Determinants of Dietary Quality: Evidence from Bangladesh

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Abstract

Whereas a large number of empirical studies have been devoted to analyzing consumer demand for dietary energy (or dietary quantity), much less attention has been paid to the demand for dietary quality, an equally important aspect of food security. To address this gap in the literature, this paper uses data from a nationally representative household expenditure survey conducted in Bangladesh in 2000 on the food acquisition behavior of 7,440 households over a two week period. Two indicators of dietary quality are employed: household protein availability and household diet diversity. Using two-stage least squares regression to correct for the endogeneity of income, we find significant roles of income, education, gender of household head, and prices of key foods. The determination of dietary quality in the country has a strong gender dimension. While male education plays a positive role, female education is found to have a substantially stronger influence. Further, female household headship is associated with lower dietary quality than male headship. Given the crucial roles of income and education in increasing access to a high quality diet, the results call for the continued implementation of well targeted poverty reduction and education programs. Promoting female education and addressing the unique constraints faced by female headed households with respect to diet quality could be a significant policy instrument for government and non-government organizations in addressing food insecurity in Bangladesh.

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1. Introduction

As embodied in the following definition of food security adopted at the 1996 World Food Summit, the quality of one's diet is as important as the quantity in achieving food security:

> *"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."*

Contrary to established consensus in the 1980s, it is now widely recognized that consuming sufficient dietary energy, the most commonly used measure of dietary quantity, does not ensure adequate intake of protein and micronutrients necessary for leading an active and healthy life. These nutrients are found in high concentrations in legumes, foods of animal origins, and fruits and vegetables. 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. Protein deficiency also compromises immunity and increases vulnerability to infectious diseases. Recent studies are showing that the consumption of animal and fish products, which are dense in protein and micronutrients, is more highly correlated with nutritional status than is energy consumption (Smith 2004b). These studies further underscore the need to address issues of dietary quality in addition to those of dietary quality in addressing food security.

Food security in Bangladesh, the country that is the focus of this paper, is arguably one of its main development challenges. Fifty four percent of the population is food energy deficient (Smith and Subandoro 2005), signally a major dietary quantity problem. Despite significant progress over the last ten years, malnutrition rates in the country are among the highest in the world. Nearly half of all women in rural Bangladesh are undernourished, and 55% of children under five years are stunted (HES, 2000). This dire situation is undoubtedly worsened by the very poor quality of the diet, especially among the poor.

Much of the population of Bangladesh subsists on a low quality diet based on energy-dense food staples. The percent of energy derived from cereals, at over 83% in 2000 (Smith and Subandoro 2005), is among the highest in the world, indicating a diet that is seriously imbalanced in terms of nutrition (Gill et al. 2003). Most poor households cannot afford high-calorie-cost foods such as meats and fish in sufficient amounts. Their food expenditures are dominated by low-calorie-cost, but mineral and vitamin poor staple foods, such as rice and to much smaller extent wheat, to prevent hunger and starvation (IFPRI/BIDS/INFS/DATA/ RDHN, 1998). Consequently, consumption of nutrient-rich foods such as animal products in Bangladesh is far lower than recommended levels (Del Ninno et al. 2001). The most important source of animal protein, and an important source of vitamin A as well, is fish. However, stock depletion caused per capita fish consumption to fall over 30% between the 1970s and 1990s (DFID 1998). Pulses, another important source of protein in addition to iron, have also seen reduced consumption due to changes in production technology over the 1980s and 1990s (BBS 2001; GOB 2000), further compromising dietary quality.

Micronutrient deficiencies, including those of iron, iodine and vitamin A, are widespread (Del Ninno et al 2001). 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. Iron deficiency is a particularly serious problem in the country. In 2001 half of all children under five and pregnant women suffered from iron deficiency anemia. One third of school-age children, adolescents and non-pregnant mothers had 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, and thereby their prospects for escape from poverty (HKI/IPHN, 2002).

What are the reasons for such poor dietary quality? And what kind of program and policy interventions can be adopted to improve food security in Bangladesh? Finding answers to these questions is the principal objective of this paper.

Whereas a large number of empirical studies have been devoted to analyzing the determinants of dietary energy consumption (or dietary quantity), much less attention has been paid to the examination of factors that determine dietary quality. This study provides an analysis of the determinants of dietary quality using a unique Household Expenditure Survey (Bangladesh Bureau of Statistics, 2000) with data collected from 7,440 households in Bangladesh. In particular, we examine the varying roles of income, education, female headship, food prices and other demographic characteristics of households in determining two key indicators of dietary quality: household protein availability and diet diversity. The latter is measured as the number of food groups acquired by households over a two week period. The empirical model employed for the analysis of protein availability is a standard regression model. That employed for the measure of diet diversity, which is a "count" variable, is a zero-truncated Poisson regression model estimated using a maximum likelihood procedure. Two-stage least squares instrumental variables estimation is used to correct for the endogeneity of income.

The remainder of this paper is organized as follows. Section 2 briefly discusses previous studies addressing the determinants of dietary quality. Section 3 provides descriptions of the data used and empirical methodology. In section 4, the empirical results are presented are discussed. Conclusions and policy implications are given in Section 5.

