WPS7301

Policy Research Working Paper 7301

Stagnant Stunting Rate Despite Rapid Economic Growth in Papua New Guinea

Factors Correlated with Malnutrition among Children under Five

Xiaohui Hou

WORLD BANK GROUP
Health Nutrition and Population Global Practice Group
June 2015

Policy Research Working Paper 7301

Abstract

Maternal and child undernutrition is a pervasive and detrimental condition in Papua New Guinea. Despite rapid economic growth during the past decade, the stunting rate for children under 5, one of the primary indicators for child undernutrition, was estimated at 46 percent in Papua New Guinea in 2010, stagnant from 44 percent in 2005. This paper analyzes the association between the demographic, socioeconomic, environmental, and health-related factors on nutritional status for children under age 5 years, using the 2009–10 Papua New Guinea Household Income and Expenditure Survey. Stunting and underweight rates sharply rise in the first 24 months. Even in the better-off quintiles, children suffer from suboptimal breastfeeding and complementary food in the first 24 months. In general, the regression results showed that household wealth and geographic location are crucial factors that contribute to children's malnutrition. More importantly, food quality, measured by protein intake, has significant predicting power on child malnutrition. Broadly increasing socioeconomic status and improving the quantity and quality of caloric intake are general steps to improving health outcomes in Papua New Guinea. In addition, three key areas were identified as critical to alleviating the persistent and detrimental stunting rate in the country: (1) exclusive breastfeeding and complementary food; (2) interventions by health workers; and (3) nutrition education.

This paper is a product of the Health Nutrition and Population Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at xhou@worldbank.org.

Stagnant Stunting Rate Despite Rapid Economic Growth in Papua New Guinea - Factors Correlated with Malnutrition among Children Under Five

Xiaohui Hou

Key words: Nutrition, Child Health, Economic Growth, Early Child Development, Papua New Guinea

JEL Code: I12, I 31, D10

Acknowledgement:

This policy note was prepared by Xiaohui Hou, senior economist of World Bank and the Task Team Leader of Papua New Guinea Programmatic Health Analytical and Advisory Activities. Toomas Palu (Practice Manger, Health, Nutrition and Population Global Practice), Venki Sundararaman (program leader), Steffi Stallmeister (Country manager, PNG) and Franz Drees Gross (Country Director of Timor-Leste, PNG and the Pacific Islands) provided the overall management guidance for this task.

The policy note has greatly benefited from discussions with National Department of Health and United Nations Children's Fund (UNICEF), and the Australian Department of Foreign Affairs and Trade.

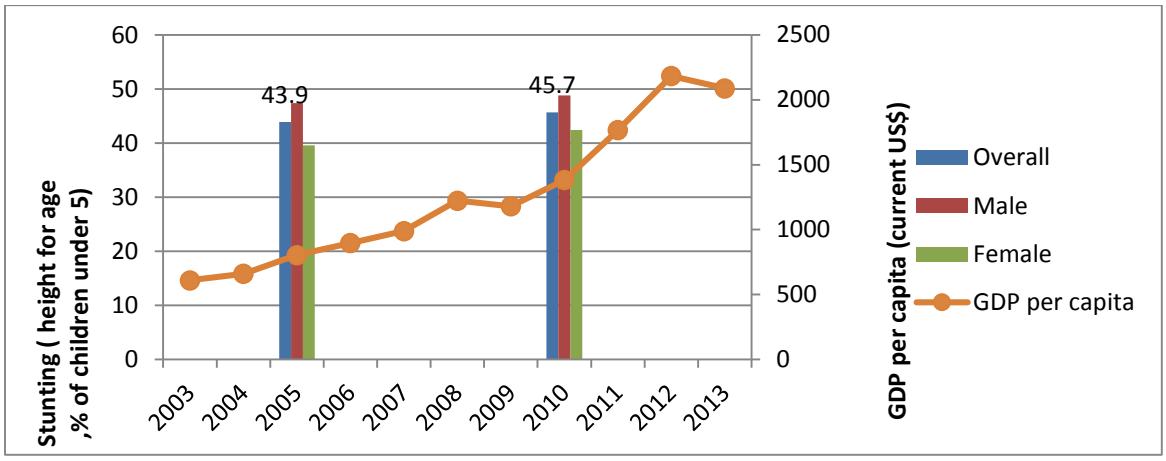
Ali Subandoro, Alex Stephens, Lara Andrews, Kerry Main Pagau, Meera Shekar, Nkosinathi Mbuya and Wila Saweri provided invaluable comments to the earlier drafts. Xiaochen Xu and Yu Sun Bin prepared for the data and conducted the statistical analysis. Sarah Harrison, Tasha Sinai and Kate Barker have provide great assistance.

Financial support for this work was received from the Australian Government.

Introduction

In 2014, following a number of years of high growth, the gross domestic product (GDP) per capita growth in Papua New Guinea (PNG) reached 8.0 percent. However, despite the relatively robust economic growth, maternal and child undernutrition remain pervasive and damaging conditions in PNG. Undernutrition, which encompasses stunting, wasting, and deficiencies of micronutrients (essential vitamins and minerals), is one of the most significant causes of child mortality and morbidity. The stunting rate (low height-for-age, indicating chronic restriction of a child's potential growth) for children under 5 in PNG was estimated at 46 percent in 2010. Despite GDP growth of 6.85 percent on average from 2005 to 2010 (Figure 1), the stunting rate remained basically stagnant from the 44 percent in 2005. Stunting in early life can have both short and long-term impacts on child and adult health. It is associated with poor cognition and educational performance in childhood. Stunting is also associated with low adult wages, lost productivity, and increased risk of nutrition-related chronic diseases when accompanied by excessive weight gain later in life (Subramanyam, Kawachi et al. 2011).

Figure 1: Stunting Rate for Children Under 5 and GDP per Capita Growth from 2005 to 2010



Data source: GDP is from World Development Indicators; stunting rate in 2010 is from Household Income and Expenditure Survey (HIES) 2009-2010; 2005 stunting rate is from 2005 National Nutrition Survey.

