DETERMINANTS OF DIETARY QUALITY: AN EMPIRICAL STUDY USING DATA FROM BANGLADESH

By

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STATEMENT BY AUTHOR

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LIST OF ACRONYMS AND ABBREVIATIONS

BBS	Bangladesh Bureau of Statistics
IFPRI	International Food Policy Research Institute
UNICEF	United Nations Children's Fund
NPAN	National Plan of Action for Nutrition
ACC/SCN	Administrative Committee on Coordination, Sub-committee on Nutrition
WHO	World Health Organization
DFID	Department for International Development
GoB	Government of the People's Republic of Bangladesh
PEM	Protein-Energy Malnutrition
FAO	Food and Agricultural Organization
HDR	Human Development Report
GDP	Gross Domestic Product
HKI	Helen Keller International
NSP	Nutritional Surveillance Project
BMI	Body Mass Index
HES	Household Expenditure Survey
PSU	Primary Sampling Unit
SMA	Statistical Metropolitan Area
USDA	United States Department of Agriculture
ANZFCT	Australia-New Zealand Food Composition Table
OLS	Ordinary Least Squares
CBN	Cost of Basic Needs
2SLS	Two Stage Least Squares
VIF	Variance Inflation Factor
RESET	Ramsey Regression Specification Test
BIDS	Bangladesh Institute of Development Studies
PEM	Protein Energy Malnutrition
AFINS	Improving the Empirical Basis for Assessing Food Securitry in Developing Country
MLE	Maximum Likelihood Estimation
LR	Likelihood Ratio
ANOVA	Analysis of Variance

ABSTRACT

This study investigates the determinants of dietary quality using data from a national household expenditure survey conducted in Bangladesh in 2000. Malnutrition is particularly severe in Bangladesh. Nearly one half of all mothers in rural areas are undernourished. The child malnutrition rate is among the highest in the world, with 55 percent of children under five years being stunted. This malnutrition is partially caused by a diet that has a high concentration of starchy staples and relatively little consumption of protein and micronutrient rich foods. Understanding how household income, food prices, education and household demographic characteristics determine food consumption patterns, and thus protein and micronutrient intakes, can provide crucial information for designing policies and intervention programs to improve food and nutrition security in Bangladesh .

Reduced-form equations for household protein availability and demand for selected protein and micronutrient rich foods (meat, fish, pulses, vegetables, and fruits), as well as for dietary diversity, are estimated after testing and, if necessary, correcting for endogeneity of income. A reduced form equation for household energy availability is also estimated in order to asses whether the determinants of dietary quality differ from those of dietary quantity, the traditional focus of food security analyses.

Using a variety of measures of dietary quality to investigate the role of its determinants, the study identifies the following principal determinants of dietary quality: income, education, gender of the household head, number of adult equivalents in the

household, and prices of food commodities. These factors were found to have statistically significant and quantitatively strong impacts on the quality of diet.

This study has found strong evidence that income and education are the most robust determinants of dietary quality. Women's education was found to have particularly strong influence. While men's education plays an important role in improving household dietary quality, its influence is not as strong as women's. These results are consistent across the various measures of dietary quality employed as dependent variables.

Female headed households are found to be at a disadvantage when it comes to both dietary quality and quantity. Limited mobility of women in Bangladesh may be one of the reasons that prevent them from going to market and getting access to a wide variety of foods that could improve the dietary quality. Those households whose main source of income is casual labor may get wages in food, presumably rice, which could constrain them from buying other types of foods. The disadvantage could also be due to the gender differences in knowledge and preferences and/or the ability of female headed households to put them into practice. Further research is needed to investigate this finding.

As expected, the demand for protein, fish, meat, vegetables, fruits, and pulses are sensitive to price changes. The income elasticity computed at sample mean suggests that vegetables and pulses are necessities in Bangladesh while meat, fish and fruits are luxury goods.

In answer to the second question asked "Do the determinants of dietary quality and quantity differ?," this study concludes that income, gender of household head,

number of adult equivalents in the household, and food prices are common determinants of both dietary quality and dietary quantity. While analysis reveals that men's education has some limited influence (at the 10 percent level of significance) on energy availability (i.e., dietary quantity), education in general only has explanatory significance as a determinant of dietary quality.

Given the crucial role of income and education in increasing access to sufficient and high quality food, this study recommends the design and implementation of well targeted poverty reduction and education programs. Education raises awareness about commonly consumed sources of micronutrients and protein, and thus has the potential for improving intake. Promoting women's education in particular could be a significant policy tool for government and non-government organizations in addressing the issues related to dietary quality. This will require a departure from previous food security policies which tended to focus predominantly on dietary quantity.

Vegetables, the most accessible non-staple food for the poor, have seasonal availability. As such, they are highly subject to price volatility, further disrupting dietary sufficiency and quality for the poor. In order to ensure consistent availability of nutrient rich vegetables throughout the year, crop diversification programs may be successful in promoting and helping to increase the cultivation of seasonally appropriate crops. Their increased supply in the market may translate into more stable and affordable prices.

This study also advocates promoting plant breeding strategies for increased micronutrient content and bioavailability in staple foods. The potential of these

technologies are enormous in improving dietary quality of populations relying mainly on cereal staples.

Although not a direct conclusion from the analysis of the thesis data, improving access to resources, technology and information – especially for women – in support of homestead crop production has the potential to improve nutritional quality as well as general food security. Many rural households in Bangladesh are engaged in homestead gardening to some degree. It is the major source of vegetables for poor households. Therefore, targeting homestead production for technical and informational support, in conjunction with crop diversification programs, may be a direct route to enhancing dietary quality. Furthermore, since homestead production is often under the domain of women, increased support may help to address the disadvantages faced by female-headed households.

Chapter 1: INTRODUCTION

The most vulnerable of the world's citizens are often the first to suffer from food and nutrition insecurity: 167 million developing-country children under age five, or about one in three, are malnourished. It is estimated that over 50 percent of child deaths in developing countries are related to malnutrition (Pelletier et. al.1995). Haddad (1995, p. 93), vividly portrayed the situation as

> *"malnutrition has far-reaching consequences for the ability of those children who survive to contribute to their countries' development as adults: For nearly half of the children in the . . . least developed countries, being born is a shock from which they will never recover. In these countries, nearly all of which are in South Asia or sub- Saharan Africa, out of every 1000 children born alive, 112 will die before their first birthday. Another 48 will die before their fifth birthday. Of the remaining 840, 300 will be significantly underweight. As school-aged children, they will be less able to learn in school. As adults, they will earn less income and accumulate less wealth. Only the remaining 540 children will emerge relatively unscathed."*

Despite significant progress over the past 10 years, rates of malnutrition in Bangladesh are still among the highest in the world. Average mean daily calorie consumption was 2,240 kilocalories per person (HES, 2000), which is just below the minimum energy requirement of 2,273 (Del Ninno et. al. 2001). Apart from caloric deficiency, the Bangladeshi dietary quality is poor because of its over-dependence on the consumption of rice.

An exceptionally large percentage of households in Bangladesh do not consume enough food to meet their members' dietary energy requirements, which according to a recent national food expenditure survey accounts for approximately 55 million people (BBS 1998). Additionally, consumption of nutrient-rich animal products is far lower than

recommended levels (Del Ninno, et. al. 2001). Other research documents a distinct seasonal pattern of malnutrition in Bangladesh, which is often associated with the periods of increased illness and the agricultural production cycle (Gill et. al. 2003).

Although dietary quality appears to have no official definition in the current nutrition literature, in the present study it refers to nutrient adequacy (Ruel 2002). Nutrient adequacy, in turn, refers to a diet that meets the minimum requirements for energy and all essential nutrients. In developing countries the rationale for emphasizing dietary diversity as an indicator for dietary quality stems mainly from a concern related to nutrient deficiency and the recognition of the importance of increasing food and food group variety to ensure nutrient adequacy. Lack of dietary diversity is a particularly severe problem among the poorer segments of population in the developing countries, which is mainly because of the diets that are predominantly based on starchy staples and often include little or no animal products and few fresh fruits and vegetables. These plant-based diets tend to be low in a number of micronutrients, and the micronutrients they contain are often in a form that is not easily absorbed (Ruel 2002).

Poor dietary quality is a primary cause of micro-nutrient deficiencies in Bangladesh. Low intake of animal products, vegetables and fruits are compounded by frequent attacks of diarrhea and other infectious diseases in a spiral of increasing deficiencies. Non-staple foods, particularly animal products, are rich sources of bio-available minerals and vitamins while fruits and vegetables are rich sources of micronutrients. Typically, fish and meat are among high status foods but most poor households and individuals cannot afford these high-calorie-cost foods in sufficient

amounts. Their food expenditures are dominated by low- calorie-cost, but mineral- and vitamin-poor staple foods, such as rice and to a much smaller extent wheat, to prevent hunger and starvation (IFPRI/BIDS/INFS/DATA/ RDHN, 1998). Micronutrient deficiencies, for example deficiencies of iron, iodine, and vitamin A, are widespread owing to low-quality diets consisting primarily of the main food staples, rice and wheat (Bouis and Novenario-Reese 1997; UNICEF-ADB 1997; NPAN 1997; Ahmed et al. 1998).

So, what are the factors that determine consumption behavior related to animal products, pulses, fruits and vegetables, and thus the dietary quality? Do the factors influencing diet quantity and diet quality differ or can the same policy instruments be employed to improve both? This study looks at these issues from the demand side. Using a nationally representative household data set from Bangladesh, it investigates the determinants of energy and protein availability and the demand for animal products, pulses, fruits and vegetables, and of dietary diversity in Bangladesh.

Specifically this study examines the following two key questions:

a) What are the determinants of dietary quality in Bangladesh? and

b) Do the determinants of diet quality and quantity differ?

A proper understanding of principal factors that cause poor diet quality in Bangladesh is crucial for designing policies and programs to overcome it. In the existing development literature there are many studies that have investigated the determinants of

dietary energy consumption, but little attention has been devoted to examination and identification of specific factors that determine dietary quality.

This thesis is organized as follows. Chapter Two contains a review of the alternative theories and widely held views on the determinants of dietary quality and dietary quantity. Chapter Three sets the context by looking at the demographic and socio economic characteristics of the study area. Description of data, definition and selection of variables, econometric models and their estimation techniques are discussed in Chapter Four. The empirical results on the determinants of protein availability, dietary diversity, food demand and energy availability, and their interpretation are presented in Chapter Five. The final chapter summarizes the conclusions, suggests policy recommendations and identifies areas for future research.

Chapter 2: DIETARY QUALITY & QUANTITY – A Brief Review of Literature

2.1 Dietary Quality and Quantity

The definition of food security adopted at the 1996 World Food Summit[1] is:

> *Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.*

This definition of food security highlights the fact that quality of food is as important as the quantity of food that people consume. Indeed, poor dietary quality is a major food security issue across the developing world (Ruel 2002; Scrimshaw 1999). Food energy, the most common nutrient used to describe dietary quantity, is not the only nutrient that people need to lead active and healthy lives. Deficiencies of micronutrients, such as iron, Vitamin A and iodine cause impaired cognitive development and blindness among children, reduced productivity, increased morbidity, and in severe cases, mortality (ACC/SCN 2000). In addition to impairing physical and intellectual development, protein deficiency compromises immunity and increases susceptibility to infectious diseases (Scrimshaw 1999). Recent studies show that the consumption of protein and micronutrient –dense animal and fish products is relatively strongly correlated with anthropometric measures of nutritional status than total energy consumed (Bouis 1999, 2000; Bouis and Hunt 1999).

[1] Rome Declaration on World Food Security., World Food Summit, 13-17 November, 1996, Rome Italy.

Contrary to established consensus in the 1980s (Foster 1992), it is now recognized that consumption of sufficient dietary energy does not ensure adequate protein intake. The diets of the poor in developing countries consist primarily of high energy –content food staples to meet minimum energy requirements. These foods do not provide sufficient protein and essential micronutrients, which are found in legumes or foods of animal origins and in fruits and vegetables (Smith 2004).

2.2 Determinants of Dietary Quality

Dietary diversity is one of the indicators of dietary quality. Theil and Finke (1983), using a cross-sectional data for thirty countries conclude that the demand for dietary diversity increases with per capita real income. Similarly, estimation of cross-country Engel curves indicates that the number of foods consumed increases, and the concentration of expenditure decreases with income per capita (Falkinger and Zweiüller, 1996).

