PN-ACA-319

Draft for review
March 1995

Evaluating Trends in Children's Nutritional Status in Rwanda

by

Scott Grosse[1]

Katherine Krasovec[2]

Serge Rwamasirabo[3]

Jean Bosco Sibomana[4]

Prepared for USAID under the terms of

Cooperative Agreement (AEP-5459-A-00-2041-00) Add-on for Rwanda Food Security II/ Rwanda

Department of Agricultural Economics
Michigan State University
East Lansing, Michigan

[1] Department of Population Planning and International Health, University of Michigan
[2] Wellstart International, Washington, DC. Formerly Programme Officer for Nutrition, UNICEF/Kigali, Rwanda
[3] Program officer for Food Security, UNICEF/Kigali, Rwanda
[4] National Field Supervisor, Direction des Statistiques Agricoles, Ministry of Agriculture, Rwanda. Currently at Department of Agricultural Economics, Michigan State University

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EXECUTIVE SUMMARY

Introduction

This report analyzes data on anthropometric indicators of Rwandan children's nutritional status to assess whether the extent of malnutrition has been increasing in recent years. Evidence on food production from surveys conducted by the Division des Statistiques Agricoles (DSA) of the Rwandan Ministry of Agriculture (MINAGRI) since 1984 indicates that the per capita availability of own-produced food has been rapidly declining. In the absence of data on trends in food consumption we cannot assume that food consumption has declined proportionately. Offsetting factors include increased unofficial cross-border imports of food from neighboring countries and official food aid. Nonetheless, the presumption is that food availability has been declining at both the national and household level. We know that the vulnerability of rural Rwandan households to food insecurity from drought and crop failure has increased greatly in recent years. Our expectation was that increased household food insecurity would manifest itself in increased prevalence of child malnutrition, but this is not what we found.

Child anthropometry and food security

The potential impact of declining food availability on children's nutritional status is reviewed in an appendix to this report (Appendix 1). We discuss the multifactorial causation of child malnutrition and growth retardation and its implications for the association of food security with children's nutritional status. It is often argued that variations in child feeding practices and household hygiene are much more important causes of malnutrition than is inadequacy of household food availability. However, the relative importance of each of these factors is likely to vary between settings. One must conduct statistical studies investigating the association of household food availability and children's nutritional status in a given country before reaching any conclusions about whether food insecurity is an important cause of child malnutrition in that country.

Evidence from several previous statistical studies of child anthropometry in Rwanda reviewed in Appendix 1 indicates that household food security may be an important

influence on children's nutritional status. In addition, analysis of data from the National Nutrition and Food Security Survey (ENNSA) conducted by DSA/MINAGRI during 1991-92 demonstrates that Rwandan farm households suffering food availability problems are more likely to have poorly nourished children. For example, at round 1, the proportion of children classified as severely stunted (HAZ < -3 SD) was 32.2% among the 40% of children ages 24-59 months living in households which reported having experienced food shortages within the previous year and 22.5% among the remaining 60% of children.

In Appendix 1 we also present evidence that food availability may be even more strongly predictive of nutritional status at the population level than at the household level. Individual-level variations in child anthropometry are dominated by idiosyncratic characteristics and statistical noise. Across regions of the world, changes over time in the prevalence of child underweight appear to be closely related to changes in aggregate food availability. Within sub-Saharan Africa, variations in the prevalence of growth retardation are found to be significantly related to national-level estimates of food energy availability, controlling for per capita income.

Differences in the nutritional status of children across surveys in Rwanda

Rwanda has had more national nutrition surveys than the vast majority of African countries. However, most of these have been based on samples not designed to be statistically representative of the population. Consequently, one cannot necessarily draw valid inferences about national prevalences of malnutrition at different times based on data from those surveys. Despite this, the overall impression is one of steadily declining prevalences of child malnutrition in Rwanda from the late 1960's to the early 1980's. This is consistent with the indications that per capita food production and consumption also rose steadily during the same period.

Three surveys appear to have had nationally representative sample frames. The Rwandan Ministry of Planning (MINIPLAN) carried out a national budget and consumption survey (Enquête Nationale de Budget et Consommation or ENBC) during the early 1980's, in which anthropometric data were collected for samples of preschool children in rural areas in 1983 and in urban areas during 1984-85. During June to October 1992, the Enquête Démographique et de Santé Rwanda (EDSR) was conducted in both rural and urban areas of Rwanda by the Office Nationale de Population (ONAPO) as part of the Demographic and Health Survey (DHS) program financed by USAID (Barrère et al., 1994). Finally, the

Enquête Nationale sur la Nutrition et la Securité Alimentaire (ENNSA) was conducted by DSA/MINAGRI on an ongoing basis from November 1991 to early 1994 under the sponsorship of UNICEF/Kigali and with additional assistance from USAID provided through Food Security II/Rwanda. Since the ENNSA was carried out on a sample of farm households, we compare the results with the rural subsamples from the ENBC and EDSR.

In this paper we present information from unpublished tabulations of data for the first four rounds of the ENNSA. These survey rounds were conducted during November-January 1991-92, February-May 1992, July-October 1992, and December-January 1992-93. We present the prevalences of undernutrition indicated by proportions of children with z-scores for height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) more than 2 standard deviations below the international reference, along with the means and standard deviations for each of the distributions for the four rounds. Comparing the four rounds of data, statistical tests show no clear evidence of changes between late 1991 and early 1993 in the prevalence of malnutrition in Rwanda. The prevalence of underweight (WAZ < -2) was significantly lower in round 3 than in the other 3 rounds, and the mean WAZ and WHZ scores were also significantly higher in that round. However, this appears to be a statistical aberration rather than a genuine, albeit temporary improvement. The EDSR survey, which was carried out at the same time as round 3 of ENNSA, reported prevalences of underweight and wasting (WHZ < -2) which were comparable to those of the other ENNSA rounds and significantly higher than in the round 3 data.

Excluding round 3 of ENNSA, data on weight-for-age display rough stability across the three surveys for which we have tabulations available. The proportion of children ages 0-59 months classified as underweight was 31.4% in 1983, 30.0% in the 1992 EDSR, and 28.8% in the round 1 ENNSA during 1991-92. The mean WAZ was -1.33 in the rural ENBC, -1.37 in the rural EDSR subsample, and -1.39 in the round 1 ENNSA. None of these differences were statistically significant. The prevalences of low anthropometric values in the rural ENBC survey are overstated by age misstatement, but since the age misstatement appears to have been random, mean values do not seem to have been affected. The rural ENBC and ENSSA survey data were both subject to very substantial age misstatement, which resulted in bloated standard errors and overstatement of prevalences of low values in preliminary reports. For the ENNSA, this problem was resolved in the case of the first three rounds by taking advantage of the fact that all three rounds were based on a single cohort of households. Comparison of information on child

ages and birth dates among the three rounds and also with reference to a household demographic registration form completed for each household in the sample during October 1990 allowed us to correct birth dates and to exclude cases where the birth dates were either unknown or implausible.

Height mismeasurement appears to be an important source of difficulty in interpreting differences in the HAZ and WHZ indicators across surveys in Rwanda. The EDSR reports significantly lower prevalences of stunting (HAZ < -2) than either the rural ENBC or the ENNSA, which appears to be due to systematic understatement of infant lengths and child heights in the latter two surveys. In particular, the prevalences of low HAZ in infants under 6 months of age are much higher in these surveys than in the EDSR, the urban ENBC, or in surveys from other countries. In addition, the mean HAZ in the rural ENBC is biased upwards by the inclusion of a large number of positive outliers which are clearly due to measurement or recording error. This accounts for the fact that the mean HAZ in the rural ENBC is significantly higher than in the ENNSA, even though the proportion with low HAZ was also higher. Because of the apparent pervasiveness of the height measurement problems, use of the HAZ and WHZ indicators may be misleading, as is discussed in Appendix 2 to this report.

Another anthropometric indicator, mid-upper arm circumference (MUAC), was measured in the ENNSA and in two previous surveys in Rwanda collected on non-representative samples. This indicator is a measure of short-term nutritional status which is largely independent of weight-for-height, even though the proportion of children over 12 months of age with MUAC below 12.5 cm corresponds roughly to the proportion of children with WHZ below -2 SD. The proportion of children ages 12-59 months with MUAC < 12.5 cm is found to be very slightly and insignificantly higher than in a 1980 survey, while the proportion of children ages 13-36 months with similarly thin arms is found to be very slightly and insignificantly lower than in a 1987 survey. In addition, there are no significant differences in MUAC values across survey rounds within the ENNSA.

Data on children in urban Rwanda are available from three surveys, the urban ENBC of 1984-85, the Kigali Urban Health and Nutrition Study (KUHNS) carried out in May-June 1990, and the urban sample for the EDSR of 1992. The proportions of children with low HAZ values are erratic across these three surveys as a result of lack of comparability in height measurements, but the proportion with low WAZ values is much more stable. The prevalence of underweight is 22% in 1984-85, 22% in 1990, and 18% in 1992. One possible explanation for the apparent improvement between 1990 and 1992 is that many

thousands of disadvantaged urban residents who lacked work permits were obliged to leave Kigali during 1990-91.

Conclusion

The analyses reported here all lead to the conclusion that there was no worsening in the nutritional status of children in established rural and urban populations of Rwanda between the early 1980's and the early 1990's. The nutritional situation of internally displaced populations in Rwanda during the early 1990's was more grim, and varied with the availability of food aid. Slightly over 4% of Rwandans lived in displaced camps in 1993. Representative population-based surveys have covered only the non-displaced population and hence lead to a very slight downwards bias in the prevalence of malnutrition during the early 1990's.

Data on maternal anthropometry are also available from the ENNSA and provide another perspective on nutritional status of the farm population. While these data cannot be compared with other data from Rwanda to calculate trends, they are a useful benchmark for assessing the nutritional status of the Rwandan farm population as of 1991-92. The proportion of adult non-pregnant women with body mass index (BMI) below 18.5 kg/m^2 is an indicator of chronic energy deficiency in a population. The proportions of non-pregnant Rwandan women with low BMI values in the various ENNSA rounds, 5 to 9%, are among the lowest reported for rural African populations. This is unambiguous evidence that chronic deficiency of food energy was not a widespread problem in Rwandan farm households during 1991-92.

In summary, we find no evidence from the anthropometric data that food availability appreciably worsened in Rwandan farm households during the period from the early 1980's to the early 1990's. Nor was there any evidence of short-term deterioration during the crisis years of late 1991 to early 1993. The sources of resilience which allowed Rwandan farm households to maintain their nutritional situation in the face of economic and political crisis and agricultural stagnation bear further investigation.

Introduction

This paper utilizes data from the National Nutrition and Food Security Survey, or Enquête Nationale sur la Nutrition et la Securité Alimentaire (ENNSA), to analyze trends in the nutritional status of children in Rwanda. Beginning in November 1991, the Direction de Statistiques Agricoles (DSA) of the Ministry of Agriculture (MINAGRI) collected anthropometric data for cohorts of children under 5 years of age and their mothers on a regular basis. This panel study was conducted at the initiative, and with the direct financial and technical support, of UNICEF/Kigali. Additional activities were also supported by funds provided to DSA from USAID through Food Security II/Rwanda. Additional data cleaning supported by Food Security II/Rwanda has since been conducted at Michigan State University.

The National Nutrition and Food Security Survey was developed at the impetus of UNICEF/Kigali as a nutritional surveillance system in which information was to be collected on an ongoing basis. Between late 1991 and early 1994, data were collected in a total of six rounds from two successive panels of farm households. The first panel of roughly 1200 households with preschool-age children were part of the extended-sample cohort of roughly 2500 families which had been followed up by DSA since late 1988. The first round of data collection for the nutrition survey took place between November 1991 and January 1992. The second round stretched from February to May 1992. The third round lasted from July to October 1992. Beginning with the 1993 crop year (starting in October 1992), a new cohort of farm households was recruited by DSA, and three more rounds of nutrition survey data were collected for the new sample. Only the data for the three rounds from the first panel and the first round from the second panel, collected from December 1992 to January 1993, are available at present.

To provide a context for a comparison of the statistics based on the ENNSA with those from other surveys, we begin with a brief review of the economic and political situation in Rwanda through 1993. We next discuss the interpretation of anthropometric indicators of nutritional status in children and the question of their suitability for assessing changes in food security at the population level. While the nutritional status of very young children is a good indicator of a broad range of living conditions, it is not necessarily a very sensitive indicator of household food security. Furthermore, methodological difficulties in collecting anthropometric data under field conditions and differences in survey design and management can render the comparison of

anthropometric data from surveys collected by different organizations difficult at best (Gorstein and Akre, 1988).

Despite these limitations, we believe that we can make some conclusions about trends in the nutritional status of children in Rwanda. It is important to note is that Rwanda has long been reported to have one of the highest prevalences of child growth retardation in sub-Saharan Africa (Bailey, 1975; Schnepf, 1991). The reasons for this are only partially understood, but include a very late introduction of solid foods to infants, a monotonous diet which is virtually devoid of animal protein and fats of any type, the lack of preparation of weaning foods for infants and young children, and extremely poor environmental sanitation with an associated very high prevalence of parasitic and diarrheal diseases.

The prevalence of all forms of malnutrition in preschool-age children appears to have remained stable in Rwanda between the early 1980's and the early 1990's. To the extent there has been any trend, it appears to be in the direction of a slight reduction in child malnutrition and growth retardation. This is in spite of evidence of deteriorating food security in Rwanda during the same period. One possible reason for the apparent stability in the prevalence of child growth retardation is that the major causes of poor growth in children may also have remained stable. Another possibility is that there may have been offsetting changes in child care practices and food availability. A third possibility is that food consumption trends have not deteriorated as much as data on farm production would suggest.

Economic and agricultural trends in Rwanda

Food production and per capita food energy availability

As is discussed elsewhere, the early-1980's were a negative turning point for agriculture in Rwanda (FAO, 1990; UNICEF/Kigali, 1992; Grosse, 1994). Until about 1983, food production in Rwanda consistently expanded more rapidly than population growth. Food production increased by approximately 4% per year, one of the highest rates of growth in sub-Saharan Africa. The increase in production occurred almost exclusively through the expansion of cropped area, with no increases in crop yields per unit of cropped area (Uwizeyimana, 1991). Cropped area grew as a result of cultivation of areas previously devoted to pasture, conversion of forest and swamp land to cultivation, reduced frequency of fallowing, and an increased frequency of cropping.

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As a result of the sustained increases in food production between the early 1960's and the early 1980's, per capita food consumption is also estimated to have risen in Rwanda. The average daily availability of food energy per person is estimated to have risen from 1710 kcal in 1961-63 to 1880 kcal in 1971-73 and still further to 2010 kcal in 1981-83. Caloric availability is then estimated to have fallen to 1950 kcal per person in 1985 and 1798 kcal per person in 1987 (FAO, 1990). The estimates for the earlier years lack precision, and may be understated, but the trend is clear.

In the early 1980's, agricultural production suddenly began to stagnate, as a result of a slowdown in the expansion of cropped area in combination with declining crop yields. A report from the Rwandan Ministry of Agriculture (MINAGRI, 1992) states that total domestic food production fell by roughly 5% from 1984 to 1990. This was based on a comparison of production data from the 1984 and 1990 national farm household surveys (Table 1). This decline is reported to have occurred in spite of the fact that the 1984 harvest had already been depressed relative to normal levels as a result of inadequate rainfall and crop pests (MINAGRI, 1991).

Table 1. Evidence on trends in domestic food production and availability in Rwanda

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total production (DSA) 1984-90 = 100		101.2		106.6	96.9	103.2	96.4	95.9	
Per capita production (DSA) 1984-90 = 100		113.1		110.8	97.1	100.4	90.9	87.6	
Per capita domestic calories (DSA)		1932		1892	1659	1715	1552	1496	
Total production (FAO) 1984-90 = 100	100.4	92.6	108.2	99.4	99.3	95.1	103.7	101.5	106.8
Per capita production (FAO) 1984-90 = 100	113.4	101.7	115.4	102.7	99.4	92.0	97.0	91.8	93.3
Caloric availability 3-year moving average (FAO)	1983	1952	1889	1875	1737	1703	1659	1666	1624

Sources: FAO (1991; 1993), MINAGRI (1992)

The Food and Agriculture Organization of the United Nations (FAO, 1993) provides independent estimates of domestic food production in Rwanda which differ from the DSA data but confirm the impression of stagnation. The FAO estimates that total food production in 1990 was 10% higher than in 1984, owing to the depressed level of the

1984 harvest (Table 1). In comparison with normal crop years (1983 and 1985), total domestic food production in 1990 was higher by about 1%. Between 1990 and 1992, domestic food production in Rwanda is reported by the FAO to have increased a further 5%, which is about the same as the rate of population growth during the same 2-year period. On an annual basis, from 1981-83 to 1992, total food production in Rwanda can be calculated to have increased by an average of only 0.5% per year. This is a drastic slowdown from the impressive rates of increase which had consistently been recorded in Rwanda up to the beginning of the 1980's.

