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Pathways to food security in South Africa: Food quality and quantity in NIDS Wave 1

by
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Pathways to food security in South Africa: Food quality and quantity in NIDS Wave 1

Amy Julia Thornton, Murray Leibbrandt and Cally Ardington

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Abstract

South Africa is food secure at the national level; however widespread food insecurity persists at the household level. To understand the dynamics of micro-level food insecurity this paper investigates how two different aspects of 'food access' – diet quality and diet quantity – affect two outcomes of 'food utilisation' – hunger and nutrition. Diet quantity is captured by food expenditure in Wave 1 of the National Income Dynamics Study (NIDS). To capture diet quality I use dietary diversity, which is not directly available in NIDS. I build and test a food group dietary diversity score and a food variety dietary diversity score using NIDS Wave 1. Both dietary diversity indicators are found to usefully summarise information about food security in South Africa by using methods found in the dietary diversity literature. The paper then turns to testing whether the theoretical differences between diet quality and quantity play out empirically in the case of nutrition (adult BMI) and hunger (self-reported household hunger). The results reveal that food variety and food quantity are complementary in explaining the chance of household hunger, with food quantity having a slightly more important effect. The pathways to BMI differ by gender. Dietary diversity and food expenditure are substitutes in the case of male BMI; however, food variety and food expenditure are complementary to explaining female BMI when food expenditure enters into the model as a quadratic. Overall, food variety proved to be a stronger and more significant correlate of both outcomes than the food group dietary diversity score.

List of acronyms

AFSUN	African Food Security Urban Network
BMI	Body Mass Index
DHS	Demographic & Health Survey
FANTA	Food & Nutrition Technical Assistance
FAO	Food & Agriculture Organisation
FCS	Food Consumption Score
FWL	Frisch-Waugh-Lovell
GHS	General Household Survey
HAZ	Health-for-Age Z-Score
HDDS	Household Dietary Diversity Score
HFSSM	Household Food Security Survey Module
HSRC	Human Sciences Research Council
LCS	Living Conditions Survey
MAR	Mean Adequacy Ratio
NAR	Nutrient Adequacy Ratio
NDDS	NIDS Dietary Diversity Score
NFCS	National Food Consumption Survey
NFVS	NIDS Food Variety Score
NIDS	National Income Dynamics Study
OHS	October Household Survey
PoU	Prevalence of Undernourishment
PSU	Primary Sampling Unit
RDA	Recommended Daily Allowance
SALDRU	Southern African Labour & Development Research Unit
StatsSA	Statistics South Africa
WAZ	Weight-for-Age Z-Score
WHO	World Health Organisation
WHZ	Weight-for-Height Z-Score

1. Introduction

The year 2015 was the deadline for the Millennium Development Goals adopted by members of the United Nations in 2000, including Goal 1c which states the aim of "cutting by half the proportion of people who suffer from hunger by 2015" (FAO, 2015: 4). The FAO (2015) can fortunately report that the number of hungry has decreased steadily since 2000. The number of undernourished individuals has fallen from 1 011 million in 1990/2 to 795 million in 2014/5 (FAO, 2015).[1] Many developing countries have achieved MDG 1c, including South Africa. But, what exactly does the FAO mean when it says hunger has fallen? The FAO measures hunger as the prevalence of undernourishment (PoU), which is "the probability that a randomly selected individual from the reference population is found to consume less than his/her calorie requirement for an active and healthy life" (FAO, 2015: 49). More specifically then, the FAO's method suggests that consumption of calories in the world has increased steadily since 2000.

However, as calorie-deficiency is falling, obesity is on the rise in the developing world (Kanter & Caballero, 2012; Keats & Wiggins, 2014; Mendez et al., 2005). The World Health Organisation (WHO) (2016) reports that 1.9 billion people over the age of 18 were overweight in 2014 and 600 million of these were obese. Two thirds of the overweight or obese people in the world live in the developing world in which overweight and obesity tripled between 1980 and 2008 (Keats & Wiggins, 2014). Obesity often masks 'hidden hunger' - the newer phenomenon of a lack of micronutrients disguised by sufficient calorie or energy consumption (Burchi et al., 2011; Kennedy et al., 2003). It is estimated that over two billion people suffered from hidden hunger in 2012; a number much higher than the 820.7 million estimated hungry in 2012 by the FAO (Jones et al., 2013). Kennedy et al. (2003: 8) explain that micronutrient deficiencies often go unnoticed because they are "subclinical" and in some cases difficult to assess (e.g. zinc deficiency). Micronutrient deficiencies can lead to severe conditions such as goitre and blindness. Other afflictions include loss of productivity, diminished immune system functioning (e.g. Vitamin A, zinc, folate), mental disability (e.g. iodine), anaemia (e.g. iron), and infant and maternal mortality (e.g. iron).

Together, these three phenomena constitute the 'triple burden of malnutrition': falling hunger, rising obesity, and ubiquitous hidden hunger (Fan, 2014). The trends of the triple burden are partly explained by many developing countries undergoing 'nutrition transitions' since the 1980s (Faber & Wenhold, 2007). This means population diet patterns changed in accordance with economic, social or demographic changes such as increasing globalisation, urbanisation, supermarketisation, and technological change (Popkin et al., 2012; Kimenju et al., 2015). Nutrition transitions typically signal changes to a more sedentary lifestyle, decreased consumption of traditional vegetable foods and increased consumption of sugary, fatty and energy-dense foods (Popkin et al., 2012; Kimenju et al., 2015; Faber & Wenhold, 2007). A consequence of this is the explosion of obesity in the developing world in which there are now more overweight women than underweight ones (Monteiro et al., 2004).

According to the FAO South Africa has achieved the MDG 1c of halving hunger by 2015 (FAO, 2015). Nonetheless, South Africa is far from food secure at the household level (Hendriks, 2014; Hendriks, 2005; Altman et al., 2009; Frayne et al., 2010). Just over a quarter of households experienced hunger in 2012, whilst a further 28.3% were at "risk of hunger" (Hendriks, 2014). Approximately 26.5% of children aged 0-3 years were stunted in the same year. Evidence exists that micronutrient deficiencies (i.e. hidden hunger) are high amongst samples of South African children (Steyn et al., 2005) and adults

[1] These numbers have been challenged by Butler (2015) who argues that frequent changes in the FAO methodology have adjusted the numbers favourably towards attainment of the MDG 1c. Estimates for the '90s have been revised upwards, while estimates from the 2000s have been revised downwards. Pre-2013 estimates put the number of hungry at 830-40 million in 1990/2

(Hendriks, 2014; Msaki & Hendriks, 2013; Oldewage-Theron & Kruger, 2008), and that these deficiencies coexist with high levels of overweight and obesity (Oldewage-Theron & Kruger, 2008).

The aim of this paper is to better understand food security and the triple burden of malnutrition in South Africa. To do this, this paper examines two measures of food security which theoretically capture different aspects of food access. Food expenditure is a traditional measure which theoretically captures quantity of consumption (de Haen et al, 2011; Hoddinott & Yohannes, 2002; Jones et al., 2013). Dietary diversity is a newer measure which theoretically captures quality of consumption (Jones et al, 2013; Ruel, 2002; Hoddinott & Yohannes, 2002). The hope is that together these two indicators can intersect to capture food security in a way that a calorie-specific approach like the FAO's PoU cannot.

This paper undertakes two empirical tasks which follow on from each other. The work is carried out using Wave 1 of the National Income Dynamics Study (NIDS) which is a nationally representative panel data set for South Africa. First, a dietary diversity indicator is created and compared to food expenditure which is readily available in the data set. The aim of the first task is to check whether dietary diversity can work as an indicator of food security for this South African sample. The second task is to compare both indicators to other food security outcomes, namely the Body Mass Index (BMI) and hunger. The aim in this case is to identify to what degree each indicator contributes different information given how they differ in theory. The second task addresses questions like: are theoretical differences playing out empirically? Is it worthwhile to look at both indicators because they have a complementary relationship, or can we select one? More generally, what do the pathways between food quality and quantity and South African hunger and nutrition look like?

The paper is organised as follows: first literature concerning food security, dietary diversity, and the food security status of South Africa is discussed in Section 2. Next, the study sets up a conceptual framework in Section 3 and draws up hypotheses. The NIDS data is then described in Section 4, and a dietary diversity indicator is created in Section 5. I spend Section 6 setting up assumptions and acknowledging caveats of the dietary diversity indicator for precise interpretation in empirical work later on. Section 7 lays out methodology for the two tasks described in the paragraph above. Section 8 presents the empirical results affirming the usefulness of dietary diversity. Since I now have a new indicator, I take the opportunity to use it to describe South African food security and observe how it interacts with the outcome variables in Section 9. Section 10 offers empirical results for task two. The paper ends with a discussion and conclusion in Section 11.

2. Literature Review

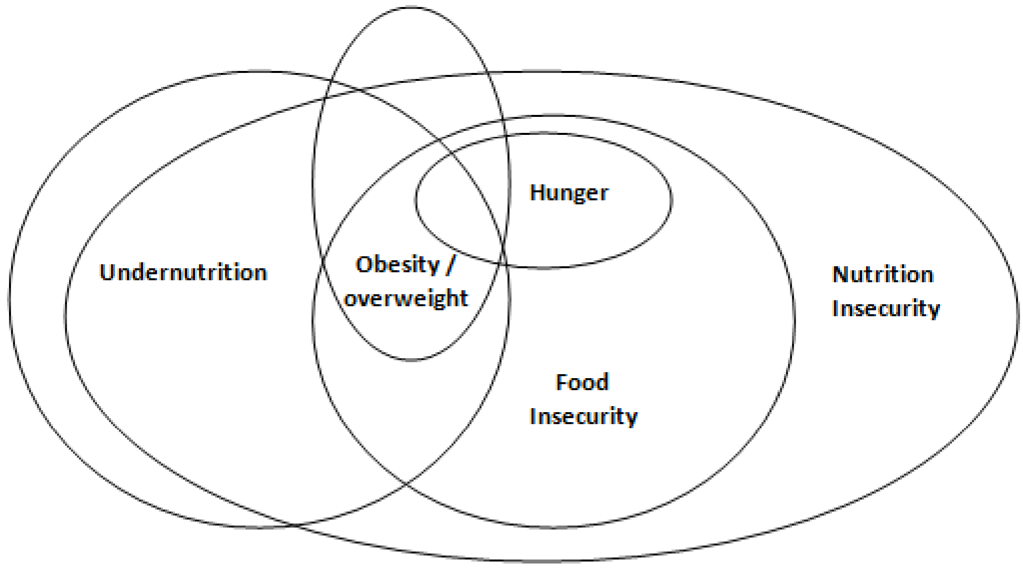
2.1. Food Security and its Manifestations

Food security is a multi-dimensional concept that tries to capture how food relates to poverty (Hendriks, 2005; Webb et al., 2006). There are many overlapping factors to food security and different ways in which countries, regions, households, and individuals can be vulnerable to food insecurity (Webb et al., 2006; de Haen et al., 2011; Jones et al, 2013). The multi-dimensional character of food security makes it difficult to define and measure. Hendriks (2005) quotes Maxwell (1996) who points out that there were more than 250 definitions of food security by 1996; and Hoddinott (1999) who recorded more than 450 indicators for food security by 1999. This proliferation of definitions makes it worthwhile to think carefully about what is meant when talking about food security (Hendriks, 2005; Jones et al., 2013).

Figure 1 below provides a structure to think about food security. The concept of nutrition insecurity is broader than that of food insecurity as it also pertains to safety, care, and hygiene (Jones et al., 2013). Food insecurity overlaps with undernutrition and obesity/overweight, but completely encompasses hunger. Hunger and undernutrition are the key concepts with which food insecurity is understood. Hunger is the lack of sufficient calories (Burchi et al., 2011) and undernutrition the lack of adequate nutrients for healthy bodily functioning (Ruel, 2002). The intersection of hunger and undernutrition is a serious manifestation of food insecurity. However, undernutrition can also be unrelated to food insecurity or hunger if it is caused by factors like disease (Jones et al., 2013). Obesity/overweight can be a function of overeating or medical conditions which is why it is broader than that of food insecurity and nutrition security. However, obesity/overweight can co-exist with (and therefore mask) a lack of micronutrients and even hunger (Kennedy et al., 2003). Such a masking is an example of hidden hunger.

Figure 1: Conceptualising Food Security

Adapted from Jones et al. (2013), page 482, Figure 1.



The influential 1996 World Food Summit in Rome recognised three domains of food security: availability, access, and utilisation. Availability pertains to calories available for consumption, typically at the national level. The PoU is a measure of availability, for example. Access relates to the ability of households to obtain food, taking constraints like income into account. An example of a food access indicator is food expenditure. Utilisation concerns what is done with food once it is obtained, for example intra-household distribution decisions. Child Height-for-Age Z-scores are an example of a food utilisation indicator. The domains are hierarchical to each other in that availability is necessary but not sufficient for access which in turn is necessary but not sufficient for utilisation (Webb et al., 2006). The Summit adopted the following widely-used definition employed by this paper:

> "*Food security exists, at the individual, household, national, regional, and global level when all people at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life*" (FAO, 1996)

2.2. Dietary Diversity

In a context of rising obesity and hidden hunger, emphasis on indicators that capture diet quality (versus. quantity) has increased. A useful definition of diet quality has not been formed in the literature, however, it is often assumed to be proxying for nutrient adequacy (Ruel, 2002). Nutrient adequacy "refers to a diet that meets requirements for energy and all essential nutrients" (Ruel, 2002: 3). A diverse diet improves the chances of nutrient adequacy and reduces the chance of a deficiency or excess of a single nutrient (Ruel, 2002; Faber & Wenhold, 2007). This happens by increasing exposure to more foods with potentially more micronutrients and to complementary foods, like fats, which assist in the absorption of certain vitamins (Kennedy et al., 2003; Ruel, 2002).

Dietary diversity is a proxy for access to diet quality and thereby nutrient adequacy; however, diet diversity and diet quality are not the same thing and should not be conflated. Faber and Wenhold (2007: 393) write that individuals should not be classified as over- or undernourished based on dietary diversity, but dietary diversity can be used to "identify an at-risk state". Variety of food consumed is an aspect of a good quality diet, but is not sufficient for healthy eating. Diet quality pertains to more than dietary diversity, like portion control for example (Ruel, 2002).

Stricter measures of nutrient adequacy exist than dietary diversity. The most commonly used measures are the Nutrient Adequacy Ratios (NAR) usually aggregated into a Mean Adequacy Ratio (MAR). NARs compute consumption of individual nutrients in relation to recommended daily allowance (RDA) (Ruel, 2002). However, this method is more intensive and has greater technical requirements than dietary diversity which has been described as non-invasive, easy to recall, and quick to survey (Hoddinott & Yohannes, 2002).

Dietary diversity is usually operationalised as a summing of foods or food groups over a given reference period (Ruel, 2002; Hoddinott & Yohannes, 2002). There is no standard way in which to operationalise dietary diversity which has led to many studies employing their own version of the score. One of the most commonly used indicators is the Household Dietary Diversity Score (HDDS). The HDDS was developed by the Food & Nutrition Technical Assistance Project (FANTA) and is supported by USAID and the FAO (Jones et al., 2013; FAO, 2011). Respondents are asked about consumption of 12 food groups which are summed with equal weight. The HDDS has no set cut-off and the FAO (2011) recommends using the mean score. Later, this paper draws on the HDDS in building a dietary diversity indicator.

There is a distinction between food variety scores, which sum foods, and dietary diversity scores, which collect foods into food groups. Yet scores using either configuration have been found to have strong positive and statistically significant associations with nutrient adequacy (NAR) in countries as diverse as Iran (Mirmiran et al., 2004); Mali (Torheim et al., 2004); Mozambique (Rose et al., 2002); Vietnam (Ogle et al., 2001); and Kenya (Onyango et al., 1998). Dietary diversity and food variety have been found to be significantly related to nutrient adequacy in children (Steyn et al., 2005), a rural farming sample (Msaki & Hendriks, 2013) and the elderly (Oldewage-Theron & Kruger, 2008) in South Africa. Dietary diversity has also been found to be correlated with BMI. Dietary diversity and food variety scores were both found to be significantly and positively related to overweight and obesity in Sri Lanka (Jayawardena et al., 2013).

Studies have also confirmed the link between dietary diversity and child nutritional status. Arimond & Ruel (2004) found dietary diversity to be significantly related to child Height-for-Age Z Scores (HAZ scores) in the Demographic & Health Surveys of seven developing countries (Ethiopia, Mali, Rwanda, Zimbabwe, Cambodia, Nepal, and Columbia). Dietary diversity was significant as an interaction effect for a further three countries: Malawi, Haiti, and Peru. Torlesse et al. (2003) and Thorne-Lyman et al. (2010) found that child nutritional status improved when the price of staples decreased because families used the extra income to diversify their diet and purchase non-staple food. Onyanga et al. (1998) found food variety was significantly associated with five child nutritional scores: HAZ, WAZ, WHZ, triceps skinfold and mid-upper arm circumference. This study also found that dietary diversity was especially important for children who were no longer breastfed highlighting the role of complementary relationships between foods for nutrient absorption.

Food variety and dietary diversity scores are remarkably well-related to socio-economic factors (Arimond & Ruel, 2004; Hoddinott & Yohannes, 2002). Hoddinott & Yohannes (2002) find an exceedingly strong relationship between dietary diversity and per capita consumption (food and non-food) for ten developing countries (India, the Philippines, Mozambique, Mexico, Bangladesh, Egypt, Mali, Malawi, Ghana, and Kenya). Hatloy et al. (2000) found a strong and significant relationship between socio-economic status and dietary diversity in rural and urban areas in Mali where socio-economic status was measured as a count of 14 possible possessions e.g. radio, plough. Thorne-Lyman et al. (2010) also found high and significant correlations between dietary diversity and variables like parent's education, the amount of land owned, and household size. Ruel (2002) insists that analysis of dietary diversity must control for socio-economic factors or risk seriously overestimating its effect.

The relationship between dietary diversity and socio-economic status has been formalised in Bennett's Law which states that as income rises the number of calories individuals obtain from starchy staples decreases as individuals choose to diversify their diets (Timmer et al., 1983). In studies like Thorne-Lyman et al. (2010), Torlesse et al. (2003) and Jensen & Miller (2008) households use additional income to diversify diet. Jensen & Miller (2008) found households took advantage of subsidised staples in China to buy more shellfish and palatable or prestigious foods; not more staples.

Studies have also examined whether dietary diversity is associated with food security itself, defined in terms of well-established proxies. Hoddinott & Yohannes (2002) compare dietary diversity to consumption (food and non-food) which is a proxy for food access, and caloric availability, which is a proxy for energy availability. The authors find that dietary diversity has strong positive and statistically significant relations to these proxies. They conclude that dietary diversity "provides information" about food security and "holds promise" as an indicator thereof.

A second study by Melgar-Quinonez et al. (2006) found the Food Consumption Score (FCS) – the indicator used by the World Food Programme – was positively and significantly related to a modified version of the Household Food Security Survey Module (HFSSM) in three developing countries. The HFSSM was originally designed by the U.S. Department of Agriculture to monitor food security in a household survey and has since been adapted for developing country settings. The modified version of the HFSSM is a 9-question survey probing respondents about food quantity over the past 12 months. Questions were asked about food quantity, quality, and psychological aspects, like worry. The FCS was positively and statistically significantly related to the HFSSM in Bolivia and the Philippines. This relationship was also found in urban areas in Burkina Faso.

In light of the literature in this area, this paper applies dietary diversity as a proxy for diet quality under the access domain of food security. There is substantial evidence that dietary diversity indicators provide useful information about outcomes pertaining to food security (e.g. nutrition) and is well-associated with other food security indicators.

2.3. Food Security in South Africa

Studies on food security in South Africa fall into three main categories. Firstly, there are studies based on small samples (e.g. Msaki & Hendriks, 2013; Oldewage-Theron & Kruger, 2008). Secondly, there are studies mining general-purpose nationally representative data sets for information about food security, such as those from South Africa's statistics bureau, Statistics South Africa (StatsSA) (e.g. Aliber, 2009; Jacobs, 2009). Finally, there are purpose-built surveys for food and nutrition security without official status, such as the National Food Consumption Survey (NFCS) (e.g. Steyn et al., 2005) and the African Food Security Urban Network (AFSUN) (e.g. Frayne et al., 2010).

The 2009 Human and Social Research Council (HSRC) report which collated information from all three of these research categories explains that differing samples and methodologies lead to different conclusions about the same statistics (Altman et al., 2009). As such, despite all of the research that has been carried out and all of the data that is available, there is a lot of uncertainty surrounding food security statistics in South Africa. Hendriks (2005) was concerned about this in an article published in 2005 and called for more research on food security. A decade later, there has been a proliferation of research on food security, but uncertainty remains. Hendriks (2014) repeated her call for well-targeted research in 2014.

To illustrate the uncertainty in South African food security statistics, consider two surveys: the National Food Consumption Survey (NFCS) and the General Household Survey (GHS). The 2007 GHS reports 10% of adults and 12% of children are hungry compared to the 2005 NFCS which reports that about 52% of households experience hunger. These numbers are very different and – even given the year difference – hard to reconcile.

The differences may be explained by differences in the surveys. The GHS – previously the October Household Survey (OHS) - is a nationally representative survey run by StatsSA. It surveys a cross-sectional sample of 29 000 households and asks questions about socio-economic outcomes and welfare. The NFCS was commissioned by the Department of Health in 1999 to understand health and hunger amongst South African children aged 12 – 108 months (NICUS, unknown date). It surveys about 2 000 households, is nationally representative, but is not accorded official status (Altman et al., 2009). However, it has a more nuanced understanding of hunger comprised of eight questions, compared to the single question in the GHS. The GHS asks "Has a child/adult gone hungry in the last 12 months?" to which respondents can answer in five degrees of intensity.

