Progress in Nutrition 2020; Vol. 22, N. 3: e2020021 DOI: 10.23751/pn.v22i3.8404

Role of Socioeconomic Factors to overcome Micronutrient Malnutrition in Pakistan: Application of Partial Proportional Odds Model

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Summary. The study determines the role of some important socioeconomic factors to overcome micronutrient malnutrition at household level in Pakistan using cross sectional data taken from national survey name as Household Integrated Income and consumption Survey (HIICS) 2015-16. Sample data shows that availability of five out of eleven micronutrients is less than the requirements of more than 70% households which reveals the worst situation of micronutrient malnutrition in Pakistan. The study concludes that household's income, maternal paid employment, agricultural employment, Benazir Income Support Program (BISP) and rural residential status are the important factors for improving micronutrient malnutrition in Pakistan. Varying estimates of income across the two cut-points induce that significant rise of overall households' income level on the basis of sustainable economic growth will be effective to overcome hidden hunger in Pakistan. Live stock ownership and cultivation of agricultural land seem to have the most effective role for improving micronutrient security. The most critical result is insignificance of educational dummies which implies that even educated parents are not aware of the importance of micronutrients. Adverse impact of paternal paid employment induces revision of salary structure and minimum wage level along with annual increase according to the prevailing rate of inflation in the economy. U type quadratic impacts of household size as well as head age, and the adverse impact of dependency ratio induce effective policies to control high birth rate in Pakistan. It may be concluded that sufficient financial resources by raising households' income level, growth of agricultural sector, women financial empowerment, effective family planning and continuation of BISP are the important recommended policy guidelines but creation of awareness about nutrition and balanced diet for a healthy family is the most important to overcome hidden hunger in Pakistan.

Keywords: Micronutrient malnutrition, Socioeconomic Factors, Gender Dimensions, Ordinal Logistic, Pakistan

Introduction

Malnutrition is often used to specifically refer to undernourishment rather than overnutrition, where undernourishment means that an individual is not getting enough calories and nutrients (1-2). Nutrients are of two types, i.e. macronutrients and micronutrients. All the known vitamins and important trace minerals are included in micronutrients. Sufficient micronutrients' consumption is imperative for human health. Micronutrient malnutrition grows when consumptions of bioavailable micronutrients are too small to fulfill requirements (3). Unlike energy-protein malnutrition, health impacts of micronutrient deficiency

are not always acutely visible and therefore, it is sometimes called as 'hidden hunger'. It has been found that 2 billion people, i.e. one-third of global population, are malnourished in one or more important micronutrients which is badly affecting health, knowledge ability and productivity (4). In general, micronutrient malnutrition affects health and mental development in young children more severely than old persons (5). It causes high mortality rates, particularly in children and women, poor pregnancy outcomes and reduced work output in adults (6). Different diseases like heart disease, diabetes, anemia, stroke, cancer, child growth retardation and low birth weight are due to deficiency of micronutrients (7). Various studies conclude that sufficient consumptions of micronutrients is imperative for psychomotor coordination, psychological functions, and skinny health in children (8-11). Overcoming micronutrient malnutrition is a precondition for ensuring rapid and appropriate development. A framework developed by UNICEF determines commercial, social and political factors as the underlying causes of malnutrition. Four main strategies, i.e. dietary improvement, food fortification, supplementation, and global public health and other disease control measures can be applied to overcome micronutrient deficiency. However, Food-based strategies, i.e. dietary improvement and food fortification are considered the most sustainable approaches to improve micronutrient status of the people by raising consumptions of micronutrients. Hence, dietary consumption of micronutrients by households is the most important factor that helps to overcome hidden hunger in developing countries.

There are a number of socioeconomic and demographic factors that determine food based micronutrients consumption at household level. Analyzing the impact of these factors may be helpful for effective policy making in developing countries. Literature contains a number of studies showing causes and consequences of micronutrient malnutrition. Sociodemographic factors and lifestyle determine micronutrient status of households (12). Limited access to a variety of food is declared as the main cause of micronutrient malnutrition in small income populations (13,14). Low household income, large family size and lack of nutritional awareness generally cause micronutrients' deficiency (15). Wealth has been found as an important factor for micronutrients rich food consumption in women of Dominican Republic (16). Positive association of micronutrient intake and socio-economic status of households is found in Europe (17). High level of maternal education is generally linked to lower rates of micronutrients' deficiency (18). Output of nutrition-rich crops and fruits helps to fulfill requirement of micronutrients at household level (19). Micronutrient-fortified beverage is helpful to overcome common diseases among poor residential school children (20). A review of 98 articles finds out age, gender, birth order, religion, ethnicity, educational and literacy level, working status, and marital status as the important factors affecting under nutrition in developing countries (21). Income, gender of the meal preparer, primary education and home gardens for vegetable and fruit production are found significant factors affecting micronutrient intakes in rural households of three East African countries, i.e. Rwanda, Uganda, and Tanzania (22). Herrador et al. (24) analyzes the distribution of micronutrients and anemia in school going children of Ethiopia on the basis of socio-demographic characteristics, health position and nutritional habits. Meshram *et al.* (25) finds out that public health problem, parental education level, HH wealth index, morbidity and inadequate dietary intake are the significant factors affecting micronutrient malnutrition in Pre-School Tribal Children of Maharashtra State, India. Review of the studies reveals that parental education, parental occupation, family size, income, socioeconomic status, resources, and some household characteristics are found important determinants of malnutrition and micronutrient deficiencies at household level. Moreover, understanding the underlying mechanisms influencing micronutrients malnutrition in a developing country, like Pakistan, is imperative for designing policies and intervention programs (26).

