Child Growth as a Measure of Household Resilience:

A Re-Examination of Child Nutrition Situation Using New Growth Reference Standard

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Abstract

The paper examines child health and nutrition status under a frame work of social-ecological resilience. It is argued that nutrition indicators can be used as a measure of household resilience because the indicators, i.e. stunting, wasting, and underweight, are closely linked to household available resources which determine household capacity to recover from shocks. We use data from Living Condition Monitoring Survey which is a nationally representative survey of various years to examine nutritional status and trends of children under-five years old. Our anthropometric indicators are estimated based on the WHO multi-growth center of 2006. We contrast our results to CSO estimates that are based on the NCHS 1978 child growth standard. It is found that the WHO standard yields higher prevalences of stunting and wasting because the reference children are taller than those in the NCHS 1978. The underweight prevalence of the WHO reference, on the other hand, are lower than one based on the NCHS since the WHO children are relatively lighter.

Nutrition status of Zambian pre-school children is characterized by very high prevalence of stunting coupled with low prevalence of wasting and moderate level of underweight. Overtime, under-nutrition situations have shown signs of gradual improvement. Although there are signs of gradual improvements, nutritional situation in Zambia has not categorically changed since 1991. The nutritional pattern as defined by WHO threshold classification was and still is characterized by low prevalence of acute malnutrition and critically high prevalence of chronic malnutrition. However, changes in intensity of degree of seriousness are occurring in opposite directions. While the acute malnutrition that brings death to children is approaching a natural level observed in reference populations, the chronic malnutrition that causes impaired physical and intellectual development has grown more severe than what it was at the start of the economic adjustment program in 1991. With half of children malnourished, a nutritional security situation of Zambian children is in a precarious position. The under-fives are on the edge of falling into a full scale nutrition crisis when a large scale shock either from social or ecological environments hits the economy.

Introduction

Zambia is a country in a semi-arid region. The economy is largely a resource base. Minerals, e.g., copper, cobalt, lead, zinc and agricultural products, e.g., sugar, cut flowers, tobacco, vegetables and cotton are Zambia’s primary source of foreign earnings. Four out of five usually working populations are in agricultural sector that comprises largely of small-scale rainfed farmers. Climate variability, therefore, poses a substantial common risk to the livelihoods of Zambia economy. Since 1990, Zambian farmers have experienced several agricultural droughts and occasional floods in recent years. A major continental-wise drought occurred in 1992/93 agricultural season and caused serious crop damages; maize yield was at merely 40 percent of the normal level under good weather conditions (Lekprichakul 2008).

In an uncertain environment, households need to build resilience to income or consumption shocks. Here, resilience is defined as a household capacity to recover from negative shocks. The household's recovery capacity depends on households' available resources which can be categorized into five distinct capitals: i.e., human, social, natural, physical and financial capitals (Sakurai 2006). Assessing household resilience by directly measuring all five categories of capitals can be impractical especially for social capital. Alternatively, one can assess household resilience from outcome variables that reflects resource availability on child growth. Here, we focus our attention on three common nutrition indicators: wasting, stunting and underweight. The three indexes and its combination can be used to shed light on timings of food or health deprivations. Wasting indicates a recent episode of consumption short fall or a recent episode illnesses; stunting is a measure of linear growth failure resulted from cumulative energy consumption deficits or chronic illnesses; underweight is a composite indicator of the aforementioned two indices. Our approach to household resilience is similar to ones used to assess food security (FAO 2006), livelihood security (Crooks, Cliggett, and Cole 2007) and human security (UNDP 1994).

Objectives

Objectives of this study are two folds. First, we re-examine stunting, wasting and underweight situation of Zambia preschool children using the new child growth reference standard released by the World Health Organization (WHO) in 2006 and compare that to the official reported figures that are based on the National Center for Health Statistics (NCHS) 1978 growth chart. Different patterns of child under nutrition can have important policy implications on targeting vulnerable groups. Second, we examine child nutritional dynamics to see how malnutrition situation in Zambia has changed over time. Both research questions are expected to shed some light on the household resilience situation in Zambia overtime.