Some findings are more consistent; for example, the conclusion that wage income is very important to food security (Jacobs, 2009; Hendriks, 2014; Aliber, 2009). Aliber (2009) uses the GHS to probe the characteristics of households that became hungry between 2006 and 2007. Households that became hungry experienced an increase in the number of children, a drop in the number of elderly, a decline in the number of employed adults, a rise in grant income, and a fall in food expenditure. This analysis highlights the importance of income to food security in South Africa. Jacobs (2009) estimates the cost of a basic nutritionally adequate food basket which is determined to be R262.66 per month per capita in 2005. Using data from the Income and Expenditure Survey (IES), Jacobs (2009) establishes that 82% of households could not afford this basket. The IES is run by StatsSA and surveys a cross-sectional sample of 21 000 households every five years asking questions primarily about income and expenditure. Jacobs' (2009) results are consistent with the NFCS which also finds 80% of households to be food insecure. However, food expenditure data varies considerably depending on the survey used. The food budget share of the poor is 51% according to the NFCS, 38% according to the IES, and 71% according to the Bureau for Marketing Research Survey (Jacobs, 2009).

Statistics pertaining to expenditure-related food security are typically higher than those regarding hunger. Hendriks (2014) reports that household hunger fell from 29.5% to 16.3% of households between 2002 and 2011 according to the GHS. Aliber (2009) uses the panel of 22 000 households in the GHS to compute transition matrices of households moving between severe, moderate, and no hunger between 2006 and 2007. Although a very similar percentage of households were severely, moderately or not hungry in each year, these were not always the same households. 2.6% were severely hungry in 2006 and 2.2% in 2007; but only 0.2% were severely hungry in both years. Quite high proportions were also churning in and out of moderate and no hunger. This analysis led Aliber (2009) to describe hunger in South Africa as transitory.

International literature reports that obesity and overweight affect women sooner when a country undergoes a nutrition transition, than it affects men (Kanter & Caballero, 2012; Wells et al., 2012; Mendez et al., 2005). Several studies have indeed found female overweight is more prevalent in South Africa than male overweight (Ardington & Case, 2009; Kruger et al., 2005; Bourne et al., 2002). This gender disparity may be due to body-preference. A study by Puoane et al. (2005) surveyed 44 community health workers in Khayelitsha, a township in Cape Town. The majority of these respondents were overweight or obese and explained that they preferred being so. Thinness was associated with ill health. Chopra & Puoane (2003) found that healthier forms of cooking, like boiling, were considered unsophisticated compared to more modern and unhealthy forms, like frying. In an overview of regional studies of South African overweight, Kruger et al. (2005: 493) report that few women who are overweight and obese view themselves as so and that heavier weight is “associated with respect, dignity and affluence”. This is supported by a paper by Wittenberg (2013) that examines the relationship between BMI and income in South Africa using NIDS. NIDS is a panel sample of about 7 000 households and 28 000 individuals surveyed at the household, adult, and child level about a variety of socio-economic outcomes. Using regression analysis, the author determines that there is a non-decreasing relationship between BMI and income amongst the African population. Wittenberg (2013) considers this could be because heavier weight is desired and viewed as an indicator of success among the African population.

However, Case & Menendez (2009) propose that there is more to the gender-obesity discrepancy than body preference. The authors modelled the probability of adult obesity in Cape Town, South Africa, and found that childhood nutritional deprivation and adult socio-economic success fully accounted for the difference between male and female adult obesity. They added that preferences about a larger body type were a contributing factor but described them as “speculative”.

South Africa’s nutrition transition has shouldered a lot of blame for the rise in obesity (Faber & Wenhold., 2007; Bourne et al., 2002; Faber & Kruger, 2005). Bourne et al. (2002) explain that the traditional diet of the African population shifted towards an atherogenic Western diet associated with more non-communicable diseases between 1940 and 1992. The authors show that fat intake increased significantly, whilst carbohydrate and plant protein intake decreased significantly. ‘Supermarketisation’ – the proliferation of supermarkets – is part of the nutrition transition. More supermarkets, especially in more rural areas, increase people’s access to food, but the constraints of the cold chain also dictate which foods people get access to. Crush & Frayne (2011) explain that the diets of the poor become lower quality, energy-dense and cheaper. Kimenju et al. (2015) found shopping at a supermarket was associated with an increased chance of overweight of 13% for a sample of Kenyans.

Deficiencies of micronutrients like Vitamin A, Vitamin E, and iron have been found in a nationally representative study of South African children and a rural farming community of adults in KwaZulu Natal (Steyn et al., 2005; Msaki & Hendriks, 2013). A study of 170 elderly individuals in Sharpeville, South Africa, found high rates of obesity and micronutrient deficiencies for Vitamin A, iron, and folate, amongst others (Oldewage-Theron & Kruger, 2008). This final study in particular is evidence of hidden hunger because micronutrient deficiency is being masked by overweight and obesity.

Even though precise figures vary, broad trends in South African food security can be extracted from the literature. South Africa is food secure at the national level, although in very recent years this has come under threat (Hendriks, 2014). Hunger is decreasing at the household level and at the individual level obesity is rising and child malnutrition remains high (Hendriks, 2014; Altman et al., 2008; Ardington & Case, 2009). Small studies provide evidence of the presence of hidden hunger in the population.

It should be clear from this literature review that a large amount of research has been done on nutrition and food security in South Africa. This means that continued lack of certainty surrounding questions like 'how many households are food insecure in South Africa?' is especially frustrating. Part of why this is happening is the differing methodologies and samples pointed out by Altman et al. (2009) and Hendriks (2014). However, another reason is that there are many pathways to food security; many more than were explored in this literature review. Thoroughly researching one (e.g. the nutrition transition or micronutrients) does not guarantee a complete conclusion about food security in general.

This study contributes to the South African literature via its focus on dietary diversity within a large nationally representative survey. Aliber (2009) briefly runs analysis on dietary diversity in the GHS which is also large and nationally representative. However, his focus is primarily descriptive with emphasis on spatial variables as opposed to the food security outcomes used in this study. Steyn et al. (2005) use the NFCS, which is nationally representative, to find the association between dietary diversity and nutrient adequacy for children. This paper extends by studying an adult sample and additionally exploring the relationships between food expenditure, BMI, and hunger. The first task of this paper is to confirm that dietary diversity is indeed measuring food access in my sample. Dietary diversity in South Africa has typically been examined in smaller samples in once-off studies, such as Msaki & Hendriks (2013) and Oldewage-Theron & Kruger (2005). These studies collect very detailed information about individual nutritional intake to link nutrient adequacy directly to dietary diversity. The data I use, NIDS Wave 1, is a household survey with less detailed information about what individuals ate. This means I need to use different methods to ascertain whether my indicator is usefully summarising information about food security. To do this, I follow Hoddinott & Yohannes (2002) and compare dietary diversity to the well-established food access indicator of food expenditure.

The second contribution of this study is to compare how dietary diversity and food expenditure explain South African BMI and hunger. The hope is that these two indicators can intersect to provide unique information about food security in a context of the triple burden where neither calories nor nutritional adequacy alone are enough to guarantee food security. Aliber (2009) analyses hunger in a nationally representative survey and finds a negative relationship between food expenditure and hunger. I extend by using a more rigorous method, regression analysis, and additionally evaluating the role of dietary diversity. Authors like de Haen et al. (2011) and Msaki & Hendricks (2013) think quantity and quality are complementary; is this the case in NIDS?

In the next section I set up the conceptual framework behind the questions just described. The framework assists with isolating indicators from outcomes and setting up hypotheses.

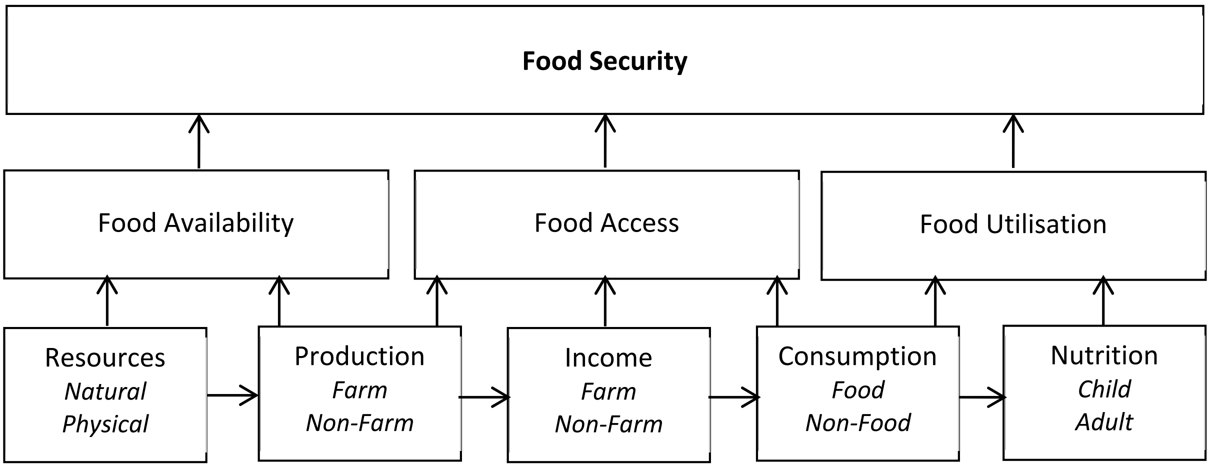
3. Conceptual Framework

3.1. Conceptualising Food Security

The literature review above motivates why I choose to investigate dietary diversity as a tool for measuring food security. My first task tests whether dietary diversity is associated with food access in the NIDS sample of adults. However, my second question is to test whether there is complementarity between diet quality and quantity. For that, I need to disentangle concepts like indicators and outcomes and quality and quantity. To do this, I conceptualise food security as illustrated in **Figure 2** below taken from Webb et al. (2002: 14). In the figure, pathways to food security are boxed into availability, access and utilization. These are the overarching domains of food security recognised by the 1996 World Food Summit in Rome.

<u>Figure 2</u>: Conceptual Framework for Food Security Measurement

Reproduced from Webb et al. (2002), page 14.



Individual indicators, like dietary diversity, signal food security via one of the domains of availability, access, or utilisation. The breadth of these domains means we are able to use a variety of indicators for each, falling into categories like 'Resources' or 'Production' for 'Availability'. Figure 2 also describes a causal flow. Arrows move upwards and rightwards. The arrows move upwards because without having the characteristics captured by the individual indicators, you can't have a particular domain; and without a particular domain, you can't have food security. Similarly, the domains are hierarchical so the arrows move rightwards. Food availability is necessary but not sufficient for access, which in turn is necessary but not sufficient for utilization (Webb et al., 2006).

This brings me to where dietary diversity and food expenditure are located on the figure. Webb et al. (2002) categorise monetary metrics under 'Income'-type measures and dietary diversity under 'Consumption'-type measures. Measures pertaining to 'Consumption' span 'Food Access' and 'Food Utilization'. This points to how food expenditure and dietary diversity tap into different angles of food security, although I am mainly interested in dealing with both as access to food indicators. I treat dietary diversity as proxying for access to nutrient adequacy, which is broadly understood as diet quality. Food expenditure is used as a proxy for access to calories, which pertains to diet quantity. Before I discuss where my outcomes fit into Figure 2, I motivate why I chose them.

3.2. Choice of Outcomes

In order to tease out differences between dietary diversity and food expenditure, my outcomes need to represent different aspects of food security. The outcomes I look at are nutrition captured by adult BMI and hunger captured with self-reported household hunger. Several sources suggest these may be advantageous choices. Burchi et al. (2011:361) describe the concept of food security as " ...go[ing] beyond caloric intake and address[ing] both hunger and undernutrition". Although, I am also hoping to capture the trend of rising obesity, or overweight, with BMI. Jones et al. (2013) conceptualise hunger and nutrition as largely making up food security in Figure 1 (above in Section 2: *Literature Review*). De Haen et al. (2011) identify nutrition and food consumption as different concepts which complement each other:

> "*Given that there is currently no single indicator available that shows excellent performance with respect to all criteria [of food security], a suite of indicators is required for assessing different aspects of food insecurity. Indicators that are based on food consumption and anthropometric surveys are particularly complementary*" (de Haen et al, 2011: 767)

De Haen et al. (2011) think a useful way of moving forward is to combine the food consumption data available in household consumption surveys with anthropometric modules – this is precisely the type of data I have at hand. The main difference is that I am treating these as outcomes whereas de Haen et al. (2011) call them indicators.

Another motivation for this choice is that two different schools of thought about measuring food security are represented with these outcomes. Pradhan & Ravallion (1998) in Webb et al. (2006) discuss how the objective-quantitative school focuses on poverty lines and monetary metrics of food security outcomes e.g. food expenditure, budget shares. BMI is one such quantitative measure of nutrition with cut-offs for different weight categories. The subjective-qualitative school tends to ask questions about the experience of being food insecure which includes stress and uncertainty about where the next meal is coming from. This approach "reflects their [local people's] sense of deprivation, which may or may not always coincide with some external or absolute standard" (Webb et al, 2006: 1407S). The hunger question in NIDS is subjective; it asks respondents about their experience of hunger.

There are strengths and weaknesses to both schools. The quantitative school has been criticised for being too detached from the actual experience of poverty (Webb et al, 2006). The subjective school faces challenges around anchoring concepts, comparability, and the possible lack of alignment between personal perceptions and actual outcomes (Webb et al., 2006; Jones et al., 2013). In this way, my outcomes represent both schools of thought about food security and the relative strengths and weaknesses.

3.3. Outcomes versus Indicators

I treat indicators as theoretically causal to, or as 'inputs' for, outcomes. To clarify why dietary diversity and food expenditure are indicators whereas BMI and hunger are outcomes, I return to Figure 2. The horizontally flowing arrows depict how the domains are hierarchical and my indicators are further 'upstream' or leftwards, than my outcomes. BMI is a measure of nutrition (Webb et al., 2002; Jones et al., 2013; de Haen et al., 2011). Both dietary diversity (falling into 'Consumption') and food expenditure (falling into 'Income') appear earlier in the chain than BMI. Webb et al. (2002) name household caloric adequacy and number of meals per day in the 'Consumption' category so this seems like the appropriate place to house hunger. I choose to mainly understand hunger as representing utilisation i.e. capturing how much food is eaten. Food expenditure comes earlier in the flow of causation than hunger. Dietary diversity is in the same box. Adequate food expenditure and dietary diversity are necessary but not sufficient for good nutrition and energy consumption.

Overall, my indicators represent food access whilst my outcomes represent food utilisation. My second empirical question therefore seeks to better understand pathways between food access and food utilisation for South African households. Now that I have completed my conceptual framework, I combine it with evidence from the literature review to form expectations about my empirical work.

3.4. Forming Expectations of the Data

My first task sets out to establish whether dietary diversity is associated with food access, proxied by food expenditure. Msaki & Hendriks (2013) find that dietary diversity and food intake are positively and significantly related in a study of 200 respondents in rural KwaZulu Natal. 'Food intake' in this paper is an index called the Household Food Intake Index developed by the authors. Principal component analysis is used to combine variation in household per capita consumption of energy, protein, and micronutrients. The authors concluded that diet quality and quantity are related for their sample. I expect the same result although I am using a much larger and nationally representative data set, and also a less sophisticated measure of food consumption.

Turning to my second task, I expect a significant positive association between food expenditure and BMI. There is a straight-forward connection between food consumption and weight gain. The relationship between dietary diversity and BMI is more ambiguous. Both very high and low BMI is unhealthy and could be indicative of a poor diet. I know that BMI in South Africa will be reflecting high levels of overnutrition (Wittenberg, 2013; Ardington & Case, 2009). For individuals who are overweight, better diet quality could mean substituting calorie-rich starches for nutritious but calorie-low vegetables which could lead to weight loss. However, studies have found a positive relationship between dietary diversity and energy intake in countries in the developing world, like Mali (Torheim et al., 2004), Iran (Mirmiran et al., 2006), South Africa (Msaki & Hendriks, 2013), and Sri Lanka (Jayawardena et al., 2013). A review of 39 human and animal studies found that greater diet variety was correlated with greater energy intake (Raynor & Epstein, 2001). The authors suggest this could be because variety in palatability and taste means it takes longer for our senses to be sated. Moore et al. (2013) found that female Rhesus monkeys ate larger meals when there was more variety and also put forward this sensory-satiety hypothesis. This leads me to expect a positive relationship between dietary diversity and BMI. Food expenditure acts on BMI via energy-consumption, but diet quality works through pathways like sensory-satiety and nutrient adequacy. I am predicting a complementary relationship between diet quality and quantity for BMI.

Typically, hunger is associated with calories and the 'empty feeling' (Webb et al., 2002; FAO, 2015; Burchi et al., 2011). The FAO defines hunger as consuming less than 1 600-2 000 calories per day (Burchi et al., 2011). The importance of calories to feeling hungry leads me to expect a strong negative relationship between hunger and food expenditure. However, hunger in NIDS Wave 1 is self-reported and not a quantitative measure of calories. Aliber (2009) analyses hunger using the General Household Survey, which uses an almost identical question to NIDS.[1] He is very cautious about what is being measured by this question. Aliber (2009: 386) says the following when introducing the variable: "... it is not clear precisely what these subjective, vague indications of hunger *mean* ..." (Aliber's italics). Jones et al. (2013) discuss how hunger is one of the least well-defined concepts in food security. Hunger has physiological as well as socio-economic aspects all bound up together (Jones et al., 2013). Self-reported measures, such as the one available in NIDS, confer deprivation relative to individual's personal and cultural norms (Webb et al., 2006). This might not coincide with an objective standard of calorie consumption. It also means one is capturing a lot more information than might be desired when using subjective measures e.g. social norms. Depending on your approach however, this type of information can enrich the data as opposed to introducing noise. Webb et al. (2002) find that food variety is a significant correlate of hunger when hunger is assessed qualitatively (as opposed to just using calories) by enumerators. The authors rationalise the role of dietary diversity by explaining that for a hungry household, consuming an additional food group on a regular basis represents a meaningful improvement in well-being.

To return to my expectations about this outcome, it is therefore plausible that self-reported hunger in NIDS is reflecting more than food quantity (calories). I therefore shouldn't pin the burden of my expectations on food expenditure entirely. Instead, I can expect dietary diversity to have some positive impact on hunger via softer aspects like social norms and preferences. Bennet's Law explains that poorer households typically have low dietary diversity characterised by starchy staples (Timmer et al., 1983). Some foods, like meat, eggs, dairy, and pulses, are both highly nutritious and calorie-rich. For a given level of consumption, diversifying diet to include these types of food could increase health whilst maintaining calorie levels and therefore reduce proneness to hunger. Overall, I expect negative

[1] The 2002-2007 GHS asks "In the past 12 months, did any adult in this household go hungry because there wasn't enough to eat?" The respondent can answer in five degrees of intensity: never, seldom, sometimes, often, and always. NIDS Wave 1 (2008) asks "In the past 12 months, how often did any adult in this household go to bed hungry because there wasn't enough food?" The respondent (the eldest female in the household) can answer in five degrees of intensity: never, seldom, sometimes, often, and always.

statistically significant effects from both food expenditure and dietary diversity because they are explaining different aspects of what is packed together in self-reported hunger. I look forward to a complementary relationship.

Part of the menace of the triple burden is that it blurs the traditional way in which we can think about nutrition and hunger. It is not possible to simply draw a line between nutrition and diet quality and hunger and food quantity, even though this is more intuitive. Part of what I expect is that intuitive relationships won't play out because of how the twin phenomena of obesity and hidden hunger have infiltrated food security in the developing world. These complications bring to mind the following insight from Amartya Sen (1981: vii):

> *"...much about poverty is obvious. One does not need elaborate criteria, cunning measurement, or probing analysis, to recognise raw poverty and to understand its antecedents. But not everything about poverty is quite so simple. Even the identification and the diagnosis of poverty may be far from obvious when we move away from extreme and raw [conditions]. Different approaches can be used...and there are technical issues to be resolved within each approach."* (Emphasis added)

Now that I have set up a conceptual framework and expectations, I start the empirical work by inspecting the data in the next section.

4. Data & Descriptive Statistics

4.1. The NIDS Data

This paper uses Wave 1 of the National Income and Dynamic Study (NIDS). NIDS is a nationally representative household survey carried out by the Southern Africa Labour and Development Research Unit (SALDRU) at the University of Cape Town on behalf of the South African Presidency. NIDS uses a stratified, two-stage cluster sample design to select the households included in the base wave. The 400 Primary Sampling Units (PSUs) in NIDS are a subset of StatsSA's Master Sample of 3 000 PSUs used for the Labour Force Surveys and the General Household Surveys. The 400 PSU's are randomly selected within the strata, which proportionally represent South Africa's 53 district councils (Leibbrandt et al., 2009). Wave 1 was carried out in 2008 on 28 226 individuals in 7 296 households. These individuals form the panel for the next waves. NIDS collects information on socio-economic outcomes such as income, expenditure, demographics, education, employment and mobility. Data is collected at the adult, child, and household level. This paper concerns itself with the adult and household questionnaires.

NIDS has particular strengths over other nationally representative datasets. Wave 1 in particular offers a range of variables pertaining to food security not collected by other surveys. The GHS collects information about hunger, but not detailed food expenditure data required for dietary diversity. The IES provides far more detailed food expenditure data than NIDS, but no food security outcome variables – like hunger and BMI – against which to measure indicators like dietary diversity. A potentially useful survey is the Living Conditions Survey (LCS) which captures food expenditure, hunger, and adult anthropometrics. More will be mentioned about the LCS in the conclusion as an avenue for future research. For now, however, the LCS was not a clearly better option than NIDS and so I continue with NIDS. As food security is a multifaceted concept that requires more than one metric to capture, de Haen et al. (2011) argue for the combining of food consumption data from household surveys with anthropometric data. This is precisely what NIDS provides with the additional advantage of combining all this data for the same sample.

