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Does A Wife's Bargaining Power Provide More Micronutrients to Females

Evidence from Rural Bangladesh

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Abstract

Using calories in a unitary framework, previous literature has claimed lack of gender inequality in intrahousehold food distribution. This paper finds that while there is lack of gender disparity in the calorie adequacy ratio, the disparity is prominent among children, adolescents, and adults for a number of critical nutrients. Pregnant and lactating women also receive much less of most of these nutrients compared with their requirements. A wife's bargaining power (proxied by assets at marriage), as opposed to her husband's, significantly and positively affects the nutrient allocations of children and adolescents and of adult females. The bargaining effects remain significant after controlling for unobserved household characteristics and the potential nutrition-health-labor market linkage. The findings, which have important policy implications for the growing problem of micronutrient malnutrition in the developing world, also imply that perhaps the nutrition-health-labor market linkage as a key explanation for intrahousehold food distribution has been overemphasized in the previous literature.

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Does A Wife's Bargaining Power provide more Micronutrients to Females: Evidence from Rural Bangladesh

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1 Introduction

Micronutrient malnutrition is a critical problem in many developing countries[1], and Bangladesh is no exception. Women and children are most vulnerable due to their elevated micronutrient requirements for reproduction and growth. Approximately 60% of Bangladeshis suffer from various micronutrient deficiencies, of which deficiencies in vitamin A (a prime cause of night blindness), iron, and iodine are the most common (Government of Bangladesh, 1997). There is a growing concern about riboflavin, vitamin C, vitamin D, and zinc deficiencies (IFRPI-BIDS-INFS, 1998). About 70% of the women of age 15-45 years and children of 0-14 years, and 80% of the pregnant and lactating women have blood hemoglobin levels below the acceptable limit and suffer from anemia (Government of Bangladesh, 1995), which accounts for about 25% of all female deaths in Bangladesh (IFRPI-BIDS-INFS, 1998).

To better understand the age-gender dimension of micronutrient malnutrition, it is important to understand how nutrients are allocated within the household. Viewing calorie[2] as a sufficient statistic for nutrients, Pitt, Rosenzweig, and Hassan, 1990 (henceforth, PRH) argue that gender inequality in calorie distribution is due to gender inequality in energy-intensity of occupations. In a subsistence economy, men engage in energy-intensive occupations in which health and food consumption influence productivity and wage rates (Strauss, 1986; Deolalikar, 1988), while women are mostly confined in (less energy-intensive) household activities. These gender-segregated occupational choices (given by social norms) in turn influence a household's decision to allocate more calories to men as opposed to women, while there is not much gender disparity in calorie allocation among children. PRH estimates also imply that the households are inequality averse as men, despite being involved in energy-intensive activities, compensate their nutrient allocations in favor of women.

Although useful, the PRH framework does not provide much insight to the micronutrient malnutrition problem. Contrary to the PRH view, as I demonstrate, calorie is not a sufficient statistic for different nutrients[3]. Calorie adequacy often exists alongside micronutrient deficiency

[1] Nearly three billion people (including 56% of the pregnant and 44% of the nonpregnant women) suffer from iron deficiency anemia (IDA), and one-third of the world's population suffer from zinc deficiency (Standing Committee on Nutrition, 2004, 2000; McLean et al., 2008). Twenty percent of the maternal deaths in Africa and Asia are due to IDA (Ross and Thomas, 1996). One in every three preschool-aged children in the developing countries are malnourished (Smith et al., 2003). Undernutrition, coupled with infectious diseases, accounts for an estimated 3.5 million deaths annually (See, Scaling Up Nutrition, A Framework for Action, available at http://siteresources.worldbank.org/NUTRITION/). At levels of malnutrition found in South Asia, approximately 5% of GNP is lost each year due to debilitating effects of iron, vitamin A, and iodine deficiencies alone (World Bank, 1994).

[2] While calorie is a measure of energy, I use calorie and energy interchangeably throughout the paper. Calorie implies kilocalorie (kcal).

[3] The simple rice-dominated diet with low intakes of vegetables, animal and dairy products, typically consumed by rural Bangladeshis, meets the calorie need of the people but does not fulfill all the micronutrient requirements as rice is not a significant source of many essential nutrients, such as, vitamin A, vitamin C, iron, calcium, and

(Bouis et al., 1992). Moreover, while calorie intake is a direct function of calorie expenditure, as the principles of nutrition suggest, the intakes of various macro- and micro-nutrients are not (World Health Organization, 1985). Despite men's (as opposed to women's) engagement in energy-intensive activities, the requirements for many micronutrients are higher for women, particularly, for pregnant and lactating women, and children than men due to reproduction and growth requirements.

Moreover, PRH and previous studies on intrahousehold nutrient allocation have applied a unitary framework. A number of studies in recent decades fail to accept the fundamental assumption of the unitary model —- resource pooling —- in a range of outcomes, such as household expenditure, agricultural production, schooling, and health in developed and developing countries.

Applying a bargaining framework[4], I demonstrate that (i) while there is lack of gender disparity in the calorie adequacy ratio, for a range of critical nutrients, the disparity is prominent within children, adolescents, and adult groups; (ii) pregnant and lactating women receive much less of these nutrients vis-a-vis their requirements; (iii) there is evidence of significant intrahousehold bargaining with a wife's bargaining power, as opposed to her husband's[5], significantly and positively affecting the allocation of various nutrients for children and adolescents of both sexes and adult females; and (iv) these findings combined with the estimates of health technology imply that perhaps the nutrition-health-labor market linkage as a key explanation for gender disparity in PRH is overemphasized.

I thus attempt to contribute to the literature in four ways. First, I expand PRH analysis from calorie allocation to the allocation of a number of critical nutrients. While calorie has been the focal point in previous literature, it neither addresses the growing concern of micronutrient malnutrition, nor provides adequate understanding of gender-role in alleviating malnutrition. Although, some studies (Behrman, 1988; Behrman and Deolalikar, 1990) focused on nutrients other than calorie, they applied a unitary framework, which could be misleading if the household decision-making process is affected by the bargaining power of different members. My second contribution is the demonstration of intrahousehold bargaining (in addition to typical income and price effects) on nutrient allocations. Third, previous studies have demonstrated intrahousehold bargaining on various outcomes other than individual nutrient intakes. I add to this literature by focusing on nutrient intakes using an innovative panel dataset of rural Bangladesh. Fourth, with the exception of a few natural experiments, previous studies have used bargaining measures that

zinc (IFRPI-BIDS-INFS, 1998).

[4]To the best of my knowledge, this is one of the first exercises that applies a bargaining framework to analyse intrahousehold nutrient allocation based on actual individual dietary intakes.

[5]I use household head or husband and his wife or spouse interchangeably.

are endogenous to decisions made within marriage. While my measure of bargaining power—husband's and wife's assets at marriage—-is culturally relevant and exogenous to the decisions made within marriage, it can be endogenous to marriage due to marriage market selection. Failure to control for such effect can result in erroneous rejection of unitary model (Foster, 1998). A number of standard covariates (in the empirical literature of unitary or collective framework), such as, household size and composition could be also potentially correlated with unobserved household characteristics, such as fertility preference. Applying household fixed effect estimates (henceforth, HFE), I thus demonstrate evidence of intrahousehold bargaining that should not be contaminated by marriage market selection effect and other unobserved household characteristics.

The rest of the paper is organized as follows. Section 2 briefly reviews the literature. Section 3 discusses the theoretical framework. Section 4 lays out the econometric methodology. Section 5 describes the data and provides descriptives. Section 6 discusses the empirical results, and section 7 concludes the paper.

2 Related Literature

Gender disparity in nutrition is a salient feature of many low-income economies (Bardhan, 1974; Sen and Sengupta, 1983; Sen, 1984; Behrman, 1990). Although South Asia (SA) performs better than Sub-Saharan Africa (SSA) on many long-accepted determinants of child nutrition (i.e., national income, democracy, food supplies, health services, and education), the malnutrition prevalence is much higher in SA than SSA, which is arguably due to women's low status in SA (Ramalingaswami et al., 1996; Smith et al., 2003). Girls (boys) seem to be nutritionally favored than boys (girls) in SSA (SA), which could be influenced by the dowry system in SA that requires families to pay bridegrooms to marry their daughters as opposed to the norm in SSA that bridegrooms pay a bride-price (Quisumbing, 2003).

Using a unitary framework (Becker, 1973), several studies attempt to explain this gender disparity. As mentioned, PRH explain that gender differences in calorie consumption is due to men's engagement in more energy-intensive occupations than women. While occupational choices can be endogenous, PRH view that these choices are given by social norms. Bardhan (1974) and Rosenzweig and Schultz (1982) demonstrate the relationship between sex differences in infant mortality rates and sex differences in labor-market participation rates. However, Behrman (1988) does not find any relationship between expected labor market opportunities and sex disparity in children's nutrient consumption, but finds that households compensate for girls' nutrient allocations during the agricultural surplus season, but reinforce boys' endowments during lean seasons, which is more evident for lower-caste households. Behrman and Deolalikar (1990) find that females eat less when food is scarce and the marginal value of food is high, and vice versa.

Considerable evidence against the unitary framework (Strauss and Thomas, 1995; Haddad et al., 1997) has made collective framework (Chiappori, 1988, 1992; Bourguignon et al., 1993, 1994) attractive. Using the latter, Thomas (1990) finds a mother's unearned income has greater impact on daughters' anthropometric outcomes than that of sons, while a father's unearned income has the opposite effect. Using household food expenditure data, he also finds that the estimated impact of women's unearned income is about seven times that of men's unearned income for (per capita) calorie and protein consumptions. Schultz (1990) finds that women's unearned income has significantly different effect (i.e., reduces more) than men's unearned income on women's labor supply, and women's but not men's unearned income has a significant positive effect on fertility. Hallman (2003) uses maternal shares of current assets, premarital assets, and marriage payments as proxy measures for resource controls, and finds that a mother's assets are generally more beneficial for girls and a father's for boys as far as child morbidity is concerned, which is consistent with Thomas (1994). She further finds that a greater share of marriage payments to husbands reduce child morbidity, regardless of a child's sex. This is consistent with Rao (1997), who shows that lower dowries increase wife-beating and reduce child calorie intake during marriage. Targeting mothers for cash-transfers seems to increase secondary school enrollment, particularly for girls, and has positive effects on a child's health, nutrition, and food consumption (Skoufias and McClafferty, 2003; Adato et al., 2003). Pitt and Khandker (1998) find that household consumption and child nutrition and education are significantly better when the micro-credit borrowers are women. None of these studies using collective framework, however, focuses on individual nutrient intakes - the topic of this paper.

While collective models provide useful insights, often it is difficult to distinguish (empirically) their predictions from those of unitary model (Behrman, 1990, 1997). For instance, a unitary model will predict that better schooled women are more efficient in household production and knowledgable about health and child bearing technology. A collective model will argue that the better schooled women bargain more effectively over household resources, and that women are more interested in nutrition than their husbands. Moreover, spouses' education could be correlated with other unobserved factors, such as marriage market selection (Foster, 1998), and may pick up unobserved wealth or income effects. Using a unitary framework, Rosenzweig and Schultz (1982) demonstrate that the sex differences in infant mortality rates is influenced by the sex differences in labor-market participation rates, while Folbre (1984) argues that this relationship is supportive of a non-unitary framework in which women who have greater incomes have greater influence in intrahousehold allocations that leads to greater investments in daughters.

Finding convincing measures of bargaining power is a challenge. The measures should reflect bargaining power but should be exogenous to the outcomes under consideration. Income share of women (Hoddinott and Haddad, 1995), unearned income (Schultz, 1990; Thomas, 1990), current assets (Doss, 1999), inherited assets (Quisumbing, 1994), spouses' education (Quisumbing and Maluccio, 2003), and assets at marriage (Thomas et al., 2002; Quisumbing and Maluccio, 2003) are used as bargaining measures in the literature. A few studies also use natural experiments to identify the effect of bargaining power on intrahousehold resource allocation (Lundberg et al., 1997; Qian, 2008).

With the exception of natural experiments, the above measures are arguably endogenous. Women's income includes labor income that reflects time allocation and labor force participation decision of the household, and is thus endogenous to the household decision-making processes. Unearned income, as observed in Thomas (1990) and Schultz (1990), may include income from pensions, social security, unemployment benefits, or earnings from accumulated assets, which are related to past labor market activities and thus to wages and productivity. Women's unearned income on recent fertility (as measured in terms of co-resident children under five years of age) in Schultz (1990) may also reflect reverse causality if women with younger children do not participate in the labor market and are likely to be compensated by transfers from their families and other sources (Behrman, 1997). Similarly, current asset holdings are affected by the asset accumulation decisions made during marriage. While inherited assets and assets at marriage are less likely to be influenced by decisions within marriage, these are also problematic if correlated with individual unobserved characteristics (such as taste, human capital) that tend to influence the outcomes under study (Strauss and Thomas, 1995). These measures could be also endogenous to marriage due to marriage market selection (Foster, 1998).

3 Theoretical Framework

Consider a collective model where preferences of husband (h) and wife (w) matter. Each cares about his/her own and other $N-1$ ($i \in N$) household members' consumption of nutrients ($\mathbf{C}$), health outcomes ($\mathbf{H}$), and effort level (e). Thus, husband's and wife's utility functions are:

$$U_h = U_h(\mathbf{C}_i, \mathbf{H}_i, e_i; \mathbf{Z});$$

$$U_w = U_w(\mathbf{C}_i, \mathbf{H}_i, e_i; \mathbf{Z});$$

where, $\mathbf{Z}$ is a vector of household characteristics[6]. For all Pareto-efficient outcomes, there exists some weight λ for which the household's objective function becomes:

$$Max \qquad \lambda U_h(\mathbf{C}_i, \mathbf{H}_i, e_i; \mathbf{Z}) + (1-\lambda) U_w(\mathbf{C}_i, \mathbf{H}_i, e_i; \mathbf{Z}) \tag{1}$$

where, λ, also known as the sharing rule, is a function of husband's and wife's relative bargaining power:

$$\lambda = \lambda(a_h, a_w)$$

The higher is the bargaining power of the individual, the greater the weight his/her utility function carries in the household's maximization problem[7]. The household maximizes its objective function subject to the following constraints:

$$\mathbf{H}_i = H(\mathbf{C}_i, e_i, \mu_i) \tag{2}$$

$$w_i = w(\mathbf{H}_i, e_i) \tag{3}$$

$$v + \sum_i w_i = Y = \sum_i \mathbf{PC} \tag{4}$$

The health outcomes of an individual i (equation 2) are functions of intakes of different nutrients, his/her effort level (assumed to deplete health), and his/her health endowment (μ_i). Individuals are differentiated by their health endowments, which are known to all household members. Wage (w_i) equation (3) implies that effort is rewarded in the labor market with returns to effort increasing with an individual's health status. Equations 2 and 3 capture the essential assumption of the efficiency wage literature that food consumption affects labor market productivity through health (Stiglitz, 1976; Leibenstein, 1957). While the efficiency wage literature assumes purely technological relationship between effort, health and food consumption, these are choice variables in the above framework. Finally, in household's budget constraint (equation 4), Y is total household income, v is total unearned household income, $\mathbf{P}$ is the price vector for

[6]Bold-faced arguments imply vector notations

[7]Equation 1 converts to a unified household utility function:

$$U = U(\mathbf{C}_i, \mathbf{H}_i, e_i; \mathbf{Z}); \forall i = 1, ..., N$$

when one person is the dictator (i.e., λ is 0 or 1) or when both persons have the identical preferences, $U_h = U_w$. The household decision making process in the collective framework can also be viewed as a two-stage budgeting process, in which at the first stage, the individuals pool all their income and allocate it according to the weight or sharing rule, λ. Then, at the second stage, each individual maximizes his/her own utility given his/her share or weight within the household.

different nutrients and leisure, and total labor time is normalized to 1.

