Staff Paper

Understanding and Reducing Child Malnutrition in Mali: Interim Research Findings for the Project on Linkages between Child Nutrition and Agricultural Growth (LICNAG)

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With assistance from the
LICNAG Research Team

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Interim Research Findings for the Project on Linkages between Child Nutrition and Agricultural Growth (LICNAG)

a Ministry of Health/Institut du Sahel/Michigan State-coordinated study

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Abstract

The study of the Linkages between Child Nutrition and Agricultural Growth (LICNAG) seeks to understand the positive and negative repercussions that agricultural-led growth has on children's health and nutritional status. The project's goal is to identify means of strengthening positive linkages between agricultural development and factors that influence child health and nutritional status. To accomplish this, we conducted a study (May 2001 - April 2002) of 750 rural households located in three agricultural systems: an irrigated rice zone in the *Office du Niger* of the Ségou Region, a rain-fed cotton zone in the Sikasso Region, and a traditional millet and sorghum zone in the Mopti Region. This paper reports the results of preliminary analysis using the first six months of survey data.

In comparing the irrigated rice zones to other zones, LICNAG results show that (1) per capita income for the parents of children less than four years old is significantly higher than in other zones, (2) women have greater access to and control over income, and (3) rates of wasting and stunting are significantly lower. In the cotton zones income is concentrated in the hands of the heads of large extended families and women have little access to personal income. Reducing the concentration of income and increasing women's income are key challenges in this zone. In the coarse grain production systems of the Mopti Region, adults as well as children are not getting enough to eat. Increasing access to food and income requires measures to reduce price and climatic risk (e.g., water management and transport infrastructure, and diversification of incomes). Households in these regions depend heavily on off-farm income to meet their food needs, particularly remittances from both men and women working as laborers in the *Office du Niger* irrigated rice zone. As Mali moves forward in its efforts to expand irrigated perimeters in the *Office du Niger*, it will be important to encourage positive spillover effects from the irrigated rice sector that can contribute to improved food security for households in the neighboring Mopti Region.

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1 Background and Context

1.1 The Nature of the Nutrition Problem in Mali

The first Malian Demographic and Health Survey (DHS I) conducted in 1987 found relatively high rates of child malnutrition among children under five years of age: 24 percent had chronic malnutrition, 11 percent had acute malnutrition and 31 percent were underweight. These results were disturbing but not surprising given the very poor economic growth characterizing the period. The publication of the 1995/96 DHS II survey suggesting even higher rates of child malnutrition (30 percent chronic, 23 percent acute, and 40 percent underweight), however, came as a shock to many people in the Malian government and the donor community because these findings came at a time of strong economic growth, particularly in rural areas. For example, value added in the cotton sector had grown annually by 7.3 percent and that in the irrigated rice sector by 10.3 percent between 1987 and 1999 (Tefft et al. 2000). The strongest growth for both sectors occurred after the January 1994 devaluation of the CFA franc. Farm survey data suggest that by 1996/97, the devaluation had stimulated a 58 percent increase in real income per hectare for irrigated rice, 30 percent for maize grown in the cotton zone, and 14 percent for cotton (Tefft et al. 2000, Mariko et al. 2001, Kébé et al. 1998).

The DHS II results prompted much discussion about the potential reasons for this paradox of a perceived deterioration in children's nutritional status during a period of higher economic growth. Among the most commonly mentioned hypotheses were:

- The potentially positive health and nutritional impacts of the post devaluation growth spurt occurred too late to be captured by the 1995 DHS II;
- The distribution of income growth across zones and households was too uneven to have a positive impact on aggregate nutritional levels;
- The within-household distribution of additional income from the best performing crop sectors favored increases in discretionary consumption spending by individuals rather than increases in general household expenditures on basic foods and health care;
- Factors other than household income (e.g., mothers' knowledge of proper feeding, hygiene, and health care practices) are the most important determinants of child health and nutrition status, therefore it is not surprising to see little correlation between growth in agricultural productivity and child health/nutrition status;
- Investments in donor-financed child survival projects are not providing adequate levels of access to health and nutritional services.

1.2 Designing Research to Better Inform Nutrition Policy and Programs

In the interest of better understanding this paradox of seemingly worse rates of child malnutrition and higher rates of economic growth, USAID financed a two-part

research/action study: Linkages between Child Nutrition and Agricultural Growth (LICNAG).[1] This collaborative research effort joins Michigan State University (MSU) researchers with colleagues from the Food and Nutrition Monitoring Division (DSSAN) in the Planning and Statistics Unit of the Ministry of Health (CPS/MS), the Sahel Institute (INSAH), the National Public Health Research Institute (INRSP), the National Statistical Office (DNSI) and the Institute of Rural Economy (IER) with financing provided by USAID/Mali/SEG through Food Security II Cooperative agreement at Michigan State University.

Phase I of the study, initiated in 1999, focused on an analysis of existing databases and a review of previous research conducted on child malnutrition, health, agricultural productivity, consumption, food security and incomes.[2] It included a review of findings from countries other than Mali and an analysis of data from five major national studies: two Demographic and Health Surveys in Mali (1987 and 1995), a Budget-Consumption Study (1989), World Bank Socio-Economic Study (1994), and the annual Agricultural Surveys conducted by DNSI. Data from socioeconomic surveys conducted by the farming systems and subsector programs at the Insitute of Rural Economy (IER) over the last ten years were also analyzed.