Wave 1 in NIDS is especially useful even compared to other waves. Questions about hunger and self-perceived food security offered in Wave 1 are not offered in subsequent waves. Section E1: *Food Spending & Consumption* in the Household Questionnaire is relevant for configuring the dietary diversity indicator and is well-answered in Waves 1 and 2. However, only about 1 300 households answered enough questions about food expenditure in Wave 3 for me to undertake my analysis. The comparable figures are 6 924 in Wave 1 and 6 339 in Wave 2.

Table 1 below offers descriptive statistics for the adult sample of NIDS used for my analysis with accompanying rates of missing data. I limit the sample to those aged 20 years and older, following Wittenberg (2013). This is because the cut-offs for BMI weight categories alter by age younger than 20. The sample is predominantly African, slightly more female and middle-aged with a mean age of 39 years. There are very few Indian/Asian individuals. The mean level of education is less than Matric. 10% of the sample has no schooling and 13% have some form of tertiary education. In the middle, a fifth of the sample has matric and over half have some level of primary or secondary schooling. About a quarter of the sample is not economically active, 45% is employed, and just less than a fifth are unemployed in a strict or discouraged sense.

Table 1: Summary Statistics for Adults in NIDS Wave 1

	MEAN	MISSING (%)
Age	39.62	0.00
Gender		0.00
Female	0.55	
Male	0.45	
Race		
African	0.77	
Coloured	0.09	
Asian/Indian	0.03	
White	0.11	
Education		
Education in Years	8.89	0.01
No Schooling	0.10	
Some Primary	0.20	
Some Secondary	0.36	
Matric	0.20	
Some Tertiary	0.13	
Employment		0.11
Not Economically Active	0.26	
Unemployed (Discouraged)	0.05	
Unemployed (Strict)	0.13	
Employed	0.45	
Total Adults Sampled	15 500	
Total Adults with Sampling Weights	13 978	

Notes: adjusted with sampling weights; own calculations NIDS Wave 1; sample restricted to adults aged 20+ years.

Turning to household characteristics in **Table 2**, the sample is largely urban with average household size of 3.44 and 0.36 small children. The most striking statistic is the difference between mean monthly per capita expenditure for quintile five compared to the bottom four quintiles. Mean expenditure less than doubles as quintile rises; and then explodes up by just less than a factor of five for the fifth income quintile. This is a reflection of the high level of inequality in South Africa.

Table 2: Summary Statistics for Households in NIDS Wave 1

	MEAN	MISSING (%)
Location		
Urban	0.66	
Rural	0.34	
Receive Pension Income	0.13	0.01
Household Size	3.44	
No. Children Under 5 Years	0.36	
Mean Per Capita Monthly Expenditure (R)		
Quintile 1	393.37	
Quintile 2	448.64	
Quintile 3	690.90	
Quintile 4	1234.13	
Quintile 5	5413.82	
Mean Per Capita Monthly Food Expenditure (R)		0.07
Quintile 1	88.99	
Quintile 2	136.37	
Quintile 3	200.43	
Quintile 4	349.67	
Quintile 5	755.71	
Total Households Sampled	7296	
Total Households with Sampling Weights	7289	

Notes: adjusted with sampling weights; own calculations NIDS Wave 1; sample restricted to adults aged 20+ years.

4.2. Food Expenditure in NIDS

My first indicator variable is food expenditure. The food expenditure variable used is a derived variable made available by NIDS. In Section E1: *Food Spending & Expenditure* of the Household Questionnaire, the eldest female in the household is asked whether the household consumed X (e.g. samp), and if so, what the value was in Rands. The questionnaire repeats this process for X received as gifts, grown in own production, and received as payment in kind. This process is repeated for 32 different food-expenditure questions.[2]

[2] The 32 food categories are: (1) mealie meal (2) samp (3) flour and bread (4) rice (5) pasta (6) biscuits, cakes, rusks (7) red meat (8) canned red meat (9) chicken (10) fresh fish and shell fish (11) tinned fish (12) dried peas, lentils, beans (13) potatoes (14) other vegetables (15) fruits and nuts (16) oil for cooking (17) margarine, butter, ghee, other fats (18) peanut butter (19) milk, cheese, yoghurts and dried milk (20) eggs (21) sugar, jam, honey, chocolates and sweets (22) soft drinks and juices (23) tinned fruit and vegetables (24) breakfast cereal and porridge (25) baby food and baby formula (26) salt and spices (27) soya products (28) coffee and tea (29) food hampers (30) readymade means brought into the household (31) meals prepared outside the home (incl. restaurants and take-aways. (32) other food expenditure.

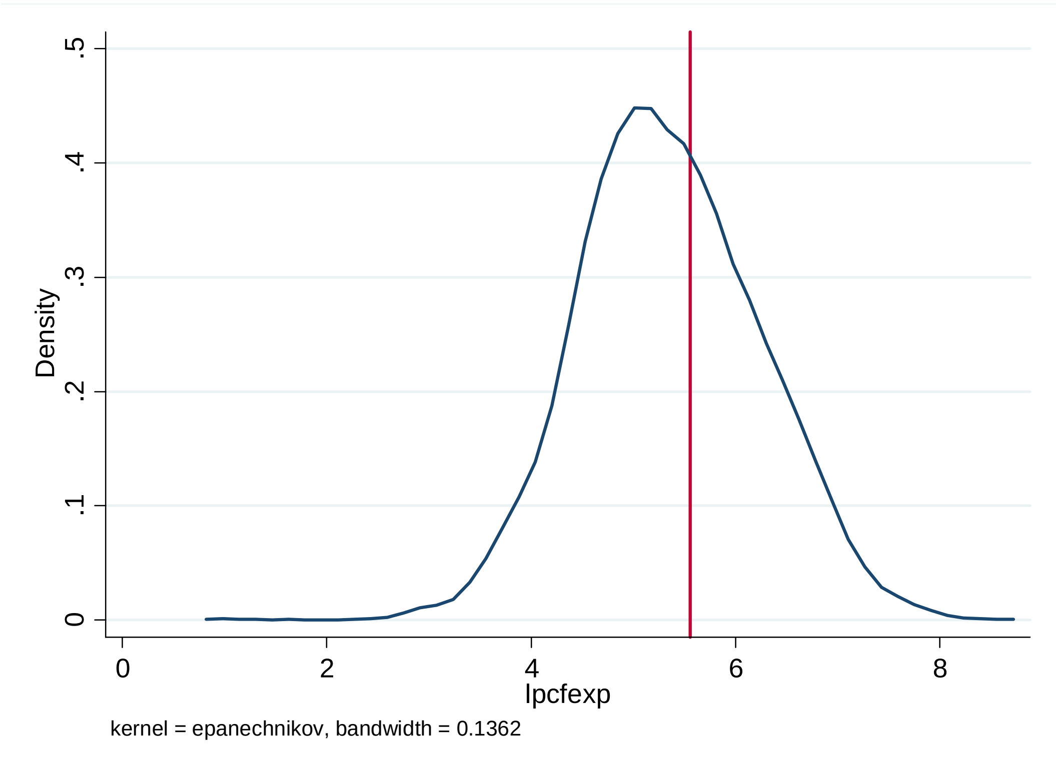
The derived variable made available by NIDS aggregates over these sources and imputes an aggregate consumption per item when there is missing data. The 32 aggregate values are then summed to arrive at a total monthly food expenditure value. The imputation method used was regression-based imputation. However, if there were fewer than 100 observations, instead of imputation, the value was set at the population median. If more than 40% of the data was missing, imputation was not carried out. Neither of these cases occurred with the food items. Generally, the proportion of missing data was around 10% per food item (Finn et al., 2009).

Overall, 0.63% of the total NIDS Wave 1 household sample had to have a full imputation for all 32 items. 26.06% had a partial imputation of food data. The authors note that data was not missing at random and that households with missing data tended to have lower median values. As a result, the authors caution that whilst imputation does not alter the median, it does decrease the mean in almost every case (Finn et al., 2009).

Returning to Table 2, I report the average food expenditure per income quintile. The food poverty line for 2008 according to StatsSA was R259 per person per month. Only the mean food expenditure for the fourth and fifth income quintiles exceeds this number. I apply this poverty line as the cut-off for food security in **Figure 3** which plots the density of logged per capita monthly food expenditure. The distribution is bell-shaped with a tail on the left. According to this poverty line, 51.26% of South Africans are food insecure.

Figure 3: Density of Logged Per Capita Monthly Food Expenditure for the Household Sample in NIDS Wave 1

Food security cut-off indicated in red



Notes: adjusted using sampling weights; own calculations using NIDS Wave 1.

4.3. Hunger & Nutrition in NIDS

Now, I turn to my outcome variables in NIDS. NIDS offers anthropometric data which can be used to measure nutrition. Height and weight were collected twice for individuals in the anthropometric module of the adult questionnaire. If the two measurements were too different, a third measure was taken. Height and weight in these data is an average of these two or three numbers.[3] These numbers are combined to create an adult BMI variable using the formula:

$$\mathrm{BMI} = \frac{weight\ in\ kg}{(height\ in\ m)^2}$$

The hunger variable in NIDS comes from a question asked of the eldest female in the house in the household questionnaire: "In the past 12 months, how often did any adult in this household go to bed hungry because there wasn't enough food?" This can be answered in five degrees of intensity: never, seldom, sometimes, often, and always. An important difference between the variables is that BMI is an individual-level variable whereas hunger is household-level. The quality of each of these variables is reported in **Table 3** below:

Table 3: Missing Data in Food Security Outcome Variables of NIDS Wave 1

	BMI (Adults)	*Hunger (Households)*
Missing	2 813 [20.12%]	24 [0.33%]
Non-Missing	11 165 [79.88%]	7 265 [99.67%]
Total Observations	13 978 [100%]	7 289 [100%]

Notes: percentages and numbers adjusted with sampling weights; own calculations using NIDS Wave 1; sample restricted to adults aged 20+.

There is substantial missing data for BMI. This is likely reflecting the more arduous process of collecting the component parts of the BMI data.

4.4. Describing BMI in NIDS

Adults are classified into weight categories using cut-offs for BMI from the World Health Organisation (WHO) reported in **Table 4**.

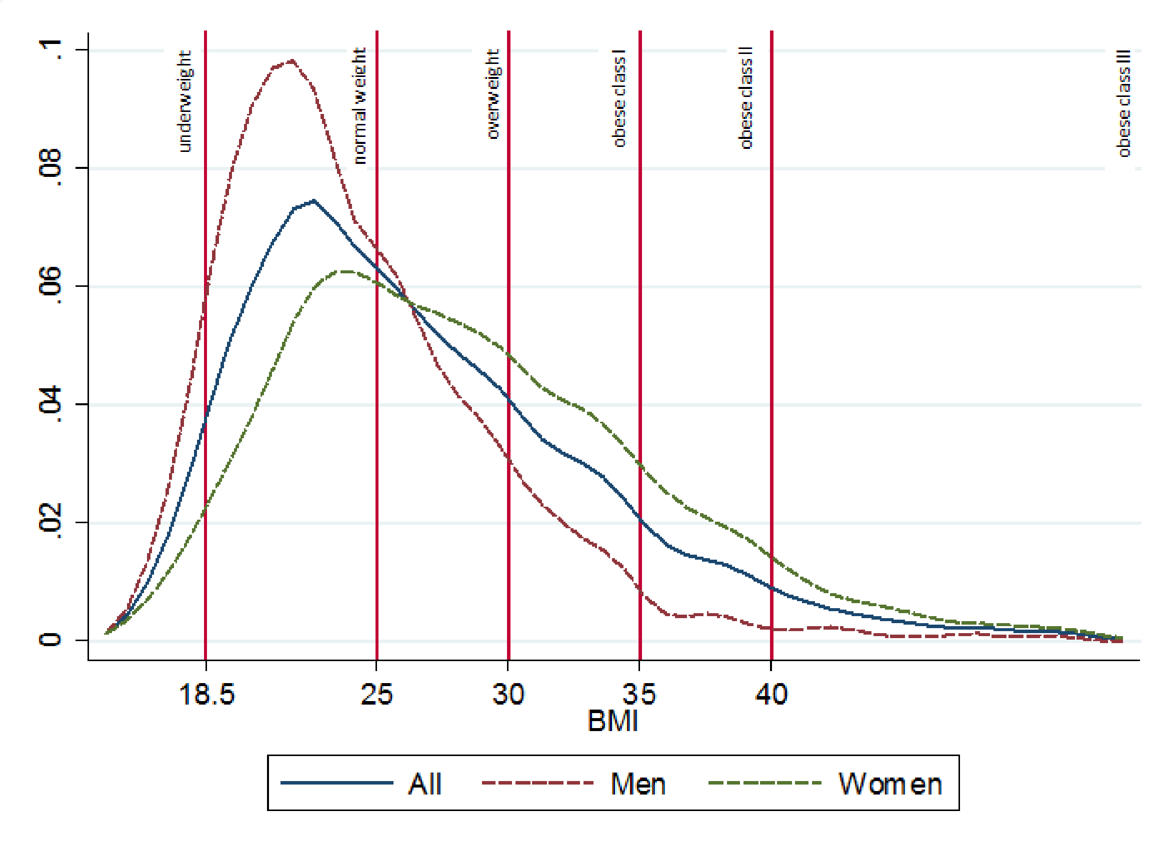
Table 4: WHO Cut-offs for BMI Weight Categories for Adults Aged 20+ Years

Category	**BMI**
Underweight	less than 18.5
Normal (healthy weight)	18.5 to 24.99
Overweight	25 to 29.99
Obese Class I (Moderately obese)	30 to 34.99
Obese Class II (Severely obese)	35 to 39.99
Obese Class III (Very severely obese)	40 and over

[3] I include observations for BMI so long as they have at least one data point for weight and height. I also exclude the top and bottom 1% of the distribution for adults aged 20 years and older, to exclude extreme and unrealistic values of BMI.

The distribution of BMI in the NIDS adult sample is skewed largely to the right as can be seen in **Figure 4** below. South Africa's distribution begins in the category of underweight and extends until class III obesity. This skewness is split along gender lines. The distribution for men is substantially more skew that that for women. Such gender dynamics are typical of developing countries (Kanter & Caballero, 2012; Wells et al., 2012; Mendez et al., 2005). The creep of obesity into the developing world affects female weight sooner and more seriously than it affects male weight (Wells et al., 2012; Monteiro et al., 2004) which is makes the flatter female distribution unsurprising.

<u>Figure 4</u>: The Distribution of BMI by Gender for the Adult Sample in NIDS Wave 1



Notes: adjusted using sampling weights; sample restricted to adults aged 20+ years; own calculations using NIDS Wave 1.

The breakdown per weight category is reported in **Table 5**. The gender profiles are so different it is clear that BMI should be inspected separately by gender. About half of adults in the sample are of normal or under-weight, and half are either overweight or obese. Just more than a third of women in the sample are of normal or under-weight. Just over a quarter are overweight; about a third are obese. By contrast, 63% of men are of normal weight or under-weight. A quarter of men are overweight which is comparable to women, but then far fewer are obese. Just more than a tenth are of men are obese.

<u>Table 5:</u> Summary Statistics of BMI by Gender in the Sample of Adults in NIDS Wave 1

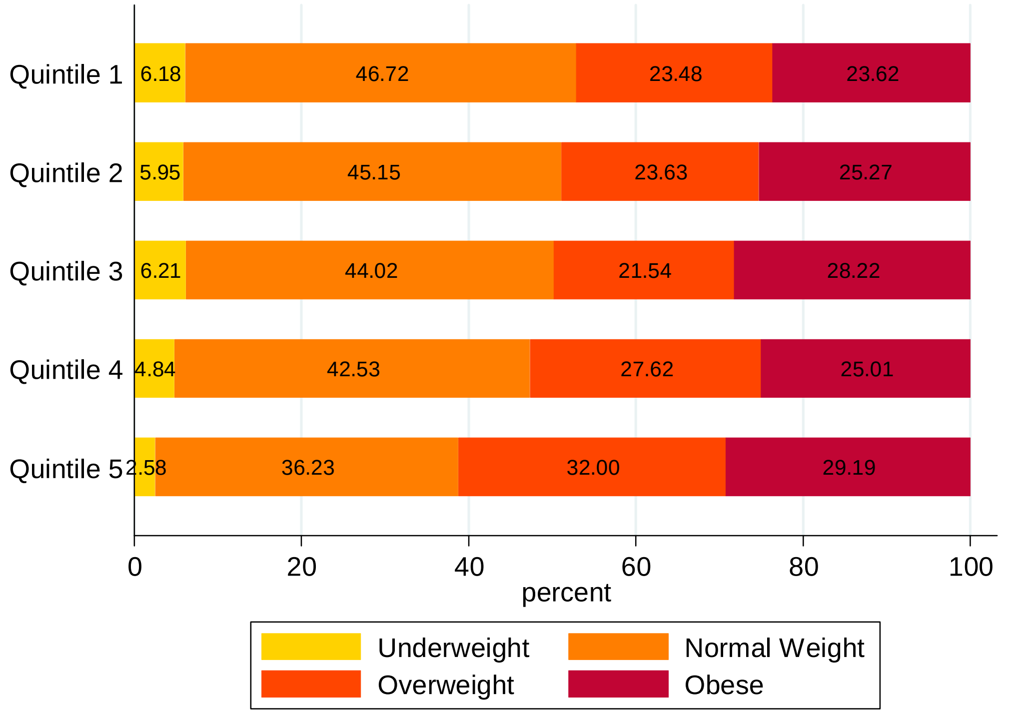
Weight Categories	Percent of All	Percent of Women	Percent of Men
Underweight	4.97	3.27	7.24
Normal Weight	42.44	32.4	55.78
Overweight	26.14	27.6	24.19
Obese Class I	15.3	19.85	9.26
Obese Class II	6.92	10.62	2.02
Obese Class III	4.21	6.26	1.5
Total Percentage	100	100	100

Notes: adjusted with sampling weights; sample restricted to adults aged 20+ years; own calculations using NIDS Wave 1.

These findings are consistent with work by Ardington & Case (2009) and Wittenberg (2013) who also find wide discrepancies by gender in the NIDS Wave 1 data. Other studies also find female overweight to be more predominant than male overweight in South Africa (Kruger et al., 2005; Case & Menendez, 2009).

Besides gender, BMI in the sample also matches the international trend of overweight and obesity affecting the poor (Kanter & Caballero, 2012; Menendez et al., 2005; Monteiro et al. 2004). **Figure 5** below shows the distribution of weight within each income quintile. Obesity and overweight affect those in the bottom income quintile almost as much as they affect those in income quintile four. Overall, there are more overweight and obese individuals in the fifth income quintile than those below and weight does rise with economic status; however, the difference is not as large as one might think. About 46% of adults over 20 are overweight and obese in the bottom income quintile. Recall that this is achieved with a mean per capita food expenditure of just R88.9 per month. Compare this number to 52% of those in the fourth income quintile – a difference of just 6 percentage points across very different income profiles.

Figure 5: The Distribution of BMI Weight Category by Income Quintile for the Sample of Adults in NIDS Wave 1



Notes: adjusted using sampling weights; sample restricted to adults aged 20+ years; own calculations using NIDS Wave 1.

4.5. Describing Self-Reported Hunger in NIDS

The distribution of household hunger is presented in **Table 6**. A very high proportion of households are never hungry at about 70%. Together, households that are seldom or sometimes hungry make up about a quarter of the sample. This leaves about 4% of households being often or always hungry. On the basis of the smaller numbers for often and always hungry, I collapse the variable into four categories for my empirical analysis later on: never, seldom, sometime, and often/always.

Table 6: Distribution of Hunger in the Household Sample of NIDS Wave 1

Hunger Intensity	*Freq.*	*Percent*
Never	5202.86	71.62
Seldom	605.06	8.33
Sometimes	1164.22	16.03
Often	229.30	3.16
Always	63.57	0.87
Total	7,265	100

Notes: adjusted using sampling weights; own calculations using NIDS Wave 1.

The statistics for hunger in NIDS are somewhere in the middle of the statistics provided by other data sets previously discussed. 10% of adults are hungry in the 2007 GHS (Aliber, 2009); 52% of households were hungry in the 2005 NFCS (Altman et al., 2009). Somewhere in the middle is NIDS with 28.38% of households reporting any hunger in 2008.

Now that I have described the variables that I use that are readily available in NIDS, I turn to building my dietary diversity indicator.

5. Creating a Dietary Diverity Indicator using Nids

5.1. The Data

The NIDS Household Questionnaire, answered by the eldest female in the house, includes Section E1: *Food Spending & Consumption*. Then there are a series of questions that go into detail about what the household ate and the source of this food. Respondents are asked whether they ate X (e.g. samp) in the last 30 days; if so, how much in Rands they spent on it; what the Rand value is they ate from their own production; what the Rand value is of gifts of X they received; and, what the Rand value is of payment they received in kind of X. Then the enumerator goes to the next food type e.g. pasta and the whole process is repeated 31 times.