Maximizing a household's objective function, subject to these constraints yields a set of reduced form nutrient demand functions:

$$\mathbf{C}_i = f(\mathbf{P}, Y, \lambda; \mathbf{I}, \mathbf{Z}) = f(\mathbf{P}, Y, \lambda(a_h, a_w); \mathbf{I}, \mathbf{Z}) \tag{5}$$

where, $\mathbf{I}$ is a vector of individual characteristics, such as, age, gender, endowment, etc., and $\mathbf{Z}$ is a vector of household characteristics, such as, household size and composition.

As is well-known, the key difference between these reduced form demand function of the collective framework with those of the unitary framework is that in the case of the former, the sharing rule and thus the bargaining power of individuals become an explanatory variable for individuals' demand for nutrients (and for other outcomes) in addition to total household income. Since income pooling implies that controlling for household income, individual bargaining power does not affect the demand functions of the household members, using measures of spouses' bargaining power, one can test the key assumption of the unitary model – income pooling – vis-$\grave{a}$-vis – intrahousehold bargaining – for nutrient allocation:

$$\frac{\partial \mathbf{C}_i}{\partial a_i} = 0; i = h, w \tag{6}$$

In the case of income pooling, $\frac{\partial \mathbf{C}_i}{\partial a_i} = 0$, whereas in the presence of intrahousehold bargaining, $\frac{\partial \mathbf{C}_i}{\partial a_h} \neq \frac{\partial \mathbf{C}_i}{\partial a_w}$.

4 Econometric Framework

To analyze intrahousehold bargaining in nutrient allocation, I use the following empirical specification of equation 5:

$$lny^k_{ijvst} = \alpha^k_0 + \alpha^{\mathbf{k}}_{\mathbf{1}}\mathbf{A}_{ijvst} + \alpha^k_2\kappa_{ijvs} + \alpha^{\mathbf{k}}_{\mathbf{3}}\mathbf{X}_{hjvst} + \alpha^{\mathbf{k}}_{\mathbf{4}}ln\mathbf{P}_{vst} + \alpha^{\mathbf{k}}_{\mathbf{5}}\mathbf{R}_t + \alpha^{\mathbf{k}}_{\mathbf{6}}\mathbf{S}_s \tag{7}$$

$$+\alpha^{\mathbf{k}}_{\mathbf{7}}\mathbf{X}_{mjvs} + \alpha^{\mathbf{k}}_{\mathbf{8}}\mathbf{X}_{wjvs} + \alpha^{\mathbf{k}}_{\mathbf{9}}(\mathbf{A}_{ijvst} \times \mathbf{X}_{mjvs}) + \alpha^{\mathbf{k}}_{\mathbf{10}}(\mathbf{A}_{ijvst} \times \mathbf{X}_{wjvs}) + \epsilon^k_{ijvst}$$

where k indexes a nutrient (e.g., calorie, protein, iron, etc.), i individual, j household, v village, s survey location ($v \in s$), t survey round, and ln, natural log. The dependent variable, y^k is an individual's adequacy ratio of nutrient k (see section 5 for variables' definitions and descriptives). The covariates are: a vector of dummy variables indicating the age-sex group (with adult male as omitted category) and pregnancy and lactating status of an individual ($\mathbf{A}_{ijvst}$), a measure of individual's health endowment, κ_{ijvs} (described below), which, based on PRH, is used to control for any potential nutrition, health, and labor market linkages, time variant and invariant household characteristics ($\mathbf{X}_{hjvst}$), village food prices ($\mathbf{P}_{vst}$), dummy variables for survey round ($\mathbf{R}_t$) and sites ($\mathbf{S}_s$), and characteristics of household head ($\mathbf{X}_{mjvs}$) and his wife ($\mathbf{X}_{wjvs}$).

Controlling for individual and household characteristics, gender difference in nutrient adequacy ratios will be reflected in the coefficient vector $\alpha_{\mathbf{1}}^{\mathbf{k}}$. Controlling for household composition, any potential household scale (dis)economies (Deaton and Paxson, 1998) that might make individuals of a larger household (worse)better-off in nutrient consumption (at the same level of per capita expenditure) will be captured by the household size. Controlling for aggregate household resources, spouses' characteristics are of interest from intrahousehold bargaining perspective.

4.1 Health Endowment and Occupation

A challenge is to obtain consistent estimate of an individual's unobserved health endowment to control for nutrition-health-labor market linkage. I follow PRH approach of estimating endowment through a residual approach first used by Rosenzweig and Schultz (1983) in which the health technology (equation 2) is estimated directly. Then based on the technology parameter estimates and actual resources consumed or spent by individuals, individual-specific endowments are computed. However, in estimating the technology, I differ from PRH in terms of econometric method. A problem with the residual approach, as PRH argued, is that the consistent estimates of the technology parameters could not be obtained using OLS as estimated technology parameters could be biased if $\mathbf{C}_i$, and e_i are correlated with unobserved individual endowment, μ_i in equation 2. So PRH followed a 2SLS approach to estimate a health production function similar to the following form:

$$ln(h_{ijst}) = \beta_1 + \beta_2 lnc_{ijst} + \beta_{\mathbf{3}}\mathbf{D_{ijst}} + \beta_{\mathbf{4}}\mathbf{X_{hjst}} + \beta_5(age_{ijst}) + \beta_6(age^2_{ijst}) \tag{8}$$

$$+\beta_7 sex_{ijs} + \beta_8(sex \times age)_{ijst} + \eta_{ijst}$$

where,

$$\eta_{ijst} = \mu_{ijs} + \gamma_{js} + \theta_{ijst}$$

The notations for i, j, s, and t are the same as above, h is an individual's weight for height, c is calorie intake, $\mathbf{D}$ is a vector of dummy variables indicating whether or not an individual's occupation is highly energy intensive and whether the individual is pregnant or lactating, $\mathbf{X}$ is a vector of household characteristics, and θ_{ijst} is a random error term. In terms of household characteristics, PRH used drinking water source. While the error term, η_{ijst} could contain unobserved time-invariant household specific effects (γ_{js}), such as spouses' taste and fertility preference, which can affect both calorie allocation and health outcome, such effects were ignored in PRH. PRH estimated equation 8 instrumenting calorie intake, energy intensity of occupation, pregnancy, and lactating status by household head's age and schooling, household landholding, and their interactions with food prices to address the correlation between individual endowment (μ_{ijs}) and the covariates ignoring unobserved household characteristics embodied in η_{ijst}.

While PRH did not present any analysis of the strength and validity of their instruments, many of these instruments, such as household landholding and head's schooling could directly affect individual health outcomes, such as in Behrman (1990). These could be also correlated with other potential determinants of health outcomes, such as wife's schooling and age (not controlled for and thus are embodied in η_{ijst}). Effect of spouses' characteristics on individuals' health and nutrition could be also biased due to marriage market selection effects. Similarly, pregnancy (which in turn influences lactating status) of individuals could be influenced by household's unobserved fertility and sex-preference (arguably, in this case, age and sex of children are also endogenous). The latter could also influence allocations for individuals' nutrients and health outcomes. Spouses' bargaining power (embodied in their characteristics, observed and unobserved) can affect fertility decision (Rasul, 2008) and thus household size and composition as well as individuals' health and nutrition outcomes. It is thus difficult to obtain valid instruments to account for endogeneity in estimating the health technology.

Hence, instead of a 2SLS, I estimate the health technology using individual fixed effect estimate (IFE), which should eliminate all individual, household, and location fixed effects and provide consistent estimates for calorie intake coefficient[8]. However, the downside of IFE is that the effect of individual characteristics (i.e., sex) and time invariant household characteristics on health outcome will remain unmeasured. To go around this problem, I measure the technology parameters separately for males who are engaged in highly energy-intensive occupations and those who are not, and for females. Obtaining an estimate for endowment through this approach, however, relies on a number of assumptions. First, I assume that as far as an individual's attributes are concerned, other than his/her unobserved health endowment, calorie intake, age, sex, pregnancy and lactating status, and occupation, there is no other individual characteristics that affect his/her weight-for height in the short-run. Second, similar to PRH, I assume that occupational choices are predetermined[9]. Although occupational choice can be endogenous, PRH

[8]Weight-for-height in the short-run is supposed to be influenced by only calorie intake and calorie expenditure. PRH demonstrated that controlling for calorie intake, other nutrient intakes do not have significant influence on this short-term measure of health.

[9]I require this PRH assumption because an individual's occupation data is collected only once in the survey (in first round and for new members only in subsequent rounds when they first appear in the household). If I had

argued that they are given by social norms that limit females' outside labor market participation, while men are engaged in energy-intensive labor market activities. Thus, few women are engaged in plowing in India, while in Bangladesh no women are observed to pull rickshaw[10]. As a consequence of gender-segregated occupations, as PRH demonstrated, health endowment in the labor market matters only for males. Behrman and Deolalikar (1989) and Sahn and Alderman (1988) also find that health and calorie consumption have significant positive effects on men's but not on women's wage rates. So for females, I estimate the technology without differentiating them based on the energy-intensity of their occupation. Moreover, consistent with PRH assumption, there are only a very few females engaged in high energy intensive occupations in the data (see Section 5). Thus, for each of these three categories, I estimate the following health technology function using IFE:

$$\Delta ln(h_{ijst}) = \beta 1_{IFE} + \beta 2_{IFE} \Delta lnc_{ijst} + \beta 3_{IFE} \Delta ln(age_{ijst}) + \beta 4_{IFE} \Delta [ln(age_{ijst})]^2 + \quad (9)$$

$$\beta_{\mathbf{5_{IFE}}} \Delta \mathbf{X_{hjst}} + \sum_t \gamma_t \Delta R_t + \Delta u_{ijst}$$

where household characteristic vector, $\mathbf{X_{hjst}}$, includes monthly per capita expenditure and its square, per capita household landholding, and household size, all in logs, share of different demographic composition of the household, R_t are survey round dummies to control for any potential seasonal effects on health outcomes, and Δ indicates deviation of an individual's observation in a given round from its mean (over four rounds). In estimating equation 9 for females, I also include pregnancy and lactating dummies.

Applying IFE estimates of the parameters for calorie intake, age and its square, and household characteristics from equation 9 to the individual data of the corresponding variables, I obtain estimated log weight for height ($ln\hat{(h)}$) for each individual who belongs to any of the three above sex-occupation categories. Deducting this estimated value from the observed value of log weight for height (lnh) yields a health measurement that includes an individual's unobserved health endowment (μ) and an aggregate unmeasured effect of time-invariant household characteristics (ρ) (e.g. the effect of spouses' characteristics, such as education, assets, unobserved preferences, household landholding, short-run time-invariant living and hygiene conditions, drinking water source, etc. as discussed above):

time-varying occupation data, I could obtain consistent estimate of its impact on health using IFE without this assumption.

[10]Morris (1997) finds that traditions in Bangladesh often inhibit a woman's ability to obtain employment outside of home. Purdah, or female seclusion, is an Islamic tradition routinely practiced in Bangladesh among the Muslim majority, which limits women's labor market participation.

$$ln(h) - ln(\hat{h}) = \mu + \rho = \kappa$$

As I have four rounds of data for an individual, I average κ over four rounds and use it as a proxy measure for an individual's health endowment in equation 7. Obviously, estimating equation 7 using OLS will be problematic as the health measure κ will include the effect of unmeasured household characteristics, but these should be eliminated by estimating equation (7) using household fixed effect. Thus, the measure κ along with other factors discussed below motivates HFE estimation of equation 7.

4.2 Test of the Unitary Model and Household Fixed Effect

Based on OLS estimate of equation 7, a test for unitary model will be the tests of the restrictions that for an individual's nutrient allocation (conditional on individual and household characteristics), the effect of a head's characteristics will be same as the effect of the corresponding characteristics of his wife. Thus, for the adult male (omitted category), the restrictions are:

$$\alpha^k_{7_e} = \alpha^k_{8_e}, e = assets, education \tag{10}$$

for each of the remaining age-gender category ($g \in G$):

$$\alpha^k_{7_e} + \alpha^k_{9_{e_g}} = \alpha^k_{8_e} + \alpha^k_{10_{e_g}} \tag{11}$$

for adolescent (adolf) and adult (adulf) pregnant (preg) and lactating (lact) women:

$$\alpha^k_{7_e} + \alpha^k_{9_{e_d}} + \alpha^k_{9_{e_p}} = \alpha^k_{8_e} + \alpha^k_{10_{e_d}} + \alpha^k_{10_{e_p}}, d = adolf, adulf; p = preg, lact \tag{12}$$

and, for each of the age-gender-pregnancy-lactating category, relative to adult males:

$$\alpha^k_{9_{e_g}} = \alpha^k_{10_{e_g}} \tag{13}$$

$$\alpha^k_{9_{e_d}} + \alpha^k_{9_{e_p}} = \alpha^k_{10_{e_d}} + \alpha^k_{10_{e_p}}$$

The OLS estimates, however, have a number of econometric concerns, which in turn motivate HFE estimation. In addition to the effect of ρ in the endowment measure κ, household size and composition could be potentially endogenous to the household's unobserved fertility preference, the latter could also influence the nutrient allocation decisions. If households have preference for sons and follow a male-biased stopping rule that could influence household size and composition.

This could result in girls living in bigger families (with more siblings) than boys (Barcellos et al., 2010). As already mentioned, bigger families may have scale (dis)economies that can affect individuals' nutrient intakes. To the extent the unobserved fertility preference is time-invariant, it could be eliminated by HFE method. Household income (proxied by expenditure) is also potentially endogenous as both nutrient consumption and health endowment of individuals may affect household income. In the literature, household expenditure is often instrumented by household landholding. However, Behrman and Deolalikar (1990) distinguish the effect of current income vis-*à*-vis permanent income on nutrient intakes, arguing that if households protect their nutrient intakes from short-term fluctuations, the income elasticities of nutrient intakes would be biased downward relative to the true household response to permanent income changes. They find that the effect of nutrient intake responses to both current and permanent income are quite small. Following Behrman and Deolalikar (1990), I use both current and permanent income (proxied by per capita landholding) measures as explanatory variables. If a household's nutrient allocation decision based on an individual's endowment and labor market productivity is time invariant, then this unobserved household characteristic that might influence household income is eliminated in HFE estimates.

