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Nutrition Knowledge, Household Coping, and the Demand for Micronutrient-Rich Foods

Abstract

This study applies both parametric and non-parametric techniques to a new household data set from rural Indonesia to explain previous findings of a reduced-form relationship between nutrition knowledge and child micronutrient status. Households of mothers with and without nutrition knowledge allocate identical budget shares to food; yet, within the food budget, "knowledge" households allocate substantially larger shares to micronutrient-rich foods and smaller chares to rice than do "non-knowledge" households. Knowledge households are also less willing to sacrifice consumption of micronutrient-rich foods in the face of increased staple food prices than are non-knowledge households. Differences are not attributable to differences in maternal schooling.

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I. Introduction

Existing literature has clearly established the importance of maternal education as a determinant of the demand for child health. The bulk of this literature, however, is limited by the definition of child health as essentially synonymous with height-for-age. Block (2002) extends that literature to consider the demand for child micronutrient status. In that context, the distinction between maternal schooling and specific knowledge of nutrition becomes critical: foods' micronutrient content is essentially invisible, and micronutrient deficiencies in children may also be difficult to detect. Thus, demand for child micronutrient status may depend largely on maternal nutrition knowledge. Indeed, Block (2002) finds that maternal nutrition knowledge is a more central determinant of child micronutrient outcomes than is maternal schooling. Yet, simply establishing a reduced form relationship between maternal nutrition knowledge and child micronutrient outcomes sheds no light on *how* nutrition knowledge produces that result.

The present paper takes a more structural approach in analyzing a central mechanism through which nutrition knowledge may operate to result in improved child micronutrient status – the demand for micronutrient-rich foods.[1] Does nutrition knowledge affect household budget allocation between food and non-food? Within the food budget, does nutrition knowledge affect the allocation of spending on micronutrient-rich foods versus starchy staples? Do key demand parameters differ as a function of maternal nutrition knowledge? In particular, if staple food prices are volatile, do households' coping strategies differ as a function of nutrition knowledge? If the answer to any of these questions is yes,

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[1] "Micronutrient-rich foods" in this paper refers to a composite commodity constructed from household survey data. This composite good includes beef, fish, chicken, vegetables, fruits, milk, and eggs. The budget share for micronutrient-rich foods is thus the sum of households' expenditures on these commodities divided by total expenditures. Construction of the price of this composite commodity is discussed below. It is not possible with the present data set to convert total household food consumption into its micronutrient equivalents, as has been done in other studies. Indeed, doing so may introduce various forms of measurement error, as such conversions fail to address issues of bioavailability and the interaction effects of various micronutrients on their bioavailability.

then an investigation into the sources of maternal nutrition knowledge may have important policy implications. This paper applies both parametric and non-parametric techniques to recently collected household survey data from rural Central Java (Indonesia) to address these questions.

Awareness of micronutrient malnutrition has gained substantial prominence in recent years among nutritionists and public health specialists. Iron deficiency, for example, remains the world's most widespread micronutrient deficiency-related disease, affecting well over 2 billion people mostly in developing countries (WHO, 1992). In rural central Java (Indonesia), the focus of the present study, the prevalence of child anemia during 1999-2000 was 50 percent. In infants, iron deficiency has a permanent impact on mental development; iron deficiency at any age is associated with impaired cognitive performance, and has been shown to reduce resistance to infection and to adversely affect child development and growth (Bloem and Darnton-Hill, 2001). Severe anemia kills 30 percent of children who enter the hospital with it and do not receive an immediate blood transfusion (World Bank, 1994). Despite recent progress in combating other forms of "hidden hunger," such as vitamin A and iodine deficiency, progress in reducing the prevalence of iron deficiency anemia has lagged (Darnton-Hill, 1999).

While the humanitarian dimensions of this problem, themselves, justify increased analysis, those health effects also have important economic implications. Childhood anemia is associated with a reduction of one-half of one standard deviation on cognitive tests, which in turn has been found to reduce adult wages by 4% (Ross and Horton, 1998; Horton, 2001). The combination of cognitive loss and reduced productivity of physical labor resulting from iron deficiency has been estimated to be on the order of 1% of GDP in poor countries (and higher in the poorest countries). In South Asia, such a loss represents $5 billion annually

(Horton, 2001). It is curious, then, that economists have devoted relatively little attention to the determinants of micronutrient status and the demand for micronutrients.[2]

Maternal education has played a central role in empirical studies of the demand for child health (read, height). Behrman and Wolfe (1984, 1987), Barrera (1990), Alderman and Garcia (1994), Lavy, et.al. (1996), and others consistently find a strong positive association between maternal education and child height. Far fewer studies (Glewwe, 1999; Thomas, Strauss, and Henriques, 1990; Desai and Alva, 1998; and Christiaensen and Alderman, 2001) have extended the analysis to consider the mechanisms through which maternal education contributes to child height.

Thomas, Strauss, and Henriques (1990), find in a Brazilian sample that nearly all the impact of maternal schooling on child height could be explained by access to media, and that schooling and community health services are substitutes. Glewwe (1999) addresses this question with Moroccan data, considering three possible mechanisms: 1) the direct teaching of nutrition knowledge in school, 2) the facilitation of gaining nutrition knowledge that comes from the literacy and numeracy learned in school, and 3) exposure to modern society through school. He finds that maternal health knowledge stands alone among these possible mechanisms in contributing to child height (his proxy for health), and that such knowledge is gained largely outside the classroom. Such findings have direct and important policy implications. As formal schooling is often limited among the poor, the potential benefits of specific nutrition training may be substantial.

The finding that some part of the contribution of maternal education to child height comes through its contribution to nutrition knowledge, however, does not address the central question of the present study: *how* does nutrition knowledge affect child health outcomes?

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[2] Exceptions include Bouis (1991), Bouis and Novenario-Reese (1997), Pitt and Rosenzweig (1985), Behrman and Deolalikar (1987).

In particular, what is the operational link between nutrition knowledge and child micronutrient status as described in Block (2002)? The central hypothesis to be established and tested in this study pertains to the effect of nutrition knowledge on the demand for micronutrient-rich foods, the consumption of which is a primary determinant of micronutrient status.[3] Critical parameters include budget shares, as well as the income (expenditure) and own-price elasticities of demand for micronutrient-rich foods. An additional parameter of potentially critical concern is the cross-price elasticity of demand between micronutrient-rich foods and starchy staples. During the Indonesian crisis of 1997/98, for instance, rice prices tripled yet mean child weight-for-age remained constant (Block, et. al., 2002). This counter-intuitive finding is explained by household substitution out of high quality micronutrient-rich foods as rice prices soared. Yet, that substitution came at a severe cost to child micronutrient status.[4]

It is thus interesting to consider the possibility that households' propensity to reduce expenditures on micronutrient-rich foods in the face of staple price increases may also be a function of nutrition knowledge. Does maternal nutrition knowledge protect child micronutrient status from volatility in staple food prices? The findings presented below indicate that nutrition knowledge does indeed condition both the budget shares and the demand parameters associated with micronutrient-rich foods, including this key cross-price elasticity.

Direct examination of the effect of nutrition knowledge on the demand for particular types of food has received relatively little attention. One of the few studies is Variyam, et. al. (1999), who consider the impact of maternal nutrition knowledge on children's dietary intake.