Pakistan is a developing country of 210 million people where micronutrient malnutrition is a serious health issue due to poverty, lack of governmental support, and inadequate awareness. No significant improvements regarding malnutrition have been seen over the past few decades (27). About one-third of babies are born with low birth weight, 42% of children are stunted and 14% are wasted under the age of five years in Pakistan (28). 10% of pregnant women and 13%

of preschool-aged children are deficient in vitamin A, more than 4 million infants are facing iodine deficiency disorders while 51% of preschool-aged children and 39% of pregnant women are affected by anemia due to iron deficiency (28). Diet cereals are known as main staple food which provides 62 % of the total required energy in Pakistan. Use of fruits, vegetables, fish and meat remain very low but milk use is very common in Pakistan compared to other Asian countries. Variation in the obtainability of these important diets is likely to be one of the factors responsible for micronutrient malnutrition disorders observed in Pakistan (29). A number of studies regarding analysis of micronutrients in Pakistan are found, i.e. (30-35). However, these studies contains descriptive analysis of micronutrients in children and women by covering only part of the country. None of the above studies uses national level households' data to analyze the factors affecting availability of micronutrients for consumption in Pakistan. Soofi *et al*. (30) contains cluster analysis by taking a sample from Sindh province of Pakistan and finds that the use of micronutrient powders is helping to overcome iron-deficiency anemia in young children. Sharieff et al. (31) evaluates significant positive impact of micronutrient consumptions on occurrence of diarrhea in young children of Karachi, Pakistan. Bhutta *et al*. (32) analyses impact of micronutrient malnutrition on pregnant women and their newly born babies in Karachi (Pakistan). Ejaz and latif (33) evaluates micronutrient deficiency in children aged 6 to 60 months admitted in a tertiary care hospital Karachi, Pakistan. Khan et al. (34) conducts an analysis of micronutrients deficiency in children randomly chosen from District Bannu of KPK, Pakistan. Tariq *et al*. (35) finds out age of mother at the time of birth, mother's intake of iron supplements during pregnancy, wealth, and awareness as the leading factors affecting under nutrition in Pakistan. To the best of authors' knowledge, no study has been conducted so far to determine the factors affecting micronutrient malnutrition at household level in Pakistan. The analysis may provide a detailed insight to policy makers for stunting growth in Pakistan. Hence, econometric analysis about the impact of some important socioeconomic and demographic factors on households' micronutrient consumption in diet is set as the major objective of this study. Moreover, most of the econometric studies related to households' nutritional security use binary logistic framework. However, ordered logistic regression framework provides detailed analysis as compared to binary logistic regression framework. Hence, another distinct feature of the study compared to the previous econometric studies on nutrition is the application of partial proportional odds model which provides a deep insight to analyze households' malnutrition in micronutrients by estimating varying cumulative estimates at three levels of households' micronutrients security. Rest of the study contains material and methodology, results and discussion, and policy implications.

Material and Methodology

Material and methodology consists of three subsections, i.e. specification of model, data and construction of variables, and methodology of analysis.

Theoretical framework and model's specification

Households' utility model in the framework of a Bergson-Samuelson social welfare function is generally considered as the standard theoretical framework for analyzing malnutrition at households' level. Households follow bargaining process to maximize utility of the members subject to nutrition provision functions and budget constraints (36). Following Smith (2004) (37) utility functions may be specified as

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

Where N_i $,i=1,\ldots.I$ are members' nutrition provision functions, F_k, k=1, …, K are individual foods consumed by each member, is non-food commodities and services consumed, and is leisure time. The utility function is followed by specifying nutrition provision functions as follows.

$N_i = N_i(M_i, X_{N0}, T_{\_N}, \Omega_N)$, $i = 1, \ldots, I$ (2) where $M_i = M_i(F_1,\ldots,F_k)$ (3).

Here represents nutrients demand by ith household, is non-food inputs, is time spent in nutrition. The framework allows to focus on micronutrients demand by households. Generally, people do not demand particular nutrients but they demand food. Household's demand of micronutrients depends on the availability of food items for consumptions. Hence, theoretical

framework for households micronutrients demand can be built within the framework of consumer demand and production theories. Following the pattern of Singh . (1986), Feleke . (2005) and Ogundari (2017) (38-40), general household level reduced form equation for micronutrient demand (assuming that households desire to maximize utility) is given as follows.

$M_i=M(\pi_{hf}, \pi_{mf}, \pi_{nf}, w, I_i^* (\pi_{hf}, w, L_i^o, K_i^o, N), F_i^o, F_h^o)$ (4).

Here M_i represents household level micronutrients consumption, π_{hf}, π_{mf}, and π_{nf} are price variables for home produced food, food purchased from market, and non-food items respectively. w I_i^*, L_i^o, K_i^o, and represent wages, income of household, fixed land, human and physical capital, and non-labor income respectively. F_i^O and F_h^O represent other factors that are not related to prices but they affect agricultural production, purchasing power and preferences (41).

The empirical model is specified under the framework of Eq. 4 while excluding price vector due to cross-sectional data. The reduced-form equation for micronutrient security is specified by including income, education, employment, ethnicity and culture, agricultural activities, social welfare program, and some household characteristics as explanatory variables. Income and wealth of a household determine access dimension of food based nutrients consumption. Household's human capital, such as paternal and maternal educational level create awareness of nutrition and balanced diet. Moreover, education is helpful for optimal food production and consumption (42,43). Paternal employment and maternal employment are considered important for generating resources but these may have adverse impact on micronutrient consumption by limiting time for purchasing and cocking food. Hence, we include a number of dummies representing different types of employment status. Households involve in agricultural activities to generate financial resources as well as to produce food items for consumption. Hence, two dummy variables representing households' involve in cultivation of agricultural land and the households who own livestock are considered in order to test role of agricultural sector in malnutrition. Demographic factors are expected to influence malnutrition due to differences in physical and economic access and lifestyle patterns. These effects are captured by introducing three dummy variables representing household's origin of four provinces and a dummy representing rural versus urban region in the model. Linear and quadratic terms of household size are taken to explore the role of high population growth at household level. Moreover, some households' characteristics are also included as control variables. Hence, empirical specification as reduced form of Eq. 4 is given as follows, i.e. eq. 5.

$M_i=f(Age_i^h, Age_i^{sh}, Size_i, Size_i^2, Res_i, Mar_i^H, P_i^{kp}, P_i^p, P_i^s, I_i, EM_i^c, EM_i^m, EM_i^f, E_i^{\wedge mp}, E_i^{mm}, E_i^{mh}, E_i^{\wedge pp}, E_i^{pm}, E_i^{ph}, E_i^{ch}, L_i, DR_i, W_i, C_i, BISP_i)$ (5).

Here represents status of household malnutrition in micronutrients.

$Res_i, Mar_i^H, P_i^{kp}, P_i^p, P_i^s, EM_i^c, EM_i^m, EM_i^f, E_i^{mp}, E_i^{mm}, E_i^{mh}, E_i^{pp}, E_i^{pm}, E_i^{ph}, E_i^{ch}, L_i, C_i$ and $BISP_i$ are dummy variables representing residential status, HH marital status, Khyber Pakhtunkhwa origin, Punjab origin, Sindh origin, couple paid employment, maternal paid employment, paternal paid employment, maternal primary, middle, and high education, paternal primary, middle, and high education, interaction term of paternal and maternal high education, livestock, own cultivation, and Benazir income support program respectively.