Spouses' assets and education at marriage could be correlated with their unobserved characteristics, such as their preference for children's (of particular sex) nutrition and health, which in turn could be correlated with household formation through marriage market selection. For instance, a man (woman) who wants healthy children may also choose an educated and/or wealthy wife (husband). So a wife's (man's) education and/or assets may appear to influence a child's nutrition, even if for the same man (woman) changes in wife's (husband's) assets or education would not affect the child's outcome. The effect of a wife's (husband's) bargaining measures on child's nutritional allocation will be overestimated if husband (wife) with a high taste for children's nutrition tend to choose educated and/or wealthier spouse. This could in turn lead to erroneous rejection of unitary model in favor of intrahousehold bargaining. Hence, another motivation for HFE is to eliminate spouses' time-invariant unobserved characteristics that could be correlated with their bargaining measures and could influence individuals' nutrient allocations.

The survey, as described in the next section, was conducted in four rounds. Using within household variation of individuals' nutrient intakes in different rounds, and variation of time varying household characteristics across rounds, I estimate the following HFE version of equation (7):

$$\Delta lny^k_{ijvst} = \alpha^k_{0_{FE}} + \alpha^{\mathbf{k}}_{\mathbf{1_{FE}}}\mathbf{\Delta A}_{ijvst} + \alpha^k_2\Delta\kappa_{ijvs} + \alpha^{\mathbf{k}}_{\mathbf{3_{FE}}}\mathbf{\Delta X}_{hjvst} + \alpha^{\mathbf{k}}_{\mathbf{4_{FE}}}\mathbf{\Delta} ln\mathbf{P}_{vst} \tag{14}$$

$$+\alpha^{\mathbf{k}}_{\mathbf{5_{FE}}}\mathbf{\Delta R}_t + \alpha^{\mathbf{k}}_{\mathbf{9_{FE}}}\mathbf{\Delta}(\mathbf{A}_{ijvst} \times \mathbf{X}_{mjvs}) + \alpha^{\mathbf{k}}_{\mathbf{10_{FE}}}\mathbf{\Delta}(\mathbf{A}_{ijvst} \times \mathbf{X}_{wjvs}) + \Delta\epsilon^k_{ijvst}$$

where Δ indicates deviation of observations from household mean. However, eliminating household fixed effects also eliminate time-invariant observable household characteristics, in my case which include spouses' bargaining measures. Therefore, to assess intrahousehold bargaining, I can now only test the restrictions in equation 13. Moreover, the data is collected over four rounds within a year, so there will be very limited variation of household size, demographic composition, and per capita landholding (as landholding data is only from first round) across rounds. So the effects of these variables could be imprecisely estimated. The HFE estimates will be also based on a restricted sample of households that have at least one member of each of the age-sex group under consideration. Also, the noise to signal ratio is likely to increase due to differencing.

Finally, as I analyze intrahousehold bargaining for a number of nutrients, the likelihood that no gender differences are found along any margin is very low. So the results might be biased towards finding discrimination. Moreover, individuals' consumption of one nutrient may affect the consumption of others as typically they consume a food-bundle in which different food items contain different nutrients in different proportions. To address these issues, adequacy ratios for all nutrients under level specification 7 and HFE specification 14 are estimated simultaneously in a seemingly unrelated regression (SUR) framework (henceforth, referred to as SUR_{LS} and SUR_{HFE}, respectively).

5 Data and Descriptives

I use an innovative household survey data from the International Food Policy Research Institute (IFPRI). The data come from four rounds of surveys at four month intervals during 1996-97 (Round 1: June-September, 1996; Round 2: October-December, 1996; Round 3: February-May, 1997; and Round 4: June-September, 1997) in 47 villages from three sites in four districts of Bangladesh[11]. The survey objective was to evaluate the impact of commercial vegetable production in Saturia (site 1), polyculture fish production in household-owned ponds in Mymensingh (site 2), and polyculture fish production in group-managed ponds in Jessore (site 3) on household income, nutrition, and time allocation. In each site, villages were categorized into program villages (A villages) where the technology was already introduced and comparable control villages (B villages) where the technology was yet to be introduced. From each of these categories, surveyed A and B villages were randomly selected. A household census was conducted in all the randomly selected A and B villages, from which households of two categories (adopters and

[11]Bangladesh is divided into six divisions. A division is then divided into districts. A district is composed of several thanas. Thanas are divided into unions. A union is composed of several villages.

non-adopters in A villages, and households who expressed interest to adopt if the technology is introduced and who were uninterested in B villages) were selected[12].

The survey questionnaire was administered to 5,541 individuals in 955 rural households in each round who were selected through this multi-stage sampling approach. The survey collected detailed information on demographic characteristics, agricultural production, other income-earning activities, expenditure patterns, time allocation, individual food intakes, health, morbidity, and education. It also collected information on family background, marriage history, assets at marriage, transfers at marriage, inheritance, women mobility, and empowerment.

IFPRI sampling required that the households were representative of adopters and non-adopter households in A villages and likely adopters and likely non-adopters in B villages, and not necessarily representatives of rural Bangladeshi households. Nonetheless, a comparison of IFPRI sample with that of 1995-96 National Household Expenditure Survey (HES) of Bangladesh Bureau of Statistics of the Government of Bangladesh indicates that the IFPRI sample is broadly comparable to the nationally representative HES rural sample of 5,020 households based on household size, per capita expenditure, landholding, and poverty rates (Table 1).

5.1 Variables and Descriptives

Table 1 provides the descriptive statistics of the variables used in the econometric analysis, and the variables are described below.

Survey round and site dummies: Survey round dummies (with 4th round omitted) are included to control for any agricultural seasonality that may affect nutrient consumption as in lean seasons there may be lack of food availability and labor market activities that can affect household food expenditure and income. As there are two major rice cultivation seasons, there are also two lean seasons that reduce employment and income earning opportunities. The major lean season is from mid-September to mid-November preceding the Aman harvest, which falls in round 2. The other lean season falls in round 3, which is from mid-March to mid-April, prior to Boro harvest[13]. Site dummies (with Jessore as omitted site) are included to control for any location specific effects, such as infrastructure, location endowment, market condition, health facility, etc., which may affect income earning opportunities, food availability and prices, health, and nutrition.

Village prices: The survey collected data on household food expenditure and quantity

[12]The IFPRI evaluation concluded that adoption of these programs, had neither improved the micronutrient status of the adopting households through better quality diet nor increased their incomes. For a detailed description of the survey, see (IFRPI-BIDS-INFS, 1998).

[13]Aman and Boro are the rice grown in monsoon and dry season, respectively.

purchased of a wide range of food items, which were further classified into 17 different food groups. Village prices are proxied by village level mean unit value for each of these food groups, which are constructed by averaging the household level unit value of these food groups within each village. I control for log village price of rice, pulses, big fish, small fish, and egg in the regression functions[14]. Table 1 indicates substantial variation of village prices across rounds, while high and low prices of different food groups are observed at different times of the year. For instance, while the mean rice price is lowest in round 2 and highest in round 3, for pulses the highest is observed in round 2 and lowest in round 4, implying seasonality (if any) differs for different food groups.

Household size and composition: Household size is based on number of individuals present in the household in each round. Consistent with nutritional requirements at different stages of life-cycle and activity patterns, males and females are categorized into: children (< 10 years), adolescents ($10 \leq age < 18$ years), and adults (≥ 18 years). Dummies for each of these six age-sex categories (with adult male as omitted category) and a dummy for whether a female is pregnant or not, or lactating or not in a given round are used in the econometric analysis. Log household size and share of males and females in each of these age groups (with adult males' share as omitted category) are used to control for household size and composition. Compared to HES sample, on average an IFPRI sample household is consists of 1-2 more people with highest share of individuals in the adult category. As expected, there is very limited variation of household size and composition across rounds within one year. The lactating women outnumbered pregnant women, and these statuses vary across rounds.

Household landholding, expenditure, and poverty: Household landholding is a time invariant variable for which information was collected in the first round. The share of landless households is lower in IFPRI than in HES samples. The distribution of landholding is also less unequal in IFPRI sample compared with HES sample with higher share of households with 1-7.5 acres in IFPRI sample. The mean per capita landholding in IFPRI sample is 0.23 acre (which varies slightly across rounds due to limited variation in household size).

Both samples are similar in terms of mean per capita monthly expenditure, which varies significantly across rounds (p-value of t-tests are not reported) in IFPRI sample with the lowest value observed in round 2 and highest value in round 3.

The absolute and hard core poverty lines based on direct calorie intake (DCI) method are 2122 kcal and 1805 kcal per person per day, based on which the poverty incidence is higher in IFPRI compared to HES sample. HES regional upper and lower poverty lines based on cost of

[14] A comprehensive set of village prices were initially included. Subsequently, I have included the food prices that appear to be significant most of the times for the set of nutrients analysed in this paper.

basic needs (CBN) approach in 1995-96 are Takas 593 and 492 in site 1, 529 and 484 in site 2, 592 and 499 in site 3, and 591 and 499 for national rural households. Comparison of HES sample with site specific poverty incidence based on CBN gives a mixed picture with some sites in some rounds having higher poverty rates compared to national rural average and vice versa. Similar to monthly per capita expenditure, poverty incidence varies substantially across rounds. Based on CBN, the highest poverty incidence in all sites are observed in round 2, while based on DCI, the poverty peaks in round 3. As mentioned, round 2 contains the major lean season, while round 3 the minor one.

Spouses' characteristics - age, education, and assets at marriage: On average, husbands are about 8 years older than their wives. To focus on bargaining between husbands and wives, following Quisumbing and Maluccio (2003), I restrict the sample to monogamous households[15] with husband and wife present and with no change in marital status (i.e., divorce, separation, re-marriage, death, etc.) during the survey period. The resulting sample selection bias (if any) would lead to a conservative estimate of bargaining effects as households in which the disagreement between the spouses are the strongest would be more likely to split and are thus absent in this sub-sample.

The marriage module of the survey asked the heads and their wives the assets they owned at the time of their wedding. These assets included land, cattle, housing, food items, and durable (jewelery, watch, clothes, and household utensils). The reported values of these assets at the time of marriage were converted in 1996 taka using national consumer price index. Bangladeshi wives had far less assets at the time of their marriage than their husbands primarily because their value of landholding, housing, and cattle were much less than those of their husbands (see Table 1). The assets at marriage may suffer from measurement errors due to recalling information, particularly for longer marriages. One option is to instrument spouses' assets by their respective family background information, such as the wealth of their parents. However, those measures may also suffer from recall errors. Hence, I do not instrument these bargaining measures. To the extent the measurement errors are white noise, the evidence of bargaining (if any) will be an underestimation of the true bargaining effects. Education is measured by years of schooling. The mean years of schooling of husbands is almost double of that of wives.

While spouses' assets at marriage are my key bargaining measures, following Quisumbing and Maluccio (2003), in the empirical analysis, I also include spouses' age and age square to control for cohort effects, and for the possibility that their age difference could be another source of

[15] 1% of households have two wives, while 4.5% are female headed with no husband, and 3% have head without his wife. 91% households are intact with both head and his spouse. Based on data availability of assets at marriage, my analysis contains almost 98% of these intact households, or, roughly 89% of the all surveyed households.

bargaining power that may be correlated with the education and assets measures. While spouses' education are included as a potential bargaining source, its caveats are already discussed (see section 2). My focus, however, is not to evaluate intrahousehold bargaining based on education, but to control for any potential correlation between education and asset measures of bargaining.

Individual health and occupation: There is limited variation across rounds even in the short-term health outcome measure, an individual's weight (in kilograms) for height (in centimeters). Boys tend to do better than girls and adult males better than adult females, while this gender difference reverses for the adolescent group. This might be indicative of some transitory catch-up for females as they past childhood, which later disappears as they progress toward adulthood.

As mentioned before, occupation data were collected once in the survey. These were coded into 47 different occupations. Based on the metabolic constant (mc) provided for a detailed list of activities for male and female in World Health Organization (1985), I classify the energy intensity of occupations into high ($mc > 4$), medium ($2.5 < mc \leq 4$), and low ($mc \leq 2.5$) category[16]. Energy intensity of occupation of different age-sex group vis-a-vis their energy intake are further discussed below. As described in Section 4, both the energy intensity of occupation and health outcome are utilized to construct the health endowment measure.

Calorie intake and energy-intensity of occupation: A useful feature of IFPRI survey is that it provides individual food intake data for each round using a 24-hour recall methodology asking the person with primary responsibility for preparing meals, about recipes prepared, ingredients for those recipes and amounts eaten by various family members and guests. The survey has information of quantity of individual intakes of about 200 food items (categorised into 17 food groups), which are converted into calories, protein, and micronutrients (vitamin A, vitamin C, vitamin D, niacin, riboflavin, thiamine, folate, iron, and calcium).

Calorie intake data broadly resembles to PRH claim that gender difference in calorie allocation is age-dependent and so is the gender difference in energy-intensity of occupations. To replicate PRH finding in IFPRI sample, I first use PRH's age-group classification ((age<6, 6≤age<12, and age≥12). The mean calorie consumption (averaged over four rounds) across age-groups are higher in IFPRI than in PRH sample (see Table 2). However, there is no significant gender difference for the group less than <6 years. Conversely, consistent with PRH, I find significant gender difference for the age-group ≥ 12 years. While PRH does not find any significant gender

[16]PRH cited the same source for classification of energy intensity of occupations but did not describe different cut-off points of mc they used for their classification. Basal metabolic rate (BMR) for an individual is the amount of energy spent when the person is in sleep. Energy requirement for different activities per minute is BMR times the mc of that activity. For instance, mc for cleaning house for a female is 3, while that for digging earth for male is 5.7.

difference for the age-group 6-12 years, I find this difference is small but significant. In line with PRH, the within-household inequality in calorie distribution, measured by the coefficient of variation, is higher among males than females (the difference is significant) for age-group ≥ 12 years, while this inequality is not significant for the groups <6 years and $6-12$ years.

Based on my age-group classification, I find that boys have about 100 calories more than girls (the difference is significant at 5% level). There is neither a marked difference in energy requirement of occupations for children, nor any significant difference between intrahousehold inequality among boys compared to the inequality among girls based on coefficient of variation. The gender difference in calorie allocation increases almost three-folds for adolescents compared with that of children. Compared to 1% adolescent females, 18% adolescent males are engaged in high energy-intensive occupation. Within household inequality for adolescent males is about 23% higher than that for the adolescent females (significant at 5% level). Adult males receive about 700 calories more than adult females, which reflects the fact that more than half of the adult males compared with only 2% adult females are engaged in high energy-intensive occupations. Thus, the broad linkages between work-activity and calorie distribution as observed by PRH tends to hold for these age-groups as well.