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[3] Bhargava, Bouis, and Scrimshaw (2001) establish a firm association between dietary intake and blood hemoglobin concentration in a sample of Bangladeshi women.
[4] Block, et. al. (2002) found that mean child hemoglobin concentrations fell by over one-third of a standard deviation during the Indonesia crisis, increasing the incidence of anemia from 50% to over 70% in rural Central Java.

They find that maternal nutrition knowledge does influence children's fat intake, though the effects are a declining function of the child's age. However, this study is based on U.S. consumption data, and does not explicitly consider the mechanisms (such as demand the parameters of present focus) through which knowledge operates.

The present study is organized as follows. Section II describes the household survey data and the construction of the knowledge proxy. Section III presents non-parametric evidence on the effect of nutrition knowledge, maternal education, and per capita expenditures on budget shares and demand parameters. Section IV supports this analysis with a model of the demand for micronutrient-rich foods that incorporates nutrition knowledge. Section V presents parametric results, and Section VI concludes.

II. Data and Nutrition Knowledge Proxy

The data derive from a detailed survey implemented by Helen Keller International, an NGO associated with a social marketing campaign, supported by UNICEF Indonesia, which sought to increase vitamin A intake by children and their mothers. The campaign promoted eggs and dark-green leafy vegetables as good sources of the vitamin: "One egg and a bowl of vegetables are healthy foods for every day: they will make under-fives healthy and clever and stimulate breast milk production." (de Pee et. al. 1988) The campaign started in March 1996 and covered the entire province of Central Java, with a population of over 30 million people.

The survey began in December 1995 and involved regular collection of a range of information, including dietary diversity, expenditure, asset ownership, demographics, morbidity, nutritional status.[5] For each round a random sample of 7,200 households was

[5] Five rounds of data were collected through January 1997. There was an hiatus through 1997 until June 1998, after which 7 more rounds were collected (up to January 2001). The present analysis only uses the 7 rounds of survey data (collected between December 1998 and January 2001) because the prior surveys did not include data on household expenditure.

chosen using a multi-stage cluster sampling design. Each time a total of 30 villages was selected from each of the province's 6 agroecological zones by probability proportional to size sampling techniques. Each village provided a list of households containing at least one child less than 36 months of age (the age criterion was expanded to 59 months in August 1998 for Round 7 of data collection). From this list, 40 households were selected by fixed interval systematic sampling using a random start.[6] Table 1 presents descriptive statistics for variables included in the analysis covering the entire sample.

The food price data used in this study are drawn both from the HKI surveys (which asked respondents to report on market prices for various commodities) and from market surveys undertaken monthly in rural markets by the Indonesian Bureau of Statistics. Market enumerators collected individual commodity price data, and the resulting data are aggregated to the province level and deflated (to base year 1993) using appropriate rural price deflators. For the present application, I construct an aggregate price for micronutrient-rich foods as the weighted average of the province-wide prices of beef, chicken, vegetables, milk, eggs, fruit, and fish. I calculate the weights based on the village non-self mean shares of each micronutrient-rich commodity in total spending on the group of commodities. Thus, even though the underlying commodity-specific prices are common throughout the sample region, the aggregate price for the micronutrient composite good varies by village to the extent that mean budget shares differ geographically.[7]

The nutrition knowledge proxy constructed for this study is based on the objective accuracy of mothers' opinions regarding a key health choice. Specifically, mothers were asked their opinion as to the proper age at which to introduce complementary foods to their infants. Current nutrition research (Wardlaw and Kessel, 2002) defines the correct answer to

[6] Greater detail on the nutritional surveillance methods is available in de Pee et. al. (2000).

[7] Village mean budget shares are calculated as "non-self" means – that is for each household *i*, the mean village budget share is calculated excluding *i* in order to mitigate correlation between the aggregate price and unobserved characteristics of household *i*.

this question as being four to six months, with some allowance for local circumstances and practice. It is clear from the distribution of responses in the Central Java survey data mothers there had been taught that four months is the appropriate age – 58% of mothers surveyed gave that answer (with nearly all other respondents answering 2 weeks to 3 months). For the present purpose of splitting the sample between mothers with and without nutrition knowledge, I thus create a dummy variable equal to one for mothers in whose opinion complementary foods should be introduced at four months, and zero otherwise. While this indicator is far from comprehensive, it serves as a proxy for broader nutrition knowledge. As such, it is almost certainly measured with error, a problem that I address with instrumental variables techiniques described in Section IV. The following section presents non-parametric evidence of the effect of nutrition knowledge on household resource allocation with regard to alternative types of food.

III. Non-Parametric Evidence

This section assesses the effect of nutrition knowledge on household budget allocations and demand parameters for micronutrient-rich foods based on a series of non-parametric relationships.[8] Figure 1 begins with the broad question of whether nutrition knowledge is associated with higher or lower food shares in per capita household expenditures. While the sample is large enough to distinguish statistically between the food budget shares of the two groups in the bottom half of the expenditure distribution, the absolute differences are trivial. Food budget shares for households with nutrition knowledge are effectively the same as those of households without nutrition knowledge (and note that in

[8] The non-parametric relationships presented in this study are smoothed values of the y-variable plotted against the x-variable. Smoothing is performed around each data point in the sample, based on an unweighted mean with a specified proportion of the sample around the given point. Confidence intervals indicate the 95% certainty range around each smoothed point. Estimation if performed using the "running" command in Stata, which approximates the more computationally demanding results of locally weighted kernel regression (for which confidence intervals are not available).

the bottom half of the expenditure distribution, both types of households allocate over 70 percent of total spending to food). If nutrition knowledge matters to the demand for micronutrient-rich foods, then such differences must lie in the allocation of the food budget itself between micronutrient-rich foods and rice (which together account for nearly three-fourths of mean food expenditures).

Figure 2 demonstrates a substantial effect of nutrition knowledge on food budget allocations to micronutrient-rich foods. Two distinct dimensions of micronutrient demand differences are apparent in Figure 2. It is clear that households of mothers with nutrition knowledge devote larger shares of their food budget to micronutrient-rich foods. This difference is a declining function of per capita expenditures, but is large at the lower end of the distribution, and remains statistically significant (as indicated by the 95 percent confidence intervals) throughout the distribution. It is also clear that nutrition knowledge substitutes for income in driving the demand for micronutrient-rich foods: the mean budget share for the knowledge group at the 10^{th} percentile of the expenditure distribution is not attained by the non-knowledge group until they reach the sample median expenditure level.

The second dimension of demand that is apparent in Figure 2 is the income elasticity of demand. If the budget share was a flat function of log expenditures, the implied income elasticity would equal unity. However, it is well-established that the income elasticity of demand for the types of high quality foods included in the micronutrient aggregate is greater than unity, and this is reflected in the positive slopes of the budget share paths. The positive slope of these budget share paths thus indicates that micronutrient-rich foods are a luxury for both groups. Yet, the tendency for the budget share paths of these two groups to converge as expenditures increase (e.g., the steeper rate of incline for the non-knowledge group) implies a higher income elasticity of demand for those households lacking in nutrition knowledge.[9]

Figure 2 is vulnerable to the criticism that it confounds nutrition knowledge with schooling. A simple way to add one additional dimension to this non-parametric analysis is to limit the sample. Thus, it is possible to control for maternal education by limiting the sample to households of mothers with complete secondary schooling. Yet, repeating this analysis with that sample restriction leaves Figure 2 virtually unchanged (though the absolute gap between the paths is slightly smaller.[10] This suggests that the impact of schooling on household food budget share allocations to micronutrient-rich foods works via its impact on nutrition knowledge, but that most of the effect of nutrition knowledge is independent of schooling.

