ages 2-5years)

Variables	Child Nutritional Status (HAZ)			
	OLS without community-fixed effects		OLS with community-fixed effects	
	Coeff.	t-stat	Coeff.	t-stat
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	-0.1518	-1.5	0.05709	0.5
Greater than or equal to .10 and less than .30	-0.2460	-1.7 *	-0.02910	-0.1
Greater than or equal to .30 and less than .70	-0.4637	-2.5 ***	-0.00211	0.0
Greater than or equal to .70	-0.4747	-2.7 ***	-0.09049	-0.4
Total expenditure per capita (Zambian Kwacha)	0.0001	2.1 **	0.00004	0.9
Mother's Education: any primary	-0.1469	-1.6	-0.01600	-0.2
Mother's Education: any secondary	0.1455	1.4	0.12751	1.2
Age of child (months)	-0.0095	-2.8 ***	-0.00723	-2.1 **
Sex of child (female= 1)	0.2378	3.2 ***	0.23860	3.2 ***
Whether female headed household	-0.1010	-0.9	-0.22459	-2.0 **
Household size	0.0110	0.8	-0.01223	-0.9
Age of household head (years)	-0.0057	-1.6	0.00212	0.6
Percent females 16-30 (years)	-0.0026	-0.7	-0.00119	-0.3
Percent females over 30 (years)	0.0095	2.0 **	0.00330	0.7
Percent males 0-16 (years)	0.0001	0.0	-0.00059	-0.2
Percent males 16-30 (years)	-0.0043	-1.1	-0.00381	-1.1
Percent males over 30 (years)	0.0031	0.5	-0.00102	-0.2
Whether household is urban	0.2406	2.8 ***		
R-squared	0.0459		0.3349	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	3.6	0.0064	0.12	0.9757
Test for joint significance of community-fixed effects			1101.3	0.000
Number of Clusters			575	
Number of Observations	3920		3920	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

Table 10. OLS Regression Results for Calorie Availability Per Adult Equivalent

	Calorie Availability Per Adult Equivalent			
	OLS without community-fixed effects		OLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	558.15	6.2 ***	523.97	6.9 ***
Greater than or equal to .10 and less than .30	-352.33	-2.6 ***	-287.41	-2.4 ***
Greater than or equal to .30 and less than .70	-936.76	-7.3 ***	-899.88	-6.4 ***
Greater than or equal to .70	-1769.38	-18.5 ***	-2009.20	-12.6 ***
Total expenditure per capita (Zambian Kwacha)	0.22	5.3 ***	0.20	5.0 ***
Adult Education: any primary	-59.44	-0.6	36.16	0.4
Adult Education: any secondary	23.34	0.2	122.28	1.2
Whether female headed household	6.36	0.1	24.29	0.4
Household size	-150.99	-12.7 ***	-158.81	-14.9 ***
Age of household head (years)	-5.32	-2.5 ***	-4.81	-2.4 **
Percent females 16-30 (years)	6.41	3.7 ***	6.00	3.7 ***
Percent females over 30 (years)	9.74	4.4 ***	10.49	5.1 ***
Percent males 0-16 (years)	-4.53	-3.0 ***	-4.66	-3.7 ***
Percent males 16-30 (years)	-1.97	-1.3	-2.13	-1.4
Percent males over 30 (years)	5.04	2.5 ***	3.62	1.9 **
Whether household is urban	-250.62	-3.5 ***		
R-squared	0.2038		0.3821	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	107.1	0.000	63.2	0.000
Test for joint significance of community-fixed effects			231.9	0.000
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

Table 11. OLS Regression Results for Protein Availability Per Adult Equivalent

	Protein Availability Per Adult Equivalent			
	OLS without community-fixed effects		OLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	14.95	6.1 ***	12.56	5.9 ***
Greater than or equal to .10 and less than .30	-15.01	-4.4 ***	-13.09	-4.1 ***
Greater than or equal to .30 and less than .70	-34.07	-12.2 ***	-32.54	-9.1 ***
Greater than or equal to .70	-60.51	-28.5 ***	-62.13	-15.0 ***
Total expenditure per capita (Zambian Kwacha)	0.01	5.1 ***	0.01	4.8 ***
Adult Education: any primary	-1.08	-0.4	1.78	0.7
Adult Education: any secondary	0.21	0.1	3.36	1.2
Whether female headed household	-0.45	-0.3	0.13	0.1
Household size	-4.18	-13.1 ***	-4.29	-14.7 ***
Age of household head (years)	-0.14	-2.4 **	-0.12	-2.2 **
Percent females 16-30 (years)	0.16	3.5 ***	0.16	3.7 ***
Percent females over 30 (years)	0.26	4.4 ***	0.29	5.2 ***
Percent males 0-16 (years)	-0.13	-3.1 ***	-0.13	-3.6 ***
Percent males 16-30 (years)	-0.06	-1.5	-0.06	-1.4
Percent males over 30 (years)	0.11	2.0 *	0.09	1.8 *
Whether household is urban	-8.38	-4.2 ***		
R-squared	0.2262		0.3923	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	233	0.000	75.1	0.000
Test for joint significance of community-fixed effects			340.3	0.000
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