2. Previous Studies

The few studies that have examined the role of income in determining dietary quality find a positive influence, as would be expected given that greater variety makes diets more palatable and pleasant (Ruel 2002). Theil and Finke (1983), using cross-sectional data for 30 countries, showed that the demand for dietary diversity increases with increasing per capita real income. Estimation of cross-country Engel curves indicates that the number of foods consumed increases, and the concentration of expenditure decreases, with increasing per capita income (Falkinger and Zweiüller, 1996). Pollack (2001) and Regmi (2001) also confirm that the demands for fruit and vegetables increase with income. These findings are consistent with the fact that vegetables are an expensive source of energy for low income households that prioritize the fulfillment of their basic energy requirements to avoid hunger (Ruel, Minot and Smith 2004).

The view that malnutrition will disappear with improvements in income accompanying the development process (e.g., World Bank 1981) has now been widely disproved. In investigating the role of income in developing country nutrition, Behrman and Deolalikar (1987) find that food expenditures increase more or less proportionally to income but that marginal increments in food expenditures are not devoted primarily to obtaining more nutrients. Rather, the authors conclude 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 other factors that could play important roles in improving dietary diversity? Bouis and Novenario-Reese (1997) find that in a population in central Bangladesh the main determinants of the demand for micronutrients, in addition to income, are: education, occupation, gender of the household head, household size, food prices, and household age-sex composition. 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 principal determinants (Thiele & Weiss 2002).

A number of studies conducted across the world have documented the importance of women's education in improving nutritional status, especially of women and children (Smith and Haddad 2000; Smith et al. 2003). A study conducted in Indonesia finds that mothers with greater nutrition knowledge allocate a larger share of their food budget to foods that are rich in micronutrients, including fruits and vegetables (Block 2003). These studies suggest that it is important to distinguish between women's and men's education in understanding the determinants of dietary quality.

3. Data and Empirical Strategy

(a) Data

This paper uses data collected as part of a nationally representative household expenditure survey conducted in 2000 by the Bangladesh Bureau of Statistics. In order to capture seasonal variability, data collection was evenly spread throughout the year. The survey was conducted using a two-stage stratified sampling design. The strata were made up of the three groups within the country's five divisions: (i) rural areas, (ii) urban municipalities, and (iii) statistical metropolitan areas (SMA).[1] 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 SMAs, where only 10 households were interviewed. The total sample size was 7,440 households. With such a complex sampling design, 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, sampling weights and variables delineating the strata and PSU for each household provided with the survey are used. 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, the Taka. Data were collected on food purchases, consumption of food from home production, and food received as wages and gifts. 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 alternate 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, that is, the time period over which data collection took place in total, was two weeks.

Quantities of foods acquired were recorded directly in metric units (grams) except for a few exceptions where they 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 (FSANZ 2004) were used to convert to metric weights.

Household expenditure surveys can be 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 thus subject to thorough cleaning in three stages. First, for each food, metric unit values (expenditure divided by metric quantities) were cleaned manually by examination for outliers at both ends of the distribution separately by district. When outlying unit values were detected, both the expenditure and quantity used to calculate them were set to missing. Second, metric quantities of individual foods were cleaned. Any quantity per household adult equivalent that was more than three standard deviations from the sample median value was set to

[1] Because there are no SMAs in the division of Barisol, the total number of strata is 14 rather than 15.

missing. Third, metric quantities set to missing in the first and second stages were replaced with an estimated value using OLS regression.[2] Households for which at least one food quantity could not be estimated due to insufficient number of observations for the food were dropped from the sample.

(b) Measuring Dietary Quality

We employ two measures of dietary quality. The *first* is daily household protein availability per adult equivalent, where an "adult equivalent" is defined using a male 30-60 years old as the reference category. To construct this measure, the cleaned metric quantities of foods acquired by households were multiplied by the food's protein value, which was then multiplied by the food's edible portion, which is finally divided by the number of days in the reference period and the number of adult equivalents. The protein values were obtained primarily from the India Food Composition Table (Medindia.net), supplemented by the American food composition table (USDA, 2003) for foods known to vary little in protein composition across countries.[3]

The *second* measure of dietary quality is dietary diversity, defined as the number of different foods or food groups consumed over a given reference period. Dietary

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[2] 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 2006).

[3] For foods acquired for consumption outside the home, as is typical in household expenditure surveys, only total expenditures were reported, which hampers direct conversion to protein values. The only way to take this source of food acquisition into account is to apply the price per gram of protein of foods acquired for consumption inside home to the expenditures on food consumed outside of home (Smith and Subandoro 2006).

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 because it is thought to ensure adequate intake of essential nutrients, and thus promote good health (WHO/FAO 1996; U.S. Department of Agriculture Human Nutrition Information Service 1992). In fact studies from both developing and developed countries give evidence of a strong positive association between diet diversity and nutrient adequacy (Ruel 2002). In this study, we define dietary diversity as the number food groups,[4] out of 12, that a household acquired food from over the survey reference period. These 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.

(c) Measures of Potential Determinants of Dietary Quality

The list of determinants of dietary quality examined in the present paper is presented in Table 1. Per capita daily total household expenditure (measured in Takas) is used as the measure of income. It is expected that dietary quality is positively affected by the level of income (Theil and Finke, 1983; Behrman and Deolalikar, 1987; Falkinger and Zweiuller, 1996; Pollack, 2001; Regmi, 2001; Thiele and Weiss, 2003).

The second determinant considered is education. Past studies suggest that education plays a crucial role in the determination of the nutritional status (Block, 2003).

[4] The question of whether individual foods or food groups should be used to define dietary diversity has been addressed in a number of studies (Hatløy, Torheim, and Oshaug 1998; Ogle, Hung, and Tuyet 2001; Krebs-Smith et al. 1987). The general finding is that use of food groups predicts nutrient adequacy just as well as or better than does use of individual foods, which suggest that, for simplicity, dietary diversity is best assessed using food groups.