If households with nutrition knowledge allocate substantially larger shares of their food budgets to micronutrient-rich foods while their total food budget share is not different from that of non-knowledge households, then what is it that the knowledge households are *not* buying as intensively? The answer is rice, the staple food in central Java.

Figure 3 repeats the exercise of Figure 2, but analyzes the share of rice in household food budgets. The result is virtually a mirror image of the micronutrient case. Households lacking in nutrition knowledge allocate substantially larger food budget shares to rice throughout the expenditure distribution. As in the previous case, these statistically and economically significant differences are a declining function of expenditures. This is a particularly striking result in the context of Indonesia's rural economy, where over 90 percent of households consume rice and where rice accounts for over half of total caloric intake (Chernichovsky and Meesook, 1984). The difference in rice shares of the food budget

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[9] I leave it to the parametric analysis presented in Section IV to assign magnitudes to these elasticities and to test whether those elasticities are statistically different across groups.
[10] Alternative graph available from the author on request.

between the knowledge and non-knowledge groups accounts for essentially the entire difference in budget allocations to micronutrient-rich foods.

Rice shares of the food budget are a declining function of per capita expenditures for both groups, but as before, the share for the non-knowledge group at the sample median expenditure is attained by the knowledge group at the 10th percentile of the expenditure distribution. The negative slope for the budget share path implies an income elasticity less than unity (e.g., a normal good) for both groups; yet, the steeper rate of decline for the non-knowledge group suggests a relatively higher income elasticity for the knowledge group. As in the micronutrient case, controlling for maternal schooling by limiting the sample to households of mothers with complete secondary educations somewhat narrows the gap between the rice budget shares for the two groups, but alters none of the basic conclusions from Figure 3.

One difficulty in the aggregation of the micronutrient-rich composite good is that it masks potential substitution within the composite. An illustrative approach to addressing that problem is to limit the analysis to a single micronutrient-rich food. In the context of rural Central Java, eggs are the best proxy for high quality food – they are widely available, comparatively inexpensive, and excellent sources of iron, vitamin A, and folates.

Figure 4 repeats the previous analyses for the share of eggs in households' food budget. Here, again, the allocative decision of the nutrition knowledge group is substantially (and by now, predictably) different from that of the non-knowledge group. The poorest households devote approximately 3.5 percent of their food budget to eggs, as compared with the approximately 2.5 percent allocated by non-knowledge households (a difference on the order of 40 percent). Here, too, the differences are a declining function of per capita expenditures, and eggs are a luxury good for both groups; yet, the egg share of the food budget allocated by the knowledge group at the 10th percentile of the expenditure distribution is not reached by the non-knowledge group until well over the sample median expenditure level. The differences between groups in this case are less robust to controlling for maternal schooling, though the point estimates continue to suggest larger egg share allocations at the bottom end of the expenditure distribution for the nutrition knowledge group (and the confidence intervals remain distinct only near the bottom of the expenditure distribution).

As noted in the previous section, the Indonesian economic and financial crisis resulted in a tripling or rice prices and a substantial decline in child micronutrient status (e.g., hemoglobin concentration), even while gross caloric intake (e.g., weight-for-age) remained constant. These facts suggest, on average, a negative cross-price elasticity between micronutrient expenditures and rice prices. Noting that the mean decline in hemoglobin concentration reflects a greater than average decline in some households and a less than average decline in others, it is possible that one factor distinguishing those households was maternal nutrition knowledge. One might hypothesize that knowledge of the importance of micronutrient consumption would lower the absolute value of the cross-price elasticity between micronutrient-rich foods and rice.

This result is suggested in Figure 5, which tracks the change in the micronutrient share of the food budget as a function of the (log) real price of rice. The negative slope suggests a negative cross-price elasticity. Figure 5 shows that while the cross-price elasticity is negative for both the knowledge and the non-knowledge families, the path of the non-knowledge households is more negative, implying a greater absolute valued cross-price elasticity. This result is somewhat more apparent when the sample is limited to households of mothers with secondary education. One cannot determine the statistical significance of the difference in these slopes from this analysis. The regression analogue to this analysis presented below permits not only such testing but also permits controls for other dimensions of the demand function.

This effect may also be clouded by the potential for different patterns of substitution *among* micronutrient-rich foods in households with and without nutrition knowledge. Figure 6 addresses this problem by looking at the food budget share of eggs in particular. It is clear in Figure 6 that as the real rice price increases, households with nutrition knowledge maintain an essentially constant food budget share for eggs while households lacking in nutrition knowledge decrease their egg expenditures.[11] This effect of nutrition knowledge on demand for micronutrient-rich foods may be a key factor for understanding the nutritional implications of how households cope with instability in the price of staple foods.

The parametric counterpart to these non-parametric relationships supports the general conclusion that maternal nutrition knowledge conditions the demand for micronutrient-rich foods in ways that explain the reduced form association between nutrition knowledge and child micronutrient status. A formal demand model clarifies these relationships.

IV. A Demand Model with Nutrition Knowledge

The demand model underlying this analysis is, with modest revision, the standard model of household demand used widely in the literature and given detailed derivation by Behrman and Deolalikar (1988).

Assume the household maximizes its utility over health status *H*, leisure *L*, and consumption of goods *G*, given household and community characteristics:

(1)
$$\max_{H,L,G} \quad U = U(H, L, G; X_h(NK), X_c, \psi) \qquad U' > 0, U'' < 0$$

[11] In this case as well, limiting the sample to mothers with secondary education reduces the difference (and the statistical significance of the difference) between household types. Yet, the point estimates are consistent with those presented in Figure 6.

where X_h is a vector of household characteristics (including maternal nutrition knowledge, *NK*), X_c is a vector of community characteristics (including water and sanitation infrastructure, and food prices), and ψ represents unobserved heterogeneity of preferences. The household maximizes this utility function subject to two constraints: a budget constraint and a biological health production function for micronutrient status. This production function takes the form:

(2) $$H_i = H(N_i, M_i, X_h(NK), X_c, X_i, \eta_i)$$

where N_i are nutrients consumed by member *i*, M_i are non-food health inputs (such as medical care), X_i is a vector of member-specific characteristics, and η_i are unobserved individual health endowments. H_i is taken here to represent micronutrient status. Note that household characteristics explicitly include maternal nutrition knowledge (NK).

Solution of this utility maximization problem yields a reduced form demand function for nutrients, N_i:

(3) $$N_i = N(P^N, P^R, P^L, P^G, I, X_h(NK))$$

where P^N is the price of micronutrient-rich food, P^R is the price of rice, P^L is the price of leisure, P^G is the price of other goods, and *I* is household income per adult equivalent.

The estimating equation for (3) is thus:

(4) $$\omega_N = \alpha + \beta_1 \ln I + \beta_2 \ln P^N + \beta_3 \ln P^R + D_{NK}[\beta_4 \ln I + \beta_5 \ln P^N + \beta_6 \ln P^R] + X_h\gamma + u$$

where D_{NK} is a dummy variable equal to 1 for households with nutrition knowledge and 0 otherwise, and ω_N is the budget share of micronutrient-rich food.[12] This specification permits estimation of separate price and expenditure elasticities for households of mothers with and without nutrition knowledge.