The year-to-year changes in total food production for the DSA and FAO series are mostly comparable for the years for which both sets of data are available, with the singular exception of the change between 1988 and 1989. According to DSA data, total production declined by 7% between 1988 and 1989, while according to FAO estimates, total production increased by roughly 9% between those two years. This one discrepancy is entirely responsible for the more bleak impression conveyed by the DSA data relative to the FAO data for the entire period. What is the explanation for the difference between the two series limited to this one-year interval? Only two possibilities suggest themselves. First, the DSA data have been collected from varying samples. From 1989 to 1992, the production data were collected from a single panel of 1248 households followed on a continuous basis. One possibility is that the cohort followed beginning in 1989 had substantially lower productivity on average than the samples studied in previous years. The other possibility is that the FAO changed their methodology in 1989 in a way which resulted in a ratcheting upwards of estimates of production for that year and all subsequent years. There is no indication that the FAO changed their methodology at that time.

With stagnant total domestic food production, estimation of per capita domestic food production depends upon the population figures, which are necessarily imprecise. The August 1991 census indicated a total population of 7.15 million (MINIPLAN, 1993), but this may have reflected an undercount. The intercensal growth rate in comparison with the 1978 census was 3.1% per year, which was not constant over the period. Birth rates began falling rapidly after 1983, with a roughly 20-25% decrease in fertility rates between 1983 and 1991. Retrospective birth history data from the 1992 Demographic and Health Survey confirms that the decline began around 1982 and accelerated beginning in 1986 (Barrère et al., 1994). We have estimated annual population figures assuming a growth rate of 3.5% per year from 1978 to 1983, of 3.2% per year from 1983 to 1986,

and of 2.6% per year from 1986 to 1991. The resulting population totals almost exactly coincide with the population totals used by the FAO (1991) for successive 3-year periods from 1979-81 to 1986-88, although the FAO does not indicate how their population projections were made.

By all accounts, per capita food production declined during the second half of the 1980's. According to Ministry of Agriculture survey data, the per capita availability of food energy from domestic production of major food crops fell by 23% between 1984 and 1990, from 1932 kcal per person per day in 1984 to 1496 kcal per person per day in 1990 (MINAGRI, 1992:35). The decline is slightly overstated, because MINAGRI assumed that population growth rates were constant throughout the period, which is certainly not correct. Our revised population figures suggest that the rural population probably grew by roughly 18% between 1984 and 1990 rather than by 22%, so per capita availability would have declined by 20% rather than 23%.

The FAO data paint a less drastic picture of declining domestic food availability. Per capita food energy availability is estimated to have declined by about 10% between 1984 and 1990, from an index of 88.7 (1979-81 =100) to a value of 80.0 (FAO, 1993). However, as already noted, 1984 was a very bad crop year, so this understates the actual decline. Based on a 3-year moving average (sixth row in Table 1), there was a steady decline from 96.1 in 1984 (1983-85), relative to the 1979-81 average, to 82.0 in 1990 (1989-91), a decrease of 14%. In terms of calories per person per day, the decline is from 1952 kcal to 1666 kcal.

The decline in per capita domestic food production as reported in Table 1 probably substantially overstates the decline in per capita food availability. From another FAO source we have estimates of food availability based on domestic production, change in stocks, and net imports (FAO, 1991). These estimates are provided for successive 3-year periods. The average value of per capita food energy availability is reported to have been 1999 kcal per person per day during 1982-84, 1936 kcal during 1984-86, and 1830 kcal during 1986-88. This decline between the first and last periods is a magnitude of 170 kcal/person/day, which is quite large in absolute terms. The comparable number relative to decline in energy availability based just upon the FAO domestic production data is 275 kcal/person/day during the same period of time.

No direct information on change in food consumption levels in Rwanda is available. Given that Rwanda is a landlocked country where the cost of transportation

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makes the unsubsidized importation of bulk foods from overseas prohibitively expensive, domestic food availability is largely determined by domestic food production. The FAO (1991) estimates that in the mid-1980's less than 2% of Rwanda's food needs were met by imports. Accordingly, one might use domestic food production in per capita terms as a rough proxy for domestic food availability in Rwanda at that time, except for 1984-85 when food aid flowed into the country (Pottier, 1986). However, as we discuss below, the official import figures grossly understate the amount of food being imported into Rwanda from neighboring countries.

From 1989 onwards even more substantial amounts of food aid were brought into Rwanda and on a long-term basis. Accordingly, one cannot calculate per capita food availability after this point without estimates of these imports. Until 1990, the Rwandan government had made it difficult to import food, in order to protect local producers. The structural adjustment program adopted at the behest of the World Bank and the International Monetary Fund in late 1990 obliged them to abandon these restrictions. According to Chossudovsky (1994), cheap, subsidized food imports from European countries poured in. As a result, domestic food production is said to have fallen.

A substantial cross-border trade in foodstuffs which escaped official notice seems to have increased in magnitude during the 1980's (Pottier, 1986). In particular, important quantities of beans, one of Rwanda's two major staple foods, were being imported from Zaire and Uganda, where relative prices differed and made the cultivation of beans cheaper. Loveridge (1988) estimated that imports of beans were equivalent to 14% of total bean consumption in Rwanda, virtually none of which entered into the statistics generated by the Ministry of Agriculture and FAO. Loveridge notes that these increasing unofficial food imports were financed by sales of livestock, palm wine, and reconditioned second-hand clothing imported from Europe, among other things. By 1989-90, these unofficial food imports appear to have increased quite substantially. Loveridge (1992) estimates that net imports to the farm household sector of Rwanda were equal to 23% of their bean consumption, 14% of their pea consumption, 16% of their sorghum consumption, and 7% of their cassava consumption. This includes the differences between purchases and sales by farm households. The national level imports would necessarily be substantially greater, since the consumption of the 7% of the population living in non-farm households would almost entirely add to this deficit.

Another source of food for which we lack data is urban agriculture. The urban ENBC survey of 1984-86 estimated that slightly over 5% of all urban food consumption

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was produced directly by urban households (Schnepf, 1992b). No subsequent estimates are available. It is quite possible that the amount of food produced by urban agriculture in Rwanda has been increasing over time (Pottier, 1989). Given the small size of the urban population of Rwanda (roughly 5% of the total population) this could only have a trivial impact on national food availability, although it may be important for food security in vulnerable urban households.

In terms of food security, we do know that by the end of the 1980's the vulnerability of rural Rwandans living in disadvantaged parts of the country, especially Gikongoro, Butare, and Kibuye prefectures, had greatly increased. This was directly reflected in the 1989 famine, Rwanda's first famine in almost half a century. The direct effects of this food crisis lasted through part of 1990. Hundreds of people died, and hundreds of thousands of others became dependent upon international food aid (UNICEF/Kigali, 1992; Reyntjens, 1993). Further food crises occurred during the early 1990's, and in early 1994 there were predictions that a famine might occur again in Rwanda during that year.

Economic trends

Prior to the 1980's, Rwanda was one of the more successful economies in sub-Saharan Africa. The average rate of growth of GDP was calculated by the World Bank to have been 4.9% per year between 1965 and 1980. After 1983, agricultural stagnation brought about a drastic slowdown in economic growth, with the average annual rate of GDP growth reduced to 1.0% per year between 1980 and 1990 (World Bank, 1992). Agricultural output is calculated to have contracted in real terms at a rate of 1.5% per year, while industrial output grew slowly, at 1.2% per year, and services expanded at 3.9% per year. With the population growing at an average rate of 3% per year, per capita output was decreasing exponentially by 2% per year. Actually, the 1980's can be subdivided into multiple, contrasting periods: continued growth in the first couple of years, stagnation in the middle, and decline in absolute terms at the end of the decade. The average rate of growth of per capita income was a positive 0.4% per year during 1981-86 and a negative 5.5% per year from 1987 through 1991 (Chossudovsky, 1994).

A second turning point in the Rwandan economy occurred between 1987 and 1989. Rwanda used to derive 80% of its export revenues from coffee, mostly grown by smallholders as the main cash crop. The collapse of the International Coffee Agreement and world coffee prices between 1987 and 1989 resulted in a 40% decline in export

revenues between 1987 and 1989. Coffee sales accounted for 82% of all export earnings in 1986, and for only 59% of a smaller total in 1991 (Reyntjens, 1993). During the first two years of the fall in coffee prices, the government had maintained producer prices, which previously had been far below world market levels. By 1989, the government could no longer sustain this.

The government was also obliged to devalue the currency by 50% and to adopt massive budget cuts as part of a structural adjustment program announced in November 1990. The resulting inflation reduced the purchasing power of salaries and other money incomes. These budget cuts are said to have further contributed to increased economic deprivation in Rwanda ("brutal impoverishment') and helped set the stage for the political crisis which engulfed the country (Chossudovsky, 1994; Newbury and Newbury, 1994).

The civil war which began in October 1990 also caused severe economic hardship. Even before April 1994, this war had caused major economic and social dislocation in Rwanda. Approximately 40% of the central government budget went to the war effort. Much of northern Rwanda in areas bordering Uganda was occupied by RPF troops, and fighting took place in other areas as well. This deprived the government in Kigali of the revenues from the export crops grown in those areas. Most damaging was massive population displacement. By February 1993, more than 1 million people out of not quite 8 million people in Rwanda had become displaced at least temporarily, and roughly 350,000 were living in camps for displaced persons. Also, the closure of the border with Uganda greatly raised transportation costs for imports and exports, since the major land route to the coast runs through Uganda and Kenya. Transportation through alternative routes was also periodically disrupted.

Anthropometric indicators of children's nutritional status

The major anthropometric indicators used to assess children's nutritional status are height-for-age, weight-for-height, and weight-for-age. Traditionally, values of weight-for-age below a certain percentage of the median in a reference population from an affluent setting are used to diagnose 'protein-energy malnutrition.' However, weight-for-age reflects two distinct components which are typically unrelated to each other, height-for-age and weight-for-height (Keller and Fillmore, 1983). For the last two decades, it has been recognized that height-for-age is the appropriate indicator of long-term or chronic malnutrition and weight-for-height is the appropriate indicator of short-term or acute malnutrition (Waterlow, 1972, WHO Working Group, 1986; Gorstein et al., 1994).

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Children who are very short for their age are conventionally said to be 'stunted' and children who are very thin for their height are said to be 'wasted.'

Standardized anthropometric indicators can be utilized both as continuous variables and as dichotomies relative to defined cutoffs which are used to classify children as being either malnourished or normally nourished. The three major forms in which standardized indicators can be expressed are percent of median, centiles, and standard deviation or z-scores (Cole, 1993). Centiles have traditionally been used in growth charts in industrialized countries and percent of median in developing country populations. In the past, it was conventional to use 80 percent of the median weight-for-age or weight-for-height in the reference population as cutoffs below which children were classified as being underweight or wasted and 90 percent of the height-for-age median for classifying children as stunted. The disadvantage with these indicators is that their meaning in terms of relative ranking changes with age. In particular, as children get older, the distribution of normal weights and heights widens, so that a given percent of median corresponds to a progressively less severe state of malnutrition (Shann, 1993).

Since the late 1970's, it has been accepted practice to use cutoffs set at -2 standard deviations below the reference median (Waterlow et al., 1977; WHO Working Group, 1986; Dibley et al., 1987b; Gorstein et al., 1994). The standard deviation scores are better known as 'z-scores' and we use HAZ, WAZ, and WHZ to refer to z-scores for height-for-age, weight-for-age, and weight-for-height, respectively. Each of these indicators has a mean of zero and a standard deviation of unity. Non-statisticians generally find percent of median to be a more intuitive concept, but z-scores have the advantage of more consistently classifying the nutritional status of children of different ages. In a population with growth similar to the reference population, one would find roughly 2.5% of children below the -2.0 SD cutoffs for each indicator. Fortunately, it makes little practical difference whether one uses z-scores or percent of median for calculating prevalences in preschool children, as long as one consistently uses the same type of measure and the same reference for evaluating different samples (Haas and Habicht, 1990).

Traditionally, the Harvard growth reference was used for calculating percent of median, especially for weight-for-age. This reference is an outmoded single-sex standard which neglects the fact that normal growth curves for girls lie below those of boys. Further, the Harvard reference can only be used with percent of median since it does not provide standard deviations. Since the 1980's the convention has been to calculate z-scores using the NCHS/CDC reference adopted and propagated by the WHO as the

international reference for growth curves (WHO Working Group, 1986; Gorstein et al., 1994). Drawbacks to this reference include the fact that there is a disjunction at 24 months of age, partly because recumbent length is measured below this age and standing height above it, but primarily because the curves below 24 months of age were based on a select population of children who were taller and heavier than the children comprising the sample for older ages (Dibley et al., 1987a). This accounts for the universal finding that height-for-age is higher on average in 24-35 month old children than in 12-23 month old children (see Table 3).

Anthropometric indicators are reliable only at the population level as indicators of nutritional status in preschool-age children (Gorstein and Akre, 1988). Differences in body measurements among individual children are dominated by genetic and other idiosyncratic characteristics. In contrast, differences in average heights among prepubertal children of varying ethnic groups but high-socioeconomic status tend to be very small in magnitude relative to observed differences associated with environmental factors (Habicht et al., 1974; Frisancho et al., 1980; Martorell, 1985). Changes over time in average height are very closely related to changes in dietary and living conditions (Tanner, 1987). Whenever living conditions improve markedly, the prevalence of linear growth retardation rapidly diminishes, regardless of ethnicity (Malina, Martorell, and Mendoza, 1986; Yip, Scanlon, and Trowbridge, 1992). Conversely, declines in food availability can lead to leftward shifts in the distribution of heights. For example, during the collapse of living standards in Japan in the 1940's, the trend towards increasing child heights halted and reversed (Kimura, 1984). These studies and many others have demonstrated that changes in child heights and weights can be very sensitive diagnostic indicators of changes in living standards and food security (see Appendix 1).

Weight-for-height is useful for diagnosing individual children as acutely malnourished and for detecting sudden food crises at the population level (Bloem and Mulder, 1990; Kelly, 1992). It is less useful for classifying the usual nutritional status of populations, since prevalences of low values of weight-for-height tend to quickly return to normal following the acute phase of a crisis. For example, in a rural district in northwestern Rwanda, the proportion of children with weight-for-height below 80% of the reference median was 11.0% in late 1985 during an acute food crisis, and this fell to 2.2% just 12 months later (von Braun, de Haen, and Blanken, 1991). In most undernourished populations, the prevalence of low values of weight-for-height is quite low, since children either adapt to inadequate dietary intakes by slowing down linear

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growth to compensate (Martorell, 1982), or die. Furthermore, weight-for-height is not linearly related to nutritional status but is sensitive only to large deviations from the norm (Habicht, Yarbrough, and Martorell, 1979).

A fourth anthropometric indicator which is less commonly used in routine nutritional surveillance is mid-upper arm circumference (MUAC). This indicator is often used for rapid assessment in emergency situations because it does not require interviewers to carry scales or measuring boards and is not dependent upon accurate age assessment. Like weight-for-height, MUAC is a good indicator of nutritional status only at the extremes (Tomkins et al., 1978). At the individual level, MUAC and weight-for-height are less than perfectly correlated, and often classify different children as malnourished (Gayle et al., 1988). Some researchers have taken this as reason not to use MUAC to diagnose malnutrition, but this reasoning overlooks the fact that the prevalence of low MUAC values may be extremely useful for categorizing the prevalence of malnutrition at the community level (Loewenstein and Phillips, 1973; Smith and Heywood, 1991). Also, MUAC is reported to be superior to weight-for-height in discriminating children who are severely underweight relative to their age (Shakir, 1979; Trowbridge and Staehling, 1980). Further, there is no good reason why either weight-for-height or weight-for-age should be considered the gold standard for defining malnutrition, since low MUAC values may be better at discriminating which malnourished children are at greatest risk of dying (Briend et al., 1987; 1989a).

Many analysts have observed that the use of the standard cutoffs of 12.5 cm and 13.5 cm to detect severe or moderate malnutrition, respectively, in children over 12 months of age results in much higher proportions of children classified as malnourished than is true using standard cutoffs for WHZ. The obvious solution is to use lower cutoffs for MUAC. Specifically, 11.5 cm for severe and 12.5 cm for moderate malnutrition generally give prevalences comparable to standard cutoffs for WHZ (Carter, 1987). Several studies have demonstrated that a cutoff of 12.5 cm corresponds most closely to cutoffs of 80% of median for weight-for-height or -2 SD (Shakir, 1975; Frerichs, Becht, and Foxman, 1981; Lintjorn, 1985; Carter, 1987; Isherwood, Dimond, and Longhurst, 1988; Bloem and Mulder, 1990). For the same reason that one does not use WHZ < -1 SD as a cutoff for measuring acute malnutrition, it may not be advisable to use MUAC below 13.5 cm to diagnose acute malnutrition. In part because arm circumference rises with age, one should calculate age-sex-specific z-scores for MUAC in place of absolute

measurements, but at present there is no readily available algorithm for doing so (Hall, Chowdhury, and Bloem, 1993).