Nutrient Adequacy Ratio: While PRH's focus was only on individual calorie intake, individuals' intakes of calorie and different nutrients[17] are not very useful unless compared against their requirements. I thus construct nutrient adequacy ratio for each of the k nutrients:

$$y_i^k = \frac{C_i^k}{RDA_i^k}$$

where, y_i^k is individual i's adequacy ratio of nutrient k, C_i^k is his/her daily consumption of nutrient k, and RDA_i^k is his/her recommended daily allowance (or requirement) of nutrient k based on age, sex, pregnancy, and lactating status. The appendix provides a detailed description of how the RDA figures for calorie and different nutrients are constructed. As discussed in the appendix, for protein and iron, not only quantity but also quality matters. Protein from animal sources are good quality protein, while iron from animal sources (also termed as haem-iron) have high bio-availability and promotes bio-availability of iron from non-animal sources. Hence, in addition to individual's nutrient adequacy ratio, I also use an individual's intake of animal protein as a share of protein requirement and intake of haem iron as a share of total iron requirement as

[17] All foods are made up of a combination of macronutrients (protein, fat, carbohydrate) and micronutrients (vitamins and minerals). Macronutrients form the bulk of the diet and supply all the energy needed for the body for body functions, growth, and physical activities. Macronutrients provide different amounts of energy, expressed in kilocalorie (loosely termed as calorie as well). Fat provides approximately twice as much energy (9Kcals/g) as the same amount of protein or carbohydrate (4Kcals/g).

dependent variables in the empirical analysis.

5.2 Nonparametric Analysis

Sex difference in the adequacy ratio of different nutrients at each age are nonparametrically (using locally weighted regression method, lowess with bandwidth 0.8) shown in Figures 1 and 2. These figures illustrate a number of points. First, sex disparity in adequacy ratio is least observed for calorie and among the micronutrients, for niacin. As discussed in the appendix, calorie requirement figures for children and adolescents are based on US National Child Health Survey (NCHS) standard and not based on actual energy expenditure because of lack of data on time allocation for these age groups. Only for these groups, the adequacy ratio seems to be less than 1. This might imply that perhaps these groups are having calories based on their actual energy expenditure (which is unobserved in the data), but still they are having calories less than NCHS standards to meet their full long-term growth potentials. On the other hand, for the adults for which the requirements are based on actual energy expenditure, the adequacy ratio for both males and females are at or above 1. Calorie intakes of all ages are also most stable (compared to other nutrients) across different rounds (as requirement figures are fixed, any movement in adequacy ratio across rounds implies fluctuation in intakes). All these are consistent with the view in nutrition literature that given the wide variety of sources to meet one's calorie need, in normal circumstances (i.e., without famine) an individual can always meet his/her calorie need (World Health Organization, 1985).

Second, for most of the other nutrients, sex disparity is prominent, persistent, and often widens for adolescents and adults compared with children. For vitamin A and D in some rounds, at a relatively high age (above 70 or so), females' adequacy ratio cross over males'. However, this cross-over should be interpreted with caution due to the limited number of observations at those ages (with number of males higher than females). Third, with the exception of protein and vitamin C, nutrient deficiency is prominent across ages for all other nutrients with adequacy ratio lower than 1. The situation is most alarming for iron, where both males and females across ages are in deficiency, with females' deficiency worse than males'. While protein adequacy ratio is above 1 across all ages (with males' ratio higher than females'), the good quality protein (i.e., protein from animal, dairy, and fish, jointly termed as animal protein) as a share of required protein is very low. The situation is even worse for haem iron. Finally, (vertical) shift of these age-adequacy profiles for most of the nutrients (and changes in shapes for some nutrients) across rounds imply variation of individual intakes of these nutrients across rounds.

To illustrate the role of bargaining in intrahousehold nutrient allocation, lowess graphs of calorie and calcium adequacy of different age-sex groups, as examples, are shown in Figure 3. The left (right) panel shows intakes of different age-sex group at different levels of wife's (head's) assets at marriage when head's (wife's) assets at marriage is zero. For calorie, most contrasting pattern is reflected for female child. Her calorie adequacy ratio tends to increase with wife's assets but declines with husband's assets. The rate of decline of female adolescent's adequacy ratio is also much faster with the increase in head's assets as opposed to his wife's assets. While male adult's adequacy ratio increases with the increase in head's assets, a v-shaped pattern appears for this adequacy ratio and wife's assets.

For calcium, adult female's intake initially increases and adult male's intake decreases with the increase in head's assets. After a point, the female's intake sharply declines while the opposite is observed for the male's intake. Conversely, the initial rate of increase of adult female's intake is faster with the increase in wife's assets, and after a point the intake declines at a slower rate with the increase in wife's assets (compared to the increase in head's assets). Adult male's intake appears to be negatively related with wife's assets. The male child's intake increases with head's assets. This intake moderately increases with the initial increase in wife's assets and then tends to decline.

All these contrasting relationships between individual intakes and spouses' assets at marriage motivate a more detailed empirical analysis of intrahousehold bargaining on individual nutrient allocations in the following section.

6 Estimation

6.1 Calorie intake and health technology

Table 3 presents the estimates of the health technology (equation 9) for males engaged in highly energy intensive occupations (HEIO) (as defined in the preceding section) and non-HEIO and for females. OLS estimates are presented along with IFE estimates for comparison purpose. The results imply three points. First, the role of calorie intake on individual's health outcome is much limited once unobserved individual and household fixed effects are accounted for. For each of the three categories of individuals, the effect of calorie intake on health outcome is much higher in OLS than IFE estimates, indicating upward bias in OLS estimates, presumably driven by unobserved individual endowment and household characteristics (such as spouses' tastes). For males in HEIO, doubling calorie intake will increase their weights for heights by 5% in OLS estimate, while the corresponding increase is only 0.67% in IFE estimate. Second, this effect of calorie intake varies only marginally across individuals based on their energy intensity of occupations. Doubling the calorie intake of males who are not engaged in HEIO and of females will increase their weight for height by 0.54% compared to that by 0.67% for males in HEIO based on IFE estimates. Third, comparison of IFE results with that of PRH (in which, doubling calorie intake will increase the weight for height of individuals by about 13.6% in 2SLS estimate and 3% in OLS estimate), implies that PRH's 2SLS estimate of calorie elasticity could be potentially biased upward. As discussed above, the validity of PRH instruments is questionable as head's schooling seems to have a significant direct effect on males (non-HEIO) health outcome, while wife's education (not controlled in PRH) seems to positively and significantly[18] affect females' health outcomes in OLS estimates. These effects are not identifiable in IFE estimates as they are absorbed in household fixed effects. Another PRH instrument, household landholding seems to significantly affect males' (in HEIO) health outcomes in IFE estimate. All these in turn may imply that perhaps the inequality in calorie distribution due to inequality in energy intensity of labor market activities is overemphasized in PRH analysis.

As regards other variables, economies of scale (in terms of household size, holding the household composition constant) in health production is observed for males (particularly for those in non-HEIO) but not for females. Health outcomes for males in HEIO only slightly worsens (by 3%), while that for males not in HEIO and females slightly improves (by 1-3%) in round 1 and 2 compared with round 4 (results not shown). As discussed above, IFE estimates of the coefficients of the health technology are used to construct a measure of unobserved health endowment, κ, which is used in the nutrient demand equations discussed below.

6.2 Intrahousehold Bargaining and Nutrient Allocation

Calorie, Protein, and Vitamin A: Table 4 presents the SUR_{LS} and SUR_{HFE} estimates of intrahousehold bargaining and allocation of calorie, protein, protein from animal sources (i.e., good quality protein), and vitamin A for boys, girls, male adolescents, female adolescents, female adults, male adults (omitted category), pregnant, and lactating females. As SUR_{LS} estimates could be biased (see Section 4), the analysis focuses on SUR_{HFE} estimates, while SUR_{LS} estimates are provided for comparison purposes. Spouses' assets at marriage and schooling are interacted with each of these age-gender-physical status categories to analyze whether a head's bargaining measures have significantly different effects on intrahousehold allocation of these nutrients than the corresponding bargaining measures of a wife. Given the caveats associated with education as a bargaining measure, I focus on bargaining based on assets measures although

[18]Throughout the paper, "significant" implies statistical significance at 10% level or lower, unless specifically mentioned otherwise.

I use spouses' education and the corresponding interaction terms to control for any potential correlation between education and assets of spouses.

Boys' and girls' calorie adequacy ratio are about 29% and 26% lower than that of adult males in SUR_{HFE} estimate, implying that girls have about 3% higher calorie adequacy ratio than boys. While adolescent males' calorie adequacy ratio are about 5% lower than that of adult males, there is no significant difference among the adequacy ratio of adolescent females, adult females and adult males. This pattern of within age-group gender difference, however, reverses for the allocation of protein, good quality protein[19] and vitamin A. Within each of the age-groups, a female's adequacy ration is significantly lower than that of a male for each of these nutrients. Compared to calorie adequacy ratio, the adequacy ratio for each of these nutrients for pregnant and lactating women are much lower than that of adult males (with the exception of pregnant womens' vitamin A adequacy ratio).

A wife's assets significantly and positively affect the calorie and protein adequacy ratio for girls, calorie adequacy ratio for male adolescents, protein and vitamin A adequacy ratio and allocation of good quality protein for female adolescents, and protein and vitamin A adequacy ratio for female adults. For example, doubling a wife's assets would increase the allocation of good quality protein for female adolescents by 6%. A head's assets, on the other hand, negatively and significantly affect the allocation of good quality protein for boys, girls, male adolescents, and female adolescents, and calorie adequacy ratio for male adolescents. For instance, doubling a head's asset would reduce the allocation of good quality protein for girls by 3% in household fixed effect estimates. Tests of unitary model for the equality of the effects of head's and wife's assets [20] (bottom panel of Table 4) provide evidence of significant intrahousehold bargaining for allocation of calorie, protein, and good quality protein for girls, calorie and good quality protein for male adolescents, total protein and good quality protein for female adolescents, and calorie and total protein for female adults with a positive association between a wife's assets and these allocations.

The effect of individual health endowment (κ) implies compensation for protein and vitamin A allocations with no significant effect on calorie allocation. Doubling an individual's endowment will roughly reduce the adequacy ratio of protein by 1.7% and vitamin A by 1.6%. Apart from vitamin A, at the initial level of income, individual intakes of these nutrients increase with the

[19]The term "adequacy ratio" is loosely used for good quality protein and haem-iron, for which it measures intake of good quality protein as a share of total protein requirement, and intake of haem iron as a share of total iron requirement.

[20]I test the complete set of restrictions for bargaining described in equations 10, 11, 12, and 13 for education and asset measures for each of the age-sex-pregnancy-lactating group, which are available upon request. As I focus on assets as the key bargaining measure, the discussion concentrates on the restrictions in equation 13 based on assets as the results are comparable between SUR_{LS} and SUR_{HFE} models.

increase in household income. The increase is most prominent for good quality protein. Although inelastic, the expenditure elasticity at the initial level of income is higher for total protein than total calorie intake. Household economies of scale appears to be significant for calorie and protein (in OLS estimates) and for vitamin A (in HFE estimates) intakes. In terms of agricultural seasonality, individual intakes of calorie, protein and good quality protein appear to be lowest in round 3.

Vitamin C, D and Iron: Table 5 presents the results of intrahousehold bargaining and individual allocation of vitamin C, D, iron, and haem iron. The adequacy ratio for all age-sex groups and pregnant and lactating women are significantly lower than that for adult males for each of these nutrients. Within each age-group, the adequacy ratio for males are significantly higher than that for females for each of these nutrients, while pregnant and lactating women have significantly lower adequacy ratio than adult males. For instance, based on fixed effect estimates adult females' iron adequacy ratio are about 93% lower than adult males', while the former's haem iron share is 108% lower than that of adult males. A pregnant woman's iron adequacy ration is 171% lower than that of an adult male, while her haem iron allocation (as a share of her total iron requirement) is about 178% lower than that for an adult male. Similarly, a female adolescent's iron adequacy ration is about 18% lower than that of a male adolescent, while her haem iron share is about 25% lower than that of a male adolescent. The degree of sex-disparity in iron allocation is comparatively lower among children as a boy's iron adequacy ration and haem iron share are about 9% higher than those of a girl. Among children, the magnitude of sex-disparity appears to be higher for vitamin C and D than iron.

Significant intrahousehold bargaining is observed for haem iron share for boys, male and female adolescents, and for lactating adolescents (see bottom panel of Table 5). A head's assets negatively affect the haem iron allocation for boys and adolescents, while a wife's assets has the opposite effect. For instance, doubling a wife's assets would increase the haem iron share by 10% for female adolescents while the corresponding increase in head's assets would decrease it by 1.5%.

The effect of κ implies that households tend to compensate for lower endowments. Doubling an individual's endowment would reduce his/her adequacy ratio of vitamin C by 1%, vitamin D by 2%, iron by 3%, and haem iron share by 2%, approximately. Among these nutrients, the expenditure elasticity seems to be highest for vitamin D at the initial level of income, while household economies of scale appears to be significant for vitamin C and iron intakes. Vitamin C intake appears to be significantly lower in all three rounds compared to round 4, while vitamin D consumption is about 16% lower in round 1 and 39% lower in round 3 than that in round 4.

Calcium, Niacin, Riboflavin, Thiamin, and Folate: Table 6 presents the results for this last set of nutrients. Based on fixed effect estimates, calcium adequacy ratio for boys are 15% higher than that for girls. The corresponding ratio for male adolescents are 11% higher than that for female adolescents, and adult females' calcium adequacy ratio are 32% lower than that of adult males. Compared with adult males, the situation for pregnant (83% lower) and lactating females (74% lower) are even worse. While female adults' niacin adequacy ratio are not significantly different from that of male adults, both pregnant and lactating women have 19% and 14% lower niacin adequacy ratio than that of adult males. Sex disparity among children is also significant with boys having higher niacin adequacy ration than girls. While pregnant women's riboflavin adequacy ratio are not significantly different from that of adult males, lactating women's adequacy ratio are 8% lower and female adults' ratio 13% lower than that of adult males. Boys' riboflavin adequacy ratio are 9% higher than girls'. Similar pattern of sex disparity across all age-sex-physical status groups is observed for thiamin and folate as well. For folate, while girls' adequacy ratio is not significantly different from that of adult males, boys' adequacy ratio are about 10% higher than that of adult males (and girls).

Evidence of significant intrahousehold bargaining appears (bottom panel of Table 6) for calcium allocation for male and female adolescents and female adults and riboflavin and thiamin allocations for male adolescents. A wife's assets as opposed to head's assets, positively affect each of these allocations. For instance, doubling a wife's assets would increase the calcium adequacy ratio for adult females by 4%, while the effect of corresponding increase in head's assets is not significantly different from zero.

Allocation of these nutrients also imply that households tend to compensate for low individual health endowments. Although inelastic, intakes of niacin and thiamin are positively associated with the increase in household expenditure at lower level of expenditure. OLS estimates also indicate significant economies of scale for individual consumption of these nutrients within the household. There does not appear to be a consistent pattern of seasonality, perhaps because seasonality varies for different foods. Compared to round 4, calcium intake is about 6% higher in round 1, niacin intake is about 7% higher in round 2 and 4% higher in round 3, riboflavin intake is 6.5% lower in round 3, folate intake is about 13% lower in round 3, and thiamin intake is about 9% higher in round 3.

