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Economic analysis on the socioeconomic determinants of child malnutrition in Lao PDR

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【Abstract】The prevalence of stunting and underweight among Lao children is amongst the highest in the region. This paper provides a theoretical framework which integrates the mechanism of child malnutrition and a household decision-making behaviour and investigates the relationship between socioeconomic factors and child health outcomes. Using the Lao Multiple Indicator Cluster Survey 3 dataset, it reveals that mother's age and education level, ethnicity, household assets and community factors such as water, sanitation and communication infrastructure have a statistically significant impact on child nutritional status. The unobserved heterogeneities of both household and community are also found to be associated with child nutrition production.

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1. Introduction

Chronic malnutrition[1] in children is highly prevalent and remains a global challenge. 178 million and 112 million of children under-five are stunted (below -2 height-for-age Z-scores) and underweight (below -2 weight-for-age Z-scores) in developing countries respectively (1). The Millennium Development Goal (MDG) 1 "Eradicate extreme poverty and hunger" addresses reducing the proportion of children who are underweight by half between 1990 and 2015. Since malnutrition is an underlying cause of an estimated more than a half of all under-five deaths (2, 3), the improvement of malnutrition will also assist in the goal to reduce child mortality (MDG 4).

It has long been recognised that socioeconomic factors such as economic growth, poverty, water and sanitation, education and gender are important determinants of health outcomes (4-12). Thomas and Frankenberg 2002, who review both experimental and observational studies on this issue, state that there is abundant evidence at both the microeconomic and macroeconomic level that a variety of health indicators are positively associated with different dimensions of economic prosperity and the causal pathways linking health and economic outcomes run in both directions—with higher income, individuals can invest more in their health, or healthier workers are more productive and can enjoy higher wages— (13).

[1] Malnutrition has a meaning both for undernutrition and overnutrition. In this paper, the term refers only to cases of undernutrition.

1.1. Returns to improving child nutrition

Nutritional status during childhood affects every phase of their life and therefore many international agencies have launched strategies and reports addressing the significance of focusing on child malnutrition (5, 14-18). Investment in child nutrition contributes not only to improving their current welfare but to enhancing their opportunities over their life cycles. There is a huge amount of literature on this issue (for review papers see: 19-25).

Importantly, malnourished children are much more likely to die due to a common childhood disease than those who are sufficiently nourished. Many studies have shown that malnutrition is highly associated with high child mortality (26-29) and therefore child survival could be accelerated by reducing the general level of malnutrition. Furthermore, the risk of mortality is inversely related to anthropometric indices of child nutritional status and malnutrition has a 'potentiating' effect on mortality rather than additive fashion (30, 31).

On the other hand, better nutrition during early childhood improves educational attainment (32-37) and post-schooling performances (38). Amongst recent studies, Hoddinott et al. 2008 find that a nutrition intervention in early childhood (food supplementation during 0-24 months) led to 46% increase in the average wage in the male sample in Guatemalan villages (39). Carba et al. 2009 using the longitudinal survey in the Philippines confirm that higher height-for-age Z-scores at age 2 are significantly associated with a 40% increase in the likelihood of being engaged in 'formal work', compared to 'no job' in the male sample population (40).[2]

1.2. Socioeconomic and health situation in Lao PDR

The Lao People's Democratic Republic (Lao PDR) has a population of 5.6 million and a sparse population density. There are 49 officially recognized ethnic groups (42, 43). 52.5% of the total population is ethnic Lao, the principal lowland inhabitants and the politically and culturally dominant group. The other ethnic minorities predominate in the highlands. Most of the population are dependent on subsistence rice production and therefore food security is a serious concern (44). While the official poverty rate dropped from 39% in 1997 to 33.5% in 2002 (45), Laos ranked 133th out of 179 nations on the Human Development Index in 2006 (46). The Lao National Growth and Poverty Eradication Strategy (NGPES), which aims to reduce poverty through strong economic growth, focuses on 47 poorest districts identified by the Government of Laos (GoL) as priority districts for poverty alleviation (47).

Lao PDR reduced its under-five mortality rate (U5MR) from 170 per 1000 live births in 1995 to 75 deaths per 1000 live births in 2006, but the figure is much worse than neighbouring Thailand and Vietnam (48)[3]. In addition, the prevalence of child malnutrition is high. During the period 2000–2007 Lao PDR experienced the worst

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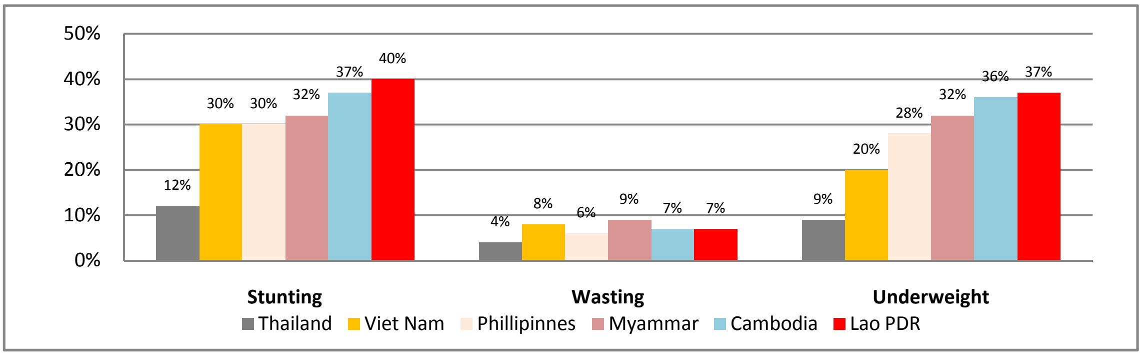
[2] Another example is that exposure to China's 1959-61 famine in early life led to shorter stature and lower earnings (41).

[3] The U5MR is 8 deaths per 1000 live births in Thailand and 17 deaths per 1000 live births in Vietnam respectively.

prevalence of stunting (40%) and underweight (37%) in children under-five in the region (Figure 1).

Figure 1: Prevalence of malnutrition among children under-five (2000-2007)



Source: UNICEF 2009 (49)

The GoL committed itself to the international obligations of the "Right to Adequate Food" by ratifying the International Covenant on Economic, Social and Cultural Rights (ICESCR) (50) in 2007 to ensure that all Lao citizens would be able to avail of their "fundamental right to be free from hunger". In 2008 the GoL promulgated the 'National Nutrition Policy' (NNP)[4] to synchronise the international obligations with its national policy. The NNP aims to "accelerate the reduction of malnutrition among all ethnic groups and decrease associated morbidity and mortality risks" (51).

A fragile health system is thought to hamper the improvement of child health status in Laos[5]. Although there is now a global consensus that stronger health systems

[4] The NNP serves as a "legally binding document to substantially reduce levels of malnutrition, especially vulnerable groups, and to mainstream nutrition in National Socio-Economic Development Plans in line with the implementation of the National Growth and Poverty Eradication Strategy".
[5] For instance, only 40% of infants under the age of one were immunised against measles and just 48% of the population had access to adequate sanitation facilities in 2007 (49)

are key to achieving the MDGs (52), there is no clear answer to how a country's health system and socioeconomic factors interact with child health outcomes.

Empirical studies on the causes of child malnutrition assist in programming effective nutrition interventions. Nevertheless, there exist a limited number of studies which measure nutritional status of Lao children and/or examine the causes of malnutrition (53-58)[6]. Phengxay et al. 2007 performed a cross-sectional study in Luangprabang province to obtain anthropometric measures of 798 children and investigate risk factors of them. They found low maternal education, poor nutrition knowledge and restricted intake of meats were main causes for child malnutrition (65).

1.3. Aims of the paper

As discussed above, a proper understanding of the mechanisms and determinants of child malnutrition is pertinent to designing a strong nutrition strategy which triggers better child health gains and a further reduction in child mortality. Accordingly, this paper aims to investigate the relationship between socioeconomic factors and child nutritional status, and use these findings as the basis for recommendation for effective nutrition interventions. Specific objectives are: 1) to provide an analytical framework and empirical model on the determinants of child malnutrition; 2) to identify the socioeconomic determinants of child nutritional status in Laos using a nationwide

[6] The number of empirical studies is limited even in neighbouring countries (Cambodia: 59, Thailand: 60-62 and Vietnam: 63, 64).