It 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). Here it is measured using dummy variables indicating (1) whether any adult household member has a primary (but none have a secondary) education and (2) whether any member has a secondary education. To take into account any gender differences in the influence of education, the variables are constructed separately for women and men.

We also include a dummy variable indicating whether households have a female, as opposed to male, head. While some past studies find that a higher proportion of household resources is devoted to basic needs such as food and health care in female than male headed households (Haddad, Hoddinott and Alderman 1997; Blumberg, 1991; Bruce, 1989; Dwyer and Bruce, 1988; Guyer, 1980, and Rogers, 1996) at present there is little evidence specifically relating to diet quality. One study in the Dominican Republic found that higher quality, more expensive and protein-dense foods are consumed in female headed households than male in that country (Rogers 1996). It is reasonable to think that gender of headship may make a difference if there are gender differences in knowledge about or preferences for dietary quality or in the ability to put such knowledge and preferences into practice (Smith, 2004b). The age of the household head, who is often the most powerful decision maker in a household, is also included, which captures the expected increase in knowledge with experience.

The number of household adult equivalents and variables representing the age-sex composition of households are included to account for possible scale effects and the demographic structure of households. Additionally, dummy variables for district of residence (not shown in table) are included to account for location-specific heterogeneity, such as proximity to a water body, or a vegetable growing zone, for example, which potentially can influence consumption behavior. Dummy variables are also included for month of interview to capture the strong seasonal variations in dietary patterns in Bangladesh that follow the agricultural production cycle (Smith and Subandoro 2006), which influences the prices and availability of foods.

Finally, price variables for nine types of foods-- rice, fish, pulses, egg, meat, vegetables, diary, edible oil, and fruits--are included. As has been shown in a plethora of studies, prices have a major influence on the food consumption patterns of households. The price variables are constructed from computed household-level unit values. Households not consuming a particular food are assigned the median estimated price of the consuming households in the same PSU.[5]

(d) Empirical Model

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). Following Smith (2004b), utility functions may be specified as

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

[5] In the case of eggs, meat, dairy and fruit, some of the households were assigned district or region level median prices. Only in the case of eggs was this a substantial percentage of households, at 52.5%.

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[6]. 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. We 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.

Reduced-form nutrient demand functions take the form:

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

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

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

preparation and consumption time costs (Behrman and Wolfe, 1984; LaFrance, 1999, as reported in Smith 2004b). They value the nutrients contained in food indirectly through their influence on nutritional status. The framework allows focus on only one nutrient such as protein (Z_1, for instance) as well as broader consideration of dietary quality as characterized by all of the nutrients required for nutritional health ($Z_1, \ldots, Z_J$).

Empirical Specification for Protein Availability

The dependent variable, daily protein acquired per adult equivalent (in grams) (denoted by Y_i), is a continuous variable hypothesized to be determined by K explanatory variables, denoted as *X* and indexed as $k = 1,...,K$. The basic model takes the form

$$Y_{id} = \beta_0 + \sum_{k=1}^{K} \beta_k X_{k,id} + \mu_d + u_{id}\ , \qquad (5)$$

$$u_{id} \sim N(0, \sigma^2),\ \ i = 1,...,n,\ \ d = 1,...,D,$$

where i denotes households and *d* denotes districts. The μ_d are unobservable district specific, household-invariant effects and the u_{id} are stochastic. Unbiased and consistent estimates of β_k can be obtained using ordinary least squares (OLS) estimation if the error term does not contain components that are correlated with an explanatory variable. However, in the present case, this assumption may be violated for two reasons. The first has to do with measurement error in the collection of household expenditure survey data that can introduce bias into the estimation of the relationship between income and diet quality (Smith and Subandoro 2006). The second is that the explanatory variable total expenditure per capita (a proxy for income) may be endogenous due to potential reverse causality with protein availability. This is a concern because one's income depends on her/his productivity and protein-deficient people are likely to be less productive food producers and income earners. Thus, in order to obtain unbiased and consistent parameter estimates of equation 5, we employ the two-stage least squares (2SLS) procedure after conducting a Hausman-Wu test for endogeneity (Davidson and Mackinnon 1993).

Empirical Specification for Dietary Diversity

Let y_i denote the number of food groups, out of 12, consumed by the *i*th household. The empirical specification of this "count" variable assumes that it is random and, in a given time interval, has a Poisson distribution with probability density

$$\Pr(y_i = n_i) = \frac{e^{-\lambda_i}\lambda_i^{n_i}}{n_i!}, n_i = 0,1,2,...,12, \tag{6}$$

where n_i is the realized value of the random variable. This is a one-parameter distribution with mean and variance of y_i equal to λ_i. To incorporate a set of explanatory variables X_i into the analysis and to ensure non-negativity of the mean y_i, the parameter λ_i is specified such that

$$E[y_i \mid X_i] = \lambda_i = \exp(x_i'\beta) = \exp(\beta_1 + \beta_2 x_{2i} + ...\beta_k x_{ki}) . \tag{7}$$

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, a feature that is taken into account 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. The violation of this assumption in the Poisson 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 null 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. 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.

For the reasons discussed in the last section, the explanatory variable per capita total expenditure may also be endogenous in this model. Therefore, we estimate the Poisson regression model using the 2SLS estimation procedure in order to obtain unbiased and consistent parameter estimates.