Five of these questions cannot be used. Questions about baby food, eating out, food hampers, ready-made food and 'other' are no discernible food type and have been excluded. For the remaining 27 foods, if respondents answered 'no' to whether they had consumed that food in the last 30 days, they were given a zero for all other questions relating to that food e.g. Rand expenditure or Rand value of production. Data diagnostics for the remaining 27 are provided in **Table 7** for the NIDS household sample:

Table 7: Diagnostics of Missing Data on 27 Food Consumption Variables for the Household Sample in NIDS Wave 1

	Consumption Dummy	*Expenditure in Rands*	*Production in Rands*	*Payment in Kind in Rands*	*Gifts in Rands*
Any Missing	372	1815	964	908	934
All Zero	31	58	6156	6340	6164
Non-Missing and Non-Zero	6893	5423	176	48	198
Total (Sum)	7296	7296	7296	7296	7296

Notes: own calculations using NIDS Wave 1

From this table, the best data source is the consumption dummies in terms of non-missing data. The consumption dummies also offer the best option in terms of variation with the highest number of households having non-missing and non-zero answers for all 27 foods. The 31 households with all zero answers for the 27 questions are suspicious. In its guidelines for the Household Dietary Diversity Score (HDDS), the FAO (2011) allows the index to range from zero using a 24-hour recall. A minimum of zero is appropriate for a reference period of 24 hours; it is not appropriate for NIDS's reference period of a month. As a result, the 31 zeroes could be measurement error, unless these households subsisted on baby food or food in the 'other' category. Ten of these households consumed food hampers, two consumed readymade meals, and one had eaten food outside of the house, all of which are made up of distinct foods that should be found in the previous 27 questions. An answer of zero is thus not plausible for these households. It is possible the 27 foods didn't cover the food these households ate, but given the breadth of food covered, this seems unlikely. This is probably measurement error and these 31 households are dropped from the sample.

Although the expenditure variables are also of good quality with 5 432 households providing non-zero and non-missing information, I decided not to use these variables. It would have been informative to use this data either to derive frequencies or calories. Frequency of consumption could have been determined by dividing the Rand value by price. With a calorie conversion table this could be used to estimate calorie intake. This would have provided very rich data. Whilst this was possible for some questions, others were not specific enough to make it possible to connect the food to a price. Questions specifically about "peanut butter" or "chicken" were manageable. However, questions about "red meat" or "pasta" were far too general. It is also impossible to tell how much of the expenditure on "fruit & nuts" belongs to fruit and to nuts – foods which cost very different prices. Terms like "other vegetables" combine a whole host of foods each with their own packaging conventions and prices. This led me to abandon the idea of using the per item expenditure data.

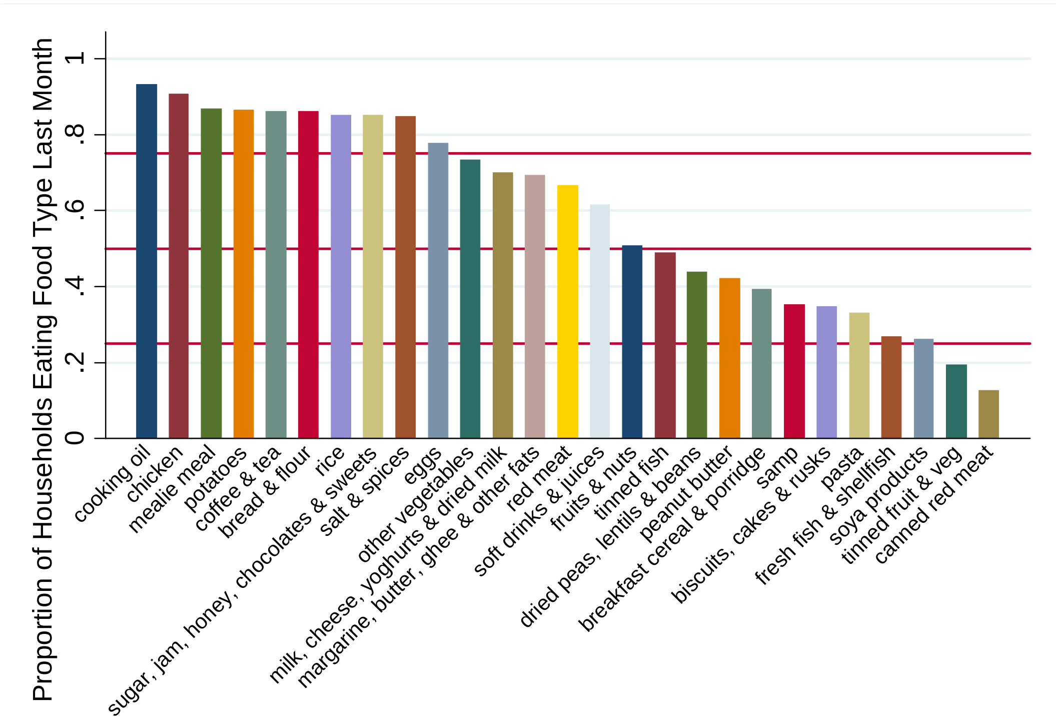
The other variables on gifts, payment in kind, and own production were too sparsely non-zero and non-missing to be useful for my purposes.

5.2. Descriptive Statistics

The chosen variable to create a dietary diversity indicator in NIDS is therefore the consumption dummy. **Figure 6** below describes the distribution of each food type for the household sample. Almost all households were eating cereals like mealie meal, rice, and bread & flour. Just over and under 75% were eating eggs and other vegetables, respectively. More concerning, is the low level of fruit & nut consumption at about half of households. Evidence of the nutrition transition is observed in that the traditional meal of samp and beans (Faber & Kruger, 2005) has been usurped by mealie meal according to their relative places on the bar graph.

Figure 6: Proportion of Households Consuming 27 Foods in the Past Month in NIDS Wave 1

The 25%, 50% and 75% marks are indicated in red

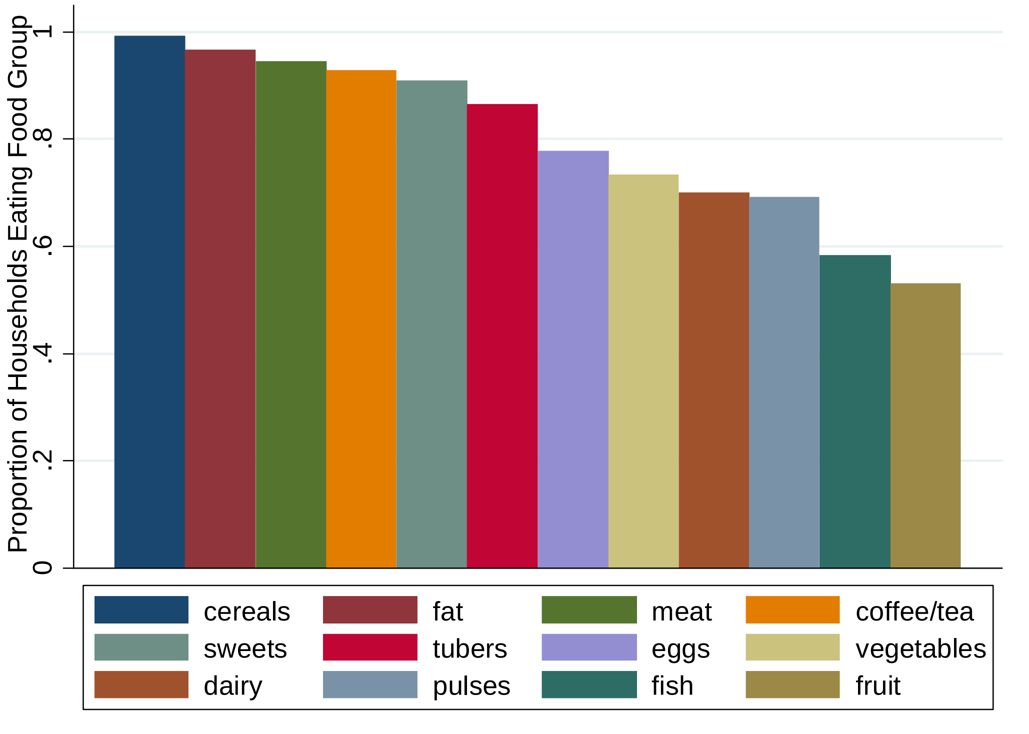


Notes: adjusted with sampling weights; own calculations using NIDS Wave 1.

The FAO's (2011) *Guidelines for Measuring Household and Individual Dietary Diversity* details how the Household Dietary Diversity Score (HDDS) is put together and how different foods are classified. The HDDS is made up of 12 food groups: (1) cereals; (2) meat; (3) oils & fat; (4) fish & other seafood; (5)

legumes, nuts, & seeds; (6) milk & milk products; (7) white tubers & roots; (8) sweets; (9) eggs; (10) spices, condiments, & beverages; (11) fruit; and, (12) vegetables. The food groups in the HDDS are meant to capture the economic ability of a household to consume a variety of foods; it is an indicator of food access (FAO, 2011). I grouped the 27 foods in NIDS into these 12 food groups and created **Figure 7** below.

Figure 7: Proportion of Households Consuming FAO-Defined Food Groups in the Past Month in NIDS Wave 1

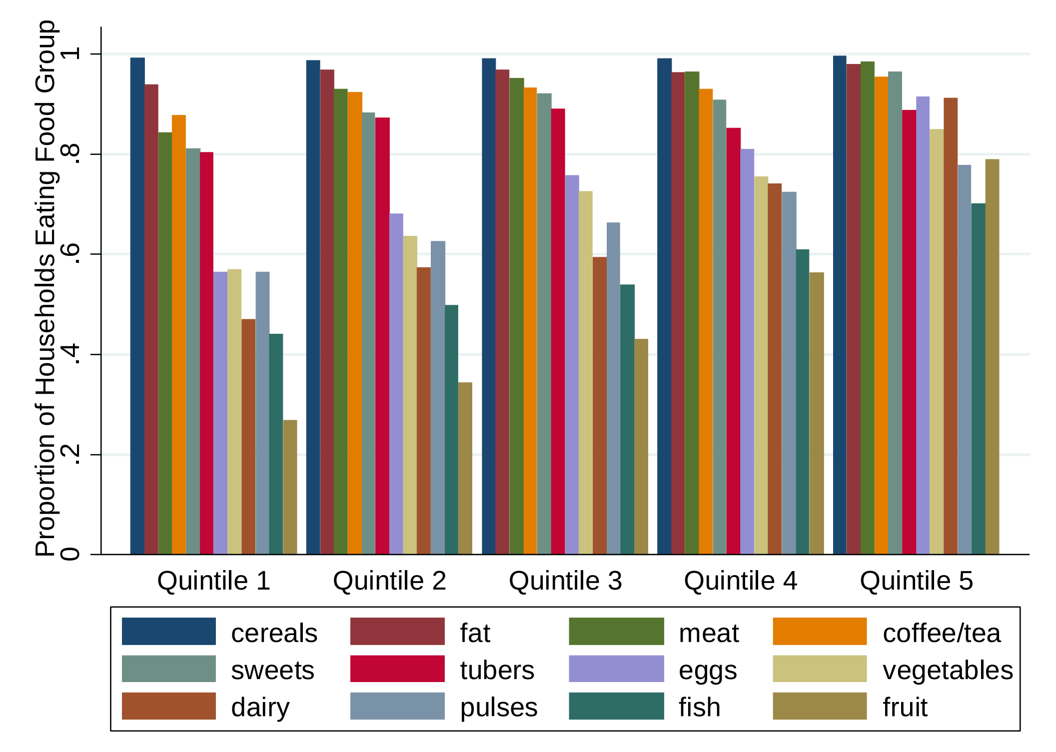


Notes: adjusted with sampling weights; own calculations using NIDS Wave 1.

Cereals dominate with almost all households having eaten cereals. Fat is shortly behind although this is mostly the role of cooking oil comparing to the previous graph. Many South African households eat meat at over 90%. More than 80% of households have also eaten sweets of some kind. There is a slight discontinuity in the graph after the first five food groups. On the opposite end of the graph, the dearth of fruit consumption evident again. Just over half of households have eaten fruit. About two thirds have eaten vegetables.

Figure 8 below splits the sample by income quintile. This is a useful graph because it shows, firstly, the positive relationship between income and dietary diversity. Bennet's Law applies in South Africa. Secondly, I can see which food groups are filling in the diversity for households in richer quintiles.

Figure 8: Proportion of Households Consuming FAO-Defined Food Groups in the Past Month by Income Quintile in NIDS



Note: adjusted using sampling weights; own calculations using NIDS Wave 1.

Cereals are the staple, eaten consistently by almost all households in all income quintiles. Eggs, vegetables, dairy, and fruit increase substantially across the income quintiles. Less than a third of households in the bottom income quintile are eating fruit; just over half are eating eggs. Meat is also eaten quite consistently across all income quintiles – more than 80% of households in the bottom income quintile ate meat in the last month. Coffee & tea and sweets are also commonly eaten. In the bottom three income quintiles, there is a large discontinuity between tubers and eggs. It appears there is a portion of households in these quintiles subsiding on a diet of cereals, coffee & tea, meat, tubers, sweets, and fats, compared to the fourth and fifth income quintiles.

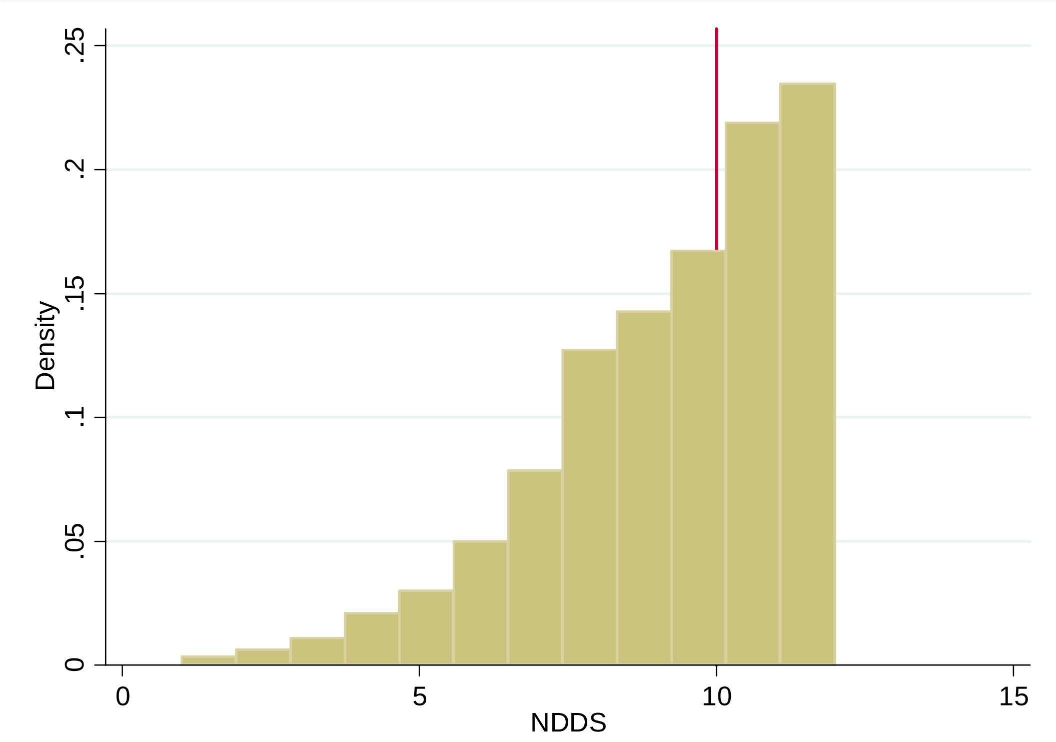
5.3. The NIDS Dietary Diversity Score

After classifying the 27 foods into 12 food groups according to the guidelines that make up the HDDS, I had configured the NIDS Dietary Diversity Score (NDDS).[4] This score has a minimum of 1 and a maximum of 12. The FAO guidelines offer no cut-off for food security and recommend using the sample mean (FAO, 2011). The mean for the weighted household sample is 9.47 which I round up to 10 because the score is discrete. **Figure 9** is the distribution of the NDDS for the household sample.

[4] See Appendix A(a) for the exact classification

Figure 9: Distribution of the NDDS by Household in NIDS Wave 1

Food security cut-off indicated in red



Notes: adjusted with sampling weights; one bin in the histogram per discrete step in the NDDS; own calculations using NIDS Wave 1

The prominent feature of this distribution is it is skewed to the left. A quarter of households are consuming the total number of food groups. It might be the case that Bin 12 includes very different households with quite different diets. This is likely the result of the long recall period which gives households more time to consume more foods that would not normally be reflected in a three-day or week-long reference period for which the HDDS food group break down is designed (FAO, 2011; Ruel, 2002).

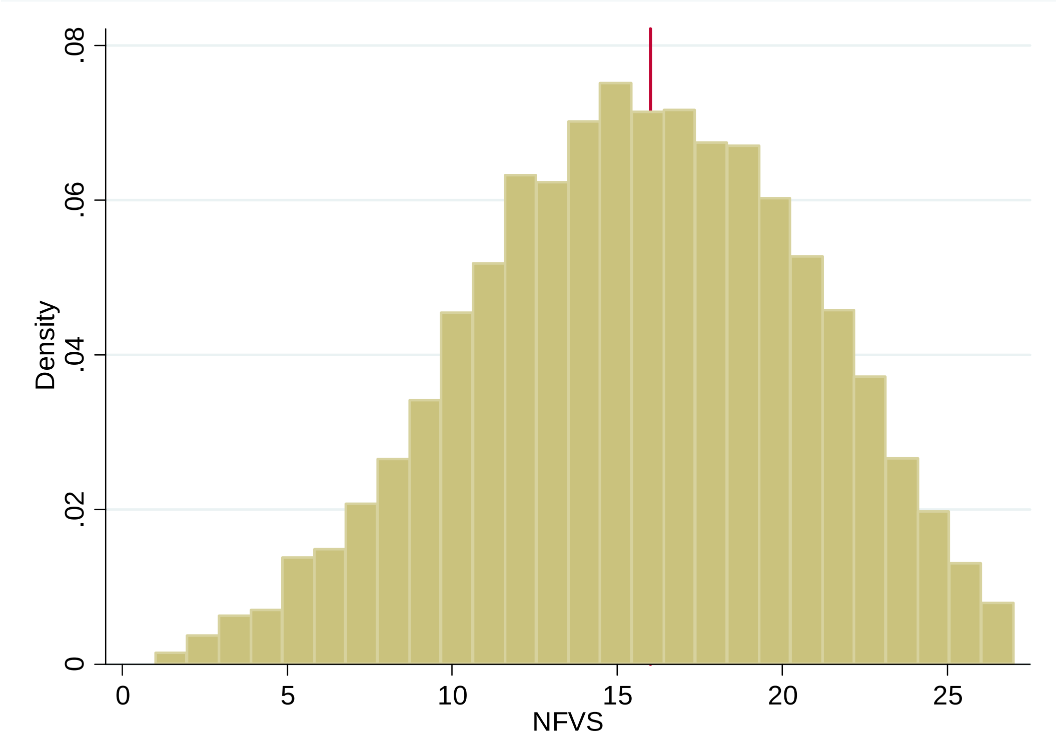
5.4. The NIDS Food Variety Score

Concern about the distribution of NDDS led me to create a second score called the NIDS Food Variety Score (NFVS). This score was simply a summing of all the 27 foods.[5] The score ranges from 1 to 27. Following the advice of the FAO (2011) for the HDDS, I set the food security cut-off according to the internal distribution. In this case, a weighted mean of 15.69 was rounded to a score of 16. The distribution of the NFVS is described n **Figure 10**:

[5] See exact composition in Appendix A(b)

Figure 10: Distribution of the NFVS by Household in NIDS Wave 1

Food security cut-off indicated in red



Notes: adjusted with sampling weights; one bin in the histogram per discrete step in the NFVS; own calculations using NIDS Wave 1

The NFVS follows an approximately normal distribution. It appears to capture variation in South African diets better than the NDDS. I have discussed previously that food variety scores are reliable indicators of nutrient adequacy, including in South Africa (Steyn et al., 2005; Maski & Hendriks, 2013; Ruel, 2002). This finding is surprisingly robust to country and score, given that food variety scores are idiosyncratic to the survey used. Steyn et al. (2005) report a higher correlation between their food variety score and MAR than between dietary diversity and MAR. The coefficients were 0.726 for food variety and 0.657 for dietary diversity. Both coefficients were highly significant. The correlation coefficient between MAR and food variety was also a few percentage points higher than between MAR and dietary diversity for different age groups and child HAZ and WAZ scores.

Now I have created two dietary diversity indicators – one based on food groups and one based on food variety. Before I use these indicators in empirical analysis, I want to understand precisely what they mean so that I can interpret them properly. This is covered in the next section.

6. Assumptions & Caveats for the Empirical Work

It is important to fully realise the conceptual underpinnings and implicit assumptions in each of these indicators before embarking on and interpreting empirical analysis. This is what this section seeks to do for NDDS, NFVS, and food expenditure.

6.1. From Concepts to Empirical Variables

Food expenditure measures food consumption. Measuring calorie consumption based on household consumption surveys is more accurate than that of the Food Balance Sheet approach of the FAO (de Haen et al., 2011). Fewer assumptions need to be made about missing data and distribution across households and the data is also more disaggregated which makes its tie to calories tighter (de Haen et al, 2011). A useful aspect of the NIDS derived version of food expenditure is that it includes the Rand values of food received as gifts, grown in own production, and received as payment in kind; as opposed to just including food bought on the market. This tightens the link between expenditure and consumption. Analysis by Mhlongo & Daniels (2013) confirms that food expenditure in NIDS Wave 1 reflects the downward sloping Engel curve associated with food being a necessity.

Ruel (2002) explains that dietary diversity is only one component of a healthy diet. Its role is to increase the likelihood of nutrient adequacy and to reduce the likelihood of an excess or deficiency of a particular nutrient (Ruel, 2002). The indicators NDDS and NFVS capture this likelihood. They cannot be capturing nutrient adequacy perfectly since it is possible for scores to increase because of the addition of nutrient poor foods like sweets. Two households eating the same basket of foods and having the same dietary diversity score will still have their diet quality represented as equal if one starts eating nuts and the other starts eating sugar.