Assessing trends in nutritional status in Rwanda

Children's nutritional status has been well-studied in Rwanda compared to most African countries. National surveys in which anthropometric measurements were collected from hundreds or thousands of children were conducted in 1969, 1971, 1976, 1982-83, 1985-86, 1987, 1992, and also on a quarterly or half-yearly basis from late 1991 through early 1994. Each of these surveys covered the rural population of Rwanda, which has consistently comprised about 95% of the total population of the country. Two of these surveys also covered the urban population. We focus on data for the rural population of Rwanda, since this includes virtually the entire population. In addition, a number of smaller surveys of child anthropometry have been carried out. This includes information on weight-for-height of under-5 children in displaced person camps in northern Rwanda from May 1992 onwards.

Because of the divergent trends in agricultural production statistics before and after the early 1980's, it may be necessary to separately evaluate trends in child anthropometry for these two different periods. The expectation is that there would be an improvement in nutritional status between the 1960's and the 1980's followed by a deterioration. Based on the gloomy agricultural and economic statistics from Rwanda, one might reasonably expect children's nutritional status to have deteriorated sharply in Rwanda during the late 1980's and early 1990's as in had in Ghana during the first half of the 1980's (see Appendix 1). However, despite the evidence of increasing food insecurity in Rwanda since the mid-1980's, surveys have not substantiated a trend toward increased malnutrition.

Surveys in rural samples

A substantial number of studies of child anthropometry have been carried out in rural Rwanda. These have used a variety of indicators, growth references, and age ranges, which limits the comparability of results across surveys. National nutrition surveys were conducted in 1969, 1971, 1976, 1985-86, and 1987, each of which used percent of median, and most of which seem to have used the Harvard reference. None of these surveys was based on a sampling frame which was statistically representative of the population of the country. We discuss in some detail the findings of each of these surveys.

The reader who is interested only in recent trends in Rwanda may skip the sections dealing with percents of median, based on either the Harvard or international reference, and move directly to information on z-scores.

1. Using the Harvard reference for weight and height

The first national surveys of child anthropometry in Rwanda were conducted by the World Health Organization in 1969 and 1971, the first measuring 430 children under 5 and the second one measuring 7021 children (FAO, 1990). The second survey is the largest survey of its kind ever conducted in Rwanda. No information is available which would allow one to assess the representativeness of the sampling frame for either of these surveys. According to the FAO (1990), the proportion of children with weight-for-age below 80% of the Harvard reference median was 59% in the first survey and 54.7% in the second one. Substantial confusion exists in the literature as to just what either of these surveys found. According to Bailey (1975), the WHO found 65% of children to be underweight in the first survey. This proportion was the highest reported from any of the surveys conducted by the WHO in African countries which were reviewed by Bailey. UNICEF/Kigali (1988) reports that the second WHO survey found that only 45% of children were below 80% of the weight-for-age median, which might be a typographical error.

A second national survey was conducted involving 3,029 rural children ages 0-5 years in 12 selected communes in 1976 (Meheus et al., 1977; van Sprundel et al., 1979). This survey was intended to be representative of rural Rwanda, although not representative in a statistical sense. The researchers, from Antwerp, Belgium, selected one commune from each of 12 agro-ecological zones without regard to the population residing in each zone. Thus, households located in small or relatively lightly-settled zones were more likely to be included in the sample frame than those living in larger, densely-settled zones. Without sample weighting based on the probability of a household being selected, it is not clear that valid conclusions can be drawn from this survey about the national prevalences of child malnutrition.

The Belgian researchers reported prevalences of low values of three anthropometric indicators relative to the Harvard reference: below 80% weight-for-age, below 90% height-for-age, and below 80% weight-for-height. These three proportions in the 1976 survey are reported to be 39%, 33%, and 6% respectively. The traditional core of west-central Rwanda is represented by 4 communes: Maraba, from the Plateau Central,

Tambwe, from the Dorsal Granitique, Rwamiko from the Crete Congo-Nil, and Nyamyumba, from the shores of Lake Kivu. The underweight proportion for these 4 communes are 46, 45, 37, and 47%, for an average of 44% compared to 39% for the whole sample (Meheus et al., 1977). The proportions of short children in the four communes are 39, 45, 28, and 44%, for an average of 39%, compared to 33% for the whole sample. The proportions of very thin children in the four communes are 6, 4, 8, and 5%, for an average of 6%, the same as for the whole sample. Thus, it is quite plausible that the prevalences of low height-for-age and low weight-for-age are substantially understated in the reports based on the 1976 survey.

A UNICEF/Kigali-funded weaning foods survey (WFS) was carried out in 1987 with assistance from the Cornell Food and Nutrition Policy Program for a sample of 1,847 children ages 6-36 months in 8 selected communes from 7 prefectures. Schnepf (1991) reports that only 23.9% of the 1,328 children in this survey for whom weight measurements were made had weights below 80% of the Harvard weight-for-age median, the lowest figure ever reported from Rwanda. However, the 1987 weaning foods survey was not a random sample, but a partially randomized stratified sample, which overrepresented Kigali city and areas near Kigali and Butare (36.8% of the sample). The proportion of children below 80% of weight-for-age was only 12.6% in the 3 communes located in and around the two cities and 30.6% in the remaining 5 communes. These latter communes are presumably more representative of the rural population of Rwanda.

Some other limited data relating to the proportions of preschool-age Rwanda children classified as malnourished relative to the Harvard reference are also available. Jolly (1988) cites data collected from CRS feeding centers in Rwanda during 1980-84 according to which a stable 40-41% of children were moderately to severely underweight (below 80% of the Harvard weight-for-age median). Hitchings (1979) reports that over half of children attending health centers in Rwanda during 1970-75 were similarly underweight, but sick children were presumably overrepresented in those measures. The FAO (1990) cites estimates from the late 1970's of 49.6% to 38.5% of children attending feeding centers being underweight. In 1985, of 55,280 children under 5 who were newly enrolled in feeding centers, 42.8% were reported to be below 80% of the weight-for-age median (FAO, 1990). Unfortunately, there is no valid basis for making comparisons among these various numbers.

Two articles published in the *Journal of Tropical Pediatrics* in the early 1980's reported the results of anthropometric surveys conducted in localities within the catchment

areas of individual hospitals. Both articles reported on the prevalence of stunting or low height-for-age, but not relative to underweight. The results of these two studies are disparate and difficult to compare with each other or with other studies. Dowler et al. (1980) measured 1,074 preschool age children in selected areas of two communes located close to a mission hospital in Gikongoro prefecture. Using the Harvard standards, they report that the proportion with height-for-age below 90% of median was 6.7% at 0-6 months of age, 14% at 7-12 months, 27% at 12-24 months, 50% at 25-36 months, 56.5% at 37-48 months, 56.6% at 49-60 months, and 58% at 61-72 months. Cant et al. (1982) studied roughly 800 children in 2 rural communities near the Gahini hospital in eastern Rwanda. They report that the overall prevalence of stunting was 31%, peaking at age 30-36 months at 45% in one community and 37% in the other community.

One of the major hazards of comparing data from different studies is variations in the age composition of the sample. The data from the Dowler et al. (1980) study can be used to calculate age-standardized prevalences for varying age intervals assuming a uniform age distribution. Thus, if children were evenly distributed by 6-month age intervals, the prevalence of stunting for ages 0-72 months would be 43%, for ages 0-60 months it would be 40%, for ages 0-48 months it would be 36%, and for ages 6-36 months is would be 34%. Only if all studies report age-specific prevalences and the numbers of children in each age interval is it possible to calculate comparable indicators for comparison of results between studies.

2. Using the international (WHO/NCHS/CDC) reference for weight and height

Percents of median

A national nutrition survey was carried out in Rwanda during December 1985 and January 1986 by the Ministry of Health and Social Affairs (MINISAPASO, 1987). A sample of 2,995 children under five years of age were measured. The sample was drawn from 20 administrative sectors (one per commune) from all 10 prefectures (provinces). The proportion of children below 80% of the NCHS weight-for-age median was reported to be 27.6% (Csete, 1989:67). Schnepf (1991) notes that the sample frame for this survey was not representative, with sectors chosen purposively rather than randomly, since the survey was designed to evaluate the usefulness of clinic-based data. Hence, it is not clear that this survey can be used to calculate valid national-level prevalences. Also, since z-scores were not calculated, the results cannot be directly compared with survey data from Rwanda calculated as z-scores. For example, the prevalence of underweight from the

1991-92 ENNSA survey is 29.3% using -2 SD as a cutoff for weight-for-age z-score and 34.7% using 80% of the CDC/NCHS weight-for-age median as a cutoff.

A longitudinal cohort study was carried out in Giciye commune in Gisenyi prefecture during 1985-86 which reported anthropometric indices as percents of median relative to the international reference. This survey appears to have been carefully done, but the sample chosen was from one of the most advantaged areas of all of Rwanda. The commune selected was very close to the President's home area, was politically well-connected and benefited enormously from outside development projects and remittances from favored migrants working in urban centers (Csete, 1989). Consequently, the distributions of anthropometric indicators were far more favorable than those found elsewhere in rural Rwanda. The proportion of 303 preschool-age children (under 7 years of age) with weight-for-age below 80% of the CDC/NCHS median was only 14.5%, roughly half of that reported in the national nutrition survey taken at close to the same time. The proportion with weight-for-height below 80% of median was 3.3%, and the proportion with height-for-age below 90% of median was 24.8% (Csete, 1989:148).

Two studies have reported height-for-age both in terms of percent of median and z-scores. The proportion of children ages 0-74 months stunted, defined by height-for-age below 90% of the NCHS median, was found to be 37.7% in the 1983 rural budget survey discussed below, compared to 52.3% with HAZ < -2 SD (Schnepf, 1992a). Similarly, the National Nutrition and Food Security Survey data discussed below can be reanalyzed in terms of height-for-age percent of median. Doing this, it is calculated that the prevalence of stunting in children ages 0-59 months using the 90% of median cutoff is 35.7%, compared to 53.4% using -2 SD as the cutoff.

Prevalences of low z-scores

Data from several surveys in Rwanda have now been analyzed in terms of z-scores relative to the international reference. During 1982-83, the Ministry of Planning (MINIPLAN) carried out a national budget and consumption survey (Enquête Nationale de Budget et Consommation or ENBC) with assistance from the French and U.S. governments. This longitudinal survey involved 297 households in rural Rwanda in which anthropometric measurements were taken on 276 children ages 0-74 months during August-November 1983. These data have been analyzed by Schnepf (1992a) on behalf of the Cornell Food and Nutrition Policy Program and UNICEF/Kigali. Schnepf reports that using cutoffs of -2 standard deviations, the prevalences of stunting (<-2 SD HAZ),

underweight (<-2 SD WAZ), and wasting (<-2 SD WHZ) were 52.8%, 29.8%, and 5.4% respectively. The fact that children between 60 and 74 months of age were included in these tabulations means that these proportions should not be directly compared with those from other studies which only include children younger than 60 months. Restricting the sample to children 0-59.9 months of age, one can calculate, based on Table 4 of Schnepf (1992a), that 56.6% of children in the sample were recorded as being stunted, 31.4% were underweight, and 6.1% were wasted (see Table 2).

The ENBC data reported in Schnepf (1992a) have problems. The sample composition is skewed by age and sex. First, almost three fifths (58.6%) of the 276 children included were boys. Second, the sample overrepresented older children. By 2-year age intervals, 40.2% of the sample were aged 5-6 years, 29.7% were aged 2-3 years, and 30.0% were aged 0-1 year. In a normally distributed sample in a population with high fertility and high child mortality, the number of children in each successive age interval diminishes appreciably. In a normal survey, a sample skewed to older children would result in an overstatement of the prevalence of stunting, since older children have a higher prevalence of stunting than very young children. However, the age-specific prevalences in this survey are such that the opposite appears to be true in this case.

The reported prevalences of stunting, underweight, and wasting in the rural ENBC data were divergent across age and sex groups, which may reflect the very small sample size. The proportion of girls with low WHZ scores was reported to be more than twice as high as for boys, 8.2% vs 3.4%. Similarly, the prevalence of stunting is reported to have been 59.6% among girls and 48.0% among boys and the prevalence of underweight is reported to have been 38.8% among girls compared to 23.5% among boys. Most other information from Rwanda indicates that girls are if anything *less* likely than boys to be stunted, underweight, or wasted (e.g., Csete, 1989; MINAGRI, 1993; Barrère et al., 1994), although the MINISAPASO survey also found a higher risk of underweight in girls. By age, the prevalence of stunting is reported to be highest at 12-23 months of age, 72.4%, compared to only 36.4% among children 60-74 months of age (see Table 3). This pattern is quite inconsistent with any age pattern found in the literature. The problems of the ENBC data appear to be specifically greater for heights than for weights, which is not unusual under field conditions with inadequately trained interviewers. These are discussed further below.

In 1992, the Enquête Démographique et de Santé Rwanda (EDSR) was conducted by the Office Nationale de Population (ONAPO) in collaboration with Macro International

Inc. as part of the USAID-supported Demographic and Health Survey (DHS) program (Barrère et al., 1994). Between June and October 1992, a nationally representative sample of 6,252 households, including 6,551 women of reproductive age (15-49 years), were interviewed. These women had 5,042 children of their own under 5 years of age (0-59 months) living with them. Plausible anthropometric data were collected for 87% of the children, or 4,363. It is not known to what extent the missing data introduce a degree of bias in calculating prevalences. Also, it should be noted that these calculations are based on a representative survey of reproductive-age women, not of children. Children being taken care of by women other than their own mothers, or by women over the age of 49 years are necessarily excluded from the EDSR survey. The prevalences for the children in the rural EDSR sample calculated directly from the data file are 49.6% for low HAZ, 30.0% for low WAZ, and 3.7% for low WHZ (Table 2). The data were kindly made available to our project by Macro International Inc. These numbers differ very slightly from those published in the official EDSR report (Barrère et al., 1994).

Table 2. Prevalences of low standardized anthropometric indicators in rural Rwandan children ages 0-59 months

Survey	*Number*	*HAZ < -2*	*WAZ < -2*	*WHZ < -2*
Rural ENBC, August-November 1983	223	56.5%	31.4%	6.1%
Rural EDSR, June-November 1992	4159	49.6%	30.0%	3.7%
Round 1 ENNSA, Nov.-Jan. 1991-92	1847	54.2%	28.8%	3.9%
Round 2 ENNSA, Feb.-May 1992	1628	52.3%	27.5%	4.5%
Round 3 ENNSA, July-October 1992	1521	52.9%	23.8%	2.8%
Round 4 ENNSA, Dec.-Jan. 1992-93	1548	52.6%	27.0%	4.1%

Sources: Schnepf (1992a), unpublished tabulations of ENNSA and EDSR data

The National Nutrition and Food Security Survey offers an abundance of data, with four rounds of data presently available. The first and third rounds were previously tabulated and analyzed in Rwanda, with no report prepared for the second round because DSA staff concluded that it gave the same results as the other rounds. The report for the first round of the ENNSA survey (MINAGRI, 1993a) covers 1939 children nominally ages 0-60 months. Using -2 SD cutoffs, the proportions stunted, underweight, and wasted were reported to be 52.2%, 28.6%, and 5.2% respectively. The report from the third round covered 1642 children ages 0-60 months and stated the prevalences of stunting,

underweight, and wasting to be 56.3%, 25.5%, and 3.8% respectively (MINAGRI, 1993b).

Additional data cleaning on the first three rounds of the ENNSA data set took advantage of the fact that the three rounds covered the same cohort of children. Comparison of reported ages and birth dates of children present in more than one of the three rounds revealed hundreds of cases of discrepancies. We were able to resolve most of the cases of discrepancies, partly with reference to a household demographic registration form completed for each household during October 1990. We excluded cases where the birth date was unknown, implausible, or implied an age of 60 months or greater (to maintain an age range of 0-59.9 months in line with the usual practice). In 15% of the cases in round 1 which were retained, the corrected ages differed from the reported age by a month or more; in 36 cases the corrected age differed by at least 12 months. There was also a systematic tendency to round down ages to the previous completed month, a practice which is known to quite substantially understate the prevalence of malnutrition in infants (Gorstein, 1989). Besides age misstatement, many children's heights were misrecorded. A number of cases where the recorded height measurement was implausible but where no value could be reasonably imputed were dropped. Most cases were retained, some with modifications. In 57 cases in round 1, the discrepancy between the recorded height and the corrected height is calculated to have ranged from 5 cm to 30 cm.

In Table 2 above, we present figures based on the cleaned data from the first four rounds of the ENNSA. For the reasons outlined in the previous paragraph, the prevalences for rounds 1 and 3 differ from the preliminary estimates previously reported. For 1854 cases in round 1, the prevalence of stunting was 54.2%, which is slightly higher than that initially reported for the full sample of 1939 children. At the same time, data cleaning tightened up the distribution of height-for-age values, so that fewer children were reported to be severely stunted (HAZ < -3 SD). According to the DSA report, 25.0% of children were severely stunted, while the revised figures indicate that 24.3% of children had HAZ scores below -3. These corrections also reduced the numbers of children with very low weight-for-height values. Only 3.9% of children in the cleaned sample had WHZ scores below -2, compared to 5.2% in the original data set. The prevalences of underweight were almost identical, 28.8% in the revised sample compared to 28.6% in the original sample.