4. Results

(a) Household Protein Availability

The results for household protein acquisition (in grams) from 2SLS regression are reported in Table 2. 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 associated tests for the endogeneity of income are reported at the bottom of the table. Total expenditure per capita is indeed found to be endogenous, with the test result being significant at the 1% level.[7] The identifying instruments for income used are two dummy variables created based on household asset possession of vehicles (bicycles, cars and motorcycles) and kitchen utensils (plates, glass, bowls and lamps). An instrument relevance test (Bound, Jaeger, and Baker 1995) was used to select instruments that are sufficiently well associated with per capita total expenditure. An overidentification test (Davidson and Mackinnon 1993) confirms that the instrument set is statistically associated with household protein availability only through its association with total expenditure per capita, a pre-condition for performing the Hausman-Wu test.

Unobserved cluster-specific attributes will influence protein acquisition similarly for households living in the same cluster, leading to biased estimates of parameter covariance matrix. Additionally, a Breuch-Pagan test indicates strong heteroskedasticity. Thus, STATA's "robust" command is used to calculate White-corrected standard errors (and thus t-statistics).We also test for the presence of multicollinearity among the explanatory variables and do not find any evidence of its presence[8].

Statistically significant determinants of protein availability per adult equivalent are: total expenditure per capita, both women's and men's education, whether the

[7] 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 biased and inconsistent, and thus IV estimates are preferred.

[8] 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).

household is headed by a female, the number of adult equivalents in the household, the age-sex composition variables, and prices of rice, fish, eggs, dairy products and edible oils. Tests for joint statistical significance of the district effects, seasonal effects, and levels of education all indicate statistical significance.

The results in Table 2 confirm the importance of income in increasing household protein availability. The income elasticity of protein demand is 0.58, which suggests that a one percent increase in income would lead to a 0.58 percent increase in per adult equivalent protein acquisition.

The empirical results also support the hypothesis that diet quality, as measured by household protein demand, increases with education. For female education, both the primary and secondary education coefficients are positive and statistically significant at the 5% level. They suggest that having at least one woman with primary education in the household increases household protein demand by 3.06. Having at least one woman with a secondary education increased it by even more, 3.56 grams. The effect of education for men is also positive. This is not surprising as in Bangladesh it is typically the man who does most of the food shopping, and thus his education level can play an important role in deciding what to purchase. However, the effect of male education is not as strong as the effect of female education. The coefficient on men's primary education is about the same as it is for women's, being only slightly higher. However, men's secondary education does not have any additional effect on household protein availability.

Controlling for the other factors considered, many of which differ strongly for male and female headed households, female headed households are found to have lower protein availability by far. The estimated coefficient on the household headship dummy variable is a large -12.6 grams and significant at the 1% level. This could be explained by gender differences in knowledge and preferences or the ability to put the knowledge into practice. In fact, women's mobility is quite limited in Bangladesh due to social and cultural norms. Typically markets are under the domain of men in rural areas. As mentioned above, men go to the market and do most of the shopping. As most female headed households do not have an adult male member, limited mobility may be one of the reasons that prevent them from getting access to protein-rich foods. The other possible reason could be that many female household heads are casual laborers who often receive wages in the form of food in kind that constraints their ability to buy other types of foods.

The relationship between the number of household adult equivalents and protein availability is positive and significant. The estimated coefficient is 4.41, indicating that an increase in the number of adult equivalents of one increases protein demand 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 the economies of scale in consumption expenditure associated with larger households.

The coefficient of the price of rice is -1.27 and significant at the 5% level. The elasticity of protein availability with respect to rice price is relatively large (-0.23). Note that rice is the major source (54 percent) of protein in Bangladesh. The demand elasticities of protein with respect to prices of fish, eggs, and dairy products are also negative and significant suggesting that an increase in the price of any of these food items will worsen protein acquisition. 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 demand. Note that fish is the second largest source of protein

(13%) in Bangladesh, while meat and poultry rank as the third major source (6%) (BBS, 2000). Increases in the price of edible oil positively influences proteins availability while increases in the prices of fruits, pulses, meat, and vegetables do not have statistically significant effects.

The strong joint significance of the district fixed effects terms suggest that district-specific, household invariant effects play a role in the determination of household protein availability in Bangladesh. This could be due to cultural differences, differences in eating habits, or heterogeneity with respect to such factors as proximity to a water body or to a vegetable growing zone that influence household consumption behavior.

The joint significance of the month dummy variables suggests that seasonal variation associated with the food production cycle is also an influential factor in household protein availability in the country. 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.

(b) Dietary Diversity

The results for dietary diversity are presented in Table 3. Deviance and Pearson statistics (Cameron and Trivedi 1998) indicate that the Poisson regression model is appropriate for our data. The reported results in the table are thus estimates from the zero-truncated Poisson regression model. Since, the explanatory variable, total expenditure per capita (a proxy measure of income) is an endogenous variable, the Poisson model is estimated by a 2SLS procedure. As for the household protein availability analysis, two dummy variables created based on household asset possession of vehicles and kitchen utensils are used as identifying instruments for income. The relevance test indicates that they are jointly significant.

Statistically significant determinants of household demand for dietary diversity are: total expenditure per capita, female and male education, the number of adult equivalents in the household, whether the household is headed by a female, some of the age-sex composition variables and food prices.

The result for total expenditure per capita is as expected and consistent with earlier findings. This variable is statistically significant at the 1% level. In Bangladesh, as elsewhere, income is a key determinant of diet quality. Increased incomes lead to increased access to a diet of high quality foods.