These analyses resulted in the following conclusions about agricultural growth:

- Although aggregate national statistics show strong agricultural growth during the recent past, the higher farm incomes associated with this growth have been concentrated in the irrigated rice sector and among the better-equipped cotton farmers with animal traction;
- Many farm households that are (1) increasing cotton and cereal production through area expansion (characterized by sub-optimal use of inputs and farming practices), or (2) growing cereals in rainfed areas, or (3) growing rice outside of the *Office du Niger* are not increasing their productivity, food production or income;[3]
- Average aggregate national cereal production (188 kg/capita) from 1986 through 1999 exceeded estimated needs (168 kg/capita), suggesting that poor nutrition may be more a problem of access and utilization than of aggregate production;
- Well over half of rural households still do not produce sufficient food to meet their needs, hence their food security depends on regular access to income and proper functioning markets that supply food at affordable prices throughout the year;
- Hypotheses concerning potentially negative repercussions from agricultural-led growth have not been adequately tested, in particular the effects of increased female labor in agriculture and the role of increased cash income in the hands of men.

[1] Other information detailing the project can be located on the Food Security web site: http://www.aec.msu.edu/agecon/fs2/mali_nut/index.htm.

[2] These findings and others are presented in detail in *Linkages between agricultural growth and improved child nutrition in Mali* by Tefft et al. 2000.

[3] The scarcity of microeconomic data on different types of livestock production systems prevented analysis of their recent evolution and impact on incomes.

An analysis of DHS databases and other health statistics led to the following conclusions:

- Although the incidence of child illness and malnutrition is high in Mali, as measured by the DHS II, differences in the samples used in DHS I and II (rural/urban mix, age distribution of children, month of data collection) make it difficult to statistically compare the two samples or to conclude that child malnutrition has increased between 1987 and 1996;
- Income (represented by assets such as radios, televisions, and bicycles) is positively but weakly related to better child health and nutrition;
- Living in proximity to health services is positively related to better health and nutrition (to the extent that community infrastructure is financed by agricultural profits, this serves to strengthen the link between agriculture and child health);
- The education, knowledge and childcare practices of the primary caregiver are among the most important determinants of a child's dietary intake; the caregiver must have both the knowledge and the will to ensure correct nutrition if the child is to thrive;
- Children's health also has a major effect on their nutritional status and is affected by their exposure and susceptibility to disease and the care provided to them.

The 1995 DHS II survey may have taken place too soon after the 1994 devaluation to have captured some of the positive income outcomes reported by others. Also, the unequal geographical distribution of agricultural growth since 1994 and the unequal distribution of income growth across households means that there might have been a reduction in childhood malnutrition among some households in some zones, but that the positive outcomes were too localized to be detected by DHS II, which reported average results for broad administrative regions. Another relevant point to keep in mind is that all urban households and well over half of Mali's rural households do not produce sufficient food to meet their own needs. Therefore, access to good nutrition for most Malians depends on having income (farm and non-farm) to purchase food and well-functioning national and regional markets to deliver it to consumers. As noted in the bullets above, household income and food production tend to be weak indicators of child health and nutritional status, suggesting that the positive impact of income is realized only when combined with the knowledge and the will necessary to invest in better nutrition and health outcomes.

Participants in the LICNAG Phase I project workshop in February 2000 discussed these results and unanimously agreed that child malnutrition remains a serious problem in Mali (whether it is increasing or not). Designing an effective program to address the problem is, however, hindered by a poor understanding of the relative importance of the different determinants of child health and nutritional status and how the determinants interact with each other. The analyses conducted on existing Malian data bases during the first phase of the LICNAG study were often inconclusive or of weak statistical significance, in large part because there was no single data base permitting the simultaneous analysis of a wide range of household characteristics (e.g., income levels and sources, health/nutrition indicators, education levels, and childcare practices) and community variables (e.g., available infrastructure and services) for the same sample. Without such a data base it is virtually impossible to

correctly evaluate hypotheses concerning both the positive and negative repercussions that agricultural-led growth might have on children's health and nutritional status or to develop sound recommendations for increasing positive outcomes. Consequently, the national ad-hoc nutrition group coordinated by the Food and Nutrition Monitoring Division (DSSAN) in the Ministry of Health recommended that a second project phase be designed and implemented to collect and analyze the data needed to improve our understanding of the links between agricultural growth and child nutritional status.

This ad-hoc group recommended that the second phase of the project focus on developing a better understanding of four key issues:

- The links between child nutritional status and a household's productive assets (e.g., land, farm equipment), farm and non-farm income, and food availability from own-production and purchases;[4]
- The impact of seasonal factors (in consumption patterns, labor allocation and work load, and the presence of disease) on childhood nutrition;
- The effect on children's nutritional status of feeding and hygienic practices and the use of health care services;
- The links between growth in agricultural incomes and the potential for collective investments in social infrastructure.

During the workshop and in subsequent committee meetings, numerous participants recommended that the survey be conducted on a sub-sample of the upcoming Demographic and Health Survey III (DHS III) to avoid some of the problems associated with combining results from unrelated surveys.