Designs and Settings

Data used in this study are from a series of Living Condition Monitoring Surveys (LCMS) which are nationally representative surveys conducted by the Central Statistical Office (CSO) of Zambia. The surveys are conducted every two years with some exceptions. Currently available data cover a period from 1991 to 2006, a total of seven survey years, i.e. 1991, 1993, 1996, 1998, 2002, 2004 and 2006. Each year of data contains a sample of no less than 5,000 pre-school children with complete and valid anthropometric measurements. Sex ratio of our samples is approximately equal. Child height and weight are measured by trained enumerators using standard measurement protocol. The height of child under 24 months is measured in length. A child age less than 3 months old are excluded from measurements.

Methods

We use standard definitions to classify child nutritional status as wasted, stunted and underweight. A child with weight-for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ) of less than two standard deviations below the mean of the reference children is classified as underweight, stunted, and wasted respectively. When the z-scores are less than -3 SD, the child is considered in severe conditions of the respective classifications. The z-scores based on the WHO 2006 are estimated using WHO's software called IGROWUP for STATA. The classifications based on the NCHS 1978 standard are provided to us by the CSO. Extreme z-scores for each indicator are dropped following the WHO's recommended systems[1]. The classifications are then evaluated descriptively.

Results

Children in the WHO's multicenter growth reference chart are relatively taller but lighter than American children in the NCHS 1978 growth chart (de Onis, Garza et al. 2007). We can expect that the existing CSO published prevalence of stunting and wasting is likely to be underestimated and underweight incidence overestimated.

As expected, our result indicates that the NCHS understates stunting and wasting prevalence, on average, by 11.3 and 4.4 percent respectively (see table 1). The largest relative difference is in the underweight which overstates, on average, by 22.9 percent. Year-to-year differentials of stunting and underweight indices significantly vary and are generally in directions that are expected. The year-to-year variations of wasting differentials between the two standards vary in relatively smaller range and are significant only in 1993, 1996 and 2004. Surprisingly, both standards produce nearly identical prevalences of stunting and wasting in the year 2006. To verify, we examine the means of all three anthropometric measurements. Table 2 clearly shows that the two standards produce quantitatively different standardized scores that are consistent with the expectations, e.g. the |NCHS 1978| < |WHO 2006| for HAZ and WHZ and the |NCHS 1978| > |WHO 2006| for WAZ; all pairs of means of standardized scores are statistically significant differences. The variations of relative differences

[1] A z-score of each indicator is considered an extreme value if it lies outside the following bounds:

- $-6 < WAZ < 5$
- $-6 < HAZ < 6$
- $-5 < WHZ < 5$

across year might be attributable to non-systematic sampling variations which result in differentials in age composition therein.

Yang and Onis (2008) proposed an algorithm to convert prevalence rates from the NCHS standard to the WHO 2006 growth reference when data for re-estimation of anthropometric indices are not available. In comparison, the proposed conversion algorithm would suggest under/over estimation of 12, 25 and -12 percent for stunting, wasting and underweight respectively (Yang and Onis 2008). The conversion of stunting estimates fit Zambia data, on average, remarkably well but not so with the other two indicators. Poorer fit of the algorithm appears to associate with the body weight component. However, since the prevalence of wasting and underweight of Zambia are at a relatively small base, the differences between the converted and the actual estimates are not likely to be meaningful.

Table 1: Prevalence of Anthropometric Failure of Children under Five by Growth Reference Standards, Zambia[2]

Year	N	WHO 2006			NCHS 1978			Relative Differences		
		Stunting	Wasting	Underweight	Stunting	Wasting	Underweight	Stunting	Wasting	Underweight
1991	5,699	46.1	7.1	18.7	39.6	6.9	22.4	-15.2 ***	-2.7	18.2 ***
1993	6,306	52.5	6.4	20.2	47.1	5.5	24.5	-10.9 ***	-14.8 ***	19.5 ***
1996	7,035	56.0	5.1	18.8	50.1	4.8	22.9	-11.0 ***	-6.7 *	19.5 ***
1998	8,040	57.7	5.3	19.2	50.8	5.3	22.8	-12.7 ***	-0.7	17.3 ***
2002	9,234	51.8	5.3	15.5	43.8	5.3	18.7	-16.8 ***	-1.6	18.4 ***
2004	5,636	55.5	4.7	17.8	49.1	4.2	23.0	-12.3 ***	-10.1 **	25.8 ***
2006	5,868	50.4	5.1	12.8	50.4	5.4	19.5	0.1	5.8	41.6 ***
Average	**6,831**	**52.9**	**5.6**	**17.6**	**47.3**	**5.3**	**22.0**	**-11.3**	**-4.4**	**22.9**

Source: LCMS of various years

Note: Mean differences are statistically significant at < 0.01, < 0.05 and < 0.10 level if denoted by ***, **, * respectively

The relative differences are estimated as ln(NCHS/WHO).

