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Children's Protein Consumption in Southeast Asia: Consideration of Quality as Well as Quantity of Children's Protein Consumption in Southeast Asia

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Abstract

Inadequate dietary intake and prolonged undernourishment can lead to short term and long term consequences, which can deplete financial, physical, and social capital, further exacerbating the cycle of undernutrition, poverty, and unhealthy household environment that most food-insecure families already have. Children are a particular focus of interest because of the formative impact nutrition can have on development. Previous research establishes the particular importance of protein consumption in normal childhood growth. This paper seeks to explore dietary protein consumption patterns in countries in Southeast Asia with high rates of stunting, a cumulative indicator of chronic malnutrition – Indonesia, Philippines, Vietnam, Myanmar, and Cambodia – using international health databases. First, it examines the current protein intake level compared to recommended standards for children under five years old. Second, it examines the sources of protein to evaluate the quality of the protein consumption profile. Results show that there are no significant protein-energy deficits based on aggregate protein supply figures. However, the quality, even more than the quantity, of protein may be contributing to high instances of malnutrition. The predominant staples in the Southeast Asian diet, rice and other cereals, contain lower utilizable protein and are low or lacking in necessary amino acids and micronutrients. Thus, interventional programs should focus on supplementing and fortifying the existing diets with higher quality proteins and necessary micronutrients.

Keywords

protein inadequacy, protein-energy malnutrition, protein quality, stunting, children, Southeast Asia, PDCAAS

Disciplines

Business

Consideration of Quality as well as Quantity of Children's Protein Consumption in Southeast Asia

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Abstract

Inadequate dietary intake and prolonged undernourishment can lead to short term and long term consequences, which can deplete financial, physical, and social capital, further exacerbating the cycle of undernutrition, poverty, and unhealthy household environment that most food-insecure families already have. Children are a particular focus of interest because of the formative impact nutrition can have on development. Previous research establishes the particular importance of protein consumption in normal childhood growth. This paper seeks to explore dietary protein consumption patterns in countries in Southeast Asia with high rates of stunting, a cumulative indicator of chronic malnutrition – Indonesia, Philippines, Vietnam, Myanmar, and Cambodia – using international health databases. First, it examines the current protein intake level compared to recommended standards for children under five years old. Second, it examines the sources of protein to evaluate the quality of the protein consumption profile. Results show that there are no significant protein-energy deficits based on aggregate protein supply figures. However, the quality, even more than the quantity, of protein may be contributing to high instances of malnutrition. The predominant staples in the Southeast Asian diet, rice and other cereals, contain lower utilizable protein and are low or lacking in necessary amino acids and micronutrients. Thus, interventional programs should focus on supplementing and fortifying the existing diets with higher quality proteins and necessary micronutrients.

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Consideration of Quality as well as Quantity of Children's

Protein Consumption in Southeast Asia

Introduction

Food security is a multifaceted, critical problem worldwide commonly defined as having both physical and economic access to food that meets people's dietary needs and their food preferences, as well as having appropriate food use based on knowledge of basic nutrition and care[1]. Global interest in food security and nutrition has increased dramatically, especially as food shortages, rising food prices, increasing cases of obesity, and persisting problems of hunger have spurred on widespread concern and action[2]. Over one billion people worldwide, 200 million of them children, go to bed hungry every night[3]. Malnutrition and hunger are critical issues not only because of the large numbers of people affected, but also because they pose as risk factors for many diseases.

Children are a particular focus of interest because of the formative impact nutrition can have on development, and the lasting influence it can have even across generations. Inadequate dietary intake and prolonged undernourishment stunt growth, slow cognitive development, and increase susceptibility to illness. This can lead to short term and long term consequences, such as mortality, morbidity, disability, metabolic and cardiovascular diseases, decreased reproductive performance, and decreased economic productivity. These consequences of undernutrition deplete financial, physical, and social capital, further exacerbating the cycle of undernutrition, poverty, and unhealthy household environment that most food-insecure families already have.[4]

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[1] World Health Organization, "Food Security."
[2] World Health Organization, "Food Security."
[3] U.S. Agency for International Development. *Agriculture and Food Security*.
[4] UNICEF. (2013). Improving child nutrition. *The achievable imperative for global progress. United Nations Children's Fund, ed. New York,* 1-132.

Thus, inadequate nutrition can have intergenerational consequences and diminish productivity at both the individual and national levels, affecting the development potential of nations.

Abnormal development, as categorized below, can act as indicators for inadequate nutrition.

Indicators	United Nations International Children's Emergency Fund (UNICEF) Definition
Low birthweight	Less than 2,500 grams
Underweight	Moderate and severe - below minus two standard deviations from median weight for age of reference population; severe - below minus three standard deviations from median weight for age of reference population.
Wasting	Moderate and severe - below minus two standard deviations from median weight for height of reference population.
Stunting	Moderate and severe - below minus two standard deviations from median height for age of reference population.

Stunting and other forms of malnutrition reduce a child's chance of survival, while also hindering optimal health and growth. Of these indicators closely tied to inadequate nutrition, emphasis is placed on stunting, or inadequate height for age, as a particularly effective indicator for measuring progress towards reducing undernutrition, even more than inadequate weight for age[5].