A weakness of the NFVS is that it is very idiosyncratic to the survey. Cereals are overrepresented in the 27 food questions and fruits and vegetables underrepresented. There are six questions about different types of cereal, two questions about fruit (one of which is shared with nuts) and two questions about vegetables. This is unfortunate because fruit and vegetables are of special interest when wanting to connect dietary diversity to nutrient adequacy. For example, many dietary diversity scores, including the HDDS on which the NDDS is based, single out dark green leafy vegetables because they are so rich in Vitamin A (FAO, 2011; Msaki & Hendriks, 2013; Arimond & Ruel, 2004). In NIDS, these special vegetables are included together with a host of other vegetables in the homogenous question about “other vegetables”.

6.2. Unit of Analysis

Dietary diversity is a household level variable that is going to be compared to BMI, which is individual level. It could be the case that a household member’s diet is being misrepresented by what the household in general eats. It is problematic to generalise dietary diversity scores with the statement “Everyone in the household ate meat” but I can be surer that “Nobody in the household ate fruit”.[6] The dietary diversity score represents an upper threshold of possible dietary diversity. It captures maximum possible dietary diversity and the fact that this differs by household provides information. In fact, this is similar to how food availability measures work, like the FAO’s Prevalence of Undernourishment (PoU). The FAO estimates a distribution of calories available in a country, but data constraints mean they cannot claim that the calories are actually consumed. The PoU can be interpreted as measuring the number of people for whom there are not enough calories available in the country to nourish themselves (vs. the number of people who actually aren’t eating enough). This is imperfect, but still informative. So it is with household dietary diversity on the micro scale.

A relevant study is that by Arimond & Ruel (2002) who examine how household level dietary diversity terciles explain individual child nutritional status in the form of Z-scores for seven developing countries. The authors interpret the dietary diversity score as capturing what the child *may* have eaten. Yet, the authors go on to link child dietary diversity with child nutritional status, implying a stronger assumption. In order to add dietary diversity into my models, I too make a strong assumption about intra-household distribution that household dietary diversity represents the diet of every individual in the household.

The food expenditure variable also makes strong assumptions about intra-household distribution and the path from expenditure to consumption. It is assumed that household level acquisition implies

[6] This statement can still be contaminated by food eaten outside the home.

equal individual level consumption. I assume that all adults and children in the household consume the same amount of food as represented by per capita monthly food expenditure in Rands. This assumption not only ignores differences in food quantity intake in the household, but also economies of scale, food lost, fed to pets, or wasted (Jones et al, 2013; de Haen et al., 2011).

Whilst the disjuncture between the household and individual level is a weakness, it does not paralyse the analysis. The average standard deviation of BMI within households for adults aged 20 and older in the restricted household sample is 2.57 points of BMI.[7] This number is not very high. With average standard deviation of 2.57 points it is likely that household members fall into the same weight category. This makes adults within a household similar enough to link to household dietary diversity and food consumption.

Furthermore, it is common for models in the dietary diversity or nutrition literature to include household level variables when modelling individual outcomes (Kimenju et al. (2015), Wittenberg (2013), Arimond & Ruel (2002), Hatloy et al. (1998)). For example, Kimenju et al. (2015) explain individual propensity for overweight with whether households had shopped at a supermarket. Wittenberg (2013) predicts individual level BMI with household level per capita income. Arimond & Ruel (2002) link individual level child Z-scores to household level dietary diversity. Precedent for this format exists in the literature.

6.3. Recall Error & Recall Period

A weakness of food expenditure versus dietary diversity is a concern about recall error. It is quite difficult to precisely recall how much was spent on all food items in the past 30 days. Hoddinott & Yohannes (2002) praise dietary diversity for being easier to recall, less invasive and less time consuming in surveys, thus hopefully reducing recall error.

Even if recall error is less of a problem for dietary diversity, the length of the recall period in general is still important. In NIDS, household heads are asked to recall food consumption in the past 30 days. This makes an unusual dietary diversity indicator as most dietary diversity surveys use a maximum recall period of 7 days; some have extra detail for the past 3 days or even past 24 hours (Arimond & Ruel, 2004; Hoddinott & Yohannes, 2002; Thorne-Lyman, 2010; FAO, 2011). Drenowski et al. (1997) tested recall periods by collecting cumulative food variety over a 15 day period for individual adults in the United States. They found that dietary variety increased very quickly over the first 3 days and then stabilised around 10 – 15 days. The authors discussed that a recall period of 10-15 days was more reflective of total dietary diversity. Whilst a shorter time period is useful for reducing recall error, this study shows that it might be biased by the differences between day dietary diversity and overall dietary diversity.

The 30 days of the NDDS and NFVS is still longer than usual and so warrants the investigation to follow. Thirty days is certainly not biased downwards as the Drenowski et al. (1997) study suggests, but could be biased upwards. This is because frequency is not observable. Foods enter into the score whether they were eaten every week or once in the past month. This makes the dietary diversity indicator agnostic in debates about what frequency of consumption merits inclusion in an individual's 'representative diet' (Ruel, 2002; FAO, 2011).[8] If an individual eats a chocolate once in the past month,

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[7] Confidence Interval [2.36; 2.77]; "Restricted sample" refers to the restriction imposed on the sample in the next section in order to carry out regression analysis. The restriction is that dietary diversity and food expenditure data are non-missing and non-zero.

[8] Inclusion and exclusion criteria have been determined for the United States and Europe e.g. milk in coffee does not count as dairy product intake (Ruel, 2002). The levels have not been established properly for the developing world. Ruel's (2002) experience in Ghana demonstrated the importance of taking frequency into account. Intake of fish was overestimated when ignoring portion size because Ghanaian preschoolers consumed fish by

it is weighted equally with their daily consumption of fruit. Shorter recall periods might capture less arbitrary deviation – like the once-a-month chocolate – and reduce the bias that comes from not being able to identify frequency.

The empirical analysis will inform me to what degree the concerns just raised are problematic. The caveats keep me from overstating the power of the measures. The indicators are, after all, aggregations of data which entail a degree of blunting that in this case happens through recall period and unit of analysis. At the same time, I also shouldn't be paralysed by imperfect measures in an imperfect world. The empirical work will tell me whether I can summarise information in a useful way using dietary diversity which is what I mean when I say the measure is a good one. This discussion helps me discern where dietary diversity has more traction compared to food expenditure and clarify my thoughts about why I think so.

I have now created my new dietary diversity variables and thought carefully about exactly what they mean. The next section lays out my strategy to answer my empirical questions.

7. Methodology

I have two empirical tasks in this paper. Firstly, I want to ascertain whether my new dietary diversity variable usefully summarises information about food security or not. Assuming I answer this question affirmatively, I want to know whether I need a variable like dietary diversity in a data set that already includes food expenditure – are these two substitutes or complements for explaining food security?

7.1. Testing Dietary Diversity

The first step is to limit the sample to households and individuals for whom dietary diversity and food expenditure is non-missing. This gives an unweighted restricted sample for analysis of 6 424 households and 12 550 adults over 20 years of age.[9]

In her comprehensive overview of research on dietary diversity, Ruel (2002) identifies Hoddinott & Yohannes' (2002) paper as one of two papers published up until 2002 that assess the ability of dietary diversity to capture food security (as opposed to correlation with socio-economic factors or nutrient adequacy). Hoddinott & Yohannes (2002) conducted a study of ten developing countries (India, the Philippines, Mozambique, Mexico, Bangladesh, Egypt, Mali, Malawi, Ghana, and Kenya). The authors examine the relationship between dietary diversity/food variety and consumption (i.e. food access) and energy availability (i.e. food availability). They find that a "1% increase in dietary diversity is associated with a 1% increase in per capita consumption (food and non-food); a 0.7 % increase in total per capita caloric availability; a 0.5% increase in household per capita daily caloric availability from staples; and a 1.4% increase in household per capita daily caloric availability from non-staples." (Hoddinott & Yohannes, 2002: iii).

These results account for sample (ten developing countries), location (urban or rural), econometric method (multivariate analysis or correlation coefficients), and summing over food groups or foods (dietary diversity or food variety). Based on the robustness of the results, the authors conclude that dietary diversity "would appear to show promise as a means of measuring food security and

sprinkling tiny amounts of fish powder on their porridge. Rose et al. (2002) successfully employed a frequency tool in Mozambique. Integrating portion size requires a detailed knowledge of local dietary patterns.

[9] Sample restriction: Households for whom dietary diversity and food expenditure data are non-missing and non-zero. Adults aged 20+ years for whom dietary diversity and food expenditure data are non-missing and non-zero.

monitoring changes and impact, particularly when resources available for such measurement are scarce." (Hoddinott & Yohannes, 2002: 3).

Hoddinott & Yohannes (2002) used calorie availability and per capita consumption as their proxies for the availability and access domains of food security, respectively. As previously explained, NIDS does not offer the information needed to derive caloric consumption of any kind, which is why I cannot use caloric availability variables. However, I do have consumption variables available in the form of total consumption and food consumption. I replicate Hoddinott & Yohannes (2002) insofar as I test whether NDDS and NFVS have a positive and statistically significant association with my chosen proxies for access (total expenditure and food expenditure) in terms of correlation coefficients and multiple regression analysis in both urban and rural samples. The expenditure variable I use has been fully imputed by the NIDS team in the same way as food expenditure was described in Section 4.2. The variable is an aggregation of food and non-food expenditure (Finn et al., 2009).

Like Hoddinott & Yohannes (2002) I begin with correlation coefficients, although I report only Pearson and not Spearman correlation coefficients. Spearman coefficients are favoured for ordinal variables and Pearson coefficients are preferred for interval variables. Because there is a meaningful interpretation of one unit of NDDS or NFVS, Pearson is more appropriate. The multiple regression approach that follows is preferred to the correlation coefficient approach because of its ability to control for other socio-economic variables (Hoddinott & Yohannes, 2002; Ruel, 2002). Hoddinott & Yohannes (2002) control for household size, age and education of household head, and location. Location does not refer to rural-urban location, but rather to region; I use provinces. Hoddinott & Yohannes (2002) examine robustness to rural-urban location by running separate samples. My extensions are to add race, employment and income to these replications given South Africa's recent history of racial segregation, persistent structural unemployment, and high income inequality, respectively.

In each case I follow Hoddinott & Yohannes (2002) and log the left hand side variable and my dietary diversity variable in order to obtain an elasticity interpretation. Standard errors are corrected for clustering and sampling weights. My specifications closely follow Hoddinott & Yohannes (2002) and are the following:

$$\ell(\text{P.C. Mnthly Expenditure}) = \beta_0 + \beta_1\ell(\text{NDDS}) + \mathbf{X\beta}^{10} + \varepsilon$$
$$\ell(\text{P.C. Mnthly Expenditure}) = \beta_0 + \beta_1\ell(\text{NFVS}) + \mathbf{X\beta} + \varepsilon$$
$$\ell(\text{P.C. Mnthly Food Exp.}) = \beta_0 + \beta_1\ell(\text{NDDS}) + \mathbf{X\beta} + \varepsilon$$
$$\ell(\text{P.C. Mnthly Food Exp.}) = \beta_0 + \beta_1\ell(\text{NFVS}) + \mathbf{X\beta} + \varepsilon$$

The models are designed to reveal the correlation between our new indicator of food access and an already established one. I can then decide whether that correlation is high enough to call my dietary diversity variables good indicators of access to food security by comparing Hoddinott & Yohannes' (2002) results.

7.2. Pathways to Food Security

My second task is to test whether the theoretical differences between dietary diversity and food expenditure come out empirically. I hypothesised that this would happen in the form of complementary relationships with BMI and hunger.

[10] These are: ℓ(Household Size) + ℓ(Age of Household Head) + Education of the Household Head + Race of the Household Head + Employment Status of the Household Head + Province Dummies + ℓ(per capita monthly income)

I follow Wittenberg (2013) for my analysis of BMI and Melgar-Quinonez et al. (2006) for my analysis of hunger, but allow for cross-fertilization between methodologies. Wittenberg (2013) uses the 1998 Demographic & Health Survey (DHS) and NIDS Wave 1 (2008) to show that the relationship between economic resources (assets in the DHS and income in NIDS) and BMI is non-decreasing for the African population. He concludes that this implies BMI can be used as a "crude" measure of wellbeing in South Africa. A similar pattern is found for surrounding countries using their respective DHS's; these were Lesotho, Swaziland, Malawi, Mozambique, and Namibia. Wittenberg's (2013) interest was in the role of economic resources, but my focus is on access to food security proxies. I extend Wittenberg's (2013) research by adding dietary diversity and food expenditure to his model and observing the contribution of each to BMI.

Few studies model the type of hunger I am using; that is, self-reported hunger. Melgar-Quinonez et al. (2006) compare a Food Consumption Score (FCS) to the U.S. Household Food Security Survey Module (HFSSM) for rural samples of households in Bolivia, Burkina Faso, and the Philippines. I use this study as a guideline because the HFSSM is a predominantly experience-based indicator. The indicator comprises 9 questions probing the extent of hunger over the past 12 months. The FCS measures dietary diversity but is more sophisticated than my indicators (Jones et al., 2013). The FCS blends expenditure and dietary information to derive frequencies and casts judgements about food groups through a weighting system. The results of the study showed that households deemed food secure by the HFSSM had higher daily per capita food expenditure. These households also spent more on animal source foods, vegetables, and fats and oils.

In order to test whether the association between indicators and outcomes is in the direction I expect, I begin with Pearson correlations, following Melgar-Quinonez et al. (2006). I expect positive and statistically significant associations between the indicators and BMI and negative and statistically significant associations between the indicators and hunger. Wittenberg (2013) runs non-parametric regressions of income or assets on BMI. I undertake this for BMI but not for hunger. This analysis is inappropriate for hunger because it is an ordinal discrete variable. Wittenberg (2013) splits the sample into gender-race sub-samples. I am more concerned with the gender effect and so only split by gender.

Next I embark on parametric analysis to test whether dietary diversity and food expenditure are substitutes or complements in explaining my outcomes. Substitutes are understood as explaining the same part of the variation in the outcome – the implication being that only one of the variables is needed to analyse the impact of food access, in these terms, on the outcome (Un & Cuervo-Cazurra, 2004). A complementary relationship means that both variables contribute uniquely to explaining the outcome and so both are needed for a sound understanding of how food access affects the outcome. An example of methodology that tests a similar question is Un & Cuervo-Cazurra (2004) in the business management literature. Un & Cuervo-Cazurra (2004) test whether two different management strategies are substitutes or complements in creating new knowledge. The authors run regressions including each management strategy separately and then include both in the same regression. They then observe statistical significance to evaluate whether the strategies are substitutes or complements. I follow this two-stage strategy and test food security indicators first separately and then together.

The Frisch-Waugh-Lovell (FWL) Theorem is the statistical proof that the coefficient of a variable in a multiple regression is its impact on the dependent variable, having taken the effect of all the other regressors into account (Wittenberg, 2011). Take two regressors, X1 and X2. The effect of X1 on the dependent variable can be diluted if it overlaps with the effect of X2 on the dependent variable. In other words, there is a level of correlation between X1 and X2 corresponding with variation in the dependent variable. The extent to which this overlapping occurs can be measured by whether the effect of X1 on the dependent variable remains statistically significant when X2 is controlled for. I draw on Un & Cuervo-Cazurra's (2004) decision rules for classifying significance patterns in **Table 8** below. If X1 and X2 explain a sufficiently similar part of the variation in the dependent variable, they are substitutes and will both be statistically insignificant (Un & Cuervo-Cazurra, 2004). If they explain sufficiently distinct parts, they are complements and will both be statistically significant.

Table 8: Using the FWL Theorem to Interpret Significance in Multiple Regression Output
** denotes significance; - denotes insignificance*

	Variables included as Regressors			Interpretation of Relationship between X1 and X2
	X1	X2	X1 + X2	
1.	*	*	*+*	Complementary
2.	*	*	-+-	Substitutes
3.	*	*	*+-	X1 and X2 are correlated; X1 is more important than X2
4.	*	-	*+-	X1 has a significant role to play
5.	*	-	-+-	X1 and X2 are correlated; X1 has a role to play
6.	-	-	-+-	No variable is empirically important

For BMI, I use Wittenberg's (2013) regression model and add my indicators to the model to observe sign and significance of the coefficient. Wittenberg's (2013) model controls for log of monthly income, smoker status, household size, number of young children, age, age squared, years of education, gender, employment status, race, and province. He runs several versions of this model including a pooled (gender) OLS, OLS by each gender separately, a fixed effects and a random effects regression. I discard with the fixed effects model because it precludes the ability to control for fixed socio-economic variables. The random effects model applies very stringent assumptions that the household level effects are independent of the explanatory variables (Wittenberg, 2013). This is left out in my analysis as well. My approach is to run three OLS regressions – men, women, and both genders – and to add food expenditure and dietary diversity to these regressions individually and then together.

Parametric analysis for hunger follows Melgar-Quinonez et al. (2006). Controls included rural-urban location, membership of a microfinance program, age, gender, educational level, marital status, self-perception as household head, household size, number of children under five years, number of adults over 65, ownership of dwelling, number of durable goods and food group dummies. I use this model as a guide to create a set of controls using the variables available in NIDS.[11]

The more discrete nature of our hunger variable *vis-à-vis* the HFSSM means I must adjust this model. The hunger variable ranges from one to four in increasing intensity. I run an ordinal logit and interpret the results for the ultimate category (always/often being hungry) and the penultimate category (sometimes). This allows me to keep the detail of the data and still interpret the categories of most interest. First I run specifications including food security indicators one at a time and then include them both in the same regression.

I now turn to the empirical results for my first task: testing dietary diversity.

[11] The NIDS version of this model is presented and motivated in Appendix B

8. Empirical Results: Testing Dietary Diversity

8.1. Correlation Coefficients

Pearson correlation coefficients between food expenditure and NDDS and NFVS are reported in **Table 9.** All coefficients are positive and statistically significant at the 5% level. The coefficients are moderately positive for food expenditure and weakly positive for total expenditure. NFVS displays a stronger association to both expenditure variables than NDDS.

Table 9: Pearson Correlation Coefficients between Dietary Diversity and Expenditure Variables using the Restricted Sample of Households in NIDS Wave 1

	Per Capita Monthly Food Expenditure	**Per Capita Monthly Expenditure**
NFVS	0.46*	0.33*
NDDS	0.40*	0.29*
N	6424	

Note: * indicates significance at the 5% level; sample limited to households for which both dietary diversity and food expenditure are non-missing and non-zero; own calculations using NIDS Wave 1; adjusted with sampling weights.

8.2. Multiple Regression

The results of my multiple regression replication and extension of Hoddinott & Yohannes' (2002) model are reported in **Table 10**. All the coefficients are positive and highly significant at the 0.1% level. Extending the model by including race and employment status of the household head and per capita household income diminishes the magnitude of my coefficients substantially, particularly for total expenditure. Overall, the association of dietary diversity with food expenditure is higher than with expenditure, especially in the extension. NDDS has marginally stronger associations than NFVS in the replication specification, and the opposite is true in the extension specification.

The replication reports that a 1% increase in NDDS is associated with a 0.99% increase in per capita monthly expenditure, all else equal; a 1% increase in NFVS is associated with a 0.96% increase in per capita monthly expenditure, all else equal. All else equal, a 1% increase in NDDS is associated with a 1.09% increase in food expenditure and a 1% increase in NFVS is correlated with a 1.05% increase in per capita monthly food expenditure.

Table 10: OLS Regression Output Comparing Expenditure and Dietary Diversity in a Model from Hoddinott & Yohannes (2002) for the Restricted Household Sample in NIDS Wave 1

Dependent Variable:	**Log Per Capita Monthly Expenditure**				**Log Per Capita Monthly Food Expenditure**			
	Replication [a]		*Extension* [b]		*Replication* [a]		*Extension* [b]	
Log NDDS	0.99*** (0.07)		0.47*** (0.05)		1.09*** (0.07)		0.80*** (0.06)	
Log NFVS		0.96*** (0.06)		0.50*** (0.04)		1.05*** (0.05)		0.81*** (0.04)
N	6236	6236	6236	6236	6236	6236	6236	6236
R^2	0.63	0.66	0.81	0.82	0.66	0.71	0.76	0.79

Notes: Standard errors in parenthesis; * p<0.05, ** p<0.01, *** p<0.001; own calculations using NIDS Wave 1; standard errors corrected for clustering and sampling weights; the restricted sample is limited to households for which dietary diversity and food expenditure data is non-missing and non-zero; (a) The following variables were controlled for: log of household size, log of age of the household head, education of the household head, and location (province) (b) The following variables were controlled for: log of household size, log of household head age, education of the household head, location (province), race of the household head, employment status of the household head, and log of per capita monthly income.

Hoddinott & Yohannes (2002: 39) surveyed ten countries and found that "a 1 percent increase in dietary diversity is associated with households experiencing between a 0.65–1.11 percent increase in per capita consumption". All my replication regression coefficients fall within this bracket and my food expenditure coefficients for the extension also do. The authors interpret associations within this bracket as indicative of dietary diversity being a 'good indicator'. Based on this, I can use these results to call the NDDS and NFVS promising indicators of food security in the fashion of Hoddinott & Yohannes (2002).

8.3. Rural-Urban Robustness Test

Hoddinott & Yohannes (2002) perform a robustness check of comparing performance across rural and urban areas. The authors are only able to do this for two countries, Mozambique and Egypt. While Egypt had roughly equal associations across location, Mozambique had stronger correlations in urban areas. **Table 11** below runs the replication specification and shows that South Africa has stronger urban associations like its Sub-Saharan neighbour. Mozambique had an elasticity of 0.614 in rural areas and 1.002 in urban areas. The coefficients for the expenditure regressions are quite similar.