Table 2: Means of Standardized Anthropometric Measurements, LCMS 2006

Z-Score	Mean		Relative Differences
	WHO 2006	NCHS 1978	
Height-for-Age	-2.60	-2.3 **	-11.1
Weight-for-Height	1.72	0.8 ***	-71.6
Weight-for-Age	-0.26	-0.7 ***	104.6

Source: LCMS 2006

[2] It is worth noting that the prevalence of under-nutrition incidence based on the WHO/NCHS standard may differ from the CSO published report. This may be a result of two factors: i.e., (i) using different exclusion criteria, (ii) imposing additional screening criterion of BMI-for-age onto the dataset and (iii) removing records that failed to uniquely match with identifiers in the household roster section.

A long-run average level of stunting over a period of decade and a half showed a persistent growth faltering trend at 52.9% which is very high by WHO classification (WHO 2008). This classification remains qualitatively unchanged when it is compared to the NCHS estimates. For the underweight indicator, opposite is the case. The shift in the standard results in a lower severity classification, i.e., from a severe level of 20% or higher to a moderate level at 17.6%. For the wasting index, the shift in reference standards does not matter. Wasting remains at a low level of prevalence of 5.6 percent.

Table 3: Anthropometric Failures by Asset Quintile, LCMS 2006

Asset Quintile	Overall (< -2 SD)			Severe (< -3 SD)		
	Stunting	Wasting	Underweight	Stunting	Wasting	Underweight
First	54.0	7.1	16.7	33.4	2.6	6.4
Second	59.4	4.8	14.6	38.5	2.4	5.1
Third	49.8	5.3	14.2	32.2	2.7	5.4
Fourth	49.0	4.2	10.4	28.9	1.3	3.5
Fifth	36.3	4.4	6.9	21.3	1.5	1.8

Source: LCMS 2006

Table 3 shows how anthropometric failures vary with resource endowment as measured by assets[3] in 2006. All three nutrition indicators are negatively related to asset level. Although the stunting appears to show some curvature with respect to the asset level, wasting and underweight indictors show clearer linear relationship with asset quintile. Of the lowest asset quintile, wasting prevalence which reflects current energy consumption shortfall is almost twice as high as that of the highest quintile. Higher severity of anthropometric failures (< -3 SD) also shows similar patterns.