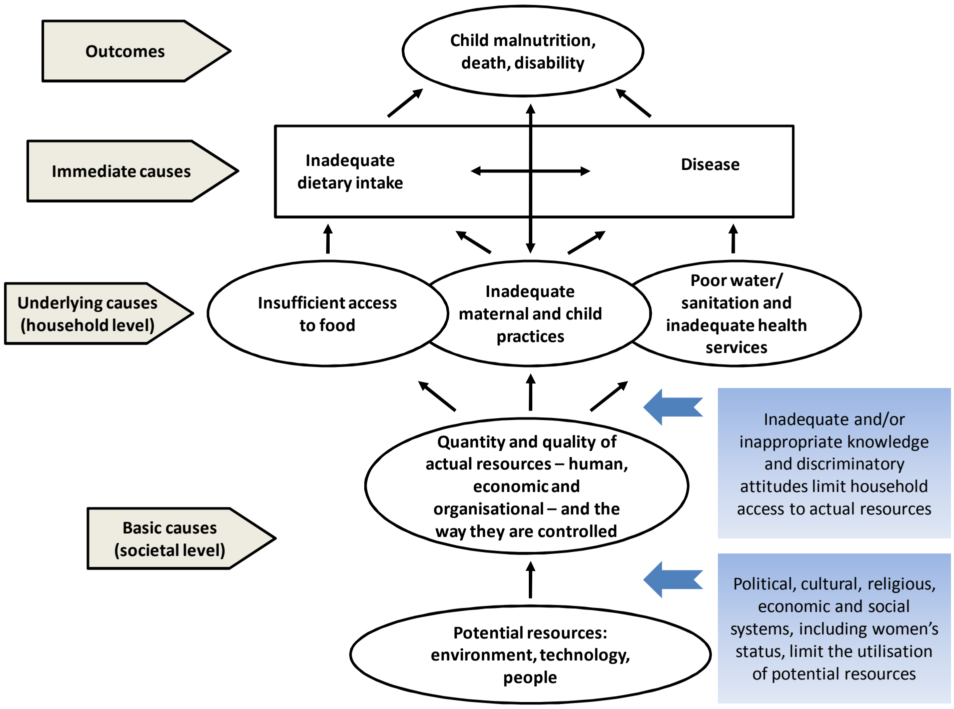
household survey dataset; 3) to identify the patterns of growth faltering by age among under-five children; and 4) to suggest effective interventions to improve child nutritional status.

2. Theoretical framework

2.1. Conceptual framework of the determinants of child malnutrition

The causes of child malnutrition are diverse, multidimensional and interrelated. A framework developed by UNICEF encompasses these complexities (Figure 2).

Figure 2: Framework of the determinants of child nutrition by UNICEF



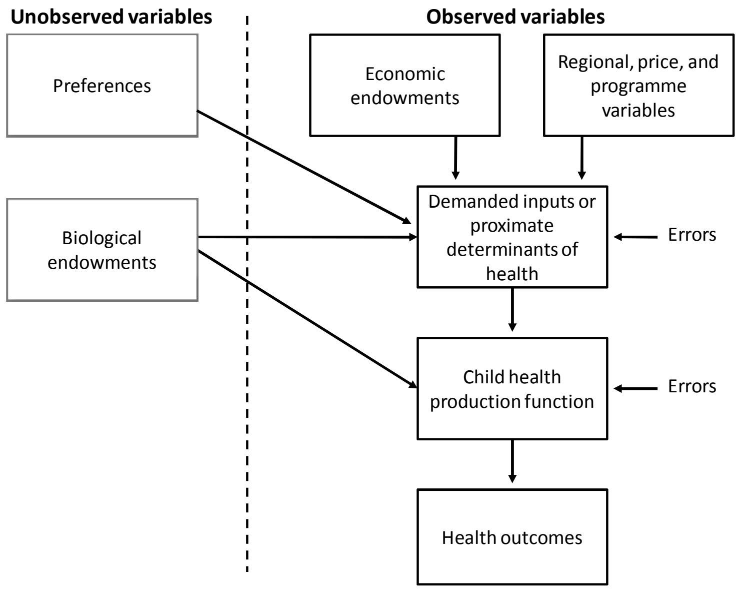
Source: UNICEF 1990 (15), UNICEF 1998 (14)

It categorises the causes of child malnutrition into 1) *immediate causes*:

inadequate dietary intake and illness, 2) *underlying causes*: insufficient access to food in a household (66); inadequate health services and unhealthy environment (poor water/ sanitation and inadequate health services); and inadequate care for children and women at household level (67), and 3) *basic causes*: insufficient actual resources (human, economic and organisational resource) as well as potential resources (social, political and environmental) at societal level (14, 15).

In measuring the determinants of child malnutrition, two approaches have been mainly undertaken: epidemiological approach which measures the direct association between health inputs and outcomes and economics approach which focuses on the relationship between constraints on people's opportunities and health outcomes (68-70). Epidemiological approach could be statistically biased and misleading as it often does not take into account the people's health endowment which is not normally observed by researchers. Considering this point, Schultz 1984 proposes a 'stochastic framework' which integrates the biological determinants of child health and economically constrained selection of health inputs in the presence of health heterogeneity in order to obtain unbiased estimates of the determinants of child health (69). He emphasises the importance of distinguishing observed variables such as economic endowments, regional price, health inputs and health outcomes and unobserved variables such as people's preferences and biological endowment in his model structure (Figure 3).

Figure 3: Framework of the determinants of child malnutrition by Schultz 1984



Source: Schultz 1984

2.2. Measurement of child nutritional status

Traditionally, nutrient consumption (health inputs) played a central role in measuring and analysing child health status. However, the data of nutrient consumption are highly likely to be subject to both random and systematic measurement errors because a respondent's recall method is the most common strategy for data collection (71-73). Thus, anthropometry which directly measures people's height and weight (health outcomes) has become more widely used in empirical studies on child nutrition[7].

Anthropometry has a tradition going back to the 1950s and has been used to measure the state of child health based on their height, weight, and age[8]. Anthropometry

[7] Strauss and Thomas 1996 argue that even if the anthropometric methods are undertaken, self-reported height and weight are prone to systematic errors which are associated with individual's income level.

[8] Child height proved to be an informative measure of child nutritional status in the 1970-80s (74, 75).

has advantages in assessing child malnutrition over other measures such as clinical signs of malnutrition or biochemical indicators because anthropometry is quite sensitive to every spectrum of malnutrition, whereas clinical signs or biochemical indicators are useful only at the extreme of malnutrition (26).

To measure the degree of malnutrition, anthropometric values are compared across individuals or populations in relation to a reference population. The international reference of child growth was produced by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC) and WHO in 1978 (referred to here as the 'NCHS reference') (76, 77). In April 2006 WHO released new growth standards (referred to here as the 'WHO standards') because the NCHS reference had been found to contain several technical limitations (78-80).

Anthropometric measures for child nutrition are expressed as Z-scores which correspond to standard deviations from the median of the reference population. Z-score for an individual *i* is calculated as follows:

$$Z\ score_i = \frac{X_i - X_r}{\sigma_r}$$

where X_i is an observed value for i in a target population. X_r and σ_r are a median and a standard deviation (SD) of the reference population, respectively. The following three Z-scores are commonly used to measure child nutritional status (81, 82).

First, height-for-age Z-score (HAZ) is a longer-term index and represents linear growth of a child. It gives the information about chronic malnutrition or 'stunting' which reflects the accumulation of past outcomes. Second, weight-for-height Z-score (WHZ) is a shorter-time index of child health status. It exhibits the situation of acute malnutrition or 'wasting'. Wasting is usually caused by a recent nutritional deficiency and may manifest significant seasonal variations according to changes in the availability of food or disease prevalence (83). Third, weight-for-age Z-score (WAZ) is an index of both acute and chronic malnutrition. It provides the information about 'underweight'. Low weight-for-age can be due to either stunting or wasting (26)[9].

Among the three indices, HAZ is usually considered as the best index to represent children's long-term health status because it is associated with greater mortality risk (26, 30, 84). Interestingly, there is no apparent correlation between HAZ and WHZ, and this phenomenon has been considered as a 'puzzle' (85, 86). It implies that stunting and wasting can be determined by different mechanism and therefore separate interventions are required to improve them (87).

Anthropometry is useful not only in representing children's health status but also in assessing social deprivation (88). WHO recommends that height-for-age is a reliable measure of overall social deprivation (89), whereas the UN's MDG applies weight-for-age as the main indicator of malnutrition.

[9] A child whose HAZ, WHZ and WAZ is more than 2 SD below the median of the reference population are classified as 'moderately or severely' stunted, wasted and underweight respectively. Those whose WAZ, WHZ and WAZ is more than 3 SD below the median are classified as 'severely' stunted, wasted and underweight respectively.

2.3. Literature review

Over the past several decades, there have been a large amount of experimental and observational studies on the determinants of child malnutrition in developing countries. Previous studies identified the characteristics at the level of 1) child, 2) household, and 3) community as the main causes of child malnutrition. Recently, an increasing number of studies emphasises the 4) interaction effects (complementarity and substitutability) between the household and community factors, and 5) heterogeneities at both the household and community levels because they have important policy implications.

2.3.1. Child characteristics

Sex: Many studies confirm that boys are significantly malnourished than girls (90-94) especially in Sub-Saharan Africa after controlling for socioeconomic factors. On the other hand, Strauss 1990 and Lomperis 1991 found no gender difference in the sample of children in Cote d'Ivoire and Colombia respectively (95, 96). In Vietnam there was no significant gender difference in both the urban and rural area (63).

Age: There is a common age-specific pattern in nutritional status of children under-five in developing countries: a child is shorter and weigh less for higher age-bracket and malnutrition increases up to the age of 2 and then levels off (97)[10].

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[10] Birth order among children is also confirmed to be significantly associated with child health status. It is reported that elder children are more favoured by their parents both intentionally and unintentionally (98-100).

