# Evaluating the Impact of Early Childhood Nutrition and Availability of Health Service Providers on Subsequent Child Schooling: Evidence from Indonesia Family Life Survey*

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Abstract

This paper evaluates the impact of childhood nutritional status and the presence of a public health program on subsequent child schooling in Indonesia during 1990s. We estimate dynamic relationship of childhood nutrition and subsequent child schooling in which we carefully address the potential correlation between childhood nutrition and important but unobserved factors such as child innate healthiness and parents' taste toward child quality. We find that reducing incidence of poor childhood nutrition reduces the probability of delayed enrollment, but not the probability of repeating a grade. More importantly, the estimated effects when taking into account the endogeneity of childhood nutrition are 5-7 times stronger than when ignoring it. The effect of childhood nutrition on subsequent child schooling is even higher if child has access to public health facilities. Particularly, we find that the presence of midwife magnifying the effect of childhood nutritional status on subsequent child schooling. This result suggests that the exposure to midwife during early childhood improved child nutritional status that in turn helped child schooling.

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## 1. Introduction

Due to the perceived importance of both health status and education of children for both current well-being and their future productivity as adults, much attention in both the research and policy communities has focused on early childhood nutritional status and the enrollment of children in school. With strong interest in these areas, studies documenting correlations between these dimensions of child human capital and subsequent well-being as adults have multiplied in recent years.[1] In addition, empirical research has also attempted to identify intermediate factors affecting the relationship between child health schooling, and thus also affecting the outcomes of children as adults. The general assumption about the direction of influence between child health and educational investments is that child outcomes in school are more favorable with improvements in early childhood nutrition.

While the findings from a substantial body of existing research suggest that child nutrition is important for child schooling outcomes, many of these studies suffer from serious bias and fail to establish a causal relationship between child nutritional status and child schooling.[2] The most important source of bias stems from a failure to take into account the fact that both child schooling and child health status reflect household decisions. Many studies estimate the effect of early childhood nutrition on subsequent child schooling outcomes assuming that there is no correlation between childhood

[1] For most recent review in related studies see Glewwe and Miguel (2007) and Strauss and Thomas (2007).
[2]See the reviews in Pollit (1990), Behrman (1996) and Behrman and Lavy (1998).

nutrition and important unobserved factors such as child innate ability, parent preferences toward child quality, or parent gender preferences.

Although estimation controlling for this source of endogeneity may still be sensitive to underlying household behavioral assumptions and the nature of unobserved heterogeneity, research by Behrman and Lavy (1998), has shown that estimates of the effect of childhood nutrition on child schooling are biased downward when early childhood nutrition is treated as exogenous. Behrman and Lavy (1998) further demonstrate that if estimation assumes that (i) child health is correlated with unobserved individual, household and community level heterogeneity such as genetic endowment, home study environment, or availability of education facilities, and (ii) that if there are no unobserved inputs into child cognitive development and prices can be used as instruments, then the impact of health status on educational outcomes is three to seven times as large as those when ignoring endogeneity of child health. The bias is even larger when the second assumption is dropped.

Studies using only cross-section data frequently suffer from an additional source of bias. Typically they estimate current period child nutritional status on contemporaneous child schooling or use recall methods to measure past childhood nutrition and estimate an effect on current period child schooling. While it is difficult to argue that the parameters estimated from the former approach can be used to establish a causal relationship between health and schooling outcomes within the same period, parameters estimated using retrospective information are likely to suffer from recall bias. Once we recognize these concerns, it is difficult to imagine that causality between childhood nutrition and child schooling can be established using cross-sectional survey data.

To date there are four significant studies exploiting panel data which examine the relationship between nutritional status and child schooling and also address the methodological concerns noted above.[3] Alderman et al (2001), use panel data from rural Pakistan and find that child nutritional status affected school enrollment, and that the impact was greater for girls than for boys. Their preferred estimate employs a dynamic model and uses price shocks at the time when children were of 5 years old as instrumental variables.[4] Their results show that when one controls for endogeneity in child nutritional status, its effect was three times more important for enrollment than when the model was estimated without controlling for endogeneity in childhood nutrition.

Findings from Ghuman et al (2006) demonstrate the importance of pre-school nutritional status (using height-for-age z-scores and hemoglobin levels) for child enrollment in first grade. Using similar assumptions as

[3]See Alderman, Behrman, Lavy and Menon (2001); Alderman, Hoddinott, and Kinsey (2006); Glewwe, Jacoby and King (2001), and Ghuman, Behrman, Gultiano and King (2006).

[4]The choice of price shocks as instruments avoids the strong identifying assumption that there is no correlation between child height-for-age up to age two and after two years of age, as in Glewwe et al (2001). Still, one might be concerned about the timing of the price shocks used. As they also note, price shocks at age 5 might not adequately capture health status of children when of preschool age. Strauss and Thomas (2007) also note the potential for long-term effects of shocks to affect current period household welfare, which would further complicate estimation of the childhood effect. We consider this issue further in our empirical discussion of our instrumental variables below.

Alderman et al (2001), they instrument endogenous child nutritional status with characteristics of day care centers in villages where children lived prior to elementary age. They find that childhood nutrition has a significant and positive impact on school enrollment, but in contrast with Alderman et al, their instrumental variables estimates suggest upward bias in parameters produced by OLS.[5]

Another strategy is used both in Alderman et al (2006) and Glewwe et al (2001). These two papers share a similar assumption that child nutritional status is correlated with two important (unobserved) factors that also affect child schooling performance: (i) the *home environment* provided by a parent and affecting school performance; and (ii) the child's *health endowment*, which affects how a child performs relative to others in school. To deal with these unobservables, they combine household (maternal) fixed-effect and instrumental variables estimation techniques. Alderman et al (2006) use negative shocks (from war and drought) that affected children of preschool age to instrument for child nutritional status. They find that better preschool nutritional status is associated with more completed years of schooling. Glewwe et al (2001) use height-for-age for older siblings and differenced month of birth dummy variables as instrumental variables. They find that

[5] The inconsistency might be caused by weak instruments bias. As indicated in their results, F-statistics for their excluded instrumental variable instrumental variable is only significant at 10% level and it is not clear whether the results are robust to weak instruments bias.

undernourished children entered school later and performed more poorly on cognitive achievement tests relative to better-nourished children.

This paper has two objectives. First, we add to the existing literature examining the relationship between early childhood nutrition and subsequent child schooling using a unique dataset collected in Indonesia. In common with the four studies discussed above, we use an instrumental variable technique to estimate the effect of childhood nutrition on the probability of delayed enrollment or repeated grade. We use rainfall shocks occurring *in utero* for sampled children along with other household and community variables to identify children's nutritional status during pre-school age. We argue that shocks experienced prior to birth are relevant for determining both height-for-age z-scores and stunting as measures of long-term malnutrition. Contemporaneous shocks, such as price shocks, are unlikely to generate an appreciable effect on long-term measures of nutritional status such as height-for-age z-scores.

In addition, as health and nutritional status may as well be affected by government policy as well as parental choice and health shocks affecting the innate healthiness of children (Glewwe 2005), we evaluate how exposure to community-based health service providers during early childhood affected the influence of health status on educational outcomes. In particular, we examine whether exposure to village midwives alleviates the effect of low early nutritional status in early childhood on subsequent school enrollment, or alternatively, whether presence of midwives complements the benefits of early nutritional status for school enrollment. At present, there are few studies that directly link past experience of malnutrition, exposure to public health programs and subsequent socio-economic outcomes.

Results of our analysis have important policy implications regardless of the estimated effect. Presence of a village midwife may reduce the effects of negative shocks to early childhood nutrition on subsequent school outcomes and assist with recovery from the effects of shocks to health status during early childhood. Alternatively, if midwives simply complement the effects of good health status, then they may still be playing an important role in maintaining health status and facilitating school enrollment, but this result would underline the importance of finding other means to support early childhood nutritional status. We use presence of a village midwife in the community when children were of pre-school age to represent child exposure to community-based health services, and interact this indicator with our measure of childhood nutrition. We then include community dummy variables in this intent-to-treat approach to control for features of the community correlated with placement of a midwife. This approach allows us to identify how presence of a midwife influences the effect of early childhood nutrition on subsequent enrollment while avoiding bias from endogenous placement of a midwife in the village.