Pollack (2001) and Regmi (2001) argue that the demand for fruit and vegetables increases with increase in income. This implies that at low-income levels, the demand for fruit and vegetables is small. This is largely due to the fact that low-income households prioritize the fulfillment of their basic energy requirements to avoid hunger, and that fruit and vegetables tend to be an expensive source of energy (Ruel, Minot & Smith 2004).

So, why are intakes of animal products, fruits and vegetables often so far from the requirements, and what can be done to improve the nutritional situation? Among the many views to combat malnutrition, one widely held view is that malnutrition will

disappear only with the improvements in income that accompany the development process. The World Bank (1981, p. 59) articulates this view forcefully:

"There is now a wide measure of agreement on several broad propositions….. Malnutrition is largely a reflection of poverty: people do not have income for food. Given the slow income growth that is likely for the poorest people in the foreseeable future, large numbers will remain malnourished for decades to come…. The most efficient long-term policies are those that raise the income of the poor."

However, a review of existing studies of nutrient determinants in developing countries lead to a less confident appraisal of the prospects for substantial nutrient improvements as income increases in the process of economic development (Poleman 1981; Behrman and Deolalikar 1987). Many studies suggest that nutrient elasticities with respect to expenditure or income are fairly low (Behrman & Deolalikar, 1987).

In investigating the role of income in developing country nutrition, Behrman & Deolalikar (1987) found that food expenditures increase substantially – more or less proportionally to income – but the marginal increments in food expenditures are not devoted primarily to obtaining more nutrients. Rather, the authors concluded that:

"….. with more education about the relation between nutrients and other food characteristics or with development of food varieties in which the nutritional benefits are more highly associated with the food attributes that consumers' value highly at the margin, stronger associations between nutrient intakes and increases in income could be developed". (Behrman & Deolalikar, 1987 p. 505).

So what are the other factors that could play important roles in improving dietary diversity? A recent study on consumer demand for food diversity conducted in Germany identifies household size, age, sex composition, employment status (whether an individual is full time employed), and the education level of the principal income earner

in addition to income as the principal determinants (Thiele & Weiss 2002). Similarly, Bouis and Novenario-Reese (1997) find that the main determinants of food demands and micronutrients are: income, household size, food prices, the age-sex composition, gender of the household head, education and occupation.

In explaining poor dietary quality, Neumann & Harris (1999) suggest that poor availability and accessibility to animals can also preclude inclusion of animal products in the household diet. When animal products are priced out of reach of poor households, people are forced to rely more heavily on less expensive staple cereal grains, legumes or starchy roots. The limitations of these foodstuffs, such as low levels of individual micronutrients and/or the presence of inhibitory compounds, become important determinants of a person's nutritional status.

Moreover, a number of studies conducted across the world highlight the importance of women's education in improving nutrition, reducing child malnutrition, and improving dietary quality. One study conducted in Indonesia, finds that mothers who have greater nutrition knowledge devote the same share of their budgets to food, but allocate a larger share of their food budget to foods that are rich in micronutrients, including fruits and vegetables (Block 2003).

This discussions leads to a conclusion that increases in income alone might not be sufficient to bring about a positive change in dietary quality.

2.3 Why is Quality of Diet Important?

A large number of Bangladeshi households, poor households in particular, do not have access to a balanced diet. Many people subsist on diets based on rice and little else. Such diets lack diversity, which may result in protein and micronutrient deficiencies thus constituting poor dietary quality. Vegetables, fruits, and animal products, which are much richer sources of micronutrients and protein than food staples, are consumed in insufficient quantities in Bangladesh (Ruel, 2001).

Dietary quality, or the ability of a given diet to provide the entire complement of high-quality protein, minerals, trace metals, vitamins and the energy necessary to meet the requirements to lead an active and healthy life, is as important as dietary quantity. Increases only in the quantity of poor-quality foods will not address dietary quality, which requires provision of adequate amounts of specific micronutrients and protein.

The effects of poor nutrient intake are most pronounced during early childhood, adolescence, and during pregnancy and lactation in women; thus, children and women of reproductive age group are the most vulnerable groups (Neumann & Harris, 1999). The severity of protein and micronutrient deficiencies in Bangladesh and their consequences are discussed in the following paragraphs.

The World Health Organization (1992) has estimated that over 70 percent of pregnant women in Bangladesh were anemic in 1988, one of the highest rates in the world. Iron deficiency is harmful at all ages. In young children it may impair physical growth, cognitive development, and immunity; in school-age children, it may affect school performance; in adulthood, it can cause reduced work capacity. In pregnant

women, severe anemia may cause fetal growth retardation or low birth weight, and it is responsible for a large share of maternal deaths (Gillespie, 1998).

Similarly, the prevalence of vitamin A deficiency in Bangladesh is also among the highest in the world (WHO 1995), indicating that vitamin A deficiency is a serious public health problem (Bouis and Novenario-Reese, 1997). Vitamin A deficiency impairs growth, development and vision, and compromises immune systems. In severe cases it can lead to blindness and death (Ruel, 2001).

A 1993 study of iodine deficiency indicates that about 70 percent of Bangladeshis are iodine deficient (Yusuf et al., 1993). Iodine deficiency is the greatest single cause of preventable brain damage and mental retardation in the world (Bouis and Novenario-Reese, 1997).

Mild to moderate protein-energy malnutrition (PEM) is also prevalent in Bangladesh. Children are particularly susceptible to PEM, with malnutrition contributing significantly to adverse outcomes such as poor growth, diminished mental development, and illness (Neumann & Harris, 1999).

2.4 Measuring Dietary Quality

Dietary diversity has long been recognized by nutritionists as a key element of high-quality diets. Increasing the variety of foods across and within food groups is recommended by most dietary guidelines internationally (WHO/FAO 1996; U.S. Department of Agriculture Human Nutrition Information Service 1992), because it is thought to ensure adequate intake of essential nutrients, and thus promote good health.

Dietary diversity can be defined as the number of different foods or food groups consumed over a given reference period and it is used to measure dietary quality. Dietary diversity is usually measured by summing the number of foods or food groups consumed over a reference period. The reference period usually ranges from one to three days, but seven days is also often used, and periods of up to 15 days have been reported (Drewnowski et al. 1997).

The question of whether individual foods or food groups should be used to define dietary diversity has been addressed in a number of studies that compared both types of indicators. Studies in Mali (Hatløy, Torheim, and Oshaug 1998) and Viet Nam (Ogle, Hung, and Tuyet 2001) compared a food variety score with a food group indicator and found that both indicators were significantly associated with nutrient adequacy. The study in Mali, however, demonstrated that food group diversity was a stronger predictor of nutrient adequacy than the simple count of individual foods.

Krebs-Smith and colleagues also compared three dietary diversity indicators with respect to their association with dietary quality and found that variety between the five major food groups studied explained as much variation in the mean adequacy ratio as did variety within those groups (Krebs-Smith et al. 1987). They conclude that, for simplicity, dietary diversity is best assessed by measuring intake of foods from each of the major groups.

Chapter 3: BACKGROUND INFORMATION ON BANGLADESH

3.1 Geography

Figure 3.1: Map of Bangladesh

Bangladesh is located in the northeastern portion of the Indian subcontinent. It is bordered on the west, north, and east by India, on the southeast by Myanmar (formerly known as Burma), and on the south by the Bay of Bengal. The area of the country is 147,570 sq km (56,977 sq mile).

It has a tropical climate with cool, dry weather conditions from October to March. Summers are hot and humid. The monsoon season is characterized by heavy rainfall from June to October. Natural calamities such as floods, cyclones, and droughts are common.

Mean annual precipitation ranges from about 1,400 mm (about 55 inch) along the country's east central border to more than 5,080 mm (200 inch) in the far northeast (MS Encarta, 2002). In addition to the normal monsoonal rainfall, Bangladesh is subject to devastating cyclones, originating over the Bay of Bengal, in the periods of April to May and September to November. Often accompanied by surging waves, these storms can cause great damage and loss of life.

A larger part of Bangladesh lies within the broad delta formed by the Ganges and Brahmaputra rivers and is exceedingly flat, low-lying, and subject to annual flooding. Much fertile, alluvial soil is deposited by the floodwaters. About 73 percent of the land is arable (MS Encarta, 2002). The only significant area of hilly terrain, constituting less than one-tenth of the nation's territory, is the Chittagong Hill Tracts District in the narrow southeastern panhandle of the country. Small, scattered hills lie along or near the eastern and northern borders with India. The eroded remnants of two old alluvial terraces—the Madhupur Tract, in the north central part of the country, and The Barind, straddling the northwestern boundary with India—attain elevations of about 30 m (about 100 ft). The soil here is much less fertile than the annually replenished alluvium of the surrounding floodplain.

The landscape has an extensive network of rivers that are very important for the socioeconomic development of the country. Among the major rivers are the Ganges-Padma, Brahmaputra-Jamuna, and the Meghna.

Bangladesh is divided into six administrative divisions. Only 22 percent of households in Bangladesh have electricity (Bayoumi, 2000). Nine out of ten households obtain their drinking water from tubewells, making them the major source of drinking water. Only 43 percent of homes in Bangladesh have hygienic toilets, while 26 percent have no facility at all (Bayoumi, 2000). Tin is the most common roofing material in Bangladesh and nine out of ten households live in residencies with floors made of earth.

3.2 Demography

The estimated population of Bangladesh in 2003 was 146 million, making it one of the ten most populous countries of the world. Its population density is 1018 persons per sq km, which is much higher than that of other countries except for microstates such as Singapore (MS Encarta 2002). Bangladesh has a large rural population, with only 21 percent of people living in urban areas. The distribution of the population is relatively even, except in the sparsely populated Chittagong Hill Tracts District and the almost totally uninhabited Sundarbans. The age composition of population is highly skewed, with 60 percent being under the age of 25, and only 3 percent being 65 or older. Life expectancy at birth is 61 years.

Age composition of urban population is vastly different from the age composition of rural population. For instance, urban areas have 36 percent population under the age of 15 whereas rural areas have 42 percent population under the same age group. The

average household size is 5.3 persons, with no difference between rural and urban areas. More than 90 percent of households are headed by males. The national language is Bangla. Muslims make up 90 percent of the population and the remaining ten percent comprise of other religious minorities including Hindus and Christians (Bayoumi, 2000).

3.3 Economy

Bangladesh is one of the world's poorest nations, with overpopulation adding to its economic woes, and it is heavily reliant on foreign aid. Its economy is heavily based on agriculture. Rice, jute, tea, sugarcane, tobacco, and wheat are the major crops. Bangladesh used to be the world's largest producer of jute. Fishing is also an important economic activity, and beef, dairy products, and poultry are also produced. Except for natural gas (found along its eastern border), limited quantities of oil (in the Bay of Bengal), coal, and some uranium, Bangladesh possesses few minerals. Dhaka and Chittagong (the country's chief port) are the principal industrial centers; clothing and cotton textiles, jute products, processed food, steel, and chemical fertilizers are manufactured. In addition to clothing, textiles, jute, and jute products, exports include tea, leather, fish, and shrimp. Remittances from several million Bangladeshis working abroad are the second largest source of foreign income. The major imports include capital goods, petroleum, and textiles. Western Europe, the United States, India, and China are the main trading partners.

Approximately 36 percent of the population lives below the poverty line (< $1 a day) (HDR, 2003) and a similar percent of the population is unemployed (1996). There is

a seven percent inflation rate in consumer prices (1999). The per capita income was $444 (2003-04), one of the lowest in south Asia (Bayoumi, 2000).

Agriculture is the most important sector of the nation's economy, providing employment for 64 percent of the work force and accounting for 30 percent of the gross domestic product (Bayoumi, 2000). The cultivation of rice is the single most important activity in the economy. Other agricultural products include jute, tea, wheat, sugarcane, and potatoes.

3.4 Nutritional Status

Undernutrition contributes to more than a half of all childhood deaths (Pelletier *et al.*, 1995) and it has long-term consequences for child development. Childhood undernutrition is commonly assessed in terms of the percentage of children who are stunted and underweight when compared with well-nourished and healthy children of the same age and sex. According to the Nutritional Surveillance Project of Bangladesh the prevalence of childhood stunting is 55 percent, and the prevalence of underweight children is 61 percent (NSP, 1999), put Bangladesh in the list of the countries with highest malnourishment rates in the world. The proportion of low birth weight babies is estimated to be between 30 and 50 percent of live births (UNICEF, undated).