<u>Table 11</u>: OLS Regression Output Comparing Expenditure and Dietary Diversity in a Model from Hoddinott & Yohannes (2002) for the Restricted Urban and Rural Household Sample in NIDS Wave 1

Depvar:	**Log Per Capita Expenditure**				**Log Per Capita Food Expenditure**			
	Rural		*Urban*		*Rural*		*Urban*	
Log NDDS	0.69*** (0.07)		1.17*** (0.12)		0.82*** (0.06)		1.30*** (0.13)	
Log NFVS		0.69*** (0.06)		1.08*** (0.10)		0.81*** (0.05)		1.21*** (0.08)
N	2941	2941	3295	3295	2941	2941	3295	3295
R^2	0.57	0.60	0.59	0.62	0.67	0.72	0.63	0.69

Notes: Standard errors in parenthesis; * p<0.05, ** p<0.01, *** p<0.001; own calculations using NIDS Wave 1; standard errors corrected for clustering and sampling weights; the restricted sample is limited to households for which dietary diversity and food expenditure data is non-missing and non-zero; The following variables were controlled for: log of household size, log of age of household head, education of the household head and location (province).

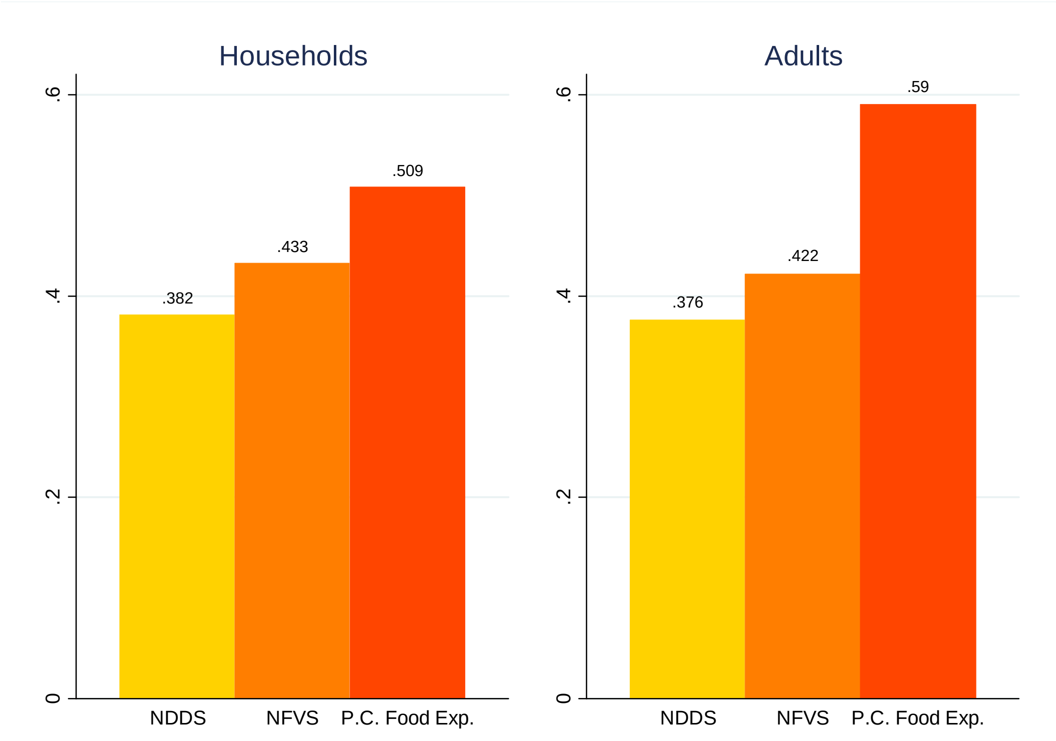
With these final results, I have successfully shown my indicators to be positively and significantly related to expenditure and food expenditure. The results are robust to econometric method used (correlation, regression), location (urban, rural), and type of score (food group, food variety). Dietary diversity in the NIDS sample is a useful variable to summarise information about food security in the fashion of Hoddinott & Yohannes (2002).

Before I move on to the empirical results of the second task, I take the opportunity to put my new indicators to use. In the next section I use NDDS and NFVS to describe the South African population, BMI, and hunger; and compare this to food expenditure. The descriptive exercise provides preliminary evidence that diet quality and quantity may be complements in explaining South African food security.

9. Describing Food Security in South Africa using Dietary Diversity

In order to describe food security in my sample, cut-offs are needed to divide the population into food secure and insecure. StatsSA's 2008 food poverty line is employed as the divider for food expenditure (StatsSA, 2008). This is R259 per person per month. For the NFVS and NDDS I use the weighted sample mean as per the recommendation of the FAO (FAO, 2011). This is 10 in the case of NDDS and 16 in the case of NFVS. The decision to make households 'on the line' count as food secure changes the status of 442 households with a NFVS of 16 and 978 households with an NDDS of 10 from food insecure to secure. **Figure 11** depicts histograms of the percentage of the sample classified as food insecure.

Figure 11: Histograms of the Percentage of the Restricted Sample in NIDS Wave 1 Classified as Food Insecure by NDDS, NFVS, and Per Capita Food Expenditure



Notes: adjusted with sampling weights; sample restricted to households or adults aged 20+ years for which/whom dietary diversity and food expenditure data is non-missing and non-zero; own calculations using NIDS Wave 1

Food expenditure is the strictest measure classifying half of households and about 60% of adults as food insecure. These numbers are lower than other literature using expenditure to determine food security. Jacobs (2009), for example, finds that 82% of households couldn't afford a basket of food of adequate nutritional value. Just over 40% of households and adults have lower than average NFVS and are therefore are classified as food insecure. Just less than 40% of households and adults are food insecure according to NDDS.

Food insecurity in terms of dietary diversity can be interpreted as increasing the chance of micronutrient deficiencies because it is indicative of a potentially nutrient poor diet. I say 'increasing the chance' because dietary diversity is not a rigorous test of micronutrient deficiency.[12] Food insecurity by dietary diversity can therefore be used to estimate the level of hidden hunger in the South African population. **Table 12** below compares weight category with food security by NDDS and NFVS. I interpret those of normal weight or overweight living in households with lower than average dietary diversity as potentially suffering from hidden hunger. This is because the weight of these individuals masks the fact that their diet might be poor enough to lead to micronutrient deficiencies. Those who are underweight and have poor diet are treated as malnourished – their hunger is observable to the eye. I estimate that 37.19% of adults in South Africa potentially suffer from hidden hunger according to NDDS. The figure is 41.68% of adults according to NFVS.[13]

Table 12: The Intersection of Weight and Diet Quality for the Restricted Adult Sample in NIDS Wave 1

UW: underweight; NW: normal weight; OW: overweight or obese

%	NDDS				NFVS			
	UW	NW	OW	**Total**	UW	NW	OW	**Total**
Food Insecure	2.35	18.90	18.29	**39.54**	2.65	21.29	20.39	**44.33**
Food Secure	2.43	23.61	34.42	**60.46**	2.13	21.22	32.33	**55.67**
Total	**4.77**	**42.51**	**52.72**	**100.00**	**4.77**	**42.51**	**52.72**	**100.00**

Notes: adjusted with sampling weights; sample limited to households for which dietary diversity and food expenditure data is non-missing; own calculations using NIDS Wave 1.

The second task in this paper is to determine whether dietary diversity and food expenditure are complementary in explaining food security. I can use the basic binary classifications as a preliminary test of whether this might be the case. Figure 11 describes how food expenditure is stricter than dietary diversity. Perhaps all the households food insecure by dietary diversity are already captured as food insecure by food expenditure? The theoretical difference between how we think of households as food insecure by diet quality or diet quantity may not matter empirically if this is the case. To see whether this is the case with these binary classifications, I present contingency tables in **Table 13** below.

[12] Faber and Wenhold (2007: 393) write that individuals should not be classified as over- or undernourished based on dietary diversity, but dietary diversity can be used to "identify an at-risk state".

[13] In case an NDDS of 10 or an NFVS of 16 is too high to truly represent a diet lacking in micronutrients, I calculate a lower bound of hidden hunger in Appendix C. I use a cut-off of one standard deviation below the mean instead of the mean itself.

<u>Table 13</u>: Contingency Tables for Food Security Classification by Dietary Diversity and Food Expenditure using the Restricted Household Sample of NIDS Wave 1

(a) NDDS

		NDDS: Food Insecure	NDDS: Food Secure	Total
Food Expenditure	Food Insecure: N	1850	1417	3267
	%	28.80	22.05	50.86
	Food Secure: N	601	2556	3157
	%	9.35	39.79	49.14
	Total	2451	3973	6424
	%	38.16	61.84	100.00

(b) NFVS

		NFVS: Food Insecure	NFVS: Food Secure	Total
Food Expenditure	Food Insecure: N	2079	1188	3267
	%	32.36	18.50	50.86
	Food Secure: N	702	2455	3157
	%	10.93	38.22	49.14
	Total	2781	3643	6424
	%	43.28	56.72	100.00

Notes: adjusted with sampling weights; sample limited to households for which dietary diversity and food expenditure data is non-missing and non-zero; own calculations using NIDS Wave 1.

There is a high level of agreement about food security and insecurity. NDDS classifies 68.59% and NFVS 70.58% of households in the same way as food expenditure. The contingency tables reflect the relative strictness of food expenditure. Many households that food expenditure rates food insecure are classified as food secure by NDDS and NFVS. This amounts to just over and under 20% of the total sample for NDDS and NFVS, respectively. The crucial part, though, is that there are a handful of households – about 10% of the total sample in each case – that dietary diversity deems food insecure, that food expenditure considers food secure. This translates to about a quarter of the households deemed food insecure by NDDS and NFVS.

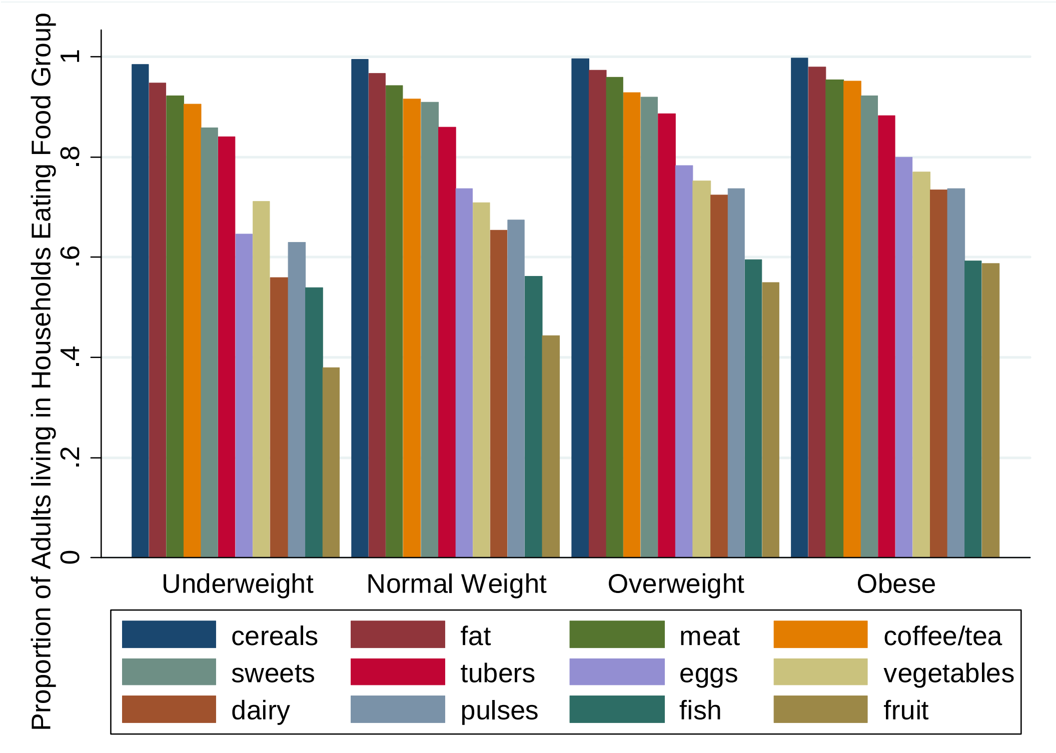
The contingency tables show that it is not the case that food expenditure consumes all the space that dietary diversity explains. Some households are only diet poor, some households just calorie poor, and a portion are both. This is not a stringent test and the binary classifications don't make the most of the data. But, this is a clue that the theoretical differences between the indicators may be coming out in the data. This descriptive exercise is taken further by observing what the new dietary diversity indicators look like when combined with my outcome variables, BMI and hunger.

9.1. Food Security Indicators & BMI

Figure 12 plots food group consumption by weight category for the restricted sample. Consumption of the top five foods remains consistent across weight categories: cereals, fat, meat, tea & coffee, sweets, and potatoes. There is a large discontinuity after these five food groups for all weight groups. Eighty percent of individuals in all weight categories lived in households that consumed these foods.

Diversity increases as weight category becomes heavier. Fruit, pulses, eggs, and dairy increase noticeably as weight category increases. Only about 40% of underweight people live in households that consumed fruit in the previous month compared to about 60% of obese people.

Figure 12: Proportion of Adults Living in Households Consuming Twelve Food Groups by BMI Weight Category for the Restricted Sample of Adults in NIDS Wave 1



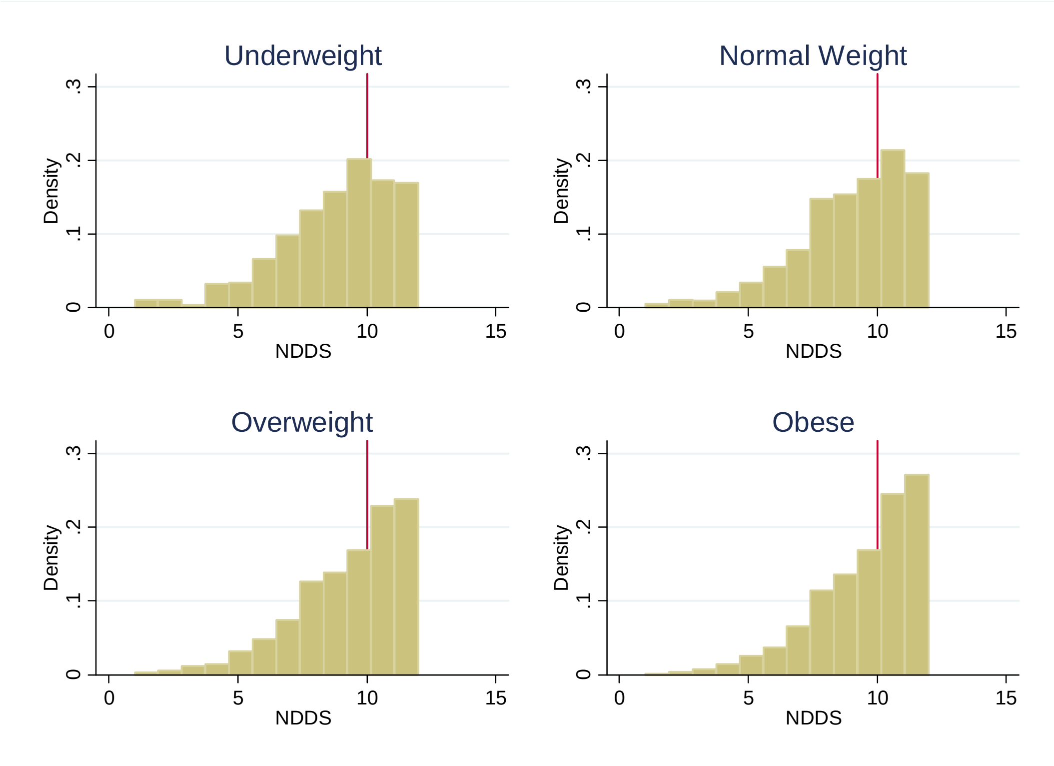
Notes: adjusted using sampling weights; own calculations using NIDS Wave 1 data; sample restricted to adults aged 20+ for whom dietary diversity and food expenditure data is non-missing and non-zero.

Next, dietary diversity indicators are split by weight category to get **Figure 13**. Both panels demonstrate how diversity increases as weight becomes heavier. The shifting is clearer for NDDS than for NFVS. The restraint of the movement in Figure 13 could be reflecting the difficulty of detecting differences at the individual level with a household level variable.

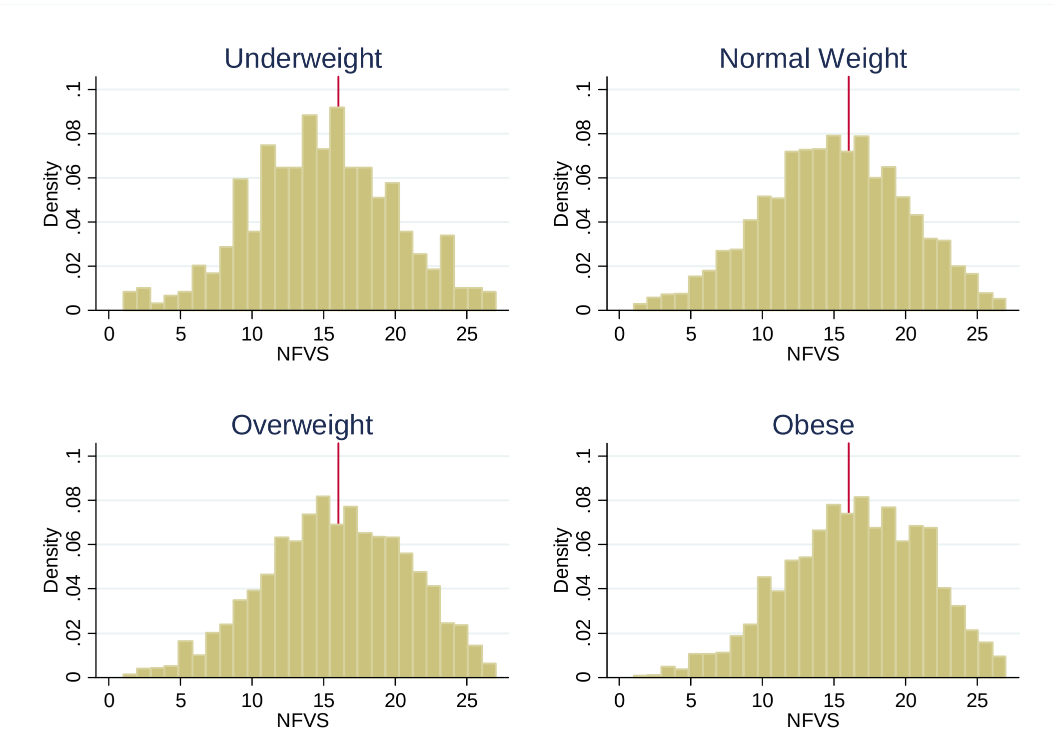
<u>Figure 13</u>: Histograms of Dietary Diversity Indicators by Weight Category for the Restricted Sample of Adults in NIDS Wave 1

Food security cut-offs indicated in red

(a) NDDS



(b) NFVS

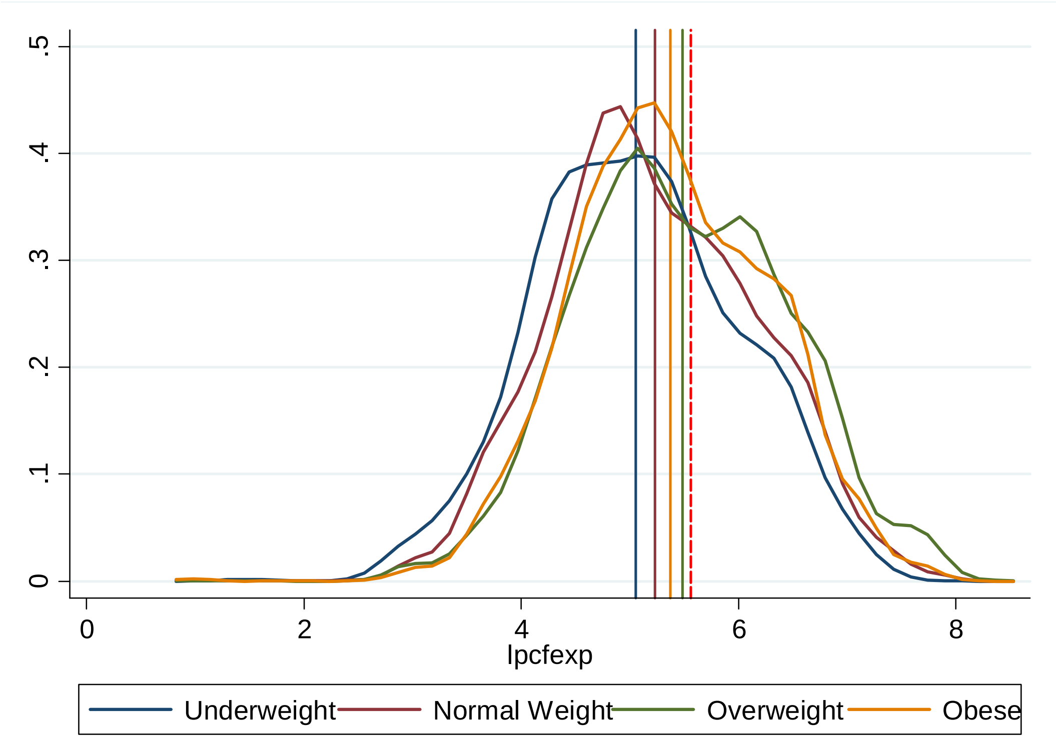


Notes: one bin in the histogram per discrete step in the NDDS or NFVS; sample restricted to adults aged 20+ years for whom dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