The group also recommended that a multi-disciplinary technical steering committee be created to coordinate the design and planning of the second phase. Over the following months, this committee drafted a detailed research proposal presenting the conceptual framework, research hypotheses and methods that would guide the study (LICNAG 2000).

1.3 Conceptual Framework for Linkages between Agriculture and Nutrition

In designing research to study links between childhood nutritional status and agricultural growth it is essential to have a model that identifies the principal determinants of nutritional status and the key factors affecting these determinants. Following a review of numerous existing models and theories developed by UNICEF and WHO on the factors affecting child nutritional status, the technical committee used an International Food Policy Research Institute (IFPRI) framework (Kennedy 1983) as the basis for developing the analytical framework presented in Figure 1.1. The committee judged that the IFPRI framework effectively linked the factors affected by agricultural growth (food production, income) with child nutrition status while at the same time underlining the importance of other factors such as care, illness, feeding practices.

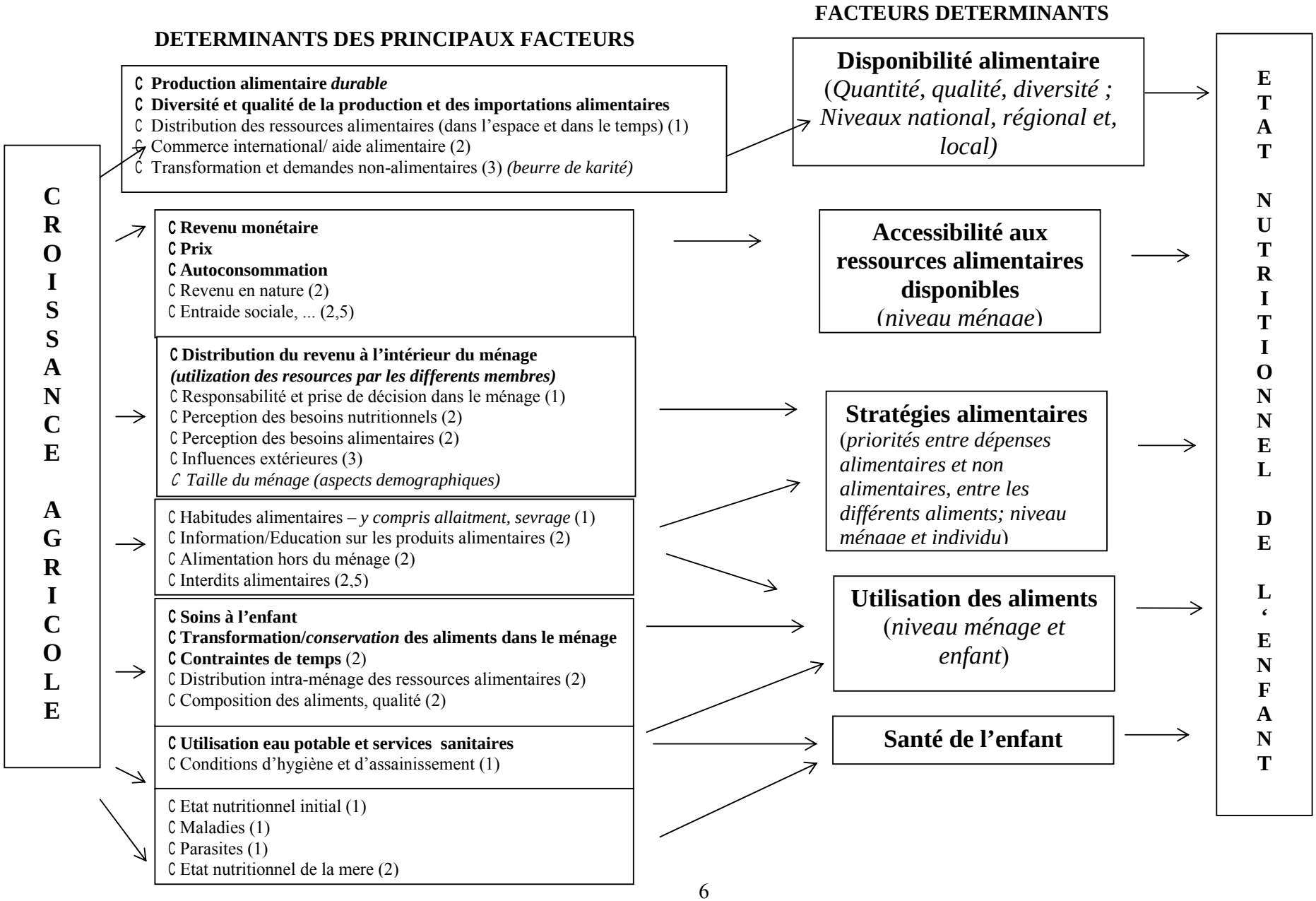
[4] The workshop also recommended that the study focus on the problem of protein-energy malnutrition. The serious problem of micronutrient deficiencies would be addressed in another study.