The results show that female education has a strong effect on dietary diversity. Having at least one female in the household with a primary education results in a 4.8% increase in dietary diversity as measured here, while having a secondary educated female leads to a 5.8% increase, even higher. To get a sense of the strength of this latter effect, at the population mean of 9.9 food groups, having a woman with a secondary education would increase the dietary diversity score of a household to 10.5 food groups, which is quite near the maximum of 12. 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).

The coefficient on the male primary education variable suggests that having at least one male with a primary education results in a 1.7% increase in dietary diversity. A household with at least one male with a secondary education has 4.1% higher dietary diversity than one having no educated men. These results indicate that male education is also an important and positive factor in the determination of dietary diversity. However, the positive influence of male education is substantially weaker than that of female education.

The estimated coefficient on the female household headship variable is -0.0179; it is statistically significant at 5% level of significance. This suggests that, as for household protein availability, and for the same potential reasons discussed in the last section related to constraints on female mobility in Bangladesh, female headed households are at a disadvantage when it comes to dietary quality.

The number of adult equivalents in the household has a positive influence on dietary diversity. 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 consumption patterns of a child, adult and an elderly person are not necessarily the same. Second, larger households may be able to allocate more time to kitchen gardening and hence diversify their diet. Finally, economies of scale in consumption expenditure may be at play.

Demand for dietary diversity is sensitive to changes in the prices of rice, vegetables, fish, fruits, pulses, meat, dairy products, and edible oils but not with the price of eggs. The estimated coefficients for all price variables are positive except the price of edible oils. The estimated coefficients for all price variables are positive and small except the price of edible oils (coefficient is -0.0005). This could be due to the 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 in turn increases the dietary diversity.

We note that dietary diversity decreases with an increase in the price of edible oils. This result can be partly explained by the fact that edible oil is used for cooking other food items. Therefore, if the price of edible oil increases, households may not be able to reduce the consumption of edible oil (price elasticity of demand of edible oil is not very elastic) and instead will be compelled to reduce or eliminate the consumption some of the food items, and hence a decrease in dietary diversity.

The district fixed effects are significant, suggesting that, as for household protein availability, there are district-specific, household invariant effects. Also we observe from Table 3 that there is a significant seasonal variation in dietary diversity of households.

5. Discussion and Conclusions

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

This study has examined the determinants of household protein availability and diet diversity using household expenditure survey data collected from 7,440 Bangladeshi households in 2000. The empirical results suggest that crucial determinants of dietary quality in Bangladesh are: income, female and male education, gender of household head, the prices of rice, fish, eggs, dairy products and edible oils, and household size and demographic composition. A significant role is also found for seasonal variation associated with the agricultural cycle.

As expected, increased income and education are found to lead to improvements in dietary quality. While male education plays a positive role, its influence is not as strong as female education in improving household dietary quality. This result is consistent across the two measures of dietary quality. Controlling for the other factors considered, the results show that female headed households have lower dietary quality than do male headed households. On explanation for this finding is that women have lower mobility than men in the country, which makes it more difficult for female headed households to travel to markets and obtain a wide variety of foods that could improve the quality of their households' diets. These findings indicate that there is a significant gender dimension to the determination of dietary quality in Bangladesh, a country in which gender inequalities are particularly high (Smith and Byron 2005).

In summary, our results suggest that households likely to be the most vulnerable to problems of dietary quality are those with: low incomes, low education (especially those having low or no female education), and female heads.

(b) Limitations of the study

It is important to recognize some limitations of this analysis. First, as mentioned above, household expenditure survey data can suffer from a host of errors, from respondent bias to enumerator bias and data entry errors. Therefore, in order to minimize any influence of major errors, we subjected the raw data to a through cleaning. Careful attention was paid while deriving metric quantities (and determination of protein contents of food acquired). Nevertheless, we recognize that influence of such survey errors can never be completely accounted for.

Second, because of the limitation of the data available, total expenditure per capita was used as a proxy for income, which may limit interpretation. Moreover, as discussed in Section 3, income is an endogenous variable and thus in order to obtain unbiased and consistent parameter estimates, we instrumented income by constructing two instruments based on household asset possession of durable goods. Although this type of approach is becoming increasingly popular in the absence of detailed information on income (Filmer and Pritchett, 2001; Stifel, Sahn, and Younger, 1999), the method warrants further validation.

Third, following the existing literature, we examined dietary diversity by analyzing households' acquisitions of foods as contained within 12 food groups. However, it is not yet clear whether diversity between and within food groups is determined by the same socioeconomic, and location-specific heterogeneity.

Fourth, given that our analysis is based on household data for Bangladesh in 2000, we were unable to analyze household consumption behavior over time (which is possible with panel data). An analysis of household behavior over time would have allowed us to eliminate unobservable time-invariant household effects and address the issue of trends as well as inertia in consumption behavior (Thiele and Weiss, 2003).

A final limitation of the study is that have not explored the intra household differences in dietary quality, which would have allowed us to assess the extent of gender inequality.

(c) Policy implications

In spite of these limitations, the results presented here are robust across alternative specifications of dietary quality and corroborate some of the findings by earlier studies that analyzed data for different countries. Results highlight crucial roles of income and education in increasing access to sufficient and high quality food. They suggest the design and implementation of well targeted poverty reduction and education programs in order to enhance dietary quality. Promoting female education in particular could be a significant policy instrument for government and non-government organizations in addressing food and nutrition security in Bangladesh.

For decades the emphasis on food security implicitly has focused attention on energy consumption while diverting attention from protein and the entire range of micronutrients, both of which are essential for a balanced 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 nutritional deficiencies in Bangladesh, sound policies and programs are required that have long term scope. Policy makers have a tendency to choose policies that are short term in nature and often fail to effectively address 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 is unsustainable in the long run and has the potential to create dependency on the providers. Therefore, the governmental and non-governmental organizations need to adopt multi-pronged sustainable strategies to address poor dietary quality and its consequences.