7 Summary and Conclusion

In light of the growing concern about micronutrient malnutrition as a critical public policy issue, I attempt to extend the previous literature on intrahousehold food distribution by analyzing intrahousehold nutrient allocation in a bargaining framework. While the focus of the previous work has been on calorie allocation, I demonstrate that calorie intake may not necessarily be a sufficient metric of nutrient adequacy as micronutrient deficiency can co-exist with calorie adequacy. The gender disparity is more prominent in intrahousehold allocation of a range of critical nutrients than calorie allocation. Pregnant and lactating women appear to be most vulnerable as their intakes fall far short of their elevated requirements, which in turn might lead to nutrient deficiency of the newborns.

Previous work on intrahousehold food distribution has adopted a unitary framework, which has been rejected empirically for a wide range of outcomes in recent decades. PRH, an influential work in this genre, further have demonstrated that food distribution in a poor economy like Bangladesh is due to gender-disparity in the energy intensity of labor market activities in which health influences labor market productivity and returns for males but not for females. However, the individual fixed effect estimates of health technology in this paper indicate that PRH claim might be overemphasized as their estimate of the effect of calorie on individual's health outcomes might be biased upward due to unobserved household fixed effects. These unobserved effects also question the validity of PRH instruments used in reaching their conclusion. Moreover, as the nutrition literature suggests, while calorie intake is a direct function of calorie expenditure and thus of energy intensity of labor market activities, various nutrients analyzed in this paper need not.

In a bargaining framework, controlling for potential marriage market selection and unobserved household fixed effects, I demonstrate evidence of intrahousehold bargaining and positive effect of a wife's bargaining power as opposed to her husband's in the allocation of a number of critical nutrients for children and adolescents of both sexes and for adult females. Thus, my policy implication fundamentally differs from that based on a unitary framework. Based on a unitary framework, a key policy paradigm of the previous literature is to increase energy-intensive labor market opportunities for women, or to achieve economic development by transforming work activities to those in which linkages between food consumption and productivity are weak, which however, might increase within-group inequality for women due to wider variation in their economic activities. On the other hand, my findings imply that for any given level of economic development and household income, gender disparity (both between the sexes and within the adult women group) could be potentially reduced through increased women's bargaining power within the household achieved through various legal and policy changes that grant women more control over resources. This policy implication is consistent with a number of studies that provide evidence that more control of resources by women leads to an improvement in child health, nutrition, education, and on women's own well-being. Moreover, women's participation in the labor market, a key policy lever in the unitary framework itself is endogenous, and is an outcome of intrahousehold bargaining.

However, the change in a woman's bargaining power may affect marriages (and perhaps divorces). The measure of bargaining power used in this paper (assets at marriage) is largely determined by parental wealth, and in this society the norm is that parents arrange marriages for their offspring. Thus, future work perhaps could focus on how the policy change leading to increased female controls of resources could potentially affect household formation and dissolution and not just intrahousehold allocation in a traditional poor rural society.

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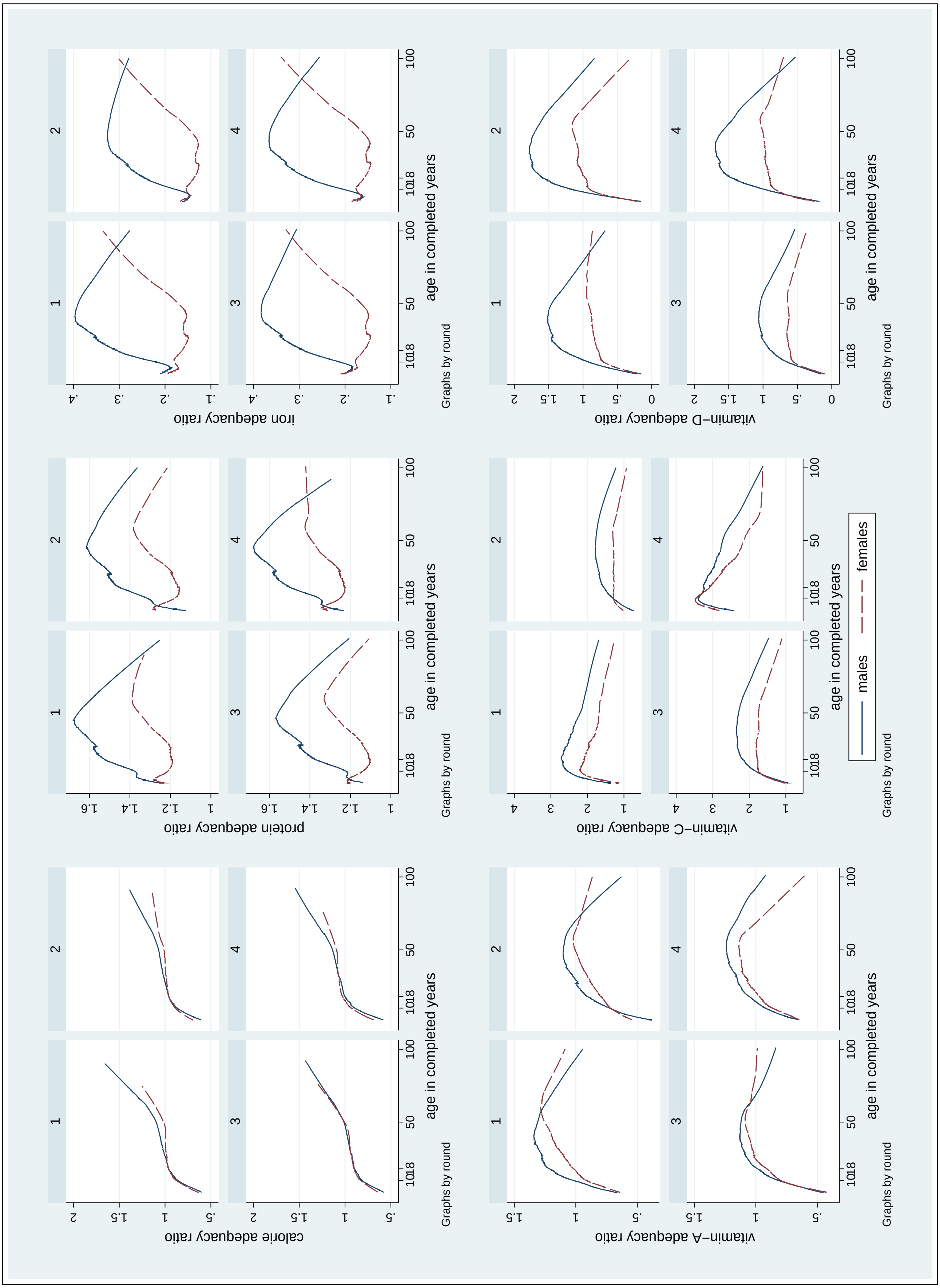

Figure 1: Adequacy Ratio, Lowess Fit, Bandwidth=0.8

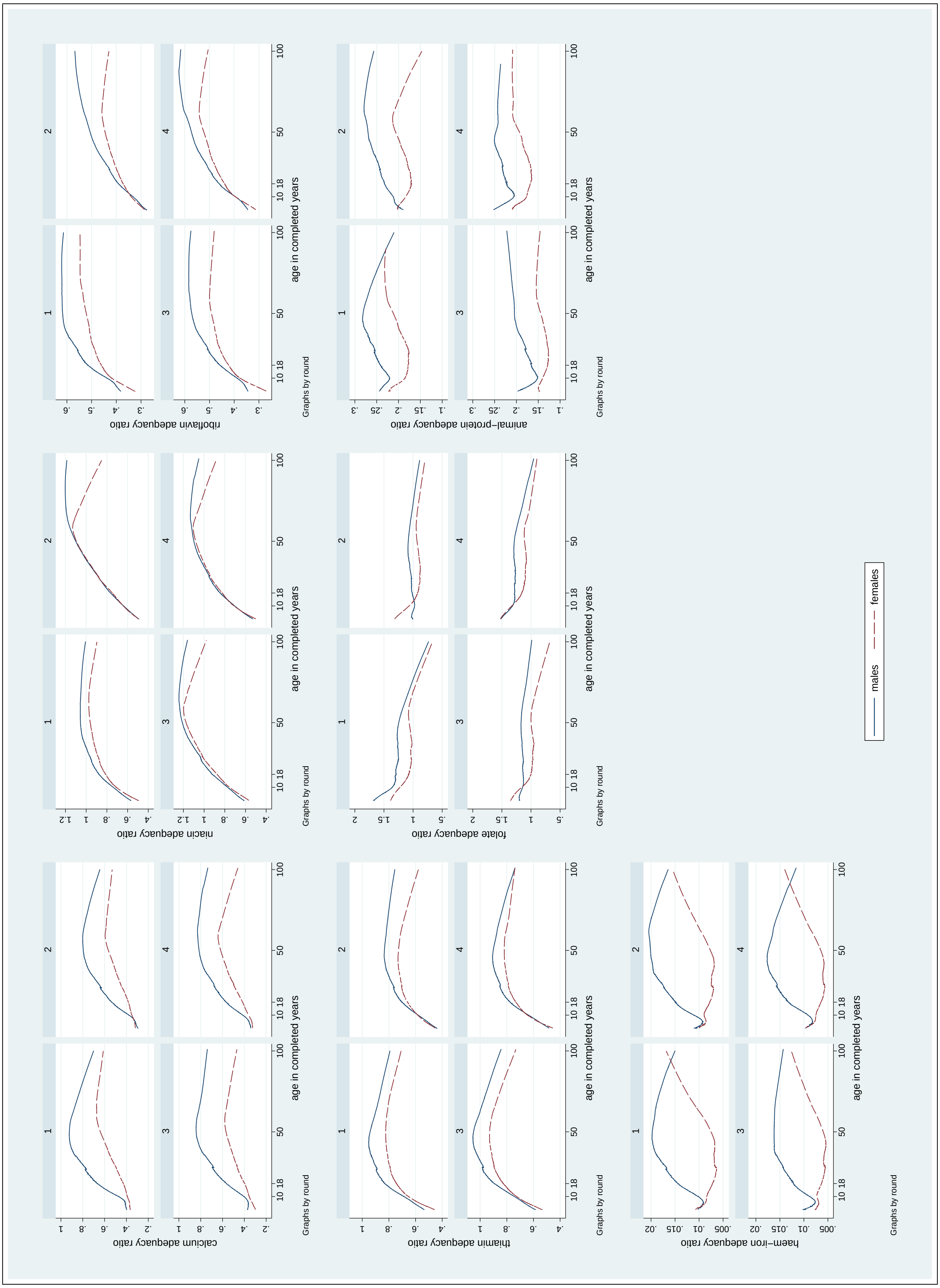

Figure 2: Adequacy Ratio, Lowess Fit, Bandwidth=0.8

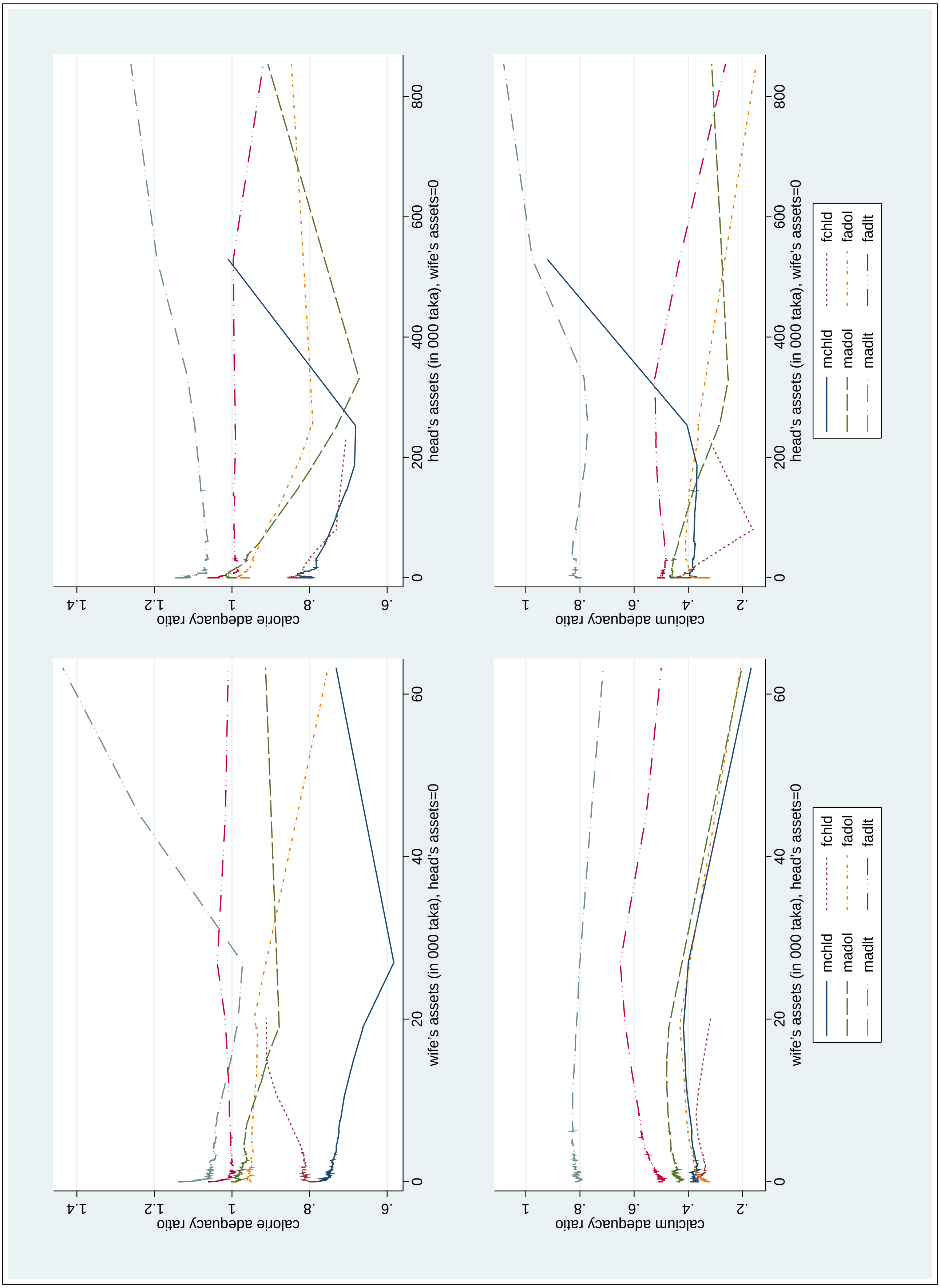

Figure 3: Adequacy Ratio & Spouses' Assets, Lowess Fit, Bandwidth=0.8

Note: mchld, male child, fchld, female child mdol, male adolescent, fadol, female adolescent, madlt, male adult, fadlt, female adult