$Age_i^h, Age_i^{sh}, Size_i, Size_i^2$ I_i, DR_i, and W_i are the variables representing HH age, HH age square, household size, household size square, household total income ,dependency ratio and wealth index respectively. Detailed explanation of the variables is provided in Table 1.

Data and Construction of Variables

Data of all the variables are taken from HIICS 2015-16, i.e. a national level survey conducted and published by Pakistan Bureau of Statistics.1 HIICS 2015-16 contains the data which were collected in 2015-2016 by employing two-stage stratified sample design. In the first stage, 1668 sample blocks as primary sampling units were selected from urban and rural areas of all the four provinces of Pakistan. In the next stage, 16 households were randomly nominated from each sample block. Keeping in view the purposes of survey, the sample sizes in the four provinces were fixed at 1668 sample blocks (PSU's) covering 26688 households (SSU's). However, 24238 households were

1 Data of HIICS 2015-16 are available at http://www.pbs.gov.pk/content/microdata.

covered during enumeration from all the four provinces. It contains a section of food consumption by the surveyed households during the last 14 or 30 days. 172 food items are mentioned from different food groups like meat, fish, milk, cheese, eggs, fresh fruits, dry fruits, vegetables (fresh/chilled/frozen/dried), sugar, jam, honey, chocolate & confectionery, condiments and spices (whole and powder), non-alcoholic beverages, readymade food eaten out of home, public places, offices, bread & cereals, edible oils and fats. The data about consumption of food groups like bread, cereals, edibles oils, and fats etc. are taken for 30 days and the consumption of food groups as meat, fish, milk, cheese, eggs, dry fruits, fresh fruits, vegetables (fresh, chilled, frozen and dried), sugar, honey, condiments, spice, nonalcoholic beverages and ready-made foods at home and out of home etc. are taken for 14 days. Using Food consumption table for Pakistan given by (44), eleven micronutrients including calcium, iron, iodine, zinc, phosphorus, vitamin A, vitamin C, vitamin D, thiamine, riboflavin, and niacin are extracted from the given consumed food items during the specific days for each household. Calcium, iron, zinc, phosphorus, vitamin C, thiamine, riboflavin and niacin are computed in milligram (mg) while iodine is measured as parts per million (ppm) and vitamin A and D are taken as microgram (mcg) . In the first step, consumption of eleven micronutrients for each household from all the consumed food items during 14 and 30 days are extracted and are converted into 24 hours. In the second step, 24 hours micronutrients consumptions are divided by adult equivalent index value of the household. It gives eleven variables, i.e. per adult capita daily consumption of eleven micronutrients for each household. The calculation of adult equivalent index value as the 24 hours requirement of micronutrients of each

Table 1. Description of the variables

Notations	Variables label	Description	Notations	Variables label	Description
Y_i	Household Micro nutrients status	An ordinal variable with values as 0,1,2 for insecure status, partially insecure status and secure status in micronutrients respectively	EM_i^c	Couple paid employment	Couple paid employment = 1 & zero otherwise
Age_i^h	Age of household head	HH Age in years	EM_i^m	Maternal Paid employment	Mother Paid employment = 1 & zero otherwise
$Size_i$	Household size	Number of family members in the household	EM_i^f	Paternal paid employment	Father paid employment =1 & zero otherwise
$Size_i^2$	Household size square		E_i^{mp}	Maternal Primary education	Mother primary education =1 & zero otherwise
Res_i	Residential status	Rural=1 & zero otherwise	E_i^{mm}	Maternal middle education	Mother middle education =1 & zero otherwise
			E_i^{mh}	Maternal High education	Mother high education =1 & zero otherwise
Mar_i^H	HH Marital Status	HH married=1 & zero otherwise	E_i^{fp}	Paternal primary education	Paternal primary education =1 & zero otherwise
P_i^{kp}	KPK Origin	Household's origin as KPK=1 & zero otherwise	E_i^{fm}	Paternal middle education	Paternal middle education =1 & zero otherwise
P_i^p	Punjab origin	Punjab origin=1 & zero otherwise	E_i^{fh}	Paternal High education	Paternal high education =1 & zero otherwise
P_i^s	Sindh origin	Sindh origin=1 & zero otherwise	E_i^{ch}	Couple High education	Both mother and father high educated =1 & zero otherwise
I_i	Monthly income of Household	Total monthly income in rupees	DR_i	Dependency ratio	
L_i	Ownership of Livestock	Household's ownership of Livestock=1& zero otherwise	C_i	Households' cultivation of agricultural land	Household involve in cultivation=1 & zero otherwise
W_i	Wealth index	Wealth index of households	$BISP_i$	BISP received by Household	BISP received =1 & zero otherwise

household divided by the recommended daily value for adult per day of each micronutrient follow the procedure of adult per capita calorie availability presented by (45). Recommended daily value for adult per day given in Table 6 (Appendix) are taken from (44,53) . In the third step, Principle Component Analysis (PCA) method is applied to the eleven variables of micronutrients in order to construct micronutrients security index. To apply PCA, we make standardization of per adult capita daily consumption of the eleven micronutrients into the same unit. PCA is a technique which is used to decrease the dimensionality of a large number of variables in a dataset. It changes a set of associated variables with a set of uncorrelated "principal components" while minimizingdata loss (46). The first principal component score extracts maximum variation of the eleven variables and, hence, is taken to categorize micronutrient security status of each household on the basis of three quantiles, and see e.g. (47,48). The households lying within first quantile () are declared as insecure category of households w.r.t. micronutrients. The households which lie between first and third quantiles are declared as partially insecure category of households w.r.t. micronutrients. Those households which are lying above the third quantile are termed as secure category of households w.r.t. micronutrients. Hence, the dependent variable is an ordered categorical variable represented by 0, 1 and 2 for insecure, partially insecure and secure w.r.t. micronutrients respectively. Table 1 presents description of all the variables used by the study.

HIECS 2015-16 contains data of 24238 households but our sample size is 14948. Out of 24238 households, 14948 households are included for the final analysis because only these households have complete data of all the variables used by the study. Some limitations of the data are necessary to discuss here. The HIECS survey is not specifically collected with dietary issues in mind and bioavailability of micronutrients for each member of the household cannot be extracted from the data. The data provide us information about gross quantity of micronutrients available prior to cocking of food and prior to deteriorating effects of parasites or diseases. However, nutritional availability is the first connection in the chain of micronutrient deficiency and it lies at the heart of interventions like dietary education, food fortification and dietary supplementation.