Stature is increasingly used as an indicator of general well-being, with stunting being a cumulative indicator of nutritional deprivation starting from birth[6]. A severely stunted child faces four times higher risk of dying, and a severely wasted child is at nine times higher risk[7]. Longitudinal studies among cohorts of children from Brazil, Guatemala, India, Philippines, and South Africa confirmed association between stunting and reduction in schooling, and also found

[5] UNICEF, "Improving Child Nutrition: The achievable imperative for global progress"
[6] Steckel, R. H. (1995). Stature and the Standard of Living. *Journal of Economic Literature*, 1903-1940.
[7] Black, R.E., et al. 'Maternal and Child Undernutrition: Global and regional exposures and health consequences.'

that stunting was a predictor of grade failure[8]. While the developing brain has the capacity for repair, it is also highly vulnerable, and nutrient deficiencies during critical periods have long term harmful consequences for cognitive ability, school performance, and future earnings[9].

Globally, about a quarter of all children under five years old are stunted. An estimated 150 million children are underweight, and 182 million are stunted[10]. Although data about the prevalence of stunting, as well as the negative consequences associated with stunting, are becoming more widespread, less is known about the dietary patterns that lead to stunting during childhood[11]. This paper examines dietary patterns in countries with high prevalence of stunting, with specific focus on protein consumption.

Although physical indicators of malnutrition stem from a myriad of confounding factors, particular importance is placed on protein consumption in development. Animal experiments have shown that isolated dietary protein deficiency results in wasting, stunting, weight loss, delay in worm expulsion, weakened immune system, and depressed levels of growth hormone[12]. Due to the complex and holistic nature of nutrition, manifestations of isolated protein deficiency in human populations are not readily observed. However, protein is often consumed in conjunction with zinc and energy, all of which are essential for the normal function of almost all cellular and metabolic processes. Deficits in these nutrients have a myriad of generalized clinical effects.

Research has revealed the relationship between protein consumption and nutritional indicators. The fraction of dietary energy derived from protein, also known as the protein:energy

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[8] Martorell, R., et al. (2010). 'Weight Gain in the First Two Years of Life Is an Important Predictor of Schooling Outcomes in Pooled Analyses from Five Birth Cohorts from Low- and Middle-Income Countries'

[9] Cusick, S. E., & Georgieff, M. K. (2012). Nutrient supplementation and neurodevelopment: timing is the key. *Archives of pediatrics & adolescent medicine*, *166*(5), 481-482.

[10] Ghosh, S. (2013). Assessment of protein adequacy in developing countries: Quality matters. *Food and nutrition bulletin*, *34*(2), 244-246."

[11] Esfarjani, F., Roustaee, R., Mohammadi-Nasrabadi, F., & Esmaillzadeh, A. (2013). Major dietary patterns in relation to stunting among children in Tehran, Iran. *Journal of health, population, and nutrition*, *31*(2), 202.

[12] Stephenson, K., Amthor, R., Mallowa, S., Nungo, R., Maziya-Dixon, B., Gichuki, S., ... & Manary, M. (2010). Consuming cassava as a staple food places children 2-5 years old at risk for inadequate protein intake, an observational study in Kenya and Nigeria. *Nutrition journal*, *9*(1), 9.

ratio (P:E), is inversely correlated with stunting for many populations[13]. A study in sub-Saharan Africa found that dietary protein intake is a predictor of height, and children consuming food with inadequate amounts of protein had greater incidences of stunting[14]. Protein intake at 9 months of age was positively associated with height and weight but not percentage of body fat at 10 years of age in Danish children[15]. A study of first grade students in Tehran found adherence to dietary patterns high in protein and carbohydrates to be associated with reduced odds of being stunted among children[16]. A study of the Chinese population and international comparisons also showed height to be correlated with dietary protein intake, even when controlling for energy intake, socio-economic status, and income[17]. In fact, only dietary protein intake was associated with height, suggesting that protein rather than energy deficiency is the principal dietary cause of growth failure. Studies from Bangladesh[18] and the Philippines[19], which demonstrated that dietary protein intake, but not dietary energy intake, is associated with child growth, further support this finding.

Associations between growth and protein intake, as demonstrated by previous studies, do not prove a causal relationship, especially since micronutrient content of the diets as well as other environmental factors are likely to be confounding factors. However, the evidence from observational human studies and animal intervention studies implies that stunting results if a minimum threshold of protein to energy ratio is not met. Thus, while acknowledging the complex nature of development and existence of confounding factors in nutrition, this paper