Nearly one half of all mothers in rural Bangladesh are undernourished according to data collected by the Nutritional Surveillance Project (NSP). Surveys in 2000 showed that 45 percent of rural mothers had a low body mass index (BMI), a prevalence that is amongst the highest in recent surveys in Asia and indicates 'critical' food insecurity (NSP 2001).

Under-nutrition in adults is mostly due to a diet that is inadequate both in quality and quantity. According to the World Health Organization, the prevalence of undernourished mothers in rural Bangladesh indicates a 'critical' food insecurity situation (prevalence of under nutrition >40%), and the prevalence in the urban slums indicates a 'serious' food insecurity situation (prevalence of under-nutrition 20-39%) (NSP 2001). In most parts of the world these grades of food insecurity only occur after emergencies that drastically reduce the availability or access to food, such as famines, wars and economic crises. Maternal malnutrition is a chronic problem in rural Bangladesh. Even though the country is self-sufficient in rice production, the diet of rural people is very low in energy and micronutrients. It is mainly because households do not have access to the resources they need to grow or purchase enough food.

All nutritional surveys during the past decade confirm that mothers in Bangladesh have a low quality diet. Nutritional Surveillance Project data from 2000 revealed that less than 15 percent of mothers ate pulses (*dal*), green leafy vegetables, eggs or yellow/orange fruit and vegetables on at least four days in the week prior to the surveys. The poor diet of mothers is reflected in the high prevalence of micronutrient deficiencies. Data from the 1997 National Vitamin A and Anemia Survey conducted by the NSP found that 2.7 percent of pregnant mothers had night blindness and 45 percent of non-pregnant mothers were anemic.

3.5 Quality of Diet – Bangladesh Context

Among Asian[2] countries, Bangladesh has the lowest total energy intake. It derives the highest proportion of energy from cereals (82.5 percent), the second lowest proportion of energy from non-cereal vegetative products (14.3 percent), and by far the lowest proportion from animal products (3.1 percent). The Bangladeshi figure of 82.5 percent of dietary energy deriving from cereals (and 81 percent comes from rice alone) is one of the highest in the world, indicating a diet that is seriously imbalanced in terms of nutrition (Gill et. al. 2003).

Traditionally, the two most important non-cereal foods for the poor in Bangladesh were fish and pulses. The poor obtain almost all of their animal protein from capture fisheries, but stock depletion has caused per capita fish consumption to fall from 11kg in 1970 to 7.5kg by the late 1990s (DFID, 1998). Fish provide a wide range of macro- and micronutrients. Vitamin A deficiency is very widespread, and fish is a rich source.

Per capita availability of pulses fell by 27 percent between 1987/8 and 1998/9 (BBS, 2001), primarily because the spread of irrigation made it possible for farmers to switch to rice (which under irrigation is a much less risky crop than pulses). Thus the price of pulses relative to rice increased. In the mid 1980s the most important pulse cost about the same as rice, but by the end of the 1990s it cost twice as much (GoB, 2000) and the poor have been substituting rice for pulses.

Pulses are an important source of iron, and the National Anemia Survey completed in November 2001 found that half of all children under five and pregnant

women are iron-deficiency anemic, while one third of school-age children, adolescents and non-pregnant mothers have low hemoglobin concentrations. Anemia in pregnancy increases the risk of maternal or infant mortality at birth. In children it impairs physical growth and learning ability, and lowers resistance to infections. In adults it reduces work capacity and productivity. Thus its effects are not only harmful to them, but reduce prospects for escape from poverty (HKI/IPHN, 2002).

The typical diet is predominantly rice because people cannot afford other nutritious foods such as pulses, vegetables, fruits and animal products. Rice, considered to be low-quality protein, also contributes the most to protein intake (58 percent). Consumption of protein and micro-nutrient rich animal products is very low, but is much higher in urban than rural areas. Although, we know that animal-proteins are high in quality and readily digestible protein and are rich in energy, only 12 percent of the protein in Bangladeshi diets comes from animal-sources. Fish accounts for 68 percent of daily dietary animal-protein consumed. Since fish is relatively more affordable than other animal protein sources, it is the principal source of animal protein.

During the last ten years, quantity and quality of diet in Bangladesh has not changed much. For instance, daily food energy intake declined from 2266 kilocalories in the year 1991 to 2240 kilocalories in the year 2000 (HES 2000), per capita daily cereal intake declined from 516 to 487 grams during the same period, per capita daily protein intake remained constant at 63 grams, and per capita daily fish and vegetable intake slightly increased from 35 to 39 grams and from 137 to 141 grams respectively.

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[2] Countries compared include Bangladesh, Cambodia, China, India, Indonesia, Nepal and Vietnam

Quality of diet as opposed to quantity of diet has received too little attention in the malnutrition debate at all levels. Defining food insecurity in terms of hunger may address its most obvious and distressing manifestation, but unless the qualitative issue receives more attention, further progress in reducing the main anthropometric indices of malnutrition is likely to be increasingly constrained.

Chapter 4: DATA, MEASURES & METHODOLOGY

4.1 Data Collection and Processing

4.1.1 Data Collection

The Household Expenditure Survey employed in this study was conducted in 2000 by the Bangladesh Bureau of Statistics. In order to capture the seasonal variability, the data collection process was evenly spread throughout a full year.

The survey was conducted using a two-stage stratified sampling design, thus ensuring full geographic coverage and representation at the national level. The fourteen strata are made up of the three groups within the country's five divisions: (i) rural areas, (ii) urban municipalities, and (iii) statistical metropolitan areas (SMA). In the first stage of sampling, 442 Primary Sampling Units (PSUs) were chosen with probability proportional to size of the division. In the second stage, 20 households per PSU were selected, except in all Statistical Metropolitan Areas, where only 10 households were interviewed. The total sample size was therefore 7,440 households.

With such a complex sampling design, rather than simple random sampling being used, it is important to correct for the design effect so that any calculated statistics apply to the population group of interest (Deaton, 1997). To correct for the sampling design effect, I used the sampling weights provided with the survey, and variables delineating the strata and PSU for each household.

Data were collected on households' acquisition of 138 different food items. The food data collected include quantity acquired, the sources of food acquisition, and their

values in Bangladeshi currency, taka. Data were collected on food purchases, consumption of food from home production, food received as wage-in-kind, and food received as a gift.

The recall period was two days for all food items except spices, for which the recall period was one week. Each household was visited every alternative day in a fortnight -- 7 times in 14 days-- to collect information on food acquisition. The spices data were collected at the end of the first week and then again at the end of the second week. The reference period for food data collection, the time period over which data collection takes place in total, was two weeks.

4.1.2 Cleaning of the Food Data

Food acquisition data collected in household expenditure surveys are subject to a host of errors, from reporting on the part of households to recording on the part of enumerators to entering on the part of data entry operators (Smith, 2004a). The raw data were subject to a thorough cleaning so as to avoid any influence of major errors on the estimates of food quantities acquired, food energy availability and protein availability. Data cleaning was done in three stages.

First, for each food unit values (expenditure divided by metric quantities) were cleaned manually by examination for outliers at both ends of the distribution separately for each districts. When outlying unit values were detected, both the expenditure and quantity used to calculate them were set to missing.

In a second stage, the computed metric quantities of individual foods (see section 4.2.1.2 below) were cleaned. Any quantity per household adult equivalent that was more than three standard deviations from the sample median value was replaced with an estimated value using OLS regression. This technique was also used to replace values set to missing in stage 1 of the data cleaning. An "adult equivalent" is defined using a male 30-60 years old as the reference category. The average energy requirement of an adult equivalent for moderate activity is 2,900 kilocalories (Smith, 2004a). The independent variables in the food specific regression equations were: number of household adult equivalents, variables representing the age-sex composition of the household, whether it is a female headed household, age of the household head, whether at least one adult member has a primary or secondary education, total expenditure per capita, region of residence, and month of survey. Since this technique takes into account household-specific characteristics, it preserves variation in the data better than the more common one of replacement with means or medians of other households (Smith 2004). Households in which at least one food quantity was missing or an outlier could not be estimated were dropped from the sample.

The third stage of data cleaning took place for household-level energy availability. A household's total calories per adult equivalent was replaced with an estimated value using OLS prediction regressions (with the same set of regressors as above) when (a) a metric quantity that was identified as an outlier or set to missing in the cleaning process could not be estimated[3] or (b) not enough information was available to

[3] In some cases not enough non-missing observations were available for running a regression.

estimate calories from food consumed outside of home[4] or (c) a household had no reported food acquisition data.

As households with predicted energy or protein values have not been used in analyzing the determinants of calorie and protein in this study, 7413 out of 7440 households are used in the analysis.

4.2 Measures

4.2.1 Dependent Variables

4.2.1.1 The Variables & their Measures

Table 4.1 lists the eight dependent variables examined in this study. For diet quality, a number of measures are employed. The first is protein availability per adult equivalent. The second is a measure of dietary diversity, the number food groups, out of 12, that a household acquired food from over the reference period. The groups are: cereals, roots and tubers, pulses and legumes, milk and milk products, eggs; meat, fish and seafood, oils and fats, sugar and honey, fruits, vegetables, and a miscellaneous category. Finally, to focus on specific foods that make up a high quality diet, metric quantities of five foods are used: fish, meat, fruits, vegetables, and pulses.

The last one is a measure of dietary quantity, daily household calorie availability per adult equivalent, a valid and reliable measure of access to food in its quantitative

[4] Households with more than 75% of total food expenditures on food acquired outside of the home were not considered eligible for the "price per calorie of food acquired for consumption in the home" method. These households' acquisition of in-home food was deemed to be too small.

dimension (Smith 2003). Although, this study primarily focuses on the determinants of dietary quality, additional insights may be gained by looking at the determinants of dietary quantity, and also it enables us to compare whether the determinants of both dietary quality and quantity are the same.

Table 4.1 Dependent variables examined

Variable	Type
Dietary Quality	
Per adult equivalent protein availability	Continuous
Number of food groups available out of 12	Count
Quantity of fish acquired	Continuous but censored
Quantity of meat acquired	Continuous but censored
Quantity of fruits acquired	Continuous but censored
Quantity of vegetables acquired	Continuous but censored
Quantity of pulses acquired	Continuous but censored
Dietary Quantity	
Per adult equivalent calorie availability	Continuous

4.2.1.2 Calculation of Metric Quantities of Food

For most of the food items the data were recorded in grams except for a few exceptions where data were recorded either in "unities" (for example number of eggs) or in milliliters. In a few cases the households were asked to report expenditures on food acquired only (and not the quantity), and expenditures were divided by a metric price to derive metric quantities. Metric quantities available from pre-existing databases, such as the United States Department of Agriculture Nutrient Database for Standard Reference, Release 15 (USDA 2003) or other surveys were used to get the quantities when the data were recorded in unities. When the data were recorded in volumetric measures

(milliliters), specific gravities from the Australia-New Zealand Food Composition Table (ANZFCT 2003) were used to convert to metric weights.

4.2.1.3 Calculation of Household Energy and Protein Availability

Once conversion to metric quantities is done, determination of the energy and protein content of foods acquired for consumption in the home is quite simple. The conversions factors for energy were from data bases created by IFPRI and Bangladesh Bureau of Statistics (BBS). For protein conversion, the food composition table of India was used (Medindia.net). In some cases the American food composition table (USDA 2003) was used for foods known to vary little in calorie or protein composition across countries.

The actual energy value of a food acquired was computed as metric quantity multiplied by the food's calorie value, which was then multiplied by the food's edible portion. Edible portions are generally 100 percent for grains and beverages but are lower for fruits, vegetables, roots, tubers, and animal products. The protein value of a food acquired was computed as metric quantity multiplied by the food's protein value, which was then multiplied by the food's edible portion.

For foods consumed outside the home, only total expenditures were reported, which hampers direct conversion to energy and protein values. The only way to take this source of food acquisition into account is to apply the price per calorie of foods acquired for consumption inside the home to the expenditures on food consumed outside of the home (Smith, 2004a). A similar technique was also used for converting to protein values.

This method was adopted from the AFINS[5] Project keeping in mind that the method reduces the accuracy of estimates of household energy and protein availability.

The energy and protein requirements used are the average energy and protein requirements of specific age-sex groups for basal metabolic function and light activity (FAO/WHO/UNU, 1985).

4.2.2 Explanatory Variables and their Measures

This section discusses the explanatory variables and their measures. The list of the explanatory variables and their descriptive statistics are reported in Table 4.2.

[5] AFINS stands for "Improving the Empirical Basis for Assessing Food Insecurity in Developing Countries" and is a project of the International Food Policy Research Institute under which this research was conducted.