The methodology of analysis

The specified model in eq. (5) can be written as general linear regression model, i.e.

$M=\beta Z+\mu$ (6).

Here M is an ordered variable representing three categories of micronutrient malnutrition of households, is the vector of explanatory variables, is the vector coefficient and is the random error term having logistic distribution. The dependent variable has three ordered categories which are defined by two threshold parameters and, hence, the standard ordered logit model may be used for modelling this type of phenomenon (49).

There is variety of ordinal models to analyze categorical response variable. Among these model, Cumulative Logit Modelling framework is considered most suitable due to its simplicity in interpretation. Cumulative Logit Models are of three types, i.e. Proportional Odds Model (POM), Non-Proportional Odds Model (NPOM) and Partial Proportional Odds Model (PPOM) (50-52). Parallel lines assumption decides one among the above mentioned three models. If parallel lines assumption holds, then proportional odds (PO) model can be estimated using cumulative probabilities as follows.

$$P(M \le j / Z) = P(\beta Z + \mu \le \gamma_j) = P(\mu \le \gamma_j - \beta Z) = F(\gamma_j - \beta Z) = \frac{\exp(\gamma_j - \beta Z)}{1+\exp(\gamma_j - \beta Z)} = P_j; j \in [1,2.....,J-1]$$

Cumulative logit model is derived from logit link function which is then transformed to linear form via calculating logarithms of odds ratios, i.e.

$$\ln\left[\frac{P_j}{1-P_j}\right] = \ln\left[\frac{\frac{\exp(\gamma_j - \beta Z)}{1+\exp(\gamma_j - \beta Z)}}{1-\frac{\exp(\gamma_j - \beta Z)}{1+\exp(\gamma_j - \beta Z)}}\right] = \gamma_j - \beta Z\,;\, j = 1,2,.....,J-1 \quad (7)$$

Brant test is applied to test parallel lines assumptions for overall model as well as for each parameter separately. When some of the parameters do not follow parallel lines assumption, then unconstrained partial proportion odds (PPO) model is estimated. Two types of coefficients are estimated in PPO model. One is the set of parameters that holds parallel lines as-

sumption while the other set doesn't hold parallel lines assumption. The following equation shows general form of unconstrained PPO model.

$$P(M \le j / Z) = P(\mu \le \gamma_j - \beta Z_1 - \alpha_j Z_2) = F(\gamma_j - \beta Z_1 - \alpha_j Z_2)$$

$$P(M \le j / Z) = F(\gamma_j - \beta Z_1 - \alpha_j Z_2) = \frac{\exp(\gamma_j - \beta Z_1 - \alpha_j Z_2)}{1 + \exp(\gamma_j - \beta Z_1 - \alpha_j Z_2)} = P_j; j \in [1,2.....,J-1] \quad (8)$$

The model can be transformed by calculating natural logarithm of the odds ratio. Here consists of those explanatory variables which fulfill parallel lines assumption and is the vector of those explanatory variables which do not hold parallel lines assumption. Maximum likelihood method is applied to estimate parameters of PO model as well as PPO model.

Results

Before regression analysis, it may be useful to conduct a descriptive analysis of the response variable. The response variable consists of eleven micronutrients and how much proportion of sampled households are secure w.r.t. each of the micronutrients will give us a bird eye view of the prevailing situation in the whole population. Hence, requirement of the households for each of the micronutrients is calculated while considering ages of the family members. Moreover, availability of each micronutrient at household level is extracted from food items. Then, the difference between availability of each of the micronutrient for consumption per day and requirement of each of the micronutrient per day is computed to decide status of each household. Proportions of secure and insecure households' w.r.t. each of the eleven micronutrients are computed and are shown as Figure 1 which reveals that more than 70% of the households are insecure in five micronutrients.

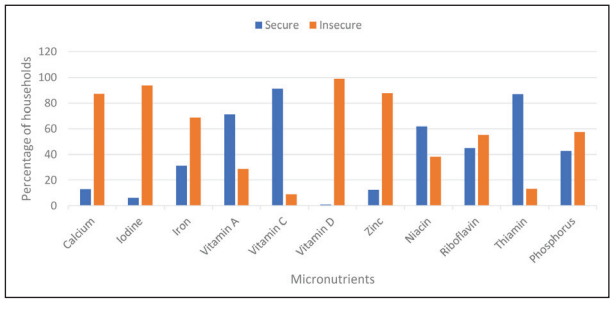

Figure 1. Secure and Insecure Percentages of Households using micronutrients

There are only four types out of eleven micronutrients where proportions of secure households are larger than the proportions of insecure households. It reveals the worst conditions of hidden hunger in Pakistan. It may be the important reason of serious health issues which needs to make improvements by devising effective and focused policy steps in Pakistan.

The specified model as eq. 5 is estimated assuming proportional odds model. Maximum likelihood method is employed to estimate the model and the results are given in Table 2. To test parallel lines assumption, Brant test is applied for full model as well as for each explanatory variable and the results are shown in Table 2. Brant test statistic provides evidence that parallel lines assumption is violated for full model. Results of separate Brant test for each predictor show that some variables violate the assumption while some other variables fulfill the assumption and hence, unconstrained partial proportional odds (PPO) model is to be estimated. Residential status, household size and its quadratic term, income, Benazir Income Support Program and interaction term of high education violate parallel line assumption which indicates that the impact of these variables vary across the two cut-points of the response variable. Coefficients' estimates and odds ratio of PPO model are given in Table 3 while marginal effects of PPO model are presented in Table 4. Validity of the unconstrained PPO model as compared to the proportional odds model is tested on the basis of some diagnostic tests given in Table 5. Estimates of AIC, BIC and chi square deviance tests are lower for PPO model compared to PO model. Estimates of R2 and pseudo R2 are larger for PPO model than PO model. Hence, unconstrained PPO model is selected as the appropriate model to analyze the phenomenon under consideration.