Our analysis examines another dimension along which village midwives may play an important role for influencing outcomes. Earlier studies demonstrated the important role played by village midwives in improving the health of prime age women (Frankenberg and Thomas 2001) and of pre-school age children (Frankenberg et al 2005).[6] We argue that if there is link from childhood nutrition to child schooling, then the presence of a public health program that improved child health could also have an important impact on child-schooling.

Our analyses make use of panel data from three waves Indonesia Family Life Survey (IFLS). This ongoing survey provides a rich source of information on individuals and households, as well as their access to facilities and the characteristics of the communities where they reside. In particular, we will link the childhood nutritional status of children between 6-59 months in 1993 with their schooling in 1997 (for an older group, who were 3 to 4 years old in 1993) and in 2000 (for a younger group, who were up to 2 years of age in 1993). We further link sampled children with presence of a midwife in the community where they lived in 1993 to evaluate how exposure to a village midwife prior to five years of age interacted with early childhood nutrition influenced school enrollment. In order to identify nutritional status, we also exploit historical rainfall data (Kirono, 2000, and Kirono et al, 1999) from the month and year when the sampled children were conceived.

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[6]Extensive discussions of the village midwife program can also be found in Frankenberg and Thomas (2001)

Our results show that childhood nutritional status reduced the probability of delayed enrollment, but not the probability of repeating a grade. The effect of childhood nutrition on subsequent schooling is greater for boys than for girls. Our preferred specifications produce estimates that are 5 to 7 times larger than when estimates ignore the endogeneity of childhood nutrition. In addition, we find that presence of a village midwife in the community in fact magnifies the effect childhood nutrition on child schooling implying that a village midwife complements nutritional status in early childhood. We also perform simulations to show the likely effects of increasing the share of communities with midwives. The result shows further improvement in the role of child health and nutrition in improving child schooling. This implies that exposure to village midwife, particularly during childhood, might be used as policy instrument to reduce gap in child schooling through improvement of child health and nutrition.

This paper thus contributes to the literature on impacts of early childhood nutrition in two significant ways. First, this study adds to existing studies which control for the endogeneity of childhood nutrition when estimating its impact on child schooling. In particular, we utilize exogenous rainfall shocks as source of identification for nutritional status during childhood. Second, we examine how placing health service providers in Indonesian communities affects the relationship between early childhood nutritional status and subsequent schooling outcomes. We thus estimate whether the importance of early childhood nutrition status for subsequent school enrollment is affected by presence of community based health service providers. Our results provide an indication of how presence of health providers may interact with child health status to improve schooling outcomes.

The remaining of the paper is organized as follows. In section 2, we provide a simple framework to explain analytically how childhood nutrition may affect child schooling conditional on other variables. We also show how government policy may determine child schooling through a change in health, health environment and health prices. In section 3, we propose an empirical model and strategy to identify the effect of early childhood nutrition on schooling, and then extend our discussion to examine how presence of a village midwife interacts with early childhood nutrition to affect child schooling. We next discuss data, the community setting, and concerns with the data in section 4. In section 5, we present and discuss our results and conclude in section 6.

## 2. Analytical Framework

This section presents a simple analytical framework to model the relationship between past child nutritional status, availability of a health service provider and child schooling.[7] We adopt a two-period analytical framework developed by Glewwe (2005, 2007). The first period is a preschool

[7]Our discussion in this section draws inspiration from Glewwe (2005).

stage in which children are younger than 5 years of age. Clinical nutritionists argue that this period, and in particular the period between 6 and 24 months, is when nutritional interventions and supplemental feeding are likely to have the greatest impact on subsequent child biological and cognitive development. If parents and the health service provider have knowledge of this relationship, we expect greater investment in child health during the period. The second period occurs when children are of primary school age, or age 5 and older. During this period, and conditional on child health and nutritional status, parents and government invest in child education, and achievements in schooling may be related to child nutritional status in the first period.

We start with production function for child schooling in period two which is specified as a function of child and parent characteristics during both periods one and two:

$$S_2 = A(H_1, H_2, EI_1, EI_2, \phi, SC) \qquad (1)$$

where $S$ is a child schooling outcome, $H_i$ represents health and nutritional status during period $i$ (i=1,2), $EI_i$ is (parental) education input at period $i$, $\phi$ is (unobserved) innate child ability (e.g., intelligence, motivation), and $SC$ are school characteristics. Equation (1) focuses on assessing the role of child nutritional status on child schooling while holding other factors constant. This relationship is expressed as a structural equation since it only includes variables that measure direct effects of each right hand side variable on child education.

Academic achievement, as highlighted by (1), is important but not our main object of analysis. It is difficult to estimate because child academic attainment and some other factors such as $EI_i$ ($i$=1,2) are endogenous as they are under the control of parents and thus reflect parental preferences toward children's education as well as health.[8] School characteristic, *SC*, are also potentially endogenous since parents can choose the school their children attend and the government can decide by how much to invest in school quality. In addition, other important factors, such as child innate ability and school inputs, are unobserved. Our objective here is to evaluate the effect of child nutritional status and health policy on child schooling using conditional demand functions for child education. By estimating conditional demand, we avoid some of the complications arising when estimating the effect of childhood nutrition on child schooling using the schooling production function described above.

We derive the conditional demand function for child education by first substituting the endogenous independent variables, other than nutritional status, with relevant exogenous variables. The reduced-forms for each of the education inputs $EI_i$ ($i$=1,2) are specified as:[9]

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[8] Assuming that household face resources constraint, allocating resources toward educational inputs should affect those toward children's health inputs.

[9] As discussed in Glewwe (2005), one complication arises when specifying the reduced form for child educational inputs: it is reasonable that child health and nutritional status may

$$EI_1 = ei_1(Y, Med, Fed, PS, \sigma, \alpha; PH_1, HE_1, \tau, \eta) \quad (2)$$

$$EI_2 = ei_2(H_1, Y, Med, Fed, PS, \sigma, \alpha; PH_2, HE_2, \tau, \eta) \quad (3)$$

where $Y$ is parental income, *Med* and *Fed* are mother and father education, respectively, *PS* are prices of schooling and educational inputs, $\sigma$ is parental preference toward child schooling, $PH_i$ (i=1,2) are prices for health in each period, *HE* is health environment, $\tau$ is parents' preferences toward child health, and $\eta$ is the innate healthiness of the child.

We next substitute equations (2) and (3) into equation (1) to yield the conditional demand function for child schooling as:

$$S_2 = a_{CD}(H_1, H_2, Y, Med, Fed, PS, SC, \sigma, \alpha; PH_1, PH_2, HE_1, HE_2, \tau, \eta) \quad (4)$$

This function is still not fully in reduced form because it includes current nutritional status as an endogenous variable in addition to exogenous variables. This specification picks up the direct impact of changes in health status (as in equation 1) as well as an indirect effect when change in health affects other variables before the impact on change in child schooling, S. For

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enter into parent decisions about the education inputs of their children. This creates a problem particularly since current health status is endogenous. To avoid this complication, researchers sometimes use previous period health status in current period reduced form education demand functions to avoid this complication.

example part of the impact of good health in period 1 operates indirectly through parental education input in period 2, as parents respond to health status by increasing or decreasing their inputs into child education.

In addition, equation (4) can also be used to identify the impact of government policies in health and education on child schooling. The impact of health policy can be characterized as a change in either health prices ($PH_i$) or health environment ($HE_i$). In particular, the impact of health policy is channeled through two pathways. First, a health pathway includes the direct impact of child health on children cognitive development through equation (1), and indirect impacts of (lagged) child health on parental education inputs through equations (2) and (3). Secondly, there is a reallocation pathway through which substitution and income effects of $PH_i$ and $HE_i$ influence parental education through equations (2) and (3).

## 3. Empirical Model and Identification

We first focus on estimating the effect of childhood nutritional status on subsequent child schooling. Our empirical model of the conditional demand for child schooling is represented by a dynamic model of the impact of nutrition on subsequent schooling:[10]

[10] For our conditional demand for child schooling to be consistent with equation 4, we should include current nutritional status in the empirical model shown in equation 5. As discussed by Behrman and Lavy (1998) and Alderman et al (2001) the coefficient on current health status in relation to child schooling is difficult to interpret as the estimated impact of current

$$S_{2i} = \alpha + \beta H_{1i} + \boldsymbol{\delta}'\mathbf{X}_{2i} + \boldsymbol{\gamma}'P_{2h} + \boldsymbol{\lambda}'\mathbf{Z}_{2c} + v_{2i} \qquad (5)$$

where $S$ is child schooling, $H$ is nutritional status in period one when children are 5 years old or younger, $\boldsymbol{X}$ is vector of household characteristics (including, among others, income, mother's education and father's education), $\boldsymbol{P}$ is a vector of prices, $\boldsymbol{Z}$ is a vector of community characteristics, which might have an effect on child school enrollment, and $v$ is a disturbance term. Numbers in subscript indicate period of realization for each variable. While letters in subscript, *i, h* and *c*, each indicate individual, household or community level variables.