The empirical results showed that the demand for dietary quality in Bangladesh has a seasonable pattern associated with the agricultural production cycle. Uncertainties of agricultural incomes are strong due to strong climatic variability associated with the monsoon rains. Crop diversification could be an important policy instrument to minimize such uncertainty. Additionally, it can lead to the production of nutrient rich crops and their increased supply in the market will, in turn, translate into affordable prices.

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, they 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.

Although it is not a direct conclusion from the analysis of this study, 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. Bouis et al. (1997) suggest that nutritional benefits may accrue to poor households through intensification of homestead production. Many rural households in Bangladesh are engaged in homestead gardening, which is the major source of vegetables for most poor households. Therefore, targeting homestead production, 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.

References

ACC/SCN (Administrative Committee on Coordination/Sub-Committee on Nutrition) (2000). *Fourth Report on the World Nutrition Situation: Nutrition Through out the Life Cycle*. Geneva: United Nations.

BBS (Bangladesh Bureau of Statistics) (2001). *Preliminary Report of the Household Income and Expenditure Survey – 2000, Dhaka: Bangladesh* Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh.

Behrman, J. and A. Deolalikar (1988). Health and Nutrition. Chapter 14 in *Handbook of Development Economics,* Vol. 1. Edited by H. Chenery and T.N. Srinivasan. Elsevier Science Publishers.

Behrman, J. and A. Deolalikar (1987). Will Developing Country Nutrition Improve with Income? A Case Study for Rural India, *The Journal of Political Economy* Vol. 95., No. 3, 492-507.

Behrman, J. and B. Wolfe (1984). More Evidence on Nutrition Demand: Income Seems Overrated and Women's Schooling Underemphasized. *Journal of Development Economics* 14: 105-128.

Block, S. (2003). Maternal Nutrition Knowledge and the Demand for Micronutrient-Rich Foods: Evidence from Indonesia. Tufts University, Waltham, MA.

Bound, J., D.A. Jaeger and R.M. Baker (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association* 90 (no. 430): 443-450.

Bouis, H. (2000). Development of modern varieties of rice: impacts on food security and poverty. Paper prepared for presentation at the International Rice Research Conference held at IRRI, Los Banos, Philippines, March 31-April 3.

Bouis, H. (1999). Demand for non-staple foods and the role of micronutrients in improving nutrition: an analysis for Cambodia, Laos, Myanmar and Vietnam. Paper presented at the Indochinese Symposium on Globalization, Hanoi, Vietnam.

Bouis H. and Hunt, J. (1999). Linking food and nutrition security: past lessons and future opportunities. *Asian Development Review*, 17(1-2): 168-213.

Bouis, H., and M. J. G. Novenario-Reese (1997) The determinants of demand for micronutrients: An analysis of rural households in Bangladesh. Food Consumption and Nutrition Division Discussion Paper No. 32. Washington D.C.: International Food Policy Research Institute.

Blumberg, Rae (1991), "Income under female versus male control," in Rae Blumberg (Ed.), *Gender Family and Economy: The Triple Overlap* (Newbury Park, CA: Sage Press), pp. 97-127.

Bruce, Judith (1989), "Homes divided," *World Development*, Vol. 17, No. 7, pp. 979-992.

Cameron, A. C. and Trivedi, P.K. (1998). Regression analysis of count data. Cambridge University Press, Cambridge CB2 2RU, UK.

Davidson, R., and J.G. Mackinnon (1993). *Estimation and inference in econometrics.* New York: Oxford University Press.

Deaton, Angus. (1997). The analysis of household surveys: A microeconomic approach to development policy. Baltimore: Published for the World Bank, Johns Hopkins University Press.

Deaton, A.S. & Irish, M., 1984 Statistical models for zero expenditure in household budgets. *Journal of Public Economics*, 23, 59-60.

Department for International Development (DFID) (1998). Support for University Fisheries Education and Research: Project Memorandum, Dhaka: Department for International Development, Aid Management Office.

Del Ninno, C., Dorosh, P., Smith, L. & Roy, D. (2001). The 1998 Floods in Bangladesh Disaster Impacts, Household Coping Strategies, and Response. Research Report 122, International Food Policy Research Institute, Washington D.C.

Drewnowski, A., S. Ahlstrom Henderson, A. Driscoll, and B. Rolls. (1997). The Dietary Variety Score: Assessing dietary quality in healthy young and older adults. *Journal of the American Dietetic Association* 97: 266-271.

Dwyer, Daisy and Judith Bruce (1988), “A home divided: Women and income in the Third World” (Stanford, CA: Stanford University Press).

FAO/WHO/UNU. (1985). Protein and Energy Requirements.

Falkinger, J., and Zweimueller, J. (1996). The cross country Engel curve for product diversification. *Structural Change and Economic Dynamics* 7, 79-97.

Filmer, D., and Pritchett, L. (2001), “Estimating wealth effects without expenditure data-or tears: An application to educational enrollments in States of India,” *Demography*, 38(1), 115-132.

Foster, P. (1992). The World Food Problem: tackling the causes of undernutrition in the Third World. Lynne Rienner Publishers, Boulder.