The mean and distribution of food expenditure by weight category is described in **Figure 14** below. Mean food expenditure increases with weight, except that overweight individuals live in households spending slightly more on food on average than obese individuals in this sample. What is interesting is that none of the mean values per weight group are above the food poverty line. This reflects how evenly weight categories are spread across income quintiles i.e. that there are also some very poor individuals in the obese category (See Figure 5). All the means were statistically significantly different from each other at the 5% level of significance, except for those between obese and overweight individuals which were significantly different at the 10% level.[14]

<u>Figure 14</u>: Density of Logged Per Capita Monthly Food Expenditure by Weight Category for the Restricted Sample of Adults in NIDS Wave 1

Category means indicated by the line on the X-axis in the corresponding colour; food security cut-off indicated dashed in red



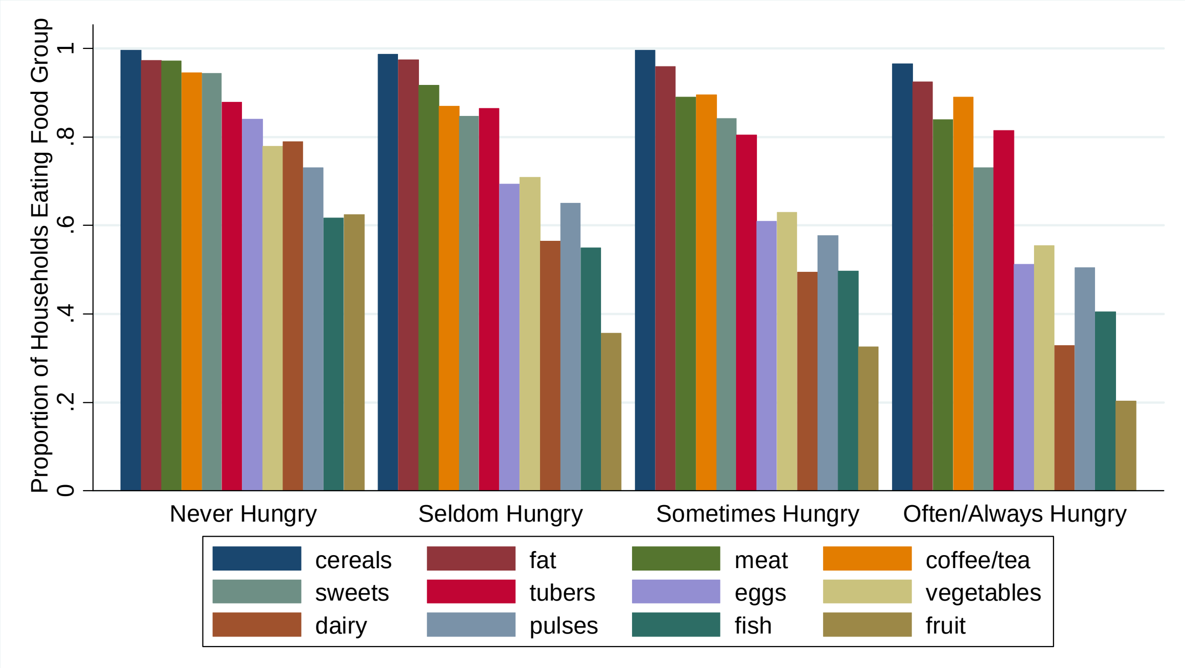
Notes: adjusted using sampling weights; sample restricted to adults aged 20+ years for whom dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

9.2. Food Security Indicators & Hunger

Next I observe how our indicators describe hunger in our sample. I plotted the proportion of households eating a food group in the past month by hunger categories to get **Figure 15.** Dietary diversity decreases as hunger increases. Fruit consumption is quite dire for often/always hungry households. Only about 20% of them consumed fruit; about 30% consumed dairy; and only about half consumed eggs. Fruit and dairy consumption falls quite dramatically as hunger increases. Additionally, one of the top five food groups, sweets, falls below a consumption prevalence of 80% for the first time. This is also for often/always hungry households. The shift in dietary diversity seems a lot clearer than it was for BMI.

[14] See Appendix D Table D1

<u>Figure 15</u>: Prevalence of Household Consumption of Twelve Food Groups by Hunger Category for Households in the Restricted Sample for NIDS Wave 1



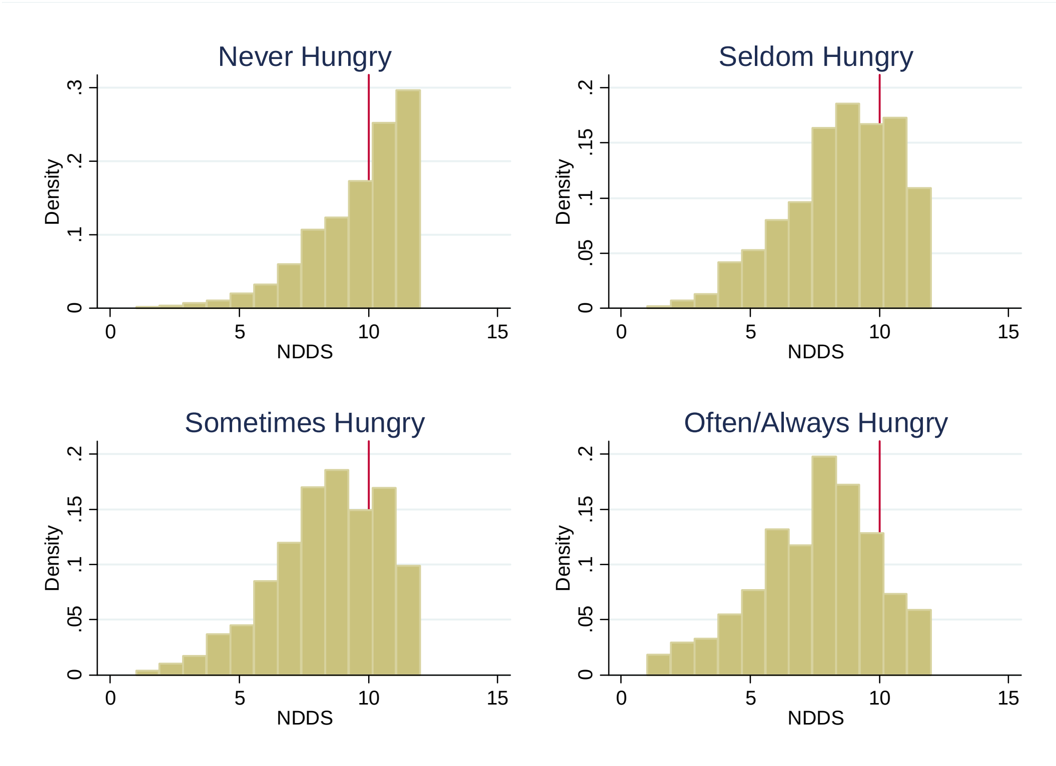
Notes: adjusted using sampling weights; own calculations using NIDS Wave 1 data; sample restricted to households for which dietary diversity and food expenditure data is non-missing and non-zero.

As with BMI, I compute histograms of the NDDS and NFVS for each hunger category in **Figures 16**. The movement between categories is much more obvious for hunger than it is for BMI. Both the NDDS and NFVS appear to have a negative relationship with hunger. The mode for both indicators creeps further leftward as hunger rises. The clarity of the pattern could be a function of both indicators and outcomes using the same unit of analysis, households.

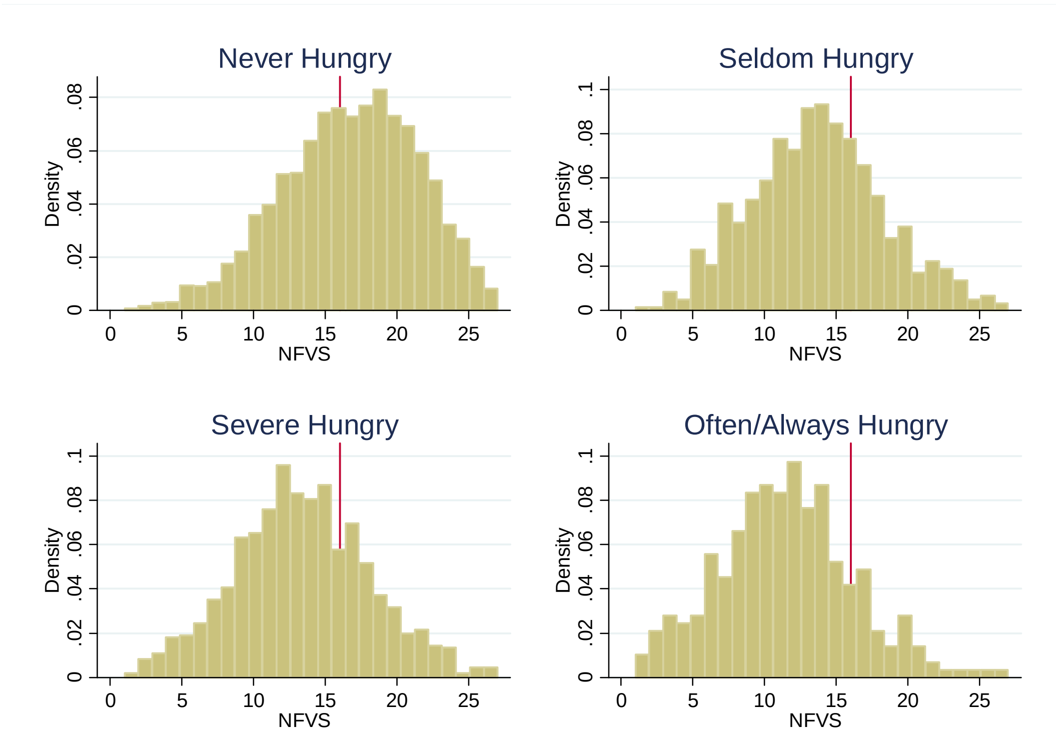
<u>Figure 16</u>: Histograms of Dietary Diversity Indicators by Hunger Category for the Restricted Sample of Households in NIDS Wave 1

Food security cut-offs indicated in red

(a) NDDS



(b) NFVS

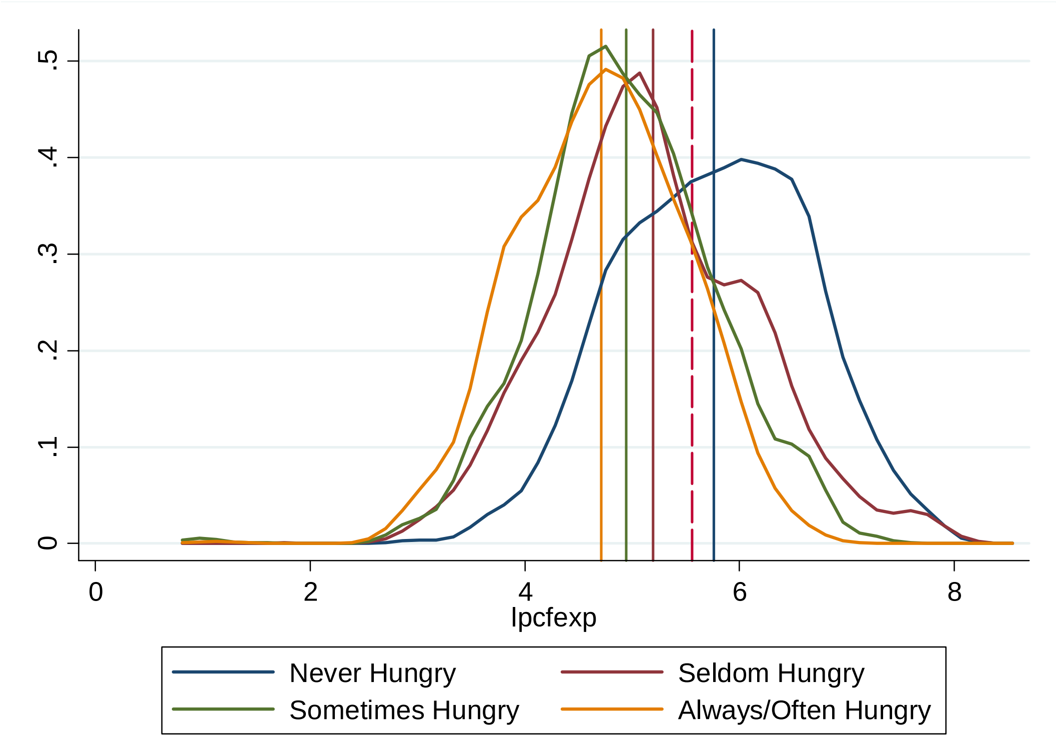


Notes: one bin in the histogram per discrete step in the NDDS or NFVS; sample restricted to households for which dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

A more obvious pattern is also visible between food expenditure and hunger in **Figure 17**. The curves move rightward as hunger decreases expressing a negative relationship between food expenditure and hunger. The means have also been reported in this figure and are all statistically significantly different from each other at the 0.1% level, except that between households sometimes and often/always hungry which is significant at the 1% level.[15]

Figure 17: Density of Logged Per Capita Monthly Food Expenditure by Hunger Category for the Restricted Sample of Households in NIDS Wave 1

Category means indicated by the line on the X-axis in the corresponding colour; food security cut-off indicated dashed in red



Notes: adjusted using sampling weights; sample restricted to households for which dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

So far, I have established that dietary diversity is a workable tool to understand food security in my sample. I then used my new indictor to describe food security in my sample and compare it to how food expenditure does so. The descriptive exercise uncovers that food expenditure and dietary diversity have a positive relationship with BMI and a negative one with hunger. It also provided a preliminary hint that food expenditure and dietary diversity are complements in explaining food security. I now turn to a more rigorous testing of these relationships with my empirical results in the next section.

10. Empirical Results: Pathways to Food Insecurity

10.1. Correlation Coefficients

The first set of results present correlation coefficients reported in **Table 14**. All the coefficients are statistically significant at the 5% level. For all outcomes, NFVS offers slightly stronger association than NDDS. Indicators have a weak positive association with BMI and a moderate negative one with hunger.

[15] See Appendix D Table D2.

There is a considerable gender discrepancy for BMI. The correlation between female BMI and NFVS and NDDS is roughly half what it is for men. The correlation between female BMI and food expenditure is very weak at 0.04 and less than a fifth of what it is for men. Male BMI is more strongly correlated with expenditure, whereas female BMI has a stronger association with dietary diversity.

Table 14: Pearson Correlation Coefficients for Food Security Outcomes and Indicators in the Restricted Sample of NIDS Wave 1

Indicators / Outcomes	*NFVS*	*NDDS*	*Log Food Expenditure*	**N**
BMI	0.13*	0.10*	0.06*	**10 005**
BMI (Women)	0.10*	0.07*	0.04*	**6 192**
BMI (Men)	0.21*	0.18*	0.25*	**3 813**
Hunger	-0.33*	-0.31*	-0.37*	**6 405**

Notes: * indicates significance at the 5% level; adjusted using sampling weights; sample for BMI restricted to adults aged 20+ years for whom dietary diversity and food security data is non-missing and non-zero; sample for hunger restricted to households for which dietary diversity and food security data is non-missing and non-zero; own calculations using NIDS Wave 1.

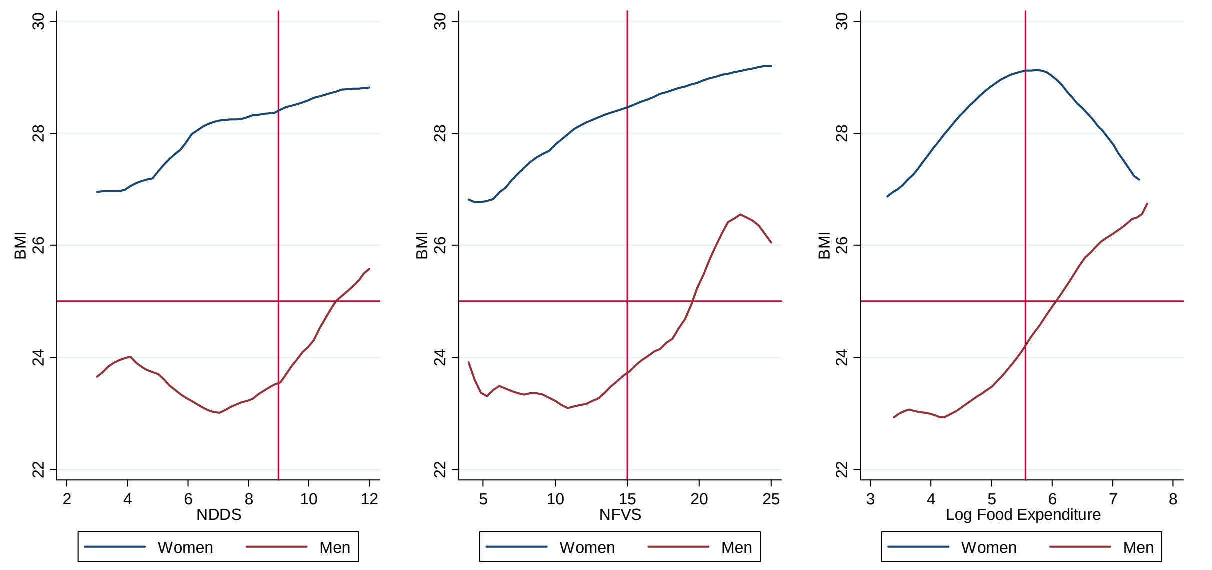
10.2. Non-Parametric Regression Analysis of BMI

The next piece of analysis is a non-parametric regression for BMI only. I run a local polynomial from the 1st to the 99th percentile following Wittenberg's (2013) explanation that the tails of non-parametric regressions can be unstable. I split the results by gender following the importance of this variable in my descriptive statistics and the literature (Kanter & Caballero, 2012; Case & Menendez, 2009).

My results are in **Figure 18**. BMI increases in a positive and largely linear fashion with all the indicators, except for female BMI and food expenditure. Female BMI first rises with food expenditure and then starts decreasing after food expenditure passes the food poverty line. As food expenditure increases, BMI starts reducing in the population of women. This could be because higher expenditure implies more expensive and possibly healthier food which is more nutrient-dense than calorie-dense. The maximum could also represent a satiation point with calories. Calories and variety of food are different in this sense in that there is a point where 'more is not always better' for consumption but not for dietary diversity. This is motivation for food expenditure to enter into my model in a quadratic fashion. Figure 18 also confirms that men and women should be evaluated in separate samples. Female BMI can always be characterised as overweight in this analysis whereas the same cannot be said for men.

<u>Figure 18:</u> Local Polynomial Regression of NDDS, NFVS and Food Expenditure on BMI by Gender in the Restricted Sample of Adults in NIDS Wave 1

Cut-off for overweight indicated in red on the Y-axis; Cut-off for food security indicated in red on the X-axis



Notes: Adjusted with sampling weights; graphed over the 1st to 99th percentile; sample restricted to adults aged 20+ years for whom dietary diversity and food expenditure data is non-missing and non-zero; own calculations using NIDS Wave 1 data.

10.3. Multiple Regression: BMI

Now I move onto testing, firstly, whether the significant relationships previously observed remain when other covariates are controlled for – Set 1 in the regression output below. Secondly, I am testing whether the indicators are complements or substitutes by adding them both to the same regression and observing sign and significance – Set 2 in the regression output below. **Table 15** offers the multiple regression coefficients on my food access proxies in the extension of Wittenberg's (2013) model split by gender. I standardise all the indicators so that they can be compared using the same unit of analysis.

Table 15: OLS Regression Output of the Association between Food Security Variables and BMI for Adults in the Restricted Sample of Adults in NIDS Wave 1

Dependent Variable: BMI

SET 1	*All*			*Women*			*Men*		
Std. NDDS	0.35**			0.40**			0.23		
	(0.11)			(0.15)			(0.15)		
Std. NFVS		0.55***			0.70***			0.34*	
		(0.12)			(0.16)			(0.16)	
Std. Log Food Exp.			0.50**			0.46*			0.47*
			(0.18)			(0.23)			(0.21)
N	9882	9882	9882	6125	6125	6125	3757	3757	3757
R^2	0.20	0.20	0.20	0.11	0.11	0.11	0.19	0.19	0.19

SET 2	*All*		*Women*		*Men*	
Std. NDDS	0.25*		0.32		0.11	
	(0.12)		(0.18)		(0.16)	
Std. NFVS		0.48***		0.70***		0.22
		(0.14)		(0.20)		(0.18)
Std. Log Food Exp.	0.36	0.19	0.28	0.01	0.40	0.33
	(0.20)	(0.20)	(0.28)	(0.29)	(0.23)	(0.23)
N	9882	9882	6125	6125	3757	3757
R^2	0.20	0.20	0.11	0.11	0.19	0.19

Notes: standard errors in parenthesis; * p<0.05, ** p<0.01, *** p<0.001; standard errors corrected for clustering and sample weights; sample limited to adults aged 20+ years for whom dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1; covariates controlled for are log of monthly income, smoker status, household size, number of young children, age, age squared, years of education, gender, employment status, race, and province.

All the coefficients are positive and less than one – an increase of a standard deviation in any indicator does not increase BMI by more than a point. NFVS continues to outperform NDDS. Whilst there is meant to be a meaningful nutritional difference in the food groups of the NDDS, it appears that the detail provided by NFVS is more helpful in predicting BMI. Some of the relationships observed with correlation coefficients in Table 14 above, change in Set 1. In particular, the association between female BMI and dietary diversity becomes a lot stronger than that of male BMI when covariates are added. The coefficients on NDDS and NFVS are roughly double for female BMI compared to men's. A one standard deviation improvement in NFVS increases female BMI by 0.7 points of BMI compared to 0.34 for men, all else equal. Female BMI increases by 0.4 points and male BMI by 0.23 points (although this is insignificant) if NDDS increases by a standard deviation, *ceteris paribus*. Adding controls to the association also affects significance. The association between male BMI and NDDS is rendered insignificant compared to significance at the 5% level in Table 14. In contrast, adding controls increases the significance level of the association between female BMI and dietary diversity.