Table 1: Descriptive Statistics of IFPRI and HES Samples

Variables	IFPRI								HES
	Round 1		Round 2		Round 3		Round 4		Rural
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean
HH size	6.57	2.98	6.54	2.94	6.46	2.79	6.40	2.79	5.25
Share of									
Boy	0.11	0.13	0.11	0.13	0.11	0.13	0.11	0.13	
Girl	0.10	0.13	0.10	0.13	0.10	0.13	0.10	0.13	
Madol	0.12	0.13	0.12	0.13	0.12	0.14	0.12	0.14	
Fadol	0.10	0.12	0.10	0.12	0.10	0.12	0.10	0.12	
Male adult	0.30	0.13	0.29	0.13	0.29	0.13	0.30	0.13	
Female adult	0.27	0.11	0.27	0.11	0.27	0.11	0.27	0.11	
Preg	71		64		55		67		
Lact	286		303		299		251		
W/H (kg/cm)									
Boy	0.139	0.026	0.141	0.025	0.141	0.026	0.142	0.045	
Girl	0.135	0.026	0.135	0.026	0.137	0.025	0.136	0.025	
Madol	0.221	0.044	0.225	0.046	0.228	0.045	0.227	0.044	
Fadol	0.231	0.048	0.233	0.047	0.233	0.045	0.233	0.047	
Male adult	0.299	0.036	0.298	0.036	0.298	0.035	0.300	0.053	
Female adult	0.280	0.038	0.277	0.038	0.279	0.038	0.282	0.040	
Mcapx	676.35	465.01	607.46	454.36	716.17	471.34	697.14	642.33	662.00
Lpc (acre)	0.22	0.25	0.23	0.26	0.23	0.26	0.23	0.27	
VUV of									
Rice	10.87	0.83	9.79	0.70	11.41	1.10	10.00	0.79	
Pulses	31.52	2.92	34.23	3.78	32.52	2.46	29.84	3.91	
Big fish	77.07	13.05	60.40	10.40	68.34	10.20	85.42	17.51	
Small fish	65.67	8.98	46.69	6.63	64.72	13.73	68.77	12.64	
Egg	64.95	7.29	78.03	10.31	65.32	8.22	69.24	9.48	
Pov rate (DCI)	Share of Individual Below the Poverty Line								
Abs poor	67.57		66.48		71.81		59.48		47.1
Hcore poor	42.53		45.69		48.82		37.46		24.6
Pov rate (CBN)	Share of Individual below								
	UPL	LPL	UPL	LPL	UPL	LPL	UPL	LPL	UPL
Site 1	0.54	0.36	66.81	53.25	50.24	32.02	54.65	38.86	55.2
Site 2	0.43	0.37	59.52	51.01	38.68	32.39	46.18	39.34	LPL
Site 3	0.53	0.33	62.29	47.58	51.72	37.98	54.37	35.74	38.5
	Time Invariant Household Characteristics								
Landless	4.75								5.5
< 1 acre	48.75								61.3
1 - < 2.5 acres	25.27								19
2.5 - < 7.5 acres	19.13								12
≥ 7.5 acres	2.1								2.2
Spouse charc.		Mean	Std		Mean	Std			
Age	Head	46.48	12.16	Wife	37.63	11.04			
Education	Head	3.50	4.16	Wife	1.74	2.79			
Assets	Head	32,266	149,113	Wife	2,683	10,704			
of which,									
housing	Head	2,364	6,624	Wife	184.29	2,044.36			
cattle	Head	7,178	29,758	Wife	479.74	3,322.83			
durables	Head	2,874	8,956	Wife	1,205.12	4,388.96			
food	Head	0	0	Wife	382.29	930.86			
land	Head	20,284	139,639	Wife	604.35	7,972.25			

Note: HH, household; Madol, male adolescent; Fadol, female adolescent; preg, pregnant; lact, lactating; W/H, weight for height; Mcapx, monthly per capita expenditure; lpc, land, per capita; vuv, village unit values; pov, poverty; abs, absolute; hcore, hardcore; CBN, cost of basic needs approach; DCI, direct calorie intake method; UPL, upper pov line; LPL, lower pov line; charc, characteristics; STD, standard deviation.

Table 2: Distribution of Calories and Energy Intensity of Occupation by Age and Sex

	Age<6		t test	6≤Age<12		t test	Age≥12		t test
	male	female	(p value)	male	female	(p value)	male	female	(p value)
IFPRI									
Mean Household Calorie Consumption	1,078	1,127	-0.39	1,802	1,635	2.70	2,800	2,163	22.13
			0.70			0.01			0.00
Mean Household Coefficient of Variation	0.32	0.27	0.60	0.18	0.15	1.50	0.18	0.15	3.62
			0.55			0.14			0.00
PRH			χ^2 (d.f.)			χ^2 (d.f.)			χ^2 (d.f.)
Mean Household Calorie Consumption	891	751	2.35	1,549	1,536	0.25	2,672	2,063	609.1
			(217)			(220)			(465)
Mean Household Coefficient of Variation	0.44	0.41	0.26	0.11	0.11	0.23	0.12	0.07	4.48
			(38)			(29)			(143)
Energy Intensity of Occupation, IFPRI					Percent				
Low	100	100		98.31	97.97		46.49	26.27	
Medium	0	0		0.54	1.45		4.83	71.85	
High	0	0		1.15	0.58		48.68	1.88	
Energy Intensity of Occupation, PRH					Percent				
Insignificant	98.7	99.3		70.5	69.1		26.8	20.6	
Light	1.3	0.7		28.8	25.6		22.6	8.5	
Moderate	0	0		0	4.5		2.82	68.2	
Very High	0	0		0.7	0.8		31.9	1.2	
Exceptionally High	0	0		0	0		15.90	1.50	
IFPRI	Age<10		t test	10≤Age<18		t test	Age≥18		t test
	male	female	(p value)	male	female	(p value)	male	female	(p value)
Mean Household Calorie Consumption	1,434	1,315	2.18	2,363	2,019	6.29	2,913	2,186	19.05
			0.03			0.00			0.00
Mean Household Coefficient of Variation	0.28	0.27	0.56	0.16	0.13	2.01	0.16	0.17	-0.14
			0.58			0.05			0.89
Energy Intensity of Occupation					Percent				
Low	99.78	99.48		77.8	75.72		38.96	14.1	
Medium	0.16	0.35		4.39	23.41		4.61	83.72	
High	0.05	0.17		17.81	0.87		56.42	2.18	

Table 3: Estimation of Health Technology: OLS and IFE

Variables	Dependent Variable: L (Individual's weight for height)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Male, HEIO		Male, not HEIO		Female	
	OLS	FE	OLS	FE	OLS	FE
L calorie	0.0513***	0.0067***	0.1097***	0.0054**	0.0760***	0.0054***
intake	(0.009)	(0.002)	(0.008)	(0.002)	(0.006)	(0.002)
preg					0.1197***	0.0333***
nant					(0.010)	(0.004)
lact					0.0653***	-0.0077**
ating					(0.008)	(0.004)
L mcapx	0.0827	0.0049	0.1384*	0.0078	0.0570	-0.0239
	(0.076)	(0.019)	(0.076)	(0.024)	(0.057)	(0.015)
(L mcapx)^2	-0.0044	-0.0003	-0.0085	-0.0007	-0.0024	0.0017
	(0.006)	(0.001)	(0.006)	(0.002)	(0.004)	(0.001)
L land	0.0108	0.0229*	0.0142	-0.0140	-0.0141	-0.0050
per capita	(0.012)	(0.012)	(0.015)	(0.024)	(0.011)	(0.011)
L household	0.0453***	0.0295**	0.0319**	-0.0079	0.0098	-0.0040
size	(0.012)	(0.013)	(0.014)	(0.020)	(0.011)	(0.012)
share of	-0.0798*	-0.0142	-0.2174***	-0.0464	-0.1576***	-0.0589**
boys	(0.043)	(0.026)	(0.047)	(0.031)	(0.040)	(0.026)
share of	-0.0748*	-0.0565**	-0.0330	-0.0178	-0.2523***	-0.0673***
girls	(0.043)	(0.024)	(0.050)	(0.032)	(0.039)	(0.025)
share of	-0.0033	-0.0309	-0.0891*	0.0031	-0.1077***	-0.0700***
madol	(0.047)	(0.025)	(0.048)	(0.029)	(0.040)	(0.024)
share of	-0.0062	-0.0490**	-0.0750	-0.0011	-0.0870**	-0.0063
fadol	(0.041)	(0.021)	(0.047)	(0.028)	(0.035)	(0.020)
share of	0.0425	0.0084	0.1949***	0.0418	-0.0003	-0.0129
madlt	(0.046)	(0.023)	(0.052)	(0.031)	(0.044)	(0.024)
head's	0.0017		0.0033***		0.0012	
schooling	(0.001)		(0.001)		(0.001)	
wife's	0.0011		0.0025		0.0046***	
schooling	(0.002)		(0.002)		(0.002)	
head's	-0.0087***		0.0019		0.0028	
age	(0.003)		(0.004)		(0.003)	
head's	0.0001***		-0.0000		-0.0000	
age^2	(0.000)		(0.000)		(0.000)	
wife's	0.0059*		-0.0067		-0.0046	
age	(0.003)		(0.004)		(0.003)	
wife's	-0.0001**		0.0001		0.0000	
age^2	(0.000)		(0.000)		(0.000)	
L hvpwed	-0.0005		-0.0022		-0.0007	
	(0.002)		(0.002)		(0.002)	
L wvpwed	0.0073*		0.0003		0.0007	
	(0.004)		(0.005)		(0.004)	
Constant	-5.6971***	-8.3137***	-3.8445***	-2.2452***	-3.6609***	-2.5293***
	(0.344)	(0.919)	(0.278)	(0.115)	(0.198)	(0.112)
Adj.R^2	0.370	0.125	0.821	0.128	0.753	0.146
Observations	2,815	2,815	4,565	4,565	7,305	7,305
Individuals	858	858	1436	1,436	2152	2,152

Note: HEIO, high energy intensive occupation; L natural log, mcapx, monthly per capita expenditure; madol, male adolescent; fadol, female adolescent; madlt, male adult; hvpwed, 1+head's assets; wvpwed, 1+wife's assets (both in 000; taka); additional controls are log age and its square; survey rounds and site dummies; robust standard errors are in parentheses clustered at individual level; *** significant at 1%, ** at 5%, and * at 1% level.

Table 4: Intrahousehold Bargaining and Calorie, Protein, and Vitamin A Allocations

VARIABLES	(1) Lcal SUR_{LS}	(2) Lcal SUR_{HFE}	(3) Lprot SUR_{LS}	(4) Lprot SUR_{HFE}	(5) Lanimprot SUR_{LS}	(6) Lanimprot SUR_{HFE}	(7) Lvita SUR_{LS}	(8) Lvita SUR_{HFE}
boy	-0.305***	-0.292***	-0.167***	-0.164***	-0.193***	-0.211***	-0.550***	-0.460***
	(0.030)	(0.030)	(0.027)	(0.025)	(0.063)	(0.050)	(0.061)	(0.050)
girl	-0.256***	-0.259***	-0.205***	-0.225***	-0.221***	-0.266***	-0.643***	-0.585***
	(0.032)	(0.032)	(0.029)	(0.027)	(0.067)	(0.054)	(0.071)	(0.057)
madol	-0.046*	-0.050**	-0.268***	-0.268***	-0.333***	-0.355***	-0.361***	-0.322***
	(0.024)	(0.024)	(0.022)	(0.021)	(0.056)	(0.046)	(0.054)	(0.044)
fadol	-0.030	-0.044	-0.358***	-0.373***	-0.556***	-0.512***	-0.376***	-0.383***
	(0.027)	(0.028)	(0.023)	(0.022)	(0.061)	(0.049)	(0.057)	(0.045)
fadlt	0.005	0.000	-0.146***	-0.143***	-0.344***	-0.297***	-0.115***	-0.089**
	(0.021)	(0.022)	(0.019)	(0.019)	(0.049)	(0.041)	(0.042)	(0.036)
preg	-0.106***	-0.111**	-0.281***	-0.317***	-0.451***	-0.518***	-0.081	-0.014
	(0.041)	(0.046)	(0.039)	(0.044)	(0.171)	(0.132)	(0.138)	(0.124)
lact	-0.048*	-0.010	-0.333***	-0.338***	-0.250***	-0.412***	-0.451***	-0.386***
	(0.025)	(0.026)	(0.023)	(0.024)	(0.077)	(0.059)	(0.074)	(0.057)
L hast ×	0.006	0.001	-0.002	-0.001	-0.049***	-0.024*	0.006	-0.009
boy	(0.009)	(0.008)	(0.008)	(0.008)	(0.019)	(0.015)	(0.022)	(0.017)
L wast ×	-0.016	-0.009	-0.015	-0.003	0.012	0.047	-0.001	-0.000
boy	(0.025)	(0.024)	(0.020)	(0.020)	(0.042)	(0.036)	(0.037)	(0.035)
L hast ×	0.003	0.003	-0.000	-0.001	-0.034	-0.030*	-0.008	0.018
girl	(0.009)	(0.009)	(0.009)	(0.008)	(0.022)	(0.016)	(0.019)	(0.017)
L wast ×	0.027	0.040*	0.010	0.031*	0.034	0.057	0.059	0.051
girl	(0.021)	(0.021)	(0.018)	(0.017)	(0.049)	(0.041)	(0.049)	(0.045)
L hast ×	-0.014**	-0.013**	-0.001	-0.001	-0.012	-0.027**	-0.004	-0.001
madol	(0.006)	(0.006)	(0.006)	(0.006)	(0.016)	(0.012)	(0.016)	(0.012)
L wast ×	0.029*	0.029*	0.021	0.018	0.023	0.035	0.035	0.022
madol	(0.016)	(0.016)	(0.013)	(0.012)	(0.036)	(0.027)	(0.030)	(0.024)
L hast ×	-0.001	-0.001	0.005	0.000	-0.019	-0.028*	0.014	0.010
fadol	(0.008)	(0.008)	(0.007)	(0.006)	(0.017)	(0.015)	(0.017)	(0.012)
L wast ×	0.015	0.030*	0.002	0.029**	0.060*	0.060**	0.002	0.057*
fadol	(0.017)	(0.018)	(0.015)	(0.013)	(0.036)	(0.028)	(0.035)	(0.031)
L hast ×	-0.007	-0.007	0.006	0.004	0.005	-0.008	0.012	0.015
fadlt	(0.006)	(0.006)	(0.005)	(0.005)	(0.012)	(0.011)	(0.012)	(0.011)
L wast ×	0.013	0.020	0.021*	0.027**	0.040	0.033	0.034	0.039*
fadlt	(0.014)	(0.014)	(0.012)	(0.011)	(0.027)	(0.027)	(0.022)	(0.021)
L hast ×	0.027	0.022	0.016	0.017	0.069	0.084*	-0.032	-0.054
preg	(0.017)	(0.019)	(0.019)	(0.019)	(0.054)	(0.046)	(0.070)	(0.069)
L wast ×	0.016	0.022	-0.006	0.020	0.002	0.055	-0.024	-0.032
preg	(0.029)	(0.036)	(0.026)	(0.032)	(0.135)	(0.135)	(0.093)	(0.087)
L hast ×	0.006	-0.005	-0.009	-0.013*	-0.017	0.006	-0.019	-0.025
lact	(0.009)	(0.009)	(0.008)	(0.008)	(0.025)	(0.020)	(0.025)	(0.018)
L wast ×	-0.022	-0.049*	-0.003	-0.030	-0.005	0.010	-0.055	-0.064
lact	(0.022)	(0.030)	(0.021)	(0.029)	(0.055)	(0.051)	(0.057)	(0.047)