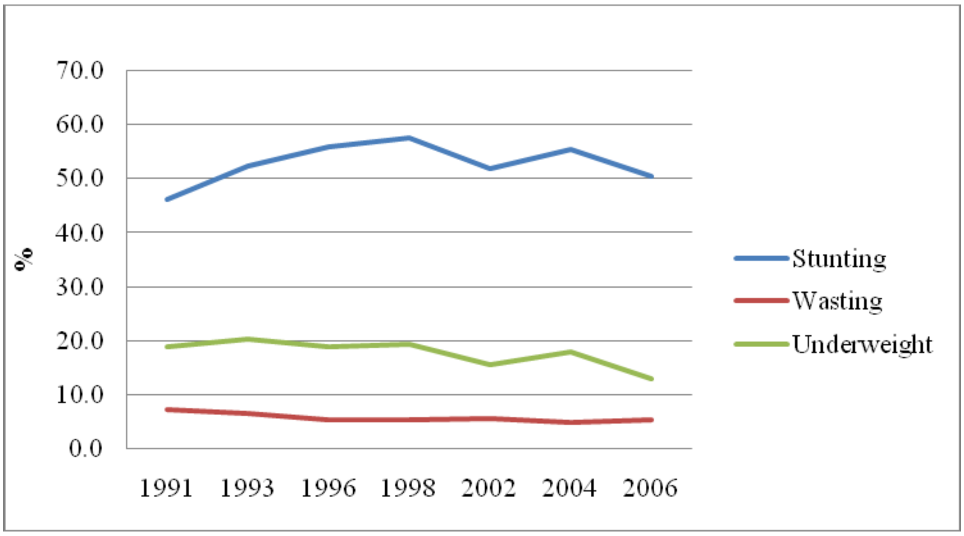
Nutritional Trend

Figure 1 shows trends of anthropometric failures of stunting, wasting and underweight of the under-fives from 1991 to 2006. The underweight situation started off at a relatively high at 18 percent in 1991 and peaked at slightly above 20 percent immediately after the severely drought year in 1993. The underweight situation was at its peak in 1993 which corresponds with a period of deep recession and implementation of the structural adjustment programs as mandated by the IMF and World Bank. However, the trend has gradually fallen since. However, this may not necessarily be a real nutritional and health improvements. The lower wasting prevalence coupled with a rise in stunting prevalence indicates that there may be a shift from acute to chronic form of under-nutrition. The stunting prevalence was at the lowest at 47 percent even after an extended period of deep recession since the

[3] Assets include productive assets, household durable goods, residential buildings, and livestock, a total of 51 items. The asset index is then constructed using principal components and factor analysis.

late 1980s and the launch of market liberalization as well as other structural adjustments required by the IMF to curb with excessive external debt burdens. The situation worsened immediately after a major drought in 1991/1992 agricultural season and continued to rise to reach the peak of 58 percent in 1998 before heading downward to 50 percent which is still higher than the prevalence in 1991.

Figure 1: Trend of Anthropometric Failure of the Under-Five Children, Zambia



Svedberg's Decomposition

Given the relationship that $\frac{W}{A} = \frac{W}{H}\frac{H}{A}$, stunting, wasting or underweight, on its own, is a partial indicator of undernutrition. Svedberg (2000) proposed an all inclusive framework that will allow disaggregated classifications of under-nutrition and, at the same time, provide all encompassing measurement of total prevalence of under-nutrition. Svedberg's decomposition is derived by combining weight deviation from weight-for-age norm; height deviation from height-for-age norm and deviation from age-specific weight-for-height norm into one single diagram as shown in Figure 2 (see Svedberg, 2000, p.194-195 for details). The framework decomposed population of children that is represented by area of an eclipse into six sub-categories, i.e., a) the well-nourished, b) wasted, c) wasted and underweight, d) stunted, wasted and underweighted, e) stunted and underweight and f) stunted. The total prevalence of under-nutrition can then be measured as:

$$\frac{(1-A)}{A+B+C+D+E+F} = 1-A$$

. Svedberg terms this a comprehensive index of anthropometric failure (CIAF) which is the percentage of children who are non-under-nourished.

Figure 2: Svedberg's Diagram to Measure
Total Prevalence of Anthropometric Failure, LCMS 2006

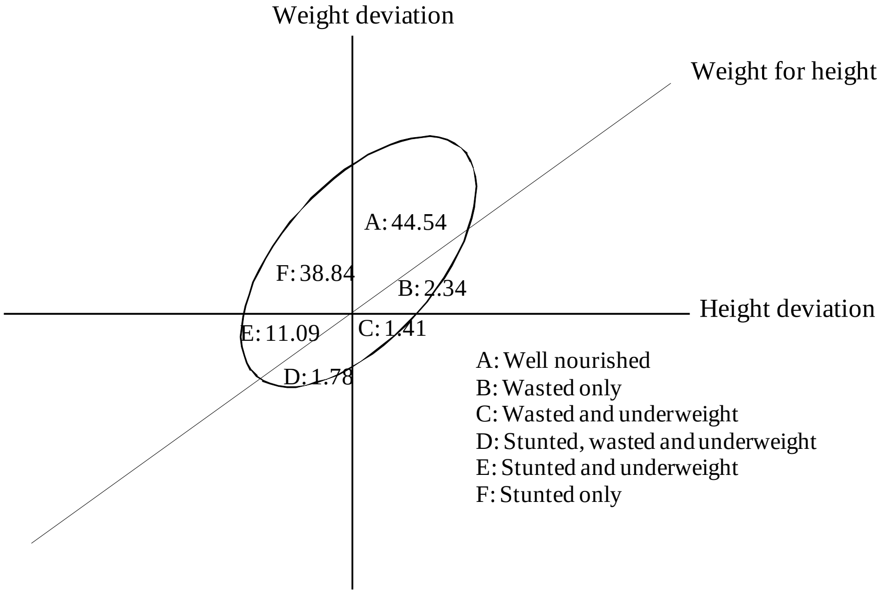


Figure 3 shows a trend of total prevalence of under-nutrition or the comprehensive index of anthropometric failure (CIAF) since 1991. The CIAF was at its lowest level at 51.6 percent in 1991. The index steadily increased thereafter and peaked in 1998 at 61.4 percent. Since then, the overall under-nutrition situation improved but remained high at 55.5 percent in 2006. It is worth noting that the CIAF does not distinguish differences in severity of under-nutrition. The index treats children who fail only one index equally to children who simultaneously fail two or more indices.