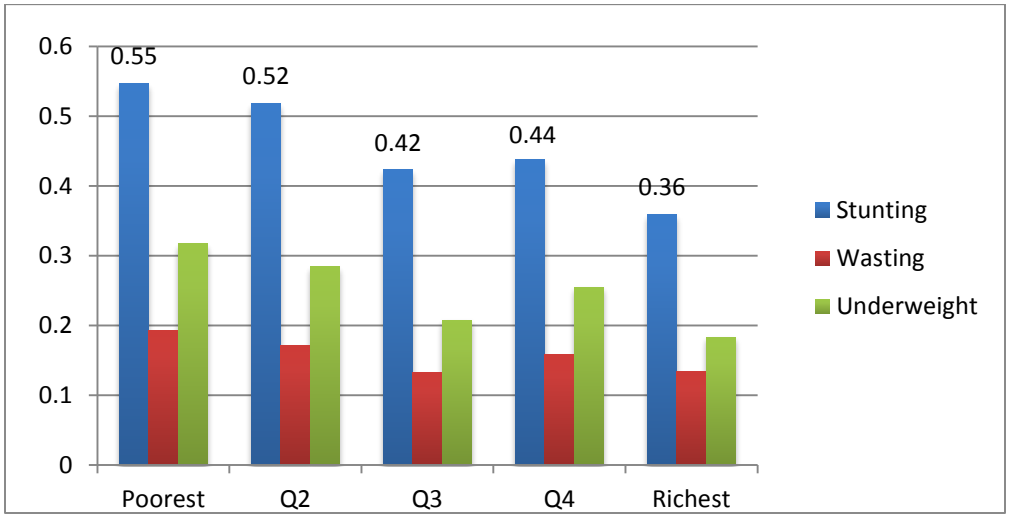
The question arises as to why the general economic development in PNG has not led to improved nutritional outcomes. Economic development and poverty are key basic contributing factors for child malnutrition (Van de Poel, Hosseinpoor et al. 2007; Van de Poel, Hosseinpoor et al. 2008). UNICEF's conceptual framework of malnutrition (UNICEF 1990) classifies the causes of malnutrition into three groups: immediate, underlying and basic causes. While dietary intake and health status are immediate causes of malnutrition; environmental, cultural and sociopolitical and economic contextual factors are all basic and underlying causes. General economic growth, measured by GDP per capita, predicts reduction in stunting rate in a reasonably large magnitude.

It is estimated that a 5.0 percent per year GDP growth rate would predict a reduction in national stunting prevalence of around 0.9 percentage point per year. Another paper (Marie T Ruel, Harold Alderman et al. 2013) noted "a 10.0% increase in GDP per capita predicts a 5.9% reduction in stunting" (p382), when economic growth was combined with other nutrition related interventions.

Despite the conceptual argument highlighting the strong linkages between economic growth and child stunting rate reduction, the empirical research has challenged this view. Vollmer et Al. (Vollmer, Harttgen et al. 2014) conclude that "the contribution of economic growth to the reduction in early childhood undernutrition in developing countries is very small, if it exists at all." This perspective was based on 121 Demographic and Health Surveys from 36 low-income and middle-income countries. Subramanyam et al. (Subramanyam, Kawachi et al. 2011) concluded that there was no consistent evidence that economic growth had contributed to reducing undernutrition in India using three waves of household level data.

Another puzzling matter regarding nutrition in PNG is the relatively high stunting rate even for the richest quintile in PNG. As expected, the poorest quintile has the highest stunting rate at 55 percent. However, the stunting rate among the richest quintile is also quite high (36 percent), and similarly high among the third and fourth quintiles. In terms of underweight and wasting, the fourth quintile has even worse nutritional outcomes compared with the third quintile. Assuming income is less of a constraint for the richer quintiles, what are the other factors driving the stunting rate among the better-off quintiles in PNG?

Figure 2. The Stunting, Underweight and Wasting Across Wealth Quintile in PNG



Data source: HIES 2009-2010

Unfortunately, the research remains quite limited in PNG. The previous nutritional studies in PNG have reported low dietary intake of protein in the traditional diet (Oomen HAPC 1971). Low energy and protein levels were also reported among children who lived in Lufa (Eastern Highlands Province) and Kaul (Madang Province, (Ferro-Luzzi, Norgan et al. 1975). One study indicated moderate iodine deficiency among a cohort of 350 school children (6–12 years old) in the Southern

Highlands Province (Temple, Mapira et al. 2004). Semba et al. (2008) and Gibson (1999) showed that improving mothers' education could significantly reduce child malnutrition in Indonesia, Bangladesh and Papua New Guinea. Sharp (1980) argued that malaria is a significant contributing factor to children's stunting status in Papua New Guinea's Highlands Region and the effect is most marked in children under two years of age. However, in general, the incidence of malaria is lower in highland than lowland areas (Maraga, Sie et al. 2010). Bauze et al. (2012) showed the substantial within-province heterogeneity of under-five mortality and suggests that under-five mortality needs to be addressed at subnational levels. Another study (Wand, Lote et al. 2012) also confirmed the impact of geographical location on the risk factors, which must be recognized as it affects both epidemiology and intervention coverage. Both Angeles (1993) and Gibson (1991) highlighted the importance of the supplement zinc on children's stunting status through case studies in Indonesia and Papua New Guinea. They argued that lack of zinc may result in retarded intrauterine growth.

The objective of this paper is to use the latest national representative survey, PNG Household Income and Expenditure Survey (HIES) 2009-2010, to further shed light on determinants of undernutrition in PNG to guide nutrition-related policies. Due to data limitation, this paper cannot establish the causal links between various factors and nutrition outcomes, nor answer why general economic development has not improved the nutrition outcomes in PNG. Rather, it analyzes the association between the demographic, socioeconomic, environmental and health-related factors on nutritional status for children under 5. Independent of the weak linkage of economic development and child undernutrition at the macro level, the household level analysis shows family wealth is a significant factor associated with the stunting rate. In addition, quality of food (for example, intake of protein) and the history of incidence of malaria are highly correlated with the likelihood of stunting.

