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Nutrition Knowledge and Parental Schooling as Inputs to Child Nutrition in the Long and Short Run

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Abstract

Drawing on a large household survey in rural Central Java, Indonesia, we address the functional distinction between formal education and nutrition knowledge. Applying parametric and non-parametric techniques to household data from rural Indonesia the study finds that: 1) Mothers' nutrition knowledge has a strong, positive impact on child nutrition in the short-term (weight-for-height), controlling for mother's education and income; 2) by contrast, formal schooling dominates nutrition knowledge in determining child anthropometric outcomes in the longer run (height-for-age); 3) to the extent that maternal education contributes to shorter-run child outcomes its effects are meditated through nutrition knowledge; and, 4) paternal education contributes independently to long-run (but not short-run) child nutrition. The results suggest a potentially large role for nutrition education in combating child malnutrition in poor countries with limited schooling infrastructure and/or limited access to education by the very poor.

Keywords: Nutrition knowledge, social marketing, determinants of malnutrition, maternal education, nutrition buffering, exogenous shocks.
JEL codes: I12, I31, I21, O15

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I. Introduction

The value to child nutrition of interventions that seek to enhance mothers' nutrition knowledge has been recognized for decades. Widely cited is the example of the World Bank's first community nutrition loan to Indonesia in the 1970s which significantly improved the nutritional status of 40 percent of target children through nutrition education alone; that is, without the transfer of any other tangible resources (Berg 1987; Andersen 1994). While the techniques used and message content vary widely across programs, recent evaluations of interventions communicating specific nutrition information continue to report positive impacts around the world.[1]

However, there remain questions about the relative importance of nutrition knowledge versus formal education with regard to nutrition outcomes. The centrality of formal education (particularly for women) to successful socioeconomic development has been widely documented in terms of gendered empowerment, social equity, delayed marriage and fertility effects, and higher income earning potential (Wolfe and Behrman1983; Bigsten 2000; Krueger and Lindahl 2001). Indeed, according to Fritchel and Mohan (2001), "few development investments can match the overwhelming evidence on the returns to [female] education."

That said, while the broad development benefits of female education are indisputable the pathways by which it contributes to nutritional outcomes in the absence of precise knowledge about nutrition are less clear. While many studies (including Frongillo et. al. 1997 and Smith and Haddad 2000), find strong, positive links between maternal education and child nutrition other studies controlling for different factors show little or no correlation between the two. For example, in Mali, Penders et. al. (2000) report "no significant effects of

[1] The communication of 'nutrition knowledge' is associated with a wide spectrum of interventions including social marketing, positive deviance, and 'knowledge, practice and coverage' (KPC) approaches. Positive results have been reported in Asia (Pollard and Favin 1997; Engle 1999), Sub-Saharan Africa (Ndure 1999; Iannotti and Gillespie 2002), Latin America (Wolf and Behrman 1983; McNelly and Dunford 1999), as well as in the United States of America (Variyam et. al. 1999).

maternal education on HAZ [height-for-age Z scores].” In the Philippines, Dargent-Molina et. al. (1994) report that improvement in maternal education alone did not always have expected beneficial effects in terms of infant outcomes. Similarly, Black and Krishnakumar (1999), who analyzed factors affecting the growth curves of children from low-income families in the United States, found that maternal education was “not related to baseline status or to growth after more proximal variables were considered.” None of these studies suggests that female education has no impact on child nutrition. Rather, they propose that in certain contexts a positive linear association between a mother’s schooling and the nutrition of her child cannot be assumed—arguably because of a lack of access to complementary capital, human or informational resources. Could the provision of nutrition knowledge relax some of these constraints, even in the absence of formal education?

Few studies have explored whether or how nutrition knowledge interacts with education—when or whether they act as substitutes or complements. Exceptions include research in Nicaragua (Lamontagne et. al. 1998), and Myanmar (Webb and Lapping, 2002) that show that maternal education and certain types of nutrition knowledge are significantly but independently associated with child outcomes. Another study in Brazil (Thomas et. al. 1990) found that most of the impact of maternal knowledge on child height (a proxy for long-run health) could be explained by mothers’ access to media messages (on TV and radio), and that formal schooling and messages gained through community health services acted as substitutes. Similarly, Glewwe (1999) found that maternal knowledge (rather than schooling) in Morocco is a strong contributor to child height-for-age (a measure of longer-term child nutritional wellbeing), and that such knowledge is obtained mainly outside the classroom through the media, from relatives and via public service messages. Variyam et. al. (1999) also report that maternal schooling in the United States has a strong impact on children’s diets, “wholly through its positive effect on maternal… nutrition knowledge.” In other words, at least some of the contribution of schooling to child nutrition appears to come through its interaction with nutrition knowledge—possibly by enhancing women's ability to acquire knowledge and/or by enabling them to put such knowledge into practice. However, since nutrition knowledge has been shown to generate nutritional improvements even among illiterate populations, and since formal education remains severely limited in most poor developing countries, the potential for targeted transfers of nutrition information to assist in nutritional improvements may be large. This paper offer preliminary support for such an argument.

The paper is organized as follows. The second section describes the survey data used in the analysis, as well as the construction of our proxy for nutrition knowledge. Section III presents non-parametric evidence of the effects of nutrition knowledge, maternal education, and per capita expenditures on nutritional outcomes. Section IV supports the non-parametric analysis with a model of the conditional demand for child nutritional status, addressing the specific question of the sources of nutrition knowledge. Section V presents parametric results, and the last section (VI) concludes with programmatic and research implications.

II. Data and the Nutrition Knowledge Proxy

Drawing on a large household survey in rural Central Java, Indonesia, the present paper addresses three questions pertaining to the functional distinction between formal education and nutrition knowledge: 1) What are the child nutrition impacts in the short-run versus long-run of maternal schooling compared with maternal nutrition knowledge? 2) Are maternal schooling and paternal schooling substitutes for good child nutrition? 3) How do maternal education and nutrition knowledge affect the mother's own nutritional status?

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 was implemented through health workers, banners and posters, and via electronic media. It 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. 1998a) 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.[2] For each round a random sample of 7,200 households was 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. The total sample size for the 7 rounds of data used in the present study is 20,214.[3] Table 1 presents descriptive statistics for variables included in the analysis covering the entire sample.

In the following analysis 'nutrition knowledge' is proxied by a measure of the accuracy of mothers' understanding about the importance of, and good dietary sources for, Vitamin A. Mothers were asked to list all of the benefits of which they were aware after having been exposed to nutrition messages during the previous year. There were 9

[2] 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. One of the authors (Patrick Webb was involved with HKI in redesigning the survey questionnaires in 1997/98 so that more account would be taken of expenditure as well as of the local impacts of the financial and drought crises.
[3] Greater detail on the nutritional surveillance methods is available in de Pee et. al. (1998a).

predetermined correct answers and the proxy is based on the proportion of correct answers given.[4] Roughly 30 percent of the sample could not report a single benefit of vitamin A, compared with 54 percent who correctly identified one benefit, and 16 percent who were able to specify two or more. Each mother's percentage correct (out of the nine possible) thus constitutes a continuous variable that we use to proxy for nutrition knowledge. Where it is convenient to split the sample between mothers with and without nutrition knowledge, we create a dummy variable that identifies mothers who were able to give at least one correct answer that tested their knowledge of vitamin A-rich foods.