To gain further insight into the dynamics of child nutrition, we examine the trend of children who failed all three anthropometric indices: stunting, wasting and underweight (hereafter SWU Index), which corresponds to area *D* in the Svedberg's diagram in figure 2. Figure 4 shows a trend of the under-fives who are simultaneously stunted, wasted and underweight. In general, proportions of children who simultaneously fail all three indices are small, varying in range from 1.5 to less than 3.0 percent. It started off at a relatively high level of 2.1 percent in 1991 after the implementation of market liberalization and other macroeconomic structural adjustment program. The severity of under-nutrition situation peaked in 1993, a combined residual impact of economic recession and a severe drought at the continental scale in 1991/1992 planting season. Since then, the SWU index was on a declining trend and reached its lowest point in the year 2004. There was no evidence of a surge of the SWU in 1998 following an increase in overall prevalence of under-nutrition. Since 2004, there was a rebound in severity of the situation. It is not immediately obvious as to what factors might cause the upswing.

Figure 3: Trend of Composite Index of Anthropometric Failure, Zambia 1991-2006

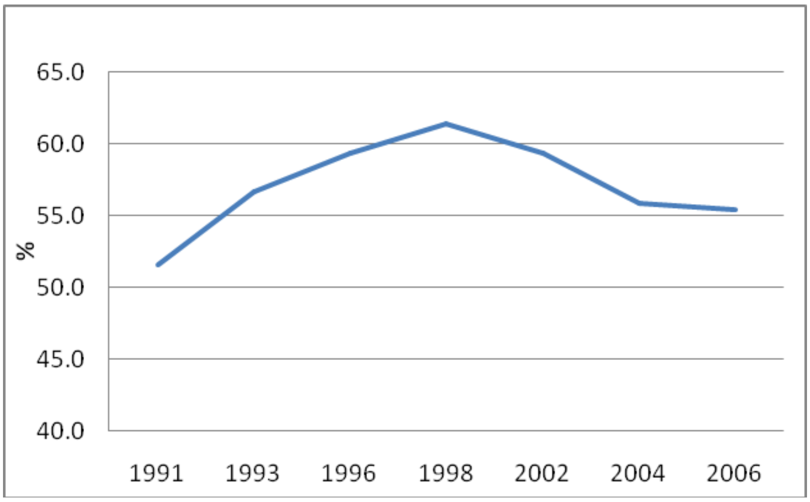
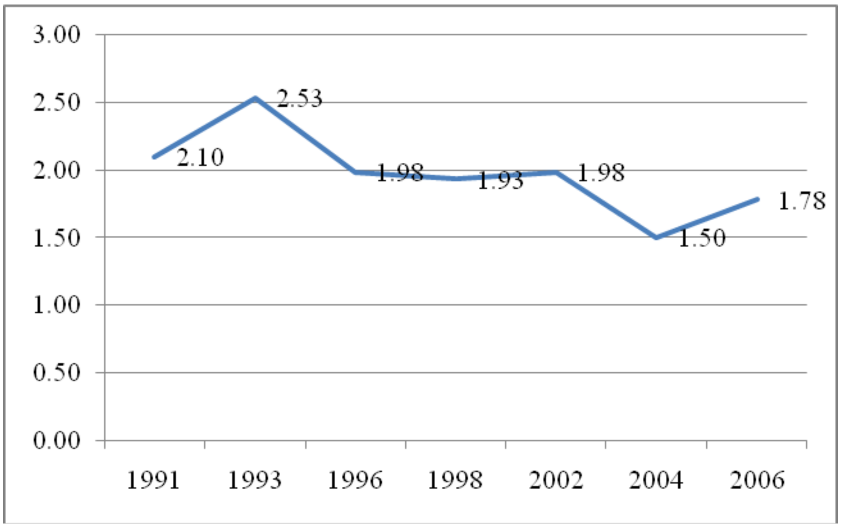
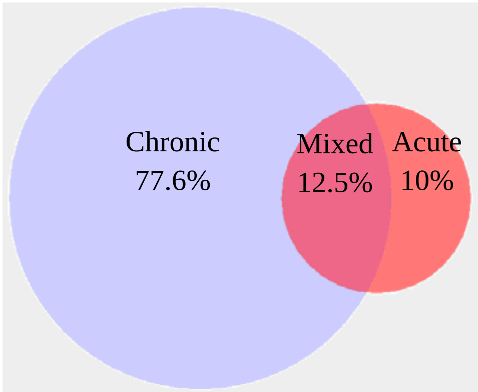