The round 2 sample gives a slightly different impression for a sample of 1676 children (see Table 2). In part because of displacement in the north of the country during

early 1992, the number of children included in the survey fell between the first and second rounds. These data indicate a slightly lower prevalence of stunting and underweight and a higher prevalence of wasting than in the first round. Based on the cleaned sample, the prevalence of moderate to severe stunting (HAZ < -2) was 52.3%, and the prevalence of severe stunting was 20.5%. Only 27.5% of children were moderately to severely underweight, but 4.5% of children were reported to be wasted.

The round 3 data, for 1558 children in the cleaned data, are intermediate between rounds 1 and 2 in terms of the prevalence of stunting. The prevalence of stunting is reported to be 52.9%, with 22.8% severely stunted. While the revised height data appear reasonable, the weight data from this round pose some problems. The prevalence of wasting is reported to be lower, at 2.8%. The prevalence of underweight, which is a cross between stunting and wasting, was also surprisingly low, at 23.8%. This figure is also quite low relative to the EDSR survey, which was conducted during the same months.

Tests of statistical significance of differences in the prevalence of the various forms of malnutrition were computed utilizing the chi-square test of significance for difference in proportions. Tests were computed relative to the round 1 of ENNSA. According to the results of these tests, only two pairwise comparisons were significantly different at the .01 level of significance. These were the difference in stunting between round 1 of ENNSA and the EDSR (54.3 and 49.0%) and the difference in underweight between round 1 and round 3 of the ENNSA (28.8 and 23.8%). In addition, two comparisons were significant at approximately the .05 level, the differences in wasting between round 1 and the ENBC (3.9 and 6.1%) and between round 1 and round 3 (3.9 and 2.8%). The weak significance of the differences in the prevalence of wasting reflects the low power of a test comparing fractions which are very small in magnitude.

The fact that none of the surveys differed significantly on both stunting and underweight is quite interesting, since if there were systematic differences in nutritional status between surveys one would have expected to find consistent differences for at least two indicators. The fact that the EDSR and the rounds 1, 2, and 4 of the ENNSA are in approximate agreement on the prevalence of underweight, but differ relative to the prevalence of stunting (all differences relative to the EDSR are significant) indicates that there are problems specifically with regard to the measurement of child height or length. The low prevalence of underweight in round 3 is significantly different from that observed in round 1. Whether the difference is real or artifactual is another question, which cannot be answered by the statistical test. Given that the prevalences of underweight and wasting

in round 3 are discrepant with both the EDSR and the other rounds of the ENNSA leads us to not put any confidence in those figures.

The overall prevalence of stunting in the DSA data appear to be somewhat overstated because of measurement problems regarding infant lengths, especially for infants under 6 months of age. The most reliable anthropometric data from Rwanda are probably those from the 1992 EDSR survey. All anthropometric measurements in that survey were taken by trained individuals who were specialized in this single task. Furthermore, rigorous attempts were made in that survey to assess interviewer precision and reliability (Barrère et al., 1994). In the ENNSA, measurements were taken by agronomic interviewers who had received very brief training in anthropometry and whose primary activity was collecting agricultural information. No record was made of which measurements were made by individual interviewers and hence it was not possible to evaluate their reliability and precision.

The EDSR survey had a sufficiently large sample size (4363 children) that age-specific prevalences should be reasonably stable (Table 3). These data indicate that 11.1% of infants under 6 months of age and 32.8% of those ages 6 to 11.9 months had HAZ scores below -2. In comparison, 50 to 60% of older children had similarly low HAZ scores. The cleaned data from round 1 indicate that 17.7% of infants under 6 months of age had HAZ scores below -2, and 45.7% of those ages 6-11.9 months had low HAZ scores (Table 3). In rounds 2 and 3, the degree of underreporting of lengths of infants under 6 months of age seems to have gotten worse, while at 6 to 11 months of age the situation improved. The high prevalence of low HAZ values among the youngest infants is clearly not a random problem due to small numbers of cases in each age interval, since if that were the case the problem of excessive numbers of short infants would not be found in each round. The 1983 ENBC rural sample appears to have overstated the prevalence of stunting in infants to a much greater extent than the ENNSA. Supposedly, 39.7% of infants under 6 months of age had HAZ scores below -2, as did 60.1% of those from 6 to 11.9 months of age (Schnepf, 1992a). In comparison, the urban ENBC corresponds quite closely to the infant lengths from the EDSR, although the heights of older children appear problematic in that survey.

Table 3. Prevalence of low HAZ (< -2 SD) by age intervals for various anthropometric surveys in Rwandan preschool children

	EDSR	ENNSA surveys			ENBC		KUHNS
Age interval	rural	Round 1	Round 2	Round 3	rural	urban	urban
0-5 months	11.9%	17.7%	24.2%	22.3%	39.7%	10.8%	7%
6-11 months	33.8%	45.7%	37.7%	29.2%	60.1%	31.7%	25%
12-23 months	56.0%	58.9%	53.8%	57.8%	72.4%	54.7%	55%
24-35 months	50.9%	51.2%	48.2%	53.6%	62.4%	27.1%	51%
36-47 months	59.2%	63.1%	59.0%	54.4%	44.2%	45.2%	51%
48-59 months	61.6%	62.7%	60.8%	62.3%	54.3%	41.3%	44%

Sources: Schnepf (1992a; 1992b), unpublished tabulations of ENNSA and EDSR data

To avoid the problems caused by mismeasurement of infant lengths, one can calculate prevalences of low height-for-age restricted to children from 12 to 59 months of age (Table 4). For the 1983 ENBC rural sample, it can be calculated that 58.3% of children ages 12-59 months had HAZ scores below -2. For the 1992 EDSR survey, the same proportion is calculated to be 55.4%. This includes the urban subsample, which had a much lower prevalence of chronic malnutrition for all children 0-59 months, 33.4% vs 49.0% in the rural subsample (Barrère et al., 1994). The prevalence for the rural sample alone would be slightly over 56%. For round 1 of the Rwanda Nutritional Status and Food Security Survey, 59.7% of children ages 12-59 months had HAZ scores below -2. In round 2, occurring 1 to 4 months after round 1, only 56.9% of children ages 12-59 months had similarly low HAZ scores. In round 3, which took place 3 to 7 months after round 2 and during the same time period as the EDSR survey, 59.8% of children ages 12-59 months had HAZ scores below -2, virtually the same as in round 1.

Weight-for-age is less subject to measurement error. The prevalence of underweight is reported to have been 31.4% in the 1983 ENBC survey and 29.7% in the 1992 EDSR survey in children ages 0-59 months (Table 2). In the three rounds of the ENNSA survey, the comparable prevalences of underweight are 28.9%, 27.6%, and 24.4% respectively. Curiously, the third round mostly overlapped with the data collection period for the EDSR survey. Previous evidence from Rwanda suggests that there is little seasonal fluctuation in child weights, and it appears that weights may have been differentially overestimated in the third round. The proportion of children with WHZ values more than 2 standard deviations below the international reference was also quite

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low in the third round, only 2.8%, compared to 3.9% in round 1, 4.5% in round 2, and 3.8% in the EDSR survey.

Mean Z-scores and standard deviations

As we discussed in the section on interpretation of anthropometric indicators, one should always examine the means and standard deviations as well as prevalences of low values. Mean HAZ scores have been reported from only a few surveys in Rwanda. The 1983 rural ENBC survey reported that the mean HAZ score was -1.87. In comparison, a study by a team of researchers affiliated with the International Food Policy Research Institute (von Braun, de Haen, and Blanken, 1991) found a surprisingly high -1.50 mean HAZ score for a sample of 238 children under 7 years of age residing in a rural commune in Gisenyi prefecture in northwestern Rwanda. As noted by Csete (1989), who helped collect the data, this area received large transfers of resources because of its proximity to the President's home area and hence was not representative of rural Rwanda.

In Table 4, we compare the HAZ means and standard deviations from the ENBC survey with those from the first and third rounds of the ENNSA survey. For these two rounds, were present both the original data as calculated by DSA and the final cleaned data. The original data are taken from the computer files and refer to those children included in the final cleaning of the data set. Children whose corrected ages were 60 months or above were dropped, as were a number of duplicate records. Thus, the means and prevalences reported for those rounds do not correspond exactly to the published tabulations. The original data are presented for the purpose of comparing the standard deviations in uncleaned and cleaned data from the same sample, since this gives a better idea of the likely sources of error from surveys where a similar thoroughness of data cleaning is not possible.

Table 4. Mean HAZ scores and standard deviations in Rwandan children ages 0-59 months

Survey	*Mean HAZ score*	*Standard Deviation*	*Proportion HAZ < -2 SD*
ENBC 1983, 0-74 months ages	-1.87	1.84	52.8%
ENNSA round 1 original data	-2.01	1.61	51.3%
ENNSA round 3 original data	-2.30	2.91	55.3%
ENNSA round 1 cleaned data	-2.09	1.33	54.2%
ENNSA round 3 cleaned data	-2.06	1.25	52.9%
EDSR 1992 (rural sample)	-1.96	1.40	49.6%

Sources: Schnepf (1992a)
unpublished tabulations from ENNSA and EDSR

Based on our experience with anthropometric data sets, a standard deviation above roughly 1.40 can be taken as a crude indicator of excessive measurement or recording error in HAZ. By this criterion, the ENBC and both rounds of the ENNSA data had excessively high standard deviations. In the rural ENBC survey, values of HAZ below -5.5 SD and above +3.5 SD were apparently deleted, based on the histogram given by Schnepf (1992a). The standard practice of eliminating outliers with z-scores more than 6 standard deviations above or below the reference was not followed by DSA staff. Since most outliers result from random errors, casting them out has little effect on the mean z-score, but this greatly reduces the standard deviation. For example, the round 4 data from the ENNSA show a mean HAZ of -2.01 and a standard deviation of 1.88. After eliminating values above +6.0 and below -6.0, the mean was -2.06 and the standard deviation was reduced to 1.48. This is still too high, but is closer to being reasonable. The high standard deviation in the original data from round 3 of the ENNSA reflected some peculiar data problems, including measurements which were made in inches but recorded as if they had been made in centimeters. The standard deviations for the distributions of HAZ scores in the cleaned data appear plausible.

The difference in mean HAZ between the ENBC and the ENNSA rounds is not indicative of a genuine leftward shift (deterioration) in the distribution of child heights in Rwanda between 1983 and 1992. The distribution curve of HAZ scores presented by Schnepf (1992a) indicates the nature of the problem. An extraordinary bulge in the right tail of the distribution is apparent, such that twice as many children are reported to have HAZ of +2.5 compared to those with HAZ of +1.5 SD. This is a highly unusual

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distribution, since the former should be far fewer in number than the latter. If the aberrant cases in this bulge were eliminated, the mean HAZ score would certainly be substantially lower (a larger negative number), presumably more in line with those of the ENNSA.

Overly large standard deviations in height-for-age can result from both problems of age assessment and height mismeasurement. The way to determine which of these sources of error is more important is to examine the distribution of WAZ scores, since if age assessment is the major problem, the standard deviation for WAZ scores will be blown up as well. In Table 5, we duplicate the preceding table, with WAZ in place of HAZ.

Table 5. Mean WAZ scores and standard deviations

Survey	*Mean WAZ score*	*Standard Deviation*	*Proportion WAZ < -2 SD*
ENBC 1983, 0-74 months ages	-1.33	1.28	29.8%
ENNSA round 1 original data	-1.33	1.26	27.7%
ENNSA round 3 original data	-1.12	1.70	23.9%
ENNSA round 1 cleaned data	-1.39	1.10	28.8%
ENNSA round 3 cleaned data	-1.29	1.07	23.8%
EDSR rural sample	-1.37	1.13	30.0%

Sources: Schnepf (1992a),
unpublished tabulations from ENNSA and EDSR

The data in Table 5 indicate that the degree of distortion of the distribution in the 1983 ENBC was much less for WAZ than for HAZ, which suggests that the major problem was in the measurement of heights. The reported distributions from the 1983 ENBC and first round original ENNSA data are very close. The result of data cleaning, mostly with regard to calculated ages, is to substantially tighten up the distributions, alter the mean WAZ scores, but to leave the prevalences of underweight virtually unchanged.

The distribution of WAZ values is shifted significantly to the right in the third round compared to the first round, as indicated by a t-test. The confidence interval for the difference in means is calculated to range from -0.03 to -0.17, which does not embrace zero. This difference could possibly partly reflects an effect of seasonality. The first round was conducted from late November to mid-January, while the third round was conducted from late July to early October. The time of year when food consumption is lowest in Rwanda is from October through December (Vis et al., 1975), and the first round of the ENNSA largely coincided with this period. On the other hand, the EDSR

was conducted at the same time and did not show any comparable pattern of heavy weights relative to age. Consequently, the significant difference across ENNSA rounds in weights cannot be reliably interpreted.

3. Mid-upper arm circumferences

Another anthropometric indicator which has been collected by several surveys in Rwanda is mid-upper arm circumference (MUAC). At least three surveys in Rwanda conducted under non-crisis conditions have measured children's arm circumferences. A survey in rural Rwanda with over 1,000 children reported that 26% of children ages 1-5 had MUAC measurements equal to or below 13.5 cm, the criterion conventionally used to define moderate malnutrition (Dowler et al., 1980). The same proportion was reported to be 12.4% in the 1983 ENBC survey, but no details are provided (Schnepf, 1991). Next, data from the WFS survey of 1987 indicate that 21.3% of children aged 13 to 36 months had MUAC measures equal to or less than 13.5 cm (Schnepf, 1991). The report based on round 1 of the Rwanda Nutrition and Food Security Survey stated that 26.5% of children aged 13-36 months and 17.3% of those aged 12-60 months had MUAC measures equal to or below 13.5 cm (DSA, 1993). Revised estimates after data cleaning are that in round 1 27.8% and 19.0% equal to or below 13.5 cm.

Table 6. Proportions of children in rural Rwanda with low arm circumferences

	Children ages 1-5 years				Children ages 13-36 months			
	Dowler	ENNSA, 1991-92			WFS	ENNSA, 1991-92		
MUAC cutoff (cm)		round 1	round 2	round 3		round 1	round 2	round 3
< 12.5	3.0%	3.9%	3.5%	3.5%	6.5%	6.3%	6.1%	5.7%
12.5-13.4	23.0%	13.1%	10.3%	11.2%	14.8%	19.5%	14.9%	16.0%
13.5 plus	74.0%	83.0%	86.2%	85.3%	78.7%	74.2%	79.0%	78.3%

Sources: Dowler et al. (1980)
Schnepf (1991)
unpublished tabulations of ENNSA data

Data on the proportions of children with arm circumferences below 12.5 cm, the criterion used to define severe malnutrition, appear to be more nearly comparable across surveys conducted in non-emergency situations. The proportion was 3% in the survey by

Dowler et al. (1980) for children ages 1-5 years. The comparable proportion was 3.9% in the 1991-92 DSA survey round 1. For children ages 13-36 months, who are more likely to have smaller arms than older preschool children, the proportion was 6.5% in the 1987 WFS survey and 6.3% in round 1 of the ENNSA survey. The discrepancies across surveys lie almost entirely in the proportion of children with MUAC of 12.5-13.5 cm, which is reported to be 23% by Dowler et al. (1980) and 13.1% for children ages 1-5 in the round 1 ENNSA. For children ages 13-36 months, the proportion with MUAC of 12.5-13.4 cm is reported to be 14.8% in the 1987 WFS survey and 19.5% in the 1991-92 round 1 ENNSA survey.

As is discussed in an earlier section of this report, a cutoff of 12.5 cm roughly corresponds to -2 SD for WHZ and hence is more interpretable than use of 13.5 cm as a cutoff. The data from the first row in Table 6 indicate overall stability in the prevalence of malnutrition in terms of arm wasting, which is consistent with the anthropometric data considered in previous sections. Compared to Dowler et al. (1980), a very slightly larger fraction of children aged 12-59 months in the ENNSA had MUAC < 12.5 cm. On the other hand, the proportion of low MUAC values was slightly lower in children aged 13-36 months in the ENNSA compared to the 1987 Weaning Foods Survey. On the other hand, given that neither of those surveys were based on representative sample frames, one can make no inferences about long-term trends. The short-term trends based on comparisons just within the first three rounds of the ENNSA would suggest a very slight reduction in acute malnutrition during 1992, among the non-displaced farm population.