2.3.2. Household characteristics

<u>Parental education level</u>: Mother's education is confirmed to possess almost universally positive effects on child health (96, 98, 101-117). Glewwe 1999 suggests three possible pathways for how mother's schooling contributes to child health and nutrition: 1) formal education directly enhances health knowledge to future mothers; 2) literacy and numeracy skills acquired in school help future mothers to diagnose and treat child health problems; 3) exposure to modern society through schooling makes women more receptive to modern medicine (118).

Using the survey data in Ethiopia, Christiaensen and Alderman 2004 confirmed both male and female household maximum attained education had a large and positive effect on child nutrition and the impact of female education was about twice as large as that of male education (90). However, Haddad et al. 2002 using the Demographic and Health Surveys (DHS) datasets for 16 countries, found that parental education had a significant and positive effects on HAZ in only about one-third of cases (119)[11]. David et al. 2004 confirmed no significant impact of mother's schooling on child nutrition in Nicaragua (121).

Wolfe and Behrman 1987 caution that the impact of parental education may be overestimated if important information about unobserved family background is omitted

[11] Desai and Alva 1998, who also used the DHS datasets for 22 countries, obtained the similar results that mother's education had a significant impact on child health status only in a limited number of countries after controlling for the socioeconomic factors and area of residence (120).

from the estimation (122). For instance, parental height is confirmed as a significant determinant of child nutrition by a number of studies (86), implying the impact of parental education might be overestimated if parental height is not included in the estimation.

Income: Positive impact of household income on child health is confirmed in numerous empirical studies (63, 90, 92, 93, 121, 123). Most of the economic literature uses instrumental variables for household income with a single variable or a set of variables to control its endogenous feature. For example, Attanasio et al. 2004 use household assets and municipality average wage as instrumental variables (123). Linnemayr et al. 2008 construct a wealth index based on principal component analysis (124) to use it as an instrumental variable (91).

Women's status: The relative status of women compared with men within the household positively affects child health through women's stronger position in decision-making in labour supply, allocation of income, provision of child care and health-seeking behaviours. Many empirical studies confirm that income or assets accruing to women or under the control of women are more likely to be used for benefiting children than those of men (125-128).

Smith et al. 2003 examine the relationship between women's status and child anthropometric indices in 36 developing countries from the three regions, South Asia, Sub-Saharan Africa and Latin America and the Caribbean, during the period 1990–1998 by using the DHS datasets (129). They employ four types of indicators of women's decision-making power relative to men: 1) whether the woman works for cash income; 2) the women's age at first marriage; 3) the percent difference in the woman's and her partner's age; and 4) the difference in the woman's and her partner's years of education. Regression analysis shows the positive effects of women's decision-making power on child health, though the impact differs widely across the three regions.[12]

2.3.3. Community characteristics

Community factors such as the availability of local health services (95, 121, 123, 130-133)[13], water and sanitation (132, 134-140) and transportation infrastructure (130) affect child health status. On the other hand, there is no clear consensus on the effectiveness of community-based nutrition programmes which normally consist of growth monitoring and promotion and food supplementation (141, 142). Community-based growth promotion programmes had a great impact on child nutritional status in Uganda (141) and in Senegal (143), but no significant impact was confirmed from 'Community Nutrition Project' in urban Senegal (144) and a milk feeding programme in Peru (145).

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[12] A strongly positive effect is observed in South Asia, followed by a more moderate effect in Sub-Sahara Africa, and only short-term effect in Latin America and the Caribbean.

[13] Strauss 1990 indicates that the availability is preferable to actual utilisation of services to measure the impact of community services (95).

2.3.4. Interactions between the household and community characteristics

Interactions between the household and community characteristics on child health are studied rigorously by economists. Both substitutability (114, 130, 146) and complementarity (147, 148) between parental education and community factors have been reported. Zhao and Bishai 2004 confirmed the basic health services which 'provide' knowledge (access to local health infrastructure) were substitutable and the more sophisticated health services which 'require' knowledge (Cesarean-section) were complementary with the education level of the household head in China (149).

2.3.5. Heterogeneities of household and community

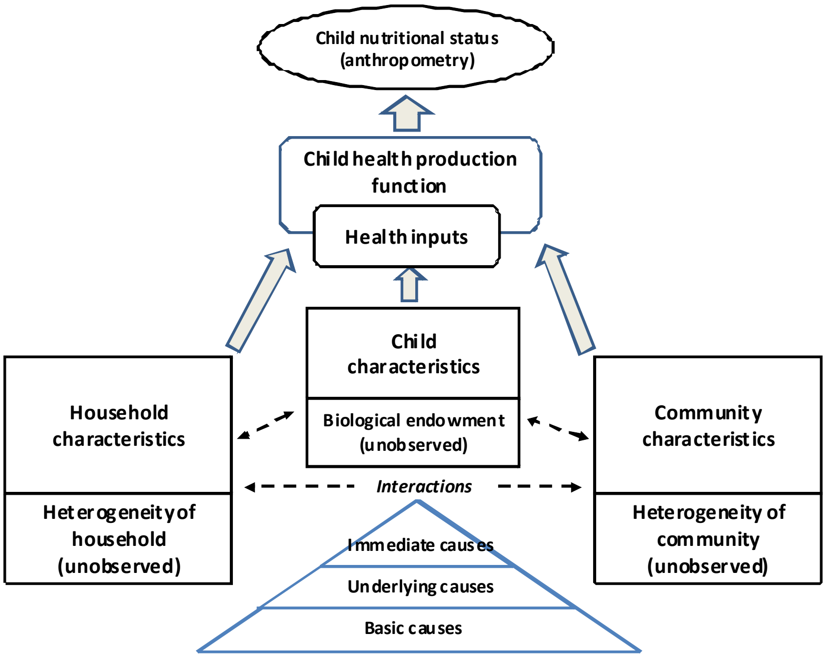
The effect of unobserved heterogeneities at the household and community levels (also called 'contextual effects' (150, 151)) on child health in developing countries have been investigated normally with a multilevel model (152, 153). Using the DHS datasets from five African countries, Fosto and Kuate-Defo 2005 find the community-level random variations are significantly different from zero (154), suggesting "neighbourhood factors per se" affect child health status (155-157). On the other hand, Uthman 2009 confirms no statistical significance of the community-level random effect after controlling for all individual and socioeconomic variables (110)[14].

[14] The problem of those studies is that most of them use endogenous variables such as breastfeeding, calorie intake, antenatal care, and utilization of community health services as explanatory variables without taking appropriate treatment like the instrument variables (IV) estimation.

2.4. Framework for the analysis

Following the theoretical framework and the empirical findings reviewed above, the framework for this paper can be drawn as Figure 4. It incorporates both observed and unobserved characteristics at the level of child, household and community. It also emphasises the importance of interactions between three factors.

Figure 4: Framework for the analysis



3. Model

Traditionally, the theoretical framework underpinning empirical analysis on the determinants of child malnutrition has been based on the standard Beckerian household utility function of consumer demand to families (158, 159) and Grossman's health production function (160). In this model a household is treated as a single economic agent that maximises its welfare function defined over child health state and a vector of consumption by family members as a whole. It is called the 'unitary household model'. and assumes that all income sources within the household are pooled and bargaining powers among household members does not affect intrahousehold resource allocation.

In the unitary household model, the household head chooses a level of child health (h) and a consumption bundle of commodities including goods and leisure ($\boldsymbol{x}$) to maximise the following household utility function:

$$U(h, \boldsymbol{x}) \quad [1]$$

Health production function for the child can be expressed as:

$$h = h(\boldsymbol{N}, \boldsymbol{\omega_{ch}}, \boldsymbol{\omega_{hh}}, \boldsymbol{\omega_{co}}; \boldsymbol{\mu}) \quad [2]$$

where $\boldsymbol{N}$ is a vector of health inputs that household provides to the child such as prenatal care, breastfeeding, micronutrient intake and vaccination; $\boldsymbol{\omega_{ch}}$ is a vector of child characteristics such as age, gender and birth order; $\boldsymbol{\omega_{hh}}$ is a vector of household characteristics such as parental education, household resources and demographics; $\boldsymbol{\omega_{co}}$ is a vector of community factors that may have an impact on child health such as the accessibility and quality of health services; and $\boldsymbol{\mu}$ is a vector of unobservable characteristics of the child, household and community which are assumed to be uncorrelated with the $\boldsymbol{N}$, $\boldsymbol{\omega_{ch}}$, $\boldsymbol{\omega_{hh}}$, and $\boldsymbol{\omega_{co}}$.

The choices of household are limited by their full income constraint:

$$\boldsymbol{p_x x} + \boldsymbol{p_N N} = Y = y_m + y_f + y_j \quad [3]$$

where $\boldsymbol{p_x}$ is a price vector of a consumption bundle and a leisure, $\boldsymbol{p_N}$ is a price vector of health input, Y is household total income which contains male income (y_m), female income (y_f) and joint income (y_j) by assuming that a household has two adults, a man (m) and a woman (*f*).

Several empirical studies have challenged the plausibility of the unitary household model. Using survey data from Brazil, Thomas 1990 (161) found that nonlabour income in the hands of women increased the probability of child survival by 20 times more than the comparable increase in male earnings. Other empirical studies also confirmed that women preferred to spend more on child health and education, whereas men preferred to consume luxury goods such as tobacco (162-165).