As discussed in the previous section, current health status is supposed to be included in equation 5. Our primary interest in equation 5, however, is to measure the impact of early childhood nutritional status on subsequent schooling outcomes. To do so, we need to exclude the current health status from the schooling outcomes equation as we assume that the impact of past nutritional status on current schooling is through current health status. Otherwise the impact of past nutritional status on schooling will be absorbed by current health status. In addition, including current health status in the

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health on current child schooling. We therefore dropped current health status from right hand side of equation 5 and focus on estimating the impact of previous period (period 1) nutritional status on current (period 2) child schooling. Our identification strategy must be robust to potential biases introduced by unobserved nutritional status.

schooling outcomes equation introduces another endogeneity problem when estimating equation 5.

Estimating equation 5 with OLS is likely to produce bias in parameter $\beta$ as nutritional health status in period 1 is correlated with unobserved time-invariant innate child health as well as parent preferences toward child health captured in *v*. Some studies such as Alderman et al (2006), Glewwe and King (2001) combine maternal-household fixed-effects with instrumental variable techniques to address unobserved heterogeneity at parent (household) and individual levels. Alternatively, as discussed in Glewwe et al (2001) and Alderman et al (2001), if we can find shocks (price or weather) that (i) are of sufficient magnitude to affect child stature but not their siblings, (ii) vary sufficiently across households (or even individuals), we can use such shocks to identify childhood height-for-age as it addresses unobserved heterogeneity at both individual and household levels.

We follow an identification strategy similar to that of Alderman et al (2001) and Alderman et al (2009), but differ with them in our choice of the timing of shocks during childhood used to identify childhood nutrition. We argue that price shocks that were measured contemporaneously with early child nutrition indicator may not be sufficient for explaining the child height –which is used to measure early childhood malnutrition. This is because any type of shock, will likely take considerable time to be reflected in child height. Alderman et al (2001) acknowledge this concern although argue that as long as such (contemporaneous) price shocks are still partially correlated with childhood nutritional status, we can still use them to identify endogenous childhood nutrition.

We make use of long-term historical rainfall data, and use *in utero* rainfall shocks, particularly those during the mother's second and third trimester of pregnancy, and interact them with child age (in months) when height was measured. The interaction between *in utero* rainfall shocks and child age is employed to improve the instruments' power in identifying child nutritional status by exploiting the length of time from the occurrence of the shocks to the time when child height was measured in 1993. The identifying assumption is that *in utero* rainfall shocks and time to the period when height was measured have no impact on subsequent child schooling except through childhood nutrition. In addition, we also include the value of total household assets, the height of father and mother and interactions of number of *posyandu* and child age, all measured in period 1, as additional excluded instruments.

There are a few potential concerns with these instruments. First, past rainfall shocks might have had large enough magnitudes to have long term impacts on household assets or consumption which thus directly affects child schooling. Alternatively, prior rainfall shocks might have led to disasters, such as floods that adversely affected long term household access to education facilities and thus also to later child schooling.  Such concerns, if not addressed, would cast doubt on the validity of the instruments. To deal with concerns about affects on wealth, we control for per-capita expenditure measure and include a village dummy in the second stage regression so the effect of past rainfall shocks on education, through household wealth, would be indirect and operating through these variables. Similarly, one might be concerned that parents' height (from period 1) should not be in excluded instruments as they might affect subsequent child education. But we argue that the effect of parents' height on child education would be conditional on child health. Thus, including a child height indicator in the second stage regression should take care of this concern.

In addition, as the model suggests, prices and some community level variables also determine child schooling outcomes. So we include in the equation some food prices and community-level fixed effects. We argue that after implementing this procedure, $H_{1i}$ is no longer correlated with omitted variables in error term and thus $\beta$ is unbiased estimator of the impact of childhood nutritional status on primary school enrollment.

We then seek to evaluate the effect of presence of midwife in the community during childhood in the same schooling outcomes conditional on past nutritional status. Our approach is to estimate intent-to-treat effect of the village midwife. The important role of midwives has been identified for several outcomes such as womens health (Frankenberg and Thomas 2001) and young child nutritional status (Frankenberg et al 2005). Nevertheless none of previous studies have examined how exposure to community-based health service providers, such as midwives, might interact with early childhood nutritional status to affect child schooling outcomes. We attempt to establish a potential link between exposure to a village midwife when children are still young (under 5 years old) and subsequent enrollment when of school age. Specifically, we are interested in how exposure to a midwife interacts with nutritional health status in early childhood. Exposure to midwife might reduce the negative effect of past malnutrition on subsequent school enrollment if village midwives provide health services that compensate for *in utero* shocks affecting nutritional health status. Alternatively, we may find that presence of a midwife reinforces the benefits of better early childhood nutritional status. We thus want to estimate the following equation:

$$S_{2i} = \alpha + T + \beta_1 H_{1i} + \beta_2 Mid_{1c}^{93} + \beta_3 H_{1i} * Mid_{1c}^{93} + \boldsymbol{\delta}'\mathbf{X}_{2i} + \boldsymbol{\gamma}'\mathbf{S}_{2i} + v_{2i} \qquad (6)$$

where $Mid^{93}$ is an indicator for a presence of midwife in the community where a child resided in period 1, or when they were of pre-school age (in 1993). We estimate equation (2) using instrumental variables methods by employing shocks at the early age of life as instruments for early childhood nutritional status. In addition to those we discussed when estimating equation 5, one concern is that presence of midwife in period 1 is likely to be correlated with some omitted variable, such as availability of education facilities within the community, that might affect subsequent school enrollment.[11] If this is true, ignoring such correlation will lead to bias in the parameter of interest. We thus include a fixed community effect, $\mu_c$ , and rewrite (6) as below:

$$S_{2i} = \alpha + T + \beta_1 H_{1i} + \beta_2 H_{1i} * Mid_{1c}^{93} + \boldsymbol{\delta}'\mathbf{X}_{2i} + \boldsymbol{\gamma}'\mathbf{S}_{2i} + \mu_c + v_{2i} \qquad (7)$$

Note that when we include $\mu_c$ to control for (potential) endogenous midwife placement, the midwife dummy can no longer be included directly as it will be perfectly collinear with the village fixed effect. By controlling for community fixed-effects, we control for endogenous placement of midwives by 1993. Community fixed-effects are also useful as they control for unobserved elementary school characteristics as we assume that the sampled children would go to the closest school to the community.[12] In this way we assume those schools' characteristics are fixed across periods.[13]

The exclusion of a midwife variable due to inclusion of a community fixed-effect means that we will not be able to estimate the direct effect of midwife on schooling outcomes. Fortunately that is not our main interest. Instead we would like to see how exposure to a midwife affects the schooling

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[11] For example, Pitt et al (1993) find that the presence of one type of facilities was correlated with another type of facilities.

[12] Although IFLS interviews elementary schools, it is not possible to link every child in the sample to the school he or she attended without making arbitrary assumptions.

[13] The use of community fixed-effect here also implies that we should focus only on the children that lived in panel communities during the observed periods.

outcomes through early childhood nutritional status. To do so, we will focus on the interaction between early childhood height-for-age and dummy variable for the presence of a midwife in community during period when child was in pre-school age.

#### 4. Data and sample setting

This study uses three waves of panel data from Indonesia Family Life Survey (IFLS) 1993, 1997 and 2000. IFLS is a panel survey which collected very rich socio-economic information on many aspects of individual lives and households as well about characteristics of communities where those individuals and households resided. The detail description about sampling in each of the three survey waves is provided in Strauss et al (2004), Frankenberg and Thomas (2000), and Frankenberg et al (1995), respectively.