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[13] Stephenson, K., et al. (2010). Consuming cassava as a staple food places children 2-5 years old at risk for inadequate protein intake, an observational study in Kenya and Nigeria.
[14] UNICEF**:** State of the World's Children 2009. *New York* 2009.
[15] Hoppe C, Molgaard C, Thomsen BL, et al. (2004). Protein intake at 9 mo of age is associated with body size but not with body fat in 10-y-old Danish children. Am J Clin Nutr 79, 3, 494-501.
[16] Esfarjani, F., Roustaee, R., Mohammadi-Nasrabadi, F., & Esmaillzadeh, A. (2013). Major dietary patterns in relation to stunting among children in Tehran, Iran..
[17] Jamison, D. T., Leslie, J., & Musgrove, P. (2003). Malnutrition and dietary protein: evidence from China and from international comparisons. *Food & Nutrition Bulletin*, *24*(2), 145-154.
[18] Becker S, Black RS, Brown KH (1991). Relative effects of diarrhea, fever and dietary energy intake on weight gain in rural Banglideshi children.
[19] Bhargava, A. (1994). Modelling the health of Filipino children. *Journal of the Royal Statistical Society. Series A.*

seeks to focus on protein intake in children of ages 0-5. Children's protein consumption will be examined of countries in Southeast Asia, one of the regions with the highest concentrated prevalence of stunted and wasted children[20]. Geographically, more than 70% of protein-energy malnutrition is in Asia[21].

This paper will specifically examine Indonesia (36%), Philippines (32%), Vietnam (23%), Myanmar (35%), and Cambodia (40%), which fall within top forty countries ranked by number of stunted children[22]. The percentages represent proportions of children under five years old who are stunted in the country.

Research Questions

This paper seeks to explore dietary protein consumption patterns in countries with high malnutrition indicators. It will evaluate the adequacy of the current protein intake, both in

[20] De Onis, M., Blössner, M., & Borghi, E. (2012). Prevalence and trends of stunting among pre-school children, 1990–2020. *Public Health Nutrition*, *15*(01), 142-148.
[21] Ghosh, S. (2013). Assessment of protein adequacy in developing countries: Quality matters.
[22] UNICEF, "Improving Child Nutrition: The achievable imperative for global progress"

quantity and quality of protein, against the needs of high-risk group of children ages 0-5. It will compare the sources and quantities of protein supply available to make this evaluation, and narrow the feasible directions of improvement. The key issues that this paper aims to address can be divided into two broad questions:

1. Is there a protein-energy deficit? If so, what is the severity?

   Determine if there is sufficient or insufficient baseline of per capita protein supply.

2. What is the protein consumption profile?

   Identify the breakdown of current sources of protein for the specified countries in Southeast Asia. If sufficient protein supply exists, identify possible causes of physical malnutrition indicators.

Methodology

Raw data were obtained from large public databases. Due to the volatility of actual amounts of daily protein intake consumed, as well as the time and resource intensive nature of such data collection, data for actual dietary intake breakdown for the developing countries of interest are lacking. This study used protein *supply* as the closest correlate for consumption.

Country specific data for protein supply was obtained from the public database of the Statistics Division of Food and Agriculture Organization of the United Nations (FAOSTAT).

Data on demographics and population distribution were obtained from the World Bank database. Data of average weight by country were obtained from the London School of Hygiene & Tropical Medicine.

Safe and recommended levels of protein were derived from technical reports by World Health Organization (WHO), FAO, and United Nations University. The specific requirements by age break-down derived from the international databases were shared by Dr. James Ferguson from the Veterinary School at the University of Pennsylvania.

To maintain standardization and accuracy across various databases, data from the year 2011, the most recent comprehensive international data available for FAO, was used when possible.

Protein Supply Data Collection FAOSTAT's Food Balance Sheets display the per capita supply data in product weight. These values were calculated by dividing the total supplies available for human consumption by the total population actually consuming the food supplies during the time period of interest.

The total supplies were calculated from a bottom-up approach of multiplying the quantity of food available, taking into account imports and exports as well as production. The target population included individuals, regardless of citizenship, residing in the geographical boundaries of the country during the annual time period of interest. Adjustments were made for part-time presence or absences, such as movement of temporary migrants, tourists, and refugees.

Protein content was then derived by applying the food composition factors to the quantities of the food commodities. To take into consideration that commodities are often not consumed in the primary forms they enter households in, food composition factors were applied to processed commodities rather than to the primary commodities.

Thus, this data attempts the best correlate of actual intake. Necessary adjustments were made to the original raw data to translate the units to the appropriate form, such as translating the per capita protein supply information to a per kg basis.

Results

I. Protein-Energy Status

Table 1a. Status of Average Protein Consumption

Countries	Per Capita Protein Supply (g/day)	Average weight (kg)	Protein Supply (g/kg/day)
Indonesia	61.1	52.47	1.16
Philippines	60.2	59.72	1.01
Vietnam	77.7	50.73	1.53
Myanmar	81.9	56.35	1.45
Cambodia	63.2	55.74	1.13

Table 1b. Standard Protein Requirements by Age

Age	Boys (g/d)	Girls (g/d)	Requirement (g/kg/day)
1	13.80	12.96	1.20
2	15.26	14.69	1.13
3	17.11	16.46	1.09
4	18.76	17.81	1.06
5	20.09	18.97	1.02
6	21.92	20.81	1.01
7	24.24	23.53	1.01
8	26.97	26.87	1.01
9	30.00	30.81	1.01
10	32.52	34.04	1.01
11	36.63	38.70	1.00
12	40.08	43.12	0.98
13	47.00	46.85	0.96
14	51.02	48.32	0.94
15	53.36	47.70	0.90
16	56.43	46.98	0.87
17	55.90	45.15	0.83
18	48.75	43.52	0.80
19	49.06	40.97	0.75