Consequently, the 'collective household model' was proposed in order to explicitly incorporate a bargaining process within the household by assuming a specific structure for parental preferences as a Pareto efficient outcome (166-168). Following this idea, the current study applies the 'Pareto-efficient collective household model' to derive a reduced-form to estimate the determinants of child nutritional status. In this model, each adult (*m=male, f=female*) has a specific utility function which is defined over child health and both members' consumptions:

$$U_m(h, \boldsymbol{x_m}, \boldsymbol{x_f}) \quad [4]$$

$$U_f(h, \boldsymbol{x_f}, \boldsymbol{x_m}) \quad [5]$$

I assume there exists a weight (α) for all Pareto-efficient outcomes and therefore the household's optimisation can be expressed as:

$$Max\ \ \alpha U_m\left(h, \boldsymbol{x_m}, \boldsymbol{x_f}\right) + (1-\alpha)U_f\left(h, \boldsymbol{x_f}, \boldsymbol{x_m}\right) \qquad [6]$$

subject to the household income constraint [3].

Thus, demand for child health can be derived as a function of characteristics of child ($\boldsymbol{\omega_{ch}}$), household ($\boldsymbol{\omega_{hh}}$), and community ($\boldsymbol{\omega_{co}}$), price vecors ($\boldsymbol{p_x}, \boldsymbol{p_N}$), household income ($Y = y_m + y_f + y_j$), a weight between man and women (α), and a vector of unobservable characteristics of the child, household and community ($\boldsymbol{\mu}$):

$$h = h(\boldsymbol{\omega_{ch}}, \boldsymbol{\omega_{hh}}, \boldsymbol{\omega_{co}}, \boldsymbol{p_x}, \boldsymbol{p_N}, Y, \alpha;\ \boldsymbol{\mu}) \qquad [7]$$

From [7] a reduced-form equation of demand for child health is written as:

$$h_i = \boldsymbol{X'_i\beta} + \epsilon_i \qquad [8]$$

where h_i is the health status for a child i and $\boldsymbol{X'_i}$ is a vector of variables of characteristics of the child, household and community, prices, income, and a weight between man and women ($\boldsymbol{\omega_{ch}}, \boldsymbol{\omega_{hh}}, \boldsymbol{\omega_{co}}, \boldsymbol{p_x}, \boldsymbol{p_N}, Y, \alpha,$). ϵ_i refers to an error term.

In this paper, a coefficient for each explanatory variable will be estimated using simple ordinary least squares (OLS) as a benchmark. However, OLS estimates will only be unbiased if there is no correlation between an error term and all the explanatory variables. For example, if any explanatory variable (especially income) in the equation [8] is endogenous, OLS estimates will be biased and inconsistent. In this situation, instrumental-variables (IV) estimation may resolve the problem. Instrumental variables must be correlated with a potentially endogenous explanatory variable and uncorrelated with the error term. Nonetheless, IV estimates will be inconsistent if the instrumental variables explain little of the variation in the endogenous explanatory variables (169). For this reason, it is quite difficult to find appropriate instrumental variables in empirical studies.

Considering the heterogeneities of households and communities which are shown in Figure 4 as well as a sampling structure of the dataset which will be described later, I also apply the two-level Hierarchical Linear Model (HLM) (170, 171). Two-level HLM can estimate random effects at both the household and community level. The model is expressed as:

$$h_{ijk} = \boldsymbol{X'}_{\boldsymbol{ijk}}\boldsymbol{\beta} + u_j + u_k + \epsilon_{ijk} \qquad [9]$$

where h_{ijk} represents health status of a child i in the household j, which belongs to the community k. u_j and u_k are an unobserved household random effect and a cluster random effect respectively.

This paper also examines interaction effects between household and community factors in child nutrition. Community variables ($\boldsymbol{\omega_{co}}$) affect child health status both directly and indirectly through household variables ($\boldsymbol{\omega_{hh}}$). For the latter route, the relationship between community and household variables can be complementary or supplementary. Using the equation [7], it is shown as follows. When a community variable ω_{co} has an effect on child health h through a household variable ω_{hh}:

if $$\partial h^2 / (\partial\omega_{hh}\, \partial\omega_{co}) > 0 \qquad [10]$$

the two factors are complements; and

if $$\partial h^2 / (\partial\omega_{hh}\, \partial\omega_{co}) < 0 \qquad [11]$$

the two factors are substitutes.

Interaction effects have the important policy implications because they imply to what extent a change of the community factors such as the improvement of community infrastructure, water and sanitation, and local health services will bring benefits to each of the advantaged and disadvantaged populations (in terms of income, education, geographical area etc). For example, basic or nonspecialised local health services are expected to act as a substitute to the poorly educated families (greater benefits to less educated families). On the other hand, more specialised services will be complementary with education (greater benefits to more educated families) (149).

As to the methodological model, some studies take approach to estimate child health production function directly (134, 172, 173). However, most of the health inputs into child health production such as breastfeeding, vaccination, health clinic utilisation, home-based care, micronutrients intakes are endogenous. Strauss 1990 addresses the danger of using such endogenous variables in the OLS regression since the OLS estimates in this situation lead to serious misleading interpretation of the results (95)[15]. Actually, it is almost impossible for researchers to obtain all the information about the household's decision-making in child health production. Besides, it is also quite difficult to find good instrumental variables for the endogenous health inputs variables. For this reason, this paper does not take this approach even if the dataset does include the information about health inputs into child health production.

4. Data and variables

The dataset from the Lao Multiple Indicator Cluster Survey 3 (MICS3) is used for the empirical analysis.[16] It includes 5,894 households comprising 33,100 members. The main sampling domains are three regions, North, Central and South of Laos. Within each region, 100 enumeration areas were selected with probability proportional to size. Then, 20 households were systematically sampled from each enumeration area (83, 175, 176)[17].

I examine the relationship between socioeconomic factors and

[15] Another problem related with OLS estimation is also mentioned by Strauss 1990. Martorell et al. 1984 find that parental education has an insignificant effect on child nutritional status using a sample in Nepal (174). Strauss 1990 suggests it is because they are holding the constant variables, such as the number of months breastfed and the type of food eaten, which the education variable could be expected to affect (114).

[16] The MICS3 was undertaken nationwide in Laos by the Department of Statistics of Ministry of Planning and Investment in collaboration with the Hygiene and Prevention Department of Ministry of Health between March and June in 2006.

[17] Thus, the sample was designed to collect information of 6,000 households in total ($3\,regions \times 100\,enumeration\ areas \times 20 households$). However, it was known in advance that one village had only 15 households and therefore the total expected number of household was 5,995.

anthropometrics of children under-five[18]. First, bivariate analysis is performed to analyse the association between the probability of becoming stunted (<-2HAZ), wasted (<-2WHZ) and underweight (<-2WAZ) and the socioeconomic characteristics. Then, multivariate regressions are conducted to analyse Z-scores as a dependent variable.

Explanatory variables are categorised into three factors—child, household and community—corresponding to the analytic framework (Figure 4).

Child variables include the age and sex of a child. Age is captured by five age-bracket dummies during 0-59 months. The baseline is 0-11 months of age.

Household variables comprise the information about ethnicity (by ethnic language the household head speaks—Lao, Khmou, Hmong and 'other' ethnic languages—, mother's age, mother's education level ('no education', 'primary education' and 'secondary education'), mother's status within the household, and household income. As a proxy for the mother's status, a dummy variable 'whether mother has higher education level than father (= 1) or not (= 0)' is used.

Since there is no information about household income in the dataset, I use the data on household assets as a proxy for income. The dataset contains the wealth index score which is calculated according to the principal components of household assets[19].

[18] Z-scores calculated based on the 'NCHS reference'.

[19] Household asset index is calculated based on the principal component analysis. Assets included in the calculation are as follows: electricity, clock, radio, electric fan, mattress, black and white television, colour television, CD/VCD player, water pump, bed, DVD player, satellite, mobile telephone, telephone, refrigerator, air conditioner, cloth washing machine, sofa, watch, bicycle, oxcart, motorbike, tractor, Tuktuk, car or truck, engine boat, type of sanitation facility, type of cooking fuel, type of materials used for floor, roof, and wall.

However, some of the components in the index such as water pumps, refrigerators and motorbikes may be correlated with child health status. For this reason, I use two variables 'hectares of agricultural land' per household and 'the number of milk cows' per household, which are not included in the calculation of the wealth index score, as a set of instrument variables for the IV estimation on the ground that these two variables are correlated with household income and are not correlated with the error terms (ϵ_i).

Community variables include information about the area where the household is located ('urban', 'rural with road' and 'rural without road') and five variables of the community characteristics. The first three: 1) households' average time (a mean in minutes) per cluster to get water; 2) the proportion of households per cluster without a latrine; 3) the proportion of children per cluster who had diarrhoea in the last two weeks, represent the condition of sanitation and water in the community (177, 178). The other two: 4) the proportion of households per cluster which own a coloured television; and 5) the proportion of households per cluster which own a radio, are included to represent the situation of communication infrastructure which may alter child health production process (69). For instance, ownership of a television enables households to acquire information about health production and leads to more efficient resource allocation (90).