Deaton and Muellbauer (1980) demonstrate that in such an equation, the key demand parameters for the non-nutrition knowledge households can be derived as follows:

(5) Own Price Elasticity $$\varepsilon_{NN} = \frac{\beta_2}{\omega_N} - 1$$

(6) Cross Price Elasticity $$\varepsilon_{NR} = \frac{\beta_3}{\omega_N}$$

(7) Income Elasticity $$\eta_i = \frac{\beta_1}{\omega_N} + 1$$

By extension, the analogous demand parameters for the nutrition knowledge households are estimated by:

(5′) Own Price Elasticity $$\varepsilon_{NN} = \frac{\beta_2 + \beta_5}{\omega_N} - 1$$

[12] Equation (4) excludes the prices of goods and leisure for lack of available data.

(6′) Cross Price Elasticity

$$\varepsilon_{NR} = \frac{\beta_3 + \beta_6}{\omega_N}$$

(7′) Income Elasticity

$$\eta_i = \frac{\beta_1 + \beta_4}{\omega_N} + 1$$

The distinction between maternal nutrition knowledge and years of schooling requires further explanation of X_h. Household characteristics in this model include: resources, number of children under six years old, maternal schooling, and maternal nutrition knowledge. Yet, the specific form through which the latter two terms enter the demand functions depends on several considerations, including assumptions about endogeneity, measurement error, and associated issues of the relationship between education and nutrition knowledge.

This study shares the assumption made by Glewwe (1999), Thomas, Strauss, and Henriques (1990), and others, that maternal education is exogenous.[13] This assumption is empirically plausible in the setting of rural central Java, where nearly 55% of mothers have precisely 6 years schooling. Nonetheless, it is possible that estimated effects of maternal education in the demand function could reflect its contribution to the demand for micronutrient-rich foods through either education's effect on per capita expenditures or through its effect on nutrition knowledge. Maternal nutrition knowledge, in contrast, is potentially endogenous and almost certainly measured with error. It may thus be important to consider possible instruments for nutrition knowledge. The search for valid instruments for nutrition knowledge begins with the question of where nutrition knowledge comes from.

As noted above, UNICEF and Helen Keller International, working with the Indonesian Ministry of Health, implemented a social marketing campaign to promote the

[13] Paternal education appeared statistically irrelevant in preliminary specifications, and was dropped.

consumption of micronutrient-rich foods. In subsequent surveys, mothers were asked about the direct source of their nutrition knowledge. Table 2 summarizes their responses. Approximately 5% of mothers had acquired their information through TV or radio; 11% said friends and neighbors; 22% had heard about nutrition in school; and, 47% had gained such knowledge from health workers. Yet, despite the predominance of health workers in imparting nutrition knowledge to mothers, it is unlikely that the decision to visit a health center is endogenous to the demand for child micronutrient status. When asked their opinion of the purpose of the health center, less than 12% of mothers surveyed responded that the function of a health center was to convey nutrition and health information (as compared with nearly 75% who believed the purpose of health centers was to weigh their children, and 6.3% who did not know its purpose).

These direct indications of sources of nutrition knowledge suggest a fairly broad set of potential instruments for nutrition knowledge. Potential instruments for nutrition knowledge include the village mean distance to the health center, maternal years of schooling, whether or not the mother brought her child to the health center, maternal age, and maternal age squared. These exogenous instruments are plausible determinants of maternal nutrition knowledge based on the mothers' own description of the sources of their knowledge. The relevant "first-stage" regressions for nutrition knowledge are presented in Section V.

Equations (3) and (4) are written as a function of household income, yet short-run fluctuations in income, combined with the intrinsic difficulty of measuring income, typically lead researchers to use households expenditures to represent available resources. Expenditures are generally accepted as a better proxy for permanent income than is current income, given opportunities for consumption smoothing. Nonetheless, measurement error is likely to remain an issue, again suggesting potential benefits to using instrumental variables estimators. Potential instruments for per capita expenditures include assets and non-wage income, including: the previous year's remittance income, number of cows owned, number of children sleeping in a single room, and size of house per adult equivalent. This first-stage regression is also presented in the following section.

V. Parametric Evidence

This section presents the regression analogue to the non-parametric evidence presented above, implementing the model outlined in the previous section. To address issues of measurement error, I estimate equation (4) by 2SLS, using the instruments for nutrition knowledge and income described above. Estimating equation (4) by 2SLS raises special problems, given the need to treat as endogenous both expenditures and nutrition knowledge. It is necessary to instrument not only for expenditures and nutrition knowledge, but also for the interactions between nutrition knowledge and expenditures, and between nutrition knowledge and prices. Woolridge (2002) shows that the cross products of the instruments for two endogenous interaction terms are valid instruments, as are the products of the instruments for a given endogenous variable and an exogenous interaction term. It is useful first to consider the results of the first-stage regressions used to predict nutrition knowledge, per capita expenditures, and the relevant interaction terms of equation (4).

Table 3 presents these first stage results. Note that in equation (4), the dummy for nutrition knowledge enters only as an interaction term with expenditures and prices. First-stage regressions for these interaction terms can thus be estimated by OLS (which would be inappropriate were nutrition knowledge to enter linearly). Nonetheless, it is informative for policy purposes to estimate a separate probit regression for nutrition knowledge (not strictly a first-stage regression as it is not used directly in the second stage). Table 3 thus begins with a probit estimation predicting nutrition knowledge as a function of the instruments described above.

The excluded exogenous instruments for nutrition knowledge in column 1 are village mean distance to a health center, maternal age and its square, a dummy variable indicating whether the mother brought her child to the health center, and maternal schooling. The first-stage probit regresses nutrition knowledge against these instruments along with the other exogenous regressors from the second-stage demand equations. With the sole exception of family size, each coefficient estimate is significant at the .01-level and of the expected sign. In particular, the instruments for nutrition knowledge demonstrate that it is a positive function of maternal age (with diminishing returns), a declining function of mean village distance to a health center, a positive function of having brought a child to the health center, and a positive function of schooling (both maternal and paternal). As noted above, these instruments are derived from the mothers' own descriptions of the sources of their nutrition knowledge.

Table 3, column 2, presents results from the first-stage OLS regression for per capita expenditures. As expected, expenditures are a positive and statistically significant function of house size per adult equivalent and (controlling for house size) the number of children sleeping in one room. Expenditures are also a negative function of the previous year's remittance income, indicating a greater reliance on such sources among the poorer households in the sample. Column 3 predicts the interaction of nutrition knowledge and per capita expenditures (used in equation (4) to estimate the separate expenditure elasticity of households with nutrition knowledge) as the cross products of the excluded exogenous instruments used in columns 1 and 2. Columns 4 – 6 of Table 3 predict the interaction terms for commodity prices and nutrition knowledge (used in equation (4) to estimate the separate price elasticities of households with nutrition knowledge).

Table 4 presents 2SLS results for the demand functions for micronutrient-rich foods and eggs. The estimation is based on village mean prices as reported by survey respondents, and makes appropriate adjustment to the standard errors for clustering at the village level. As noted above, the specification allows for separate demand parameters for households of mothers with and without nutrition knowledge. The additional control variables include paternal schooling, family size, and (in the egg demand function) number of chickens owned. Among these, the most notable result is that household budget shares devoted to micronutrient-rich foods in general, and to eggs in particular, are a positive function of paternal education.