II. Protein Consumption Profile

Table 2a. Total Protein Supply Break-Down: Vegetal and Animal Sources

	Total Protein Supply (g/capita/day)	Protein Supply From Vegetal Products (g/day)	Protein Supply From Vegetal Products (% of Total)	Protein Supply From Animal Products (g/day)	Protein Supply From Animal Products (% of Total)
Indonesia	61.10	43.80	71.69	17.30	28.31
Philippines	60.20	35.10	58.31	25.10	41.69
Vietnam	77.70	46.00	59.20	31.80	40.93
Myanmar	81.90	48.00	58.61	33.90	41.39
Cambodia	63.20	45.40	71.84	17.80	28.16

Table 2b. Highlight of Predominant Protein Sources: Cereals

	Total Protein Supply (g/capita/day)	Protein From Cereals (g/capita/day)	Cereals as % of Vegetal Products	Cereals as % of Total Protein Supply	Rice (Milled Equivalent) as % of Cereals
Indonesia	61.10	34.40	78.54	56.30	70.35
Philippines	60.20	27.50	78.35	45.68	74.18
Vietnam	77.70	32.60	70.87	41.96	87.42
Myanmar	81.90	29.70	61.88	36.26	92.26
Cambodia	63.20	34.10	75.11	53.96	90.91

Protein-Energy Status The protein supply for the selected countries in Southeast Asia have a relatively close range from 1.01 to 1.53 g/kg/day – from countries close to the 1 g/kg/day mark including the Philippines (1.01), Cambodia (1.13), and Indonesia (1.16) to countries having around 1.5 g/kg/day, including Myanmar (1.45) and Vietnam (1.53). The results are demonstrated in Table 1a. There is greater range in per capita protein supply as compared to per kg basis, from 60.20 g/capita/day of Philippines to 81.90 g/capita/day of Myanmar, highlighting notable average weight differences across the population groups.

Table 1b lists the standard protein requirements for healthy growth by age distribution, in g/kg/day. The recommended safe levels of protein intake alter slightly throughout a child's development, with infants requiring the highest concentration of protein on a per kg basis for development at 1.2 g/kg/day. The requirement gradually decreases with children's development until the recommended protein consumption stabilizes starting from age 19 at 0.75 g/kg.

Solely based on the daily per kg protein supply available, only Vietnam and Myanmar is able to meet an individual's protein requirements starting from birth (supply exceeds 1.2 g/kg/day requirement of infants, age 1). Indonesia and Cambodia begin to meet the requirements starting from age 2 (>1.13 g/kg/day). Philippines meets the protein requirement only after the critical ages 0-5 period is over (1.01 g/kg/day).

Protein Consumption Profile For all of the countries of interest, majority of their protein supplies are derived from products of vegetal origin. The proportion of protein supply derived from vegetal products is 58.31% for Philippines, 58.61% for Myanmar, 59.20% for Vietnam, 71.69% for Indonesia, and 71.84% for Cambodia. The rest of protein supply are from animal products. Results are listed in Table 2a.

Cereals, excluding beer, is the predominant source of protein for the countries. The protein derived from cereals makes up 78.54% of protein from vegetal products and 56.30% of total protein supply for Indonesia, 78.35% of vegetal protein and 45.68% of total protein for Philippines, 70.87% of vegetal protein and 41.96% of total protein for Vietnam, 61.88% of vegetal protein and 36.26% of total protein for Myanmar, and 75.11% of plant protein and 53.96% of total protein for Cambodia. Of the cereals, rice is the predominant contributor of protein. Protein from rice makes up 70.35% of protein derived from cereals for Indonesia, 74.18% for Philippines, 87.42% for Vietnam, 92.26% for Myanmar, and 90.91% for Cambodia.

Discussion

This study examined the dietary protein consumption patterns in countries in Southeast Asia with high rates of stunting, a cumulative indicator of chronic malnutrition – Indonesia, Philippines, Vietnam, Myanmar, and Cambodia. First, it examined the status of the current protein intake compared to recommended standards for children under five years old to determine the severity of protein-energy deficit. Second, it examined the sources of protein to build a protein consumption profile.

The daily protein supply levels by weight of the five countries, all exceeding 1 g/kg/day, successfully meet the general average requirement at 0.75 g/kg/day. When examining children's protein requirements in particular, however, only Vietnam and Myanmar is able to meet an individual's protein requirements starting from birth. Per kg daily protein supply available in Indonesia and Cambodia begin to be sufficient for protein level requirements of children starting from age 2, and Philippines is able to meet the protein requirement only after the critical ages 0-5 period is over.

Solely based on the protein supply available by weight, however, the level of deficit is not particularly extreme, especially when taking into consideration that the first couple years of life are when breastfeeding is practiced and the protein sources examined in this study may be only partially applicable. In addition, after the threshold years listed above, or age 2 for Indonesia and Cambodia and age 5 for Philippines, the protein supplies consistently exceed the recommended daily average per kg protein consumption requirement, which mostly ranges from 0.75 – 1 g/kg. Yet stunting, an expression of chronic malnutrition, is excessively high in the countries, at 23% for Vietnam, 32% for Philippines, 35% for Myanmar, 36% for Indonesia and 40% for Cambodia. Thus, the important issue at hand may not be one of having insufficient quantities of protein available for consumption.