Weight-for-height in displaced rural children, 1992-93

The civil war expanded in early 1992 and displaced much of the population living in Byumba prefecture in the north of Rwanda. After a second round of fighting in early 1993 displaced even more people, approximately 350,000 people were living in displaced person camps. The Rwandan Ministry of Health in collaboration with UNICEF/Kigali instituted a nutritional surveillance program to track changes in the nutritional status of under-fives in the camps of displaced persons reliant on food aid. Unpublished tabulations supplied by UNICEF/Kigali to the ACC/SCN in Geneva are available for the periods from September to December 1992 and from May to October 1993. These tabulations include the proportions of children with WHZ more than 2 standard deviations below the international reference. In addition, the prevalences of severe wasting (WHZ < -3) are available.

During October and December 1992, the emergency nutritional surveillance system covered children ages 0-5 years in six camps. In October, the prevalence of wasting ranged from 5.2 to 14.2% across camps, and the median was between 9.8 and 11.9% (Table 6). This is in comparison to prevalences of only 3.8-3.9% in the EDSR and first-round ENNSA surveys (see table 2). In December 1992, the prevalence ranged across camps from 6.2 to 12.6%, and the median was between 10.2 and 11.4%. This indicates a very high level of acute malnutrition among the populations of the displaced camps at both points in time, but with no worsening between the two dates.

Table 6. Prevalence of acute malnutrition (WHZ < -2) in children ages 0-5 years in displaced camps in Byumba prefecture, 1992-93.

Survey	Oct 92	Dec 92	May 93	June 93	July 93	Aug 93	Sept 93	Oct 93
Range	5.2-11.4%	6.2-12.6%	6.8-27.0%	7.9-21.0%	7.2-18.0%	6.2-15.8%	5.3-13.6%	2.0-5.1%
Median	10.9%	10.8%	14.6%	11.0%	10.4%	7.8%	6.6%	3.7%

Source: Unpublished tabulations, UNICEF/Kigali

From May 1993 onwards, the under-five population of 8 to 12 displaced camps were examined on a monthly basis. In May, the prevalence of acute malnutrition (WHZ < -2) appeared substantially more severe than in the previous December, ranging from a low of 6.8% to an extraordinary high of 27.0% (Table 6). The median was 14.6%. In June, the range was from 7.9 to 21.0%, with a median between 10.6 and 11.1%. In July, the range was from 7.2 to 18.2%, and the median was 10.4%. In August, the range was from 6.2 to 15.8%, and the median was only 7.8%. In September, the range was from 5.3 to 13.6%, and the median was 6.6%. In October, the prevalence of acute malnutrition is reported to have suddenly dropped drastically, ranging from 2.0 to a high of only 5.1%. The median value was only 3.7%, which is virtally identical to that of the non-displaced child population of Rwanda.

The information on the prevalence of acute malnutrition in children living in displaced camps in Byumba prefecture during 1992-93 is consistent with the experience of emergency relief situations around the world. In famine crisis situations, it is common to find the proportion of children with WHZ < -2 standard deviations below the international reference to exceed 10% (Hogan et al., 1977). Within a few months of adequate food relief and health care being provided, the prevalence of acute malnutrition quickly returns

to that normally prevailing in the population (see Appendix 1). Thus, between May and October 1993, the prevalence of acute malnutrition in the displaced camps declined from a median value of 14.6% to a median of 3.7%. This last value almost exactly corresponds to that observed in two national-level surveys of rural Rwandan children in 1992.

Surveys in urban samples

Three surveys have collected and reported anthropometric data for children in urban Rwanda. First, the urban phase of the ENBC survey was carried out by the Ministry of Planning during 1984-86. Some 276 children ages 0-60 months residing in 264 urban households were measured between October 1984 and January 1985. The proportions of children with HAZ, WAZ, and WHZ scores below -2 SD were 37.5%, 21.9%, and 6.3% (Schnepf, 1992a; Table 8). The prevalence of chronic malnutrition or growth retardation was much lower in the urban sample than it had been for the rural ENBC sample, which for the same 0-60 month age interval was 56.6%.

Table 8. Prevalences of low standardized anthropometric indicators in urban Rwandan children ages 0-59 months

Survey	*Number*	*HAZ < -2*	*WAZ < -2*	*WHZ < -2*
Urban ENBC, Oct. 1984-Jan. 1985	276	37.5%	21.9%	6.3%
Kigali UHNS, May-June 1990	851	43.2%	22.6%	1.8%
Urban EDSR, June-November 1992	209	33.4%	18.1%	3.7%

Sources: Schnepf (1992a; 1992b), Barrère et al. (1994)

The Kigali Urban Health and Nutrition Study (KUHNS) was conducted during May-June 1990 by staff of the Ministry of Planning and the Cornell Food and Nutrition Policy Program with funding from UNICEF/Kigali (Schnepf, 1992b). This survey covered 992 children ages 0-72 months living in 576 households in 12 zones of the capital selected for non-elite housing standards. Based on a table 39 in Schnepf (1992b), we calculate that the proportions of 851 children ages 0-59 months with HAZ, WAZ, and WHZ below -2 were 43.2%, 22.6%, and 1.8% respectively. Using the chi-square test, the difference in prevalence of low HAZ values between the two surveys is weakly significant, almost equal to the .05 level using a one-tail test. The difference in prevalence of low WHZ values is strongly significant at the .001 level using either a one- or a two-tail test. The fact that these significant differences are in opposite directions while the prevalence of underweight

was virtually identical in the 1984-85 and 1990 surveys calls into question the comparability of the height measurements in one or both surveys.

The height measurements in both the urban ENBC and the KUHNS appear to be suspect. The age-specific data reported in Table 3 suggest that the urban ENBC substantially overstated the heights of children ages 24-35 months of age, thus causing the prevalence of low HAZ values to be understated and the prevalence of low WHZ values to be overstated. Based on the extremely low prevalence of low WHZ values in 1990, it is possible that the KUHNS survey systematically understated heights, thus exaggerating the prevalence of low HAZ values and understating the prevalence of low WHZ values. As is discussed further in Appendix 2, the phenomenon of systematic height mismeasurement appears to be widespread and calls into question the meaningfulness of comparisons of prevalences of low HAZ and WHZ values between surveys. If heights were indeed understated in the KUHNS, there is no evidence of any age-specific bias according to the data in Table 3. Also, the HAZ standard deviation of 1.33 is within the range of what is typically found in developing country studies, which suggests that random measurement error was not a serious problem.

The 1992 EDSR survey reported anthropometric results separately for its urban sample of 209 children (Barrère et al., 1994). Only 33.4% of urban children ages 0-59 months are reported to have HAZ scores below -2, 18.1% had WAZ scores below -2, and 3.7% had WHZ scores below -2. A comparison of the HAZ numbers might appear to suggest a reduction in child malnutrition in urban Rwanda compared to the previous surveys. However, the only significant difference is with regard to the prevalence of stunting between the 1990 and 1992 surveys. As we have discussed, the HAZ measures appear to be less reliable because of measurement problems and lack methodological comparability between surveys. The prevalence of underweight is much more stable among the three surveys. Further, the KUHNS survey substantially undersampled infants under 6 months of age, with only about 60% of the expected number present. Since young infants are rarely classified as malnourished, the effect of this biased sample composition is to slightly understate the true prevalences. Adjusting the numbers of infants upwards while keeping the age-specific prevalences the same, we calculate that the equivalent overall prevalences are 21.6% for low WAZ and 41.4% for low HAZ in 1990, instead of 22.6% and 43.2%. This adjustment reduces the one-tail test significance level of the difference in HAZ proportions from 0.005 to 0.02.

The modest reductions in the prevalences of malnutrition in urban Rwanda indicated by the EDSR in 1992 compared to the 1984-85 and 1990 surveys are at first glance surprising. One has the impression from many accounts of worsening poverty and unemployment in urban Rwanda during the early 1990's (Chossudovsky, 1994). Further, we know from both of the earlier surveys that the prevalence of child malnutrition is very strongly linked to household incomes in urban households. For example, in the 1990 KUHNS survey, households were classified into quintiles by annual consumption expenditures, and the prevalences of stunting and underweight ranged from 52.7% and 30.8% in the lowest quintile to 33.7% and 12.0% in the highest quintile (Ogden, 1993:81). While real incomes went down, it is also reported that food prices declined because of subsidized food imports (Chossudovsky, 1994). This could have substantially protected food consumption levels.

The major explanation for the apparent decrease in the prevalence of child underweight between the 1990 KUHNS and 1992 EDSR is that the 1990 survey was never intended to be representative of the entire urban population of Kigali. The purpose of the study was to examine urban poverty, so the decision was made to include only residential quarters considered to be overcrowded and with poor sanitation. Further, even within those quarters many households were clearly middle-class. To exclude these, the decision was made to exclude all households with electricity hookups, which were 28% of all of the households in the sampled areas initially considered for inclusion (Schnepf, 1992b). If these excluded households had average per capita expenditures no higher than the highest quintile of households remaining in the survey, the overall prevalence of stunting would have been reduced for children ages 0-72 months from 43.8% (Ogden, 1992) to 41.0%. The prevalence of underweight would have been 19.3% instead of 22.1%. Given that the prevalences of both stunting and underweight were overstated by the underrepresentation of young infants, taking the age composition and economic status composition biases into account simultaneously virtually eliminates the gaps with the 1992 EDSR.

In addition, the urban sample of the EDSR may be presumed to have overrepresented permanent, legal residents of the major cities, whose children are relatively advantaged. The EDSR urban sample frame is based on the census lists from the 1991 population census (Barrère et al., 1994). This census surprised many observers when it reported that the urban population of Rwanda was scarcely larger as a fraction of the total population of the country (5.4%) than it had been 13 years earlier at the last

previous census, in 1978 (4.6%) (MINIPLAN, 1993). The reason for the lack of an appreciable increase despite previous estimates of very rapid urbanization was largely political. Following the outbreak of war in October 1990, the government pressured tens of thousands of people who lacked work permits to leave Kigali for their home communes. Large numbers of unofficial migrants and temporary residents were expelled. They may have slipped back to Kigali subsequently, but they were not eligible to be included in the August 1991 census or in the subsequent 1992 EDSR sample. Their exclusion from the 1992 EDSR sample potentially could have masked a hypothetical modest worsening of children's nutritional status among lower-income urban households.

Maternal anthropometry

We also have information on maternal anthropometry from the National Nutrition and Food Security Survey. These information do not provide any corroboration for the existence of a generalized shortage of food in Rwandan farm households during the period 1991-93. The information in Table 9 is based on unpublished tabulations from cleaned data. It is generally agreed that the proportion of adults with body mass index (BMI) less than 18.5 kg/m^2 is a sensitive indicator of chronic energy deficiency (Ferro-Luzzi et al., 1992; James et al., 1994). For comparative purposes, we also report a regional estimate for Africa from the United Nations (ACC/SCN, 1992). The data used in that estimate seem to have been taken disproportionately from famine-prone African populations. Accordingly, we also present two estimates from non-Sahelian countries with higher mean values for BMI in non-pregnant women.

The Rwandan women in the ENNSA survey appear to be fairly heavy, among the heavier for their height of rural African populations. An even higher mean BMI of 23.1 kg/m^2 for non-pregnant adult women has been reported from a small sample in an economically-advantaged part of rural Rwanda during 1985-86 (Csete, 1989:174). Accordingly, the anthropometric evidence suggests that food availability was not constraining adult body weight in the resident farm household population during 1992. While we do not have any reliable information on maternal anthropometry for a representative sample from previous years, the BMI values observed in 1992 could not have been appreciably higher at a previous date. Thus, these data also contradict the hypothesis of a substantial decline in food availability and food consumption in rural Rwanda in recent years.

Table 9. Anthropometric indicators in non-pregnant adult women in the ENNSA and other African populations

Survey	Mean height	Mean weight	Mean BMI	Percent with BMI < 18.5
ENNSA Round 1	156.4 cm	54.0 kg	22.0 kg/m^2	8.7%
ENNSA Round 2	156.4 cm	55.0 kg	22.5 kg/m^2	4.8%
ENNSA Round 3	156.4 cm	54.8 kg	22.4 kg/m^2	5.6%
ACC/SCN	157.9 cm	51.4 kg	20.5 kg/m^2	22.4%
Zimbabwe	159 cm	55.1 kg	21.7 kg/m^2	
Kivu, Zaire	153.0 cm	50.0 kg	21.4 kg/m^2	

Sources: ENNSA, unpublished tabulations
ACC/SCN (1992)
Zimbabwe (James et al., 1994)
Kivu, Zaire (Carael, 1978)

Discussion

Despite evidence of adverse trends in food security at the national level, it appears that there has been no deterioration in children's nutritional status in Rwanda in recent years. It is possible that there may have been an improvement between the early 1970's and early 1980's, a period when agricultural output was expanding rapidly in Rwanda. Schnepf (1991) provided a review of anthropometric survey data from rural Rwanda from the 1970's and 1980's. The proportion of children with weight-for-age below 80% of reference median was found to be 39% in a 1976 survey (van Sprundel et al., 1979). It was found to be 33.4% in the ENBC survey carried out in rural areas in 1982-83, and it was 27.5% in the national nutrition survey of 1985-86. One difficulty in making these comparisons is that it is unclear in some cases which reference was being used. Most importantly, since none of these surveys was based on a representative sample, it is not clear that one can use them to make deductions about changes over time.

The proportion of rural Rwandan children with weights below the normal range (WAZ < -2) has not changed significantly since the early 1980's. The precise prevalence in 1983 is not known because the reported prevalence is overstated as a result of presumably random age misreporting. We do know that the mean WAZ score was only slightly and insignificantly higher in 1983 than in 1991-92 (Table 5). The prevalence of underweight was 28.8% in the 1991-92 round 1 ENSSA and 29.7% in the 1992 EDSR (Table 2). The round 3 and 4 ENSSA underweight prevalences are significantly lower

than the EDSR, but this cannot represent a trend, since they were carried out at approximately the same time. Further, the prevalences of low HAZ values were higher in those two rounds than in the EDSR. Methodological differences appear to be responsible.

A comparison of the urban samples from the 1984-85 ENBC survey, the 1990 KUHNS survey, and the 1992 EDSR survey also indicates a lack of significant change in the fraction of underweight children. This fraction is roughly 20% in each of the three surveys, which is approximately one third lower than the prevalence in rural samples in Rwanda. The data on heights do not appear to be comparable across the three surveys and hence the prevalences cannot be interpreted as indicating changes over time. Urban poverty is strongly linked to higher rates of child malnutrition in Rwanda (see Appendix 1), but the anthropometric data do not substantiate the trend towards increased poverty and food insecurity in urban areas. However, the 1990 survey excluded most higher-income households, while the urban sample used in the 1992 EDSR excluded many lower-income urban households because of their forced return migration to rural areas after October 1990. Thus, it is not possible to conclusively evaluate changes in children's nutritional status the urban sector during this period.

The lack of any evidence of a trend through 1993 towards increasing rates of child malnutrition in Rwanda in non-displaced populations is contrary to the usual impression of increasing economic distress in Rwanda. One possible explanation for the stability in the prevalence of child malnutrition is that any adverse impact from increasing food insecurity in rural Rwanda was offset by the positive impact of improving health status. Infant and child mortality rates in Rwanda have been steadily declining in recent decades, as a result of various interventions. The proportion of children dying before 5 years of age is calculated on the basis of retrospective data from the 1992 EDSR to have decreased from 24.3% during 1973-77 and 22.5% during 1978-82 to 17.6% during 1983-87 and 15.0% during 1988-92 (Barrère et al., 1994).

The two most important explanations for the recorded decreases in infant and child mortality rates in Rwanda through the early 1990's have been increased immunization and female literacy. Immunization coverage in Rwanda was until a year ago close to universal and among the highest rates attained in Africa. In the ENNSA survey, 90% of children ages 24-59 months were recorded as having been immunized against measles, and 93% had received three or more oral polio vaccinations (unpublished tabulation). Female literacy, which is one of the most important determinants of child survival, has also expanded in Rwanda. While only 40% of mothers in the ENNSA survey were recorded as

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being literate, this was true of 60% of mothers under the age of 25, compared to only 20% of mothers over age 40 (unpublished tabulation). Immunization and expansion of literacy have undoubtedly contributed to improved child survival in Rwanda, which unfortunately have been counteracted in part by increases in infant and child mortality from two causes, malaria and AIDS (UNICEF/Kigali, 1992).

Evidence from several anthropometric surveys conducted in Rwanda suggests that the factors which caused the recent reductions in infant and child mortality rates in Rwanda may not have been important influences on children's nutritional status. No relationship has ever been found in Rwanda between female literacy or primary education and child weights and heights (Csete, 1989; von Braun, de Haen, and Blanken, 1991; Schnepf, 1991; 1992a; 1992b; Ogden, 1993; unpublished analysis of ENNSA data), as is true of other African populations (Grosse, 1995). Further, while recent diarrheal morbidity, worm infections, and poor environmental sanitation have been found in these studies to be significantly related to lower child weights, there is no evidence that there has been any improvement in environmental sanitation or reduction in the burden of diarrheal morbidity in Rwanda. Also, an unpublished analysis of data from the first round of the ENNSA finds that the proportion of siblings who died before the age of 5 years, a measure of the household's child mortality experience, is unrelated to any anthropometric indicator, even though it is significantly inversely related to maternal education. In the same data set, receipt of measles vaccination is positively correlated with WAZ, but this is due to confounding with socioeconomic status. Consequently, the increases in immunization coverage and female literacy may not be expected to have exerted any positive influence on trends in nutritional status in Rwanda.