Table 5 summarizes the demand elasticities derived using equations (5) – (7) and the parameter estimates of Table 4. The broadest results are those based on the demand function for micronutrient-rich foods (column 1). These parametric results generally confirm the non-parametric evidence. Both types of households treat micronutrient-rich foods as luxuries and both are elastic in their own-price elasticity of demand. Consistent with the non-parametric results, the expenditure elasticity is significantly greater for the non-knowledge households.

The most striking result, however, pertains to how the two household types cope with changes in the price of rice. Faced with increases in the price of rice, households of mothers without nutrition knowledge sharply reduce their budget share on micronutrient-rich foods; households of mothers with nutrition knowledge do not, and may even reallocate a small portion of the budget towards micronutrient-rich foods (making such foods and rice substitutes for the latter households).[14] The household types thus differ in their preferences in such a way that the income effect appears to dominate for the non-knowledge households, while households with nutrition knowledge try to protect their micronutrient consumption in

[14] This positive cross-price elasticity for knowledge households contradicts the non-parametric analysis of Figure 5. This difference may result from the added dimensionality of the multiple regression approach.

the face of increased staple food prices. This difference is statistically significant at the .01-level.

Demand parameters for eggs tell a generally consistent story. Eggs are a luxury for both groups. While it is problematic that the estimated own-price elasticity for the non-knowledge households is positive (though statistically insignificantly different from zero), the estimated own-price elasticity for the knowledge households is quite reasonable.[15] Most critically, as in the case of the micronutrient composite good, the two household types differ starkly in their cross-price elasticity with respect to rice. The non-knowledge households sharply reduce their budget allocation for eggs as rice prices increase, while the knowledge households effectively have no reaction.

The finding that the cross-price elasticity among non-knowledge households is much greater for eggs than for micronutrients, and that the cross-price elasticity for knowledge households is significantly smaller for eggs than for micronutrients can be explained by households' opportunity to substitute within the micronutrient composite good. Thus, while non-knowledge households sharply reduce their spending on eggs when rice prices increase, some portion of that spending may be reallocated to other components of the micronutrient composite. Similarly, nutrition knowledge households appear to reallocate their budget primarily to non-egg micronutrient-rich foods when rice prices increase. Differences in the cross-price elasticities of demand for micronutrients with respect to rice are critical indicators of household coping strategies in the Indonesian context, where rice prices rapidly tripled during the early phases of the crisis of 1997/98. Identifying these differences as a function of maternal nutrition knowledge thus has important policy implications.

[15] Erwidodo, Molyneaux, and Pribadi (2002), using SUSENAS data, estimate the own-price elasticity for eggs to be –1.16 for rural Indonesian households.

The centrality of maternal nutrition knowledge in conditioning households' responses to changes in staple commodity prices vis-à-vis their consumption of micronutrient-rich foods shifts attention back to the first-stage regression for nutrition knowledge. The probit results for nutrition knowledge (Table 3, column 1) indicated that maternal schooling and accessibility of the health infrastructure are critical inputs to maternal nutrition knowledge. It is not surprising that increased schooling for girls and women contributes to nutrition knowledge. Indeed, increased female schooling is widely acknowledged as a high priority.

It is more novel, however, to recognize that greater access to and attendance at health centers has the added benefit of providing a vehicle for the transmission of nutrition knowledge (in addition to its direct curative and preventive health care functions). This is particularly valuable with regard to its effect on child micronutrient status, as micronutrient malnutrition, or "hidden hunger," may be less readily apparent to mothers and thus less likely to be treated. Expansion of the rural health infrastructure may thus have important indirect benefits for child nutrition. Indeed, these indirect benefits may quite long-term, given the permanent developmental consequences of micronutrient malnutrition in children. Similarly, it is interesting to note the positive impact of paternal education on maternal nutrition knowledge, controlling for maternal schooling.

VI. Conclusions

This paper provides a plausible explanation for the channels through which maternal nutrition knowledge affects child micronutrient status. Nutrition knowledge appears to have a strong effect on households' allocation of their food budget. Budget shares for high quality (e.g., micronutrient-rich) foods are widely known to increase as a function of income. The present study demonstrates, however, that nutrition knowledge can substitute for income among poorer consumers. Households with nutrition knowledge in the bottom decile of the expenditure distribution allocate 20 percent more of their food budget to micronutrient-rich foods than do households lacking nutrition knowledge. Controlling for maternal schooling only moderately changes the magnitude of this difference. Total budget shares on food are essentially the same for knowledge and non-knowledge households. Thus, the difference in their food budget shares devoted to micronutrient-rich foods implies that the knowledgeable households allocate smaller shares of their food budget to something else. Indeed, smaller food budget shares devoted to rice account for nearly all the difference in the allocations of the knowledge households.

In addition, this study proposes a variation of the standard model of household decisionmaking in which maternal nutrition knowledge conditions the underlying demand parameters for nutrient intake. Both parametric and non-parametric analysis supports the conclusion that nutrition knowledge does, in fact, condition the parameters underlying the demand for micronutrient-rich foods. Looking at both a composite micronutrient-rich food, and at eggs in particular, this study estimates the own-price and expenditure elasticities of demand, as well as the cross-price elasticity between micronutrient expenditures and the price of rice. The latter parameter is a key indicator of household coping with price volatility in staple foods. Mean household budget shares for rice are 22 percent, and that mean share can be close to 40% among the poorest families. Thus, the real income implications of rice price increases may well dictate reduced expenditures on higher quality micronutrient-rich foods. This appears to have been a critical factor in shaping the nutritional implications of Indonesia's economic crisis of 1997/98.

Block, et.al. (2002) found that mean child weight-for-age remained constant in the face of a severe real income shock in which rice prices tripled. The constant mean weight-for-age implies that typical families faced with this shock buffered their rice consumption.

Yet, maintaining rice consumption would have been possible for most families only by sacrificing consumption of something else. That same study demonstrated that while gross caloric intake remained relatively stable during the crisis, both the consumption of micronutrient-rich foods and child micronutrient status declined substantially. Yet, the present study demonstrates that households' propensity to reduce expenditures on high quality foods is a function of maternal nutrition knowledge. The estimated cross-price elasticity between micronutrients in general, and eggs in particular, is substantial and negative for households lacking nutrition knowledge, and effectively zero (or slightly positive) for households with nutrition knowledge. This distinction thus provides a plausible explanation for why some children fared better, particularly with respect to micronutrient status, than others during Indonesia's crisis. Maternal nutrition knowledge thus emerges as a potentially important tool for coping with the micro-level consequences of macroeconomic crises.

Household resource allocation, as conditioned by elasticities of expenditure and price, is a pervasive economic force. Economists typically take such demand parameters to be fixed and determined essentially by idiosyncratic preferences. The present findings demonstrate that maternal nutrition knowledge shapes household food demand parameters in predictable and policy relevant ways. Nutrition education programs provide a relatively cost effective and tractable vehicle through which governments can exploit the findings of this study to promote child micronutrient status (Horton, 2001).