The policy recommendations are based on empirical findings, syntheses from broader international literature and local consultations.

2. Data and Methods

The analysis in this paper uses the data from the 2009-2010 Papua New Guinea Household Income and Expenditure Survey (2009-2010 PNG HIES). The 2009-2010 HIES was the first comprehensive and nationally representative survey of the socioeconomic status of PNG households since the 1996 Household Survey of PNG conducted by Unisearch from the University of Papua New Guinea (UPNG) and the Institute of National Affairs (INA).

The 2009-2010 PNG HIES contains the final cross-section sample of 4,191 households. The sample of households was selected from a nationally representative sample frame. A comprehensive set of multi-topic questionnaires was designed to elicit information on key topics such as family demography, education, health, employment, and consumption. The survey is population based and contains records on height, weight, date of birth for children under age 5 allowing a more in-depth analysis on children's malnutrition. The final sample contains 3,000 children under 5 years old. The data are nationally representative at the regional level.

This study uses the World Health Organization Child Growth Standards for the classification of stunting, wasting and underweight status. Children are classified as stunted, wasted and underweight if their height-to-age Z-score, weight-to-height Z-score and weight-to-age Z-score are below -2 respectively. Children are classified as severe stunted, severe wasted and severe underweight if their height-to-age Z-score, weight-to-height Z-score and weight-to-age Z-score are below -3 respectively (WHO Multicentre Growth Reference Study Group 2006).

Data from two parts of the survey were combined to estimate nutritional intake: the household stocks data and the personal diary data. The household stocks of food data, involved an interviewer asking the household head or representative about food currently in the house on day 1 and day 14 of the survey. The stocks were weighed by the interviewer. Nineteen food items, identified as the nineteen most common items in the previous HIES, were specified on the questionnaire. Other items were found, weighed and listed. The second source of data was derived from the participant's recorded transactions in a personal diary for 14 days. A total number of 295,804 transactions involving food and alcohol were extracted from this diary.

The quantity of food was converted to calories using food composition information from the New Zealand FOODfiles 2012 database (2013). Energy and nutrient composition for each item was estimated by taking an average of relevant items from the FOODfiles database. The difference between stock levels on day1 and day14, plus additional purchased foods were converted to the total calories consumed by the households.

Total calories consumed by households during the two weeks were then converted to calories per capita (adult equivalent) per day. Per capita is defined by adult equivalent using children 0-14 as 0.5 adult. Guests who regularly have meals in the households were added while members of households who do not regularly eat at home were deducted. Since per adult equivalent calories were strongly right skewed, this was converted into quintiles to be included in the regression. Only per adult equivalent protein was used as an indicator for nutrition.

A logistic regression model is employed in the study. The dependent variables are children's malnutrition status including stunting status, wasting status (low weight-for-height, indicating acute weight loss and underweight status) and underweight status (low weight compared with that expected for a well-nourished child of that age and sex) (Waterlow 1972). The control variables are household wealth quintiles, protein intake quintiles, household head education level, region, and children's gender, age and health status.

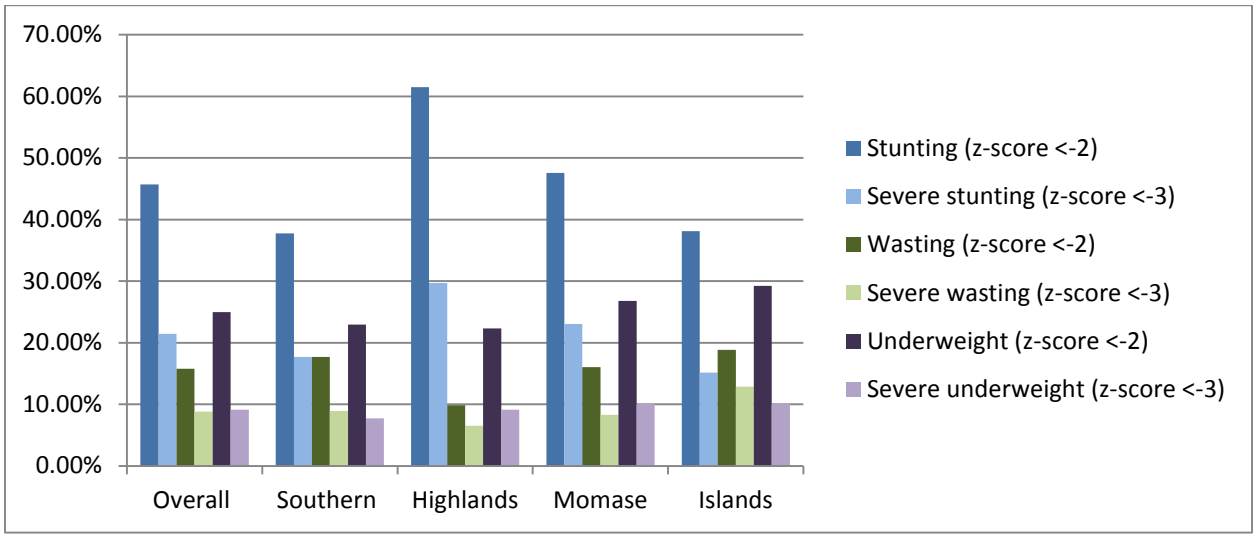
3. Results

3.1. Descriptive Results

Overall Prevalence

Malnutrition in PNG is prevalent and severe, and varies across the regions. The overall stunting, underweight and wasting rates are high, 46 percent, 25 percent and 15.8 percent, respectively. Not only are the overall rates high; the severe cases among the stunted, underweight and wasted children are also high at around 50 percent in each category (Figure 3).