It has been shown elsewhere that having such specific nutrition knowledge was helpful to mothers during the crisis years of the late 1990s in buffering their children from potential vitamin A deficiencies and iron (Block, 2002a). One issue considered here is the extent to which specific information on micronutrient-rich foods translates into improvements not only in micronutrient status but also in *overall* nutritional status as measured by anthropometry. This can be hypothesized since the social marketing campaign focus on 'good foods' might be expected to result in: a) more attention by mothers to diet quality, not just quantity, and b) more attention to the special food needs of young children as a means of ensuring improved child growth and health.

III. Effects of Knowledge and Formal Schooling on Nutrition: Non-Parametric Evidence

This section explores non-parametrically the key associations between nutrition knowledge and formal schooling as determinants of child and maternal nutrition outcomes. While inherently limited in their dimensionality, the techniques applied in this section benefit from the lack of assumed parametric restrictions, and complement the parametric analyses presented below.

[4] The community nutrition knowledge instrument introduced above is based on a different question, which asked mothers simply whether or not they had heard about vitamin A-rich foods and from what source.

A. Effects on Short-Term Child Anthropometry

Figure 1 shows the impact of communicated nutrition knowledge on child nutritional status. We demonstrate this relationship by splitting the sample between children of mothers with and without nutrition knowledge, and estimating the relationship between child weight-for-height (WHZ) and the log of real per capita household expenditure (PCE) for each group.[5,6] The figure shows, first, that there is a highly significant difference between the groups (the confidence intervals do not over-lap for the middle eight deciles of the expenditure distribution); second, that the difference between child outcomes for mothers with, versus without, nutrition knowledge is not a function of expenditure level.

Figure 1, however, provides no information on the potentially confounding effect of formal schooling. That confounder is considered in Figure 2 which only includes women who have completed secondary education. In this case the sample is split between children of educated mothers who have nutrition knowledge versus without. Controlling for income, the children of educated mothers are still better nourished if the latter also have nutrition knowledge, while children of *similarly educated* mothers without nutrition knowledge are worse off. The margin of difference between the confidence intervals is significant, with no overlap across the middle eight deciles of the expenditure distribution. Interestingly, the converse does not hold. Figure 3 shows that controlling for nutrition knowledge there is no significant difference in outcomes as a function of formal schooling. This suggests that mothers' specific nutrition knowledge can be a more powerful determinant of current (short-

[5] The non-parametric relationships presented here 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 percent confidence interval 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).

[6] Weight-for-height (WHZ) is a short-term or 'current' measure of nutritional status. A Z-Score below two standard deviations (SD) of the conventionally-used international (NCHS/CDC/WHO) reference mean has been widely adopted as the cut-off for a condition that can be called wasting. By contrast, height-for-age (HAZ) represents small stature compared with the child's age (against international reference standards), such that a Z-Score less than 2 SD reflects longer-term nutritional (and hence growth) deficiencies, a condition referred to as stunting.

term) child nutrition outcomes than formal education.[7] Note that short-term child nutritional outcomes do not appear to be a function of household expenditures. These findings contrast with results presented below for longer-term nutrition outcomes.

B. Effects on Long-Term Child Anthropometry

Figure 4 illustrates the effect of maternal schooling on child height-for-age (HAZ), conditional on household expenditures per adult equivalent. Long-term child nutrition is a positive function of expenditures, and the children of mothers with secondary schooling have uniformly and substantially better long-term nutritional status. Yet this relationship may confound the effects of nutrition knowledge with those of formal education. Figure 5 begins to address that possibility (as in Figure 3) by restricting the sample to children of mothers with nutrition knowledge. Conditional on both maternal nutrition knowledge and per capita expenditure the paths suggest that formal schooling still leads to better long-term outcomes -- although in this case the confidence intervals are distinct only in the upper half of the expenditure distribution. The contrast with the short-term results is striking: while short-term child nutritional status (WHZ) is driven primarily by maternal nutrition knowledge with little contribution from formal schooling, long-term child nutritional status is driven more by maternal schooling than by specific nutrition knowledge. Indeed, restricting the sample to mothers with secondary schooling shows nutrition knowledge to make no independent contribution to HAZ (figure omitted). The parametric results presented below reinforce these findings. Yet, before turning to those we consider two additional sets of non-parametric relationships that further illustrate the important distinctions between formal schooling and specific nutrition knowledge.

[7] The same findings apply when replicating this analysis using an alternative measure of nutrition knowledge based on a demonstrated understanding of when it is most appropriate to introduce complementary foods to breast-fed infants (another element of the nutrition education messages). For more details on the performance of this alternative proxy see Block (2002b).

C. The Role of Father's Education

Among the few studies that explore the potentially distinct roles of maternal and paternal education in relation to nutrition outcomes (see Jolliffe 1997), most find that paternal education either substitutes for maternal schooling, or becomes insignificant and drops out of the model (for example, Gupta et. al. (1991) in India, Sahn and Alderman (1997) for Mozambique, and de Pee et. al. (1998b) for Indonesia). However, our distinction between short-term and long-term outcomes reveals a more subtle result. Controlling for expenditures and maternal schooling, there is no independent effect of fathers' education on child WHZ contingent on the mothers' schooling (figure omitted). Yet, as shown in Figure 6, even in households in which all women do have a formal education, the addition of a fathers' education substantially increases child stature (HAZ), a relationship that appears to strengthen with income (as might be expected given the income and social capital multipliers linked to higher education). Thus, where both parents have secondary schooling there appear to be distinct gains for child nutrition in the longer-run, above and beyond the mother's possession of nutrition knowledge. Importantly, such gains are not manifest in relation to shorter-term nutrition outcomes, and while the schooling of two spouses is typically correlated there appear to be significant independent and complementary effects of male and female education.

Such results are in line with previous work, particularly in relation to populations facing food crises, as were the households in the current sample during the earlier rounds of the Central Java survey.[8] For example, Kiros and Hogan (2001) report that in Ethiopia, "a mother's and father's education are found to have independent significant impacts" on child outcomes (in this case reduced child mortality).[9] Similarly, in Indonesia, Wasito et. al.

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[8] For details of the nutritional impact of the food-related crises in Indonesia of the late 1990s see Block et. al. 2002.

[9] Garfield (2001) argues that the Kiros and Hogan (2001) work is "unique among the literature" in showing that "father's education was more influential than mother's education…under conditions of war and food crisis."

(2002) find that while fathers' education only approaches significance in explaining child WHZ it was highly significant, independent of mothers' education, in relation to child HAZ, presumably operating through related income and social capital effects. Such evidence suggests not only that the role of *paternal* education in buffering food crises needs to be explored more fully, but that the additionality provided by nutrition education might also be considered as a new form of 'emergency' response to food crises where practical information on nutritious foods represents a valuable resource.