Table 4.2 Descriptive statistics for variables used in this study

Dependent Variables	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Daily protein acquired per adult equivalent (in grams)	71.00	19.29	2.63	183.63
Daily calories acquired per adult equivalent (in kilocalorie)	2751.96	698.33	92.81	7568.58
Number of food groups (of 12)	9.93	1.65	3	12
Quantity of fish acquired (in grams)	207.58	143.20	0	2928.57
Quantity of fruits acquired (in grams)	147.26	228.44	0	4464.29
Quantity of meat acquired (in grams)	75.80	111.07	0	1692.86
Quantity of pulses acquired (in grams)	87.47	66.15	0	625
Quantity of vegetables acquired (in grams)	1053.89	488.55	0	8964.29
Explanatory Variables				
Total expenditure per capita (in Bangladeshi *Taka* per day)	28.14	32.07	3.26	743.31
Gender of household head (female=1)	0.06	0.28	0	1
Number of adult equivalents in the household	4.71	1.72	0.67	19.11
Woman in the household with primary education	0.15	0.35	0	1
Woman in the household with secondary education	0.24	0.43	0	1
Man in the household with primary education	0.14	0.34	0	1
Man in the household with secondary education	0.37	0.48	0	1
Age of household head	45.72	13.29	12.00	99
Percent of females 16-30 (years)	11.81	13.54	0	100
Percent of females 30 + (years)	10.82	16.29	0	100
Percent of males 0-16 (years)	16.96	17.45	0	100
Percent of males 16-30 (years)	21.67	15.11	0	100
Percent of males 30+ (years)	18.32	12.47	0	100
Price of fruits/ kg	22.42	15.21	1.50	200.00
Price of rice/ kg	12.59	2.56	5.50	40
Price of fish/ kg	55.51	20.14	11.43	172.92
Price of pulses/ kg	30.30	8.11	8.00	60.00
Price of eggs/ kg	53.69	7.69	36.36	85.71
Price of meat/ kg	74.73	13.60	18.00	200.00
Price of vegetables/ kg	8.29	2.38	2.39	24.95
Price of dairy/ kg	30.46	46.53	8.74	360.00
Price of edible oils/ kg	49.19	14.15	26.67	461.54
Number of observations	7413			

Notes: Means are adjusted for survey design.

Per capita daily total household expenditure (measured in Bangladeshi currency, taka) is used as the measure of income. The terms "income" and "total expenditure per capita" are used interchangeably in this report. It is expected that income is positively associated with household calorie availability and dietary diversity, the latter because greater variety makes diets more palatable and pleasant (Ruel 2002).

A dummy variable is included to determine the effect of the gender of the household head on dietary quality. It is assumed that the gender of the household head may make a difference for dietary quality if there are gender differences in knowledge about or preferences for dietary diversity and/ or their ability to put knowledge and preferences into practice (Smith, 2004b).

Number of adult equivalents in the household is included to account for possible economies of scale, which are widely reported in the literature.

Education is measured using step dummy variables. Four different dummy variables are used to capture the variation in women's and men's primary and secondary education. A dummy variable for women's primary education takes the value of one if a household has woman with primary education and zero otherwise. Other education dummy variables are generated accordingly. Education enhances the capability of individuals, which can play an important role in many ways in the household consumption decision. It is assumed that where food consumption is inadequate, education may serve to increase adult household members' awareness of the need to ensure adequate food consumption to be productive. Education may also help to increase the effectiveness of the management of household resources. Conversely where food

consumption is in excess of needs, education may lead households to reduce consumption in order to avoid obesity and the associated increased risk of chronic diseases. Education is expected to positively influence dietary quality as it brings greater awareness of and the ability to better understand nutrition knowledge as well as put the knowledge into practice (Smith, 2004b).

Age of household head is included to capture the change in knowledge with experience. In Bangladesh, it is a common practice for the household head (usually male) to do the food shopping. As it is assumed that knowledge and awareness may increase with experience, the variable is hypothesized to be positive.

The proportion of adult female members 16-30 and 30+ years of age in the household, the proportion of male children 0-16 years of age, and the proportion of adult male members 16-30 and 30+ years of age in the household are included to capture the effect of the age-sex composition of the household with respect to the reference category, which is female children 0-16 years of age.

Price variables for nine food groups are included to estimate price elasticities of demand. It is expected that, controlling for the per capita income level of the households, the demand for macro and micro-nutrient rich foods might be sensitive to price changes.

Price variables for each food group are created in two steps. First, the household level unit values of individual foods are calculated where available. Cluster level median unit values are used for those households who didn't acquire any particular food item during the reference period. District level median unit values are used only if during the

reference period any particular food item is not acquired either at household level or at the cluster level. In the second step, mean unit values for each food items are computed by household and then aggregated by food group. The food groups include rice, fish, pulses, egg, meat, vegetables, diary, edible oil, and fruits. Table 4.3 contains the percentages of prices at the four levels: household, cluster, district and region, calculated for the food groups.

Table 4.3 Level of aggregation at which prices used are calculated (percent at each level)

Level	Rice	Fish	Pulses	Egg	Meat	Vegetable	Dairy	Edible Oil	Fruit
Household	99.2	98.0	89.7	25.2	55.1	99.9	52.2	98.1	63.9
Cluster	0.8	2.0	10.0	22.3	38.4	0.1	32.4	1.9	27.3
District	0.0	0.0	0.3	50.2	6.5	0.0	15.4	0.0	8.8
Region	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0

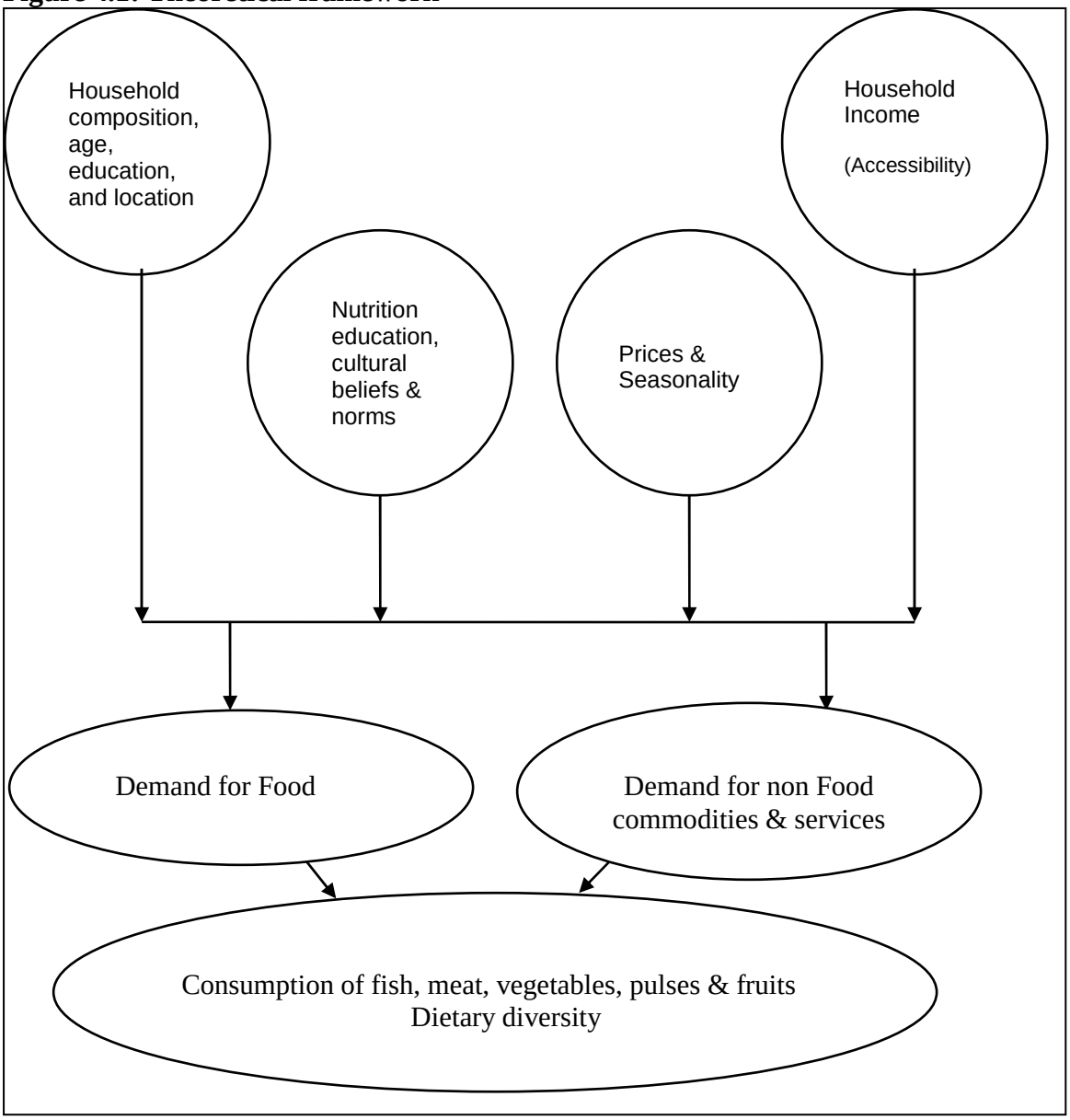
Dummy variables for district of residence are included in all of the models to account for location-specific effects, such as proximity to a water body or to a vegetable growing zone, for example, which potentially influence consumption behavior.

Dummy variables are also included for month of interview to capture seasonal effects. Seasonal variation has an effect on consumption behavior of households, as agriculture follows a production cycle which influences the price and availability of produces.

4.3 Econometric Models and Specification Tests

4.3.1 Theoretical Model of Food and Nutrient Demand

Figure 4.1: Theoretical framework



The conceptual model of household behavior considered in this study can be cast in the framework of a Bergson-Samuelson social welfare function. To maximize utility of the members subject to nutrition provisioning functions, budget constraints, and full-

income constraints, households often follow some bargaining process (Behrman and Deolalikar 1988).

As suggested by Smith (2004b), utility functions may be specified as

$$U_i = U_i(N_1,...,N_I,F_1,...,F_K,X_0,T_L), i = 1,...,I, \quad (1)$$

where the N_i, i=1,…,I, are members' nutrition provisioning functions, the F_k, k=1,…,K, are individual foods consumed by each member, X_0 is non-food commodities and services consumed, and T_L is leisure time[f]. Nutrition provisioning is the process through which goods, especially food, are combined with care time to provide for a person's nutritional health, or status. I specify nutrition provisioning functions as

$$N_i = N_i(Z_1,...,Z_J, X_{N0},T_N,\Omega_N), i = 1,...,I. \quad (2)$$

where

$$Z_j = Z_j(F_1,...,F_K), j = 1,...,J. \quad (3)$$

Here the Z_j, j=1,…,J are nutrients, such as calories, proteins and fats (the macronutrients) or Vitamin A, Zinc, and Iron (micronutrients), all of which are derived from foods. The variable X_{N0} is non-food inputs into nutrition provisioning (e.g., medicines), T_N is time spent in nutrition provisioning (e.g., feeding a child) and the vector Ω_N contains relevant individual, household, and community characteristics.

[f] The utility function contents can be extended to include the consumption of commodities and leisure of other household members without loss of generality.

Reduced-form nutrient demand functions take the form:

$$Z_j^*(P_F, P_0, W, E, \Omega_N),\ j = 1,...,J \qquad (4)$$

where P_F and P_0 are vectors of food and non-food prices, respectively, W is a vector of household members' wages, and E is a vector of exogenous incomes.

In this framework, people are seen to directly value food for its physical attributes (flavor, odor, appearance and texture) as well as for its status and symbolic value and for preparation and consumption time costs (Behrman and Wolfe 1984; LaFrance 1999, as reported in Smith 2004b).

People value the nutrients contained in food indirectly through their influence on nutritional status. The framework incorporates both dietary quantity and quality. Dietary quantity can be expressed as the sum of the calorie values of foods consumed and thus focuses only on one of the nutrients (Z_1, for instance). Dietary quality, by contrast, is characterized by all of the nutrients needed for nutritional health ($Z_1,\ldots, Z_J$).