Figure 3. The Severe Stunting, Wasting, and Underweight for Children under 5 in PNG



Data source: HIES 2009-2010

The extent of overlap of children under 5 who are stunted, underweight or wasted is not small. In PNG, 3.6 percent of children under 5 are both stunted and wasted; 16.7 percent of children are both stunted and underweight. These children are more likely to suffer from severe and life-threatening malnutrition.

The incidence of undernutrition is not evenly distributed across the regions. The stunting rate is high across all the regions but extremely high at 61.5 percent in the Highlands Region. The Islands Region has the lowest stunting rate at 38.1 percent. Contrary to the distribution of stunting rate, wasting rate and underweight rate are the highest among the Islands Region at 29.2 percent. This is similar to the findings in National Nutrition Survey 1982-83, National Nutrition Survey 2005 and the HIES 1996.

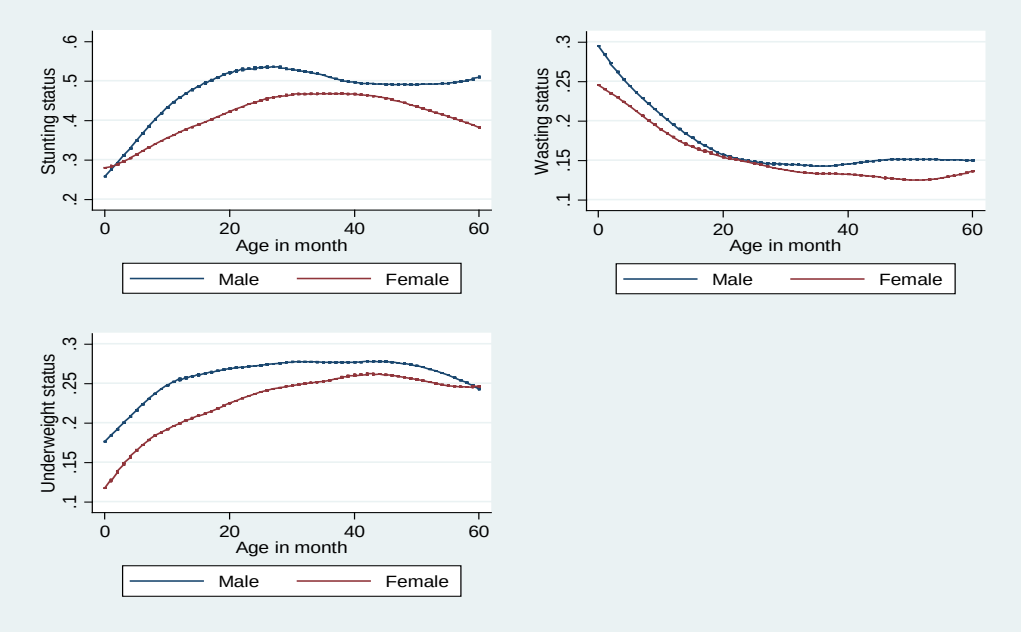
Malnutrition and Age

The stunting and underweight rate sharply rises in the first 24 months. This is similar to the findings in National Nutrition Survey 2005, which measured height from 6 months onwards. The stunting rate rises quickly from 6 month onwards to 2 years and remains stable till 59 months. Figure 4 shows the association between malnutrition and age for both boys and girls under 5 years old. The nutrition status is worse for boys than for girls. The wasting rate shows the opposite trend. This is mostly driven by the fact that wasting is a measure of weight for height and children are much more stunted than underweight, thus, the case of wasting decreases with age.

A closer examination of stunting and age by wealth quintiles showed that the trend for the first 24 months was similar across the five quintiles. However, there is a mild bend in the curve for the richest quintiles while the stunting rate plateaus for the poor quintiles (Figure 5). This implied that even in the better-off quintiles, children suffered from suboptimal breastfeeding and complementary food in the first 24 months.

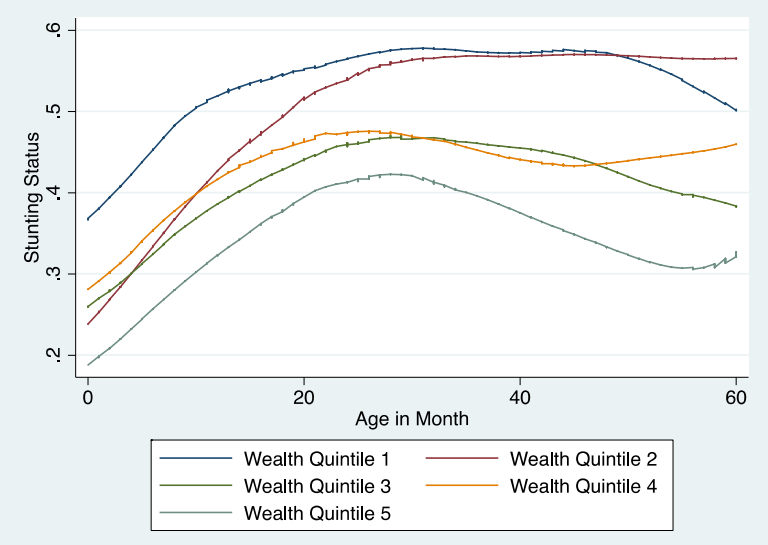
However, some of these children might be able to pick up nutritional intake given relative better access to solid food. The evidence suggests that women lack knowledge of quality feeding for their children even among better-off households. The high fertility rate and close birth gaps also make it difficult to give infants sufficient exclusive breastfeeding in the first six months.