Estimates of income are significant with positive sign and odds ratios are larger than one across the two cut-points. It implies that rising income makes improvement in household's micronutrient malnutrition. Marginal effects of income are negative for insecure and partially insecure categories while it is positive for secure category of micronutrients. It means that keeping effect of all other regressors as constant,

Table 2. Estimation results of PO model and Brant test

Variables	Estimates (S.E) (P Value)	OR for Y (S.E) (P Value)	Brant χ^2 test (P Value)	Variables	Estimates (S.E) (P Value)	OR for Y (S.E) (P Value)	Brant χ^2 test (P Value)
Age of household head	-0.2161 (.0078) (0.006)	0.9876 (.0076) (0.006)	0.01 (0.937)	Maternal primary education	-.10098 (.04427) (0.023)	.90394 (.04002) (0.023)	3.04 (0.081)
Age square of household head	.00022 (.00008) (0.007)	1.0002 (.00008) (0.007)	0.03 (0.872)	Maternal middle education	-.05967 (.0497) (0.230)	.94207 (.04682) (0.230)	0.28 (0.600)
Household size	-.17382 (.01870) (0.000)	.84044 (.015) (0.000)	14.64 (0.000)	Maternal high education	-.18491 (.1475) (0.210)	.8311 (.1226) (0.210)	0.77 (0.379)
Household size square	0053 (.0008) (0.000)	1.00536 (.0008) (0.000)	9.65 (0.002)	Paternal primary education	.0515464 (.064) (0.421)	1.0528 (.06738) (0.421)	0.20 (0.656)
Dependency ratio	-1.3404 (.086) (0.000)	.26171 (.0225) (0.000)	1.79 (0.181)	Paternal middle education	.06424 (.0650) (0.324)	1.066 (.0693) (0.324)	0.89 (0.347)
HH Marital Status	-.01344 (.0651) (0.839)	.9866 (.0651) (0.839)	1.64 (0.200)	Paternal high education	.0328 (.11422) (0.774)	1.033 (.118) (0.774)	0.47 (0.492)
KPK province	.88201 (.06647) (0.000)	2.415 (.1605) (0.000)	0.72 (0.396)	Couple high education	.3559 (.3347) (0.288)	1.4274 (0.5172) (0.288)	4.99 (0.026)
Punjab province	1.0333 (.0619) (0.000)	2.810 (.17418) (0.000)	29.43 (0.000)	Own cultivation	1.6562 (.0818) (0.000)	5.2397 (.4291) (0.000)	2.98 (0.084)
Sindh province	-.06643 (.0646) (0.000)	.9357 (.0604) (0.000)	0.70 (0.402)	Own Livestock	.79374 (.2158) (0.000)	2.211 (0.4774) (0.00)	0.40 (0.527)
Monthly income of Household	.19271 (.06562) (0.003)	1.2125 (.0795) (0.003)	6.07 (0.014)	Residential status	1.1123 (.04257) (0.000)	3.0414 (.12948) (0.000)	22.29 (0.000)
Couple paid employment	-.09108 .1098 (0.407)	.91294 (.10027) (0.407)	0.96 (0.327)	Wealth index	.03072 (.0123) (0.013)	1.031 (0.0122) (0.013)	2.68 (0.101)
Maternal paid employment	.25468 (.0890) (0.003)	1.290 (0.1149) (0.003)	0.63 (0.427)	Benazir income support program	.2433 (.07834) (.002)	1.2755 (.09993) (0.002)	6.42 (0.011)
Paternal paid employment	-.2636 (.0371) (0.000)	.76825 (.0285) (0.000))	0.08 (0.782)	Constant Model	-.916235 (.3498) (0.009)	.40002 (.1399) (0.009)	249.10 (0.000)

1% increase in income decreases the probability of a household to be lying in insecure and partially insecure categories of micronutrients and increases the probability of such a household to be lying in micronutrients secure category. However, odds ratio as well as marginal effects show that the impact of rising income is strong for partial category compared to lowest insecure category of micronutrients.

Coefficients' estimates and odds ratios of paternal paid employment show negative impact on households' micronutrients status. It implies that a household with paternal paid employment is more likely to lie in micronutrient insecure category than the households where fathers are not paid employees. Estimates of maternal paid employment indicates significant positive effect on micronutrients status at household