The modified IFPRI framework identifies a hierarchy of five determinants of nutritional status:

1. Food availability (local, national, regional)
2. Household-level ability to obtain available food
3. Household strategies used to obtain available food
4. Household strategies for using acquired food to meet nutritional needs
5. Health of individual members of the household

The list of principal factors affecting these determinants (left of Figure 1.1) allows us to see more clearly the multiple avenues by which agricultural growth can affect the nutritional status of Malian children. Items printed in bold letters are considered priority determinants shaping both agricultural growth and child nutrition. The numbers in parentheses in the box showing determinants of principal factors indicate the priority assigned to the various determinants by the technical committee: items in bold are top priority, followed in priority by items numbered (1), (2), etc.

Figure 1.1. Conceptual Framework for Linking Agricultural Growth and Child Nutrition



1.4 Objectives and Organization of this Document

The general objectives of this interim report are to present a sub-set of preliminary findings on the prevalence of childhood malnutrition found in the LICNAG survey, to elicit suggestions for future analyses, and to stimulate discussion about the design of policies and programs with potential to improve nutritional outcomes in Mali. The report draws primarily on the childhood (under four years old) anthropometric, morbidity, and mortality survey data and a small subset of the socio-economic data to provide basic descriptive analyses of childhood nutritional and health status. The focus is on cross-sectional comparisons across age/gender groups, different types of production zones and a limited number of household characteristics.

The paper does not directly address the four research topics outlined in section 1.2 above because the detailed income and childcare practices data required to answer these questions are not yet available. Nevertheless, the authors have used the available data, in combination with the results of prior research on the general topic of child nutritional status, to test some hypotheses and refine others that will be tested when the full data set is available. Among the key questions addressed in this report are:

- What is the prevalence of childhood malnutrition for the LICNAG survey?
- Does the prevalence vary by age or sex?
- How does this prevalence compare to DHS results and reference populations?
- Does the prevalence vary by household characteristics such as:
  - Type of cropping system?
  - Level of household assets?
  - Parents' level of formal education?
- What are the morbidity and mortality patterns for children under five years of age?
- What is the relationship between morbidity and growth?
- How are households dealing with the treatment of childhood illnesses:
  - What types of treatments are used?
  - Who is providing treatment or paying for the treatment?
- What factors differentiate households with malnourished children from households with well-nourished children?
- What factors differentiate mothers with malnourished children from mothers with well-nourished children?

Given the on-going nature of this study and the continuing efforts to collect, clean and verify data, the results presented in this paper are preliminary and may change following additional cleaning and analysis.

The rest of this paper is divided into six sections. Section 2 covers research methods (sampling, survey design, and analysis). Section 3 presents anthropometric results for the overall sample and by sex and age group. Section 4 presents anthropometric results disaggregated to the sub-regional level in an effort to identify differences across geographic zones and cropping systems. Section 5 describes morbidity and mortality of children in the sample and presents descriptive information on how households dealt with children's illnesses. Section 6 presents some preliminary results on factors hypothesized to influence children's nutritional status. Section 7 concludes

with a discussion of the implications of the preliminary findings for further research, policy reform, and actions to improve the nutritional status of Malian children.

2 Research Methods

As noted above, a major weakness in the currently available data on agriculture and health in Mali is that the two topics are rarely covered in the same survey, making it difficult to examine links between agricultural productivity and child nutritional and health status at the household level. Consequently, a key objective of the present study was to select a sample having as much overlap as possible with the DHS III survey conducted during the same year; this would permit the socio-economic data being collected by the LICNAG survey to be combined with the health, demographic, and nutrition data being collected by the DHS III survey.

DHS III uses a single interview to collect data on topics such as fertility, attitudes toward contraception, and mother and child health, but does not collect information on income or expenditures. The LICNAG study collects data throughout the year using weekly, bi-weekly or monthly questionnaires, depending on the topic. Data collected cover household income and expenditures, food consumption, agricultural production practices (input and equipment use, yields, etc.), and child nutritional and health status—data that are very complementary to the DHS III data. The key characteristics of the DHS sampling methods and the procedures used by LICNAG to select a sub-sample are described in Section 2.1. Following this section we describe the demographic characteristics of the sample, survey methods, and analytical methods used to prepare this report.

2.1 Sampling Methods[5]

The DHS sampling objective was to interview 9000 women between the ages of 15 and 49 years of age and 3000 men 15 to 59 years of age, with the men being selected from a subset of the households to which the sample women belonged. DHS surveys include an urban (3221 women) and a rural (5778 women) stratum. The LICNAG sample is a subset of the DHS rural strata.

The DHS rural households were selected using a two-stage cluster sampling technique (stratification *aréolaire).* The sampling frame consisted of the list of 6598 rural "Sections d'Énumeration" (SEs) used by the Malian Central Census Bureau for the 1987 census. The average size of a rural SE is 143 households with a standard deviation of 69. For the DHS rural sample, administrative regions (e.g., Ségou, Sikasso, Mopti) were considered individual study zones from which 38 primary sampling clusters (SEs) were selected during the first stage of sampling. Because of variability in the population of SE, DHS divided larger SE into segments and then selected a single segment for their cluster. SEs (or segments) were selected in a systematic manner with a probability of selection proportional to the size of the SE (segment).

In the second stage of sampling, households were selected from a complete listing of households established by DHS for each of the SE selected in the first stage. The number of households selected per SE varied, but it was generally more than 30.