Figure 4. The Trend of Stunting, Wasting, Underweight Rates with Age



Data source: HIES 2009-2010

Figure 5. The Rate of Stunting Rate and Age Across Five Wealth Quintiles

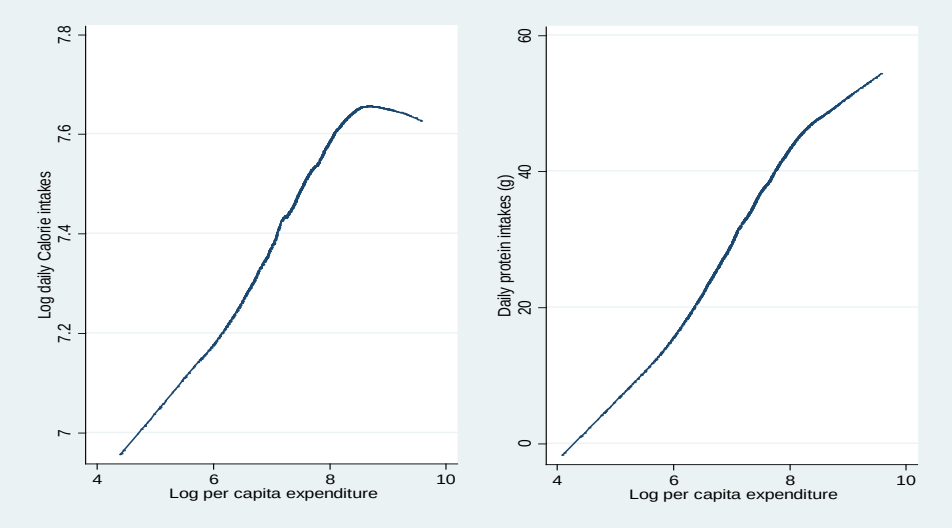


Data source: HIES 2009-2010

Caloric and Protein Intake by Social and Economic Status

Caloric and protein intake increases with social and economic status. Social and economic status is measured by log per capita expenditure. Both log per capita calories intake and protein intake increase with increase in log per capita expenditure, implying that both food quality and quantity improves with the increase of wealth status.

Figure 6. Log per Capita Expenditure and Log Daily Calorie and Daily Protein Intakes.

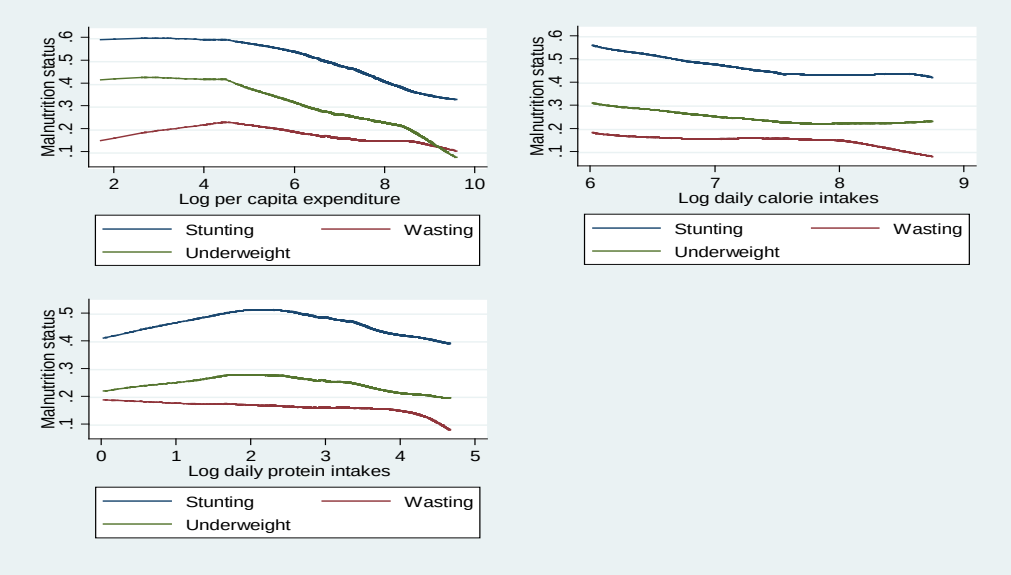


Data source: HIES 2009-2010

Wealth, Calories and Protein Intake and Malnutrition

In general, child malnutrition rates decline with an increase in wealth, daily calorie and protein intakes. Figure 7 confirmed such trends in PNG. However, child malnutrition rates started to decline with increased wealth only when the log per capita expenditure reached a critical point. The critical point, as shown in Figure 7, occurred when log per capita per month expenditure was around 5, which was equivalent to per capita per month expenditure 148 kina, or USD $1.67 per capita per day. This was still below the poverty line USD $2 per capita per day. Only when wealth passed through this critical point did the malnutrition rate started to drop. The incidence of malnutrition decreased with the increase of calorie and protein intake. The slight inverse U shape relationship between malnutrition and protein intake was mainly due to the noise at the lower end of little protein intake.

Figure 7. Malnutrition and per Capita per Day Calories Intake



Data source: HIES 2009-2010

3.2. Regression Results

Table 2 shows the regression results of stunting, wasting and underweight status for children under age 5. Household wealth was a significant indicator for children's stunting status. Children from poorer families are significantly more likely to be stunted. Household head education level has a significant effect on children's stunting status after controlling for household wealth and caloric/protein intake. Urban children are less likely to be stunted, and boys are more likely to be stunted.

Diseases, particularly infectious diseases, are important determinants of stunting (Marie T Ruel, Harold Alderman et al. 2013). Diarrhea is well documented in the literature as a contributor to stunting because of its association with mal-absorption of nutrients (Stuart Gillespie and Lawrence Haddad 2001; FAO, WFP et al. 2012). The literature also suggests malaria is an important determinant of stunting (Rowland, Cole et al. 1977). In PNG, the regression result did not show significant correlation between diarrhea and malnutrition. However, the regression results clearly showed that in PNG, children with malaria were significantly more likely to be underweight and stunted. It is hard to determine the causal effects of malaria and stunting/underweight. Malaria affects children's ability to absorb nutrition due to the malfunction of red blood cells after the incidence of malaria, which then has a negative effect on children's height and weight. At the same time, children with malnutrition may be at a higher risk of getting malaria because of their overall living environment and access to mosquito nets.