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Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Obs
Log Expenditure per adult equivalent	8.52	0.450	3.75	10.93	32345
Nutrition Knowledge (dummy)	0.579	0.494	0	1	32345
House size per a.e.	19.59	10.414	0.074	171.43	32345
No. children/rm	1.476	0.709	1	20	32345
Remittance inc.	$4x10^8$	$4.9x10^8$	0	$1.0x10^9$	32345
Maternal age	28.20	5.885	15	58	32345
Visited health center	0.898	0.303	0.116	1	32345
Budshr MN-rich fd	0.292	0.105	0.00	0.779	32345
Budshr eggs	0.026	0.025	0	0.281	32345
Dist. to Health Center (minutes)	6.77	2.69	0.116	21.61	32345
Log price MN food (village mean)	6.410	0.259	6.046	7.793	32345
Log price rice (village mean)	6.370	0.115	5.978	6.690	32345
Log price eggs (village mean)	7.469	0.172	6.655	7.893	32345
No. chickens owned	3.616	15.89	0	1000	32345
Family Size	5.209	1.813	2	16	32345
Paternal schooling	7.835	3.148	0	20	32345
Maternal schooling	7.245	3.032	0	19	32345

Table 2. Sources of Nutrition Knowledge

	Percent	Cumulative
Health Worker	46.5	46.5
School	22.3	68.8
Friends/Neighbors	10.6	79.4
TV/Radio/Magazine	4.58	83.98
Other	16.02	100

Table 3. First-Stage Regressions for 2SLS Demand Functions†

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Probit Nutr. Know	OLS PCE	OLS pce x know	OLS MNprice x know	OLS RCprice x know	OLS EGGprice x know
Nutrition Knowledge Instruments						
Maternal age	0.034***					
	(0.011)					
Maternal Age Sq.	-0.001***					
	(0.000)					
Villg. mean dist. to hlth ctr	-0.010*					
	(0.005)					
Maternal schooling	0.060***					
	(0.004)					
Child to hlth ctr? (1=yes)	0.209***					
	(0.029)					
Expenditure Instruments						
Size of House per adult equiv.		0.005***				
		(0.000)				
No. Children Sleeping in 1 rm.		0.020***				
		(0.004)				
Remittance income (past yr)		-0.000***				
		(0.000)				
Cross-Products of Commodity Price and Instruments for Nutrition Knowledge						
Price x Maternal Age				0.012***	0.011***	0.016***
				(0.004)	(0.004)	(0.004)
Price x Maternal Age Sq.				-0.000***	-0.000***	-0.000***
				(0.000)	(0.000)	(0.000)
Price x Distance to Health Ctr.				-0.004*	-0.004**	-0.003*
				(0.002)	(0.002)	(0.002)
Price x Maternal Schooling				0.021***	0.021***	0.021***
				(0.001)	(0.001)	(0.001)
Price x Hlth. Ctr. Visit				0.078***	0.075***	0.079***
				(0.011)	(0.010)	(0.011)
Cross-Products of Instruments for Nutrition Knowledge and per cap. Expenditures						
Maternal Age x Size of House			0.001			
			(0.001)			
Mat. Age x Children Sleep 1 rm			-0.013			
			(0.010)			
Maternal Age x Remit. Income			-0.000***			
			(0.000)			
Maternal Age Sq. x Size of House			-0.000			
			(0.000)			
Mat. Age Sq. x Child Slp 1 rm			-0.000			
			(0.000)			
Maternal Age Sq. x Remit. Inc.			0.000***			
			(0.000)			
Hlth. Ctr. Dist. x House Size			-0.001			
			(0.001)			
Hlth. Ctr. Dist. x Child Slp 1 rm			-0.017			
			(0.012)			

Hlth. Ctr. Dist. x Remittance Inc.			0.000			
			(0.000)			
Mat. Schooling x Size of House			0.002***			
			(0.001)			
Mat. Schooling x Children 1 rm			0.060***			
			(0.010)			
Maternal Schooling x Remit. Inc.			0.000***			
			(0.000)			
Visit Hlth. Ctr. x Size of House			0.003			
			(0.006)			
Visit Hlth. Ctr. x Children 1 rm.			0.195**			
			(0.079)			
Visit Hlth. Ctr. x Remittance Inc.			0.000*			
			(0.000)			
Addition Regressors from Second-Stage Regression						
Real PCE per adult equiv.	0.067*			0.151*	0.153**	0.181**
	(0.034)			(0.078)	(0.078)	(0.091)
Log Price MN-Rich Food (vllg mn)	0.114	-0.062*	0.296	0.812***	-0.019	0.288
	(0.069)	(0.038)	(0.220)	(0.165)	(0.167)	(0.188)
Log Rice Price (village mean)	0.604***	0.784***	2.598***	1.104***	2.019***	1.675***
	(0.173)	(0.072)	(0.522)	(0.407)	(0.390)	(0.469)
Paternal Schooling	0.027***	0.024***	0.113***	0.061***	0.060***	0.069***
	(0.004)	(0.001)	(0.011)	(0.008)	(0.008)	(0.010)
Family Size	0.000	-0.120***	-0.073***	-0.000	-0.000	0.001
	(0.007)	(0.002)	(0.016)	(0.016)	(0.016)	(0.019)
Constant	-6.256***	4.130***	-15.011***	-14.336***	-14.849***	-15.491***
	(1.174)	(0.535)	(3.617)	(2.812)	(2.740)	(3.302)
Observations	32345	32345	32345	32345	32345	32345
R-squared	0.08	0.44	0.12	0.10	0.11	0.11

Standard errors in parentheses (corrected for clustering at the village level)
* significant at 10%; ** significant at 5%; *** significant at 1%

† Each specification also includes dummy variables for survey round and zone (results suppressed, but available on request).

Table 4. 2SLS Estimates of Demand Functions[†]

	(1)	(2)
Dependent Variable:	Bud. Shr. MN	Bud. Shr. Eggs
Log Expenditures per adult equiv.	0.074***	0.017***
	(0.024)	(0.005)
Log Price MN-Rich Foods (village mean)	-0.001	
	(0.017)	
Log Price Eggs (village mean)		0.029**
		(0.012)
Log Price Rice (village mean)	-0.160***	-0.045***
	(0.037)	(0.015)
Expenditures x Nutrition Knowledge	-0.117***	-0.008
	(0.030)	(0.007)
Price MNs x Nutrition Knowledge	-0.037	
	(0.030)	
Price Eggs x Nutrition Knowledge		-0.029
		(0.022)
Price Rice x Nutrition Knowledge	0.217***	0.047*
	(0.053)	(0.026)
Paternal Schooling	0.002***	0.001***
	(0.000)	(0.000)
Family Size	-0.002	0.001***
	(0.002)	(0.000)
Number of Chickens Owned		0.000**
		(0.000)
Constant	0.623***	-0.070**
	(0.134)	(0.029)
Observations	32345	32345

Robust standard errors in parentheses (corrected for clustering at village level)
* significant at 10%; ** significant at 5%; *** significant at 1%
[†] Each specification also includes dummy variables for survey round and zone (results suppressed, but available on request).