Table 3. Estimation Results of Unconstrained PPO model

Variables	Estimates for Y=0 (S.E) (P Value)	OR for Y=0 (S.E) (P Value)	Estimates for Y=1 (S.E) (P Value)	OR for Y=1 (S.E) (P Value)
Age of household head	-0.0238 (.0090) (0.009)	.97644 (.00888) (0.009)	-0.0209 (.0093) (0.026)	.97931 (.00918) (0.026)
Age square of household head	.00023 (.00009) (0.014)	1.00023 (.000095) (0.014)	.00023 (.00009) (0.018)	1.00023 (.000098) (0.018)
Household size	-.1246 (.0209) (0.000)	.8828 (.0185) (0.000)	-.2372 (.0225) (0.000)	.7888 (.0177) (0.000)
Household size square	0.00327 (.00097) (0.001)	1.0032 (.00097) (0.001)	0.007985 (.00106) (0.000)	1.0080 (.00107) (0.000)
Dependency ratio	-1.2302 (.09864) (0.000)	0.2922 (.0288) (0.000)	-1.4196 (.1048) (0.000)	0.2417 (.0253) (0.000)
HH Marital Status	.05411 (.0764) (0.479)	1.055 (0.0807) (0.479)	-0.1001 (.0779) (0.199)	0.9047 (.0705) (0.199)
KPK province	.9946 (.07344) (0.000)	2.7036 (.19855) (0.000)	.8969 (.0981) (0.000)	2.452 (.2406) (0.000)
Punjab province	0.8599 (0.06637) (0.000)	2.363 (.1568) (0.000)	0.8969 (0.0981) (0.000)	3.7567 (0.3564) (0.000)
Sindh province	-0.0467 (0.0685) (0.495)	0.9543 (.06545) (0.000)	-0.0138 (.09826) (0.888)	0.9862 (.0969) (0.888)
Monthly income of Household	.0832 (0.0764) (0.0276)	1.0867 (0.0830) (0.0276)	0.3353 (.0794) (0.000)	1.3984 (.11103) (0.000)
Couple paid employment	-0.1649 (0.1281) (0.198)	0.8479 (.1087) (0.199)	-0.0345 (0.1334) (0.795)	0.966 (.1288) (0.795)
Maternal paid employment	.3033 (.10600) (0.004)	1.3543 (.1435) (0.004)	.2253 (.1061) (0.034)	1.2528 (.1329) (0.034)
Paternal paid employment	-0.276 (.0427) (0.000)	0.7587 (.0324) (0.000)	-0.2499 (.0456) (0.000)	0.7788 (.0355) (0.000)
Maternal primary education	-0.0531 (.0506) (0.294)	0.9481 (.048) (0.294)	-0.1581 (0.0560) (0.229)	0.8537 (.0478) (0.005)
Maternal middle education	0.0284 (.05722) (0.619)	0.9719 (.0556) (0.619)	-0.0734 (.06108) (0.229)	0.9291 (.0567) (0.229)
Maternal high education	-0.09828 (.1676) (0.558)	.9063 (.1519) (0.558)	-0.2727 (.1881) (0.147)	0.7612 (.1432) (0.147)
Paternal primary education	0.0436 (.0761) (0.566)	1.044 (.07949) (0.566)	0.0661 (.0775) (0.394)	1.0683 (.0828) (0.394)
Paternal middle education	0.0343 (.0769) (0.656)	1.0348 (0.0796) (0.656)	0.1113 (.07919) (0.160)	1.1178 (0.0885) (0.160)
Paternal high education	0.0062 (.13071) (0.962)	1.00622 (0.1315) (0.962)	.0987 (.1391) (0.477)	1.1038 (.1535) (0.477)
Couple high education	0.0039 (0.3673) (0.991)	1.0039 (.3688) (0.01)	0.7520 (.38055) (0.048)	2.1213 (.8073) (0.048)
Own cultivation	1.5129 (.1273) (0.000)	4.5402 (.5782) (0.000)	1.751 (.0869) (0.000)	5.7605 (.5006) (0.000)
Own Livestock	2.5271 (.81544) (0.004)	2.5271 (0.81544) (0.004)	0.32267 (.238) (0.000)	2.1353 (0.4967) (0.001
Residential status	.9867 (.0526) (0.000)	2.6825 (.1412) (0.000)	1.246 (0.0494) (0.000)	3.4779 (.1719) (0.000)
Wealth index	0.01792 (.0125) (0.000)	1.0181 (0.0146) (0.213)	0.04049 (.01386) (0.003)	1.0413 (.0144) (0.003)
Benazir income support program	0.3789 (.09821) (0.000)	1.022 (.1289) (0.001)	0.1574 (.09811) (0.108)	1.433 (.1413) (0.000)
Constant	1.0962 (.4116) (0.008)	2.9929 (1.232) (0.008)	-1.5314 (0.4254) (0.000)	0.21622 (.09199) (0.000)

level. Results indicate that households with maternal paid employment are more likely to be micronutrient secure than the households with unemployed mothers or housewives. Odds ratios show that a household with maternal paid employment compared to a household without maternal paid employment is 1.25 times likely to lie in secure category than insecure categories of micronutrients. Marginal effects show that probability of households with maternal paid employment to be lying in micronutrient insecure category decreases and probability of a household with maternal paid employment increases to be lying in higher category of micronutrients status. Couple paid employment are insignificant for micronutrient status of households.

Table 4. Results of Marginal effects for PPO model

Variables	M. E. (Y=0) (S.E) (P Value)	M.E. (Y=1) (S.E) (P Value)	M.E. (Y=2) (S.E) (P Value)	Variables	M. E. (Y=0) (S.E) (P Value)	M.E. (Y=1) (S.E) (P Value)	M.E. (Y=2) (S.E) (P Value)
Age of household head	-.005262 (.0020) (0.009)	-.00112 (.00205) (0.583)	-0.00413 (.0018) (0.026)	Paternal paid employment	0.06093 (.0094) (0.000)	-.0115 (.0098) (0.245)	-.04943 (.009) (0.000)
Age square of household head	-.00005 (.000021) (0.014)	-.000005 (.000021) (0.797)	.000046 (.00002) (0.017)	Maternal primary education	0.01174 (.01117) (0.293)	.0195 (.01212) (0.107)	-0.0312 (.0112) (0.005)
Household size	.0275 (.00462) (0.000)	0.0194 (.00462) (0.000)	-.0469 (.00445) (0.000)	Maternal middle education	0062 (.0126) (0.619)	0.0082 (.0132) (0.533)	-0.0145 (.0121) (0.229)
Household size square	-0.00072 (.00021) (0.001)	-0.00085 (.00020) (0.000)	0.00157 (.00021) (0.000)	Maternal high education	0.0216 (.037) (0.558)	.0322 (.0403) (0.424)	-0.053 (.037) (0.147)
Dependency ratio	0.2715 (.02172) (0.000)	.009239 (.02254) (0.682)	-0.2808 (.02068) (0.000)	Paternal primary education	-.0096 (.0168) (0.566)	-.0034 (.01749) (0.844)	0.0131 (.0153) (0.394)
HH Marital Status	0.01194 (.01688) (0.479)	0.0317 (.0168) (0.059)	-0.0198 (.0154) (0.199)	Paternal middle education	-0.0075 (.0169) (0.656)	-.0144 (.0177) (0.415)	.02202 (.01566) (0.160)
KPK province	-0.2195 (0.0162) (0.000)	0.04214 (0.0201) (0.036)	0.1774 (.01925) (0.000)	Paternal high education	-.00136 (.0288) (0.962)	-.01817 (.0297) (0.542)	.0195 (.0275) (0.477)
Punjab province	-0.1898 (0.0146) (0.000)	-0.0719 (0.01823) (0.000)	0.2618 (.01sss79) (0.000)	Couple high education	-.0008 (.0812) (0.991)	-0.1478 (.0731) (0.043)	0.1487 (.0752) (0.048)
Sindh province	0.1032 (0.0151) (0.495)	-.00758 (0.0195) (0.698)	-0.0027 (0.0195) (0.888)	Own cultivation	-.334 (.0275) (0.000)	-.0123 (.025) (0.621)	.3463 (.0175) (0.000)
Monthly income of Household	-.01837 (.0168) (0.276)	-0.0479 (.0174) (0.006)	.06633 (.0156) (0.000)	Wealth index	-.2046 (.0711) (0.004)	.0545 (.0661) (0.410)	0.1500 (.0460) (0.001)
Wealth index	-.0039 (.0031) (0.213)	-.00452 (.0029) (0.164)	.0080 (.0027) (0.004)	Benazir income support program	-.0836 (.0216) (0.000)	0.0524 (.0235) (0.026)	.0311 (.0194) (0.108)
Maternal paid employment	-.0669 (.0234) (0.004)	.0223 (.0238) (0.348)	.0445 (.0209) (0.034)	Residential status	-0.2178 (0.0115) (0.000)	-0.0287 (0.0115) (0.013)	0.246 (0.0097) (0.000)
Couple paid employment	0.03641 (0.0282) (0.198)	-0.0295 (0.0292) (0.313)	-0.0068 (.0263) (0.795)				