Though price vectors of consumption goods, leisure and health inputs are the elements which a household consider for decision-making in child nutrition (equation [8]), I subsumed them into the unobserved community factors under the assumption that prices do not vary over a community (179)[20]. I also rule out selective migration to seek for better health environment or more favourable prices by assumption (181).

5. Descriptive statistics

Table 1 presents the descriptive statistics for the analysis.[21]. The data include the information about 4,204 children from 2,955 households in 300 communities (clusters).

Table 1: Descriptive statistics

Variable	Obs.	Mean	Linearised S.E.
HAZ (Height-for-age Z-score)	4033	-1.685	0.027
WHZ (Weight-for-height Z-score)	4007	-0.741	0.017
WAZ (Weight-for-age Z-score)	4035	-1.607	0.020
Male	4204	0.510	0.008
Age 0-11 months	4136	0.194	0.007
Age 12-23 months	4136	0.200	0.007
Age 24-35 months	4136	0.205	0.007
Age 36-47 months	4136	0.227	0.007
Age 48-59 months	4136	0.174	0.006
Ethnic language: Lao	4204	0.489	0.008
Ethnic language: Khmou	4204	0.141	0.006
Ethnic language: Hmong	4204	0.152	0.006
Ethnic language: Others	4204	0.217	0.007
Mother's age	3987	28.708	0.116
Mother no education	4204	0.399	0.008
Mother primary education	4204	0.423	0.008
Mother secondary education	4204	0.164	0.006
Wealth index score	4204	-0.257	0.017
Mother’s status compared with father	4204	0.066	0.004
Urban	4204	0.168	0.007
Rural with road	4204	0.543	0.008
Rural without road	4204	0.289	0.008
Community: Average time to get water	4051	9.460	0.170
Community: Prop. of No latrine	4204	0.618	0.007
Community: Prop. of Child diarrhoea	4204	0.124	0.002
Community: Prop. of TV	4204	0.321	0.006
Community: Prop. of Radio	4204	0.429	0.004

48.9% of the children are from households where the head speaks Lao. The

[20] While the area dummy may explain a part of price fluctuation, a large portion of the variations would be left into the unobserved community factor considering the low level of market integration in Laos (180).

[21] All of the data in descriptive summary and the estimates from the regressions are corrected for a cluster survey design (170, 182).

proportion of the children whose mother has higher education than their father (= mother's status) is 6.6%. More than half the children are from 'rural with road', while 16.8% and 28.9% of the children are from 'urban' and 'rural without road' respectively.

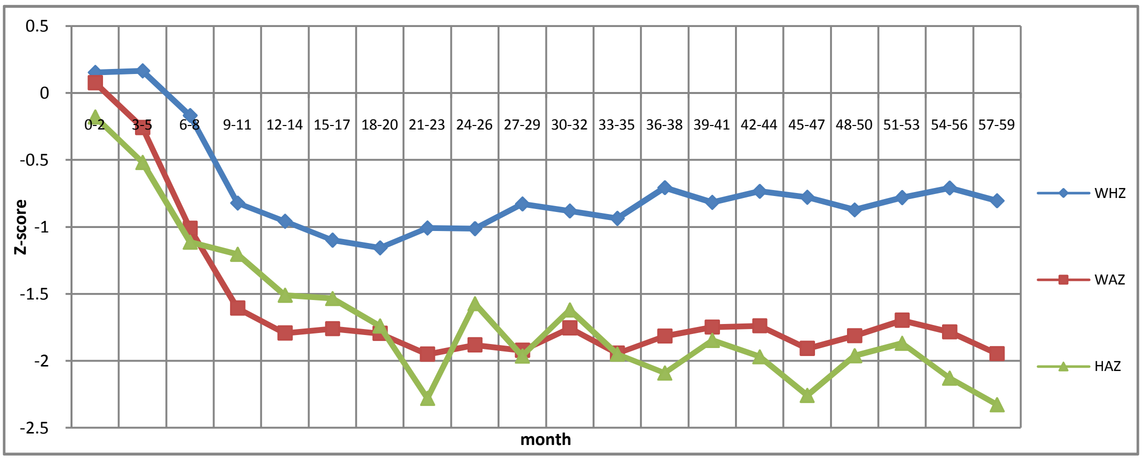
Table 2 summarises the prevalence of malnourished children in the sample population according to Z-score. The prevalence of stunting (<-2HAZ), wasting (<-2WHZ), and underweight (<-2WAZ) is 39.6%, 6.6% and 36.4% respectively.

Table 2: Percentage of malnourished children by its severity

Z-score	Severity	Height-for-age	Weight-for-height	Weight-for-age
below -1		69.2%	38.9%	71.5%
below -2	Moderate or Severe	39.6%	6.6%	36.4%
below -3	Severe	16.0%	0.9%	9.4%

Figure 5 shows the mean of Z-scores of children under-five by 3-month age-bracket.

Figure 5: Mean of Z-score by age 0-59 months



Overall patterns of three anthropometric indices are similar to the observations from 39 developing countries by Shrimpton et al. 2001 (97). WAZ remains above zero of Z-score (NCHS reference) during the first 3 months of age, while HAZ starts below zero from the first. After 3 months, both WAZ and HAZ decline steeply just before the 24th month, which is considered a critical age of child growth (25, 183), stabilizing at around -2.0 SD. After 24 months, WAZ recovers a little and keeps its score between -2.0 and -1.5 SD until the 60th month of age. HAZ fluctuates more in the range of -2.5 to -1.5 SD, taking its value of -2.3 SD at the last 3 months.

On the other hand, WAZ remains above zero during the first 6 months of age. After 6 months, it deteriorates sharply and then mildly until around 21 months of age to about -1.2 SD. Thereafter, it slowly keeps increasing until the 60th month of age to about -0.8 SD.

6. Results

6.1. Results of bivariate analysis

In Table 3, the results of bivariate analysis are presented.

Table 3: Results of bivariate analysis

Variable	HAZ <-2SD (p-value)	Odds Ratio	p-value	WHZ <-2SD (p-value)	Odds Ratio	p-value	HAZ <-2SD (p-value)	Odds Ratio	p-value
Total sample	39.6			65.8			36.4		
Sex of the child	(0.713)			(0.110)			(0.596)		
Female	39.9	1.000		5.9	1.000		36.8	1.000	
Male	39.3	0.975	0.713	7.2	1.240	0.110	36.0	0.964	0.596
Age of the child	(0.000)			(0.000)			(0.000)		
0-11 months	16.8	1.000		4.2	1.000		12.3	1.000	
12-23 months	42.2	3.617	0.000	12.8	3.344	0.000	44.3	5.686	0.000
23-35 months	41.3	3.487	0.000	7.8	1.945	0.004	44.6	5.750	0.000
36-47 months	46.9	4.372	0.000	3.3	0.784	0.368	41.4	5.047	0.000
48-59 months	50.5	5.062	0.000	4.9	1.169	0.551	38.2	4.423	0.000
Ethnic group	(0.000)			(0.000)			(0.000)		
Lao	30.1	1.000		7.0	1.000		32.4	1.000	
Kham	47.5	2.100	0.000	3.4	0.470	0.002	36.9	1.219	0.052
Mong	46.4	2.010	0.000	2.4	0.323	0.000	27.4	0.786	0.027
Others	50.8	2.398	0.000	1.0	1.542	0.004	51.2	2.187	0.000
Mother's education	(0.000)			(0.516)			(0.000)		
Secondary education	23.3	1.000		6.4	1.000		41.9	1.000	
Primary education	37.7	1.996	0.000	7.1	1.128	0.553	36.5	1.824	0.000
No education	47.6	3.001	0.000	6.3	0.985	0.945	23.9	2.289	0.000
Mother's status	(0.000)			(0.856)			(0.000)	43.4	
Lower than father	39.5	1.000		6.5	1.000		36.5	1.000	
Higher than father	39.8	1.010	0.940	7.8	1.217	0.431	35.0	0.937	0.643
Wealth index quintile	(0.000)			(0.613)			(0.000)		
Richest	15.4	1.000		6.2	1.000		17.1	1.000	
Second	31.3	2.503	0.000	6.6	1.000	0.817	31.6	2.237	0.000
Middle	37.5	3.304	0.000	7.9	1.310	0.295	39.8	3.214	0.000
Fourth	43.5	4.234	0.000	6.1	0.981	0.941	37.3	2.888	0.000
Poorest	51.8	5.905	0.000	6.3	1.019	0.938	43.8	3.776	0.000
Area	(0.000)			(0.464)			(0.000)		
Urban	24.1	1.000		6.3	1.000		24.3	1.000	
Rural with road	41.3	2.214	0.000	6.2	0.995	0.981	37.2	1.842	0.000
Rural without road	45.2	2.597	0.000	7.4	1.197	0.411	42.0	2.257	0.000
Child diarrhoea	(0.007)			(0.001)			(0.000)		
No diarrhoea	38.8	1.000		6.1	1.000		35.1	1.000	
Diarrhoea	45.3	1.309	0.007	10.2	1.754	0.001	45.8	1.562	0.000
Household's latrine	(0.000)			(0.003)			(0.000)		
With a latrine	29.5	1.000		5.0	1.000		27.3	1.000	
No latrine	45.8	2.015	0.000	7.5	1.539	0.004	42.0	1.929	0.000

Note: The p-value in a bracket is obtained by the Pearson’s chi-square test.