Table 5. Derived Elasticities for Micronutrient-Rich Foods and Eggs[a]

	(1)	(2)
Dep.Variable:	Bud. Shr. MN[b]	Bud. Shr. Eggs
Households with Nutrition Knowledge		
Own-Price	-1.128***	-0.977**
Cross-Price Rice	0.192**	0.089
Expenditure	0.854***	1.379***
Households without Nutrition Knowledge		
Own-Price	-1.004***	0.378
Cross-Price Rice	-0.594***	-2.115***
Expenditure	1.274***	1.806***
Tests for Differences Between Household Types		
Chow Test for Own-Price[c]	0.213	0.202
Chow Test for Cross-Price	0.000***	0.070*
Chow Test for Expenditure	0.000***	0.249

***=significant at the .01-level; **=significant at the .05-level; *=significant at the .10-level

a. Based on coefficient estimates from Table 4.

b. Elasticities are calculated at the sample mean budget shares.

c. Chow test (P-value) of H_0: equal elasticities for know & not know households.

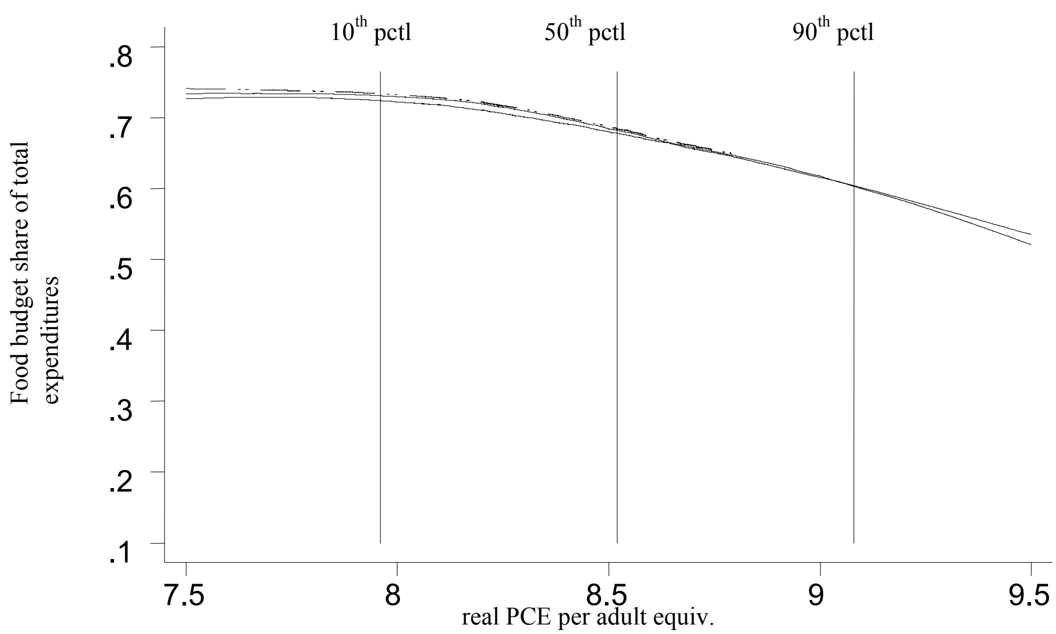

Figure 1. Food Share of Total Expenditures for Households With and Without Nutrition Knowledge

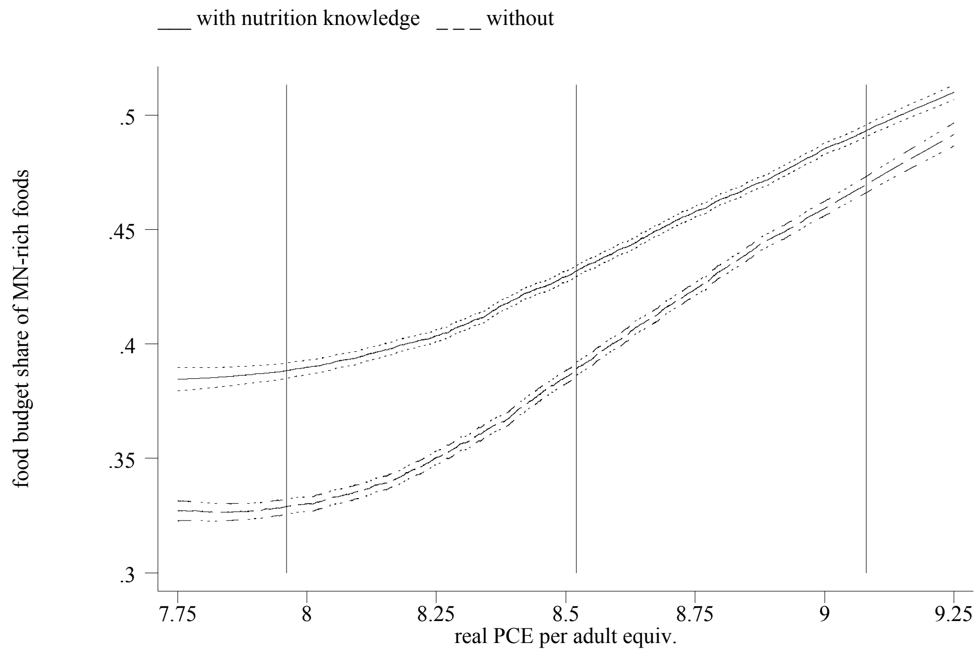

Figure 2. Food Budget Share of Micronutrient-rich foods with and without nutrition knowledge (NB: vertical lines represent the 10th, 50th, and 90th percentiles of the expenditure distribution.)