Even with sufficient protein supply levels, as this data can potentially be interpreted as, there are many plausible explanations for why such anthropometric manifestations of chronic malnutrition may exist. As much as they attempt to be accurate estimates of consumption levels (see methodology), the supply figures are still approximations that represent only the average supply available for the population as a whole and not necessarily what is consumed by the individuals. An individual's actual food consumption may be lower than the calculated food supply depending on differences between households as well as food wastage and losses during the steps of storage, preparation, and cooking[23]. Average protein consumption may also be misleading if disparity in living standards influence the accessibility of food and protein sources. In addition to the variability between households, there may be an uneven distribution of protein across different age demographics. As demonstrated by Table 1b listing the protein requirement for health growth by age distribution, younger infants and children require highest concentrations of protein by weight. Even if the population on average has enough protein, children, who are a high-risk group that requires higher levels of protein during critical phases of development, may not be receiving sufficient quantities.

The consistency of protein consumption matters as well. Even with adequate quantities of protein, these supplies may be available or consumed only in a volatile pattern. Consistency of protein intake is important for healthy development, a nutritional fact that should be incorporated into educational outreach. Previous research shows that the body needs a constant supply of protein, and the body is unable to catch-up protein after a certain point of continued deprivation.

The specified requirement levels may also be lower than what is actually necessary in developing countries, especially in populations exposed to persistent or repeated infections and impaired intestinal absorptive capacity. In such populations, there is increased demand for protein, even when there are no overt clinical symptoms[24]. Protein and amino acid needs are

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[23] http://faostat.fao.org/site/375/default.aspx

[24] WHO (2007) Protein and amino acid requirements in human nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation. Geneva: World Health Organization (WHO Technical Report Series, No. 935); 2007 Contract No.: Document Number.

likely to be greater in high risk populations such as women and children who are commonly affected by acute and chronic infections. The need to evaluate using increased protein level requirements is supported by the positive relationship between energy deficit and protein needs. People in energy deficit need additional protein for appropriate balance, with even a modest energy deficit of 5% increasing protein needs by about 10%[25]. Thus, exactly meeting standards may not be sufficient.

There is also a need to evaluate the protein quality in addition to the quantity by examining the sources. Even when taking into consideration the aggregate amount of food and nutrition being wasted in the value chain from primary food commodities production to consumption, the percentage breakdown of sources of protein, as represented in Tables 2a and 2b, likely remains fairly consistent and reliable. Based on the results, extremely skewed diets are observed in the countries. Majority of protein supplies are derived from vegetal products, with cereals supplying majority of the vegetal proteins. Of the cereals, rice is the predominant contributor of protein. For all five countries, the greatest contributor of protein is their main staple, rice.

This composition of protein sources that is heavily biased towards cereals is most likely the greatest factor contributing to the high prevalence of stunting in the countries despite apparent adequate protein supply levels. The countries' staples, mostly cereals including rice, may be subpar sources of protein for two main reasons: digestibility and quality.

Plant proteins are harder to digest, and there can be lower conversion and absorption rates by the body compared to animal proteins. Protein digestibility-corrected amino acid score (PDCAAS), the currently most widely accepted method of evaluating protein quality, assesses

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[25] Garza C, Scrimshaw N & Young V (1976) Human protein requirements: the effect of variations in energy intake within the maintenance range. Am J Clin Nutr 29, 3, 280–287.

quality of protein based on digestibility of the protein sources and essential amino acid composition, coming up with an estimate of "utilizable protein." Food of animal origin generally have total protein and utilizable protein values higher and closer to each other compared to diets based on cereals and other grains, which have low contents of essential amino acids and are poorly digested[26]. Risk of protein inadequacy based on total protein estimate is only 4% for Philippines and around 3% for Myanmar but this doubles when using utilizable protein estimates[27]. Utilizable protein levels in Southeast Asia, where there is an average stunting rate of 35.4%, remains low. Research in Africa on diets based on cassava also supports that having staples with low protein content such as cassava, rice, etc., could be dangerous to development[28].

Cereal grains provide relatively low quality protein. Plant-based diets tend to be deficient in one or more essential amino acids, especially lysine, methionine, and threonine, of which lysine is the most important limiting essential amino acid [29]. Prior research has shown that in diets deriving over 50% of protein from cereal sources, protein quality is relatively poor, affecting biological value and limiting protein utilization[30]. Animal source foods supply not only high-quality and readily digested protein (high PDCAAS) and energy, but are also an efficient source of important micronutrients needed by the body. Iron, zinc, vitamin A, and calcium tend to be more bioavailable in animal-source foods, and some, such as vitamin B12, are naturally found exclusively in animal-source foods[31]. At 33.1%, the percentage of individuals at risk of