FSANZ (Food Standards Australia New Zealand). 2004. Explanatory notes for use with the on-line nutrition panel calculator (NPC). Supported by AUSNUT Special Edition(3) (Australian Food and Nutrient Database for Nutrition Labelling – Release 3). Commonwealth of Australia and Food Standards Australia New Zealand. http://www.foodstandards.gov.au/_srcfiles/Explanatory_notes_for_the_NPC_coldfusion_October_2004_final.pdf.

Gill, G.J., John, F., Edward, A., Cecilia, L., Tim, C., Saxena, N.C., & Rachel, S. (2003). Food Security and Millennium Development Goal on Hunger in Asia. Overseas Development Institute. 111 Westminister Bridge Road, London, UK.

Government of Bangladesh (GOB) (2000). Report of the Task Force on 'Comprehensive Food Security Policy for Bangladesh', Dhaka: Government of the People's Republic of Bangladesh.

Guyer, Jane (1980), "Household budgets and women's incomes," Working Paper #28 (Boston: Boston University African Studies Center)

Haddad, L., J. Hoddinott, and H. Alderman, (1997). Intra Household Resource Allocation in Developing Countries: Models, Methods, and Policy. International Food Policy Research Institute, Washington, DC.

Hatloy, A., L. E. Torheim, and A. Oshaug. (1998). Food variety a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *European Journal of Clinical Nutrition* 52 (12): 891-898.

HKI/IPHN. (2002). 'Anaemia is a Severe Public Health Problem in Pre-school Children and Pregnant Mothers in Rural Bangladesh', *Nutritional Surveillance Bulletin* 10, March, Dhaka: Helen Keller International and Institute of Public Health and Nutrition, accessed 01/10/03 at: http://www.hkiasiapacific.org/_downloads/NSP/20Bulletin/2010.pdf

IFPRI/BIDS/INFS/DATA/RDHN (1998). Commercial Vegetable and Polyculture Fish Production in Bangladesh: Their Impacts on Income, Household Resource Allocation, and Nutrition. Final Report. International Food Policy Research Institute, USA; Bangladesh Institute of Development Studies, Bangladesh; Institute of Nutrition & Food Science, Bangladesh; Data Analysis & Technical Assistance, Bangladesh; & Research Department of Human Nutrition, Denmark.

Keen, M. (1986). Zero expenditures and the estimation of Engel curves. *Journal of Applied Econometrics*, 1, 277-286.

Krebs-Smith, S., H. Smiciklas-Wright, H. Gutherie, and J. Krebs-Smith. (1987). The effects of variety in food choices on dietary quality. *Journal of the American Dietetic Association* 87: 897-903.

Lafrance, J. (1999). An econometric model of the demand for food and nutrition. CUDARE Working Paper Series No. 885. Department of Agricultural and Resource Economics and Policy, University of California at Berkeley.

Medindia.net: http://www.medindia.net/patients/Food%20Calories/index.asp

Neumann, C. and Harris, D. (1999). Contribution of Animal in Improving Diet Quality for Children in the Developing World. Prepared for the World Bank. Washington D.C.

Ogle, B. M., P. H. Hung, and H. T. Tuyet. (2001). Significance of wild vegetables in micronutrient intakes of women in Vietnam: An analysis of food variety. *Asia Pacific Journal of Clinical Nutrition* 10: 21-30.

Poleman, T. (1981). Quantifying the Nutrition Situation in Developing Countries. Food Res. Inst. Studies 18, No. 1: 1-58.

Pollack, S. L. (2001). Consumer demand for fruit and vegetables: the U.S. example. In: Changing structure of global food consumption and trade. Agriculture and Trade

Report. WRS-01-1 (Regmi, A., ed.), pp. 49-54. Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Quisumbing A., Brown L., Haddad L. and Meizen-Ruth D. (1998). The importance of gender issues for environmentally and socially sustainable rural development. In: Lutz E. (ed), Agriculture and the environment: Perspectives on sustainable rural development. The World Bank, Washington, DC, USA. pp. 186–202.

Regmi, A. (2001). Changing structure of global food consumption and trade. Market and Trade Economics Division. Economic Research Service, USDA, Agriculture and Trade Report. WRS-01-1. United States Department of Agriculture, Washington, DC.

Ruel, M., Minot, N. & Smith, L. (2004). Patterns and determinants of fruit and vegetable demand in developing countries: a multi-country comparison. Paper prepared for the Joint WHO/FAO Workshop on Fruit and Vegetables for Health. Kobe, Japan, September 1-3, 2004.

Ruel, M. (2002). Is Dietary Diversity as Indicator of Food Security or Dietary Quality? A review of measurement and research needs. *FCND Discussion Paper* No. 140. International Food Policy Research Institute, Washington D.C.

Ruel, M. (2001). Can Food-Based Strategies Help Reduce Vitamin A and Iron Deficiencies?- A review of recent evidence. International Food Policy Research Institute, Washington D.C.

Scrimshaw, H. (1999). Meeting world food needs for micronutrients. Chapter 8 in El Obeid, A., S.R. Johnson, H. Jensen and L. Smith (eds), Food Security: New Solutions for the 21st Century. Ames: Iowa State University Press.

Smith, L. (2004a). Food Insecurity in Sub-Saharan Africa: New Estimates from Household Expenditure Surveys. IFPRI Research Report No. 146. International Food Policy Research Institute, Washington D.C. (forthcoming).

Smith, L.C. (2004b). Understanding the causes of food insecurity in Sub-Saharan Africa: Do the determinants of diet quantity and quality differ? Mimeo. International Food Policy Research Institute, Washington D.C.

Smith, L. C. (2003). The use of household expenditure surveys for the assessment of food insecurity. In Methods for the measurement of food deprivation and undernutrition. Rome, Food and Agriculture Organization of the United Nations.