Figure 4: Trend of Under-Fives Simultaneously Failing
Stunt, Waste and Underweight Indicators, Zambia, 1991-2006



Additional benefit of the Svedberg's diagram is its ability to decompose causes of low weight-for-age index into an acute, chronic, and a mixture of acute and chronic under-nutrition. Underweight is defined by the area *C*+*D*+*E* in figure 2. The area *C* is underweight resulting from wasting; area *E* is underweight resulting from stunting; area *D* is underweight from a complex combination of acute cause and chronic nutritional insults. Figure 5 shows that the underweight among the Zambian preschoolers is largely from chronic nutritional insults (77.6 %). Only 10 percent are acutely caused, perhaps, by recent food shortage or recent episodes of illnesses such as malaria, diarrhea or respiratory infections. The remaining 12.5 percent of underweight is a result of a combined effect of acute and chronic under-nutrition. There is a residual of 1.5 percent of an underweight only category whose cause is not identifiable. It is observed that younger age children are more likely to be classified as underweight from acute causes. Older-age children are more likely to be underweight from chronic nutritional insults (table not shown).

Figure 5: Decomposition of Causes of Underweight



Trends in Body Weight and Height

Figure 6-8 show long term trend of mean weight, height and BMI of the under-fives by age group. The under-five children in the most recent survey of 2006 are significantly heavier than those of the 1991 at all age group but the oldest. The rise in average weight comes with surprising shortfalls in mean stature. Compared to those of the same age group in 1991, children in the most recent survey are, on average, relatively and significantly shorter in nearly every age category, which seems to suggest worsening linear growth faltering situation. As a result, mean BMIs of sampled children in 2006 as compared to those in 1991 are significantly higher across all age group except the infant.

Figure 6: Mean Weight of Under-Five Children, SDAPS 1991 vs. LCMS 2006

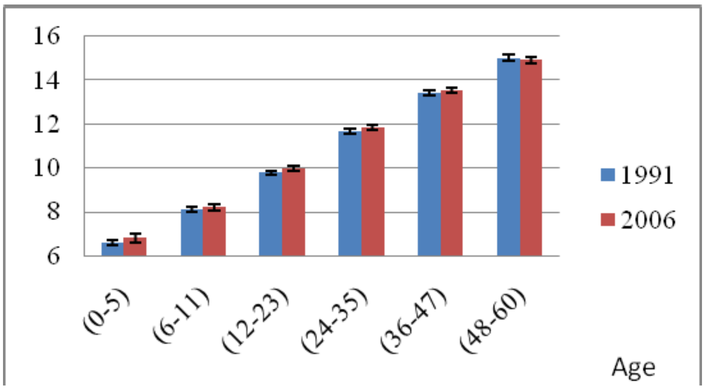


Figure 7: Mean Height of Under-Five Children, SDAPS 1991 vs. LCMS 2006

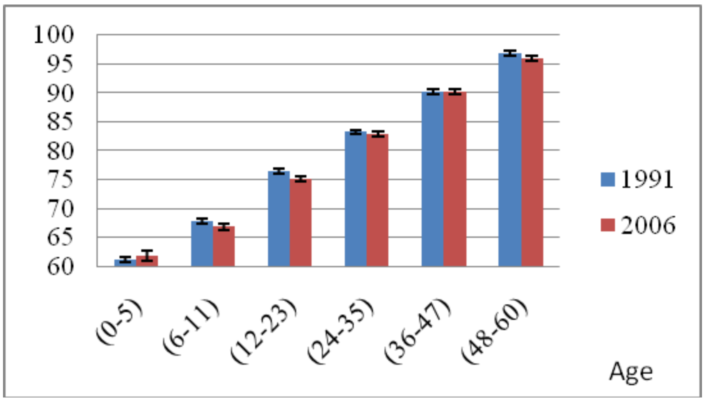
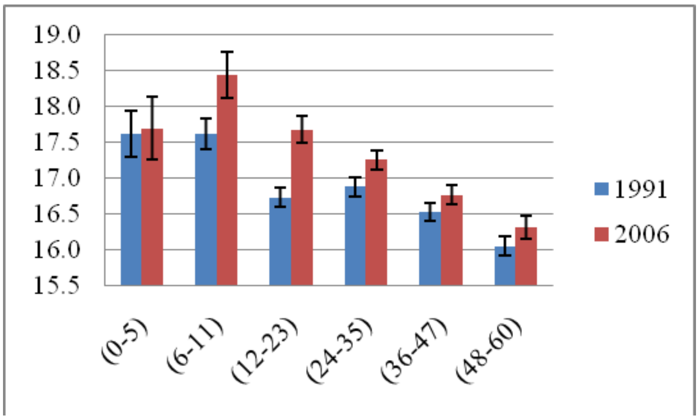