To summarize, the non-parametric results suggest: a) nutrition knowledge dominates schooling in determining short-term child nutrition outcomes, b) schooling dominates nutrition knowledge in determining long-term child nutrition outcomes, and c) father's education complements mothers' education (but only in terms of long-run outcomes). The next section proposes a formal model that seeks to disentangle further the complex set of relationships that link child and adult nutrition outcomes with schooling and knowledge.

IV. Theoretical Foundations and Estimation Strategy

The analysis below builds conceptually on a model widely used in the literature on demand for child wellbeing (health), given its most detailed exposition by Behrman and Deolalikar (1988). In this model, demand for good nutrition is a function of household characteristics (including maternal human capital) X_h, individual characteristics (especially gender and age) X_i, community characteristics (including water and sanitation infrastructure, access to health centers, and the proportion of mothers working outside the home) X_c, and total family income (in terms of expenditure per capita) y.

Assume the household maximizes a utility function:

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

where N_i (nutritional status), L_i (leisure), G_i (consumption of other goods), and ψ (unobserved heterogeneity of preferences) are 1 x T vectors (as in Pitt and Rosenzweig, 1984) for every family member i, $i = 1\ldots T$. Household characteristics, X_h, are explicitly a function of maternal nutrition knowledge (*NK*) and schooling (*S*). The household maximizes this utility function subject to two constraints: a budget constraint and a biological health production function for nutritional status. This production function takes the form:

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

where N_i are nutrients consumed by member i, M_i are non-food health inputs (such as medical care), and η_i are unobserved individual health endowments. Nutritional status as measured in conventional anthropometric outcomes is taken here to represent H_i.

This maximization problem leads to a reduced-form demand function for nutritional status:

(3) $$H_i = h(X_h(NK, S), X_c, X_i, \upsilon_i)$$

where υ_i represents unobserved heterogeneity nutritional outcomes.

The distinction between nutrition knowledge and years of schooling requires further explanation of X_h. Household characteristics in this model include: productive resources, maternal schooling and age, paternal schooling, and maternal nutrition knowledge. This model accommodates the possibility that nutrition knowledge may have different impacts on the demand for nutritional status of different members of the household. The specific form through which maternal schooling and nutrition knowledge enter the demand functions depends on assumptions about endogeneity and relationships between those variables.

Following assumptions made by Thomas et. al. (1990), Glewwe (1999), and Block (2002a) maternal education is taken to be exogenous. This assumption is empirically plausible given that almost 55 percent of mothers in this setting had 6 years schooling. Nonetheless, it is possible that estimated effects of maternal education in the demand function could reflect its contribution to child status through the effect of schooling on per capita expenditure, or indeed through its effect on the application of nutrition knowledge. In contrast, we assume that nutrition knowledge is measured with error. We thus rely on instrumental variables for the parametric estimates. The search for instruments logically begins with the question of where mothers got their nutrition knowledge.

The mothers in the sample were asked directly to state the sources of their nutrition knowledge. Roughly 4 percent absorbed the information through TV or radio; 12 percent said friends and neighbors; 24 percent had heard about vitamin A-rich foods in school; and 44 percent gained knowledge from health workers. Despite the fact that health workers were instrumental in imparting this particular nutrition information it is unlikely that the decision to visit a health center is endogenous to the demand for child nutritional status: less than 12 percent of mothers surveyed responded that the function of a health center was to convey nutrition and health information, compared with nearly 75 percent who believed the purpose of health centers was to weigh their children (and 6 percent who did not know its purpose).

Based on these mothers' own indications of the sources of nutrition knowledge, we instrument for nutrition knowledge with the following variables: village mean distance (in minutes) to the health center, maternal schooling, maternal schooling squared, a dummy indicating whether the mother had taken her child to the health center in the previous year, and a dummy indicating whether the mothers had access to television. The health center visit, as indicated above, is plausibly exogenous to any search for nutrition knowledge, as very few mothers perceived the health center to be a source. Access to television (defined by either ownership or the choice to watch television outside the home) is also plausibly exogenous (unless one believes that mothers purchase or seek out television specifically in search of nutrition knowledge).

We also share the assumption of Glewwe (1999), Thomas et. al. (1990), and others, that household expenditures are endogenous in this context, and thus also require instrumental variables. Our excluded exogenous instruments for expenditures, as is common in the literature, derive from household assets and non-wage income. In this case, we use size of house per adult equivalent, the number of children sleeping in one room, and the previous year's remittance income as instruments.

Table 2 presents results for our "first-stage" regressions based on these instruments, along with the other regressors suggested by equation (3). As we also consider the potential interaction effect between maternal nutrition knowledge and schooling in estimating equation (3), our first-stage regressions include determinants of that interaction term. Woolridge (2002) demonstrates that the products of a vector of instruments for an endogenous (or poorly measured) regressor and an exogenous regressor are valid instruments for the interaction of those two regressors. We return to the discussion of these first-stage regression results in drawing policy and programmatic conclusions.

V. Knowledge versus Schooling in the Long and Short Run: Parametric Results

This section presents 2SLS estimates of equation (3) for the dependent variables analyzed non-parametrically in Section III: child weight-for-height z-scores (WHZ), and child height-for-age z-scores (HAZ). In each case, we instrument for both maternal nutrition knowledge and household expenditures, and present six alternative specifications chosen to highlight the distinctions between specific nutrition knowledge and formal schooling. Each set of results begins by including nutrition knowledge and excluding schooling. We then exclude nutrition knowledge and include schooling. The third specification includes both nutrition knowledge and maternal schooling, while the fourth specification adds paternal schooling. The final two specifications add the interaction of maternal schooling and nutrition knowledge (first excluding, then including paternal schooling).[10] The results are fully consistent with the non-parametric illustrations, yet complement those results with the benefits of additional dimensionality. The following discussion highlights key results by category of explanatory variables (e.g., household and maternal characteristics, child characteristics, and village characteristics).

A. Short-Term Child Nutritional Status

Table 3 presents results for child WHZ. The key findings pertain to household and maternal characteristics. Consistent with the non-parametric analyses, child WHZ is not a function of household expenditures. This suggests that short-term child nutritional status relies more directly on care and feeding practices than on household resources *per se*, especially among younger children. In that regard, Table 3 shows maternal nutrition knowledge to dominate – its coefficient estimates are positive and statistically significant at either the .05- or the .01-level in every specification. In contrast, maternal schooling consistently falls out of the equation. (Its marginally significant negative effect in specification 3 is clearly unstable.) Nor does paternal schooling appear to contribute to child WHZ. Moreover, maternal schooling and nutrition knowledge are neither substitutes nor

[10] Note that in each specification, we make appropriate adjustments to the standard errors to account for clustering at the village level.

complements in determining short-term child nutritional status, as demonstrated by the insignificant results for the interaction terms in specifications 5 and 6.[11]

At first sight the lack of positive explanatory power for maternal education appears to contradict the large literature documenting a positive role for maternal schooling in determining child nutritional status (e.g. Smith and Haddad 2000 and Borooah 2002). However, it is important to note that most of that literature either does not discriminate between types of malnutrition, or focuses only on measures of stunting or underweight, when much research during the 1990s has shown that "stunting and wasting have different causes." (Frongillo et. al. 1997) For example, the work of Victoria (1992), Frongillo and Hanson (1995), Thwih and Thoung-Aree (2002) concludes that child wasting (short-term outcome) and stunting (longer-term outcome) have different etiologies and therefore the analysis of determinants should differ according to the type of child nutritional outcome under consideration. In these cross-country studies maternal education is typically significant in explaining child stunting (and often mortality) but is much less relevant in explaining wasting.