4.3.2 Empirical Specifications for Calorie and Protein Availability

The theoretical foundation of the reduced-form equations (see equation 4, above) for dietary quantity (calorie availability) and dietary quality (protein availability) has been explored. Calorie and protein availability (Y_i) are hypothesized to be determined by K explanatory variables as follows:

$$Y_{id} = \beta_0 + \sum_{k=1}^{K} \beta_k X_{k,id} + \mu_d + u_{id},\ u_{id} \sim N(0, \sigma^2), \quad for\ i = 1,2,.....,N,\ d = 1,2,....,D \qquad (5)$$

where i denotes households, β is a $(K+1)\times 1$ vector of parameters, X is set of explanatory variables, and u_i is an error term. The μ_d are unobservable district specific, household invariant effect. This equation is estimated using two-stage least squares (2SLS) after testing for endogeneity of income (see below).

A set of explanatory variables were identified through careful review of the existing literature and the theoretical framework of nutrition demand model, presented in section 4.3.1. A mis-specified model may lead to biased estimates, thus it is important to specify the model correctly. Following are the specification tests employed in this study to address this issue.

4.3.2.1 Testing for endogeneity of income

Total expenditure per capita – a proxy for income is potentially endogenous because it may have a reverse causality with calorie and protein availability as well as other macro and micro nutrients. Reverse causality for total expenditure per capita is a concern because one's income depends on her/his productivity and malnourished people are likely to be less productive food producers and income earners.

Hausman-Wu endogeneity test

The Hausman-Wu instrumental variables (IV) test tests for endogeneity of the explanatory variables (Haddad et al. 1995; Davidson and Mackinnon 1993). It determines whether there is a significant difference between the parameter estimates of the explanatory variables using ordinary least squares (OLS) and using IV or "two-stage least squares" (2SLS) estimation of which the later is consistent in the presence of endogeneity.

The test is undertaken in two steps. First, the potentially endogenous variables are regressed on the remaining (assumed exogenous) variables and a set of "instruments". Such instruments must be good predictors of the potentially endogenous variables and must not be associated with the dependent variable. In the second step of the test, the dependent variable is regressed on all explanatory variables plus the predicted residuals from the first stage. The null hypothesis is that the explanatory variable is not endogenous. If the null hypothesis is rejected then, in the presence of endogeneity, OLS estimates are consistent but not efficient and thus IV estimates are preferred.

Over-identification Test

In choosing instruments it is important to determine whether numerical estimates of the parameters of a structural equation can be obtained from the estimated reduced-form coefficients. The over-identification test determines whether a chosen instrument set affects the dependent variable other than through total expenditure per capita. If it does, then the instrument set is not valid.

The test takes place in two steps. In the first, the predicted residuals from a 2SLS regression of the calorie or protein availability equation denoted are calculated. In the second step, the predicted residuals are regressed on the exogenous variables and the instruments. The statistic $N \times R^2$, where N is the number of observations, is distributed with degrees of freedom equal to the number of instruments minus the number of potentially endogenous variables being tested. The (joint) null hypothesis to be tested is that the instruments are uncorrelated with the error term.

Test for the relevance of the Instrumental Variables

If the endogeneity problem does not exist, then ordinary least square (OLS) results would provide unbiased and consistent estimates. Testing for endogeneity becomes important because the set of explanatory variable includes total expenditure per capita for which the reverse causality with calorie and protein availability per adult equivalent exists. Solving this problem requires the usage of instrumental variables. Relevance test is important to determine which set of instruments to use that truly explains variation in the endogenous variable.

The null hypothesis is: the instruments are not jointly significant in a regression of total expenditure per capita on the instrument set and all exogenous variables. Rejection of the null suggests relevance of the instruments.

Test for Heteroskedasticity

An important assumption of the classical linear regression model is that the error terms u_i appearing in the population regression function are homoskedastic, that is, the variance of the error term is constant. If the error terms do not have constant variance, they are said to be heteroskedastic. The presence of heteroskedasticidty does not influence coefficients so the parameters are still unbiased but it causes standard errors to be biased (Gujrati, 2003).

The Breusch-Pagan test is used to detect any linear form of heteroskedasticity. This test tests the hypothesis that the error variances are all equal versus an alternative

that the error variances are a multiplicative function of one or more variables. A large chi-square indicates the presence of heteroskedasticity (StataCorp 2003).

STATA's *"robust"* command is used to calculate White-corrected standard errors in the presence of heteroskedasticity. Robust standard errors are computed based on a variable list and a covariance matrix. It uses first-order Taylor series linearization method in calculating the robust standard error (StataCorp 1999).

In linear models, heteroskedasticity causes parameter estimates to be inefficient. That is the estimated parameters are unbiased but parameter variances are not the smallest, which causes inefficiency of the parameter estimates. When heteroskedasticity is present, robust standard errors tend to be more trustworthy. Use of robust standard errors gives reasonably accurate p-values in the presence of heteroskedasticity

Test for Multicollinearity

The Variance inflation factor (VIF) test is used to identify the existence of more than one linear relationship between explanatory variables. The VIF test shows how the variance of an estimator is inflated by the presence of multicollinearity. VIF > 10 or the mean VIF considerably greater than one indicates presence of multicollinearity (Stata Corp 2001).

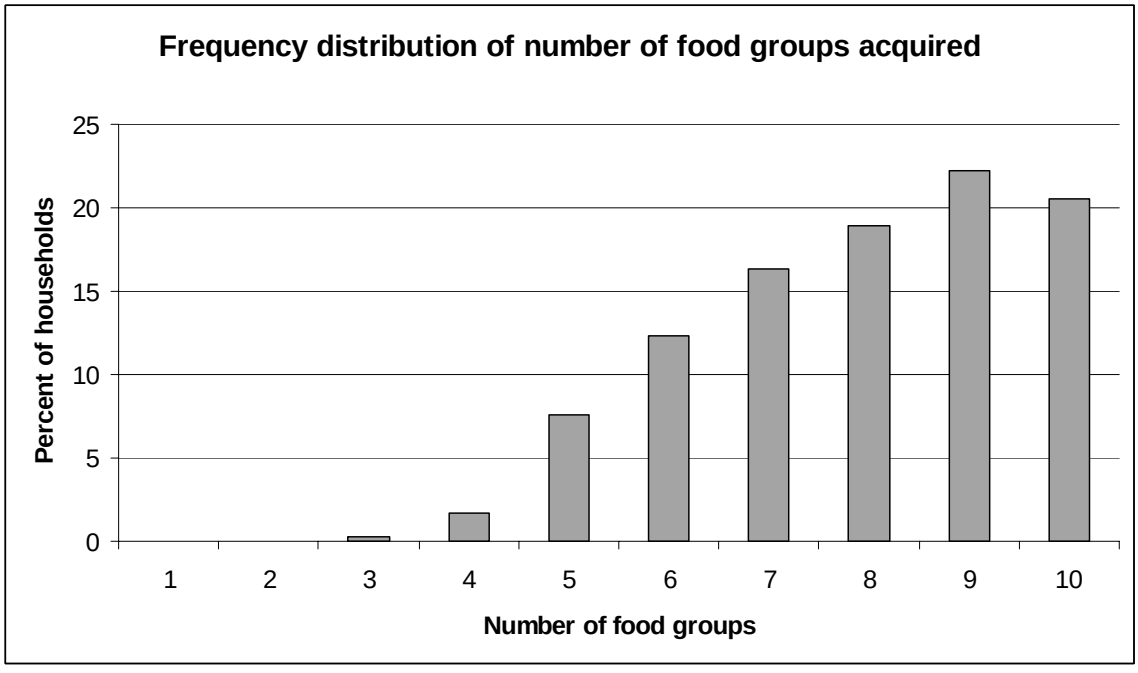
Note that the VIF information can only be obtained by calculating an OLS regression model. As the same set of regressors is used in all of the models, I consider the results obtained from OLS remain valid for all of them. As Menard (2002) argues that when there is a concern about the relationship among the independent variables, the

functional form of the model for the dependent variable is irrelevant to the detection of collinearity (2002).

4.3.3 Empirical Specification for Dietary Diversity

There are many phenomena where the dependent variable is of the "count" type, such as the number of vacations taken by a family per year or number of food items consumed in a meal. The underlying variable in each case is discrete, taking only a finite number of values. In the present study, the nature of the dietary diversity variable is of the count type, and it takes discrete values ranging from 1 to 12. Figure 4.2 highlights this particular feature of the dietary diversity data, where dietary diversity is measured by the number of food groups in a meal.

Figure 4.2: Frequency distribution of number of food groups acquired



For count data, a suitable probability distribution is the Poisson probability distribution. The Poisson density function is given by

$$f(y_i \mid x_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!}, \quad i=0, 1, 2,.....$$

A property of the Poisson density is equality of mean and variance, i.e.

$E[y_i \mid x_i] = V[y_i \mid x_i] = \mu$.

In Poisson regression model, the scalar dependent variable, y_i, is the number of occurrences of the events of interest (which in this case, is the number of food groups acquired). A regression model based on Poisson distribution follows by conditioning the distribution of the dependent variable, y_i, on a vector of explanatory variables, x_i, and parameters β, through a continuous function $\lambda(x_i, \beta)$, such that $E[y_i \mid x_i] = \lambda(x_i, \beta)$.

In the log-linear version of the model the mean parameter λ is parameterized as

$$E[y_i \mid X_i] = \lambda_i = \exp(x_i'\beta) = \exp(\beta_1 + \beta_2 x_{2i} + ...\beta_k x_{ki})$$

Y is the observed number of events, N is the number of observations, and x is the known set of explanatory variables.

A Poisson regression model is specified as follows:

$$\Pr[Y = y \mid N(x), x] = \frac{e^{-\lambda(x)}\lambda(x)^y}{y!}, y = 0,1,2..... \qquad (6)$$

The Poisson Regression model is estimated by using a maximum likelihood estimation procedure. Note that, $y_i > 0$ (as the number of food groups acquired by a

household over the reference period must be strictly positive). This is a case of truncation from below and thus this particular feature of truncation in the data must be taken into account. This is accomplished by specifying a zero-truncated Poisson model (Cameron & Trivedi, 1998).

The implicit assumption in the Poisson model is that the variance of y_i equal to its mean or the data is equally dispersed. Violation of this assumption in the poison regression model has similar qualitative consequences as the failure of the assumption of homoskedasticity in the linear regression model (Cameron & Trivedi, 1998). A simple regression based procedure is used for testing the hypothesis that the variance of y_i is equal to its mean. The test statistic is given by:

$$z_i = \frac{(y_i - \hat{\lambda}_i)^2 - y_i}{\hat{\lambda}_i \sqrt{2}},$$

where $\hat{\lambda}_i$ is the predicted value from the regression. A simple t-test of whether the coefficient is significantly different from zero tests the null hypothesis which is equi-dispersion against the alternative. If this test is statistically significant, it would imply that the Poisson regression model is inappropriate, and a negative binomial model could be a better alternative.

While there is good reason to believe that the explanatory variable *per capita total expenditure* is endogenous, given the significant complexity in estimation, I am deferring this for future research.

4.3.4 Empirical Specifications for the Demand for Fish, Vegetables, Pulses, Meat and Fruits

In the data set used, there are many households with zero consumption of different foods. In a household survey with as many as 7,413 observations, it is not unusual that several food items have an acquisition/consumption value of zero (Deaton & Irish, 1984). Such zero values can be due to any of three broad factors: (i) variation in preferences across the sample (households may simply not consume some food items); (ii) infrequent purchasing (household may not buy the food items during the reference period; (iii) misreporting (Keen 1986). I assume that zero acquisition of the reported food item is a household decision choice and is mainly due to infrequent purchasing.

Given the above, the application of the usual continuous dependent variable regression techniques will result in biased and inconsistent estimates. The limited dependent variable model of Tobin, known as the Tobit model, provides a method for estimating the demand equation in this case, as it allows a probability of observing zero value for the dependent variable.

The Tobit model is:

$$Y_{id}^{*} = \beta_0 + \sum_{k=1}^{K} \beta_k X_{k,id} + \mu_d + \varepsilon_{id}^{*}, \quad \varepsilon_{id}^{*} \sim iid\ N(0,\sigma^2) \tag{7}$$

Where the recorded sample of data is censored at a lower bound of 0. The observed data satisfy: $y_i = \begin{Bmatrix} y_i^{*} \\ 0 \end{Bmatrix}$ if $y_i = \begin{Bmatrix} y_i^{*} > 0 \\ y_i^{*} \le 0 \end{Bmatrix}$

where i denotes households, β is a $(K+1)\times 1$ vector of parameters, X is set of explanatory variables, and u_i is an error term which is independently and normally distributed. The μ_d are unobservable district specific, household invariant effect. This equation is estimated using instrumental variable techniques after testing for endogeneity of income (StataCorp 2003).