Smith, L.C. and Ali Subandoro. 2006. Measuring food security using household expenditure surveys. Report under review for inclusion in IFPRI's *Food Security in Practice* series. International Food Policy Research Institute, Washington, D.C.

Smith, Lisa C. and Elizabeth M. Byron (2005). "Is greater decisionmaking power of women associated with reduced gender discrimination in South Asia"? Food Consumption and Nutrition Division Discussion Paper No. 200. International Food Policy Research Institute, Washington, D.C.

Smith, Lisa C. and Lawrence J. Haddad (2000). *Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis*. IFPRI Research Report No. 111. Washington, D.C.: International Food Policy Research Institute.

Smith, Lisa C., Usha Ramakrishnan, Aida Ndiaye, Lawrence Haddad, and Reynaldo Martorell (2003). *The importance of women's status for child nutrition in developing countries.* IFPRI Research Report #131. International Food Policy Research Institute, Washington, D.C.

Stifel, D., Sahn, D., and Younger, S. (1999), "Inter-temporal welfare changes: Preliminary results for nine African countries," CFNPP Working paper 94, Cornell University, Ithaca, NY.

Thiele, S. & Weiss, C. (2003). Consumer demand for food diversity: evidence for Germany. *Food Policy*, 28 (2003) 99-115.

Theil, H. & Finke, R. (1983). The consumer's demand for diversity. *European Economic Review* 23, S395-S400.

USDA (United States Department of Agriculture) (2003). Composition of Foods, raw, processed, prepared. USDA Nutrient Database for Standard Reference Release 15. United States Department of Agriculture, Agricultural Research Service, Beltsville, Maryland, USA.

World Bank. (1981). World Development Report, Washington D.C.

Table 1. Descriptive statistics

	Mean	Standard deviation	Minimum	Maximum
Dependent Variables				
Daily protein acquired per adult equivalent (in grams)	71.00	19.29	2.63	183.63
Number of food groups (of 12)	9.93	1.65	3	12
Independent Variables				
Total expenditure per capita (in *Taka* per day)	28.14	32.07	3.26	743.31
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
Gender of household head (female=1)	0.06	0.28	0	1
Age of household head	45.72	13.29	12.00	99
Number of adult equivalents in the household	4.71	1.72	0.67	19.11
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 (Taka per kg)	22.42	15.21	1.50	200.00
Price of rice (Taka per kg)	12.59	2.56	5.50	40
Price of fish (Taka per kg)	55.51	20.14	11.43	172.92
Price of pulses (Taka per kg)	30.30	8.11	8.00	60.00
Price of eggs (Taka per kg)	53.69	7.69	36.36	85.71
Price of meat (Taka per kg)	74.73	13.60	18.00	200.00
Price of vegetables (Taka per kg)	8.29	2.38	2.39	24.95
Price of dairy products (Taka per kg)	30.46	46.53	8.74	360.00
Price of edible oils (Taka per kg)	49.19	14.15	26.67	461.54
Number of observations	7,413			

Note: Means are adjusted for survey sampling design.

Table 2. Household protein availability per adult equivalent: Two-stage least squares regression results

Independent variable	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	
Whether female headed household	-12.64	-3.01 ***	
Age of household head	0.07	1.16	
Number of household adult equivalents	4.41	3.2 ***	
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 **	
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***	
Women's education		3.57**	
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.
Notes: Robust standard errors are used in computing t-statistics. STATA does not report R-squared for the 2SLS model. Thus the R-squared from the equivalent OLS model is reported here.

Table 3. Dietary diversity (number of food groups): Zero-Truncated Poisson regression (2SLS) estimates.

Independent variables	Coefficient	z-statistic	
Total expenditure per capita (in Taka)	0.0019	5.62	***
Women's education: any primary	0.0479	10.32	***
Women's education: any secondary	0.0575	11.91	***
Men's education: any primary	0.0167	3.02	**
Men's education: any secondary	0.0406	3.96	***
Whether female headed household	-0.0179	-2.21	**
Age of household head	-0.0002	-1.18	
Number of household adult equivalents	0.0059	5.16	***
Percent females 16-30 (years)	-0.0003	-0.9	
Percent females 30+ (years)	-0.0006	-3.69	***
Percent males 0-16 (years)	-0.0002	-2.16	**
Percent males 16-30 (years)	-0.0001	-0.71	
Percent males 30+ (years)	-0.0003	-1.51	
Price of fruits (Taka per kg)	0.0009	5.43	***
Price of rice (Taka per kg)	0.0061	6.12	***
Price of fish (Taka per kg)	0.0004	2.3	**
Price of pulses (Taka per kg)	0.0019	5.07	***
Price of eggs (Taka per kg)	0.0007	0.83	
Price of meat (Taka per kg)	0.0004	2.75	**
Price of vegetables (Taka per kg)	0.0043	2.14	**
Price of dairy products (Taka per kg)	0.0003	4.22	***
Price of edible oils (Taka per kg)	-0.0005	-3.35	***
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:			
Instrument Relevance (χ^2 -test)		96.56	****
Multicollinearity: Highest VIF		7.82	
Multicollinearity: Mean VIF		2.16	
Deviance statistic (χ^2 -test)		1612.79	P-value=1.000
Pearson statistic (χ^2 -test)		1569.85	P-value=1.000
Number of districts		63	
Number of observations		7,413	

***Significant at the 1% level, **Significant at 5% level, & *Significant at the 10% level.
Note: Robust standard errors are used in computing t-statistics