There is no significant gender difference in the probability of becoming malnourished. Children aged 12-59 months are much more likely to be malnourished than those aged 0-11 months (except for wasting among the children aged 36-47 months). The odds of becoming stunted and underweight in children aged 12-59 months are significantly 3.6–5.1 times and 4.4–5.8 times higher than those who are 0-11 months old respectively.

Children from Khmou, Hmong and ‘other’ ethnic language groups are more likely to be stunted than the children from Lao group. However, the odds of becoming wasted in the children from Khmou and Hmong groups are significantly lower than those from Lao group. Children from ‘other’ ethnic language groups are more vulnerable than Lao children for all of the indices.

Children who live in rural areas are significantly more prone to be stunted and underweight than those who are in ‘urban’. Both recent diarrhoea incidence and ownership of a latrine have a significant impact on child nutrition.

6.2. Results of multivariate analysis

Table 4, 5, 6 summarise the results of the multivariate analysis in three model specifications—OLS, Two Stage Least Squared (2SLS) using instrumental variables, and Two-level HLM (with random-intercept) —.

The last six rows of each table show the results of a cluster random effect (u_k) and a household random effect (u_j) in the HLM, suggesting both effects are significantly different from zero (95% CI does not include 0) for all the anthropometric indices. Thus, we can conclude that the intercepts of u_k and u_j differ from cluster to cluster and household to household respectively.

The results of likelihood-ratio tests for all of the anthropometric indices (p=<0.000 for HAZ, WHZ and WAZ) suggest the random effect model is preferable to a linear regression with fixed intercept for u_k and u_j. Accordingly, I focus on the estimates obtained by the HLM for interpretation of the results rather than OLS or 2SLS unless mentioned otherwise. The HLM is also used for the estimation with interaction terms between mother's education levels and five community variables (referred to as 'HLM2') as well as the one without interaction terms (referred to as 'HLM1').

Table 4: Results of estimation: Height-for-age Z-score (HAZ)

	OLS		p-value	**2SLS**		p-value	**HLM1**		p-value	**HLM2**		p-value
Male	0.009		0.863	0.039		0.556	0.015		0.781	0.010		0.859
Age 12-23 months	-0.933	***	0.000	-0.978	***	0.000	-1.022	***	0.000	-1.027	***	0.000
Age 24-35 months	-1.029	***	0.000	-1.109	***	0.000	-1.082	***	0.000	-1.078	***	0.000
Age 36-47 months	-1.290	***	0.000	-1.324	***	0.000	-1.306	***	0.000	-1.307	***	0.000
Age 48-59 months	-1.332	***	0.000	-1.378	***	0.000	-1.367	***	0.000	-1.372	***	0.000
Ethnic group: Khmou	-0.285	***	0.001	-0.224	*	0.074	-0.273	**	0.012	-0.252	**	0.022
Ethnic group: Hmong	-0.196	**	0.031	-0.201	*	0.078	-0.081		0.490	-0.053		0.656
Ethnic group: Others	-0.183	**	0.018	-0.178	*	0.059	-0.225	**	0.013	-0.234	**	0.010
Mother's age	0.075	***	0.008	0.101	***	0.003	0.083	***	0.007	0.086	***	0.005
Mother's age^2	-0.001	**	0.014	-0.001	***	0.008	-0.001	**	0.018	-0.001	**	0.015
Mother primary edu.	0.051		0.397	-0.019		0.805	0.061		0.388	0.735	***	0.003
Mother secondary edu.	0.055		0.555	-0.149		0.415	0.169		0.150	0.533		0.174
Wealth index score	0.211	***	0.000	0.600	**	0.047						
Agricultural Hectare							0.028	**	0.034	0.027	**	0.039
Number of cows							0.006		0.400	0.005		0.499
Mother's status	-0.052		0.584	-0.079		0.495	-0.161		0.181	-0.146		0.231
Rural with road	0.088		0.319	0.280	*	0.090	0.005		0.966	0.043		0.731
Rural without road	0.148		0.168	0.456	**	0.020	0.133		0.336	0.178		0.201
Community(1) Water	-0.007	**	0.014	-0.007	**	0.044	-0.006	*	0.091	0.000		0.973
Community(2) No latrine	-0.270	***	0.001	-0.124		0.406	-0.380	***	0.000	-0.216		0.172
Community(3) Diarrhoea	-0.488	**	0.036	-0.658	**	0.031	-0.587	**	0.048	-0.261		0.539
Community(4) TV	0.179		0.189	-0.191		0.630	0.509	***	0.000	0.654	**	0.014
Community(5) Radio	0.065		0.561	0.178		0.197	0.060		0.678	0.370		0.113
Mother P.E*Comm.(1)										-0.007		0.317
Mother S.E*Comm.(1)										-0.017		0.125
Mother P.E*Comm.(2)										-0.298		0.128
Mother S.E*Comm.(2)										-0.034		0.912
Mother P.E*Comm.(3)										-0.566		0.334
Mother S.E*Comm.(3)										-0.960		0.342
Mother P.E*Comm.(4)										-0.286		0.328
Mother S.E*Comm.(4)										0.138		0.717
Mother P.E*Comm.(5)										-0.538	*	0.067
Mother S.E*Comm.(5)										-0.289		0.539
Constant	-1.690	***	0.000	-2.159	***	0.000	-1.987	***	0.000	-2.482	***	0.000
Observations	3824			2700			2608			2632		
R-square	0.1479			0.1346								
F-statistics				13.85	***	0.000						
Wald χ2							459.26	***	0.000	473.92	***	0.000
Cluster (s.d.)							0.159			0.151		
95% CI: Cluster							[0.070	-	0.360]	[0.062	-	0.369]
Households (s.d.)							0.475			0.479		
95% CI: Households							[0.357	-	0.632]	[0.361	-	0.634]
χ2: LR test vs Linear reg.							18.2	***	0.000	18.01	***	0.000

Note: * indicates significance at 10% level, ** at 5% level and *** at 1% level of confidence.
For the 2SLS, 'hectares of agricultural land' and 'the number of cows' are used as instruments for the wealth index.
For the HLM, method of estimation is a maximum likelihood.

Table 5: Results of estimation: Weight-for-height Z-score (WHZ)

	OLS		p-value	**2SLS**		p-value	**HLM1**		p-value	**HLM2**		p-value
Male	-0.029		0.441	-0.025		0.519	-0.045		0.183	-0.043		0.199
Age 12-23 months	-0.896	***	0.000	-0.945	***	0.000	-0.949	***	0.000	-0.943	***	0.000
Age 24-35 months	-0.744	***	0.000	-0.788	***	0.000	-0.795	***	0.000	-0.792	***	0.000
Age 36-47 months	-0.626	***	0.000	-0.615	***	0.000	-0.609	***	0.000	-0.610	***	0.000
Age 48-59 months	-0.636	***	0.000	-0.616	***	0.000	-0.576	***	0.000	-0.574	***	0.000
Ethnic group: Khmou	0.254	***	0.000	0.331	***	0.000	0.296	***	0.000	0.289	***	0.000
Ethnic group: Hmong	0.597	***	0.000	0.647	***	0.000	0.578	***	0.000	0.547	***	0.000
Ethnic group: Others	-0.085		0.274	-0.127	**	0.031	-0.164	***	0.008	-0.169	***	0.006
Mother's age	-0.024		0.574	-0.034		0.112	-0.040	**	0.034	-0.035	*	0.065
Mother's age^2	0.000		0.620	0.001		0.142	0.001	*	0.050	0.001	*	0.091
Mother primary edu.	-0.011		0.449	-0.024		0.590	-0.016		0.706	0.162		0.291
Mother secondary edu.	0.119	**	0.020	0.100		0.371	0.102		0.163	0.010		0.967
Wealth index score	0.022		0.600	0.169		0.333						
Agricultural Hectare							0.004		0.651	0.004		0.635
Number of cows							0.007		0.133	0.006		0.146
Mother's status	-0.023		0.287	-0.037		0.627	-0.010		0.892	-0.001		0.992
Rural with road	0.101	*	0.092	0.088		0.404	0.049		0.572	0.063		0.465
Rural without road	0.091		0.208	0.129		0.274	0.100		0.316	0.104		0.294
Community(1) Water	-0.003	*	0.073	-0.002		0.394	-0.002		0.547	-0.007	*	0.074
Community(2) No latrine	-0.071		0.150	-0.061		0.480	-0.159	**	0.029	-0.025		0.819
Community(3) Diarrhoea	-0.332	*	0.059	-0.191		0.305	-0.173		0.432	-0.337		0.259
Community(4) TV	-0.019		0.790	-0.231		0.342	-0.080		0.433	-0.056		0.748
Community(5) Radio	0.160	**	0.044	0.151	*	0.083	0.133		0.214	0.279	*	0.080
Mother P.E*Comm.(1)										0.006		0.140
Mother S.E*Comm.(1)										0.014	*	0.053
Mother P.E*Comm.(2)										-0.154		0.216
Mother S.E*Comm.(2)										-0.388	**	0.046
Mother P.E*Comm.(3)										0.242		0.511
Mother S.E*Comm.(3)										0.629		0.323
Mother P.E*Comm.(4)										-0.075		0.680
Mother S.E*Comm.(4)										-0.021		0.931
Mother P.E*Comm.(5)										-0.362	*	0.050
Mother S.E*Comm.(5)										0.186		0.529
Constant	0.093		0.553	0.319		0.349	0.391		0.202	0.221		0.504
Observations	3826			2676			2608			2608		
R-square	0.1792			0.2029								
F-statistics				24.90	***	0.000						
Wald $\chi 2$							552.04	***	0.000	575.07	***	0.000
Cluster (s.d.)							0.226			0.216		
95% CI: Cluster							[0.175	-	0.290]	[0.166	-	0.281]
Households (s.d.)							0.238			0.237		
95% CI: Households							[0.143	-	0.395]	[0.142	-	0.395]
$\chi 2$: LR test vs Linear reg.							39.64	***	0.000	35.61	***	0.000