Table 12. OLS Regression Results for Number of Food Groups

	Number of Food Groups			
	OLS without community-fixed effects		OLS with community-fixed effects	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	0.8768	9.4 ***	1.1844	14.2 ***
Greater than or equal to .10 and less than .30	0.5158	4.1 ***	1.0245	7.4 ***
Greater than or equal to .30 and less than .70	0.2348	1.9 *	0.7474	5.5 ***
Greater than or equal to .70	-0.8296	-5.6 ***	-0.1774	-1.3
Total expenditure per capita (Zambian Kwacha)	0.0002	4.9 ***	0.0001	4.0 ***
Adult Education: any primary	0.7511	5.1 ***	0.4913	5.0 ***
Adult Education: any secondary	1.6618	10.0 ***	1.0820	10.4 ***
Whether female headed household	-0.2623	-3.0 ***	-0.3150	-4.1 ***
Household size	0.1290	9.9 ***	0.0959	8.6 ***
Age of household head (years)	-0.0212	-8.1 ***	-0.0179	-7.8 ***
Percent females 16-30 (years)	0.0030	1.6	0.0021	1.3
Percent females over 30 (years)	-0.0004	-0.2	-0.0012	-0.6
Percent males 0-16 (years)	-0.0021	-1.2	-0.0026	-1.7 *
Percent males 16-30 (years)	-0.0007	-0.4	-0.0032	-2.2 **
Percent males over 30 (years)	-0.0042	-1.9 *	-0.0086	-4.3 ***
Whether household is urban	1.7864	16.8 ***		
R-squared	0.3863		0.5992	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	52	0.000	70.6	0.000
Test for joint significance of community-fixed effects			1808.5	0.000
Number of Clusters			610	
Number of Observations	11496		11496	

Note: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level

Table 13. Regression Results for Child Nutritional Status (Children ages 2-5years): Correction for Heteroskedasticity

	Child Nutritional Status (HAZ)			
	OLS		WLS	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	-0.1096	-1.3	-0.1096	-1.4
Greater than or equal to .10 and less than .30	-0.3494	-2.6 ***	-0.3494	-2.9 ***
Greater than or equal to .30 and less than .70	-0.3874	-2.3 **	-0.3874	-2.5 ***
Greater than or equal to .70	-0.4288	-3.0 ***	-0.4288	-3.0 ***
Total expenditure per capita (Zambian Kwacha)	0.0001	3.5 ***	0.0001	2.6 ***
Mother's Education: any primary	-0.1252	-1.8 *	-0.1252	-1.8 *
Mother's Education: any secondary	0.2369	3.0 ***	0.2369	2.9 ***
Age of child (months)	-0.0055	-2.1 **	-0.0055	-2.0 **
Sex of child (female= 1)	0.1509	2.6 ***	0.1509	2.6 ***
Whether female headed household	-0.1564	-1.6	-0.1564	-1.6
Household size	0.0097	1.1	0.0097	1.1
Age of household head (years)	-0.0022	-0.7	-0.0022	-0.7
Percent females 16-30 (years)	-0.0013	-0.5	-0.0013	-0.5
Percent females over 30 (years)	0.0123	2.9 ***	0.0123	3.0 ***
Percent males 0-16 (years)	-0.0001	0.0	-0.0001	0.0
Percent males 16-30 (years)	0.0009	0.3	0.0009	0.3
Percent males over 30 (years)	0.0053	1.2	0.0053	1.2
Whether household is urban	0.2221	3.9 ***	0.2221	4.0 ***
R-squared	0.0427		0.0427	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	4.7	0.0008	5.2	0.0004
	Chi2-statistic	**p-value**		
Cook-Weisberg heteroskedasticity test	34.98	0.000		
Number of Observations	3920		3920	

The WLS t-statistics are based on White-corrected standard errors. ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Note: Results are based on standard regression models that do not account for the survey design.

Table 14. Regression Results for Calorie Availability Per Adult Equivalent: Correction for Heteroskedasticity

	Calorie Availability Per Adult Equivalent			
	OLS		WLS	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	585.408	11.1 ***	585.408	9.9 ***
Greater than or equal to .10 and less than .30	-287.592	-3.8 ***	-287.592	-4.0 ***
Greater than or equal to .30 and less than .70	-935.478	-9.8 ***	-935.478	-12.6 ***
Greater than or equal to .70	-1858.901	-22.8 ***	-1858.901	-38.8 ***
Total expenditure per capita (Zambian Kwacha)	0.178	21.0 ***	0.178	6.8 ***
Adult Education: any primary	-170.210	-2.6 ***	-170.210	-2.2 **
Adult Education: any secondary	-40.715	-0.6	-40.715	-0.5
Whether female headed households	24.363	0.5	24.363	0.5
Household size	-128.541	-17.7 ***	-128.541	-15.0 ***
Age of household head (years)	-7.362	-4.7 ***	-7.362	-4.2 ***
Percent females 16-30 (years)	8.501	6.9 ***	8.501	6.4 ***
Percent females over 30 (years)	13.308	9.4 ***	13.308	7.8 ***
Percent males 0-16 (years)	-3.823	-3.5 ***	-3.823	-3.6 ***
Percent males 16-30 (years)	-0.257	-0.2	-0.257	-0.2
Percent males over 30 (years)	8.956	6.7 ***	8.956	5.2 ***
Whether household is urban	-200.296	-5.6 ***	-200.296	-5.0 ***
R-squared	0.2068		0.2068	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	195	0.000	447.7	0.000
	Chi2-statistic	**p-value**		
Cook-Weisberg heteroskedasticity test	1844.7	0.000		
Number of Observations	11496		11496	