A more likely explanation for the apparent stability in the prevalence of growth retardation in Rwanda is that the major causes of growth retardation in Rwanda have not been subject to important modifications in recent years, at least through the end of 1992. It has long been known that Rwanda has one of the highest rates of child growth retardation in Africa (Bailey, 1975; Schnepf, 1991). The list of causal factors behind child growth retardation in Rwanda include poor sanitation and hygiene, extremely high prevalences of intestinal parasites and shigella dysentery, diets which are based on tubers and grossly deficient in fats, and inappropriate infant feeding practices. Inappropriate feeding practices include both the too-early introduction of breast-milk complements (which fortunately is not very common) and excessively late introduction of solid foods,

infrequent feeding, and the lack of preparation of special weaning foods (UNICEF/Kigali, 1992).

These characteristics or practices associated with child malnutrition appear to be of long standing in Rwanda and its immediately neighboring societies, notably Burundi and southern Uganda. Accordingly, it is not surprising that comparative DHS survey data indicate that these three countries are among the five countries with the highest recorded prevalences of chronic malnutrition in Africa. The proportion of children ages 3 to 36 months with growth retardation is reported to be 48% in Burundi, 45% in Rwanda, and 44% in Uganda (Macro International, 1994). The range in sub-Saharan Africa is from 21% in Cameroon to 52% in Madagascar. Thus, child growth retardation is a very serious problem in Rwanda and surrounding countries. On the other hand, there are dramatic economic gradients in child growth retardation within Rwanda, with much higher rates of child growth retardation among both the rural and urban poor (von Braun, de Haen, and Blanken, 1991; Schnepf, 1992a; Ogden, 1993). Thus, one should not overemphasize social and cultural determinants of growth retardation in the Rwandan context.

Finally, perhaps the most plausible explanation for the stability in children's nutritional status observed in Rwanda through the beginning of 1993 is that household-level food consumption did not decline by anywhere near as much as would be expected based on production data. This explanation is supported by the data on maternal anthropometry, which is indicative of very low levels of chronic energy deficiency in Rwandan farm households during 1991-92. The question then becomes how food consumption was maintained at adequate levels despite rapidly decreasing per capita availability of food from domestic production. The most plausible explanation is that cross-border trade had increased substantially in magnitude in order to make up much of the gap. The FSII/Rwanda project had been scheduled to carry out further research to explore this question by systematically studying cross-border trade in food, but the events of April 1994 following the assassination of the President brought a halt to all project activities within Rwanda.

In conclusion, the nutritional situation of children in rural Rwanda is bleak and has been bleak for a very long time. Rwandan children are subjected to repeated disease insults from which they scarcely have time to recover before becoming afflicted again. Their diets are inadequate in both quantity and quality. Consequently, most rural Rwandan children fail to grow according to their genetic potential. This has serious negative implications for their health, survival, and for their productivity as adults. Even

children in relatively affluent families in rural Rwanda are at high risk of growth retardation, which is a reflection of very poor environmental sanitation and hygiene and of feeding practices which do not take small children's nutritional needs into account.

The question of whether the net impact on child nutrition and growth of the various changes occurring in Rwanda since the early 1980's has been negative or positive is impossible to conclusively resolve. The bulk of evidence fails to support the existence of any deterioration. If a change did occur, it was small in magnitude. The lack of an important deterioration in nutritional status may indicate an important degree of resilience in Rwandan farm households in adapting to economic and food security stresses in recent years. The accommodations which have allowed this to happen should be the subject of further study.

Appendix 1

Food security and child growth retardation

by Scott Grosse

Analytical frameworks of child malnutrition

Various analytical frameworks have been proposed to account for the causation of child malnutrition. The one utilized by UNICEF (1990) specifies four levels, including the final level, where growth failure and disease are said to be manifestations of an underlying process. The immediate causes are two: inadequate dietary intake and disease, which interact with each other. The underlying causes are said to be three: insufficient household food security, inadequate maternal and child care (including feeding practices), and insufficient health services together with an unhealthy environment. The basic causes of malnutrition are divided into four additional factors: formal and non-formal institutions, political and ideological superstructure, economic structure, and potential resources. See Jonsson (1993) for a cogent analysis of the basic causes of malnutrition at the societal level.

In this paper, we are concerned chiefly with what UNICEF refers to as the underlying causes of child malnutrition, especially food security. Food security refers to two dimensions, the level of availability of food and regularity of access to food. Households which have incomes that are unstable are at higher risk of food insecurity than those with stable incomes, independently of the level of income. Also, households which produce a major share of the food they consume may be less subject to insecurity than households which depend almost entirely on purchased food. The temporal dimension of food insecurity is difficult to measure. Furthermore, it may be that the same households which are most subject to food insecurity in its temporal dimension are also most vulnerable in terms of everyday food availability.

Household food security is distinct from food availability at the national level, since the ability of households to command food is a function of their entitlements to resources, not the presence of food in the marketplace (Sen, 1981). Reductions in real incomes of the poor can result in severe food crisis and increased malnutrition even without any reduction in aggregate food availability (Sen, 1990). For example, decreases

in domestic food production in Botswana during the early 1980's resulted in increased child underweight until 1984, despite being more than compensated at the national level by increased food imports, owing to the importance of food production as a source of entitlements for vulnerable rural populations (Quinn et al., 1988). The distribution of food aid to vulnerable groups lacking food entitlements can reduce the prevalence of hunger and malnutrition even in the midst of a prolonged drought (Bratton, 1987; Dreze, 1990). Reductions in food availability at the national level if not compensated by such public redistribution can result in substantial increases in hunger and child underweight.

Since malnutrition is multifactorial in causation, it should not be identified with any single factor (Keller, 1988). In particular, it is often argued that the nutritional status of very young children may be less sensitive to changes in food availability than is true of other age groups. This is both because households may reallocate resources when food is scarce to buffer the youngest children from declines in food intakes (Leonard, 1991) and because factors other than low food energy intakes may be relatively more important. The major underlying causes of growth failure in very young children include inadequate sanitation and hygiene and less than optimal infant and young child feeding practices, as well as lack of food at the household level (UNICEF, 1990).

It is widely maintained that variations in the sizes of young children may be dominated by factors other than household food security (Mata, 1985; von Braun, de Haen, Blanken, 1991; Kennedy and Peters, 1992; Alderman and Garcia, 1994). At least two studies have found that body measurements in preschool-age children were not significantly related to household food intakes, even though weights of school-age children were sensitive to household food availability (Khan, 1984; Bénéfice and Simondon, 1993). Since the anthropometric measures of preschool-age children and other household members are not necessarily very highly correlated, it is essential to measure other groups in order to assess population nutritional status (Mock et al., 1994). In particular, assessment of the anthropometric status of adult women can provide important additional information about chronic energy deficiency caused by a lack of food security (Ferro-Luzzi et al., 1992; Kelly, 1992).

Household food security and child anthropometry in Rwanda

Food poverty may be an important cause of poor growth status in young children in many populations, including specifically in Rwanda. For example, a study conducted in rural Rwanda during 1985-86 found that preschool-age children in families consuming less

than 80% of recommended amounts of food energy are 50% more likely to be stunted (von Braun, de Haen, and Blanken, 1991). The same study estimated that, controlling for other factors, a 10% increase in household caloric intakes is associated with 8% higher weight-for-height, 2.9% higher weight-for-age, and 2.3% higher height-for-age. One of the major factors determining access to food in rural Rwanda is land scarcity. The amount of farm land per capita is even more strongly related to risk of growth retardation than is food energy adequacy measured at one point in time. The prevalence of stunting is reported to be 80% higher in households in the lowest quartile of land area per person than in those in the top quartile.

The Kigali Urban Health and Nutrition Study (KUHNS) conducted during 1990 found that household caloric availability was the strongest predictor of child anthropometry (Ogden, 1993). This was true both using instrumental variables, in which caloric availability was modeled as an endogenous variable and predicted caloric availability used in the anthropometric regression equations, and ordinary least squares regression with observed variables. In unadjusted terms, households were classified into quintiles by annual consumption expenditures, and the prevalence of stunting was found to range from 52.7% in the lowest quintile to 33.7% in the highest quintile. Analyzing the same survey data, Schnepf (1992b) contends that almost none of the households truly suffered from food poverty, because virtually all of the households consuming less than 80% of estimated requirements spent less than 80% of their available income on food. Even the poorest households spent almost one tenth of expenditures on alcoholic beverages. Nonetheless, since these preferences operate at all income levels, household-level food availability is strongly predicted by household expenditures, and in turn strongly predicts children's growth status.

Unpublished tabulations from the first round of the ENNSA survey conducted during 1991-92 also indicate the association between household food security and child growth status. A question was asked about whether the household had experienced food shortages within the past year. Those children who lived in households subject to food insecurity were much more likely to have severe linear growth retardation, as indicated by HAZ < -3. We also present in Table A1 comparable tabulations for two other variables indicative of household economic status, type of roofing material on the house and possession of farm animals.

Table A1. Correlates of child height-for-age in rural Rwanda

Variable	Mean HAZ	Proportion HAZ < -3	Numbers of children ages 24-59 months
Food security			1116
Shortages of food	-2.53	32.2%	439
No shortages	-2.09	22.5%	677
Roofing material			1085
Thatch	-2.62	37.9%	182
Tiles	-2.31	26.1%	463
Metal	-2.08	21.1%	440
Livestock or poultry on farm			1085
No	-2.63	41.2%	177
Yes	-2.20	23.1%	908

The specific mechanisms by which poverty leads to food insecurity and child malnutrition are not possible to disentangle with these data. In a logistic regression predicting the risk of severe stunting, the food security variable is highly significant when it alone is entered with the covariates of child age and maternal height. When a composite index of housing quality and the binary variable indicating ownership of animals are entered as measures of household assets, the food security variable loses its statistical significance. That is, households with few assets are more likely to experience recurrent food shortages and also are more likely to have malnourished children. Based on these findings, we can conclude that children's nutritional status in Rwanda is strongly positively related to the combination of household income levels, assets, and food security. Any pronounced decline in real incomes and in the availability of food can be expected to result in a substantial exacerbation of growth retardation.

A lack of availability of food at the household level can adversely affect children's nutritional status by reducing the frequency and variety of meals. The Weaning Foods Survey conducted in rural Rwanda during 1987 found that the number of meals per day served in a household is one of the most significant predictors of children's nutritional status. The proportion of children who were underweight was found to be 34.4% in the fifth of the sample which reported cooking only 1 meal a day, 24.1% in the three fifths of the sample cooking 2 meals a day, and only 13.2% in the fifth of the sample cooking 3 meals a day (Schnepf, 1991). A survey in neighboring Burundi found that children living in households preparing meals based on a single food were much more likely to be

malnourished (Lemaire, 1989). The households in that survey with severely underweight children (WAZ < -3) were found to have much lower food energy adequacy (average caloric intakes of 81.5% versus 99% in other households).

Cross-national variations in child anthropometry and food availability

Variations in anthropometric indices when evaluated at the population level may be better indicators of average access to food and food security. One reason why the association when evaluated at the household level is likely to be weak is that most individual-level variation in anthropometric measures is either genetic in origin or essentially random noise (Gorstein and Akre, 1988). Another reason is that the well-known problem of 'errors in variables' or misclassification bias in dietary assessment is chiefly a problem at the individual and household levels, while dietary assessments are more informative when aggregated to eliminate random noise (Gibson, 1990).

Dietary factors may help to account for cross-national variations in child anthropometry. For example, the much greater prevalence of stunting in Guatemalan children compared to Colombian children is reported to be associated with much lower dietary intakes in Guatemala compared to the Colombian sample, despite equivalent prevalence of diarrheal morbidity in the two populations (Lutter et al., 1992). Kennedy and Peters (1992) report data from two populations in rural Kenya and rural Malawi which also rule out disease as an explanation of differences in the prevalence of stunting. The mean HAZ scores for preschool children in male-headed households in these two samples were -1.66 and -2.41 respectively, indicating a much higher prevalence of stunting in the Malawian sample, which is consistent with other data sets. The Malawian sample was far more impoverished, and mean household caloric intake per adult equivalent was much lower than in the Kenyan sample. The period prevalence of child morbidity was substantially greater in the Kenyan sample, including a prevalence of reported diarrhea over twice as great as that observed in the Malawian sample.

Other pairwise examinations of countries with very different levels of prevalence of linear growth retardation reveal that variations in food availability are more consistently associated with long-term nutritional status than are indicators of health conditions and social development. Ghana and Côte d'Ivoire are neighboring West African countries which greatly resemble each other in terms of ecological conditions and ethnic and cultural background. In 1986-88, the prevalence of stunting in preschool-age children was roughly twice as high in Ghana as it was in Côte d'Ivoire, even though Ghana had the same life

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expectancy, slightly lower infant mortality, and higher adult female literacy. Average per capita food energy consumption was approximately 250 kcal/day higher in Côte d'Ivoire than in Ghana (Table A2).

Table A2. Economic, social, and health indicators in Ghana and Côte d'Ivoire, ca. 1988

Country	Economic and social indicators			Health status indicators		
	Per capita GNP	Daily caloric availability	Adult female literacy	Life Expectancy	Infant mortality rate	Prevalence of stunting
Ghana	$390	2,201 kcal	51%	55	85	34.8%
Côte d'Ivoire	$750	2,448 kcal	40%	55	95	19.4%

Sources: World Bank (1992) -- GNP, female literacy, infant mortality, life expectancy
FAO (1991) -- caloric availability per person, average 1986-88
Alderman (1990) -- child stunting

In another paper (Grosse, 1995), we have conducted a cross-national statistical analysis of child growth retardation in sub-Saharan African countries. We found that the single most important predictor of the prevalence of stunting in children ages 3-36 months is the estimated per capita availability of food energy. The natural logarithm of per capita GNP and caloric availability together account for more than 70% of the variation across countries in the prevalence of child stunting (Table A3). There is no association of the prevalence of stunting with female literacy rates or with indicators of mortality. In contrast, life expectancy at birth is found to be strongly related to female literacy and very weakly related to economic conditions.

Table A3. Regression results for prevalence of stunting and life expectancy in sub-Saharan African countries (beta coefficients)

Variable	Stunting	Life Expectancy
Ln (per capita GNP)	-0.449**	0.252
Adult female literacy rate	0.082	0.692**
Caloric availability (kcal/pop/day)	-0.594**	0.280
Adjusted R^2	0.734	0.514

*** Significant at the 1% level of probability
** Significant at the 5% level of probability

Trends in child anthropometry and food availability

Across regions, comparisons of indicators of household access to food and growth status in children may be confounded by a variety of country-specific factors which are invariant over time. For example, the high prevalence of low growth status in Asian children compared to children in other regions of the world appears to be unexplainable by variation in economic, dietary, or health variables (Table A3, Uvin, 1994). Over time, though, changes in the prevalences of underweight or stunting parallel changes in food intakes regardless of region-specific intercepts. The correlation between the change in the proportion of the population with inadequate diets appears to be fairly closely, albeit not exactly, related to change in the proportion of children who are underweight ($r = 0.77$, $p < 0.10$).

Table A4. Prevalence of low energy adequacy in populations and of underweight children

Region	Percentage of chronically underfed persons				Percentage of underweight preschool age children (0-60 mo)			
	1975	1980	1990	Change, 1975-90	1975	1985	1990	Change, 1975-90
sub-Saharan Africa	37	36	37	-0	31.4	29.9	29.9	-1.5
Near East and North Africa	17	10	5	-12	19.8	15.1	13.4	-6.4
South Asia	34	30	24	-10	67.7	61.1	58.5	-9.2
East Asia (excl. China)	32	22	17	-15	43.6	34.7	31.3	-12.3
Middle America	20	15	14	-6	19.3	15.2	15.4	-3.9
South America	15	12	13	-3	15.7	8.2	7.7	-8.0

Source: ACC/SCN (1992), cited in Uvin (1994)

The most striking phenomenon present in Table A4 is the stability in the prevalence of child malnutrition in sub-Saharan Africa in contrast to the large, sustained reductions in the prevalence of child malnutrition in all other parts of the developing world. According to the most recent estimates from ACC/SCN (1992), the average prevalence of underweight in preschool-age children has been stable in African countries, 31% in 1975 and 30% in both 1985 and 1990. These figures are consistent with the reports cited in the same source that the proportion of the population of sub-Saharan Africa who are chronically underfed (energy adequacy less than 80% of recommended

amounts) was essentially constant, at 36-37% during the same period of time (Table A4, cited in Uvin, 1994).