Table 4: Intrahousehold Bargaining and Calorie, Protein, and Vitamin A Allocations

VARIABLES	(1) Lcal SUR_{LS}	(2) Lcal SUR_{HFE}	(3) Lprot SUR_{LS}	(4) Lprot SUR_{HFE}	(5) Lanimprot SUR_{LS}	(6) Lanimprot SUR_{HFE}	(7) Lvita SUR_{LS}	(8) Lvita SUR_{HFE}
L hast	0.001		-0.001		0.023**		0.015	
	(0.005)		(0.004)		(0.012)		(0.010)	
L wast	-0.028**		-0.022**		-0.007		-0.014	
	(0.012)		(0.011)		(0.024)		(0.022)	
κ	0.000	0.001	-0.019***	-0.017***	-0.005	-0.005	-0.004	-0.016***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.007)	(0.005)	(0.007)	(0.005)
L mcapx	0.435***	0.300*	0.478***	0.526***	2.074***	1.405*	0.509	0.019
	(0.152)	(0.168)	(0.168)	(0.181)	(0.575)	(0.748)	(0.444)	(0.608)
(L macapx)^2	-0.026**	-0.016	-0.030**	-0.032**	-0.126***	-0.089	-0.032	0.003
	(0.011)	(0.012)	(0.013)	(0.013)	(0.043)	(0.055)	(0.033)	(0.045)
L landpc	0.052***	-0.067	0.025	-0.142	0.021	-0.236	-0.072	0.457
	(0.018)	(0.107)	(0.017)	(0.113)	(0.057)	(0.436)	(0.055)	(0.407)
L hhsz	0.030*	0.048	0.041**	-0.032	0.074	-0.249	0.049	0.824*
	(0.018)	(0.108)	(0.020)	(0.121)	(0.064)	(0.496)	(0.057)	(0.452)
round1	-0.021	-0.020	0.027*	0.019	0.166***	0.123**	0.020	0.051
	(0.014)	(0.015)	(0.015)	(0.015)	(0.057)	(0.062)	(0.056)	(0.060)
round2	0.036	0.054**	0.057**	0.062**	0.177**	0.008	-0.206**	-0.239**
	(0.023)	(0.025)	(0.024)	(0.026)	(0.081)	(0.089)	(0.085)	(0.095)
round3	-0.080***	-0.083***	-0.045**	-0.064***	-0.146**	-0.215***	-0.137**	-0.098
	(0.018)	(0.020)	(0.020)	(0.021)	(0.067)	(0.079)	(0.065)	(0.075)
Constant	-2.413***	-2.309***	-1.303*	-2.192***	-5.716**	-4.652	-5.875***	-5.709*
	(0.611)	(0.766)	(0.673)	(0.832)	(2.481)	(3.571)	(2.030)	(3.148)
Observations	10,555	10515	10,555	10515	10,555	10515	10,555	10515
test of equation 13 for L hast=L wast, for :								
boy	0.429	0.701	0.557	0.956	0.193	0.065	0.867	0.820
girl	0.282	0.103	0.610	0.103	0.221	0.059	0.220	0.513
madol	0.012	0.015	0.123	0.152	0.402	0.045	0.235	0.416
fadol	0.412	0.108	0.886	0.046	0.057	0.009	0.761	0.150
fadlt	0.189	0.084	0.283	0.064	0.279	0.196	0.404	0.318
preg, fadol	0.902	0.484	0.490	0.419	0.933	0.684	0.975	0.554
preg, fadlt	0.806	0.513	0.821	0.491	0.824	0.936	0.800	0.681
lact, fadol	0.679	0.669	0.894	0.702	0.213	0.126	0.482	0.881
lact, fadlt	0.742	0.533	0.370	0.813	0.350	0.324	0.771	0.705

Note: Robust standard errors clustered at the household level are in brackets. *** p<0.01, ** p<0.05, * p<0.1; cal, calorie adequacy ratio; prot, protein adequacy ratio; animprot, animal protein intake/total protein requirement; vita, vitamin A adequacy ratio; L, natural log; madol, male adolescent; fadol, female adolescent; fadlt, female adult; preg, pregnant; lact, lactating; hast, 1+husband's assets; wast, 1+wife's assets; mcapx, monthly per capita expenditure; landpc, per capita land; hhsz, household size; κ, individual health endowment; additional controls (not shown) are discussed in section 4.

Table 5: Intrahousehold Bargaining and Vitamin C, D, and Iron Allocations

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	Lvitc	Lvitc	Lvitd	Lvitd	Liron	Liron	Lanimiron	Lanimiron
	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}
boy	-0.350***	-0.293***	-1.026***	-0.942***	-0.673***	-0.624***	-0.630***	-0.636***
	(0.054)	(0.045)	(0.096)	(0.077)	(0.035)	(0.035)	(0.065)	(0.055)
girl	-0.471***	-0.401***	-1.087***	-1.055***	-0.740***	-0.713***	-0.690***	-0.722***
	(0.059)	(0.054)	(0.112)	(0.097)	(0.042)	(0.040)	(0.072)	(0.058)
madol	-0.103**	-0.103***	-0.135*	-0.132**	-0.516***	-0.506***	-0.512***	-0.559***
	(0.041)	(0.036)	(0.072)	(0.059)	(0.036)	(0.037)	(0.061)	(0.054)
fadol	-0.164***	-0.197***	-0.379***	-0.341***	-0.699***	-0.690***	-0.833***	-0.804***
	(0.045)	(0.037)	(0.082)	(0.062)	(0.041)	(0.041)	(0.065)	(0.058)
fadlt	-0.328***	-0.322***	-0.350***	-0.323***	-0.951***	-0.925***	-1.122***	-1.082***
	(0.035)	(0.030)	(0.064)	(0.051)	(0.029)	(0.029)	(0.051)	(0.044)
preg	-0.438***	-0.351***	-1.598***	-1.589***	-1.678***	-1.710***	-1.777***	-1.776***
	(0.114)	(0.119)	(0.209)	(0.168)	(0.076)	(0.072)	(0.164)	(0.135)
lact	-0.394***	-0.296***	-1.202***	-1.188***	-0.365***	-0.358***	-0.254***	-0.409***
	(0.057)	(0.047)	(0.108)	(0.086)	(0.038)	(0.036)	(0.079)	(0.058)
L hast ×	0.046**	0.018	0.008	-0.012	0.008	-0.005	-0.056***	-0.031**
boy	(0.020)	(0.015)	(0.030)	(0.025)	(0.010)	(0.010)	(0.021)	(0.016)
L wast ×	-0.024	-0.021	-0.013	0.007	-0.005	-0.010	0.039	0.037
boy	(0.036)	(0.034)	(0.078)	(0.070)	(0.021)	(0.022)	(0.042)	(0.036)
L hast ×	0.015	-0.001	-0.014	-0.025	0.006	0.006	-0.025	-0.023
girl	(0.020)	(0.018)	(0.035)	(0.028)	(0.011)	(0.010)	(0.022)	(0.016)
L wast ×	0.057	0.074*	-0.084	-0.021	-0.005	0.021	0.025	0.045
girl	(0.043)	(0.044)	(0.093)	(0.092)	(0.023)	(0.021)	(0.051)	(0.045)
L hast ×	-0.009	0.003	-0.006	-0.028*	-0.015	-0.013	-0.030*	-0.033**
madol	(0.014)	(0.011)	(0.020)	(0.015)	(0.010)	(0.010)	(0.017)	(0.014)
L wast ×	0.047*	0.033*	0.019	-0.004	0.041*	0.024	0.027	0.045
madol	(0.025)	(0.018)	(0.046)	(0.036)	(0.023)	(0.022)	(0.038)	(0.033)
L hast ×	0.010	0.018*	-0.002	-0.009	0.027**	0.018	-0.010	-0.015
fadol	(0.014)	(0.010)	(0.021)	(0.016)	(0.013)	(0.012)	(0.019)	(0.017)
L wast ×	-0.039	0.029	0.075	0.053	0.027	0.050*	0.111***	0.096***
fadol	(0.034)	(0.027)	(0.047)	(0.038)	(0.029)	(0.028)	(0.040)	(0.035)
L hast ×	0.018*	0.022**	0.010	0.008	0.002	0.001	-0.008	-0.015
fadlt	(0.009)	(0.009)	(0.015)	(0.013)	(0.006)	(0.006)	(0.012)	(0.011)
L wast ×	0.056**	0.058***	0.012	0.013	-0.006	-0.003	0.018	0.005
fadlt	(0.022)	(0.021)	(0.033)	(0.032)	(0.014)	(0.014)	(0.026)	(0.026)
L hast ×	-0.024	-0.025	0.106	0.186***	-0.001	0.007	0.073	0.077
preg	(0.059)	(0.056)	(0.085)	(0.065)	(0.039)	(0.034)	(0.054)	(0.047)
L wast ×	0.062	0.034	0.153	0.132	-0.009	0.041	-0.115	-0.048
preg	(0.077)	(0.079)	(0.138)	(0.117)	(0.039)	(0.040)	(0.162)	(0.172)
L hast ×	-0.007	-0.038**	0.060*	0.019	-0.006	-0.013	-0.017	0.004
lact	(0.020)	(0.016)	(0.035)	(0.031)	(0.012)	(0.011)	(0.025)	(0.019)
L wast ×	-0.101*	-0.089*	0.000	-0.015	-0.001	-0.021	-0.006	0.026
lact	(0.054)	(0.048)	(0.077)	(0.069)	(0.029)	(0.038)	(0.057)	(0.052)

Table 5: Intrahousehold Bargaining and Vitamin C, D, and Iron Allocations

VARIABLES	(9) Lvitc SUR_{LS}	(10) Lvitc SUR_{HFE}	(11) Lvitd SUR_{LS}	(12) Lvitd SUR_{HFE}	(13) Liron SUR_{LS}	(14) Liron SUR_{HFE}	(15) Lanimiron SUR_{LS}	(16) Lanimiron SUR_{HFE}
L hast	0.010		-0.010		-0.006		0.021*	
	(0.009)		(0.018)		(0.006)		(0.012)	
L wast	-0.038*		-0.027		-0.009		0.006	
	(0.020)		(0.039)		(0.013)		(0.024)	
κ	-0.003	-0.013***	-0.019*	-0.019***	-0.023***	-0.027***	-0.015**	-0.016**
	(0.005)	(0.004)	(0.010)	(0.007)	(0.004)	(0.004)	(0.008)	(0.006)
L mcapx	0.878**	0.620	2.797***	2.512**	0.492*	0.150	2.060***	0.917
	(0.397)	(0.485)	(0.939)	(1.169)	(0.254)	(0.262)	(0.586)	(0.721)
(L macapx)^2	-0.056*	-0.040	-0.186***	-0.178**	-0.029	-0.006	-0.122***	-0.052
	(0.030)	(0.036)	(0.071)	(0.088)	(0.019)	(0.019)	(0.044)	(0.054)
L landpc	-0.028	0.605*	-0.022	0.204	0.022	0.005	-0.023	-0.172
	(0.046)	(0.337)	(0.083)	(0.584)	(0.026)	(0.173)	(0.060)	(0.421)
L hhsz	0.042	0.999***	0.054	0.406	0.068**	0.085	0.062	-0.308
	(0.049)	(0.369)	(0.099)	(0.651)	(0.028)	(0.181)	(0.067)	(0.476)
round1	-0.249***	-0.236***	-0.083	-0.160*	0.039*	0.022	0.146**	0.092
	(0.044)	(0.047)	(0.086)	(0.090)	(0.023)	(0.024)	(0.058)	(0.061)
round2	-0.423***	-0.375***	0.025	-0.123	-0.013	0.008	0.207**	0.061
	(0.066)	(0.071)	(0.124)	(0.139)	(0.035)	(0.037)	(0.084)	(0.092)
round3	-0.130**	-0.096*	-0.296***	-0.390***	0.014	-0.009	0.004	-0.094
	(0.051)	(0.058)	(0.110)	(0.121)	(0.030)	(0.031)	(0.066)	(0.076)
Constant	-7.229***	-6.942***	1.876	0.430	-3.344***	-3.220***	-9.033***	-7.312**
	(1.698)	(2.515)	(3.828)	(5.076)	(1.017)	(1.201)	(2.535)	(3.393)
Observations	10,555	10,515	10,555	10,515	10,555	10,515	10,555	10,515
P-value of the tests of equation 13 for L hast=L wast, for :								
boy	0.076	0.286	0.811	0.801	0.574	0.852	0.053	0.085
girl	0.404	0.130	0.494	0.968	0.679	0.530	0.385	0.170
madol	0.067	0.189	0.636	0.554	0.028	0.131	0.194	0.034
fadol	0.189	0.703	0.156	0.126	0.991	0.267	0.008	0.005
fadlt	0.121	0.117	0.961	0.880	0.596	0.775	0.407	0.495
pregnant, fadol	0.711	0.487	0.476	0.950	0.905	0.253	0.701	0.945
pregnant, fadlt	0.204	0.337	0.773	0.729	0.788	0.585	0.351	0.581
lactating, fadol	0.021	0.437	0.863	0.706	0.880	0.583	0.084	0.029
lactating, fadlt	0.221	0.704	0.399	0.656	0.930	0.725	0.476	0.367

Note: Robust standard errors clustered at the household level are in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$; vitc, vitamin C adequacy ratio; vitd, vitamin D adequacy ratio; iron, iron adequacy ratio; animiron, animal iron intake/total iron requirement; L, natural log; madol, male adolescent; fadol, female adolescent; fadlt, female adult; preg, pregnant; lact, lactating; hast, 1+husband's assets; wast, 1+wife's assets; mcapx, monthly per capita expenditure landpc, per capita land; hhsz, household size; κ, individual health endowment; additional controls (not shown) are discussed in section 4.