Note: * indicates significance at 10% level, ** at 5% level and *** at 1% level of confidence.
For the 2SLS, ‘hectares of agricultural land’ and ‘the number of cows’ are used as instruments for the wealth index.
For the HLM, method of estimation is a maximum likelihood.

Table 6: Results of estimation: Weight-for-age Z-score (WAZ)

	OLS		p-value	**2SLS**		p-value	**HLM1**		p-value	**HLM2**		p-value
Male	0.009		0.811	0.024		0.609	0.004		0.912	0.003		0.941
Age 12-23 months	-1.132	***	0.000	-1.224	***	0.000	-1.228	***	0.000	-1.227	***	0.000
Age 24-35 months	-1.203	***	0.000	-1.309	***	0.000	-1.287	***	0.000	-1.283	***	0.000
Age 36-47 months	-1.160	***	0.000	-1.193	***	0.000	-1.151	***	0.000	-1.153	***	0.000
Age 48-59 months	-1.152	***	0.000	-1.188	***	0.000	-1.127	***	0.000	-1.128	***	0.000
Ethnic group: Khmou	0.030		0.631	0.108		0.221	0.060		0.490	0.061		0.486
Ethnic group: Hmong	0.355	***	0.000	0.401	***	0.000	0.422	***	0.000	0.413	***	0.000
Ethnic group: Others	-0.143	***	0.009	-0.171	**	0.010	-0.218	***	0.002	-0.231	***	0.001
Mother's age	0.026		0.198	0.037		0.133	0.021		0.347	0.026		0.252
Mother's age^2	0.000		0.237	0.000		0.199	0.000		0.459	0.000		0.354
Mother primary edu.	0.015		0.735	-0.028		0.607	0.015		0.767	0.524	***	0.004
Mother secondary edu.	0.110		0.117	0.000		0.998	0.157	*	0.071	0.227		0.437
Wealth index score	0.144	***	0.000	0.433	*	0.050						
Agricultural Hectare							0.017	*	0.080	0.016	*	0.083
Number of cows							0.008		0.112	0.008		0.142
Mother's status	-0.064		0.367	-0.099		0.262	-0.121		0.168	-0.105		0.235
Rural with road	0.124	**	0.043	0.198	*	0.092	0.012		0.901	0.048		0.632
Rural without road	0.178	**	0.018	0.358	**	0.011	0.143		0.203	0.175		0.120
Community(1) Water	-0.007	***	0.001	-0.006	**	0.013	-0.006	**	0.048	-0.005		0.278
Community(2) No latrine	-0.192	***	0.001	-0.112		0.292	-0.321	***	0.000	-0.172		0.168
Community(3) Diarrhoea	-0.583	***	0.001	-0.622	***	0.008	-0.536	**	0.029	-0.456		0.183
Community(4) TV	0.108		0.258	-0.212		0.468	0.252	**	0.031	0.367	*	0.070
Community(5) Radio	0.182	**	0.026	0.247	**	0.012	0.158		0.188	0.447	**	0.015
Mother P.E*Comm.(1)										-0.002		0.742
Mother S.E*Comm.(1)										-0.001		0.935
Mother P.E*Comm.(2)										-0.215		0.143
Mother S.E*Comm.(2)										-0.244		0.287
Mother P.E*Comm.(3)										-0.192		0.660
Mother S.E*Comm.(3)										0.051		0.947
Mother P.E*Comm.(4)										-0.271		0.209
Mother S.E*Comm.(4)										0.122		0.666
Mother P.E*Comm.(5)										-0.569	***	0.009
Mother S.E*Comm.(5)										-0.046		0.896
Constant	-1.082	***	0.001	-1.213	***	0.001	-1.024	***	0.005	-1.405	***	0.000
Observations	3826			2700			2632			2632		
R-square	0.2206			0.2301								
F-statistics				26.11	***	0.000						
Wald $\chi 2$							784.49	***	0.000	803.20	***	0.000
Cluster (s.d.)							0.221			0.216		
95% CI: Cluster							[0.164	-	0.297]	[0.158	-	0.293]
Households (s.d.)							0.390			0.390		
95% CI: Households							[0.308	-	0.494]	[0.307	-	0.494]
$\chi 2$: LR test vs Linear reg.							45.97	***	0.000	43.84	***	0.000

Note: * indicates significance at 10% level, ** at 5% level and *** at 1% level of confidence.
For the 2SLS, 'hectares of agricultural land' and 'the number of cows' are used as instruments for the wealth index.
For the HLM, method of estimation is a maximum likelihood.

6.2.1. Child characteristics

There is no evidence that male children are more malnourished than females for all the anthropometric indices. Child's age, which is expressed by four dichotomous variables, is found to be quite significantly associated with child nutritional status. Children aged more than or equal to 12 months of age are more stunted, wasted and underweight than those under 12 months at the less than 1% significance level. WHZ and WAZ decrease until 23 months and 35 months of age respectively, but both indices level off thereafter. However, HAZ keeps falling throughout all the age-bracket until 60^{th} months of age.

6.2.2. Household characteristics

There are striking differences between the ethnic groups. As to HAZ and WHZ, the children from Khmou and 'other' language groups are more stunted than those from Lao group (baseline group) at the less than 5% significance level, whereas the children from Khmou and Hmong groups are less wasted than those from Lao group at the less than 1% significance level. The children from 'other' language groups are more wasted than ethnic Lao children ($p=0.008$). With regard to WAZ, the children from Hmong group are less malnourished ($p<0.001$), but the children from 'other' language groups are more underweight than ethnic Lao children ($p=0.001$). It is important to keep in mind that the children from Hmong groups have equally or better nutritional status than those from Lao group, whereas the children from 'other' language groups are more malnourished than those from Lao group for all the indices even after controlling for socioeconomic factors for which this population is disadvantageous[22].

The effect of mother's education seems very limited in contrast to numerous past studies. Mother's secondary education has a positive impact on WAZ, albeit with a small statistical significance (p=0.071). Mother's age has a positive and diminishing impact on HAZ at the less than 1% significance level, whereas it affects a negative impact on WHZ (p=0.034). Mother's status within the household does not exhibit any significant effect on child nutrition.

In the OLS model, the wealth index score has a significant and positive impact on HAZ (p<0.001) and WAZ (p<0.001). Nonetheless, its significance becomes weakened in the 2SLS (p=0.047 and p=0.050 respectively) when the wealth index is instrumented with 'hectare of agricultural land' and 'the number of cows'. The F-tests for the significance of the instruments give p<0.001 for all the anthropometrics, indicating the proposed instruments have a predictive power to explain the wealth index score[23]. Concerning WHZ, the asset index does not affect any significant impact.

6.2.3. Community characteristics

There is no significant association between the area dummy and anthropometric indices.

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[22] Andersson et al. confirm that poverty is concentrated and more severe among ethnic minority groups in Laos especially due to the limited access to productive resources (184).

[23] DWH (Darbin-Wu-Hausman) test for endogeneity is not available for cluster-weighted sample. However, DWH test for a non-weighted sample in the same dataset shows that p-value from the DWH test is 0.2375, 0.2752 and 0.1379 for HAZ, WHZ and WAZ respectively. Therefore, we cannot reject the exogeneity of the wealth index.

Households' average time per cluster to get water has a weakly significant and negative impact on HAZ ($p=0.091$) and WAZ ($p=0.048$). Low latrine coverage has a strongly significant and negative impact on HAZ ($p<0.001$) and WAZ ($p<0.001$), as well as on WHZ ($p=0.029$). Recent child diarrhoea exhibits a negative impact on HAZ and WAZ at the less than 5% significance, whereas it has no significant impact on WHZ.

The television coverage has a significant and positive effect on HAZ ($p<0.001$) and WAZ ($p=0.031$), but not on WHZ. On the other hand, the radio coverage is not significantly associated with any of the nutrition indices.