[5] As the methods section of the DHS III publication is not yet available, we have used the DHS II report (pages 7-8 and Annexe A) to describe general DHS sampling procedures. Once the DHS III report is available, we will adjust the description to conform to DHS III procedures.

These sampling procedures selected 6,293 rural households to represent the regions of Kayes, Koulikoro, Sikasso, Ségou, and Mopti.

The DHS sample is representative nationally, by type of residence (urban, rural) and for each of the administrative regions covered by the rural sample (Kayes, Koulikoro, Sikasso, Ségou, and Mopti). Results are not representative at the level of *cercle* or *arrondissement*.

The LICNAG survey represents a sub-set of the DHS rural survey. The LICNAG study focuses on the three regions of Sikasso, Ségou, and Mopti, each representing a different cropping system (cotton, rice, and coarse grains, respectively). Available resources shaped decisions about sample size (750 households) and methods of selection. A minimum of 250 households per production system was considered necessary to permit analysis of inter-household differences for each system. The aim of the LICNAG survey is to present results that accurately describe the socio-economic situation and the health and nutritional status of children in each of the three cropping systems. The next several paragraphs explain how the LICNAG sample was selected.

2.1.1 Purposive selection of cropping systems and sub-regions for LICNAG

As the primary goal of the project is to examine possible synergies between agricultural development and improved child health and nutritional status, the project's multi-disciplinary technical steering committee recommended focusing on three specific agricultural production systems--two that have recently shown signs of increased production and one where production has been relatively stagnant. The systems recently increasing production are the cotton zones in the Sikasso Region and the irrigated rice zones of the *Office du Niger* in the Ségou Region. The coarse grain (millet/sorghum) systems in the Mopti region were selected to represent the less dynamic production system.

Although we refer to the Sikasso Region as the "cotton zone," readers need to keep in mind that it is also one of Mali's most important sorghum and maize zones, accounting for approximately 30 percent of national production since the mid-1980s. In other words, cotton is not a monoculture for the zone. Farmers in the *Office du Niger*, Mali's largest irrigated rice production scheme, also engage in vegetable production (primarily onions and tomatoes) during the dry season. The coarse grain farmers in the Mopti Region engage in traditional millet and sorghum production activities, but they also produce onions during the dry season and engage in a wide range of other activities to supplement income. Migration by young girls to work as maids in Bamako and by both men and women to work in the rice fields of the *Office du Niger* is particularly important in the Bandiagara sub-region. In the latter case, in-kind payment with sacks of rice is very common, providing a major source of cereals to compensate for deficit coarse grain production.

Two sub-regions (administrative units termed *cercles* in French) were chosen to represent each of the three cropping systems: Kolondieba and Koutiala in the Sikasso cotton zone; Macina and Niono in the Ségou irrigated rice perimeters; and Bandiagara and Koro in the coarse grain production zones of Mopti.

Cotton systems
Koutiala is the traditional center of cotton production while Kolondieba is a newer production zone. Farmers in the cotton zone have benefited from credit programs designed to promote the adoption of animal traction equipment and relatively high levels of input use (fertilizers and pesticides). As a result, cotton farmers on average own more traction animals than farmers in the rice and coarse grain zones (approximately three per PCU in Kolondieba and four in Koutiala).

Livestock ownership is also high on average in the cotton zones, with Koutiala farmers owning more animals than those in Kolondieba (i.e., an average of 11 cattle in addition to their traction animals in Koutiala versus 9 in Kolondieba; for sheep the equivalent numbers are 6 versus 4 and for goats 5 versus 4 animals). In the cotton zone, as elsewhere, livestock assets serve not only as a bank account (to be drawn down in times of emergency or for major PCU expenditures) but also as a source of organic matter for improving soil fertility.

The Bambara are the main ethnic group in Kolondieba while Minianka and Bambara reside in the Koutiala sub-region. Infrastructure is generally better in Koutiala, particularly in terms of feeder roads used to get cotton to market. In addition to coarse grain production, important in both sub-regions, lowland rice (traditionally a women's crop) is grown by many households and appears to have potential to be more fully developed (Dimithè 1998).

Irrigated rice systems
Niono is in the heart of the irrigated rice area and received much more donor attention than Macina during the recent periods of irrigation system "rehabilitation". Macina, the first zone to be developed during the colonial period, was thought to have much less potential for rehabilitation due to highly degraded soils and irrigation systems. In addition, Niono has been a commercial center frequented by traders from Bamako and elsewhere since the 1980s, due in large part to its market and transport infrastructure. Improvements in irrigation infrastructure have come to Macina, but they have not been as extensive. Also, it was not until after the 1994 devaluation that traders began coming to this zone of relatively difficult access to purchase rice rather than forcing farmers to transport their production to more central locations.

People living in the *Office du Niger* come from diverse backgrounds. Forced labor during the colonial period brought many people from Burkina Faso (e.g., Mossi) to settle in the area, and the current economic opportunities are attracting a wide range of new people (including civil servants, both active and retired, who are investing in rice production using hired labor). The Bozo ethnic group, found primarily in the Macina sub-region of our sample, is heavily involved in fishing. Although there are some areas with a large percentage of minority ethnic groups (Mossi, Minianka), the Bambara, Fulani, and Bozo predominate in the study zones.