The latter finding is confirmed in a different, but relevant, literature focused on the short-term impact of exogenous shocks. For example, in considering the effects of a massive currency devaluation on farm households in West Africa, Barrett et. al. (2001) showed that, "education doesn't shield people from the shock", but it does help them in the longer-term recovery from a shock. The conclusion that "being educated hastens one's response to shocks but doesn't shield one from them is a more nuanced finding than appears in the existing literature", which fails to identify context-dependent returns to education. This distinction is relevant to mothers' ability to apply focused nutrition knowledge in the short-

[11] For each set of results presented in this section, evaluating the independent marginal impact of either maternal schooling or nutrition knowledge when their interaction term appears (as in specifications 5 and 6) requires taking the relevant partial derivative of one variable evaluated at the sample mean of the other. These results and their standard errors are included at the bottom of each table.

run versus their ability to capitalize on the multipliers of formal education in the longer-run—a finding that offers a refinement to, as well as empirical support for, Schultz's (1964) seminal claim that human capital enhances one's ability to adapt to changing economic circumstances.

It is also notable throughout Table 3 that boys have significantly lower WHZ scores than girls. While the absolute difference is not great, this finding is consistent with those of Svedberg (1996, 2000), Haddad et.al. (1996), and Webb and Lapping (2002) who have noted that boys often show poorer nutritional outcomes than girls even if there is an apparent bias in favor of boys in terms of quantities of food distributed to them within the household.

B. Long-Term Child Nutritional Status

The results for child HAZ presented in Table 4 reveal several interesting contrasts between the determinants of short-term and long-term child nutrition. While household expenditures had no apparent effect on WHZ, they tend to contribute positively and significantly to HAZ. From this contrast, we infer that buffering children from the nutritional impact of short-run shocks may be largely a function of (knowledge-driven) caring practices, while income (PCE) is better able to contribute to child nutritional status over longer periods. This is consistent with the non-parametric analysis of Section III.

It is also clear that the effect of maternal age on both short- and long-term child nutritional status is indirect, operating primarily through its effects on nutrition knowledge and household expenditures. While age and age squared are statistically insignificant across both Tables 3 and 4, the first-stage regressions reported in Table 2 shows that both nutrition knowledge and household expenditures (per adult equivalent) are positive but marginally diminishing functions of maternal age (i.e., experience). The benefits of maternal experience for child nutrition thus operate via nutrition knowledge in the short run and via increased household income in the long run.

The first-stage regression for household expenditures (Table 2, column 2) also demonstrates, not surprisingly, that expenditures are greater for households in which the mother works outside the home. What is more surprising, however, is that trade-off that this creates. Table 4 shows that, controlling for household expenditures, children of mothers who work outside the home suffer a small but statistically significant decline in stature, perhaps a cumulative effect of reduced attention to childcare.[12]

The most striking contrast between the determinants of short- and long-term child nutritional status pertains to the relative effects of maternal schooling and nutrition knowledge. As suggested by the non-parametric analysis, maternal schooling appears to dominate nutrition knowledge in contributing to long-term child nutritional status while the opposite relation pertains to short-term status. In Table 4, nutrition knowledge appears to contribute strongly and significantly to HAZ when it appears without maternal schooling (column 1). Yet, in each subsequent specification, while maternal schooling retains its positive and statistically significant effect in each specification, the point estimate for nutrition knowledge falls substantially and loses significance.[13]

The parametric analysis thus sheds a more subtle light on these relationships. Note that maternal schooling has a positive effect on nutrition knowledge (as seen in the first-stage regression, Table 2 column 1). The finding that maternal schooling does not contribute to child WHZ more precisely means that schooling does not contribute to child WHZ *independently of its indirect contributions through its effect on nutrition knowledge.* This interpretation is consistent with the mothers' own indication of the source of their nutrition knowledge noted above (nearly 25% citing school as the source). This does not change, but

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[12] It is also interesting to note that mothers' working outside the home does not affect their level of nutrition knowledge (Table 2, column 1). This may explain why working outside the home had no effect on WHZ (which was affected by nutrition knowledge), and a negative effect on HAZ (which is not a function of nutrition knowledge).

[13] Recall that when the interaction term appears (columns 5 and 6) it is necessary to consider explicitly the relevant partial derivatives indicated at the bottom of the table.

rather deepens, the conclusion that it is nutrition knowledge that matters to short-term child nutritional status. In contrast, the more direct effect of maternal schooling on child HAZ suggests that broader pathways may operate in the long term. The association between schooling and child HAZ has been widely observed in previous studies (Glewwe, 1999; Thomas et. al. 1990, among others). As noted above, the finding that this effect does not operate in the short-term is consistent with research on the etiology of wasting versus stunting.

It is also notable (and consistent with the non-parametrics) that paternal schooling has an independent and positive effect on child HAZ (Table 4, columns 4 and 6). With regard to child characteristics, it is notable that the negative difference for boys seen in WHZ is not apparent in HAZ. In addition, while village health and sanitation infrastructure had no impact on child WHZ, we find that children in villages in which a higher proportion of households have tap water tend to have significantly greater long-term nutritional status. It may be reasonable in this case to interpret tap water prevalence as a proxy for broader sanitation and health conditions.

VI. Programmatic Implications and Conclusions

This study demonstrates that the oft-cited finding that maternal schooling is a primary determinant of child nutritional status is an over-simplification that, in particular, ignores important distinctions between short-term and long-term outcomes. In this regard, we also demonstrate that it is critical to distinguish the effects of formal schooling from the effects of specific nutrition knowledge. Exploring these parallel distinctions, we find that while formal schooling of mothers is indeed an important determinant of child nutritional status, its direct benefits pertain only to long-term outcomes (HAZ). Short-term child nutritional status is much more responsive to maternal nutrition knowledge than to maternal schooling. The latter contributes to short-term child outcomes only indirectly, though its role in imparting nutrition knowledge. Yet, we also find that, at least among the mothers in our sample from rural Central Java, formal schooling is only one of several – and not the primary among – sources of nutrition knowledge. We also find that paternal schooling contributes independently from maternal schooling to long-term (but not to short-term) child nutritional status.