The WLS t-statistics are based on White-corrected standard errors. ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Note: Results are based on standard regression models that do not account for the survey design.

Table 15. Regression Results for Protein Availability Per Adult Equivalent: Correction for Heteroskedasticity

	Protein Availability Per Adult Equivalent			
	OLS		WLS	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	15.556	10.9 ***	15.556	9.8 ***
Greater than or equal to .10 and less than .30	-13.586	-6.6 ***	-13.586	-7.7 ***
Greater than or equal to .30 and less than .70	-34.491	-13.4 ***	-34.491	-21.1 ***
Greater than or equal to .70	-61.501	-27.9 ***	-61.501	-52.0 ***
Total expenditure per capita (Zambian Kwacha)	0.005	20.2 ***	0.005	6.3 ***
Adult Education: any primary	-4.404	-2.5 ***	-4.404	-2.1 **
Adult Education: any secondary	-1.447	-0.8	-1.447	-0.7
Whether female headed households	0.391	0.3	0.391	0.3
Household size	-3.534	-18.0 ***	-3.534	-15.0 ***
Age of household head (years)	-0.183	-4.3 ***	-0.183	-3.9 ***
Percent females 16-30 (years)	0.210	6.3 ***	0.210	5.9 ***
Percent females over 30 (years)	0.347	9.1 ***	0.347	7.6 ***
Percent males 0-16 (years)	-0.108	-3.7 ***	-0.108	-3.8 ***
Percent males 16-30 (years)	-0.023	-0.8	-0.023	-0.7
Percent males over 30 (years)	0.221	6.1 ***	0.221	4.8 ***
Whether household is urban	-7.082	-7.3 ***	-7.082	-6.5 ***
R-squared	0.2207		0.2207	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	284	0.000	782	0.000
	Chi2-statistic	**p-value**		
Cook-Weisberg heteroskedasticity test	1970	0.000		
Number of Observations	11496		11496	

The WLS t-statistics are based on White-corrected standard errors. ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Note: Results are based on standard regression models that do not account for the survey design.

Table 16. Regression Results for Number of Food Groups: Correction for Heteroskedasticity

	Number of Food Groups			
	OLS		WLS	
Variables	**Coeff.**	**t-stat**	**Coeff.**	**t-stat**
Calories from cassava/calories from all staples:				
Greater than .0 and less than .10	0.8010	12.8 ***	0.8010	13.8 ***
Greater than or equal to .10 and less than .30	0.4383	4.8 ***	0.4383	5.2 ***
Greater than or equal to .30 and less than .70	0.2130	1.9 *	0.2130	2.1 **
Greater than or equal to .70	-0.8259	-8.5 ***	-0.8259	-9.3 ***
Total expenditure per capita (Zambian Kwacha)	0.0002	19.1 ***	0.0002	6.0 ***
Adult Education: any primary	0.7898	10.0 ***	0.7898	9.5 ***
Adult Education: any secondary	1.7202	20.8 ***	1.7202	19.3 ***
Whether female headed households	-0.2899	-5.1 ***	-0.2899	-4.9 ***
Household size	0.1231	14.2 ***	0.1231	14.1 ***
Age of household head (years)	-0.0206	-11.0 ***	-0.0206	-10.3 ***
Percent females 16-30 (years)	0.0033	2.3 **	0.0033	2.3 **
Percent females over 30 (years)	0.0005	0.3	0.0005	0.3
Percent males 0-16 (years)	-0.0013	-1.0	-0.0013	-1.0
Percent males 16-30 (years)	-0.0033	-2.6 ***	-0.0033	-2.5 ***
Percent males over 30 (years)	-0.0039	-2.4 **	-0.0039	-2.3 **
Whether household is urban	1.7591	41.2 ***	1.7591	36.8 ***
R-squared	0.3909		0.3909	
	F-statistic	**p-value**	**F-statistic**	**p-value**
Test for joint significance of cassava step dummies	69.6	0.000	84.7	0.000
	Chi2-statistic	**p-value**		
Cook-Weisberg heteroskedasticity test	21.5	0.000		
Number of Observations	11496		11496	

The WLS t-statistics are based on White-corrected standard errors. ***significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Note: Results are based on standard regression models that do not account for the survey design.

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