Our sample in this study includes children who were between 6 and 59 month in 1993 (born between 1988 and 1993) and have their height (or length) measured in the 1993 survey. We then link the 1993 measured nutritional status for children who were born between 1988 and 1990 (with their enrollment status in 1997 and for those who were born from 1991 to 1993 with their primary school enrollment in 2000 then pool those two data files. In this set up, we thus examine the impact of early childhood nutritional status on schooling of children who were between 7-9 years of age in 1997 and 2000. The IFLS data also allow us to identify how midwife exposure, when the children were 5 years old or younger, interacts with early childhood nutrition in affecting enrollment. As mentioned above, we expect that the exposure to midwife health services during such an early age might either reduce the negative effect of malnutrition during childhood, or alternatively complement the health endowment of children who were not suffering from malnutrition.

Historical rainfall data are obtained from Kirono (2000) and Kirono et al (1999) which collect rainfall from 62 weather stations across Indonesia from 1960 to 1999. For our purpose, we use calculate shocks using rainfall data from the entire period spanning 1960 to 1993, and then calculate shocks for the period when our sampled children were born. From the data, we generate monthly rainfall shocks which we define as monthly rainfall deviations from long-term monthly rainfall trends and presented as monthly shocks.

The summary statistics of key variables are in table 1 below. All variables are measured in period 2 (1997 and 2000 surveys, pooled) except for two main variables of interest, nutritional status and presence of midwife in the community, and instrumental variables that are measured in period 1 (1993 survey). We look at two child schooling measures, whether child experienced delayed enrollment when they entered primary school and whether they ever repeated a grade, both are expressed as binary dummy variables.[14] There are 18 and 10 percent of children who experienced delayed enrollment and repeated classes respectively.

For measures of nutritional status (measured by height-for-age) we use (continuous) height-for-age z-score and (binary) whether a child was non-stunted which is a measure of child malnutrition.[15] The health literature has suggested height (or length for baby and infant) is an indicator with less measurement error for child health and nutritional status relative to the other health measures.[16] More importantly, the use of height-for-age will fit with the focus of this study that investigates the long-term relationship between early childhood nutrition to subsequent child schooling. The 1993 IFLS data show that children younger than 5 of age have heights that are on average 1.39 standard deviations lower than those of children with similar age and gender in US. Meanwhile nearly 29 percent of children in the 1993 sample were exposed to village midwives.

We also control for other covariates that may affect the household decision to send children to elementary school and in part might represent parent preferences for child education, the home study environment and the intrahousehold allocation process. We control for parents' education, age of household head, household composition, and per capita expenditure. In

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[14] For Indonesia, the two indicators appear to be important measures for primary education particularly after reaching near universal enrollment for primary education.

[15] Stunted is defined when child height-for-age z-score is less than negative 2.

[16] In IFLS, height and weight are measured by special trained health workers with regularly calibrated health equipment. For this reason, we believe that measurement error is negligible in this case.

addition, as the model suggests, we also include current price for some food items (rice, sugar, cooking oil and condensed milk). We also include a time dummy to control for any secular trend across two different periods of life (1 for school age period, 0 otherwise). The mean and standard deviation for each of these variables are presented in table 1.

## 5. Results

In this section we present and discuss the results. We first focus on the impact of childhood nutritional status on subsequent child schooling outcomes. The results, consistent with some previous studies, show that childhood nutrition matter in determining subsequent child schooling. Our preferred estimates also indicate stronger effect of childhood nutrition on subsequent schooling implying biased results when correlation between nutritional status and omitted variables captured in error term are ignored. We then try to seek potential effect of the presence of village midwife in the community where those children resided when they were in pre-school age. In particular, we are interested in whether such exposure might reduce the negative effects of malnutrition which occurred earlier in childhood.

### 5.1. Impact of early childhood nutritional status on child schooling

We estimate equation 5 and firstly ignore the correlation of childhood nutritional status with unobserved heterogeneity such as child health endowment and parent preferences for child quality. The result in table 2 and shows that improved childhood nutrition lowers the probability of a child experiencing delayed enrollment. The size of the coefficient when not controlling for community fixed-effect suggests that an increase in child height-for-age by one standard deviation lowered the probability of delayed enrollment by 3.2 percent. When controlling for community fixed-effects, the effect became slightly stronger, where an increase in child height-for-age by one standard deviation reduced the probability of delayed enrollment by 3.5 percent. The effect of other covariates appears to be consistent with literature on determinants of child schooling. Increasing parent, and in particular father's education, reduces the probability of delayed enrollment. Per capita expenditure is also significant and has a negative sign as one would expect. Household composition variables are also important for child schooling but with different signs of influence on child schooling. Number of children (age 6-14 years old) residing in the household has the disadvantaged of delaying primary school enrollment. This might imply that there is competition among for household educational resources. In addition, number of male adults (age 15-59 years old) in the family reduces the probability of a child experiencing delayed enrollment, but this occurs only when we are not controlling for community fixed-effects.

Using a dummy indicator for stunting provides further support for our findings. Suffering from stunting makes the probability of delayed enrolment increase by 8 or 9 percent depending on whether we control for community fixed-effects. Other covariates show similar direction of influence on child delayed enrollment compared to when we do not control for the community fixed-effect.

Table 3 shows result from estimating childhood nutrition on probability of repeating grade using a model that fails to control for endogenous health status. Estimation results for each outcome using different specifications (with and without community fixed-effects) show insignificant and inconsistent sign of childhood nutrition effect on probability of grade repetition. Some other covariates however remain significant with consistent sign as in the previous estimation.

Although the sign of the parameters of interest appear to be consistent with theoretical model, the estimations using treating health status as exogenous will be biased for the reasons we discussed earlier. Behrman and Lavy (1998) note that the direction of the bias from this naïve model, whether upward or downward, depend on the nature of intrahousehold allocation process. To address this issue, we adopt instrumental variable technique in estimating the effect of early childhood nutrition on child schooling.

We first examine effects of early childhood nutrition on probability of delayed enrollment and present results in Table 4. We first look at the bottom panel of table 4 where some statistical test results for instrumental variables are provided. The tests are conducted both for measures of childhood nutritional status, height-for-age and stunting status, and each are conducted for specifications with and without community fixed-effects. As we see, the F-test for excluded instruments for both endogenous regressors, height-for-age and stunting status, produce a significant statistic at the 1 percent confidence level. Recent econometrics literature on instrumental variables suggests that these test statistics are not sufficient. Weak instrument bias may be present when there is non-zero but small correlation between endogenous regressors and excluded instruments although F-statistics of the excluded instruments are significant.[17]

We thus perform additional tests which include: (i) Kleibergen-Paap rk LM statistics, to test the relevance of the excluded instruments on the endogenous regressors (under Ho: equation is underidentified), and (ii) Hansen J statistics which test over-identifying restriction (under joint null hypothesis that the excluded instruments are valid). These tests show that the excluded instruments are strong and valid for the endogenous regressors whether or not we control for community fixed-effect in the equation. We also present the first stage regression results in the appendices.

Results from estimating the impact of childhood nutrition on child schooling using 2SLS are in top panel of table 4 (delayed enrollment) and table 5 (grade repetition). We start with the effect of childhood nutrition on delayed enrollment in table 4. In terms of the direction of the influence, the

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[17] see Wooldidge (2002) for theoretical implications for this problem and Bhaum et al (2003, 2007) for practical strategy to deal with this.

effects of childhood nutrition from 2SLS estimation are mostly consistent with results shown in table 2. With few exceptions, other covariates are also consistent with those in table 2. Controlling for endogeneity in childhood nutritional status makes the effect of early childhood nutrition on probability of delayed enrollment stronger, implying downward bias in the parameter estimated using OLS.

Without controlling for community fixed-effects, an increase in childhood height-for-age by 1 standard deviation lowered probability of delayed enrollment by 9.7 percent (column 1). Non-stunted children are 31.3 percent less likely to experience delayed enrollment relative to stunted children (column 3). However results from this specification may still be biased if there is omitted heterogeneity at the village level, including school characteristics that are likely correlated with child schooling. It is also possible that school access and quality differ across cohorts, particularly as the 1997/1998 economic crisis may have led to deterioration in the quality of schools. To handle these issues, we include community fixed-effects in the IV model.

As shown column 2 of table 4, the effect of controlling for community fixed-effects makes the effect of childhood nutrition on child schooling even stronger. An increase in child height-for-age in period 1 by 1 standard deviation reduced the probability of delayed enrollment by 15.8 percent. In addition, non-stunted children are more likely to avoid delayed enrollment relative to stunted child by about 54 percent. As we have addressed most of potential problems, these results, we argue, are relatively unbiased compared to those from models failing to control for endogeneity of childhood nutritional status and community fixed-effects.