A simplified likelihood ratio test is used to test for endogeneity in the simultaneous equation Tobit model (Smith & Blundell, 1986). The test involves specifying that the exogeneity of one or more explanatory variables is under suspicion. Under the null hypothesis, the models are appropriately specified with all explanatory variables as exogenous. Under the alternative hypothesis, the suspected endogenous variables are expressed as linear projections of a set of instruments, and the residuals from those first-stage regressions are added to the model. Under the null hypothesis, these residuals do not have any explanatory power. This test is related to the Davidson-MacKinnon auxiliary regression test for endogeneity in a regression context, which in turn is a convenient alternative to the commonly employed Hausman test. Large F value suggests the rejection of the null and thus instrumental variable needs to be employed (StataCorp, 2003).

The Tobit model is sensitive to misspecification and may impose a structure on censored or truncated data that is not well fitted, thereby causing inconsistent estimates. One ‘eyeball’ test used to judge whether a Tobit is misspecified is to compare the maximum likelihood estimates from the Tobit model with the estimates from a probit

model from the same data. If the tobit model is the correct specification, then the ratio of Maximum Likelihood estimates from the Tobit, $\hat{\beta}_{TOBIT} / \hat{\sigma}_{TOBIT}$, should be the same as the probit coefficients from the same data, treating nonzero values as 1 and 0 values as 0. (Johnston and DiNardo, 1997). If scaled parameter estimates from both models are very different, it suggests that the model is misspecified.

Once there is some assurance that the Tobit model is not misspecified, testing for heteroskedasticity is essential; the Tobit model is sensitive to non-spherical disturbances. To assure that the parameter estimates are consistent and not related to the error variance $\left(\sigma^2\right)$ heteroskedasticity may be tested for by the likelihood ratio (LR) test. Where the log likelihood ratio of a full model (L_f) is compared to that of a reduced model (L_r). The reduced model is under the null hypothesis of homoskedasticity.

$$LR = -2 \bullet \left(L_f - L_r\right) \sim \chi^2_{df}$$

The LR test has a chi-square distribution, where the degrees of freedom (df) correspond to the number of restrictions[g]. In the presence of heteroskedasticity, Stata's '*robust*' and/ or '*het*' commands are used. The *'het'* command corrects for the parameter estimates and the variance in the presence of multiplicative heteroskedasticity (Statacorp 2003).

[g] See Maddala 1983 (p. 179-182) for further discussion

4.4 Calculating Elasticities

Income elasticities can be computed using the following equations:

$$Income\ elasticity = \frac{\partial y}{\partial M} \bullet \frac{E(M)}{E(y \mid M)}$$ where M is the income

Price elasticities can be estimated using the following equations:

$$Own\ price\ elasticity = \frac{\partial y}{\partial x} \bullet \frac{E(x)}{E(y \mid x)}$$, and

$$Cross\ price\ elasticity = \frac{\partial y}{\partial z} \bullet \frac{E(z)}{E(y \mid z)}$$ where z is the price of other food items (substitutes or complements).

Both income and price elasticities (own and cross) are calculated at the mean value of the variable.

Chapter 5: EMPIRICAL RESULTS: The Determinants of Dietary Quality and Dietary Quantity

5.1 Household Protein Availability

The results for household protein availability (in grams) from two-stage least squares (2SLS) regression are presented in Table 5.1. The second column reports the estimated parameter coefficients, while corresponding t-statistics are presented in the third column. The last column reports income and price elasticities evaluated at the sample mean values. The results of the Hausman-Wu and related tests for the endogeneity of income are also reported. The instrumental variables used are two dummy variables created based on household asset possession of vehicles (bicycles, cars and motorcycles) and of kitchen utensils (plates, glass, bowls and lamps).

The variables that appear to have significant coefficients include: total expenditure per capita, those representing women's and men's education, the number of adult equivalents in the household, whether the household is headed by a female, age-sex composition variables, the prices of rice, fish, eggs, dairy products and edible oils. In addition to testing for the statistical significance of district effects, seasonal effects, levels of education, I have also tested for the joint statistical significance of the district effects, seasonal effects, and the primary and secondary education variables for women or men and they are found to be jointly significant in each case (see Table 5.1).

As shown in the table, the income elasticity of protein demand is 0.58, which suggests that a one percent increase in income would lead to 0.58 percent increase in per adult equivalent protein.

The empirical results support the theory that household protein availability increases with women's education. The estimated coefficients of both primary and secondary education of women are positive and statistically significant at five percent level of significance, suggesting that having at least one educated woman in the household increases household protein availability (by 3.06 grams of protein if there is a woman with primary education and 3.56 if there is a woman with secondary education). Having at least one man with primary education in the household has about the same effect on household protein availability as woman with primary education. However, having a man with secondary education does not have any additional effect on household protein availability. These can be explained by the fact that education brings a greater awareness of the need to increase the share of protein in diet as it is one of the important macro nutrients needed for nutritional health. In Bangladesh, typically it is the man who does most of the shopping. Thus, men's education may play an important role in deciding what to buy.

The relationship between the number of household adult equivalents and protein availability is positive and significant. The variable's coefficient is large, indicating that an increase in the number of adult equivalents in the household by one increases protein availability by 4.41 grams. This means larger households are likely to allocate a larger share of their budgets to protein-rich foods. This may be due to economies of scale in consumption expenditure in larger households.

Controlling for the other factors considered, female headed households have lower protein availability than male headed households. The variable's coefficient (-2.64)

is statistically significant at the one percent level. Typically markets are under the domain of men in rural Bangladesh. Men go to the market and do most of the shopping. Mobility of women is quite limited due to social and cultural norms. As most of the female headed households do not have adult man in the household, limited mobility may be one of the reasons that prevent them from getting access to protein-rich foods. The other possible reason could be as many female-headed households are presumably casual laborers who often get wage in food that constraints their ability to buy other types of foods. This could also be a result of gender differences in knowledge and preferences and/or the ability of the female headed households to put the knowledge into practice. Further research is needed to investigate the source of this finding,

The coefficient of the price of rice (-1.27) is negative and significant. The price elasticity of rice is relatively large (-0.23). Note that rice is the major source (54 percent) of protein in Bangladesh. The price elasticities of fish, eggs, and dairy products are also negative and significant suggesting an increase in price of any of these food items will worsen protein availability. Increases in the price of eggs, the third major source of protein in the Bangladeshi diet, have a particularly strong negative influence (price elasticity -0.21) on protein availability. Fish is the second largest source of protein (13 percent) in Bangladesh, while meat and poultry rank as the third major source (6 percent) (BBS, 2000). Increases in the price of edible oil positively influence protein availability while increases in the prices of fruits, pulses, meat, and vegetables seem not to have any effect.

The district fixed effects have a significant influence on protein availability, suggesting that the variation between the districts is significant. This could be due to cultural differences, eating habits, or a result of geographic-specific effects, such as proximity to a water body or to a vegetable growing zone that may potentially influence consumption behavior.

Seasonal variation in protein availability is also significant. This can be explained as the influence of seasonal variation in the production cycle of agriculture which influences the price and availability of different food products. For an example, in Bangladesh, the availability of fresh water fish significantly declines in the winter. Moreover, March–April and October–November are considered to be lean seasons or ‘hungry’ seasons, when rural people are often affected, which normally coincides with the rainy season.

Table: 5.1 Household protein availability: 2SLS regression results

Dependent Variable: Protein acquisition per adult equivalent			
		Regression Results	
Independent variables	Coefficient	t-statistic	Elasticity
Total expenditure per capita (in Taka)	1.45	4.19 ***	0.58
Women's education: any primary	3.06	2.18 **	
Women's education: any secondary	3.56	2.35 **	
Men's education: any primary	3.43	2.43 **	
Men's education: any secondary	1.51	1.06	
No.of adult equivalent in the household	4.41	3.2 ***	
Whether female headed household	-12.64	-3.01 ***	
Percent females 16-30 (years)	-0.16	-2.41 **	
Percent females 30+ (years)	-0.23	-2.69 ***	
Percent males 0-16 (years)	-0.06	-1.75 *	
Percent males 16-30 (years)	-0.34	-3.4 ***	
Percent males 30+ (years)	-0.42	-2.52 **	
Age of household head	0.07	1.16	
Price of fruits (Taka per kg)	-0.02	-0.56	-0.01
Price of rice (Taka per kg)	-1.27	-2.48 **	-0.23
Price of fish (Taka per kg)	-0.09	-2.06 **	-0.07
Price of pulses (Taka per kg)	-0.05	-0.7	-0.02
Price of eggs (Taka per kg)	-0.27	-2.55 **	-0.21
Price of meat (Taka per kg)	-0.04	-0.81	-0.04
Price of vegetables (Taka per kg)	-0.52	-1.46	-0.06
Price of dairy products (Taka per kg)	-0.04	-1.84 *	-0.02
Price of edible oils (Taka per kg)	0.16	4.28 ***	0.11
Joint significance tests (F-tests):			
District fixed effects		3.63***	
Seasonal effects		2.45***	
Effects of women's education		3.57**	
Effects of men's education		2.96**	
Specification tests:			
Instrument Relevance (F-test)		4.48***	
Overidentification (χ^2 - test)		0.45	
Hausman-Wu (F-test)		167.74***	
Breusch – Pagan (χ^2 - test)		270.47***	
Multicollinearity: Highest VIF		7.82	
Multicollinearity: Mean VIF		2.16	
R-squared		0.3201	
Number of districts		63	
Number of observations		7,413	
***Significant at the 1% level,**Significant at 5% level, & *Significant at the 10% level			

Note: a) STATA does not report R-squared for the 2SLS model. Thus the R-squared from the equivalent OLS model is reported;
b) Robust standard errors are used in computing t-statistics.

5.2 Dietary Diversity

The results of dietary diversity from the Poisson regression model are reported in Table 5.2. The measure of dietary diversity is the number of food groups out of 12 acquired over the reference period.

Variables that are found to be significant are: those representing women's and men's education, the number of adult equivalents in the household, whether the household is headed by a female, proportion of women aged more than 30 years old, and the prices of fruits, rice, fish, pulses, vegetables, dairy products and edible oils.

As expected the relationship between dietary diversity and total expenditure per capita is positive and significant. These results confirm the role of income in increasing access to a diet of high quality foods.

The analysis shows that women's education has a strong effect on dietary diversity. Having at least one woman in the household with a primary education leads to a 4.95 percent increase in dietary diversity, while having a secondary educated woman leads to a 6.4 percent increase, even higher. In rural Bangladesh, women are involved in kitchen gardening, poultry rearing, animal husbandry and food preparation. Hence the household decisions made in all of these areas are influenced by women's knowledge regarding nutritional benefits of different foods and their ability to direct household resources towards high quality foods (Quisumbing et al. 1995).

Having at least a man with secondary education in the household leads to a 4.3 percent improvement in dietary diversity suggests men's education is also important in improving dietary diversity. However this effect is much smaller compared to the effect of woman with secondary education. Having a man with primary education does not have any additional effect on dietary diversity.

The number of adult equivalents in the household appears to positively influence the quality of diet. There could be many explanations of this finding. First, a larger household is more likely to have children or an older person or both at home which can account for a larger number of food items in the consumption basket since food requirements of a child, adult and an elderly are not necessarily the same. Secondly, this could be due to the fact that a larger household may be able to allocate more time to kitchen gardening and hence diversify their diet. Third, this could also be due to economies of scale in the consumption expenditure in larger households.

The gender of household head variable is nearly statistically significant (t=-1.13), which suggests that a female headed household may be at a disadvantage when it comes to dietary diversity. This finding could be a result of number of facts. Typically markets are under the domain of men in rural Bangladesh. Men go to the market and do most of the shopping. Mobility of women is quite limited due to social and cultural norms. As most of the female headed households do not have adult man in the household, limited mobility may be one of the reasons that prevent them from getting access to a wide variety of foods. The other possible reason could be as many female-headed households are presumably casual laborers who often get wage in food that constraints their ability to

buy other types of foods. Note that some studies have found the females tend to allocate more of the resources under their control to goods and services that are beneficial to their households (rather than only themselves) than do males (Haddad, Hoddinott and Alderman, 1997). This may lead us to believe that they would have better diet quality and perhaps quantity too.