Protein intake quintiles also had significant prediction power on children's stunting status. Children from families with lower protein intakes were more likely to be stunted (Table 2). Studies have shown that people living in urban areas rely mostly on rice and wheat as their staple foods, while the majority of rural populations consume traditional root (tuber) crops of which sweet

potato is the main food item (Gibson and Rozelle 1998). However, the zinc content in root vegetables is much lower as compared with in the content in animal protein.

In general, the regression results showed that household wealth and geographic location are crucial factors that contribute to children's malnutrition. More importantly, the food quality, measured by protein intake, has significant predicting power on child malnutrition. Food quality and geographic location are correlated because in general, diet in the highlands is low in protein. Further, children's health status, more specifically, the incidence of malaria, has a significant correlation with child malnutrition.

4. Discussion

This analysis finds that the incidence of stunting is related to overall wealth, caloric intake, education level of household heads and incidence of diarrhea and malaria. Moving forward, in addition to broadly increasing social economic status and improving the quantity and quality of caloric intake, the discussion below focuses on four areas: 1) exclusive breastfeeding and complementary food; 2) interventions by health workers; 3) nutrition education; and 4) future agenda. These policy recommendations are based on empirical findings, syntheses from broader international literature and local consultations.

Exclusive Breastfeeding and Complementary Food

Growth faltering often begins in utero and continues for the first two years of life (Vollmer, Harttgen et al. 2014). The main window of opportunity to prevent stunting is the intra-uterine and postnatal periods, from conception until 24 months. Significant reductions in stunting can be achieved through a comprehensive set of priority interventions during this critical development stage.

In PNG, mothers are sometimes encouraged not to eat too much during pregnancy, as it is claimed that delivery will be easier. This is part of the reason that a high percentage of babies are born with low birth weight and classified as small-for-age in some PNG districts and provinces.

The recommended feeding of children is exclusive breastfeeding for the first 6 months of life and continued breastfeeding through the second year of life. In PNG, however, infants are introduced to solid food at a much earlier stage. One study examined various data sources in PNG and showed that exclusive breastfeeding rates were low. About 80% at 1 month, 36% at 4–5 months, 20.1% at 6–7 months and 11.5% at 8-9 months; and almost 10% of neonates and 27% of infants are given semi-solid or solid food before 4 months of age (Lagania, Mokelab et al.). This suboptimal breastfeeding practice for young children not only increases the incidence of both stunting and wasting, but also the mortality and morbidity of children.

The reasons for suboptimal feeding are multi-layered. Some are culturally linked; some are due to lack of understanding of the consequences of suboptimal feeding; and some are due to the lack of quality supplementary food. Further research is required to determine whether PNG feeding practices are related to quality food access, learned behaviors or a combination of both.

Interventions by Health Workers

Stunting often goes unrecognized in children who live in communities where short stature is so common that it seems normal. Thus, regular preventive programs such as Growth Monitoring and Promotion are necessary. Measuring length (up to 24 months) or height (from 24 months onwards) should become standard practice when assessing a child either through post natal visits or outreach visits conducted by health workers. Health workers should be trained in delivering messages on how to improve nutrition outcomes. Such trainings should also be broadened to teachers, social workers and extension officers (locally known as didimen and didimeries). Supplies of ready-to-use therapeutic foods should be available in health facilities where malnutrition cases are more prevalent. These could be included in the medical kits distributed to health centers. In addition, access to the health services that help prevent and treat malaria and diarrhea is critical.

However, it will be difficult to conduct a large-scale nutrition invention and monitoring campaign at the facility level because the country has a shortage of nutritionists to steer the endeavor. The capacity gap analysis, as part of the nutrition policy review, notes this capacity gap at all levels of the PNG health system (National Department of Health 2013). Key health care workers are not aware of up-to-date information related to infant feeding. There is an imperative need to build the human resource capacity in the country and further move the agenda to combat malnutrition challenges in PNG. This initiative requires strategy, financing and leadership's commitment.

Knowledge, Behaviors and Nutrition Education

Children living in homes where the head of the household has a higher level of education are less likely to be malnourished after controlling for wealth information. A study found that lack of access to information on proper nutrition was an important factor contributing to the high levels of malnutrition in PNG (Omot 2012). This is particularly the case in remote rural communities with prevalent illiteracy and lack of access to education. Stand-alone nutrition education programs have been carried out in the Pacific region (Englberger, Lorens et al. 2011), and their effectiveness depends on the intensity and quality of implementation. This includes appropriate communication strategies (for example, combination of mass media and interpersonal) and targeting the right audience. Good formative research is needed to identify key obstacles, identify who influences mothers' decisions in adopting healthy behavior (i.e. grandmother, husband, community leaders) and ensure that nutrition education reaches these groups.

A wider body of evidence suggests that nutrition education programs can be more effective when combined with other interventions such as to increase food or income availability or to provide nutritional supplements (Christiaensen and Alderman 2004; Omot 2012; The World Bank Group 2012). Agriculture interventions that aim to improve income and productivity tend to be successful in improving the nutrition status of children when they include a nutrition education component (Arimond, Hawkes et al. 2011).

Further Agenda

While PNG continues to battle a high stunting rate, it also faces emerging non-communicable diseases. As evidence has shown, an adult is more likely to develop non-communicable diseases if he/she was stunted as a child. The body's ability to metabolize food is being programmed in the first 1000 days from conception and disruption to this process contributes to obesity and diabetes later in life (Stuart Gillespie and Lawrence Haddad 2001). This will not only pose a huge financial burden to families, but also the public health financing schemes.

Further analytics are required to better understand the causes for undernutrition and over-nutrition and the effects of various interventions. The quality of HIES data collection methods, particularly the questionnaire design, can be further strengthened to make it a more useful tool in identifying areas for health policy interventions and reform. To the extent possible, regular nutrition surveys to monitor nutrition status add tremendous value to understand the progress of improving nutrition outcomes and the causal links. Additional analytical work that can further shed light on combating the undernutrition issue includes: investigating the prevalence of deficiencies of micronutrients (vitamin A, zinc, iron, and iodine) in the subnational population; and obtaining a better understanding of the nutrition inventions to date in PNG and analysis of the lessons learned. These efforts will help in scaling up effective interventions using various platforms and linking child nutrition with cognitive development for school readiness and beyond.