When using grade repetition as the school outcome, we also find a negative sign of the effect childhood nutritional status on probability of repeating grade (table 5), we fail to reject the null hypotheses that the effect of childhood nutrition equals to zero. As this is consistent with the result from OLS estimation in table 3, one possible explanation why we found no childhood nutrition effect is that grade repetition is rare (the mean sample value of grade repetition is 9.6 percent). This probably occurs because we use young school age children who were 7-9 years old by the time we observe their schooling outcome and therefore the occurrence of grade repetition was not as high as for older children.

We next examine whether the effect of childhood nutrition on subsequent child schooling differs between boys and girls. We focus on delayed enrollment outcomes as we do not see significant effect of childhood nutrition on grade repetition. The results are presented in table 6.

As we can see in the bottom panel of table 6, F-statistics of excluded instruments are lower than 10 although they still maintain significance at the 1 percent level. To address concern over the possibility of weak instruments, we estimate the effect of childhood nutrition on delayed enrollment based on gender using instrumental variable-limited information maximum likelihood (IV-LIML). Baum et al (2007) show that IV-LIML estimation is robust in the presence of weak instrument.

Result in table 6 shows that childhood nutrition mattered for boys more than girls. Particularly 1 standard deviation increase in height-for-age z-score lowers probability of delayed enrollment by 21.3 percent for boys compared to 12.4 percent for girls. Using an extreme measure of malnutrition, non-stunted boys have 66.1 percent chance of enrolling on time relative to stunted boys. For girls, being non-stunted improves probability of enrolling on time by 42.7 percent relative to stunted girls.

These results therefore suggest the importance of childhood nutrition for child school enrollment decisions when they about to reach school age, but not for child grade repetition. These are consistent with previous findings and therefore reinforce the need for investment and intervention to prevent malnutrition at a very young age. Consistent with previous studies (see Alderman 2001, Behrman dan Lavy 1998, Glewwe et al 2000, and Glewwe and King 2001), the results also show that the estimated effect generated by OLS may suffer a substantial bias and which may mislead policy makers in addressing the problems related to early childhood malnutrition.

### 5.2. Impact of presence of midwife during early childhood on primary school enrollment.

Knowing the importance of early childhood health and nutritional status in lowering on child schooling, we then asked whether the presence of a midwife during such critical period of age helped children when they reached school-age. The link that we try to establish between past exposure to public health program and later schooling outcomes is built on the previous findings that the presence of village midwife increased health of young children (Frankenberg et al 2005). Therefore if the presence of village midwife improved child health (as measured by height-for-age), then we may expect that such a program may also yield improvements in child schooling outcomes conditional on improvements in child health.

Identifying an effect of the village midwife is not straightforward. One might believe that presence of a midwife in period one (when child is in early age) is exogenous for education measured in period 2 (when child is in school age). However, as shown in Pitt et al (2003), placement of a public program is likely to be correlated with the presence of other programs that already exist (and remained) in the community. In our case, placement of public programs might be correlated with availability or quality of school or other education programs which in turn might affect parent decisions on investment in child education.[18] We thus argue that controlling for community fixed-effects is important in this case and this should address correlation between the placement of a midwife with time-invariant omitted heterogeneity including the presence of other public programs in the community.

As we previously mentioned, however, there is a cost of including community fixed-effect. As we seek to evaluate the intent-to-treat effect of presence of midwife, the inclusion of community fixed-effect will absorb all fixed community level effects including presence of a midwife. We thus identify the midwife effect by calculating the partial effect of childhood nutritional status when presence of midwife is explicitly controlled for in the equation and compare it with the one from equation without control of presence of midwife. The difference is attributed to the presence of midwife in the community in period 1. If presence of midwife indeed helps schooling of children given their childhood nutritional status, then we will see that the presence of midwife will increase the partial effect of childhood nutrition on subsequent schooling outcomes.

We focus on the specifications that control for community fixed-effect in column 2 and 4 of table 8. As we expect, the midwife variable is dropped by the inclusion of community variable and the sign of childhood nutrition (for both height-for-age z-score and non-stunted status) are negative. The effect of childhood nutrition is significant at the 1 percent level where the size of the

[18]Using Indonesia SUSENAS data, Pitt et al (2001) show that the placement of public programs was correlated with the presence of another program that already existed and the effect of the program is sensitive to whether or not one controls for this correlation.

effects are -0.155 (height-for-age z-score) and -0.507 (dummy for non-stunted). Interactions between childhood nutritional status (both for height-for-age z-score and dummy for non-stunted) and midwife are insignificant.

In the presence of an interaction term, however, we should not only use individual statistical test to evaluate the partial effect of parameter of interest. Instead, as noted in Wooldridge (2003), we need to conduct joint significant test for height-for-age and interaction of height-for-age and midwife. The F-statistics show that childhood nutrition variables and interactions with midwife are significant at 1 percent level as shown in bottom panel of column 2 and 4 of table 8.

We thus calculate the partial effect of childhood nutrition in the presence of a midwife and present the result in table 8A. We first look at the effect by using height-for-age z-score as a measure of nutritional status. We find that the partial effect of height-for-age (at midwife sample mean, 0.287) is -0.166 which says that an increase in one standard deviation of child height lowered the probability of delayed enrollment by 16.6 percent which is higher than the effect when no midwife at all (15.5 percent).

Based on the estimated parameter in table 8, we also predict the effect of child height in cases where presence of midwife in the communities increased to 50 and 75 percent. When probability of a midwife in the community is increased to 50 percent, a one standard deviation increase in childhood nutritional status lowers the probability of delayed enrollment by

17.4 percent. While if presence of midwife is expanded further to 75 percent, the effect of childhood nutrition becomes even stronger where an increase in one standard deviation of child height lowers the probability of delayed enrollment by 18.4 percent.

When using stunting status (column 2 of table 8A), the partial effect of childhood nutrition in the presence of midwife (sample mean=0.287) is -0.553. This suggests that by being not stunted during childhood, the probability a child enrolls in school on time is 55.7 percent higher than if he (or she) suffered stunting during childhood. Recall that when we do not explicitly control for presence of a midwife, eliminating stunting during early childhood could reduce the probability of delayed enrollment by 50.7 percent relative to those who were stunted during childhood. Predicted effects of being not-stunted during childhood on probability of delayed enrollment by hypothetically increasing the probability of a midwife in the community to 50 and 75 percent are consistent with our calculation using height-for-age z-score as measure of childhood nutrition. When the presence of a midwife is increased to 50 (75) percent, the importance of not being stunted during childhood is even higher. Non-stunted children are 38.7 (62.7) percent more likely to be enrolled in school at age 7, and this is 58.7(62.7) percent higher than if they had experienced stunting during early childhood.

We next turn to table 9 where we estimate the effect childhood nutrition in the presence of midwife on probability of repeating a grade. As in table 8, we again focus on the specifications that include community fixed-effects to control for potential endogenous placement of a village midwife. We first find that childhood nutritional status does not have an effect on probability of repeating a grade as none of coefficients for height-for-age z-score and dummy for non-stunted are significant. The join significant test for childhood nutrition (for both height-for-age and dummy of non-stunted) and its interactions with dummy for midwife presence indicate that they jointly are not significantly different from zero. This is consistent with result in table 5 which shows no significant effect of childhood nutrition on probability of repeating a grade.

Coefficients for interaction between childhood nutrition and dummy for presence of midwife, however, are negative and significant at 5 and 10 percent level. Coefficients for interaction between dummy for presence of midwife and height-for-age z-score is -0.073 (column 2), while for its interaction with dummy for not-stunted is 0.333 (column 4). What do these coefficients suggest? As the effect of childhood nutritional status on probability of repeating a grade is statistically zero (as also indicated in table 5), the significant interaction coefficients (between childhood nutrition and midwife) indicate the effect of presence of a midwife. It suggests that an increase in one standard deviation in child height among children exposed to a midwife will reduce the probability of repeating a grade by 7.3 percent relative to those who live in community without village midwife (column 2 of table 9). It also that being well nourished in a community with village midwife lowers the probability of repeating a grade by 33.3 relative to other children in the sample area.