Our "first-stage" regression for nutrition knowledge identifies sources of nutrition knowledge, providing a basis for initial policy recommendations. In considering the determinants of maternal nutrition knowledge, we find that village access to the public health system, and mothers' decision to utilize the system, are critical. Expansion of the rural public health infrastructure in places like Central Java may thus have important positive externalities beyond the direct benefits of expanded primary health care. Our analysis of the determinants of maternal nutrition knowledge permits similar conclusions with regard to the rural educational infrastructure. Access to electronic media also emerges as an important contributor to nutrition knowledge. Our broader results support several further policy and programmatic recommendations.

First, the 'nutrition knowledge' considered in this analysis was narrowly focused on communicating about good sources of dietary vitamin A, and the value of that micronutrient to child health and growth. We prefer to interpret this specific knowledge as a proxy for broader nutrition knowledge. Yet even this very specific knowledge translated into significant improvements in the overall nutritional status of children whose mothers internalized that information. An assessment of the replicability of these findings in other developing country settings is certainly a high priority. Indeed, the results suggest that operational agencies should pay closer attention not only to increasing the scope and scale of similar social marketing interventions, but need to examine the potential multiplier effects of even narrow messages. Those agencies planning to invest further in primary education in developing countries as part of the Millennium Development goals might also consider when and how schools could facilitate the transmission of effective nutrition information.

Second, even mothers lacking formal education appear to benefit from access to well-targeted nutrition information. That nutrition knowledge impacts on short-term child nutrition more than either income or maternal education is an important finding that offers hope for greater impact on nutrition in poorest developing countries that continue to face underinvestment in schooling infrastructure and/or low school attendance rates, particularly among girls. Combining clear nutrition messages with other resources targeted to poorest households in marginalized locations may offer unexpected synergies where nutritional outcomes are of concern.

Third, since the nutrition benefits of targeted knowledge are strongest in the short-term, information transfers could play a useful buffering role in the context of exogenous shocks. While price stabilization, food aid distribution and other forms of intervention may still be needed in many contexts, certain types of nutrition knowledge could help mothers at least partially shield their infants through periods of food crisis by focusing on protecting diet quality, not just quantity. Interest in the role of information as a *bone fide* relief resource is growing (including the idea of keeping schools open), but the potential for nutrition communications in crises has yet to be adequately explored (Young et. al. 2002).

Fourth, while the role of maternal education remains critical to longer-term child nutrition and growth, the associated role of paternal education should not be overlooked. Wasito et. al. (2002), remark that during Indonesia's crisis "the socioeconomic factors for predicting children's nutritional status changed." During the peak of the crisis the dominant factors explaining child HAZ were father's education and occupation, while factors associated with low WAZ were the father's education and a less frequent consumption of eggs—one of the foci of the nutrition information campaign. Thus, investments in human capital (male and female) should be seen as contributions not only towards development but also with an eye to crisis buffering.

This is not to suggest, however, that communicating nutrition messages via social marketing is either cost-free or problem-free. There is evidence from many studies that messages linked to tangible resources have a higher likelihood of being acted upon than messages alone—especially when low-income households are the main target (Carbone et. al. 2002; Iannotti and Gillespie 2002; Griffiths 2000; Bengu 1995). There is also the problem of retention (message sustainability). A majority of women in the current sample was unable to answer more than 2 questions correctly out of 9; this does not represent 'failure' necessarily but it does speak to the need for well-tailored messages (meaningful in the local context and can be acted upon locally), that are clear and simple (to enhance retention), and that can be 'refreshed' periodically such that time-decay does not set in. Assessing the status of a similar vitamin A social marketing campaign in Bangladesh three years after its termination, Hussain and Kvale (1996) found that the long-term impact of that education program was at best "uncertain". An ability to sustain, and build incrementally upon, nutrition knowledge among households facing either chronic or transitory food insecurity as a desirable goal, but it is clearly one that requires policy and investment support. This is a case where a reliance on gradual poverty reduction or 'getting girls into school' will not substitute for direct, effective public action aimed at tackling child malnutrition.

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Table 1. Descriptive Statistics

	Mean	Std. Dev.	Min	Max
Child WHZ	-0.459	1.029	-4.34	3.57
Child HAZ	-1.402	1.290	-5.49	3.0
Nutrition Knowledge	0.1044	0.095	0	1
Log Expenditures per a.e.	8.521	0.455	6.20	10.93
Village Mean Dist. to Health Center (minutes)	6.687	2.604	2.563	20.92
Took Child to Health Center?	0.907	0.291	0	1
Maternal Schooling	7.173	3.00	0	19
Access to TV?	0.876	0.330	0	1
House Size per a.e.	19.68	10.436	0.074	171.43
No. Children Sleeping in 1 Rm.	1.443	0.672	1	19
Remittance Income	3.43×10^8	4.75×10^8	0	1.00×10^9
Mother Works Outside Home?	0.174	0.379	0	1
Maternal Age	28.14	5.94	15	57
Paternal Schooling	7.74	3.104	0	20
Child Gender (1=male)	0.514	0.500	0	1
Child Age (months)	23.42	16.04	0.10	60
Village Proportion w/ Closed Latrine	0.529	0.281	0	1
Village Proportion w/ Tap Water	0.109	0.216	0	1
Village mean Dist. to Water Source (mt.)	15.74	37.44	0	450.1

Number of Observations = 20214

Table 2. First-Stage OLS Regressions[a]

	(1)	(2)	(3)
	Nutr Knwl	P.C.Expd.	Nutr Knwl x Mat. Educ.
Excluded Instruments for Maternal Nutrition Knowledge			
Village Mean Distance to Health Center (min)	-0.003***		
	(0.001)[b]		
Brought Child to the Health Center (1=yes)	0.030***		
	(0.002)		
Maternal Schooling Sq.	0.000		
	(0.000)		
Watches Television (1=yes)	0.018***		
	(0.002)		
Excluded Instruments for Expenditures			
Size of House (per adult equiv.)		0.016***	
		(0.001)	
No. of Children Sleeping in One Room		-0.042***	
		(0.007)	
Remittance Income in Previous Year		-0.000***	
		(0.000)	
Cross-Products of Nutr. Knwl. Instruments and Maternal Schooling			
Distance to Health Ctr. *x* Mat. Schooling			-0.003***
			(0.001)
Health Ctr. Visit. *x* Mat. Schooling			0.029***
			(0.003)
Maternal Schooling Sq.			0.009***
			(0.004)
Maternal Schooling (cubed)			-0.000
			(0.000)
Watches TV *x* Mat. Schooling			0.018***
			(0.003)
Other Exogenous Second-Stage Regressors			
Child Gender (1=male)			
Child Age	-0.001	0.002	-0.004
	(0.0004)	(0.002)	(0.003)
Child Age Sq.	0.000**	0.000	0.000**
	(0.000)	(0.000)	(0.000)
Child Age (cubed)	-0.000**	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)
Village Proportion w/ Closed Latrines[c]	0.053***	0.170***	0.334***
	(0.008)	(0.036)	(0.056)
Village Proportion w/ Tap Water[c]	-0.001	0.215***	0.022
	(0.010)	(0.042)	(0.084)
Village Mean Dist. to Water Source[c]	0.000*	-0.000	0.000*
	(0.000)	(0.000)	(0.000)
Maternal Schooling	0.007***	0.017***	0.013
	(0.001)	(0.002)	(0.018)
Mother Works Outside Home (1=yes)	0.002	0.065***	0.016
	(0.002)	(0.012)	(0.019)
Maternal Age	0.003***	0.043***	0.022***
	(0.001)	(0.004)	(0.006)
Maternal Age Sq.	-0.000***	-0.001***	-0.000***
	(0.000)	(0.000)	(0.000)
Log Expenditures (per adult equiv.)	0.007***		0.065***
	(0.002)		(0.019)
Constant	-0.094***	7.480***	-0.971***
	(0.024)	(0.073)	(0.179)
Observations	20214	20214	20214
R-squared	0.15	0.23	0.42

* significant at 10%; ** significant at 5%; *** significant at 1%

a. All specifications included dummies for survey round (suppressed). b. Robust standard errors in parentheses (corrected for clustering at village level). c. Village means calculated as "non-self" means.