To move toward more committed actions, it is critical to improve the political environment, aligning multiple actors, and advancing policies and legislation. The government has made some progress. The National Nutrition Policy was recently endorsed by a number of departments in addition to the National Department of Health in early 2015, highlighting the political commitment of multisectoral interventions to improve nutritional outcomes in the country. However, a much stronger political commitment along with adequate financing are required to ensure the successful implementation of the policy. Monitoring and evaluation of nutritional programs are necessary to gather the latest evidence on the effective and efficient ways to improve nutrition across different regions in PNG.

Reference

(2013). New Zealand FOODfiles 2012 Manual. Palmerston North, New Zealand Institute for Plant & Food Research Limited.

Angeles, I. T., W. J. Schultink, et al. (1993). "Decreased rate of stunting among anemic Indonesian preschool children through iron supplementation." Am J Clin Nutr **58**(3): 339-342.

Arimond, M., C. Hawkes, et al. (2011). Agricultural Interventions and Nutrition: Lessons from the Past and New Evidence FAO.

Christiaensen, L. and H. Alderman (2004). "Child Malnutrition in Ethiopia: Can Maternal Knowledge Augment the Role of Income?" Economic Development and Cultural Change **52**(2): 287-312.

Englberger, L., A. Lorens, et al. (2011). Approaches and Lessons Learned from Promoting Dietary Improvement in Pohnpei, Micronesia. FAO.

FAO, WFP, et al. (2012). The state of food insecurity in the world. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition, Food and Agriculture Organization of the United Nations. Rome. Italy.

Ferro-Luzzi, A., N. Norgan, et al. (1975). " Food intake, its relationship to body weight and age, and its apparent nutritional adequacy in New Guinean children. ." Am J Clin Nutr **28**: 1443-1453.

Gibson, J. (1999). "Can women's education aid economic development? The effect on child stunting in Papua New Guinea." Pacific Economic Bulletin **14**(2): 71-81.

Gibson, J. and S. Rozelle (1998). "Results of the household survey component of the 1996 poverty assessment for Papua New Guinea. Report submitted to the World Bank, Port Moresby, Papua New Guinea. Institute of National Affairs, Port Moresby, Papua New Guinea.".

Gibson, R. S., A. Heywood, et al. (1991). "Growth in children from the Wosera subdistrict, Papua New Guinea, in relation to energy and protein intakes and zinc status." Am J Clin Nutr **53**(3): 782-789.

Lagania, W., D. Mokelab, et al. "Papua New Guinea: real progress towards MDG4 and real challenges.".

Maraga, S., A. Sie, et al. (2010). "Population Hemoglobin Mean and Anemia Prevalence in Papua New Guinea: New Metrics for Defining Malaria Endemicity?

Nicolas Senn mail, ." PLoS ONE **2010**(5): 2.

Marie T Ruel, Harold Alderman, et al. (2013). "Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition?" Lancet **382**(9891): 536-551.

National Department of Health (2013). Consultancy National Nutrition Policy. .

Omot, N. (2012). Food security in East Timor, Papua New Guinea and Pacific island countries and territories (ACIAR Technical Report 80). A. C. f. I. A. Research. Canberra, Australia.

Oomen HAPC (1971). "Ecology of human nutrition in New Guinea. ." Ecol. Food Nutr. 1971, 1:1. **1**(1).

Rowland, M., T. Cole, et al. (1977). "A quantitative study into the role of infection in determining nutritional status in Gambian village children. ." British Journal of Nutrition **37**: 441-450.

Semba, R. D., S. de Pee, et al. (2008). "Effect of parental formal education on risk of child stunting in Indonesia and Bangladesh: a cross-sectional study." The Lancet **371**(9609): 322-328.

Sharp, P. T. and P. Harvey (1980). "Malaria and growth stunting in young children of the highlands of Papua New Guinea." Papua and New Guinea medical journal **23**(3): 132-140.

Stuart Gillespie and Lawrence Haddad (2001). Attacking the double burden of malnutrition in Asia and the Pacific., Asian Development Bank. Manila, Philippines and the International Food Policy Research Institute, Washington DC, United States.

Subramanyam, M., I. Kawachi, et al. (2011). "Is Economic Growth Associated with Reduction in Child Undernutrition in India?" PLos Med **8**(3): :e1000424.

Temple, V., P. Mapira, et al. (2004). "Iodine deficiency in Papua New Guinea (sub-clinical iodine deficiency and salt iodization in the highlands of Papua New Guinea. ." J Public Health **27**(1): 45-48.

The World Bank Group (2012). Ethiopia Community-Based Nutrition Program Helps Reduce Child Malnutrition.

UNICEF (1990). "The conceptual framework of malnutrition. ."

Van de Poel, E., A. R. Hosseinpoor, et al. (2007). "Malnutrition and the disproportional burden on the poor: the case of Ghana." International Journal for Equity in Health **6**(1): 21.

Van de Poel, E., A. R. Hosseinpoor, et al. (2008). "Socioeconomic inequality in malnutrition in developing countries." Bulletin of the World Health Organization **84**(4): 282-291.

Vollmer, S., K. Harttgen, et al. (2014). "Association between economic growth and early childhood undernutrition: evidence from 121 Demographic and Health Surveys from 36 low-income and middle-income countries." Lancet Glob Health **2**(4): e225-234.

Wand, H., N. Lote, et al. (2012). "Investigating the spatial variations of high prevalences of severe malnutrition among children in Papua New Guinea: results from geoadditive models." BMC Research Notes **5**(288).

Waterlow, J. (1972). "Classifi cation and defi nition of protein-calorie malnutrition." BMJ **3**: 566–569.