Dietary diversity is sensitive to changes in the prices of the rice, vegetables, fish, fruits, pulses, dairy products, and edible oils. The coefficients are relatively small and positive, suggesting that dietary diversity slightly increases with price increases of the above the food items. The coefficient is highest for rice (0.0067) and lowest for dairy products (0.0003). This could be a matter of fact that households may not completely eliminate a food from the food basket as price increases. Rather they may prefer to reduce the consumption. The other possible reason could be that households may substitute cheaper foods within and between food groups, which apparently increases the dietary diversity.

As for protein availability, the district fixed effects have a significant influence on dietary diversity suggesting some variation in dietary diversity between the districts. This could be due to differences in production and consumption behavior of the households across the districts because of culture, topography, access to natural resources and market facilities.

The effects of seasonal variations on dietary diversity are also significant and may shape household consumption behavior. This arises from the cycle of food production and consequent seasonal variation in the availability of different foods.

Table: 5.2 Dietary diversity: Poisson regression results

Dependent Variable: Number of food groups		
		Regression Results
Independent variables	Coefficient	z-statistic
Total expenditure per capita (in Taka)	0.0002	1.88*
Women's education: any primary	0.0495	4.24***
Women's education: any secondary	0.0640	5.46***
Men's education: any primary	0.0171	1.42
Men's education: any secondary	0.0433	3.96***
No. of adult equivalent in the household	0.0070	2.48***
Whether female headed household	-0.0190	-1.13
Percent females 16-30 (years)	-0.0003	-0.9
Percent females 30+ (years)	-0.0007	-1.84*
Percent males 0-16 (years)	-0.0003	-0.99
Percent males 16-30 (years)	-0.0002	-0.56
Percent males 30+ (years)	-0.0004	-0.86
Age of household head	-0.0002	-0.49
Price of fruits (Taka per kg)	0.0009	3.03***
Price of rice (Taka per kg)	0.0067	3.68***
Price of fish (Taka per kg)	0.0004	1.72*
Price of pulses (Taka per kg)	0.0021	3.75***
Price of eggs (Taka per kg)	0.0007	0.89
Price of meat (Taka per kg)	0.0004	1.28
Price of vegetables (Taka per kg)	0.0050	2.14**
Price of dairy products (Taka per kg)	0.0003	2.75***
Price of edible oils (Taka per kg)	-0.0005	-1.85*
Joint significance test: (F-test)		
District fixed effects		186.53***
Seasonal effects		32.68***
Effects of women's education		34.84***
Effects of men's education		15.69***
Specification test:		
Overdispersion (χ^2 - test)		1606.74
Multicollinearity: Highest VIF		7.82
Multicollinearity: Mean VIF		2.16
Number of districts		63
Number of observations		7,413

***Significant at the 1% level, **Significant at 5% level, & *Significant at the 10% level

5.3 Demand for Fish, Vegetables, Pulses, Meat and Fruits

Table 5.3 reports the regression results from the food demand models estimated using the Tobit model. The dependent variables are measured as the quantity in grams acquired by households per day. The table presents the parameter coefficients, their corresponding t-values, and income and price elasticities evaluated at the variable sample means. The results of the Smith-Blundell test for the endogeneity of income are also reported in the table. For instrumental variables, three dummy variables are created based on household asset possession of vehicles (bicycles, cars and motorcycles); tubewells, lamps and sewing machine; and appliances (fan and heater).

As we can notice from the table, statistically significant variables are: total expenditure per capita, women's and men's education, the number of adult equivalents in the household, whether the household is headed by a female, the age of the household head, proportion of male and female in the household, and food prices.

The coefficient of total expenditure per capita is highly significant for all of the foods. These results suggest that demand for micro nutrient and protein rich foods are sensitive to income. As expected, the income elasticity is highest for meat (3.50) followed by fruits (2.71), and lowest for vegetables (0.42). Meat, fish and fruits are luxury goods in Bangladesh (income elasticity is >1), while vegetables and pulses are necessities. This is because meat, fish and fruits are among the expensive foods in Bangladesh. Hence the demand for these foods is more responsive to income changes. Vegetables are considered less expensive food in Bangladesh. Moreover, many rural

households produce some varieties of vegetables in their kitchen gardens or roof tops, thus demand for vegetables is relatively less responsive to income change.

The coefficient of the variable representing women's secondary education is found to be statistically significant and large across all foods. The coefficient is largest for vegetable demand (69.60) followed by fruits (61.59), meat (43.94) and fish (31.11) demand, suggesting that the influence of women's education is most important in increasing the demand for vegetables and least important in increasing the demand for pulses. Women are responsible for preparing food and often they are involved in kitchen gardening, poultry rearing, animal husbandry and food preparation. Hence the household decisions made in all of these areas are influenced by women's knowledge regarding nutritional benefits of different foods and their ability to direct household resources towards high quality foods

Looking at estimated coefficients of men's education (both primary and secondary), we observe that for all food items they are positive and statistically significant but in most cases the coefficient is smaller compared to the coefficient of women's education. This implies that the education of men is also a positive contributing factor in enhancing the dietary quality but the effect is not as larger as women's education. Men's education is an important factor in determining dietary quality as men do most of the shopping in Bangladesh, so they are the one who decide what should be in the food basket.

As one would expect the number of adult equivalents in the household is found to be a significant determinant across all food items. A large household will have a greater demand for food holding income, education, and prices constant. The coefficient is largest for vegetables (244.97) and smallest for pulses (24.42).

As found for protein availability and dietary diversity, holding all else constant, female headed households can be expected to demand less of pulses, meat, fruits, fish and vegetables than male headed households.

The own price elasticities of the foods are negative and significant for all food items except meat. The own-price elasticity of meat is insignificant. As pointed out by Bouis (1997), in Bangladesh a majority of the households purchase only a small quantity of this expensive source of nutrients occasionally. The own price elasticity is largest for pulses (-0.45) and smallest for fruits (-0.21).

The cross-price elasticities represent the substitution or complementary effects. Two goods are substitutes (complements) when if the price of one good rises, the consumer purchase more (less) of the other. Signs of estimated cross price elasticities indicate whether the pair of goods are substitutes (positive sign) or complements (negative sign). Pulses and edible oils appear to be the substitute for fish, vegetables and fruits while rice is a complement food for fish and fruits and rice and fish both are complement for vegetables. Fruits, vegetables and edible oils are substitutes for pulses. No food appears to be the substitute or complement for meat.

Table: 5.3 Demand for fish, vegetables, pulses, meat, & fruits: Instrumental variables Tobit regression results

	Dependent Variable: Quantity acquired by households per day (grams)					
	Fish Demand			Vegetable Demand		
Independent variables	Coefficient	t-statistics	Elasticity	Coefficient	t-statistics	Elasticity
Total expenditure per capita (in Taka)	7.69	4.43***	1.04***	16.05	4.02***	0.42***
Women's education: any primary	11.97	1.34		34.29	1.67*	
Women's education: any secondary	31.11	3.43***		69.60	3.34***	
Men's education: any primary	17.22	1.83*		47.64	2.21**	
Men's education: any secondary	19.66	2.36**		42.43	2.22**	
No. of adult equivalent in the household	74.85	9.69***		244.97	13.8***	
Whether female headed household	-56.38	-3.07***		-127.35	-3.02***	
Percent females 16-30 (years)	-0.55	-1.53		-1.86	-2.24**	
Percent females 30+ (years)	-1.31	-2.84***		-3.31	-3.13***	
Percent males 0-16 (years)	-0.24	-1.13		-0.61	-1.24	
Percent males 16-30 (years)	-1.77	-3.55***		-3.78	-3.31***	
Percent males 30+ (years)	-1.82	-2.86***		-4.19	-2.87***	
Age of household head	-0.01	-0.04		0.45	0.72	
Price of fruits (Taka per kg)	0.16	0.62	0.02	-0.08	-0.14	0.00
Price of rice (Taka per kg)	-8.83	-3.28***	-0.54***	-13.86	-2.24**	-0.17**
Price of fish (Taka per kg)	-1.44	-6.35***	-0.38***	-1.18	-2.27**	-0.06**
Price of pulses (Taka per kg)	1.00	2.32**	0.15**	2.57	2.58***	0.07***
Price of eggs (Taka per kg)	-1.00	-1.58	-0.26	-1.53	-1.04	-0.08
Price of meat (Taka per kg)	-0.09	-0.37	-0.03	-0.35	-0.61	-0.02
Price of vegetables (Taka per kg)	1.11	0.55	0.04	-31.92	-6.89***	-0.25***
Price of dairy products (Tk per kg)	-0.07	-0.7	-0.01	-0.07	-0.34	0.00
Price of edible oils (Taka per kg)	0.71	2.85***	0.17***	1.42	2.5***	0.07***
Joint significance tests: (F-test)						
District fixed effects		130.6***		322.14***		
Seasonal effects		49.51***		87.33***		
Effects of women's education		11.80***		11.36***		
Effects of men's education		6.75**		7.28**		
Smith-Blundell test of exogeneity		99.33***		43.58 ***		
Pseudo R-squared		0.0525		0.0539		

***Significant at the 1% level, **Significant at 5% level, & *Significant at the 10% level

Note: STATA doesn't report R-squared for Instrumental Variable Tobit, hence Pseudo R-squared from Tobit model is reported.

Table: 5.3 Demand for fish, vegetables, pulses, meat, & fruits: Instrumental variables Tobit regression results *(Continued)*

	Dependent Variable: Quantity acquired by households per day (grams)								
	Pulses Demand			Meat Demand			Fruits Demand		
Independent variables	Coeff	t-stat	Elasticity	Coeff	t-stat	Elasticity	Coeff	t-stat	Elasticity
Total expenditure per capita (in Taka)	1.67	3.18***	0.54***	9.42	1.79*	3.50 ***	14.18	4.09***	2.71***
Women's education: any primary	4.30	1.6		29.00	2.58***		38.05	2.13**	
Women's education: any secondary	6.16	2.25**		43.94	3.81***		61.59	3.4***	
Men's education: any primary	6.26	2.21**		24.10	1.79*		24.23	1.28	
Men's education: any secondary	6.28	2.5**		26.89	2.55***		38.15	2.29**	
No. of adult equivalent in the household	24.42	10.48***		62.08	2.74***		93.96	6.1***	
Whether female headed household	-9.41	-1.7*		-81.41	-1.88*		-127.52	-3.46***	
Percent females 16-30 (years)	-0.34	-3.15***		-1.01	-1.28		-1.62	-2.23**	
Percent females 30+ (years)	-0.48	-3.44***		-1.94	-1.64*		-3.39	-3.67***	
Percent males 0-16 (years)	-0.13	-1.97**		-0.49	-1.64*		-0.76	-1.78*	
Percent males 16-30 (years)	-0.46	-3.07***		-2.35	-1.73*		-3.61	-3.64***	
Percent males 30+ (years)	-0.55	-2.89***		-3.02	-1.77*		-4.44	-3.5***	
Age of household head	0.14	1.67*		0.09	0.27		0.53	0.97	
Price of fruits (Taka per kg)	0.18	2.22**	0.05**	-0.07	-0.15	-0.02	-1.37	-2.59***	-0.21***
Price of rice (Taka per kg)	-0.28	-0.34	-0.04	1.55	0.22	0.26	-13.50	-2.52**	-1.15**
Price of fish (Taka per kg)	0.12	1.78	0.08	0.02	0.05	0.02	-0.36	-0.79	-0.13
Price of pulses (Taka per kg)	-1.31	-9.97***	-0.45***	1.53	2.34*	0.61	1.90	2.18**	0.39**
Price of eggs (Taka per kg)	-0.19	-0.99	-0.12	0.34	0.38	0.24	-0.32	-0.25	-0.12
Price of meat (Taka per kg)	-0.09	-1.15	-0.07	-0.32	-0.86	-0.31	0.13	0.25	0.06
Price of vegetables (Taka per kg)	1.54	2.53**	0.15**	-0.48	-0.13	-0.05	-3.39	-0.84	-0.19
Price of dairy products (Tk per kg)	-0.02	-0.56	-0.01	-0.19	-1.07	-0.08	-0.34	-1.82*	-0.07*
Price of edible oils (Taka per kg)	0.15	2.05**	0.09**	0.58	1.33	0.37	1.24	2.52**	0.41**
Joint significance test: (F-test)									
District fixed effects		527.85 ***			133.7 ***			215.4***	
Seasonal effects		111.21 ***			37.64 ***			415***	
Effects of women's education		5.71 **			16.03 ***			12.37***	
Effects of men's education		8.28 **			7.91 **			5.49**	
Smith-Blundell test of exogeneity		17.64***			12.43 ***			64.83***	
Pseudo R-squared		0.052			0.048			0.055	

***Significant at the 1% level, **Significant at 5% level, & *Significant at the 10% level

Note: STATA doesn't report R-squared for Instrumental Variable Tobit, hence Pseudo R-squared from Tobit model is reported.