Table 3. 2SLS Estimates of the Determinants of Child Weight-for-Height (WHZ)[a]

	(1)	(2)	(3)	(4)	(5)	(6)
Household and Maternal Characteristics						
Log Expenditure per Adult Equiv.[b]	-0.011	0.063	-0.029	-0.028	-0.022	-0.022
	(0.056)[c]	(0.051)	(0.055)	(0.055)	(0.055)	(0.055)
Maternal Nutrition Knowledge[b]	0.730**		1.679**	1.776***	1.667**	1.724**
	(0.366)		(0.667)	(0.683)	(0.790)	(0.791)
Maternal Schooling		0.002	-0.010*	-0.008	-0.007	-0.007
		(0.003)	(0.006)	(0.005)	(0.009)	(0.009)
Paternal Schooling				-0.004		-0.004
				(0.004)		(0.004)
Nutr. Knwl. *x* Matl. Schooling[b]					-0.015	-0.010
					(0.057)	(0.057)
Maternal Age	0.014	0.015	0.012	0.013	0.013	0.013
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Maternal Age Sq.	-0.000	-0.000*	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother Works Outside Home (1=yes)	-0.002	-0.006	-0.001	-0.001	-0.001	-0.001
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Child Characteristics						
Child Gender (1=male)	-0.078***	-0.080***	-0.077***	-0.077***	-0.077***	-0.077***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Child Age (months)	-0.104***	-0.105***	-0.104***	-0.104***	-0.104***	-0.104***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Child Age Sq.	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Child Age (cubed)	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Village Characteristics						
Village Proportion w/ Closed Latrines[d]	0.059	0.095*	0.014	0.012	0.019	0.017
	(0.059)	(0.055)	(0.062)	(0.061)	(0.061)	(0.061)
Village Proportion w/ Tap Water[d]	-0.030	-0.036	-0.028	-0.026	-0.028	-0.026
	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)	(0.061)
Village Mean Dist. to Water[d]	0.000	0.000	-0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.371	-0.218	0.547	0.548	0.478	0.483
	(0.453)	(0.410)	(0.456)	(0.455)	(0.457)	(0.457)
Observations	20214	20214	20214	20214	20214	20214
Partial Derivatives of Interacted Regressors						
Total Effect of Mat. Educ. on WHZ[e]					-0.009	-0.008
					(0.006)	(0.005)
Total Effect of Nutr. Knwl. on WHZ[f]					1.560**	1.654**
					(0.658)	(0.014)

* significant at 10%; ** significant at 5%; *** significant at 1%

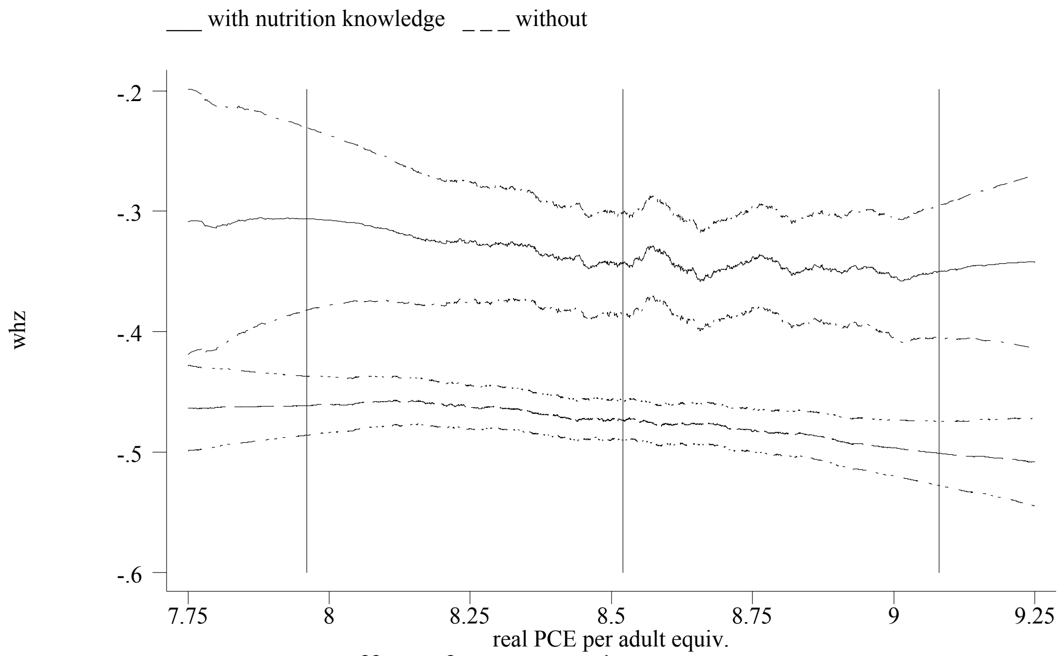
a. All specifications included dummies for survey round (suppressed)
b. Instrumented Variable
c. Robust standard errors in parentheses (corrected for clustering at village level)
b. Village means calculated as "non-self" means.
c. Partial derivative of WHZ with respect to maternal schooling (evaluated at sample mean for nutrition knowledge).
d. Partial derivative of WHZ with respect to nutrition knowledge (evaluated at sample mean for maternal schooling).