These highly aggregated data do not allow us to determine the extent to which changes over time in child anthropometry within individual countries track variations in national-level food availability, changing inequality in access to food, exposure to disease, and health care. Few analysts have tried to disentangle these influences, which is understandable given the serious constraints to data availability. Also, few studies have attempted to disaggregate changes in anthropometric indicators, since survey data must have been collected based on samples designed to be representative at subnational levels for this to be validly done. A recent study from Mexico reports that the prevalence of underweight in preschool-aged children increased slightly from 17% in 1974 to 19% in 1989, an overall stability which masked a growing nutritional polarization between advantaged and disadvantaged regions of the country (Avila-Curiel et al., 1993). An older study from Jamaica reported that a sharp rise in the price of food accompanied by decreasing food imports resulted in rising rates of malnutrition in urban areas and decreases in prevalences of malnutrition in rural populations, who benefited from higher farm incomes (Marchione, 1977).

One country with documented evidence of a marked deterioration and subsequent recovery in nutritional status occurring in parallel with changes in food availability is Ghana (Alderman, 1990). Owing to a conjunction of drought and misguided economic policies, Ghana underwent a severe economic and nutritional crisis in the early 1980s, peaking during 1983. It was estimated that per capita food consumption was 30% lower in 1982-83 than a decade earlier (UNICEF/Accra, 1988). The FAO data on per capita domestic food supply only reflect the impact of drought on agricultural production, which fell in 1982 about 5% below that prevailing in the previous few years, was 15% below the usual level in 1983, was still 5% below normal in 1984, and by 1985 had returned to normal (FAO, 1993). The actual reduction in the availability of food was much greater than the FAO data indicate, as distribution networks within Ghana collapsed as a result of government interference with markets and as farmers in border regions unofficially sold their food in neighboring countries. Data from Catholic Relief Services feeding centers in Ghana indicated a rise in the proportion of children who were underweight (below the 3rd centile on weight-for-age) from 35-36% in July 1980 and 1981 to 44% in July 1982, and 52% in July 1983, before falling to 44% in July 1984, 39% in July 1985, and 35% in July

1986 (Alderman, 1990). Thus, the duration of the period of increased malnutrition was roughly five years.

The proportion of children who are very thin for their height is the most sensitive indicator of fluctuations in food availiability (Bloem and Mulder, 1990). For example, the Sahelian countries were reported to have very high prevalences of acute malnutrition during 1974, at the end of a prolonged drought. The prevalence of wasting (weight-for-height below 80% of the reference median) was 22.5% in Chad, 10.7% in Mali, and 9.9% in Mauritania. A year later, these prevalences had fallen to 12.1%, 5.3%, and 3.1% respectively (Hogan et al., 1977). Rapid reductions in the prevalence of acute malnutrition are commonly reported following the end of food crises. For example, in western Zaire, the prevalence of wasting (weight-for-height below 80% of the reference median) was 12.2% at the height of a famine during 1978, and fell to 2.1% by the end of the recovery period (Franklin et al., 1984). Similarly, in a rural district in northwestern Rwanda, the proportion of children wasted according to the same criterion was 11.0% in late 1985 during a food crisis and fell to 2.2% a year later, following recovery from the drought (von Braun et al., 1991).

Trends in food availability and child underweight may not necessarily coincide, since improvements in public health may lead to reductions in the prevalence of child malnutrition in the absence of any improvement in economic and nutritional indicators or may help to prevent increases in malnutrition in the presence of declining living standards. Some examples can be cited, including Sri Lanka, where during the 1980s the prevalences of wasting and stunting fell, despite declining real incomes and food entitlements of the poor (Osmani, 1994). Data from Latin American countries can also be cited in support of the juxtaposition of anthropometric increases and economic stagnation. Rapid declines in underweight between the late 1970's and late 1980's were revealed by comparisons of national survey data in Colombia (Mora et al., 1992) and Brazil (Monteiro et al., 1994) despite the well-known declines in living standards in both countries during the structural adjustment problems of the early 1980's.

In Chile, which has the advantage of a well-functioning nutritional surveillance system, trends in anthropometric data can be more precisely tracked and related to economic and food policies. Between 1975 and 1982, the prevalence of underweight in preschool Chilean children fell by almost half, from 15.5 to 8.8%, while between 1982 and 1989 it fell hardly at all, from 8.8 to 8.2% (Raczynski, 1988; Vio, Kain, and Gray, 1992). Between 1975 and 1982, public distribution of food increased sharply, but this was scaled

back in 1982 as a result of a new policy. The prevalence of low birthweight moved in parallel to the preschool underweight prevalences, declining sharply from 1975 to 1982 and rising very slightly from 1982 to 1989. In contrast, infant and child mortality rates continued to decline rapidly, in reflection of continued improvements in hygienic conditions and public health (Monckeberg, 1992).

Another factor that needs to be taken into account is the ability of households to buffer dietary intakes, especially those of children, from short-term declines in real incomes. Households can cope with declines in food availability through multiple mechanisms without necessarily sacrificing nutrient adequacy for vulnerable members (Thomas and Leatherman, 1990). For example, households may adapt to reduced purchasing power by reducing their expenditures on non-food items and by reallocating their food budgets to less expensive sources of nutrients (Behrman, 1988). It is well-known that the primary allocation of higher food expenditures is the purchase of more expensive nutrients rather than greater quantities of nutrients (Shah, 1983). Reports from Latin American countries affected by inflation and decreasing real incomes indicate that household adaptations can be effective at protecting both nutrient intakes and children's nutritional status from substantial reductions in purchasing power (Kanashiro and Graham, 1984; Gross et al., 1987; Alarcon and Rivera, 1994).

Appendix 2

Assessment problems with standardized anthropometric indicators and their implications for evaluating trends in child anthropometry

by Scott Grosse

Methodological issues can complicate the interpretation of changes over time in the distribution of anthropometric indicators. The first issue we deal with is the problem of measurement error in measuring infant lengths and child heights. The standard practice is to measure recumbent length in infants and toddlers up to 24 months of age and to measure standing height or stature in children over 24 months of age. Further, to perform valid measurements on infant lengths, it is important to have two trained individuals to cooperate in laying the child down and restraining him or her while being measured (WHO, 1983). In field surveys without rigorous supervision, this may not take place according to instructions. Measurement of weights tends to be much less problematic. An important implication is that weight-for-age measurements may be less subject to bias and hence more comparable across surveys.

For the purpose of nutritional surveillance, it is usually recommended that one consider changes in both height-for-age and weight-for-height (WHO, 1983; Mason et al., 1984). A practical disadvantage with both of these indicators is that heights often are very imprecisely measured. Under field conditions, errors in measuring heights tend to be much larger than errors in measuring weights. Data on child heights from surveys in which anthropometric data are collected by interviewers who are not trained anthropometrists may be particularly suspect. A much fatter distribution (large standard deviation) of height-for-age z-scores relative to weight-for-age z-scores is a diagnostic marker of differential problems with height measurement. Another sure sign of problems with heights is when there is a substantial negative correlation between HAZ and WHZ values for individual children, since height measurement errors necessarily cause opposite biases in the two indicators for any given child (Haaga, 1986). If the correlation between the weight-for-height and height-for-age indicators is close to zero, random height measurement error is probably not a problem, although systematic under- or overstatement of heights might still be present and substantially bias the prevalences calculated on the basis of the two indicators.

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Differential problems of height measurement between two successive surveys can result in spurious opposite movements in the calculated proportions of children with low height-for-age and low weight-for-height (Haaga, 1986). The WHO (1983) manual, *Measuring Change in Nutritional Status,* gives an illustration of this problem. In Country A, between a baseline survey in 1974 and a post-intervention survey in 1977, the prevalence of low HAZ scores rose from 16.2 to 17.1% while the proportion of children with low WHZ scores decreased from 7.7 to 2.7%. The authors of the WHO manual comment that the apparent increase in prevalence of low HAZ values is spurious, because heights in the second survey were systematically understated by 1-2 cm per child. They do not acknowledge that the same problem necessarily leads to a compensating overstatement in the decline in the prevalence of low weight-for-height values. The weight-for-age distribution also improved, with the proportion with low WAZ falling from 17.6 to 9.9%, which is the only one of the three proportions in which much confidence can be placed.

Another example is a recent article analyzing trends in preschool-age children's nutritional status in a province in Cameroon. Mendoza Aldana and Piechulek (1992) emphasize that the prevalence of wasting in Coastal Province rose from 0.7% in 1978 to 9.1% in 1990 and attribute this rise to deteriorating economic and social conditions. However, both of the reported prevalences of low WHZ scores are outside the normal range observed in national-level African population samples, which is usually in the 3-6% range for preschool children. Further, the proportion of underweight children was stable between the two surveys, 16.7% in 1978 and 16.1% in 1990, and the reported prevalence of stunting declined from 23.9% to 19.8%. If the prevalence of stunting is a more sensitive indicator of long-term economic and social conditions than is wasting, as is generally believed to be the case, the authors' inference could be inverted. Most plausibly, measurement errors in height render the WHZ and HAZ values noncomparable between the two surveys, so that the weight-for-age data from the two surveys should be given greatest credence.

Interpretation of trends in age-standardized anthropometric indicators also requires assessing the reliability of the age data, which may be suspect. The biggest source of bias in calculation of height-for-age and weight-for-age is generally inaccurate age assessment (Haas and Habicht, 1990). In low-income countries, ages are usually imprecisely known at best. If ages are inaccurately recorded, the age-standardized indicators are subject to misclassification error. If the error is purely random, the central tendency of the distribution is unbiased, but the tails of the distribution are too large. This is of great

importance for our purposes, since this leads to an upwards bias in the calculations of prevalences of malnutrition, which are defined in terms of the proportion of children falling in the left tail of the distribution below some arbitrarily-selected cutoff point. Studies which have compared clinic-based child records with reliable birth dates and anthropometric information from field surveys in the same pediatric populations find that the prevalences of underweight or stunting are often substantially overstated in field surveys because of random age misreporting (Bairagi, Edmonston, and Khan, 1987; Tanner et al., 1991). On the other hand, age heaping caused by the rounding down of reported ages and systematic understating of ages caused by delayed reporting of births can result in a substantial underestimate of prevalences of low weight-for-age and height-for-age (Oshaug et al., 1994).

It is more statistically efficient to compare means of weight-for-age and height-for-age in place of the prevalences of underweight or stunting to assess changes over time in the nutritional status of populations. If the distributions of anthropometric indicators are close to normal, the mean can adequately summarize the entire distribution. This is potentially important, because statistical tests for comparing continuous distributions are less demanding than tests of proportions below cutoffs. To detect the same proportionate change in the mean of an anthropometric indicator at a given level of statistical significance requires 50-60% fewer observations than to find a significant variation of the same magnitude in the proportions below cutoffs (Briend et al., 1989). On the other hand, one should not assume that the distributions of standardized anthropometric indicators are acceptably close to normal. Leaving aside the issue of skewness, measurement error and age misstatement results in greater dispersion around the mean and relatively high standard deviations.

Unevenness in measurement and age reporting errors between surveys is another argument in favor of comparing mean anthropometric indicators rather than prevalences of low values. For example, differential age misstatement between surveys can lead to a major difference in standard deviations and corresponding changes in reported prevalences of low values without any change in mean values. If the degree of age reporting improves over time, earlier estimates of prevalences will be overstated relative to later ones (Haas and Habicht, 1990). With increases in immunization coverage, vaccination cards held at home have become an increasingly important source of birth dates for anthropometric surveys and the precision of age estimates has generally increased.

In a situation where age assessment improves over time, it is possible for the distribution of age-standardized anthropometric indicators to be shifted to the left, with a decrease in mean HAZ and WAZ, at the same time that the calculated prevalence of stunting or underweight has also decreased. This bias only applies to cases where the baseline prevalence is fairly low; if the prevalence is close to 50%, whether the distribution is flatter or steeper makes little difference. Reports which compare the prevalence of underweight or stunting may report that the nutritional situation in a country has improved, while analyses which compare the mean anthropometric indicators can reach the opposite conclusion.

We will consider an example of this problem, based on unpublished data from a country which we will refer to as Country B (Table A5). The prevalence of child underweight in Country B is reported to have declined between national anthropometric surveys conducted in 1978 and 1986. At the same time mean and median weight-for-age values decreased. This divergence in trends is the result of the fact that the standard deviation was smaller in the second survey. Because of the very large sample size in both surveys, the opposite changes in mean weight-for-age and prevalence of underweight are both highly significant. Both are probably misleading. The median value, which is less subject to skewing in either direction and is unaffected by the fatness of the tails of the distribution showed only a slight decrease between the two surveys.

Table A5. Information on trends in nutritional status of children ages 0-59 months in Country B

Year of survey	Proportion W/A < 70% of median	Mean W/A	Median W/A	Standard Deviation
1978	14.4%	83.05	80.6	12.75
1986	12.8%	81.24	79.9	11.37
Significance level	.001	.001		

ACC/SCN (1992). Second Report on the World Nutrition Situation. Volume 1. Global and Regional Results. Geneva: ACC/SCN.

Alarcon, J.A. and Rivera, J. (1994). The impact of changes in purchasing power on food consumption of an urban population in Guatemala City. Ecology of Food and Nutrition 31: 171-182.

Alderman, H. (1990). Nutritional status in Ghana and its determinants. SDA Working Paper No. 3, World Bank, Washington, DC.

Alderman, H. and Garcia, M. (1994). Food security and health security: explaining the levels of nutritional status in Pakistan. Economic Development and Cultural Change 42: 485-507.

Avila-Curiel, A., Chavez-Villasana, A., Shamah-Levy, T., and Madrigal-Fritsch, H. (1993). La desnutricion infantil en el medio rural mexicano: analisis de las encuestas nacionales de alimentacion. Salud Publica de Mexico 35: 658-666.

Bailey, K.V. (1975). Malnutrition in the Africa Region. World Health Organization Chronicle 29: 354-364.

Bairagi, R., Edmonston, B., and Khan, A.D. (1987). Effects of age misstatement on the utility of age-dependent anthropometric indicators of nutritional status in rural Bangladesh. American Journal of Public Health 77: 280-282.

Barrère, B., Schoemaker, J., Barrère, M., Habiyakare, T., Kabagwira, A., and Ngendakumana, M. (1994). Enquête Démographique et de Santé Rwanda 1992. ONAPO (Office National de la Population, République Rwandaise) and.

Bénéfice, E. and Simondon, F. (1993). Agricultural development and nutrition among rural populations: a case study of the Middle Valley in Senegal. Ecology of Food and Nutrition 31: 45-66.

Bloem, M.W. and Mulder, M. (1990). Nutritional surveillance for disaster preparedness and prevention of nutritional blindness. HKI Nutritional Surveillance Newsletter 1: 34-52.

Bratton, M. (1987). Drought, food and the social organization of small farmers in Zimbabwe. In: Glantz, M.H. (ed.), Drought and Hunger in Africa: Denying Famine a Future. Cambridge: Cambridge University Press, pp. 213-244.

von Braun, J., de Haen, H., and Blanken, J. (1991). Commercialization of Agriculture under Population Pressure: Effects on Production, Consumption, and Nutrition in Rwanda. Research Report 85. Washington, DC: International Food Policy Research Institute.

Briend, A., Garenne, M., Maire, B., Fontaine, O., and Dieng, K. (1989a). Nutritional status, age and survival: the muscle mass hypothesis. European Journal of Clinical Nutrition 43: 715-726.

59

Briend, A., Hasan, K.Z., Aziz, K.M., Hoque, B.A., and Henry, F.J. (1989b). Measuring change in nutritional status: a comparison of different anthropometric indices and the sample sizes required. European Journal of Clinical Nutrition 43: 769-778.

Briend, A., Wojtyniak, B., and Rowland, M.G. (1987). Arm circumference and other factors in children at high risk of death in rural Bangladesh. Lancet ii: 725-728.

Cant, A., Gould, M., Brooke, O.G., and Rowland, R. (1982). A nutrition study of under-fives in Eastern Rwanda. Journal of Tropical Pediatrics 28: 5-7.

Carael, M. (1978). Relations between birth intervals and nutrition in three Central African populations (Zaire). In: Mosely, W.H. (ed.), Nutrition and Human Reproduction. New York: Plenum Press, pp. 365-384.

Carter, E.P. (1987). Comparison of weight:height ratio and arm circumference in assessment of acute malnutrition. Archives of Disease in Childhood 62: 833-835.

Chossudovsky, M. (1994). IMF-World Bank policies and the Rwandan holocaust, Third World Network Features.

Clay, D., Byiringiro, F., Kangasniemi, J., Reardon, T., Sibomana, B., and Uwamariya, L. (1995). Promoting food security in Rwanda through sustainable agricultural productivity: Meeting the challenges of population pressure, land degradation, and poverty. Staff Paper No. 95-08, Department of Agricultural Economics, Michigan State University, East Lansing.

Cole, T.J. (1993). The use and construction of anthropometric growth reference standards. Nutrition Research Reviews 6: 19-50.

Csete, J. (1989). Determinants of young children's nutritional status in a Rwandan highland region with special attention to the Gishwati Potato Scheme. Unpublished Ph.D. dissertation. Cornell University, Ithaca, NY.