Figure 8: Mean BMI of Under-Five Children, SDAPS 1991 vs. LCMS 2006



What complicate the comparisons are differences in prevalent rates and differences in severity of stunting between the two years in question. To gain further insight, mean weight and height of the stunted and non-stunted children are compared in table 4 and 5. In general, both the stunted and non-stunted children have grown heavier which is consistent with the grand mean of both sub-group combined as indicated in figure 6. For height, evidences clearly suggest that, on average, children are not growing shorter over time as suggested in figure 7. In fact, there are gains in stature overtime among both the stunted and non-stunted, which indicates improving health and nutritional situation. Since weight gains are at faster rates than gains in height, we observed significant increases in BMI among children with and without linear growth falters.

Table 4: Mean Weight and Height of the Under-Fives by Age Group, Zambia, 1991-2006

Age	Weight: Stunted		Weight: Non-Stunted		Height: Stunted		Height: Non-Stunted	
	1991	2006	1991	2006	1991	2006	1991	2006
(0-5)	6.2	5.7 *	6.7	7.1 *	56.7	55.1 *	62.7	63.9 *
(6-11)	7.4	7.8 *	8.4	8.5	62.8	62.6	70.6	69.9 *
(12-23)	9.0	9.4 *	10.3	10.6 *	71.5	71.1	79.7	79.9
(24-35)	10.9	11.1	12.3	12.8 *	78.1	78.5	87.7	88.6 *
(36-47)	12.3	12.7 *	14.3	14.5 *	84.3	84.8 *	95.1	96.4 *
(48-60)	13.9	14.1 *	15.9	15.7	90.4	90.5	101.6	101.5

Note: * indicates statistically significant at 0.05 levels.

Table 5: Mean BMI of the Under-Fives by Age Group, Zambia, 1991-2006

Age	BMI: Stunted		BMI: Non-Stunted	
	1991	2006	1991	2006
(0-5)	19.2	18.6	17.1	17.4
(6-11)	18.9	20.1 *	16.9	17.3 *
(12-23)	17.6	18.6 *	16.2	16.6 *
(24-35)	17.9	18.0	16.0	16.3 *
(36-47)	17.4	17.7 *	15.8	15.7
(48-60)	17.0	17.3 *	15.4	15.3

Note: * indicates statistically significant at 0.05 levels.

Discussion and Conclusion

The research views child health and nutrition issues under a perspective of social resilience. A society with a chronically high level of child malnutrition is vulnerable to natural and economic shocks that can easily trip the child nutritional situation into a crisis level. The UNICEF has long labeled this issue a silent emergency (UNICEF 1998) despite the loud cries of hungry children. In nearly two decades, very little progress has been made to combat malnutrition among Zambian preschoolers. From the 1991 to the 2006 survey, stunting actually increased by 11 percent; wasting and underweight dropped by 20 percent. However, the level of stunting remains critically high; underweight improves from high to a moderate level; and wasting is approaching acceptable level. The low height-for-age together with weight-for-height just slightly below that of the reference population is a typical pattern observed in eastern and southern Africa (UNICEF 2007)

In comparison to the NCHS 1978 growth standard, the new WHO 2006 growth reference yields significant differences in nutritional classifications of a population. Prevalence rate of stunting and wasting tends to be higher but the underweight rate tends to be lower[4]. The new standard not only changes the level estimates but it also alters the distribution of malnutrition children across age group. Significant changes in the distribution of under-nutrition occur at the age below 24 months. The most

[4] By extension, overweight prevalence based on the new standard will be higher.

pronounced divergences are at the age of 6 months or younger. These empirical findings are consistent with past comparative studies (de Onis et al. 2006; de Onis et al. 2007).