**6. Conclusions**

This study evaluates the impact of childhood nutritional status and the presence of a public health program on subsequent child schooling in Indonesia during 1990s. Guided by the model, we estimate dynamic relationship of childhood nutrition and subsequent child schooling in which we carefully address the potential correlation between childhood nutrition and important but unobserved factors such as child innate healthiness and parents' taste toward child quality. In addition, with access to long-term historical rainfall data, we create rainfall shocks during conception period and use them to identify childhood nutritional status. By controlling for endogenous nutritional status, we find that reducing incidence of poor childhood nutrition reduces also the probability of delayed enrollment, but not the probability of repeating a grade. More importantly, the estimated effects when taking into account the endogeneity of childhood nutrition are 5-7 times stronger than when ignoring the endogeneity of childhood nutrition.

The effect of childhood nutrition on subsequent child schooling is even higher if child has access to public health facilities. Looking particularly at presence of midwife, we find that the presence of midwife magnifying the effect of childhood nutritional status on subsequent child schooling. This result suggests positive effect of presence of midwife on child schooling.

What does this result imply? From the policy perspective, this result reinforces the importance of investment on nutritional status of children at very young ages, even just after conception and before birth. One effective channel of health investment, as this study suggests, can be through local public health facilities such as village midwife. From a methodological perspective, the results presented in this study highlight the importance of taking into account the endogeneity in childhood nutrition and other estimation issues when estimating its effect on subsequent child schooling.

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Table 1. Descriptive statistics of main variables

| Variable | Mean | Std. Dev. |
|---|---|---|
| Delayed enrollment (Yes=1) | 0.146 | 0.353 |
| Ever repeated grade (Yes=1) | 0.096 | 0.295 |
| Heigh-for-age z-score (haz), lagged | -1.390 | 1.442 |
| Presence of village midwife, lagged | 0.287 | 0.453 |
| Mother education (years) | 4.205 | 5.505 |
| Father education (years) | 5.057 | 5.782 |
| Household head age (years) | 42.285 | 9.911 |
| # of children (5-14 yo) in household | 1.960 | 0.945 |
| # of female adult (15-59 yo) in household | 1.382 | 0.706 |
| # of male adult (15-59 yo) in household | 1.284 | 0.801 |
| Per capita expenditure (log) | 11.992 | 0.712 |
| Price of rice (log) | 7.414 | 0.387 |
| Price of sugar (log) | 7.813 | 0.375 |
| Price of cooking oil (log) | 7.846 | 0.376 |
| Price of condensed milk (log) | 7.781 | 0.503 |

Notes: lagged variables are measured in period 1 (1993 survey).

Table 2. Impact of childhood nutrition on probability of delayed enrollment, OLS

| Dep. Var: delayed enrollment (Yes=1) | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.032*** | -0.035*** | -0.090*** | -0.083*** |
| | (0.006) | (0.007) | (0.018) | (0.020) |
| Time dummy | 0.087** | 0.096* | 0.077* | 0.090* |
| | (0.042) | (0.049) | (0.042) | (0.049) |
| Mother education | -0.003* | -0.001 | -0.003* | -0.001 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Father education | -0.005*** | -0.004** | -0.005*** | -0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Age of head of household | 0.001 | 0.001 | 0.001 | 0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| # 6-14 yo children in HH | 0.030*** | 0.037*** | 0.031*** | 0.039*** |
| | (0.009) | (0.010) | (0.009) | (0.010) |
| # female adults in HH | 0.000 | 0.007 | -0.002 | 0.006 |
| | (0.012) | (0.014) | (0.012) | (0.014) |
| # male adults in HH | -0.027** | -0.015 | -0.027** | -0.016 |
| | (0.011) | (0.012) | (0.011) | (0.012) |
| Per-capita expenditure | -0.040*** | -0.031** | -0.042*** | -0.034** |
| | (0.012) | (0.015) | (0.012) | (0.015) |
| Price of rice | 0.017 | -0.02 | 0.016 | -0.027 |
| | (0.030) | (0.051) | (0.030) | (0.051) |
| Price of sugar | 0.008 | 0.065 | 0.011 | 0.063 |
| | (0.059) | (0.073) | (0.059) | (0.073) |
| Price of cooking oil | 0.016 | 0.006 | 0.016 | 0.002 |
| | (0.021) | (0.030) | (0.021) | (0.030) |
| Price of condensed milk | -0.082** | -0.138*** | -0.080** | -0.133*** |
| | (0.035) | (0.050) | (0.035) | (0.050) |
| Constant | 0.822** | 0.989* | 0.838** | 1.103** |
| | (0.413) | (0.515) | (0.413) | (0.515) |
| Community fixed-effect | No | Yes | No | Yes |
| R-squared | 0.06 | 0.25 | 0.06 | 0.25 |
| Observations | 1944 | 1944 | 1944 | 1944 |

Notes: Dependent variable is whether child experienced delayed enrollment (yes=1). Robust standard error is in parenthesis. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level.

Table 3. Impact of childhood nutrition on probability of repeating grade, OLS

| Dep. Var: Repeated grade (Yes=1) | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.004 | 0.001 | -0.005 | 0.005 |
| | (0.005) | (0.006) | (0.015) | (0.016) |
| Time dummy | 0.043 | 0.049 | 0.041 | 0.049 |
| | (0.036) | (0.043) | (0.036) | (0.043) |
| Mother education | -0.003** | -0.004** | -0.003** | -0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Father education | -0.003** | -0.002 | -0.003** | -0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Age of head of household | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| # 6-14 yo children in HH | 0.006 | 0.009 | 0.006 | 0.01 |
| | (0.007) | (0.008) | (0.007) | (0.008) |
| # female adults in HH | 0.001 | 0.007 | 0.001 | 0.007 |
| | (0.010) | (0.011) | (0.010) | (0.011) |
| # male adults in HH | -0.003 | 0.003 | -0.003 | 0.003 |
| | (0.009) | (0.010) | (0.009) | (0.010) |
| Per-capita expenditure | -0.019** | -0.012 | -0.020** | -0.012 |
| | (0.008) | (0.010) | (0.008) | (0.010) |
| Price of rice | -0.026 | 0.024 | -0.027 | 0.025 |
| | (0.020) | (0.030) | (0.020) | (0.031) |
| Price of sugar | 0.004 | 0.049 | 0.005 | 0.049 |
| | (0.058) | (0.075) | (0.058) | (0.075) |
| Price of cooking oil | -0.012 | -0.028 | -0.012 | -0.028 |
| | (0.021) | (0.029) | (0.021) | (0.029) |
| Price of condensed milk | 0.025 | -0.039 | 0.025 | -0.039 |
| | (0.022) | (0.036) | (0.022) | (0.036) |
| Constant | 0.391 | 0.183 | 0.397 | 0.18 |
| | (0.355) | (0.455) | (0.355) | (0.456) |
| Community fixed-effect | No | Yes | No | Yes |
| R-squared | 0.02 | 0.20 | 0.02 | 0.21 |
| Observations | 1944 | 1944 | 1944 | 1944 |

Notes: Dependent variable is dummy for child experienced repeated grade (yes=1). Robust standard error is in parenthesis. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level.

Table 4. Impact of childhood nutrition on probability of delayed enrollment: 2SLS

| Dep. Var: delayed enrollment (Yes=1) | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.097*** | -0.158*** | -0.313*** | -0.539*** |
| | (0.023) | (0.030) | (0.077) | (0.108) |
| Time dummy | 0.140*** | 0.166*** | 0.115*** | 0.154*** |
| | (0.046) | (0.058) | (0.045) | (0.059) |
| Mother education | -0.003 | 0.000 | -0.002 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Father education | -0.005*** | -0.003 | -0.005*** | -0.004* |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Age of head of household | 0.001 | 0.001 | 0.001 | 0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| # 6-14 yo children in HH | 0.022** | 0.026** | 0.024** | 0.030** |
| | (0.010) | (0.012) | (0.010) | (0.013) |
| # female adults in HH | 0.009 | 0.016 | 0.005 | 0.009 |
| | (0.014) | (0.015) | (0.013) | (0.016) |
| # male adults in HH | -0.030** | -0.018 | -0.030** | -0.026* |
| | (0.012) | (0.013) | (0.012) | (0.015) |
| Per-capita expenditure | -0.021 | -0.011 | -0.024* | -0.022 |
| | (0.014) | (0.017) | (0.014) | (0.017) |
| Price of rice | 0.011 | -0.046 | 0.000 | -0.09 |
| | (0.033) | (0.065) | (0.033) | (0.067) |
| Price of sugar | -0.025 | 0.056 | -0.023 | 0.038 |
| | (0.062) | (0.081) | (0.061) | (0.085) |
| Price of cooking oil | 0.02 | 0.043 | 0.025 | 0.034 |
| | (0.022) | (0.034) | (0.023) | (0.035) |
| Price of condensed milk | -0.090** | -0.159*** | -0.086** | -0.143** |
| | (0.037) | (0.058) | (0.037) | (0.060) |
| Community fixed-effect | No | Yes | No | Yes |
| F-stat on the excluded instrument | 23.46 | 18.85 | 19.25 | 13.56 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 122.39 | 92.71 | 111.19 | 73.68 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 3.89 | 5.74 | 4.21 | 4.53 |
| (p-value) | (0.566) | (0.361) | (0.518) | (0.477) |
| Observations | 1910 | 1890 | 1910 | 1890 |

Notes: Dependent variable is lagged height-for-age z-score. Robust standard error is in parenthesis. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs are: interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of posyandu in the village and child age, all are in period 1. First-stage regression for lagged height-for-age and stunted are in table A.1 and A.2.