The most amazing results are that all estimates of paternal education as well as maternal education are insignificant. It implies that education is not plying effective role to overcome micronutrient malnutrition at household level in Pakistan. However, the interaction term representing high educated couples show significant but varying impact across the two cut points. Its estimate is insignificant for insecure category but the estimate of partial insecure category is significant with positive sign. It implies that households with high educated couples are more likely to be micronutrient secure than the other households. Odds ratio indicates that a household with high educated couple compared to other households is 2.12 times more likely to lie in secure category than insecure or partial insecure categories. Marginal effects show that probability of a

Table 5. Results of Diagnostic Tests

Test	PO Model	PPO Model
Pseudo R2	0.1121	0.1202
Wald chi-square test		p-value = 0.0000
Thresholds		
1. Cut-point		1. p-value = 0.000
2. Cut-point		2. p-value = 0.000
Log-likelihood of		
1. Model	-14554.928	-14421.120
2. Intercept only	-16392.030	-16392.030
Chi-square Deviance	29109.857	28842.241
AIC	29163.857	28946.241
BIC	29369.390	29342.082
McFadden adj. R2	0.110	0.117

household with high educated couple to be lying in insecure category and partial insecure category decreases while probability of such a household to be lying in micronutrient secure category increases.

Agricultural activities are considered as a major source of income especially in rural areas of Pakistan. Positive and significant estimates of household's cultivation of agricultural land and ownership of livestock indicate effective role of agricultural sector to overcome hidden hunger in Pakistan. Odds ratios show that a households owning livestock compared to the other households are twice likely to lie in micronutrients' secure category than lower categories of micronutrients insecure. Marginal effects indicate that the estimated probability of a household owning livestock to be lying in insecure category decreases by 0.204 points and the probability of such a household to be lying in micronutrients' secure category increases by 0.15 points. Ownership of livestock helps households to overcome micronutrient malnutrition as it is not only a direct source of getting micronutrients but its indirect effects come through rising income. Odds ratios of household's cultivation of agricultural land compared to the other households is five times more likely to lie in secure category than insecure categories. Negative marginal effects for insecure and partially insecure categories show a significant decrease in the probability of a household involve in cultivation of agricultural land to be lying in the two categories of micronutrient malnutrition. Among the all determinants, marginal effects of the dummy variables representing household's cultivation of agricultural land and livestock ownership are largest in size for lowest and high categories of the response variable. Coefficients estimates of BISP are positive and significant and marginal effects are significant and negative for only lowest category of micronutrient insecurity. Wealth index is significant only for the households who are partially secure in micronutrients. Marginal effects indicate that the estimated probability of a wealthy household to be lying in secure category increases by 0.008 points. Marginal effects of wealth index are insignificant for two lower categories of the response variable.

Estimates of dependency ratio are significant with negative sign and odds ratios are less than one. It implies that a household is more likely to be malnourished when the dependency ratio increases. Negative marginal effect of dependency ratio shows a decline in the estimated probabilities of households to be lying in micronutrients secure category. Estimates of household size and its square term show U type quadratic effect of household size on micronutrients security. Negative impact of household size indicates that a household is likely to be insecure w.r.t. micronutrients as household size increases. However, positive estimates of its square term indicates quadratic impact on households' micronutrients status.

Coefficients' estimates, odds ratios and marginal effects of demographic and cultural dummies representing provinces i.e. Punjab, Khyber Pakhtunkhwa and Sindh while taking Baluchistan as the base category reveal that households residing in Punjab and KPK are more likely to be secure in micronutrients than the households belonging to Baluchistan. However, coefficient estimates of Sind province are insignificant which implies that there is no significant difference between households of Sindh and Baluchistan in micronutrient status. Coefficient estimates of residential status as urban versus rural are significant and positive which indicate that rural households compared to urban households are more likely to be secure in micronutrients. Odds ratios show that a rural household compared to an urban household is 2.68 times more likely to lie in higher categories of micro nutritional security than the lowest category and 3.47 times more likely to lie in highest category of micro nutritional security than insecure or partially insecure

categories respectively. Marginal effects show that the probability of rural households decreases in two lower categories and increases in highest category of micronutrients status. On average, rural households compared to urban households are 21.8 percentage points less likely to be insecure in micronutrients and 24.6 percentage points more likely to be secure in micronutrients. HH marital status is insignificant while HH age is showing quadratic impact on micro nutritional status of households. Negative impact of HH age and positive impact of HH age square link with the impact of dependency ratio.

Discussion

Most of the households lying in lowest category needs to improve energy intake and hence, initial rise of income are more likely to spend on energy intake rather than intake of micronutrients. The results of income match to the literature of nutrition which shows that rising income of household improves living standard, makes better purchasing power of food containing nutrients and makes easy access to markets (13, 14, 15, 22). It induces that policy steps to raise income of low as well as middle class households will be the most effective tool to overcome hidden hunger by making improvement in micronutrient consumption at household level.

Paternal paid employment and maternal paid employment are considered major sources of current income for households. Most of the paid employees are low paid workers or government employees in Pakistan and, therefore, they have limited financial resources to fulfil energy related dietary needs of their families. Limited financial resources of paternal paid employees makes them unable to purchase food items containing micronutrients. On the other hand, the bench mark category includes the households where fathers are not paid employees but they may be business men, self-employed, agriculturists and unemployed. However, unemployed fathers are very rare, i.e. the case of disease person where he is unable to do work while the other categories of paternal employment are usually earning more than the paid employees. Hence, the adverse impact of paternal paid employment is justified due to limited financial resources. The women financial empowerment makes significant positive contribution to improve micronutrient malnutrition in Pakistan. In spite of the fact that couple employment generate financial resources but it may limit time to manage proper diet for the family. The insignificant estimates of couple employment support the view that working couple are not spending their resources for managing proper diet.