[26] FAO/WHO (1991) Protein quality evaluation. Joint FAO/WHO. 66.
[27] Ghosh, S. (2013). Assessment of protein adequacy in developing countries: Quality matters.
[28] Stephenson, K., et al. (2010). Consuming cassava as a staple food places children 2-5 years old at risk for inadequate protein intake, an observational study in Kenya and Nigeria.
[29] Young, V.R., and P.L. Pellett. 1994. Plant proteins in relation to human protein and amino acid nutrition. Am. J. Clin. Nutr. 59: 1203S-1212S.
[30] Ghosh, S. (2013). Assessment of protein adequacy in developing countries: Quality matters.
[31] Smith, J., Sones, K., Grace, D., MacMillan, S., Tarawali, S., & Herrero, M. (2013). Beyond milk, meat, and eggs: Role of livestock in food and nutrition security. *Animal Frontiers*, *3*(1), 6-13.

inadequate zinc intake in Southeast Asia is higher than in regions of North Africa, Eastern Mediterranean, USA, and Canada, ranging around 9.3-9.5% [32].

Even modest amounts of animal source foods (2 oz/day) incorporated into weaning diets can increase the energy density through its fat content, and can supply vitamin B_{12}, vitamin A, iron, zinc, and protein of high biologic value. The iron and zinc intake increase can improve overall appetite and intake. In Kenyan children, animal products in particular, and the intake of available iron, zinc, and iodized salt, were statistically significant predictors of growth[33]. Diet quality, or inclusion of animal protein in diet, was also an important predictor of growth in Mexico, where higher consumption of animal source foods in children was a major predictor of height at 30 months of age.[34] Findings on significant positive association between intake of animal source foods and linear growth were observed in studies of Peruvian toddlers[35] and children in New Guinea[36] as well. Complementary foods, including animal source foods and breast milk, were all found to promote toddlers' linear growth.

In addition to contributing to linear growth, meat supplementation has been found to improve growth, cognitive, and behavioral outcomes. In a randomized, controlled feeding study examining the differential effects of meat, milk, and plant-based snacks on the functional outcomes of children, children assigned the meat group showed highest increases in end of term test scores, and demonstrated highest activity levels, leadership, and intelligence[37]. All supplementation groups showed greater growth in height and weight compared to baseline

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[32] Wuehler, S. E., Peerson, J. M., & Brown, K. H. (2005). Use of national food balance data to estimate the adequacy of zinc in national food supplies: methodology and regional estimates. *Public health nutrition*, *8*(07), 812-819.
[33] Neumann, C.G., and G. Harrison (1994). Onset and evolution of stunting in infants and children. Examples from the Human Nutrition Collaborative Research Support Program, Kenya and Egypt studies. Eur J Clin Nutr, 48. pp. S90–S102
[34] Allen, L.H., Backstrand, J.R., Chávez, A., and G.H. Pelto (1992). People cannot live by tortillas alone: The results of the Mexico nutrition CRSPUSAID, University of Connecticut and Instituto Nacionál de la Nutrición Salvador Zubirán.
[35] Marquis, G.S., Habicht, J.P., Lanata, C.F., Black, R.E., and K.M. Rasmussen (1997). Breast milk or animal-product foods improve linear growth of Peruvian toddlers consuming marginal diets. Am J Clin Nutr, 66, pp. 1102–1109.
[36] Smith, T., Earland, J., Bhatia, K., Heywood, P., and N. Singleton. 1993. Linear growth of children in Papua New Guinea in relation to dietary, environmental and genetic factors. Ecology of Food and Nutrition, 31, pp. 1–25.
[37] Neumann, C. G., Murphy, S. P., Gewa, C., Grillenberger, M., & Bwibo, N. O. (2007). Meat supplementation improves growth, cognitive, and behavioral outcomes in Kenyan children. *the Journal of Nutrition*, *137*(4), 1119-1123.

control, but the group given meat supplements showed superior results, despite comparable energy in calories were consumed across groups.

While there may be confounding factors that have not been considered, based on preliminary results and scope of this paper, in the five countries in Southeast Asia with high stunting rates – Indonesia, Philippines, Vietnam, Myanmar, and Cambodia – the quality, even more than the quantity, seem to be contributing to high instances of malnutrition. Rice and other cereals, the predominant staples in the diet, contain lower utilizable protein and are low or lacking in necessary amino acids and micronutrients. This can have important implications for policy and interventional programs.

Recommendations & Conclusion

The countries are recommended to pursue educational and interventional programs in parallel. A holistic approach can be taken to effect improvement in children's health and transition as self-propagating vicious cycles of ill health and poverty are broken: household education, supplementation with additional protein sources, fortification of foods with critical nutrients, and long-term diversification of diet.

Part I. Agenda

Household Education

Importance of Protein Household education should highlight the importance of protein consumption to a child's healthy development. In addition to the necessity of incorporating protein into the diet, importance of consistent consumption should be emphasized, as sporadic consumption can undermine the body's ability to catch-up, and consequently hinder growth.

As supplementation and fortification programs are put into effect, the importance of having balanced diet should continue to be emphasized to increase participation in the programs and to transition into long term enhancements in diet.