6.2.4. Interaction of mother's education and community factors

A column of HLM2 in Table 4, 5, 6 presents the results of interaction terms between mother's education levels and community factors. With regard to WHZ, the mother's secondary education is confirmed to be weakly substitutable with the household's average time per cluster to get water for WHZ ($p=0.053$) and also to be complementary with the latrine coverage ($p=0.046$). For all the child anthropometrics, the mother's primary education seems to have a substitutable relationship with the radio coverage ($p=0.067$ for HAZ, $p=0.050$ for WAZ and $p=0.009$ for WAZ).

6.2.5. Unobserved heterogeneities at the household and community levels

As explained above, the results of the HLM suggest that the unobserved heterogeneities at both the household and community levels are significantly associated with all the child anthropometric indices.

7. Discussion

7.1. Main findings

This paper has elucidated the relationship between socioeconomic factors and child nutritional status in Lao PDR using cross-sectional survey data. Main findings are summarised as follows.

First, the results have identified the socioeconomic factors which affect an impact on children's nutritional status: ethnic groups, mother's age, mother's education levels, household assets, water and sanitation, and communication infrastructure. Importantly, the factors which exert an effect on WHZ are quite different from those of HAZ and WAZ. For instance, only one community variable (low latrine coverage) exhibits a significant effect on WHZ, whereas four of the five community variables are importantly associated with HAZ and WAZ. This result is consistent with the observations by Shrimpton et al. 2001 (97).

Second, the paper has identified the patterns of child growth faltering by age. The multivariate analysis shows the age of child is directly associated with their nutritional status—children aged more than 12 months are significantly more malnourished than those under 12 months—. Noticeably, HAZ deteriorates even after 2 years of age, whilst WHZ and WAZ stabilise earlier than that age.

Finally, it has been confirmed that mother's status within the household (measured by the mother's relative educational achievement against father) has no significant impact on child nutritional status, suggesting that the 'collective household model' is not supported by the data. On the other hand, the paper has found unobserved heterogeneities of both the household and community are significantly associated with child health status, implying the existence of 'neighbourhood effect' in the sample population.

7.2. Policy implications

There is a global recognition of the efficacy of a number of nutrition interventions in developing countries such as breastfeeding, micronutrient supplementation and certain types of health care services (17, 18, 185-187). Nonetheless, these interventions are generally targeted for the elimination of *immediate causes* of child malnutrition. The empirical results suggest that socioeconomic factors are importantly associated with child nutrition, suggesting that such shorter-term nutrition interventions might not be sufficient but should be supplemented by broad social policies to tackle the *underlying* and *basic causes* to achieve a further reduction in child malnutrition (Table 7). From this point of view, the following recommendations are suggested.

Table 7: Interventions to better nutrition

	To: *Immediate causes* (short-term)	To: *Basic* and *underlying causes* (long-term)
Supply-side incentives	▪ Community-based nutrition and health services ▪ Facility-based nutrition and health services ▪ Micronutrient supplements ▪ Targeted food aid	▪ Safe water and sanitation ▪ Primary health services and infectious disease control ▪ Food and agricultural policies ▪ Food industry development ▪ Fruit and vegetable production
Demand-side incentives	▪ Conditional cash transfers ▪ Microcredit cum nutrition education ▪ Food supplementation ▪ Food stamps	▪ Economic development (income creation for the poor) ▪ Participatory programme ▪ Food price policy ▪ Employment creation
Demand-side behaviour change	▪ Maternal nutrition, knowledge, and care-seeking during pregnancy ▪ Hygiene education	▪ Improvement of women's status ▪ Reducing women's workload ▪ Increasing women's education

Modified from World Bank (2006) (18)

Recommendation 1: Institutionalise nutrition into socioeconomic development

The results of the study suggest child malnutrition is strongly associated with other social and economic sectors. For instance, the results show that the poor conditions of water and sanitations have a negative impact on both acute and chronic child nutrition. On the other hand, water and sanitation are also known to have an effect on a country's economic performances. According to the recent report by WSP 2009, inferior sanitation conditions cause serious damage to Lao economy.[24] Given the low sanitation coverage in Laos compared with other countries in the region,[25] more ambitious investment into the water and sanitation sector should be considered.

The current Lao National Socio-Economic Development Plan (NSEDP) directs

[24] According to the WSP 2009, Lao PDR made a loss of USD 193 million (approximately 5.6% of GDP) due to poor sanitation and hygiene in 2006 (188).

[25] Sanitation coverage was 48% in 2005, which was much lower than the regional average for Southeast Asian countries of 67%. There is also a huge disparity between urban (84%) and rural (32%) (189).

more enhanced growth by strengthening a link between economic development and social development.[26] Considering its multiple causes and consequences, child malnutrition is should be treated in a broader socioeconomic context rather than being handled independently. Evidence suggests that multisectoral interventions lead to great health gains (191-194). For the above reasons, policymakers should institutionalise nutrition interventions into a national socioeconomic development framework (policies and programmes[27]) so that they could promote multisectoral approach to improve child malnutrition more effectively.

Recommendation 2: Targeting resources to the most disadvantaged populations

The empirical analysis reveals the socioeconomic background of the most malnourished children in Laos. Considering the limited financial and human resources for health spending in Laos (196), a priority of the nutrition interventions should be given to the most vulnerable children. Policymakers should deliberate a plan on how to deliver necessary resources to the targeted populations by applying the basic principle of targeting as well as learning from good practices in other countries such as PROGRESA in Mexico (197).

For example, a strong social network in rural Lao villages[28] will be helpful to

[26] The six NSEDP (2006-2010) articulates the following directions to achieve higher socioeconomic development outcomes: 1) turn from under-development to fast and stable development; 2) increase competitiveness; 3) strengthen links between economic development and social development; and 4) accelerate the building of a comprehensive socio-economic infrastructure (190).
[27] Such as the Village Development Funds and the Poverty Reduction Fund (195).
[28] Patcharanarumol 2009 states that loans can commonly be made without credit guarantees or interest

select the right beneficiaries by community members (individual assessment).[29] The information about prevalence of child malnutrition by ethnic group or geographic area could help policymakers to select a districts for, for example, NGO activities such as the District-based Comprehensive Primary Health Care programme in Sayaboury province (201) (categorical/geographic targeting). Policymakers can differentiate the quality, quantity and price of goods for child health production such as Oral Rehydration Therapy (ORT) according to the needs of the households or communities (self-selection).

Recommendation 3: Design pro-poor nutrition interventions

The empirical results show that the mother's secondary education serves as a complement for the low latrine coverage in determining weight-for-height of children. It suggests that social investment into toilet facilities without consideration of the interaction effects would be more benefit to the children from better educated families rather than disadvantaged children. In such an occasion, Behaviour Change Communication (BCC) activities about sanitation and hygiene should be also provided to poorly educated mothers in order to make the most of the investment and to prevent unequal child health gains. As such, in implementing nutrition policies, policymakers should scrutinise the socioeconomic background of targeted children to anticipate

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for meeting health expenditure within the village in Lao unlike in Vietnam and Cambodia (198).

[29] Categorisation of the targeting methods ('individual assessment', 'categorical/geographical targeting' and 'self-selection') is based on Hanson 2008 (199) and Conning 2001 (200).

possible interaction effects with community factors so that a pro-poor resource allocation will be realised.

7.3. Study limitations and suggestions for future research

Some caution should be taken in interpreting the empirical results. First, variables representing child biological endowments such as parental height or weight are not included in the estimations,[30] suggesting the impact of parental education would be overestimated. However, the empirical results show that the mother's education affects only a limited impact on child nutritional status. It is not clear whether this phenomenon is caused by a real effect of mother's schooling on child health or by the other reasons. Further investigation is required on biological endowment and the effects of schooling.

Second, prices of commodities, leisure and health inputs are subsumed into the unobserved community factors under the assumption that they do not vary over a community. However, it is desirable to see actual variations in these prices by using the other source of data in order to check whether the assumption is plausible or not.

Finally, the direction of causation between socioeconomic factors and child health are ambiguous since this paper uses only cross-sectional data. Utilisation of longitudinal datasets or randomised trials would be preferable to scrutinise the actual causalities.

[30] Although the MICS3 dataset includes the information about mother's height and weight, I do not use that information because response rates are quite low.

8. Conclusion

Improving children's nutritional status brings multiple and long-term benefits. Given the complexities of the mechanism of child malnutrition, this study suggests a framework which incorporates heterogeneities at both the household and community levels. The empirical results have confirmed that socioeconomic factors such as mother's education, ethnicity, household assets and community environment have a significant impact on child nutritional status. It is verified that children aged more than or equal to 12 months are more malnourished than those below 12 months of age. The study has also revealed that unobserved heterogeneities of both household and community are associated with child health status.

Following the empirical results, policy recommendations are suggested as follows. First, policymakers should institutionalise nutrition into a socioeconomic development framework considering the multiple causes and consequences of child malnutrition. Second, they should target resources to the disadvantaged populations such as ethnic minority groups, impoverished households and communities with poor sanitation environment. Third, social policies and nutrition interventions should be designed carefully by scrutinising the socioeconomic background of children in order to achieve a pro-poor resource allocation.

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