Table 4. 2SLS Estimates of the Determinants of Child Height-for-Age (HAZ)[a]

	(1)	(2)	(3)	(4)	(5)	(6)
Household and Maternal Characteristics						
Log Expenditure per Adult Equiv.[b]	0.087	0.118*	0.124*	0.120	0.131*	0.125*
	(0.077)[c]	(0.063)	(0.075)	(0.075)	(0.074)	(0.074)
Maternal Nutrition Knowledge [b]	3.237***		1.236	1.013	0.892	0.866
	(0.471)		(0.974)	(0.993)	(1.087)	(1.083)
Maternal Schooling		0.032***	0.021***	0.013*	0.018	0.012
		(0.003)	(0.008)	(0.007)	(0.011)	(0.011)
Paternal Schooling				0.017***		0.017***
				(0.004)		(0.004)
Nutr. Knwl. *x* Matl. Schooling [b]					0.031	0.006
					(0.069)	(0.069)
Maternal Age	0.006	0.014	0.009	0.008	0.009	0.008
	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Maternal Age Sq.	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mother Works Outside Home (1=yes)	-0.044	-0.044*	-0.046*	-0.046*	-0.047*	-0.046*
	(0.027)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Child Characteristics						
Child Gender (1=male)	-0.012	-0.015	-0.014	-0.014	-0.015	-0.014
	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Child Age (months)	-0.221***	-0.220***	-0.220***	-0.220***	-0.220***	-0.220***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Child Age Sq.	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Child Age (cubed)	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Village Characteristics						
Village Proportion w/ Closed Latrines [d]	-0.161**	0.007	-0.066	-0.069	-0.059	-0.064
	(0.069)	(0.060)	(0.075)	(0.074)	(0.075)	(0.073)
Village Proportion w/ Tap Water [d]	0.144*	0.145**	0.140**	0.132**	0.137**	0.131*
	(0.073)	(0.067)	(0.067)	(0.067)	(0.068)	(0.067)
Village Mean Dist. to Water [d]	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.688	-1.055**	-1.058*	-1.040*	-1.082*	-1.079*
	(0.614)	(0.512)	(0.619)	(0.617)	(0.607)	(0.606)
Observations	20214	20214	20214	20214	20214	20214
Partial Derivatives of Interacted Regressors						
Total Effect of Maternal School on HAZ [e]					0.022***	0.013*
					(0.008)	(0.007)
Total Effect of Nutr. Knwl. on HAZ [f]					1.113	0.911
					(0.936)	(0.953)

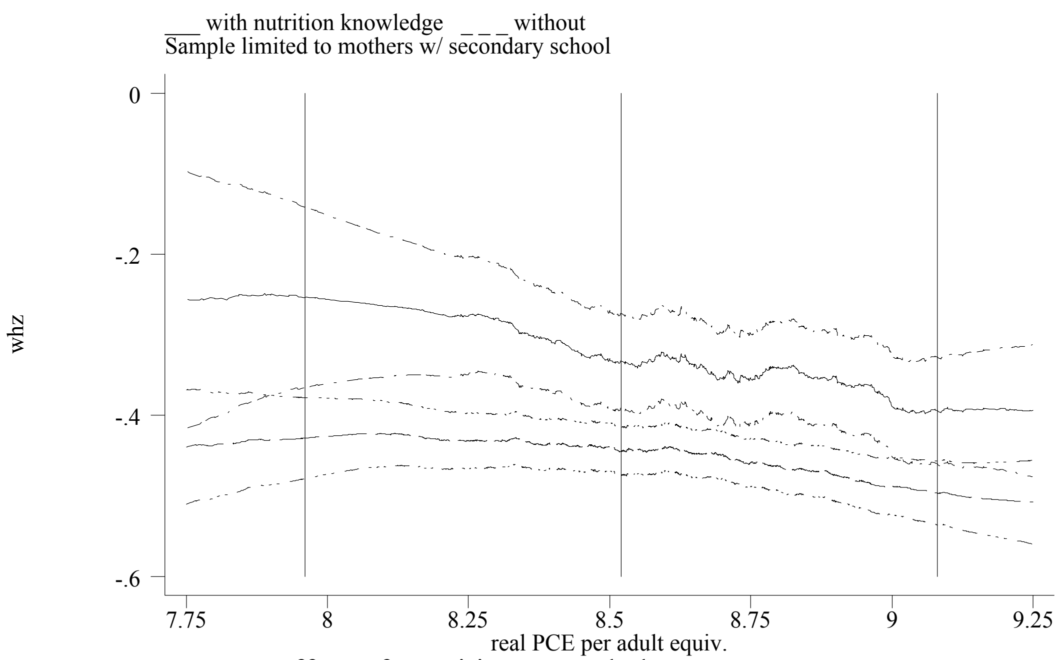
* significant at 10%; ** significant at 5%; *** significant at 1%

a. All specifications included dummies for survey round (suppressed)
b. Instrumented Variable
c. Robust standard errors in parentheses (corrected for clustering at village level)
d. Village means calculated as "non-self" means.
e. Partial derivative of HAZ with respect to maternal schooling (evaluated at sample mean for nutrition knowledge).
f. Partial derivative of HAZ with respect to nutrition knowledge (evaluated at sample mean for maternal schooling).