The education without awareness of nutrition does not affect eating pattern (15). In the case of Pakistan, knowledge related to nutrition and health practices is not part of syllabus at school or college level and therefore, most of the educated people are not aware about the concepts related to balanced food and nutrition, the food items containing micronutrients and serious consequences of malnutrition. Generally, households with high educated couples are financially well off and it is their financial resources rather than educational effect that causes to improve their nutritional status. That's why, estimates of the interaction term are insignificant for lowest category of micronutrients because households with high educated couples lie in middle or high income groups. Moreover, insignificant estimates of all other education dummies also support the view that education is not performing well to overcome hidden hunger in Pakistan.

The agricultural activities are playing vital role for improving micronutrients malnutrition at household level in Pakistan. It is because agricultural employment provides food items containing micronutrients. Moreover, income earned from agricultural activities improves access dimension of nutrition security. Hence, growth of agricultural sector may be considered as a vital factor to overcome hidden hunger in Pakistan. The donations from BISP are playing effective role for improving micronutrients status of poor households at lowest level and the results of wealth index are in line with (16).

When the number of persons cross a certain limit and then most of the family members including women and children start to work. It raises income and reduces dependency ratio which causes to improve micronutrient status of the household. The two provinces, i.e. Sind and Baluchistan are facing worst conditions of hidden hunger. It is because the nutritional secu-

rity is highly connected with agricultural employment and strong significance of cultivation of agricultural land and ownership of livestock helps to support the results in favor of rural households. The dependency ratio increases during initial increase of HH age but dependency ratio falls at the later stages of HH age when children starts to work.

Conclusions and policy implications

This study evaluates the impact of some important socioeconomic and demographic factors on micronutrient malnutrition in Pakistan using cross sectional data for 14948 households taken from HIICS 2015-16, i.e. a national level survey. Eleven important micronutrients are considered, i.e. calcium, iodine, iron, vitamin A, vitamin C vitamin D, zinc, Niacin, riboflavin, thiamin and phosphorus. Micronutrient are extracted from the reported food items consumed by the households in the data and then an index is constructed by employing principal component analysis technique. On the basis of the index, households are categorized into three categories, i.e. insecure, partially insecure and secure and hence, partial proportional odds model is employed to estimate varying cumulative impact of the determinants at three levels of micronutrient malnutrition. Literature reveals that Pakistan is facing severe micronutrient malnutrition. Sample data shows that the percentages of households who do not fulfill requirement of calcium, iodine, iron, vitamin A, vitamin C vitamin D, zinc, Niacin, riboflavin, thiamin and phosphorus are 87.1%, 93.7%, 68.8%, 28.8%, 8.9%, 99%, 87.6%, 38.3, 55.1%, 13.2 and 57.5% respectively. These statistics reveals worst situation of micronutrient malnutrition in Pakistan. Hence, determination of the important factors affecting availability of micronutrients for consumption at household level may be helpful for devising policies to improve micronutrient malnutrition in Pakistan. Important conclusions and policy implications are as follows.

The analysis shows that rising household's income is helpful to improve micronutrient malnutrition. Varying estimates of income indicate that estimates of partial insecure category are larger than insecure category because initial rise of income is spent to fulfil energy requirements rather than micronutrients' requirements. It implies that significant increase of households' income level will make economic access easy which may improve micronutrient malnutrition in Pakistan. It induces that policy steps to raise overall households' income level on the basis of higher economic growth rate may be the most effective tool to overcome hidden hunger. Significant and positive estimate of wealth index shows that sufficient financial resources induce people to spend on micronutrients requirement. Positive impact of BISP is observed at the lowest category of malnourished households which implies that the social welfare program is performing well to improve health status of poor section of the society in Pakistan. Employment is considered as an important source of current income at household level. Maternal paid employment is playing significant positive role for improving micronutrient malnourishment because these employments generate extra financial resources which are spent for dietary needs of the families. However, insignificant estimate of couple employment shows time constraints and lack of awareness about balanced diet. Hence, creation of opportunities and appreciation for women employment along with awareness of balanced diet may be an effective tool to overcome micronutrient malnutrition in Pakistan. However, adverse impact of paternal paid employment implies that households with paternal paid employment are likely to be malnourished in micronutrients due to limited financial resources. It is because most of the paid employees in Pakistan are getting low salaries in public and private sector and their salary increase does not match to inflation which makes them unable to make economic access to the food items containing micronutrients. Revision of minimum wage rate and overall salary structure along with annual increase according to the prevailing inflation is recommended so that paid employees would have reasonable financial resources to fulfil balance dietary requirements of their families. A special allowance for micronutrients consumption in salary may also be helpful to improve prevailing worst micronutrient malnutrition. Agricultural employment, i.e. households' livestock ownership and households' cultivation of agricultural land, seem to play the most effective role in improving micronutrient malnutrition at household level. It is because agricultural activities

directly provides food items to the families. Moreover, agricultural output raises financial resources of the households and it makes their economic access easy to food items containing micronutrients. That's why, results of regional dummy shows that rural households compared to urban households are enjoying better nutritional status because most of the rural households are linked up with agricultural sector. Hence, development of agricultural sector is imperative to tackle the problem of hidden hunger in Pakistan.

Insignificance of maternal and paternal education to improve nutrition is the most critical result of the estimated model. It is because nutrition related topics are not part of syllabus in education system of Pakistan and even educated people are not aware of the importance of nutrition. Hence, it is strongly recommended that the topics of food and nutrition security along with its all health related impacts must be included as part of syllabus at primary and secondary education levels in order to make awareness of educated parents as well as children. Negative impact of dependency ratio, U type quadratic impact of household size and U type quadratic impact of HH age implies that high population growth rate is badly affecting households' nutritional status which ultimately causes serious health issues particularly in women and children. Hence, effective family planning strategies and birth control programs must be implemented in order to improve micronutrient malnutrition. Results of geographical and cultural dummies show that Baluchistan and Sind provinces compared to the other two provinces are facing worst condition of micronutrient malnutrition. It induces that these areas need to focus by effective policies to overcome malnutrition e.g. infrastructure development, policies for growth of agricultural activities, allotment of major share of BISP and introduction of other social welfare schemes.

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Appendix

Table 6. Daily requirement of micronutrients for adult

Micronutrients	Recommended daily values for adult per day
Calcium	1000mg
Iron	20mg
Iodine	150mg
Zinc	15mg
Phosphorus	700mg
Vitamin C	45mg
Vitamin D	2.5ug
Vitamin A	600ug
Thiamin	1.15mg
Riboflavin	1.2mg
Niacin	15mg

Sources: (Khan et al 2001)and (FAO and WHO, 2005)