Table 6: Intrahousehold Bargaining and Calcium, Niacin, Riboflavin, Thiamin, and Folate Allocations

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
Vars	Lcalci	Lcalci	Lniac	Lniac	Lribo	Lribo	Lthia	Lthia	Lfola	Lfola
	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}	SUR_{LS}	SUR_{HFE}
boy	-0.795***	-0.772***	-0.463***	-0.446***	-0.431***	-0.411***	-0.434***	-0.415***	0.046	0.096***
	(0.039)	(0.036)	(0.031)	(0.030)	(0.030)	(0.028)	(0.029)	(0.028)	(0.041)	(0.034)
girl	-0.945***	-0.922***	-0.520***	-0.508***	-0.525***	-0.503***	-0.490***	-0.473***	-0.040	-0.013
	(0.047)	(0.044)	(0.035)	(0.033)	(0.035)	(0.031)	(0.034)	(0.032)	(0.045)	(0.038)
madol	-0.690***	-0.679***	-0.312***	-0.311***	-0.316***	-0.311***	-0.251***	-0.241***	-0.159***	-0.135***
	(0.036)	(0.034)	(0.026)	(0.027)	(0.026)	(0.024)	(0.024)	(0.023)	(0.035)	(0.029)
fadol	-0.787***	-0.793***	-0.240***	-0.253***	-0.239***	-0.247***	-0.186***	-0.197***	-0.109***	-0.118***
	(0.038)	(0.035)	(0.028)	(0.027)	(0.027)	(0.025)	(0.026)	(0.023)	(0.038)	(0.030)
fadlt	-0.330***	-0.320***	-0.028	-0.010	-0.145***	-0.128***	-0.098***	-0.075***	-0.190***	-0.166***
	(0.029)	(0.027)	(0.023)	(0.022)	(0.022)	(0.021)	(0.020)	(0.019)	(0.029)	(0.025)
preg	-0.837***	-0.830***	-0.134**	-0.188***	-0.093	-0.103	-0.144***	-0.192***	-0.975***	-0.953***
	(0.098)	(0.091)	(0.053)	(0.055)	(0.064)	(0.064)	(0.050)	(0.053)	(0.096)	(0.090)
lact	-0.774***	-0.743***	-0.132***	-0.142***	-0.087***	-0.078***	-0.136***	-0.131***	-0.367***	-0.358***
	(0.047)	(0.036)	(0.032)	(0.030)	(0.030)	(0.027)	(0.028)	(0.026)	(0.047)	(0.038)
L hast ×	0.003	-0.004	0.004	0.001	0.006	0.002	0.011	0.005	0.007	-0.007
boy	(0.013)	(0.011)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.008)	(0.013)	(0.011)
L wast ×	0.013	0.024	-0.017	-0.018	-0.002	0.013	-0.016	-0.007	-0.025	-0.006
boy	(0.023)	(0.024)	(0.026)	(0.025)	(0.021)	(0.021)	(0.022)	(0.021)	(0.022)	(0.023)
L hast ×	0.000	0.008	0.006	0.004	0.006	0.010	0.004	0.004	0.007	0.013
girl	(0.014)	(0.012)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)	(0.013)	(0.011)
L wast ×	0.068*	0.064*	0.005	0.023	0.053**	0.046**	0.004	0.028	0.017	0.037
girl	(0.035)	(0.034)	(0.021)	(0.022)	(0.022)	(0.022)	(0.020)	(0.020)	(0.033)	(0.030)
L hast ×	-0.003	-0.008	-0.012*	-0.008	-0.009	-0.008	-0.010	-0.008	-0.012	-0.009
madol	(0.011)	(0.009)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.011)	(0.008)
L wast ×	0.043**	0.042**	0.017	0.015	0.030**	0.029**	0.025*	0.015	0.032	0.013
madol	(0.021)	(0.018)	(0.015)	(0.015)	(0.014)	(0.013)	(0.014)	(0.012)	(0.022)	(0.015)
L hast ×	0.016	0.008	0.007	0.005	0.010	0.004	0.009	0.005	0.010	0.003
fadol	(0.012)	(0.010)	(0.008)	(0.007)	(0.009)	(0.007)	(0.008)	(0.006)	(0.011)	(0.008)
L wast ×	-0.007	0.054**	-0.014	0.010	-0.006	0.029	-0.013	0.015	-0.041	0.014
fadol	(0.028)	(0.025)	(0.019)	(0.018)	(0.020)	(0.018)	(0.018)	(0.014)	(0.027)	(0.020)
L hast ×	0.014*	0.010	0.015**	0.015**	0.009	0.006	0.008	0.006	0.014*	0.015**
fadlt	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)
L wast ×	0.038**	0.043***	0.014	0.019	0.022*	0.026**	0.019	0.024**	0.027*	0.023
fadlt	(0.015)	(0.014)	(0.015)	(0.014)	(0.012)	(0.012)	(0.012)	(0.011)	(0.016)	(0.015)
L hast ×	0.004	0.000	0.016	0.023	0.001	-0.003	0.020	0.028	-0.012	-0.003
preg	(0.053)	(0.049)	(0.025)	(0.027)	(0.034)	(0.034)	(0.027)	(0.023)	(0.050)	(0.042)
L wast ×	-0.016	-0.013	0.047	0.095*	-0.025	-0.002	-0.012	0.033	0.053	0.077
preg	(0.058)	(0.055)	(0.053)	(0.052)	(0.043)	(0.040)	(0.044)	(0.037)	(0.057)	(0.057)
L hast ×	-0.021	-0.025**	-0.004	-0.012	-0.011	-0.012	-0.003	-0.011	-0.031*	-0.036***
lact	(0.016)	(0.012)	(0.012)	(0.011)	(0.011)	(0.010)	(0.010)	(0.008)	(0.017)	(0.013)
L wast ×	-0.039	-0.041	-0.001	-0.031	-0.018	-0.028	0.001	-0.020	-0.037	-0.019
lact	(0.038)	(0.034)	(0.027)	(0.037)	(0.026)	(0.031)	(0.023)	(0.030)	(0.037)	(0.035)

Table 6: Intrahousehold Bargaining and Calcium, Niacin, Riboflavin, Thiamin, and Folate Allocations

Vars	(17) Lcalci SUR_{LS}	(18) Lcalci SUR_{HFE}	(19) Lniac SUR_{LS}	(20) Lniac SUR_{HFE}	(21) Lribo SUR_{LS}	(22) Lribo SUR_{HFE}	(23) Lthia SUR_{LS}	(24) Lthia SUR_{HFE}	(25) Lfola SUR_{LS}	(26) Lfola SUR_{HFE}
L hast	0.010		-0.005		0.004		-0.005		0.003	
	(0.007)		(0.006)		(0.005)		(0.005)		(0.007)	
L wast	-0.013		-0.024*		-0.020*		-0.017		0.000	
	(0.016)		(0.013)		(0.012)		(0.013)		(0.017)	
κ	-0.012***	-0.016***	-0.017***	-0.018***	-0.010***	-0.013***	-0.011***	-0.014***	-0.004	-0.010***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)
L mcapx	0.638*	-0.090	0.911***	0.591***	0.720***	0.367	0.731***	0.464**	0.393	0.183
	(0.328)	(0.356)	(0.199)	(0.209)	(0.235)	(0.261)	(0.221)	(0.226)	(0.329)	(0.382)
(L mac	-0.035	0.016	-0.060***	-0.038**	-0.044**	-0.021	-0.046***	-0.029*	-0.018	-0.007
apx)^2	(0.025)	(0.026)	(0.015)	(0.015)	(0.018)	(0.019)	(0.017)	(0.017)	(0.025)	(0.028)
L landpc	0.015	0.184	0.036*	-0.001	0.014	-0.017	0.017	0.003	0.016	0.157
	(0.035)	(0.219)	(0.020)	(0.127)	(0.022)	(0.166)	(0.020)	(0.140)	(0.036)	(0.255)
L hhsz	0.085**	0.374	0.083***	0.110	0.066***	0.125	0.064***	0.121	0.095**	0.254
	(0.035)	(0.244)	(0.024)	(0.133)	(0.025)	(0.192)	(0.024)	(0.148)	(0.040)	(0.280)
round1	0.046	0.064*	-0.018	-0.035*	0.018	0.015	0.013	-0.003	-0.069*	-0.049
	(0.034)	(0.035)	(0.018)	(0.019)	(0.022)	(0.024)	(0.019)	(0.020)	(0.036)	(0.037)
round2	0.049	0.008	0.053*	0.067**	-0.022	-0.017	0.029	0.043	-0.136***	-0.106*
	(0.050)	(0.053)	(0.030)	(0.031)	(0.035)	(0.038)	(0.031)	(0.032)	(0.051)	(0.056)
round3	-0.013	0.012	0.070***	0.042*	-0.058**	-0.065**	0.113***	0.089***	-0.165***	-0.127***
	(0.041)	(0.044)	(0.024)	(0.025)	(0.028)	(0.031)	(0.025)	(0.027)	(0.043)	(0.047)
Const.	-6.956***	-5.018***	-3.636***	-3.516***	-5.121***	-4.479***	-3.328***	-3.245***	-2.211*	-0.463
	(1.371)	(1.781)	(0.806)	(0.980)	(0.951)	(1.253)	(0.860)	(1.032)	(1.340)	(1.773)
Obs.	10,555	10,515	10,555	10,515	10,555	10,515	10,555	10,515	10,555	10,515
P-value of the tests of equation 13 for L hast=L wast, for :										
boy	0.717	0.320	0.458	0.486	0.731	0.653	0.260	0.616	0.189	0.984
girl	0.078	0.132	0.957	0.429	0.069	0.151	0.987	0.285	0.801	0.446
madol	0.065	0.016	0.095	0.188	0.017	0.012	0.031	0.089	0.081	0.226
fadol	0.456	0.089	0.330	0.823	0.481	0.195	0.283	0.520	0.092	0.606
fadlt	0.176	0.044	0.946	0.769	0.368	0.148	0.384	0.146	0.465	0.627
preg, fadol	0.606	0.687	0.880	0.247	0.475	0.654	0.370	0.762	0.863	0.218
preg, fadlt	0.961	0.800	0.640	0.219	0.801	0.721	0.712	0.622	0.326	0.219
lact, fadol	0.402	0.468	0.633	0.727	0.505	0.807	0.542	1.000	0.230	0.496
lact, fadlt	0.878	0.608	0.927	0.689	0.829	0.931	0.495	0.766	0.862	0.466

Note: Robust standard errors clustered at the household level are in brackets. *** p<0.01, ** p<0.05, * p<0.1.
calci, calcium adequacy ratio; niac, niacin adequacy ratio; ribo, riboflavin adequacy ratio; thiamin adequacy ratio; fola, folate adequacy ratio; L, natural log; madol, male adolescent; fadol, female adolescent; fadlt, female adult; preg, pregnant; lact, lactating; hast, 1+husband's assets; wast, 1+wife's assets; mcapx, monthly per capita expenditure landpc, per capita land; hhsz, household size; κ, individual health endowment; obs, observations; additional controls (not shown) are discussed in section 4.

Appendix

Construction of Adequacy Ratio for different Age-Gender Group for Calorie and Other Nutrients

Calorie Requirement, RDA_i^{cal}: As is well-known in nutrition literature, among the nutrients analyzed here, only an individual's calorie requirement depends on his/her energy expenditure. At a given age, the main component of the energy requirement is the BMR. The relationship of the energy expenditure of a given level of physical activity to BMR is affected by the metabolic constant, mc of that activity, body weight, and age. For ages 18 years and above, the energy requirement calculation proceeds as follows. First, I calculate the BMR from body weight of individuals based on the methodology described in World Health Organization (1985) (henceforth, WHO methodology)[21]. Utilising 24-hour time allocation data of individuals (for a subset of individuals, this data is available in the survey), energy requirement for different activities are then calculated as : $t_a \times mc_a \times BMR$, where t_a is time (in minutes) spent in an activity, a. Total energy requirement for individuals of age 18 years and older is the sum of his/her energy requirement in different activities in 24 hours (including sleep). Based on WHO methodology, an allowance of 285 kcal is given for pregnancy and 500 kcal for lactating status.

Energy requirement for children is estimated directly from the observed intakes of healthy children growing normally. These requirements for each age are given in World Health Organization (1985) and are based on the United States National Center for Health Statistics, NCHS, referenced children sample[22]. Finally, as time allocation data is scarce for adolescent group in IFPRI sample, the calorie requirement data of the reference NCHS adolescent group as reported in World Health Organization (1985) is used as proxy for calorie requirement of adolescent group in IFPRI data[23].

Protein and Micronutrient Requirements: While the main determinants of energy requirement are body weight, age, and physical activity, for protein requirement, the determinants are only body weight and age, and not physical activity. Moreover, measuring protein quantity is not enough, as protein quality is also important. Good quality proteins are those that provide adequate amounts of essential amino acids and have a high degree of digestibility. These conditions are satisfied by the proteins in egg, milk, meat, and fish[24]. A correction is required for digestibility and amino acid score for protein from all other sources when analysing the protein requirement[25]. I use the protein requirement figures for different age-sex groups (corrected for requirements) with necessary allowance for pregnancy and lactation from Food and Agriculture Organization (2009)[26].

[21]BMR (in kilocalorie per day) of different age-sex groups are predicted based on the following equations: (i) males (18-30 years): $15.3W + 679$, (ii) males (30-60 years): $11.6W + 879$, (iii) males (> 60 years): $13.5W + 487$; (iv) females (18-30 years): $14.7W + 496$, (v) females (30-60 years): $8.7W + 829$, and (vi) females (> 60 years): $10.5W + 596$, where W is the body weight in kilograms.

[22]The rationale for using NCHS referenced sample of children are many. First, for young infants and children, requirement for growth is a substantial component of the total requirement for energy and there are large variations within the normal range of the rate of growth among children. Second, for both infants and children, it is not possible to specify with any confidence the allowance that should be made for a desirable level of physical activity. Third, while time spent in all types of physical activities need to be known in order to calculate total energy expenditure, that information is generally not available. Finally, while children in many developing countries are smaller at birth than those in industrialized countries and grow at a slower rate during infancy and early childhood, the evidence suggests that in young children these differences are mainly due to environmental factors including inadequate nutrition, and that genetic and ethnic factors are of lesser significance. Therefore, young children of different ethnic groups should be considered as having the same or similar growth potentials. Thus, it is desirable that the growth potential of children be fully expressed and provided for in energy and protein requirements (World Health Organization, 1985).

[23]If adolescents are engaged in more energy-intensive work in rural Bangladesh, then these requirement figures will be underestimation of actual requirements for this group.

[24]For example, while the protein from egg, milk, meat, or fish has 100% digestibility relative to reference proteins the digestibility of an Indian rice and beans diet is only 82%.

[25]These corrections can be applied either to the requirement or the dietary protein intake. The total protein content of the diet = total N(nitrogen)$\times$ 6.25. The biological value of the diet = total protein $\times$ digestibility factor $\times$ amino acid score. The digestibility factor is the digestibility relative to that of the reference protein (e.g., egg, milk, meat, or fish), expressed as a percentage. The amino acid score expresses the amino acid pattern as a percentage of the appropriate reference pattern for each age group. These corrected intakes are then compared with the requirement. The corrected requirement in terms of the diet consumed is: standard requirement $\times \frac{1}{digestibility} \times \frac{1}{aminoacidscore}$. The corrected requirements are then compared with observed intakes. See World Health Organization (1985) for further discussions.

[26]The requirement is based on a diet containing a great deal of cereals, starchy roots and pulses (high fibre) and

Although required in small amounts, micronutrients are essential for life, and needed for a wide range of body functions and processes. Age-sex specific RDA figures (with pregnancy and lactating allowance) for different micronutrients are obtained from World Food Programme (2000). Analogous to quality of protein, sources of iron are important. Iron in meat (haem iron) is more easily absorbed than iron contained in plant foods (non-haem iron). Trace minerals from the meat sources have higher bio-availability and contribute to higher bio-availability of iron from plant sources. Similarly, nutrition literature indicates that minerals and vitamins from meat sources are more highly bio-available than from plant sources. Moreover, meat consumption can increase the bio-availability of minerals and vitamins contained in plant products when meats and plants are consumed concurrently. I use the iron requirement figures that assumes very low iron bioavailability as observed in South Asian Diet.

little complete (animal) protein as in the case of Bangladeshi diet.