It appears that dietary diversity is especially important for women, compared to men. Why this is the case requires more in-depth research than this paper covers, but I could speculate based on the different BMI profiles of the genders. Women are much more overweight and obese than men in this sample and in Cape Town this is linked to childhood nutritional deprivation and socio-economic success, as well as ideal body preferences (Case & Menendez, 2009). Perhaps food variety becomes important once some threshold of calories has been reached?

Moving to Set 2, I identify two sets of substitutes, and no complements according to my interpretation laid out in Section 7.2, Table 8. Taking Set 1 and 2 together, NDDS and food expenditure for women and NFVS and food expenditure for men are substitutes. That is, they look like row 2 in my table of interpretation, Table 8. Significance that is achieved in a regression without the other indicator, is lost when the other is included. At the same time, these variables are all jointly significant to the regressions they form a part of. In **Table 16** I perform an LR type test and report F-stats that are all highly significant at the 0.1% level. Food access in general is contributing significantly to explaining BMI.

<u>Table 16</u>: F-Statistics for the Joint Significance of Food Expenditure and Dietary Diversity using an LR Type Test

	All *F ~ (2, 9857)*	**Women** *F ~ (2, 6101)*	**Men** *F ~ (2, 3733)*
Std. Food Exp + Std. NDDS	39.17***	21.23***	16.54***
Std. Food Exp + Std. NFVS	63.24 ***	47.16***	19.90***

Notes: the unrestricted model is the specification used in Set 2 in Table 15; the restricted model excludes the variables in the first column of this table; * p<0.05, ** p<0.01, *** p<0.001.

NFVS and food expenditure are both significant for women in Set 1, but only NFVS retains its significance in Set 2 and the magnitude of food expenditure becomes negligible. This implies correlation between NFVS and food expenditure. Clearly these are not complements as food expenditure is not contributing significantly in Set 2. However, I do not feel comfortable calling them substitutes because of the precedence of NFVS both in significance and magnitude. This is row 3 in my interpretation table, Table 8. NFVS is more important for female BMI.

The role of NDDS and food expenditure on male BMI corresponds to row 5 in Table 8. Only food expenditure is significant in Set 1, but loses significance in Set 2 when included with NDDS. The fact that significance is lost implies a level of correlation, however, I do not think these variables are substitutes as NDDS did not have significant explanatory power in Set 1. Food expenditure contributes to male BMI, but when NDDS is controlled for this is not a statistically significant contribution. Table 16 reveals that NDDS and food expenditure are jointly significant in Set 2. Controlling for food access together does explain something about male BMI and this is likely reflecting the role of food expenditure.

Overall, when it comes to male BMI in this sample, NFVS and food expenditure are substitutes. Female BMI in this sample has a very high and significant association with NFVS even accounting for food expenditure. Here I would like to recall the non-parametric analysis in Figure 18 that plotted a quadratic relationship specifically between female BMI and food expenditure. In case this is behind the drastic fall in coefficient size and significance for food expenditure between Set 1 and 2 for female BMI, I run a robustness check reported in **Table 17**. For these regressions I added a squared version of my food expenditure variable to the regression and follow the Set 1 and Set 2 format of the previous output.

The quadratic shape observed in the local polynomial regression comes out in the parametric output in the form of a highly significant squared term in both sets. Female BMI first rises and then falls with food expenditure. In Set 2, all the variables are jointly significant in their respective regressions.[16] The continued significance of the food expenditure quadratic term suggests food expenditure is more important than NDDS and complementary with NFVS, in contrast to Table 15. The coefficient and significance of NFVS is reduced by the inclusion of the quadratic term, but not by a serious amount.

Table 17: OLS Regression Output for the Quadratic Relationship between Food Security Variables and Female BMI in the Restricted Sample of Adults in NIDS Wave 1

Dependent Variable: Female BMI

	Set 1	Set 2	
Std. NDDS		0.12 (0.19)	
Std. NFVS			0.52* (0.21)
Std. Log Food Exp.	0.39 (0.22)	0.33 (0.26)	0.06 (0.27)
Std. Log Food Exp Sq.	-0.45*** (0.10)	-0.44*** (0.11)	-0.40*** (0.10)
N	6125	6125	6125
r2	0.12	0.12	0.12

Notes: standard errors in parenthesis; * p<0.05, ** p<0.01, *** p<0.001; standard errors corrected for clustering and sample weights; sample limited to adults aged 20+ years for whom dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1; covariates controlled for are log of monthly income, smoker status, household size, number of young children, age, age squared, years of education, gender, employment status, race, and province

10.4. Ordinal Logit: Hunger

To model hunger, I followed the parametric model from Melgar-Quinonez et al. (2006). The hunger variable is ordinal and discrete in the following order: never, seldom, sometimes, often/always. As a result, I run an ordinal logit and report the results for the penultimate (sometimes) and ultimate (often/always) categories with never experiencing hunger as the base. The regression coefficients therefore are interpreted as the probability of being often/always hungry, for example, compared to not being hungry, *ceteris paribus*.

I have two sets of specifications in **Table 18** below, like I did for BMI. Set 1 confirms that the negative and significant relationship I found between hunger and the food security indicators holds true in the presence of other covariates. Set 2 adds both dietary diversity and food expenditure to the same model. All coefficients are highly significant and this is interpreted as evidence of complementarity. Dietary diversity and food expenditure significantly explain different parts of the variation in the probability of households being sometimes or often/always hungry compared to not hungry. This carves out a role for dietary diversity in explaining hunger in my sample, over and above that of food expenditure.

[16] F Stats reported in Appendix E

<u>Table 18:</u> Marginal Effects of an Ordinal Logit of the Association between Food Security Variables and Household Hunger in the Restricted Sample in NIDS Wave 1

Dependent Variable: Household Hunger

SET 1	*Sometimes*			*Often/Always*		
Std. NDDS	-0.03*** (0.01)			-0.01*** (0.00)		
Std. NFVS		-0.04*** (0.01)			-0.01*** (0.00)	
Std. Log Food Exp.			-0.05*** (0.01)			-0.02*** (0.00)
N	6193	6193	6193	6193	6193	6193

SET 2	*Sometimes*		*Often/Always*	
Std. NDDS	-0.02** (0.01)		-0.01** (0.00)	
Std. NFVS		-0.03*** (0.01)		-0.01** (0.00)
Std. Log Food Exp.	-0.04*** (0.01)	-0.03*** (0.01)	-0.01*** (0.00)	-0.01** (0.00)
N	6193	6193	6193	6193

Notes: standard errors in parenthesis; * p<0.05, ** p<0.01, *** p<0.001; standard errors corrected for clustering and sample weights; sample limited to households for which dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1; covariates controlled for are: rural location dummy, log of age of household head, gender of the household head, education level of the household head, marital status of the household head, race of the households head, employment status of the household head, household size, number of children under 5 years old, number of adults over 60 years, log of per capita monthly income, grant income dummy, and ownership of dwelling.

The size of the coefficients appears small, but these coefficients need to be compared to the base probability of falling into each group. 3.82% of households were always/often hungry in this regression sample. In Set 1, one standard deviation of either dietary diversity variable reduces the probability of being often/always hungry compared to never being hungry by 1 percentage point, all else equal. Food expenditure has a slightly larger effect at 2 percentage points. Relative to the base probability, these are large effects. In Set 2, the addition of the dietary diversity variables slightly dilutes the effect of food expenditure. Together, a one standard deviation increase in either dietary diversity indicator and food expenditure reduces the probability of often/always hunger compared to no hunger from 3.82% to 1.82%, all else equal. This is a substantial effect.

The base level for being sometimes hungry is 15.95% of households in this regression sample. Food expenditure again has the largest coefficient in Set 1. An increase of one standard deviation of food expenditure reduces the probability of a household being sometimes hungry compared to never hungry by 5 percentage points, *ceteris paribus*. The chance of being sometimes hungry versus never hungry falls from 15.95% to 9.95% if either dietary diversity indicator and food expenditure increase by a standard deviation. The precedence of NFVS compared to NDDS comes out for sometimes hungry households in the form of slightly larger coefficients for NFVS in both Sets.

When using standard deviations as our unit of measurement, food expenditure is equally or slightly more important in magnitude than dietary diversity. The link between hunger and calories holds is bolder. However, it is interesting that what households eat, as well as how much, they eat impacts their self-reported hunger.

11. Discussion & Conclusion

The first task of this paper was to build a dietary diversity indicator to capture diet quality in NIDS. I successfully built two dietary diversity tools; one based on food groups and one based on food variety. Dietary diversity classifies 38-43% of households as food insecure compared to food expenditure which classifies half of households as food insecure. In terms of how the triple burden characterises South Africa, 28% of households reported some level of hunger in 2008 and 52.57% of South African adults are either overweight or obese. I estimate that about 40% of adults in the sample are at risk of suffering from hidden hunger.

The next task of this paper was to clarify the linkages between different parts of the food security system for South Africans. The conceptual framework outlined that food expenditure pertains to the link between calories and food quantity. Dietary diversity pertains to the link between nutrient adequacy and diet quality. I find distinct empirical paths between diet quality and hunger, and diet quantity and hunger. The theoretical differences between quality and quantity come out empirically when hunger is concerned in this sample of South Africans. When comparing households that are sometimes or often/always hungry to those that are never hungry, I find that diet quantity is more important than diet quality, but that diet quality nevertheless contributes significantly. The size of the effect of diet quality and quantity is large when considering always/often hungry households, and relatively large when considering sometimes hungry households.

Does it make sense that both dietary diversity and food expenditure are predictive of hunger? As discussed above, I cannot be prescriptive about what exactly self-reported hunger is measuring. In other words, I cannot strip hunger down to quantity (calories) and then link it to food expenditure alone. Qualitative studies have found that a range of elements enter into self-reported measures of hunger and food security (Webb et al., 2002; Jones et al., 2013 Melgar-Quinonez et al., 2006). These include references to diet quality, amongst others.

Webb et al. (2002) rationalise why dietary diversity was a significant variable in their regression of a qualitative categorisation of households as hungry or not. The authors explain that for very hungry households, eating an additional food group is a tangible improvement in well-being. This reasoning can be applied to my results. This is especially the case in Set 2 (Table 18) regressions because food expenditure is held constant. There is a trade off between calories and nutrition. My descriptive statistics show that poor dietary diversity in South Africa is characterised by starchy calorie-high food groups like tubers and bread & flour. Households with higher dietary diversity are filling in their diets with more nutritious food groups like eggs, dairy, vegetables, pulses, and fruit. Pulses, eggs and dairy are both calorie high and full of vitamins (however, vegetables and fruit tend to be lower in calories). It is plausible that for the same level of consumption, adding food groups like eggs and dairy to an otherwise starchy diet will improve health and lessen hunger.

The difficulties pertaining to the hunger model were the conceptual issues surrounding what hunger reported by the eldest female on behalf of the rest of the household actually means. I suspect that I may be capturing more than just hunger in this subjective variable. I could possibly be tapping into social norms and personal preferences. In general, I think this enriches the data and ties it more closely to the *de facto* experience of food insecurity.

On the other hand, the route to BMI is more blurred and the conclusion less neat. The gender divide was stark and this is in line with international trends (Kanter & Caballero, 2012; Wells et al., 2012). South African women are much more likely to be overweight and obese than men, even in the lowest income quintile. Such different profiles implied different pathways to nutrition and this came out empirically. The empirical analysis reported that food expenditure and dietary variety (NFVS) are substitutes when explaining male BMI. However, diet variety (NFVS) and food expenditure are complements for female BMI when food expenditure enters into the model as a quadratic variable. Without the quadratic term, diet variety is of ultimate importance for female BMI.

These results are quite rich. Why is it the case that what is a complement for female BMI is a substitute for male BMI? Answering this is beyond the scope of this paper, although Wells et al. (2012) also found substantial gender differences when modelling overweight and speculated about the role of biological and gender equality factors. In general, it makes a lot of sense that diet quality and quantity should be complements. Weight and nutrition depend not only on how much you eat but also on what you eat.

Dietary diversity has a positive relationship with BMI, even though BMI can be unhealthy at both very high and low levels. In a review article, Raynor & Epstein (2001: 127) find that “food consumption increases when there is more variety in a meal or diet; greater variety is positively associated with increased body weight and body fat.” The authors suspected this could be a function of more palatable foods encouraging consumption. McCrory et al. (1999) explain that variety is a useful guideline for a healthy diet in only some cases. They find that variety within the grain group of the American Food Pyramid is associated with higher energy intake. In contrast, variety within the vegetable group is associated with negative energy intake. Cereals are over-represented in the NIDS Food Expenditure module and vegetables are under-represented. As a result, there is emphasis on grains in NFVS which might be linking the strong positive and significant coefficient for this variable to BMI.

It is also interesting that female BMI increases at a decreasing rate as food expenditure rises. This reflects the conceptual difference between consumption and food variety. More food variety is ‘always better’; however, there is a point of satiation when it comes to calorie consumption. This was only the case for women.

The major drawback of the BMI model is that the unit of analysis differs for indicator and outcome. A household level indicator (food expenditure and dietary diversity) is deployed to work at the individual level (BMI). This implies strong assumptions, such as household level dietary diversity being representative of individual diet or household per capita expenditure equalling individual consumption. The average intra-household standard deviation of adult BMI was less than 3 points of BMI, however, which is within a reasonable margin for this analysis.

This paper contributes another lens through which to study food security in NIDS – diet quality as NDDS or NFVS. NIDS already has a suite of other food security and socio-economic variables. Therefore, establishing that dietary diversity has something to contribute over and above an existing measure like food expenditure is valuable. It also makes NIDS an incredibly rich site for the study of food security. The fact that NIDS is a panel is especially promising for monitoring food security over time; something to be welcomed considering the uncertainty that surrounds South African food security statistics. The study of food security in South Africa would be greatly aided by the inclusion of detailed food consumption variables in more national and sub-national surveys. It is useful to know not only what people are eating, but how this interacts with other socio-economic variables in order to get a better grip on how food security operates. The Living Conditions Survey (LCS) holds great promise as an avenue of future research. This survey collects hunger and anthropometrics variables as well as including a diary component that covers food consumption. This opens up opportunity for detailed qualitative work. A 2014/2015 wave of the LCS was recently completed by StatsSA offering the chance of comparative analysis to the first 2008/2009 wave. Food security is a complicated system, but this paper has provided a clearer idea of how pathways move from food access (diet quality and quantity) to food utilization (hunger and nutrition) for South Africans. The analysis does this in terms of the relative size of the effects and whether these effects are complementary or not. In a context of complicated phenomena like rising obesity, hidden hunger, and a nutrition transition, this paper found complementary relationships between food variety and food expenditure in predicting household hunger and female BMI. The implication is that food variety and food expenditure should both be controlled for when studying hunger and female BMI in South Africa. Food expenditure and dietary diversity are substitutes for male BMI, which is unexpected and hard to explain. Overall, diet quantity and quality have a positive relationship with BMI and a negative one with household hunger. Food variety appears relatively more important than food expenditure for female BMI; but, diet quantity takes comparative precedence for household hunger. Food variety, NFVS, usually outperforms the food group-based indicator, NDDS, and is therefore the better choice for capturing dietary diversity in NIDS. This is likely a function of the longer recall period in NIDS.

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Appendix A:
Composition of the Dietary Diversity Indicators

(a) NDDS:

	Food Group	Foods
1.	*Cereals*	• Mealie meal • Samp • Flour & bread • Rice • Pasta • Breakfast cereal
2.	*White Tubers & Roots*	• Potatoes
3.	*Vegetables*	• Other vegetables
4.	*Fruit*	• Fruits & nuts • Tinned fruit
5.	*Meat*	• Red meat • Canned red meat • Chicken
6.	*Eggs*	• Eggs
7.	*Fish & Other Seafood*	• Fresh fish and shellfish • Tinned fish
8.	*Legumes, Nuts & Seeds*	• Dried peas, lentils and beans • Soya products • Peanut butter
9.	*Milk & Milk Products*	• Milk, cheese, yoghurts and dried milk
10.	*Oils & Fats*	• Oil for cooking • Margarine, butter, ghee, other fats
11.	*Sweets*	• Sugar, jam, honey, chocolates and sweets • Soft drinks and juices • Biscuits, cakes, rusks
12.	*Spices, Condiments & Beverages*	• Salt & spices • Coffee & tea

(b) NFVS:

1. Mealie Meal
2. Samp
3. Bread & Flour
4. Rice
5. Pasta
6. Biscuits, cakes, rusks
7. Red meat (beef, mutton, pork etc.)
8. Canned red meat
9. Chicken
10. Fresh fish and shell fish
11. Tinned fish
12. Dried peas, lentils, beans
13. Potatoes
14. Other vegetables
15. Fruits & nuts
16. Oil for cooking
17. Margarine, butter, ghee, other fats
18. Peanut butter
19. Milk, cheese, yoghurts and dried milk
20. Eggs
21. Sugar, jam, honey, chocolates and sweets
22. Soft drinks and juices
23. Tinned fruit and vegetables
24. Breakfast cereal and porridge
25. Salt and spices
26. Soya products
27. Coffee and tea

Appendix B:
Creating a Regression Model for Hunger in NIDS using Melgar-Quinonez et al. (2006) as a Guideline

The covariates Melgar-Quinonez et al. (2006) use are: rural-urban location; age; gender; categorical education variable; marital status; self-perception as the head of the household; household size; number of children under 5 years; number of adults over 65 years; ownership of the dwelling; number of durable goods; and membership of the local microfinance programme. Individual characteristics (e.g. age and gender) are those of the interviewee and one there was one interviewee per household. I use this model as a guideline because not all of these variables are available in NIDS or appropriate for my purposes.

For my purposes, I use individual characteristics for the household head. I exclude self-perception as the household head because NIDS always interviews the eldest female making the survey methodology different. Instead of the number of durable goods, I use the log of per capita monthly income. Membership of the local microfinance programme is replaced with a dummy for whether a social grant recipient lives in the household. I include the number of adults over the age of 60 instead of 65 because adults become pension eligible at this age in 2008.

My extension to this model is to add two variables pertinent to the South African context: race and employment status of the household head. The final set of explanatory variables was:

Hunger = rural location + ℓ(household head's age) + male household head + education of household head + married household head + household size + no. children under 5 + no. adults over 60 + ownership of dwelling + grant income dummy + ℓ(per capita monthly income) + race of household head + employment status of household head + ε

Dietary diversity and food expenditure are added to this model either separately or together as detailed in the paper.

Appendix C:
Estimating a Lower Bound for Hidden Hunger

I use a cut-off of one standard deviation below the mean as a stricter definition of chance of a nutrient-poor diet. In this scenario, 9.93% and 14.26% of adults potentially suffer from hidden hunger according to NDDS and NFVS, respectively.

Table C1: The Intersection of Weight with a Stricter Cut-off for Diet Quality for the Restricted Sample of Adults in NIDS Wave 1

%	NDDS				NFVS			
	UW	NW	OW	**Total**	UW	NW	OW	**Total**
Below 1 Std. Dev. of Mean	0.83	5.21	4.72	**10.76**	1.13	7.71	6.55	**15.39**
Equal/Above 1 Std. Dev. of Mean	3.94	37.30	48.00	**89.24**	3.65	34.80	46.16	**84.61**
Total	**4.77**	**42.51**	**52.72**	**100.00**	**4.77**	**42.51**	**52.72**	**100.00**

Notes: one standard deviation lower than the mean was NDDS=7 and NFVS=11 when rounded to the nearest integer; sample limited to households for which dietary diversity and food expenditure data are non-missing and non-zero; adjusted using sampling weights; own calculations using NIDS Wave 1.

Appendix D:
Food Expenditure for BMI Weight Categories and Hunger Categories

Table D1: P Values for a Two-Sample T-test with Equal Variance for the Means of Food Expenditure by Adult BMI Weight Category

WEIGHT	Underweight	Normal Weight	Overweight	Obesity
Underweight				
Normal Weight	0.0213			
Overweight	0.0000	0.0000		
Obesity	0.0000	0.0000	0.0732	

Notes: sample limited to households for which dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

Table D2: P Values for a Two-Sample T-test with Equal Variance for the Means of Food Expenditure by Household Hunger Category

HUNGER	Never	Seldom	Sometimes	Often/Al
Never				
Seldom	0.0000			
Sometimes	0.0000	0.0000		
Often/Al	0.0000	0.0000	0.0014	

Notes: sample limited to households for which dietary diversity and food expenditure data are non-missing and non-zero; own calculations using NIDS Wave 1.

Appendix E:
Joint Significance of Correlates of BMI with a Food Expenditure Quadratic

Table E1: F-Statistics for the Joint Significance of Food Expenditure, Food Expenditure Squared, and Dietary Diversity using an LR Type Test

Corresponding to coefficients of output in Table 17: Set 2

Restricted Variables	*F ~ (3, 6100)*
Std. Log Food Exp + Std. Log Food Exp^2 + Std. NDDS	80.04***
Std. Log Food Exp + Std. Log Food Exp^2 + Std. NFVS	98.45***

Notes: the unrestricted model is the specification used in Set 2, Table 17; the restricted model excludes the variables in the first column of this table; * p<0.05, ** p<0.01, *** p<0.001.

southern africa labour and development research unit

The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy. In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.

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