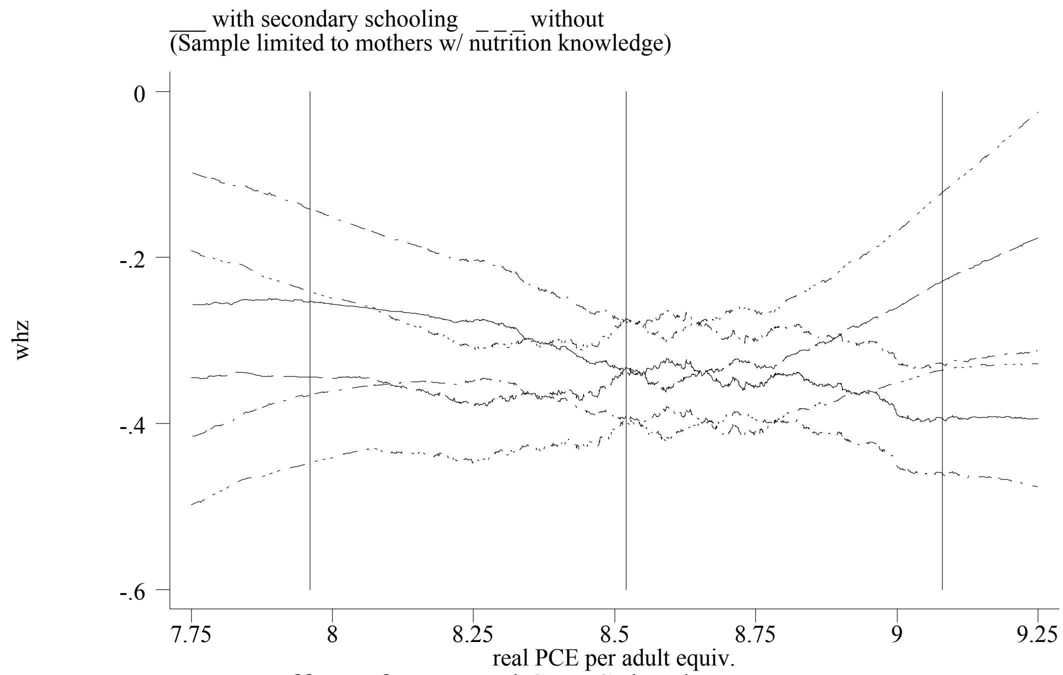
Effect of Nutr. Knwl. on WHZ

Figure 1



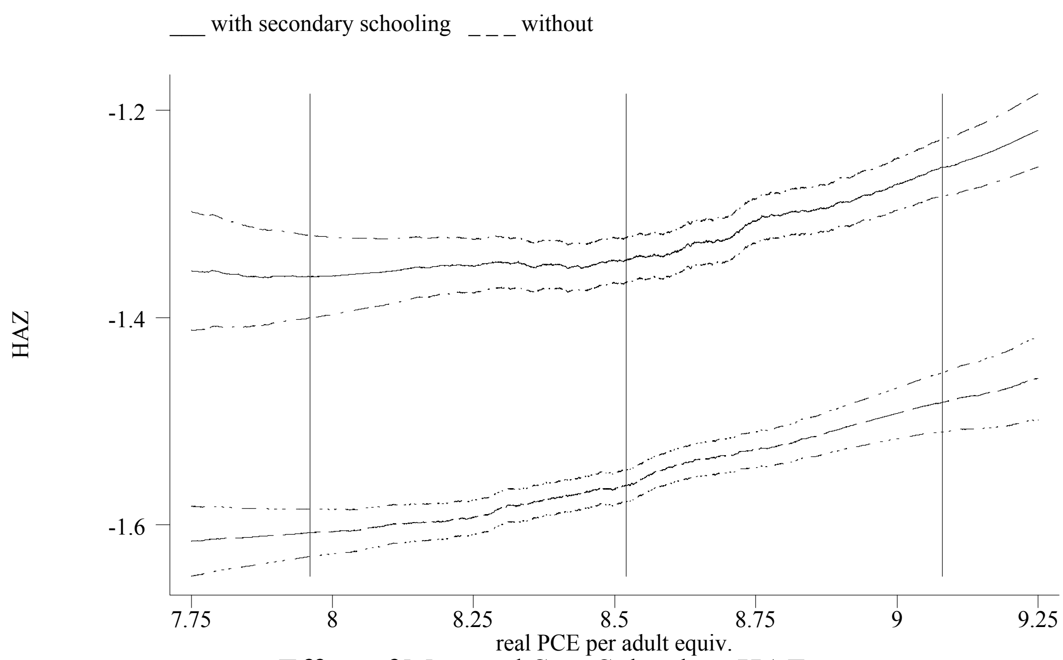
Effect of Nutrition Knowledge on WHZ

Figure 2



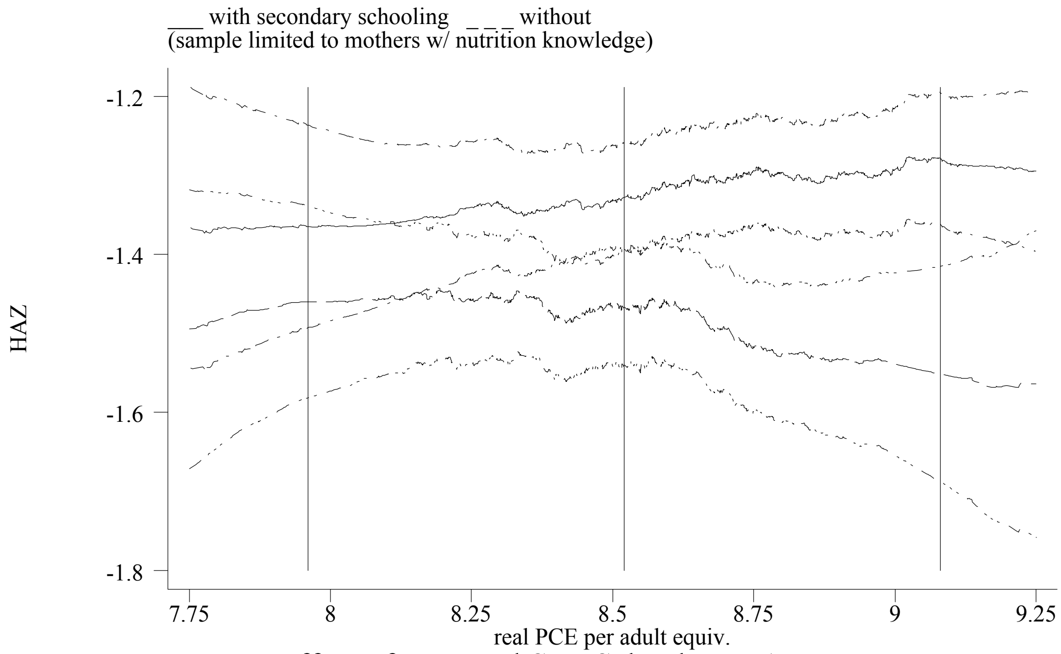
Effect of Maternal Sec. School on WHZ

Figure 3



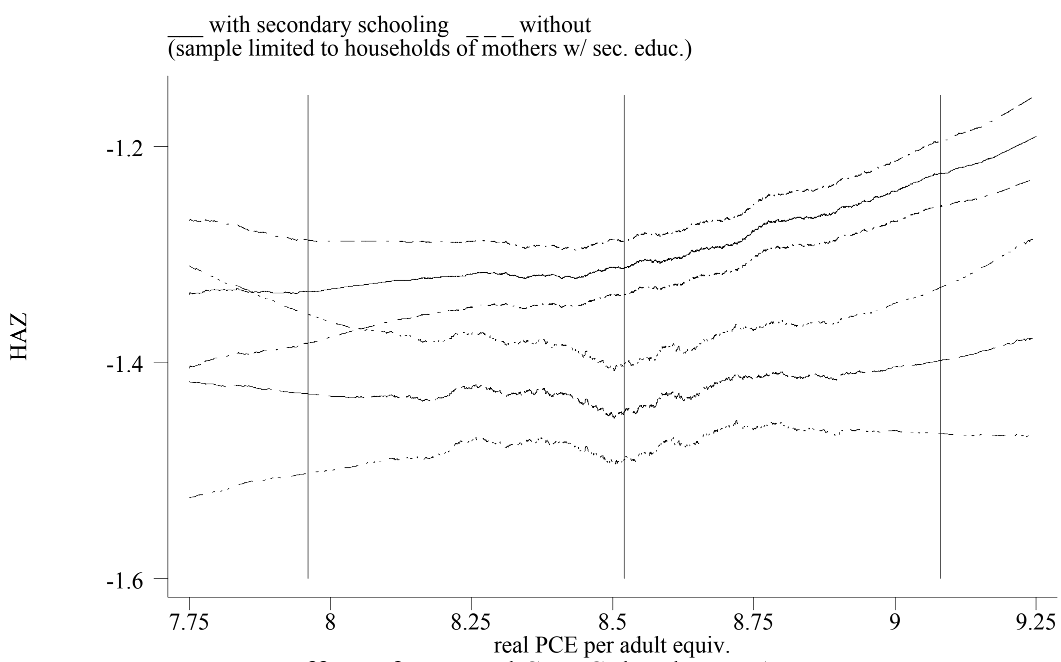
Effect of Maternal Sec. School on HAZ

Figure 4



Effect of Maternal Sec. School on HAZ

Figure 5



Effect of Paternal Sec. School on HAZ

Figure 6