Dibley, M.J., Goldsby, J.B., Staehling, N.W., Trowbridge, F.L. (1987a). Development of normalized curves for the international growth reference: historical and technical considerations. American Journal of Clinical Nutrition 46: 736-748.

Dibley, M.J., Staehling, N., Nieburg, P., Trowbridge, F.L. (1987b). Interpretation of Z-score anthropometric indicators derived from the international growth reference. American Journal of Clinical Nutrition 46: 749-762.

Dowler, E.A., Luck, B.M., Robson, V.A., and Kigeme, E.A.R. (1980). Anthropometric survey of 1074 pre-school children in southern Rwanda, Central Equatorial Africa. Journal of Tropical Pediatrics 26: 134-138.

Dreze, J. (1990). Famine prevention in Africa: some experiences and lessons. In: Dreze, J. and Sen, A. (eds.), The Political Economy of Hunger. (Volume 2, Famine Prevention), Oxford: Clarendon Press, pp. 123-172.

FAO (1990). Rwanda. Production agricole et disponibilités alimentaires, ESN - Apercu nutrionnel, Rome: FAO.

Ferro-Luzzi, A., Sette, S., Franklin, M., and James, W.P.T. (1992). A simplified approach of assessing adult chronic energy deficiency. European Journal of Clinical Nutrition 46: 173-186.

Franklin, R.R., Dikassa, L.N., Bertrand, W.E. (1984). The impact of oedema on anthropometric measurements in nutritional surveys: a case study from Zaire. Bulletin of the World Health Organization 62: 145-150.

Frerichs, R.R., Becht, J.N., and Foxman, B. (1981). Screening for childhood malnutrition in rural Bolivia. Journal of Tropical Pediatrics 27: 285-291.

Frisancho, A.R., Guire, K., Babler, W., Borkan, B., and Way, A. (1980). Nutritional influence on childhood development and genetic control of adolescent growth of Quechuas and Mestizos from the Peruvian lowlands. American Journal of Physical Anthropology 52: 367-375.

Gayle, H.D., Binkin, N.J., Staehling, N.W., and Trowbridge, F.L. (1988). Arm circumference v. weight-for-height in nutritional assessment: are the findings comparable? Journal of Tropical Pediatrics 34: 213-217.

Gibson, R.S. (1990). Principles of Nutritional Assessment. New York: Oxford University Press.

Gorstein, J. (1989). Assessment of nutritional status: effects of different methods to determine age on the classification of undernutrition. Bulletin of the World Health Organization 67: 143-150.

Gorstein, J. and Akre, J. (1988). The use of anthropometry to assess nutritional status. World Health Statistics Quarterly 41: 48-58.

Gorstein, J., Sullivan, K., Yip, R., de Onis, M., Trowbridge, F., Fajans, P., and Clugston, G. (1994). Issues in the assessment of nutritional status using anthropometry. Bulletin of the World Health Organization 72: 273-283.

Gross, R., Stange, M., Solomons, N.W., Oltersdorf U., and Esquivel, I.R. (1987). The influence of economic deterioration in Brazil on the nutritional status of children in Rio de Janeiro, Brazil. Ecology of Food and Nutrition 19: 265-280.

Haaga, J.G. (1986). Negative bias in estimates of the correlation between children's weight-for-height and height-for-age. Growth 50: 147-154.

Haaga, J., Kenrick, C., Test, K., and Mason, J. (1985). An estimate of the prevalence of child malnutrition in developing countries. World Health Statistics Quarterly 38: 331-347.

Haas, J.D. and Habicht, J-P. (1990). Growth and growth charts in the assessment of pre-school nutritional status. In: G.A. Harrison, J.C. Waterlow (eds.), Diet and Disease in Traditional and Developing Societies. Cambridge University Press, pp. 160-183.

61

Habicht, J-P., Martorell, R., Yarbrough, C., Malina, R.M., and Klein, R.E. (1974). Height and weight standards for preschool children. How relevant are ethnic differences in growth potential? Lancet i: 611-615.

Habicht, J-P., Yarbrough, C., and Martorell, R. (1979). Anthropometric field methods: criteria for selection. In: D.B. Jelliffe and E.F.P. Jelliffe (eds.), Nutrition and Growth. (Human Nutrition, Vol. 2). New York: Plenum Press, pp. 431-441.

Hall, G., Chowdhury, S., and Bloem, M. (1993). Use of mid-upper-arm circumference Z scores in nutritional assessment (letter). Lancet 341: 1481.

Hitchings, J.A. (1979). Seasonal malnutrition and the impact of health center attendance on catch-up growth in Rwanda, Food Research Institute, Stanford University, Stanford, CA, mimeo.

Hogan, R.C., Broske, S.P., Davis, J.P., et al. (1977). Sahel nutrition surveys, 1974 and 1975. Disasters 1(2): 117-124.

Isherwood, R.J., Dimond, C., and Longhurst, S. (1988). Breast feeding and weaning practices in relation to nutritional status of under-5 children in North Bangladesh. Journal of Tropical Pediatrics 34: 28-31.

James, W.P.T., Mascie-Taylor, G.C.N., Norgan, N.G., Bistrian, B.R., Shetty, P.S., and Ferro-Luzzi, A. (1994). The value of arm circumference measurements in assessing chronic energy deficiency. European Journal of Clinical Nutrition 48: 883-894.

Jonsson, U. (1993). Integrating political and economic factors within nutrition-related policy research: an economic perspective. In: Pinstrup-Andersen, P. (ed.), The Political Economy of Food and Nutrition Policies. Baltimore: Johns Hopkins University Press, pp. 193-205.

Kanashiro, H.C. and Graham, G.C. (1984). Changes over time in food intakes of a migrated people. In: P.L. White, N. Selvey (ed.), Malnutrition: Determinants and Consequences. New York: Alan R. Liss, pp. 197-205.

Keller, W. (1988). The epidemiology of stunting. In: J.C. Waterlow (ed.), Linear Growth Retardation in Less Developed Countries. New York: Raven Press, pp. 17-34.

Keller, W. and Fillmore, C.M. (1983). Prevalance of protein-energy malnutrition. World Health Statistics Quarterly 36: 129-167.

Kelly, M. (1992). Anthropometry as an indicator of access to food in populations prone to famine. Food Policy 17: 443-454.

Kennedy, E. and Peters, P. (1992). Household food security and child nutrition: the interaction of income and gender of household head. World Development 20: 1077-1085.

Khan, Q.M. (1984). The impact of household endowment constraints on nutrition and health: a simultaneous equations test of human capital divestment. Journal of Development Economics 15: 313-328.

Kimura, K. (1984). Studies on growth and development in Japan. Yearbook of Physical Anthropology 27: 179-214.

Lemaire, B. (1989). Enquête alimentaire et nutritionnelle dans la région de Ngozi, Burundi. In: D. Lemonnier, Y. Ingenbleek (eds.), Les carences nutritionnelles dans les pays en voie de développement. Paris: Karthala-ACCT, pp. 543-549.

Leonard, W.R. (1991). Household-level strategies for protecting children from seasonal food scarcity. Social Science and Medicine 33: 1127-1133.

Lindtjorn, B. (1985). Measuring acute malnutrition: a need to redefine cut-off points for arm circumference? Lancet ii: 1229-1230.

Loewenstein, M.S., and Phillips, J.F. (1973). Evaluation of arm circumference measurement for determining nutritional status of children and its use in an acute epidemic of malnutrition: Owerri, Nigeria, following the Nigerian Civil War. American Journal of Clinical Nutrition 26: 226-233.

Loveridge, S. (1992). Sources of household revenue, farm exports, and their impact on food availability among agricultural households in rural Rwanda. Agricultural year 1990, Kigali: DSA/MINAGRI, mimeo.

Loveridge, S. (1988). Uses of food and market survey data to inform food security policy in Rwanda. Unpublished Ph.D. dissertation, Michigan State University, East Lansing, MI.

Lutter, C.K., Habicht, J.P., Rivera, J.A., and Martorell, R. (1992). The relationship between energy intake and diarrhoeal disease in their effects on child growth: biological model, evidence, and implications for public health policy. Food and Nutrition Bulletin 14(1): 36-42.

Malina, R.M., Martorell, R., and Mendoza, F. (1986). Growth status of Mexican-American children and youths: historical trends and contemporary issues. Yearbook of Physical Anthropology 29: 45-79.

Martorell, R. (1985). Child growth retardation: a discussion of its causes and its relationship to health. In: K. Blaxter and J.C. Waterlow (eds.), Nutritional Adaptation in Man. London: John Libbey, pp. 13-29.

Martorell, R. (1982). Nutrition and Health Status Indicators: Suggestions for Surveys of Standard of Living in Developing Countries. LSMS Working Paper No. 13. Washington, D.C.: the World Bank.

Mason, J.B., Habicht, J-P., Tabatabai, H., and Valverde, V. (1984). Nutritional Surveillance. Geneva: World Health Organisation.

63

Mata, L. (1985). Environmental factors affecting nutrition and growth. In: M. Gracey and F. Falkner (eds.), Nutritional Needs and Assessment of Normal Growth. New York: Raven Press, pp. 165-182.

Meheus, A., Butera, S., Dindinian, O., and Eylenbosch, L. (1977). Evaluation de l'état nutritionnel des enfants 0 à 5 ans dans la République Rwandaise, 1976. Antwerp, Belgium: Universitaire Instelling Antwerpen.

Mendoza Aldana, J. and Piechulek, H. (1992). Situation nutritionnelle des enfants de 0 à 59 mois en zone urbaine et rurale du Cameroun. Bulletin of the World Health Organization 70: 725-732.

MINAGRI (Ministere de l'Agriculture et de l'Elevage. Division des Statistiques Agricoles. Republique Rwandaise). (1993). Statut nutritionnel et sécurité alimentaire au Rwanda. Résultats de l'Enquête nationale sur la nutrition et la sécurité alimentaire des enfants de 0 à 5 ans et leurs mères (Novembre 1991-Janvier 1992), Kigali, mimeo.

MINAGRI (Ministère de l'Agriculture, de l'Elevage et des Forêts, Division des Statistiques Agricoles, République Rwandaise). (1992). Enquête Nationale Agricole 1990: production, superficie, rendement, élevage et leur évolution 1984-90. Publication DSA No. 26, Kigali, Rwanda.

MINAGRI (Ministère de l'Agriculture, de l'Elevage et des Forêts, Division des Statistiques Agricoles, République Rwandaise). (1991). Enquête Nationale Agricole 1989: production, superficie, rendement, élevage et leur évolution 1984-89. Publication DSA No. 22, Kigali, Rwanda.

MINIPLAN (Republique Rwandaise. Ministere du Plan, Service National de Recensement). (1993). Analyse de l'echantillon de 10%, Version provisoire non publiée,.

Mock, N.B., Magnani, R.J., Abdoh, A.A., and Kondé, M.K. (1994). Intra-household correlations in maternal-child nutritional status in rural Guinea: implications for programme-screening strategies. Bulletin of the World Health Organization 72: 119-127.

Monteiro, C.A., Benicio, M.H.A., and Gouveia, N.C. (1994). Secular growth trends in Brazil over three decades. Annals of Human Biology 21: 381-390.

Ogden, C.L. (1993). Urban malnutrition: maternal activities and child nutrition in Kigali, Rwanda. Unpublished Ph.D. dissertation. Cornell University, Ithaca, NY.

Oshaug, A., Pedersen, J., Diarra, M., Bendech, M.A., and Hatloy, A. (1994). Problems and pitfalls in the use of estimated age in anthropometric measurements of children from 6 to 60 months of age: a case from Mali. Journal of Nutrition 124: 636-644.

Osmani, S.R. (1994). Economic reform and social welfare: the case of nutrition in Sri Lanka. American Economic Review 84: 291-296.

Pottier, J. (1989). "Three's a Crowd": knowledge, ignorance and power in the context of urban agriculture in Rwanda. Africa 54: 461-477.

Pottier, J.P. (1986). The politics of famine prevention: ecology, regional production and food complementarity in western Rwanda. African Affairs 88: 207-237.

Quinn, V., Cohen, M., Mason, J., and Kgosidintsi, B.N. (1988). Crisis-proofing the economy: the response of Botswana to economic recession and drought. In: G.A. Cornia, R. Jolly, and F. Stewart (eds.), Adjustment with a Human Face, Vol. II, Country Case Studies. Oxford: Clarendon Press, pp. 3-27.

Reyntjens, F. (1993). Rwanda: Economy. In: Africa South of the Sahara 1993. (22nd Edition), London: Europa Publications Limited, pp. 680-682.

Schnepf, R.D. (1992a). Nutritional status of Rwandan households: survey evidence on the role of household consumption behavior. (Working Paper 23). Cornell Food and Nutrition Policy Program, Washington, DC.

Schnepf, R.D. (1991). Understanding the Health and Nutritional Status of the Children of Rwanda. (Cornell Food and Nutrition Policy Program Monograph 13). Cornell University, Ithaca, NY.

Sen, A. (1990). Food, economics and entitlements. In: Dreze, J. and Sen, A. (eds.), The Political Economy of Hunger. (Volume 1, Entitlement and Well-Being), Oxford: Clarendon Press, pp. 34-52.

Sen, A.K. (1981). Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford: Oxford University Press.Shakir, A. (1979). Anthropometric field methods: simplified methods. In: D.B. Jelliffe, E.F.P. Jelliffe (eds.), Nutrition and Growth. (Human Nutrition: A Comprehensive Treatise, Vol. 2). New York and London: Plenum Press, pp. 389-398.

Shann, F. (1993). Nutritional indices: Z, centile, or percent? Lancet 341: 526-527.

Smith, T., Heywood, P. (1991). Mid-upper-arm circumference (MUAC) in relation to other indices of nutritional status in Papua New Guinea. Papua New Guinea Medical Journal 34: 26-34.

Tanner, J.M. (1987). Growth as a mirror of the condition of society: secular trends and class distinctions. Acta Paediatrica Japonica 29: 96-103.

Tanner, M., De Savigny, D., Mayombana, C., Hatz, C., Burnier, E., Tayari, S., and Degremont, A. (1991). Morbidity and mortality at Kilombero, Tanzania, 1982-88. In: R.G. Feachem and D.T. Jamison (eds.), Disease and Mortality in Sub-Saharan Africa. Oxford: Oxford University Press, pp. 286-305.

Tomkins, A.M., Drasar, B.S., Bradley, A.K., and Williamson, W.A. (1978). Water supply and nutritional status in rural Northern Nigeria. Transactions of the Royal Society of Tropical Medicine and Hygiene 72: 239-243.

65

Trowbridge, F.L. and Staehling, N. (1980). Sensitivity and specificity of arm circumference indicators in identifying malnourished children. American Journal of Clinical Nutrition 33: 687-696.

UNICEF. (1990). Strategy for improved nutrition of children and women in developing countries, A Policy Review, New York: UNICEF.

UNICEF, Accra. (1988). Adjustment policies and programmes to protect children and other vulnerable groups in Ghana. In: G.A. Cornia, R. Jolly, and F. Stewart (eds.), Adjustment with a Human Face, Vol. II, Country Case Studies. Oxford: Clarendon Press, pp. 93-125.

UNICEF Kigali. (1992). Analyse de la situation des enfants et des femmes 1992, Kigali: UNICEF, mimeo.

UNICEF Kigali. (1988). Situation analysis of children and women in Rwanda. Kigali: United Nations Children's Fund.

Uvin, P. (1994). The state of world hunger. In: P. Uvin (ed.), The Hunger Report: 1993. Switzerland: Gordon and Breach for World Hunger Program, Brown University, pp. 1-42.

Uwizeimana, L. (1991). Croissance démographique et production agricole au Rwanda: Impossible adéquation. (Cahiers du CIDEP no 8), Louvain-la-Neuve: CIDEP.

van Sprundel, M., Butera, S., Dindinian, O., Eylenbosch, W., and Meheus, A. (1979). Etat nutritionnel des enfants de 0 à 5 ans dans la République rwandaise in 1976. Médecine d'Afrique Noire 26: 665-671.

Vis, H.L. (1975). Analyse de la situation nutritionnelle dans la région des Grands Lacs d'Afrique Centrale, l'impasse démographique. Revue Tiers Monde 16: 567-594.

Waterlow, J.C. (1972). Classification and definition of protein-energy malnutrition. British Medical Journal 3: 566-569.

Waterlow, J.C., Buzina, R., Keller, W., Lane, J., Nichaman, M., and Tanner, J. (1977). The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. Bulletin of the World Health Organization 55: 489-498.

WHO. (1983). Measuring Change in Nutritional Status. Guidelines for Assessing the Nutritional Impact of Supplementary Feeding Programmes for Vulnerable Groups. Geneva: World Health Organization.

WHO Working Group (1986). Use and interpretation of anthropometric indicators of nutritional status. Bulletin of the World Health Organization 64: 929-941.

World Bank (1992). World Development Report 1992. Oxford: Oxford University Press.

Yip, R., Scanlon, K., and Trowbridge, F. (1992). Improving growth status of Asian refugee children in the United States. Journal of the American Medical Association 267: 937-940.