Increasing Exclusive Breastfeeding Rates Children should be exclusively breastfed under 6 months, and then start receiving complementary foods in addition to breast milk starting from six months of age. For children under age 2, optimal growth, development, and health can be achieved by increasing breastfeeding rates. A systematic review by WHO concluded that infants exclusively breastfed for 6 months experienced less morbidity from gastrointestinal infection and showed no deficits in growth[38]. This is especially important for the population groups examined, since relatively low proportions of protein are derived from animal sources in Southeast Asia. In a previous study conducted in Egypt, Kenya, and Mexico, even when animal

[38] Fewtrell, M. S., et al. (2007). Optimal duration of exclusive breastfeeding: what is the evidence to support current recommendations?. *The American journal of clinical nutrition*, *85*(2), 635S-638S

source food intake was low, continued breast-feeding was positively associated with linear growth[39].

Other than Cambodia, which has a high exclusive breastfeeding rate of 74%, the other countries can increase mothers' exclusive breastfeeding rates for infants less than 6 months old. Indonesia has 42%, Philippines has 34%, and Myanmar has 31% of mothers practicing exclusive breastfeeding. Particular focus should be given to Vietnam, which has a low rate of 17%, and has had the same consistently low rate throughout the past decade[40].

During breastfeeding, mothers should be aware of the importance of their own diets. Programs are needed in each area to educate women on food need during pregnancy and lactation, appropriate supplements for infants, and the importance of breastfeeding itself.

Supplementation

Given the heavy reliance on cereals of diets in the five countries, from both practical and cultural standpoints, supplementation complementing the status quo may be the option with potential for highest efficacy.

A daily supplementation of milk, cheese, and eggs is recommended to provide the appropriate micronutrients necessary for growth, especially calcium phosphorus, vitamin B12, and protein of high biologic value[41]. It is also more accessible than meat in Southeast Asia.

A number of studies with varying designs (case control, correlational, and several controlled intervention studies) in various disparate locations (China, Jamaica, Mexico, Nicaragua, and Brazil) all showed that cow's milk consumption by infants and young children

[39] Calloway, D. H., Murphy, S. P., Beaton, G. H., Allen, L., Horan, H., Merrill, K. A., ... & Bwibo, N. (1988). Food intake and human function: a cross-project perspective of the Collaborative Research Support Program in Egypt Kenya and Mexico.
[40] http://apps.who.int/gho/data/view.main.NUT1730?lang=en
[41] Neumann, C., & Harris, D. M. (1999). Contribution of animal source foods in improving diet quality for children in the developing world. *World Bank, Washington, DC*.

promoted physical growth, particularly in length or height. Diets supplemented with milk, fat, and animal protein had statistically significant positive associations with linear growth[42].

A potential challenge in supplementing the current cereal based diet with dairy protein sources can be the high lactose intolerance rates in East Asia; some figures report that there is up to 90% lactose intolerance rates in East Asia[43]. However, loss of lactase activity begins between ages of 2 and 6 years, so dairy supplements can still have desired benefits during the period of ages 0-5 without problem[44]. This is supported by the successes in Malaysia and Japan, where addition of milk to diet in school feeding programs increased linear growth and reduced stunting[45].

An alternative or complementary option for supplementation is legumes, particularly soy protein. Soybean, at 36.5%, has the highest protein concentration of plant products and has highest possible limiting amino acid (LAA) score and high score for lysine, which is the primary limiting amino acid. Nutritive value of soy protein was tested to be 86-107% of milk, with a high digestibility of 97%[46], providing the nutritive value of high quality protein without the issue of digestibility and low utilization that most plant proteins have. In addition, soy protein ingestion has been found to lead to growth in hormone secretion, one of the developmental benefits of milk consumption. Thus, soy flour and soy milk can be supported as an appropriate supplement to current cereal based diet[47].

Fortification

[42] Neumann, C., & Harris, D. M. (1999). Contribution of animal source foods in improving diet quality for children in the developing world. *World Bank, Washington, DC*.
[43] de Vrese, M., Stegelmann, A., Richter, B., Fenselau, S., Laue, C., & Schrezenmeir, J. (2001). Probiotics—compensation for lactase insufficiency.*The American journal of clinical nutrition*, *73*(2), 421s-429s.
[44] de Vrese, M., Stegelmann, A., Richter, B., Fenselau, S., Laue, C., & Schrezenmeir, J. (2001). Probiotics—compensation for lactase insufficiency.*The American journal of clinical nutrition*, *73*(2), 421s-429s.
[45] Chen, S. T. (1989). Impact of a school milk programme on the nutritional status of school children. *Asia-Pacific Journal of Public Health*, *3*(1), 19-25.
[46] Young, V.R., and P.L. Pellett. 1994. Plant proteins in relation to human protein and amino acid nutrition.
[47] Ghosh, S. (2013). Assessment of protein adequacy in developing countries: Quality matters.

Food fortification can target specific micronutrients or amino acids that are primarily lacking in the Southeast Asian diet. The two nutrients in particular are lysine and zinc.

Lysine is the most limiting necessary amino acid found in protein sources, and are low in cereals, as well as many other plant products.

Grains and cereals, along with beans, another major vegetal source of protein, are relatively poor sources of zinc. In fact, compounds in these vegetal foods tend to impair zinc absorption in the gut, so zinc is a micronutrient that is particularly lacking and should be considered for fortification.