Table 5. Impact of childhood nutrition on probability of repeating grade: 2SLS

| Dep. Var: Repeated grade (Yes=1) | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.026 | -0.015 | -0.091 | -0.043 |
| | (0.019) | (0.022) | (0.061) | (0.076) |
| Time dummy | 0.052 | 0.055 | 0.046 | 0.053 |
| | (0.039) | (0.045) | (0.038) | (0.044) |
| Mother education | -0.003* | -0.004** | -0.003 | -0.004** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Father education | -0.003** | -0.002 | -0.003** | -0.002 |
| | (0.001) | (0.002) | (0.001) | (0.002) |
| Age of head of household | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| # 6-14 yo children in HH | 0.002 | 0.007 | 0.002 | 0.008 |
| | (0.008) | (0.009) | (0.008) | (0.009) |
| # female adults in HH | 0.004 | 0.006 | 0.004 | 0.005 |
| | (0.011) | (0.012) | (0.011) | (0.012) |
| # male adults in HH | -0.004 | 0.002 | -0.004 | 0.001 |
| | (0.009) | (0.010) | (0.009) | (0.010) |
| Per-capita expenditure | -0.013 | -0.009 | -0.013 | -0.01 |
| | (0.010) | (0.011) | (0.010) | (0.011) |
| Price of rice | -0.02 | 0.028 | -0.024 | 0.024 |
| | (0.026) | (0.040) | (0.026) | (0.040) |
| Price of sugar | -0.003 | 0.044 | -0.003 | 0.043 |
| | (0.060) | (0.077) | (0.059) | (0.077) |
| Price of cooking oil | -0.011 | -0.026 | -0.01 | -0.027 |
| | (0.022) | (0.030) | (0.022) | (0.030) |
| Price of condensed milk | 0.023 | -0.04 | 0.024 | -0.039 |
| | (0.022) | (0.036) | (0.022) | (0.036) |
| Community fixed-effect | No | Yes | No | Yes |
| F-stat on the excluded instrument | 23.46 | 18.85 | 19.25 | 13.56 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 122.39 | 92.71 | 111.19 | 73.68 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 2.80 | 4.46 | 2.43 | 4.91 |
| (p-value) | (0.730) | (0.485) | (0.788) | (0.427) |
| Observations | 1910 | 1890 | 1910 | 1890 |

Notes: Dependent variable is (lagged) dummy for child was stunted during childhood. Robust standard errors are in parenthesis. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs are: interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of posyandu in the village and child age, all are in period 1. First-stage regression for lagged height-for-age and stunted are in table A.1 and A.2.

Table 6. Heterogeneity impact of childhood nutrition on probability of delayed enrollment across gender, 2SLS-LIML

| Dep. Var: delayed enrollment (Yes=1) | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | Boys | Girls | Boys | Girls |
| Childhood nutrition | -0.213*** | -0.124*** | -0.661*** | -0.427*** |
| | (0.053) | (0.043) | (0.229) | (0.145) |
| Time dummy | 0.153 | 0.157** | 0.11 | 0.166** |
| | (0.107) | (0.065) | (0.107) | (0.068) |
| Mother education | 0.001 | -0.003 | 0.004 | -0.003 |
| | (0.004) | (0.003) | (0.005) | (0.003) |
| Father education | -0.004 | -0.004 | -0.005 | -0.004 |
| | (0.004) | (0.003) | (0.004) | (0.003) |
| Age of head of household | 0.001 | 0.000 | 0.004* | 0.001 |
| | (0.002) | (0.001) | (0.002) | (0.001) |
| # 6-14 yo children in HH | 0.024 | 0.033* | 0.031 | 0.026 |
| | (0.020) | (0.017) | (0.021) | (0.019) |
| # female adults in HH | 0.028 | 0.031 | -0.01 | 0.034 |
| | (0.029) | (0.021) | (0.029) | (0.023) |
| # male adults in HH | -0.026 | -0.012 | -0.032 | -0.024 |
| | (0.022) | (0.020) | (0.024) | (0.021) |
| Per-capita expenditure | -0.011 | -0.006 | -0.015 | -0.033 |
| | (0.027) | (0.022) | (0.029) | (0.020) |
| Price of rice | -0.112 | -0.088 | -0.142 | -0.149 |
| | (0.100) | (0.095) | (0.106) | (0.092) |
| Price of sugar | 0.105 | 0.115 | 0.093 | 0.114 |
| | (0.128) | (0.118) | (0.129) | (0.126) |
| Price of cooking oil | 0.111* | 0.016 | 0.047 | 0.034 |
| | (0.066) | (0.047) | (0.068) | (0.046) |
| Price of condensed milk | -0.173* | -0.151* | -0.137 | -0.168* |
| | (0.103) | (0.085) | (0.103) | (0.087) |
| Community fixed-effect | Yes | Yes | Yes | Yes |
| F-stat on the excluded instrument | 9.34 | 19.31 | 5.77 | 6.28 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 45.70 | 45.98 | 41.73 | 32.74 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 5.26 | 2.30 | 6.96 | 1.77 |
| (p-value) | (0.385) | (0.806) | (0.224) | (0.881) |
| Observations | 914 | 878 | 914 | 878 |

Notes: Dependent variable is whether child experienced delayed primary school enrollment (yes=1). Estimation uses limited information maximum likelihood which is robust to potentially weak instruments. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs are: interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of posyandu in the village and child age, all are in period 1. First-stage regression is in table A.3 and A.4.

Table 7. Heterogeneity impact of childhood nutrition on probability of repeating grade across gender, 2SLS-LIML

| Dep. Var: delayed enrollment | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | Boys | Girls | Boys | Girls |
| Childhood nutrition | 0.011 | -0.041 | -0.008 | 0.126 |
| | (0.034) | (0.029) | (0.102) | (0.101) |
| Time dummy | 0.082 | 0.061 | 0.087 | 0.062 |
| | (0.078) | (0.057) | (0.077) | (0.057) |
| Mother education | -0.006** | -0.003 | -0.006** | -0.003 |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| Father education | -0.001 | -0.002 | -0.001 | -0.002 |
| | (0.003) | (0.002) | (0.003) | (0.002) |
| Age of head of household | -0.002 | 0.001 | -0.002 | 0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| # 6-14 yo children in HH | 0.024 | -0.005 | 0.023 | -0.007 |
| | (0.016) | (0.012) | (0.016) | (0.013) |
| # female adults in HH | 0.005 | -0.006 | 0.007 | -0.005 |
| | (0.021) | (0.018) | (0.021) | (0.018) |
| # male adults in HH | 0.011 | -0.012 | 0.011 | -0.015 |
| | (0.018) | (0.015) | (0.018) | (0.016) |
| Per-capita expenditure | -0.029* | 0.005 | -0.029* | -0.004 |
| | (0.017) | (0.018) | (0.017) | (0.016) |
| Price of rice | -0.001 | 0.067 | -0.003 | 0.048 |
| | (0.047) | (0.056) | (0.048) | (0.060) |
| Price of sugar | 0.105 | -0.094 | 0.103 | -0.096 |
| | (0.121) | (0.099) | (0.120) | (0.102) |
| Price of cooking oil | -0.078 | 0.019 | -0.074 | 0.023 |
| | (0.058) | (0.040) | (0.055) | (0.039) |
| Price of condensed milk | -0.078 | 0.028 | -0.078 | 0.025 |
| | (0.064) | (0.050) | (0.064) | (0.051) |
| Community fixed-effect | Yes | Yes | Yes | Yes |
| F-stat on the excluded instrument | 9.34 | 9.31 | 5.77 | 6.28 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 45.70 | 45.98 | 41.73 | 32.74 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 5.14 | 0.69 | 5.18 | 1.13 |
| (p-value) | (0.399) | (0.984) | (0.394) | (0.951) |
| Observations | 914 | 878 | 914 | 878 |

Notes: Dependent variable is whether child experienced grade repetition (yes=1). Estimation uses limited information maximum likelihood which is robust to potentially weak instruments. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs are: interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of posyandu in the village and child age, all are in period 1. First-stage regression is in table A.3 and A.4.