Although rice production is the principal income-generating activity of most PCUs in the Office du Niger, livestock makes an important contribution to overall income by providing manure (much of which is used by women on their onion fields) and as a means of saving. The average number of traction animals owned is greater in Macina (3) than in Niono (2). However, farmers in Niono have larger herds on average than

those in Macina (6 versus 3 cattle, 7 versus 3 sheep, and 7 versus 4 goats). Average livestock holdings in Macina are the smallest among all the six sub-regions.

Coarse grain systems
Dogon people are the majority population in both of the coarse grain production zones, but Fulani are also present throughout the Mopti Region. Bandiagara is located on the Dogon escarpment, where land is a major constraint. Farmers produce millet and sorghum during the rainy season and onions during the dry season (using small dams to retain water that is then applied to the crop manually). Koro, part of the plateau towards Burkina Faso, has much more available land, but faces the environmental constraints of increasing desertification. Millet and sorghum are the principal crops. Some farmers practice dry-season vegetable gardening, but water is a major constraint because many wells go dry. Livestock is an important part of the farming systems in both zones, although average livestock holdings are lower in this production system than in the cotton and rice systems. Farmers in both Koro and Bandiagara own 5 cattle, but PCUs in Koro (where grazing land is more abundant) have more sheep (7 versus 3) and about the same number of goats (9 versus 10). Recent improvements in roads in the Bandiagara zone have attracted numerous small truckers, making it easier for farmers to market their produce (primarily onions) and purchase cereals to compensate for deficit production. Despite road improvements, Koro remains more isolated due to the long distances that must be traveled on secondary roads from the major population centers of the region.

2.1.2 Random selection of villages within the six sub-regions

Each sub-region is comprised of multiple enumeration areas (SE). An SE is usually comprised of a single village; occasionally, it is comprised of a main village plus smaller hamlets or several small villages. The DHS III survey includes five to eight SEs randomly selected in each sub-region. The LICNAG study randomly selected five SEs per sub-region from those selected by DHS. All of the hamlets and villages within the selected SEs were included in the LICNAG survey.

2.1.3 Selecting households

Maintaining the same sample of households in the LICNAG and the DHS III surveys was complicated by differences in the definition of household used by the two surveys. For the DHS III, the sample household unit is a nuclear family—mother, father, and all unmarried children. For the LICNAG survey the sample household unit is a production/consumption unit (PCU) characterized by collective production of food crops combined with collective preparation and consumption of meals by PCU members. In some cases the PCU is the same as the nuclear family, in other cases it is a composite of several related nuclear families. In Mali, the PCU generally corresponds to the living unit referred to as a *concession*.

DHS III household selection procedures
For each selected SE, DHS did a census of all *concessions* so the nuclear families within each *concession* could be identified; a map was drawn showing the location and number of each *concession* and nuclear family. Given the objectives of the DHS survey, only nuclear families with women from 15-49 years of age were retained for

the survey. DHS randomly selected their households from this list. Approximately 40 households were selected in each sample SE.

LICNAG household selection procedures
Using the DHS map showing all PCUs and nuclear families in selected SEs, LICNAG did a preliminary interview of each to determine (1) if they included at least one child under four years of age (<48 months) and (2) if the nuclear families identified by DHS were independent PCUs.

Only PCUs with children under four were included at the beginning of the survey in an effort to ensure that each PCU would have a child in the under five years age group during the entire survey year. Limiting the children participating in the survey to less than five years of age reduces the possibility of differences in height being related to genetic differences.[6] Also, if nuclear families were not independent PCUs, they were combined with other related nuclear families to form a single sample household (PCU) in the LICNAG survey. A computerized list of all PCUs and nuclear families in the SE was created that included annotations concerning nuclear families that would not be eligible or needed to be combined with others for the LICNAG sample.

Having completed this preliminary step, LICNAG then used the list of approximately 40 sample nuclear families selected by DHS III in each SE and the information gathered on household eligibility for the LICNAG study to:

- randomly select 25 PCUs from among the DHS households which met eligibility criteria for the LICNAG survey;
- randomly select an additional 10 PCUs to use as back-up or replacement sampling units should any of the first 25 units selected prove to be unwilling or unable to participate in a year-long survey.

In three cases where the LICNAG study did not meet its objective of 25 plus 10 sample PCUs per SE, the initial list of all PCUs and nuclear families in the SE was used to randomly select additional units from those meeting the eligibility criteria. These additional sampling units will not have matching DHS data. About 75 percent of the sample in these SE will overlap with the DHS III survey.

In two other SE, the DHS team had not performed a full census and complete mapping exercise due to a flood; consequently, the LICNAG sample was randomly drawn from a list of households gathered by the LICNAG team; in this case it is unlikely that there will be much, if any, overlap with the DHS III survey.

Table 2.1 lists all the regions, sub-regions (i.e., *cercles)*, and villages and hamlets covered in the LICNAG survey. Villages that are not expected to have a full set of data overlapping with the DHS survey are identified in the table.

[6] World Health Organization has found that genetic differences in height across healthy, well-nourished populations only account for one centimeter of variation among five year-old children (WHO 1995).