5.4 Household Energy Availability

Table 5.4 reports the regression results of the two stage least squares (2SLS) estimation of household energy availability. The unit of energy reported is kilocalories per day. The results of the Hausman-Wu and related tests for the endogeneity of income are also reported in the table. The instrumental variables used are two dummy variables created based on household asset possession of vehicles (bicycles, cars and motorcycles) and of kitchen utensils (plates, glass, bowls and lamps).

From Table 5.4 we observe that statistically significant variables are: total expenditure per capita, variable representing men's education, the number of adult equivalents in the household, whether the household is headed by a female, age-sex composition variables, and many of the price variables.

As expected the relationship between household energy availability and income is positive. The income elasticity evaluated at the sample mean suggests that a one percent increase in income leads to 0.90 percent increase in per adult equivalent energy availability also suggests that the energy sources – which is essentially the rice, is considered as a necessity. This is not unlikely in Bangladesh where food accounts for 54 percent of household expenditures.

Coefficients of women's education (for both primary and secondary) are statistically insignificant, which implies that when it comes to the determination of dietary quantity, women's education is not a crucial factor. Men's primary education has

limited effect (at 10 percent level) on energy availability. However, education is not an important factor in determining dietary quantity as it is for dietary quality.

The relationship between the number of household adult equivalent and energy availability is positive and significant. The variable's coefficient is large, indicating that an increase in the number of adult equivalents in the household of one increases energy availability per adult equivalent by almost 265 kcals. Perhaps larger households allocate a larger share of their budgets to calorie dense starchy staples. This may also be due to economies of scale in larger households.

Controlling for the other factors considered, female headed households have lower energy availability than male headed households. The variable's coefficient is very large (-655.58 kcals). Further research is needed to investigate the source of this finding.

The price elasticity of rice (-0.44) – the major source of energy in Bangladesh suggests that energy availability is sensitive to rice price as would be expected. The price elasticities of fish, eggs, vegetables, fruits and dairy products are also negative and significant suggesting an increase in price of any of these food items will worsen energy availability.

The district fixed effects are found to be jointly significant at the one percent level, suggesting that energy availability varies significantly between the districts. The seasonal effects are not jointly significant.

The common determinants of both dietary quality and dietary quantity are per capita total expenditure (positive effect in both cases), whether the household is headed

by female (negative effect in both cases), number of adult equivalents in the household (positive effect in both cases), and own prices and cross prices.

While analysis reveals that men's education has some limited influence (at the 10 percent level of significance) on energy availability (i.e., dietary quantity), education in general only has explanatory significance as a determinant of dietary quality.

Table: 5.4 Household energy availability: 2SLS regression results

Dependent Variable: Kilocalorie per adult equivalent

		Regression Results	
Independent variables	Coefficient	t-statistics	Elasticity
Total expenditure per capita (in Taka)	76.47	3.34***	0.90***
Women's education: any primary	86.09	1.20	
Women's education: any secondary	47.54	0.61	
Men's education: any primary	140.32	1.89*	
Men's education: any secondary	-14.30	-0.20	
Number of adult equivalent in the household	264.88	2.84***	
Whether female headed household	-655.58	-2.70***	
Percent females 16-30 (years)	-9.10	-2.18**	
Percent females 30+ (years)	-13.13	-2.40**	
Percent males 0-16 (years)	-2.49	-1.40	
Percent males 16-30 (years)	-17.72	-2.87***	
Percent males 30+ (years)	-22.88	-2.38**	
Age of household head	3.06	0.96	
Price of fruits (Taka per kg)	-4.29	-1.73*	-0.04*
Price of rice (Taka per kg)	-96.09	-2.89***	-0.44***
Price of fish (Taka per kg)	-5.05	-1.95**	-0.10**
Price of pulses (Taka per kg)	-4.23	-1.12	-0.05
Price of eggs (Taka per kg)	-13.57	-2.36**	-0.27**
Price of meat (Taka per kg)	-2.22	-0.90	-0.06
Price of vegetables (Taka per kg)	-42.19	-2.07**	-0.13**
Price of dairy products (Taka per kg)	-2.59	-2.02**	-0.03**
Price of edible oils (Taka per kg)	7.26	3.26***	0.13***
Joint significance test : (F-test)			
District fixed effects		2.07***	
Seasonal effects		1.38	
Effects of women's education		0.72	
Effects of men's education		2.45*	
Specification tests :			
Instrument Relevance (F-test)		5.35***	
Overidentification (χ^2 - test)		0.73	
Hausman-Wu (F-test)		114.24***	
Breusch – Pagan (χ^2 - test)		164.38***	
Multicolliniearity: Highest VIF		7.82	
Multicolliniearity: Mean VIF		2.16	
R-squared		0.1405	
Number of districts		63	
Number of observations		7413	

***Significant at the 1% level, **Significant at 5% level, & *Significant at the 10% level

Note: a) STATA doesn't report R-squared for 2SLS model, thus R-squared from OLS model is reported.
b) Robust standard error is used in computing values for t-statistics.

Chapter 6: CONCLUSION

Household food security in Bangladesh is among the worst in the world. The Bangladeshi diet is dominated by rice, which is often accompanied by small amounts of non staple foods such as vegetables, fish, and pulses. Rice is an inexpensive source of dietary energy and protein but a poor source of bioavailable minerals and vitamins. To minimize hunger, poor people place highest priority on consuming rice. Partly as a result of poor dietary quality, nearly one half of all mothers in rural Bangladesh are undernourished. Poor dietary quality also contributes to the extreme high rates of malnutrition in Bangladesh. A proper understanding of principal factors that cause poor dietary quality is crucial for designing policies and programs to overcome it. This study attempts to contribute to the debate on what the determinants of dietary quality are and how to improve it in order to reduce malnutrition in Bangladesh.

Specifically, the two key questions that are explored in the study are:

a) What are the determinants of dietary quality in Bangladesh? and

b) Do the determinants of dietary quality and quantity differ?

The conclusions of the study are based on estimations undertaken with careful consideration to data quality and statistical soundness. It employs data from Bangladesh Household Income and Expenditure survey undertaken in 2000, data that have been subjected to strict quality control standards. The study employs a number of estimation methodologies. Specification tests indicate that the models estimated are a reasonably

good representation of the quantitative relationships between dietary quality and quantity and the determinants considered.

The empirical results shows that the principal determinants of dietary quality in Bangladesh are: per capita total expenditure, education, gender of the household head, number of adult equivalents in the household, and prices of food commodities.

This study has found strong evidence that per capita total expenditure and education are the most robust determinants of dietary quality. As can be seen from the elasticities and/ or coefficients, the influence of income on dietary quality is strong. The demand for protein, dietary diversity and micronutrient-rich sources of foods are sensitive to income changes. However, as discussed in section 2.2, increase in income may not be a sufficient condition to improve dietary quality but it is a necessary condition.

Returns to women's education are found to be particularly high. This result is consistent across the various measures of dietary quality employed as dependent variables. Note that women are responsible for preparing food in Bangladesh and often they are involved in kitchen gardening, poultry rearing, animal husbandry and food preparation. Hence the household decisions made in all of these areas are influenced by women's knowledge regarding nutritional benefits of different foods and their ability to direct household resources towards high quality foods.

Men's education is also found has some influence on dietary quality but the effect is smaller than women's education. As men do most of the shopping in Bangladesh, they inevitably play a role in deciding what should be in the food basket.

Female headed households are found to be at a disadvantage when it comes to both dietary quality and dietary quantity. This finding could be a result of a number of factors. Typically markets are under the domain of men in rural Bangladesh. Mobility of women is quite limited due to social and cultural norms. As most of the female headed households do not have adult man in the household, limited mobility may be one of the reasons that prevent them from getting access to a wide variety of foods that could improve the dietary quality. The other possible reason could be that many female-headed households are casual laborers who often get wages in food, this constrains their ability to buy other types of foods. Finally, it could also be due to the gender differences in knowledge and preferences and/or the ability of the female headed households to put them into practice. Further research is needed to investigate this finding.

The demand for protein, fish, meat, vegetables, fruits, and pulses are sensitive to price changes. However, the relationship between dietary diversity and the prices of the above mentioned food items is found to be positive, suggesting that dietary diversity increases with price increases. This finding could be a reflection of the fact that households may not completely eliminate a food from the food basket as price increases. Instead they may prefer to reduce consumption. The other possible reason could be that households may substitute cheaper foods within and between food groups, which apparently increases the dietary diversity.

In answer to the second question asked “Do the determinants of dietary quality and quantity differ? This study concludes that per capita total expenditure (positive effect in both cases), whether the household is headed by female (negative effect in both cases),

number of adult equivalents in the household (positive effect in both cases), and own prices and cross prices are common determinants of both dietary quality and dietary quantity.

While the analysis reveals that men's education has some limited influence (at the 10 percent level of significance) on energy availability (i.e., dietary quantity), education in general only has explanatory significance as a determinant of dietary quality.

6.1 Policy Implications

For decades the emphasis on food security implicitly focused attention on energy consumption while diverting attention from protein and the entire range of micronutrients, both of which are essential to a high quality diet. But as the hunger situation improves, lack of dietary balance will increasingly act as a constraint on achieving food security. To effectively address the problems of malnutrition in Bangladesh, sound policies and programs are required that have long term scope. Some of the policy recommendations based on the empirical results and their discussion are as follows:

1) The analysis of this paper confirms the key role of income in improving both dietary quantity and dietary quality. Thus effective poverty reduction policies and strategies need to be employed in helping households to increase income. By effectively targeting poverty reduction programs, the issues related to dietary quality can be addressed.

2) Education raises awareness about commonly consumed sources of micronutrients and protein, and thus has the potential for improving intake. Promoting women's education in particular could be a significant policy tool for government and non-government organizations in addressing the issues related to dietary quality. This will require a departure from previous food security policies which tended to focus predominantly on dietary quantity. Improvement in dietary quality will require a greater

emphasis on women's education than in the past, where food security policies mostly focused on dietary quantity.

3) Dietary quality has a low policy profile in Bangladesh. The Bangladesh government has the tendency of choosing policies that are short term in nature and often fails to effectively address the underlying causes. For instance, addressing the issue of micronutrient deficiencies by vitamin A, and iron supplementation programs may provide a short term solution but this approach in unsustainable in the long run and has the potential to create dependency on the providers. Therefore, the government and non government organizations need to adopt multi-pronged sustainable strategies to address issues caused by poor dietary quality and its consequences.

4) Although plant breeding strategies for increased micronutrient content and bioavailability are still in an early stage, and little information is available on their ultimate value to human nutrition, plant breeding strategies are promising because of their immense potential to improve the dietary quality of populations relying mainly on cereal staples. In addition, if new varieties are similar to traditional varieties in terms of taste and appearance, these strategies will not require any behavior changes on the part of the consumer, which relieves one of the main challenges of most food-based approaches.

5) Crop diversification could be another strategic policy instrument that the Government of Bangladesh, private sector, and the non government organizations should seriously implement. Crop diversification can lead to production of nutrient rich crops and their increased supply in the market will, in turn, translate into affordable prices.

6) Although not a direct conclusion from the analysis of the thesis data, improving access to resources, technology and information – especially for women – related to homestead crop production has the potential to improve nutritional quality as well as general food security. A suggestion taken from the literature review (Bouis et.al., 1997), nutritional benefits may accrue to poor households through intensification of homestead production. Many rural households in Bangladesh are engaged in homestead gardening to some degree. Homestead gardening is the major source of vegetables for most poor households. Therefore, targeting homestead production for technical and informational support, in conjunction with crop diversification programs, may be a direct route for enhancing dietary quality. Furthermore, since homestead production is often under the domain of women, increased support may help to address the disadvantages faced by female-headed households.

6.2 Suggestions for Future Research

Because of the data limitations, the policy recommendations require qualification and thus some additional research needs to be undertaken in the following areas:

a) Further study is needed to understand the vulnerability of female headed households in Bangladesh. It is important to find out why female headed households have poorer dietary quality than male headed households.

b) Future studies could explore the intra household differences in dietary quality.

c) More reliable methods for estimating the quantities of foods eaten away from home, including how they contribute to dietary quality, need to be developed.

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