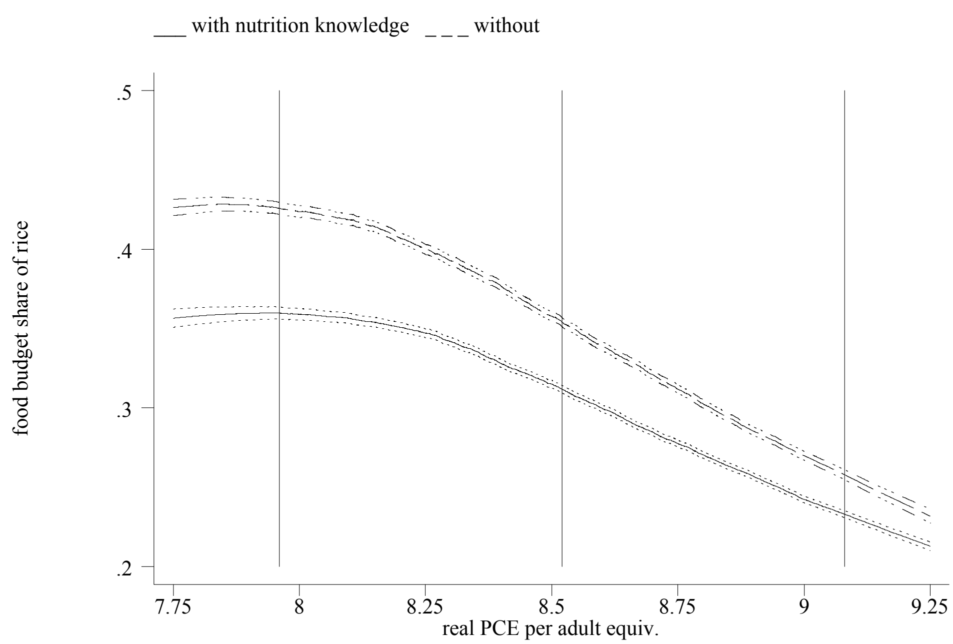

Figure 3. Food Budget Share of Rice, with and without nutrition knowledge

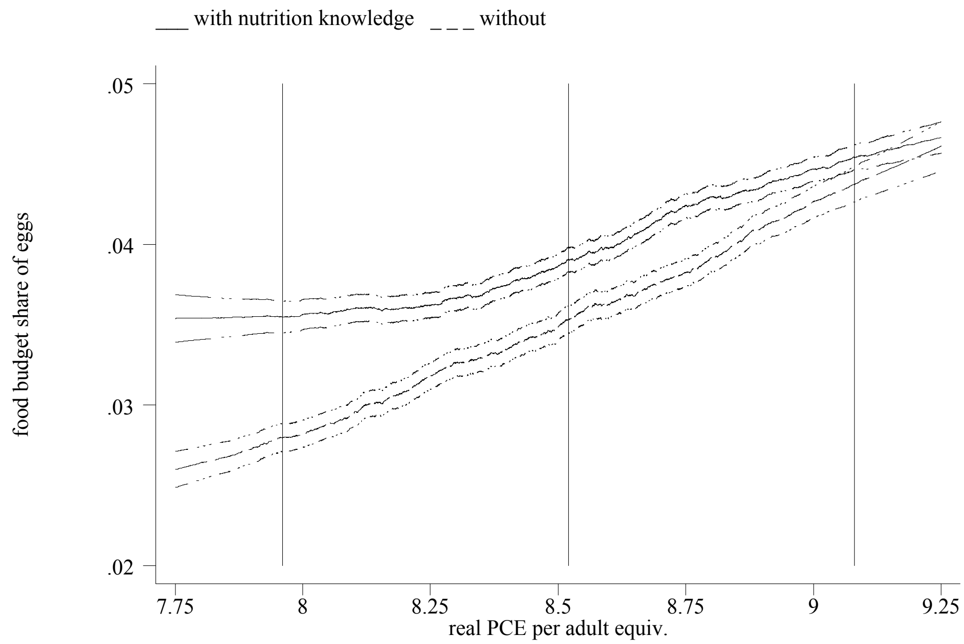

Figure 4. Food Budget Share of Eggs, with and without nutrition knowledge

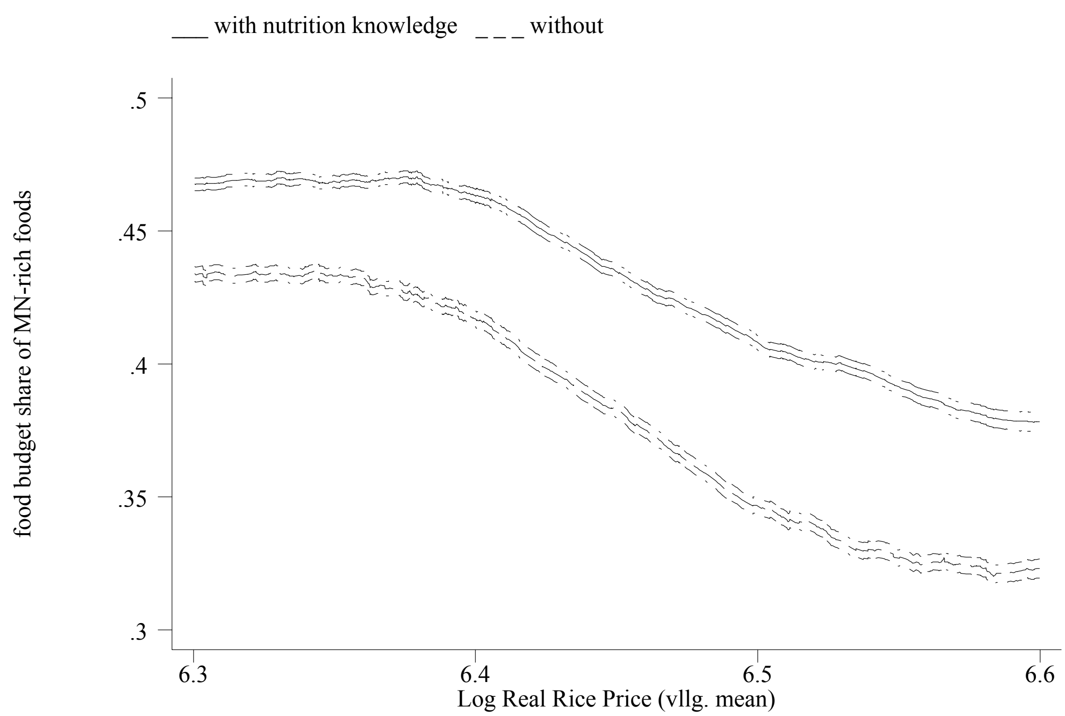

Figure 5. Food Budget Share of Micronutrient-rich foods as a Function of Log Rice Price, with and without nutrition knowledge

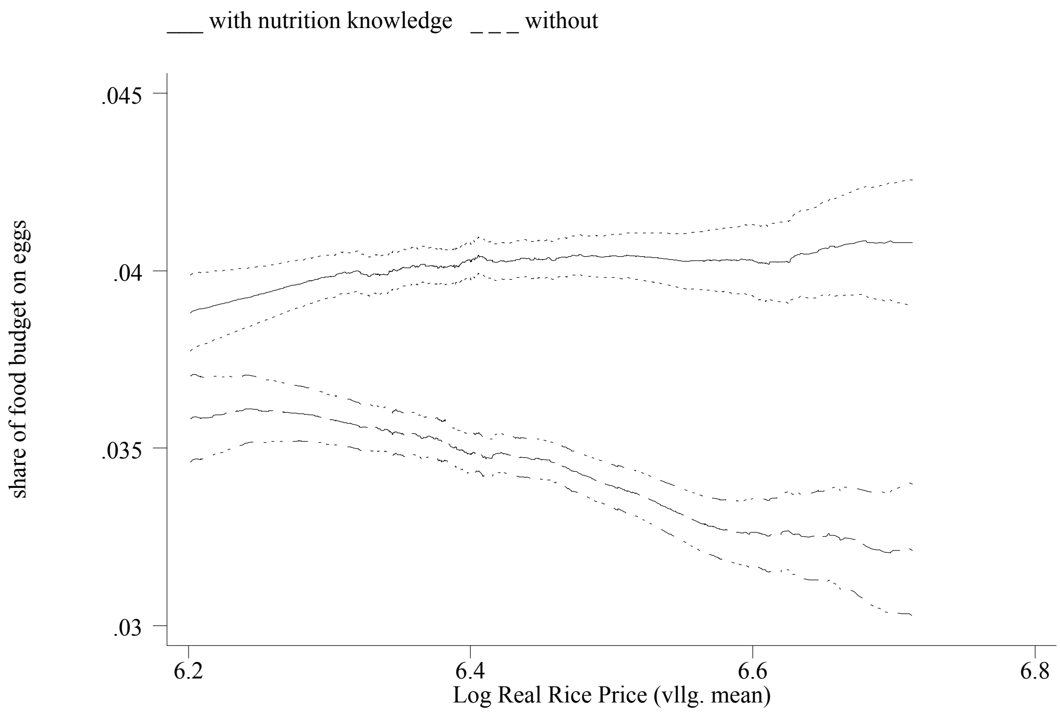

Figure 6. Food Budget Share of Eggs as a Function of Log Rice Price, with and without nutrition knowledge