Table 8. Impact of midwife exposure on probability of delayed enrollment: 2SLS-LIML

| Dep. Var: delayed enrollment | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.076*** | -0.155*** | -0.247*** | -0.507*** |
| | (0.026) | (0.039) | (0.093) | (0.150) |
| Childhood Nutrition*Midwife | -0.052 | -0.038 | -0.188 | -0.160 |
| | (0.046) | (0.058) | (0.157) | (0.224) |
| Midwife | -0.055 | | 0.147 | |
| | (0.062) | | (0.051) | |
| Community fixed-effect | No | Yes | No | Yes |
| F-test for variables of interest (p-value) | | | | |
| Childhood nutrition and Childhood nutrition*midwife | 15.30 (0.001) | 27.67 (0.000) | 15.51 (0.001) | 24.61 (0.000) |
| Midwife and Childhood nutrition*midwife | 1.71 (0.425) | | 2.10 (0.349) | |
| F-stat on the excluded instrument | 14.15 | 10.07 | 11.73 | 8.11 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 135.42 | 82.43 | 105.04 | 62.05 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 8.95 | 9.90 | 7.59 | 8.46 |
| (p-value) | (0.399) | (0.449) | (0.669) | (0.584) |
| Observations | 1910 | 1890 | 1910 | 1890 |

Notes: Dependent variable is whether child experienced delayed primary school enrollment (yes=1). Other covariates in each specifications (but not displayed here): time dummy, height of parents, age of household head, number of children as well as male and female adults in household, per-capita expenditure, and food prices. Estimation uses limited information maximum likelihood which is robust to potentially weak instruments. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs in specifications in column 1 & 3 are interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of *posyandu* in the village and child age, all are in period 1. For specifications in column 2 and 4 are those as for column 1 and 3 plus their interaction with dummy variable for presence of midwife in period 1. F-test on the excluded instruments for interaction between childhood nutrition and presence of midwife for each specification in column 1,2,3,4 are respectively 6.83, 5.69, 5.26, and 4.46.

Table 8A. Partial effect of childhood nutrition on probability of delayed enrollment conditional on the presence of midwife

| Proportion of presence of midwife | Height-for-age z-score | Non-stunted (yes=1) |
|---|---|---|
| At sample mean (28.7%) | -0.166*** | -0.553*** |
| | [0.033] | [0.121] |
| | | |
| Simulations: | | |
| Increase presence of midwife to 50% | -0.174*** | -0.587*** |
| | (0.033) | (0.118) |
| Increase presence of midwife to 75% | -0.184*** | -0.627*** |
| | (0.039) | (0.138) |

Notes: Robust standard errors are in parentheses. Calculations are based on the parameter in table 8 column 2 and 4. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level.

Table 9. Impact of midwife exposure on probability of repeated grade: 2SLS-LIML

| Dep. Var: delayed enrollment | Measure of childhood nutrition | | | |
|---|---|---|---|---|
| | Height-for age z-score | | Non-stunted (Yes=1) | |
| | 1 | 2 | 3 | 4 |
| Childhood nutrition | -0.004 | 0.02 | -0.003 | 0.138 |
| | (0.022) | (0.029) | (0.075) | (0.108) |
| Childhood nutrition*Midwife | -0.061* | -0.073* | -0.211* | -0.333** |
| | (0.037) | (0.043) | (0.127) | (0.162) |
| Midwife | -0.072 | | -0.058 | |
| | (0.051) | | (0.043) | |
| Community fixed-effect | No | Yes | No | Yes |
| F-test for variables of interest (p-value) | | | | |
| Childhood nutrition and | 3.74 | 2.97 | 3.65 | 4.26 |
| Childhood nutrition*midwife | (0.154) | (0.226) | (0.161) | (0.119) |
| Midwife and | 2.91 | | 2.98 | |
| Childhood nutrition*midwife | (0.234) | | (0.225) | |
| F-stat on the excluded instrument | 14.15 | 10.07 | 11.73 | 8.11 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Kleibergen-Paap rk LM statistic | 135.42 | 82.43 | 105.04 | 62.05 |
| (p-value) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J stat | 14.98 | 13.37 | 14.29 | 12.41 |
| (p-value) | (0.133) | (0.185) | (0.162) | (0.259) |
| Observations | 1910 | 1890 | 1910 | 1890 |

Notes: Dependent variable is whether child experienced grade repetition (yes=1). Other covariates in each specifications (but not displayed here): time dummy, height of parents, age of household head, number of children as well as male and female adults in household, per-capita expenditure, and food prices. Estimation uses limited information maximum likelihood which is robust to potentially weak instruments. (***), (**), (*) respectively indicate significant at 1, 5 and 10 percent level. Excluded IVs in specifications in column 1 & 3 are interaction rainfall shocks during second and third trimester of *in utero* period and child age (in months), total household assets (log), height of father and mother (cm), age of children (in months) and interaction between number of *posyandu* in the village and child age, all are in period 1. For specifications in column 2 and 4 are those as for column 1 and 3 plus their interaction with dummy variable for presence of midwife in period 1. F-test on the excluded instruments for interaction between childhood nutrition and presence of midwife for each specification in column 1,2,3,4 are respectively 6.83, 5.69, 5.26, and 4.46

Table A.1. First Stage Regression: Height-for-age z-score

| | |
|---|---|
| Time dummy | 0.395 |
| | (0.165) |
| Mother education | 0.010 |
| | (0.008) |
| Father education | 0.002 |
| | (0.008) |
| Household head age | -0.002 |
| | (0.004) |
| # of older children, 6-14 yo | -0.129 |
| | (0.034) |
| # of adult female | 0.114 |
| | (0.054) |
| # of adult male | -0.053 |
| | (0.044) |
| PCE (log) | 0.233 |
| | (0.048) |
| price of rice (log) | 0.057 |
| | (0.103) |
| price of sugar (log) | -0.414 |
| | (0.199) |
| price of cooking oil (log) | 0.076 |
| | (0.105) |
| price of condensed milk (log) | -0.114 |
| | (0.124) |
| 3rd trimester rainfall shock*Age in period 1 (x1000) | -0.033 |
| | (0.011) |
| 2nd trimester rainfall shock*Age in period 1 (x1000) | -0.041 |
| | (0.010) |
| Assets in period 1 (log) | 0.068 |
| | (0.020) |
| # of posyandu in period 1*age in period 1 (x1000) | -0.025 |
| | (0.065) |
| Constant | -1.762 |
| | (1.631) |

Note: Robust standard errors are in parantheses.

Table A.2. First Stage Regression: being non-stunted (Yes=1)

| | |
|---|---|
| Time dummy | 0.051 |
| | (0.06) |
| Mother education | 0.006 |
| | (0.00) |
| Father education | 0.001 |
| | (0.00) |
| Household head age | -0.001 |
| | (0.00) |
| # of older children, 6-14 yo | -0.035 |
| | (0.01) |
| # of adult female | 0.023 |
| | 0.000 |
| # of adult male | -0.02 |
| | (0.014) |
| PCE (log) | 0.06 |
| | (0.016) |
| price of rice (log) | -0.02 |
| | (0.043) |
| price of sugar (log) | -0.12 |
| | (0.075) |
| price of cooking oil (log) | 0.04 |
| | (0.034) |
| price of condensed milk (log) | -0.02 |
| | (0.039) |
| 3rd trimester rainfall shock*Age in period 1 (x1000) | -0.012 |
| | (0.000) |
| 2nd trimester rainfall shock*Age in period 1 (x1000) | -0.01 |
| | (0.000) |
| Assets in period 1 (log) | 0.026 |
| | (0.006) |
| # of posyandu in period 1*age in period 1 (x1000) | 0.003 |
| | (0.000) |
| Constant | 0.62 |
| | (0.56) |

Note: Robust standard errors are in parantheses.