Table 2.1. LICNAG sample regions , sub-regions, villages and hamlets

Region	Sub-region	Villages/Hamlets corresponding to selected SEs
Sikasso	Kolondieba	Bogodougou, Missala
		Zantoumana, Garako hameau de Farako
		Kadiana I et II*
		Wobilen*
		Bafaga
	Koutiala	N'Golokouna
		Nianabougou
		Nizanso I and II**
		N'Gania, N'Tobogou
		N'Golobabougou, Bouala, Maguena, Galabougou I and II
Segou	Macina	Touara**
		Massadougou, Segou-Coura
		Nenena
		Ouadie
		Tlenglola, Kien-Koury
	Niono	Kouyan-Ngolabala
		Niessoumana ou N6
		Bougouni ou N16
		Godji, Daouna,Tourela, Faranikoudia
		Sing-Rangabe
Mopti	Bandiagara	Boro, Dari Dogon
		Kendie
		Somoli, Douro
		Ouakarana, Perguesse, Nambagoro, Anda Medina, Irani*
		Touni, Gouni Peulh, Gouni Dogon
	Koro	Ene, Anakana
		Daga, Koundiaka, Segeré
		Diessere
		Diaweli, Oya, Anouma
		Domonosogou

Source: Survey data

* Indicates village where sample does not overlap with DHS III.

** Indicates village where some non-DHS households were added.

2.2 Demographic Characteristics of the Sample

Table 2.2 reports the characteristics of the sample production-consumption units by sub region. PCUs in the Macina and particularly the Niono sub regions are noticeably smaller than the other zones. This is due, in part, to the fact that many people living in the zones, immigrated individually or in small families to this area from other parts of Mali and neighboring countries. In the other regions, most families originate

Table 2.2. Characteristics of Sample Production/Consumption Units

Region Sub-region	Total number of PCU	Persons per PCU		Children < 4 years of age per PCU		
		Mean	SD	Total number	Mean per PCU	SD
Sikasso						
Kolondiéba	125	19.84	12.1	403	3.2	2.2
Koutiala	126	20.23	11.8	442	3.5	2.5
Ségou						
Macina	124	15.72	11.7	299	2.8	2.2
Niono	122	11.31	7.2	264	2.2	1.4
Mopti						
Bandiagara	125	20.65	13.9	343	2.9	2.0
Koro	121	18.36	14.6	272	2.7	2.7
Total	743	17.71	12.5	2023*	2.9	2.2

Source: Survey data at beginning of survey (May 2001).

* Among these 2023 children, there are 70 who were actually ≥48 months in May 2001 and another 237 for whom we are still verifying birth dates; none of these 307 children are included in the current analyses of anthropometric measures.

from the village and households are large extended families. The number of children under four years is also lower in the Niono sub-region while Koutiala has the highest number.

Table 2.3 lists children by age group. Percentages are based on children for whom the day, month and year of their birth have been reported and verified. There are 237 cases that are still being verified. As explained in section 2.1.3, the sampling procedure purposively limited the starting sample to children who were less than four years at the beginning of the survey in May 2001. By the end of the survey year we will be able to report results for children from 48 to 59 months.

Table 2.3. Number and age distribution of sample children

Age groups	Number	%
0 – 5 months	332	17
6 – 11 months	298	15
12 – 17 months	365	18
18 – 23 months	227	12
24 – 35 months	442	23
36 – 47 months	289	15
Sub-total of verified data	1953	100
Cases being verified*	237	
Grand Total	2190	

Source: Estimated from survey data using children < 4 years of age at the beginning of the survey (May 2001).
* These represent cases for which month and day of birth was not available during the original census.

2.3 Survey Methods

Formal questionnaires and guidelines for informal interviews and reporting on observations of mother/child behaviors were developed by project staff and used in conjunction with the following project activities: [7]

- Qualitative study of child feeding and care practices and women's time allocations in agriculture, taking into account the constraints that these duties have on child care and other income-generating activities;
- Survey of 750 farm households conducted over one year to collect the data on:
  - Weekly income and expenditures
  - Weekly household consumption of cereals and pulses
  - Weekly agricultural and animal transactions
  - Agricultural inputs and production during the cropping season
  - Monthly anthropometric measurements of children below five years;
- One pass survey of mothers' and fathers' knowledge, attitudes and practices (KAP) related to child feeding and care practices;
- Interviews at the community level with health center personnel and the head doctor for the sub-region on the health and nutrition situation and current programs in health centers serving sample PCUs;
- Interviews with commune mayors to discuss the community's ability to improve child health and nutrition and to establish sustainable mechanisms to finance needed interventions;

[7] Copies of most of these survey instruments and instructions to the interviewers are available on the FSII website at: http://www.aec.msu.edu/agecon/fs2/.

- Focus group discussions with fathers and mothers on KAP, mothers' time allocation and initial survey results.

Members of the multi-disciplinary technical steering committee met with the research team several times to review drafts of survey instruments and a few committee members participated directly in the design and testing of the survey instruments.

Thirty enumerators (one per SE) and six supervisors (one per sub-region) were employed full-time for the yearlong survey. To establish confidence and good relations with sample households and facilitate implementation of the weekly interview schedule, enumerators lived in the sample villages. Supervisors were based in the sub-region capitals to facilitate contact with project management personnel in Bamako.