Fortification is becoming more common, resulting in more success stories such as fortified wheat and oil in Mozambique and soy oil fortified with vitamins A and D in India. Such precedent cases have been paving the path for partnerships using multi-sector platforms.

Diet Diversification

The improvement of dietary diversity must be the long-term aim, with food fortification considered only a short term solution. A transition should be made from singular nutrient fortifications to a general shift to a more diverse diet. Consumption of adequate amounts of micronutrients, such as those that can be found in animal-source foods, is associated with more competent immune systems and better immune responses[48].

Food fortification cannot be a permanent solution. For example, vitamin A and riboflavin are both needed for iron mobilization and hemoglobin synthesis; supplementation with iron alone may not successfully treat anemia if other nutrients are deficient[49]. Protein energy malnutrition,

[48] Keusch, G. T., & Farthing, M. J. (1986). Nutrition and infection. *Annual review of nutrition*, *6*(1), 131-154.
[49] Murphy, S. P., & Allen, L. H. (2003). Nutritional importance of animal source foods. *The Journal of nutrition*, *133*(11), 3932S-3935S.

iron deficiency anemia, and vitamin A deficiency, all of which can be prevented if sufficient animal-source foods are included in the diet, cannot be successfully tackled through fortification.

As cycles of poverty and ill-health are broken, and awareness continues to become rooted through community education, people should be able to and encouraged to diversify their diet and incorporate meat into their diets.

Part II. Implementation

For the supplementation, fortification, and diversification programs to be scaled up and implemented properly, multiple stakeholders in both private and public sectors must to be mobilized to tackle the complex issue of malnutrition together.

The governments should endeavor to align key stakeholders involved in specific and sensitive nutrition interventions through improved coordination mechanisms. To maximize the impact of such programs, local government capacities should be maximized. Efforts should be decentralized, implementing initiatives at the sub-national level through existing and/or extended multi-sector platforms.

Rather than building bottom-up from scratch, the countries can take advantage of the budding world-wide efforts to improve food security and nutrition. Two example programs are Global Alliance for Improved Nutrition (GAIN) and Scaling Up Nutrition (SUN).

GAIN seeks to reduce malnutrition through sustainable strategies aimed at improving the health and nutrition of populations at risk. Its four main initiatives are large-scale food fortification, multi-nutrient supplements, nutritious foods for children and mothers, and agriculture and nutrition, but most resources have been dedicated to food fortification[50]. GAIN engages organizations in private sector, public sector, and civil society to implement sustainable

[50] GAIN, "GAIN." Last modified 2012. Accessed July 25, 2014. http://www.gainhealth.org/

programs. Currently, Vietnam, Philippines, and Indonesia have worked with GAIN previously. The World Bank and GAIN awarded the Government of Vietnam's National Institute of Nutrition, in partnership with UNICEF and the National Fortification Alliance, a grant to fortify fish sauce with iron. Indonesia and Philippines are two of the thirteen countries that the Universal Salt Iodization Project spearheaded by GAIN-UNICEF and funded by Bill & Melinda Gates foundation have targeted to reduce iodine deficiency.

SUN is a movement that unites people across issues and sectors in a collective effort to improve nutrition. The specific nutritional interventions SUN pursues are fortification of foods, micronutrient supplementation, treatment of severe malnutrition, and support for breastfeeding[51]. The SUN movement is led by countries, so it relies on national leaders to take ownership and responsibility for delivering sustainable solutions. Governments in SUN countries and their partners work together through multi-sector platforms, seek legislative endorsement for a legal framework, implement and align programs, and mobilize sufficient domestic resources, supplemented with external assistance.[52] All of the countries examined in this paper except for Cambodia are participants in SUN.

GAIN and SUN have been highlighted in particular because of the alignment of their objectives with the nutritional program needs of the five countries examined, especially in food fortification, supplementation, and focus on mothers and children. As demonstrated through the programs and partnerships formed through GAIN and SUN, nation-led efforts are necessary to effect sustainable change and even take advantage of such external resources.

Involvement in such alliances and movements can be beneficial for furthering the nutritional agenda outlined in this paper in multiple ways. Through joining, countries can

[51] Scaling Up Nutrition, "About SUN." Last modified 2013. Accessed July 25, 2014. http://scalingupnutrition.org/
[52] Scaling Up Nutrition, "SUN Country Approach." Last modified 2013. Accessed July 25, 2014. http://scalingupnutrition.org/

maximize the benefit from available external resources to complement domestic efforts. Such programs can be a platform for receiving funding and resources from non-profits and multilateral organizations, facilitating formation of efficacious partnerships. These types of trustworthy, well-known platforms such as GAIN and SUN can lend credibility to programs initiated through such platforms and allow various stakeholders to build trust – an important accomplishment when tackling the challenge of aligning different stakeholders from various sectors. Furthermore, regardless of whether the nutritional initiatives are pursued independently or through such alliances, the countries can learn from the best practices and successes of existing partnerships and programs. Thus, this paper seeks to encourage the nation-led efforts to address protein inadequacy to improve nutrition, and to utilize available resources to achieve improvement. At the same time, there should be continued community education to improve awareness and participation to provide long-term, sustainable solution.

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