WHO Multicentre Growth Reference Study Group (2006). WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development, Geneva: World Health Organization.

Table 1: Summary Statistics

Variables	Overall		Southern		Highlands		Momase		Islands	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stunting (z-score <-2)	45.71%	0.50	37.75%	0.48	61.48%	0.49	47.55%	0.50	38.10%	0.49
Wasting (z-score <-2)	15.76%	0.36	17.71%	0.38	9.85%	0.30	16.02%	0.37	18.85%	0.39
Underweight (z-score <-2)	24.97%	0.43	22.95%	0.42	22.31%	0.42	26.77%	0.44	29.22%	0.46
Severe stunting (z-score <-3)	21.43%	0.41	17.69%	0.38	29.70%	0.46	23.04%	0.42	15.15%	0.36
Severe wasting (z-score <-3)	8.83%	0.28	8.90%	0.28	6.51%	0.25	8.28%	0.28	12.86%	0.34
Severe underweight (z-score <-3)	9.13%	0.29	7.72%	0.27	9.15%	0.29	10.10%	0.30	10.17%	0.30
Per capita expenditure quintile 1	20.02%	0.40	8.00%	0.27	24.24%	0.43	28.96%	0.45	22.08%	0.42
Per capita expenditure quintile 2	19.99%	0.40	15.22%	0.36	25.68%	0.44	19.58%	0.40	23.59%	0.43
Per capita expenditure quintile 3	20.02%	0.40	21.44%	0.41	23.43%	0.42	16.88%	0.37	18.83%	0.39
Per capita expenditure quintile 4	20.02%	0.40	23.42%	0.42	16.05%	0.37	18.85%	0.39	20.35%	0.40
Per capita expenditure quintile 5	19.95%	0.40	31.92%	0.47	10.59%	0.31	15.73%	0.36	15.15%	0.36
Per capita protein intake quintile 1	20.06%	0.40	18.37%	0.39	11.09%	0.31	27.73%	0.45	20.09%	0.40
Per capita protein intake quintile 2	19.96%	0.40	14.65%	0.35	28.16%	0.45	18.37%	0.39	24.11%	0.43
Per capita protein intake quintile 3	20.06%	0.40	18.06%	0.38	24.23%	0.43	18.15%	0.39	22.93%	0.42
Per capita protein intake quintile 4	19.92%	0.40	22.81%	0.42	20.48%	0.40	17.26%	0.38	18.20%	0.39
Per capita protein intake quintile 5	19.99%	0.40	26.11%	0.44	16.04%	0.37	18.49%	0.39	14.66%	0.35
Household head's education: no formal education	27.41%	0.45	17.98%	0.38	41.73%	0.49	29.06%	0.45	25.32%	0.44
Household head's education: primary	28.30%	0.45	25.00%	0.43	25.20%	0.43	34.06%	0.47	27.71%	0.45
Household head's highest education: above primary	44.29%	0.50	57.02%	0.50	33.07%	0.47	36.88%	0.48	46.97%	0.50
Urban	46.16%	0.50	67.49%	0.47	20.22%	0.40	46.98%	0.50	32.68%	0.47
Male	52.40%	0.50	51.48%	0.50	53.29%	0.50	53.33%	0.50	51.30%	0.50
Children having had diarrhea	5.56%	0.23	3.85%	0.19	7.70%	0.27	7.40%	0.26	2.60%	0.16
Children having had malaria	7.10%	0.26	7.02%	0.26	2.25%	0.15	7.29%	0.26	13.42%	0.34
Age in month	29.30	17.02	29.04	17.40	29.93	16.19	29.13	17.07	29.40	17.17
Sample size	3057		1012		623		960		462	

Table 2: The Logit Regression of Stunting, Wasting and Underweight for Children Under 5 (odds ratio presented below)

Variables	Stunting	Wasting	Underweight
Per capita expenditure : quintile 1 (poorest) as comparison group			
quintile 2	0.966	0.908	1.018
	(0.126)	(0.154)	(0.143)
quintile 3	0.734**	0.639**	0.769*
	(0.101)	(0.121)	(0.120)
quintile 4	0.934	0.795	1.126
	(0.137)	(0.156)	(0.182)
quintile 5	0.758*	0.655*	0.823
Per capita protein intake: quintile 1 as comparison group	(0.121)	(0.144)	(0.150)
quintile 2	1.232*	1.046	1.029
	(0.153)	(0.173)	(0.141)
quintile 3	1.131	1.021	0.962
	(0.142)	(0.174)	(0.136)
quintile 4	0.971	1.168	0.882
	(0.125)	(0.202)	(0.130)
quintile 5	0.947	0.847	0.779*
Region: Southern as the comparison group	(0.125)	(0.157)	(0.119)
Highlands	1.964***	0.374***	0.616***
	(0.230)	(0.0678)	(0.0860)
Momase	1.253**	0.748**	0.938
	(0.125)	(0.0997)	(0.107)
Islands	0.844	0.914	1.097
Household head highest education: no formal education as the comparison group	(0.107)	(0.146)	(0.151)
primary	0.981	0.677***	0.716***
	(0.102)	(0.0946)	(0.0819)
above primary	0.781**	0.672***	0.583***
	(0.0808)	(0.0937)	(0.0679)
Urban	0.772***	0.967	0.715***
	(0.0752)	(0.130)	(0.0807)
Male	1.304***	1.092	1.181*
	(0.101)	(0.116)	(0.105)
Children having had diarrhea	1.089	0.912	0.950
	(0.183)	(0.217)	(0.184)
Children having had malaria	1.390**	0.950	1.333*
	(0.209)	(0.195)	(0.215)
Age in month	1.007***	0.988***	1.006**
	(0.00230)	(0.00311)	(0.00261)
Constant	0.655**	0.557***	0.492***
	(0.108)	(0.118)	(0.0896)
Observations	2,875	2,785	2,875

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1