Conceptually, the WHO growth reference standard for infants and young children is superior to the NCHS growth standard in many fundamental ways. The latter is based on a descriptive approach that describes how American children *actually* grew in 1970s and the former is based on prescriptive approach that describes how the children *should* grow under recommended health practices. These ideal health behaviors include breastfeeding, non-smoking during pre- and post-pregnancy, and sound nutritional and health care practices to minimize restrictions to growth potential. The new standard is international in that it derives from the growth of carefully selected children from six countries, i.e. Brazil, Ghana, Oman, India, Norway and the United States, to represent various parts of the world. A significant improvement of the new growth curve is among children aged 0-23 months for the growth chart was derived from a longitudinal study. The NCHS, on the other hand, is based on cross-sectional data across all age groups. The NCHS growth standard's poorest accuracy is among the infants aged 0-6 months where there were thin observations and the growth curve was basically derived from a mathematical smoothing function (Greer 2008).

Beside the difference in population, methodology used is the other critical difference that distinguishes the WHO standard from the NCHS 1978. While the WHO 2006 utilizes LMS method to address the skewness of the data so as to generate fitted curve that closely follow the empirical growth, the NCHS 1978 did not. The CDC 2000 growth standard employs LMS methodology to improve upon the NCHS 1978. The failure to address the skewness together with a transition from recumbent length to height measurement at age 24 months may have explained the observed spikes of stunting, wasting and underweight at the 12-23 month age group.

Under-nutrition situations of the Zambian preschoolers have shown signs of gradual improvement. Stunting and non-stunting children alike are all growing taller and heavier. Rising per capita income and improved public health services may have contributed to the overall development.

Categorically, nutritional situation in Zambia has not changed since 1991. The nutritional pattern as defined by WHO threshold classification (WHO 2000) was and still is characterized by low prevalence of acute malnutrition and critically high prevalence of chronic malnutrition. However, changes in intensity of degree of seriousness are occurring in opposite directions. While the acute malnutrition that brings death to children is approaching a natural level observed in reference populations, the chronic malnutrition that causes impaired physical and intellectual development has grown more severe than what it was at the start of the economic adjustment program in 1991. Does this mean that food intake is lacking micronutrients that promote linear growth? Perhaps, the answer might be no. A biochemical and parasitic investigations of stunting children in Samfya District, Luapula province, Zambia found that children with linear growth retardation had normal level of zinc and other linear growth promoting biochemical (Hautvast et al. 2000). Similarly, Friis et al. (1997) found stunting children in a neighboring country of Zimbabwe stopped responding to zinc supplement after a period of three months, which implied an existence of other linear growth limiting factors. Hautvast et al. hinted at high prevalence and recurring malaria insults and inadequate caloric intake as more likely causes of severe stunting among Zambian under-fives. Whether these findings are generalizable to other provinces of Zambia requires further study.

With half of children malnourished, a nutritional security situation of Zambian children is in a precarious position. Zambian preschool children are on the edge of falling into a full scale nutrition crisis when a large scale shock either from social or ecological environments hits the economy. Since stunting children may appear small but healthy, there is usually no immediate public pressure for the government to act. With a recognition that investments in education and economic development will not be effective unless undernutrition among small children is significantly reduced (Gross and Webb 2006; Ruel and Hoddinott 2008), the World Bank argued that reducing malnutrition is a key to reduce poverty (Gillespie, McLachlan, and Shrimpton 2003).

Halving prevalence of undernutrition by 2015 was included as one of the target parameters in the first Millennium Development Goal (MDG) of halving extreme poverty by the end of 2015. Assuming that Zambia were able to sustain an annual reduction of undernutrition by 1.2 percent, which was observed in the composite index of anthropometric failure (CIAF) from 1998 to 2006, the CIAF will reach its half of 27.5 percent by the year 2062, approximately 47 years behind the target! To achieve the MDG goal, government needs to increase their efforts by at least five folds assuming linear relationship of government efforts and reduction of CIAF. The International Food Policy Research Institute (IFPRI) recommended emphasis on preventing undernutrition by targeting optimal intervention time which is during pregnancy to age 2 years (Ruel and Hoddinott 2008).

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