Two of the thirty enumerators were women. Twenty-two enumerators had an educational level equivalent to the BAC plus four years of advanced studies at either the *Institut Polytechnique Rurale* (IPR) at Katibougou or the *Ecole Normale Superieur*. Eight enumerators completed high school and some additional technical training but did not attain the *baccalaureat* degree. Interviews were conducted in Bambara in the cotton zones, Dogon or Fulani in the coarse grain zones of Mopti, and Bambara or Fulani in the rice production zones.

2.4 Analytical Methods Used in this Report

2.4.1 Anthropomentric data

To calculate anthropometric indices, data have been collected on each child's sex, age, weight and height. Every month for one year, children who were below four years of age at the beginning of the survey were weighed and measured. Following WHO recommendations, children under 24 months were measured lying down (recumbent length) while those older than 24 months were measured standing up (stature) (WHO 1995). Enumerators were trained by participating Ministry of Health researchers to accurately carry out, read and record measurements. In the event that enumerators were not able to measure a child of a given age using the recommended method (i.e., measure a child of 24 months standing up), data were adjusted according to WHO guidelines (WHO 1995).

Results reported in this paper are based on the analysis of data from children for whom the date of birth has been verified. Children for whom there was no birth certificate or whose parents did not know the birth date have been omitted, pending verification of the birth date. As children were not measured when they were not present in the village, there are some gaps in the monthly antropometric data.

The data on childhood nutritional status are presented using two widely used anthropometric indicators that discriminate between different physiological and biological processes: age- and sex-standardized height-for-age (HAZ); and sex-standardized weight-for-height (WHZ). Low weight-for-height (WHZ) is considered an indicator of acute under-nutrition and is commonly referred to as thinness or wasting. It is generally associated with a failure to gain weight or a loss of weight, usually as a consequence of dietary deficit and/or disease. Low height-for-age (HAZ)

is an indicator of long-term cumulative inadequacies of health or nutrition. It is commonly referred to as "stunting" and is frequently associated with poor overall economic conditions and/or repeated exposure to adverse conditions.[8] While the indices can be expressed in terms of percentiles and percent of median relative to a reference population, we use Z-scores in this paper (WHO 1995, Dean et al. 2000).

A Z-score is the number of normalized standard deviation (SD) units that the child's measurement deviates from the mean of the reference population of healthy, well-nourished children. Z-scores reported in this paper were derived using EPI-Info 2000 software developed by the US Center for Disease Control (Dean et al. 2000), which uses the sex-specific 1978 CDC/WHO reference group. This group is a normalized version of the 1977 National Center for Health Statistics (NCHS) growth reference curves developed using data from the Fels Research Institute and the US Health Examination Survey, and is recommended by the WHO for international use (Dean et al. 2000).[9]

The prevalence of stunting or wasting is assessed by determining the proportion of the population that falls below a cutoff value in a reference population. Standard cutoff points and definitions advocated by the CDC and WHO are used to assess nutritional status. Children are classified as malnourished if their Z-scores are below minus two standard deviations from the mean of the reference population. Stunting is defined as height-for-age Z-scores (HAZ) below –2.00 SD and wasting as weight-for-height Z-scores (WHZ) below –2.00 SD. These cut-offs indicate which children are more likely to be malnourished and "at-risk" of growth faltering (WHO 1995).

EPI-Info extreme-value flags and WHO verification guidelines were used to identify Z-score values where there is a strong likelihood that some of the data items are incorrect (Dean et al. 2000; WHO 1995); these data were excluded from this analysis.

2.4.2 Socio-economic data

As stated earlier, only a small portion of the socio-economic data being collected in this study has been analyzed for this report. The results presented are preliminary and cover only the first six months of the survey (May through October 2001).

Analyses presented are limited to descriptive statistics, with the various socio-economic variables (demography, morbidity, assets, and expenditure patterns) used in cross-tabulations or tests of correlations with the anthropometric data.

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[8] We do not use weight-for-age (WAZ) indicators in this paper since many experts consider it to fail to distinguish tall thin children from short, well-proportioned children. It may be used in future analyses to track children's status over the twelve-month survey period.

[9] The World Health Organization Technical Expert Committee reports that in environments with no adverse influences on growth, ethnic differences in growth patterns result in height variability of approximately 1 centimeter in 5-year-old children worldwide (WHO 1995). This low level of variation provides the basis for using the median height and weight from children living in the United States as international standards. The recognition by numerous experts of the limitations of this reference for international comparisons has led to current efforts by the WHO to develop a new growth chart using data from infants who are fed according to recommended guidelines.

2.5 Presentation of Results

In all cases, the results presented in this paper cover the period from May to October 2001, representing the first six months of the study. In contrast to the DHS surveys that are conducted in single rounds, this research is based on a longitudinal study, in which children and adults are followed on a weekly or monthly basis for one year rather than a single point-estimate/cross-sectional study. The existence of multiple observations per household member presents certain challenges with respect to presenting the results, especially in a summary format.

Given some cases of missing observations and the continued efforts to verify and crosscheck anthropometric data, we do not always have six observations for every child. Presentation of results by month, therefore, limits the size of the sample. For this reason, data from the six-month period are often grouped together. Calculating summary statistics (e.g., prevalence of wasting or stunting) for the entire six-month period would logically include multiple observations per child. While useful for those interested in a single figure, this method may bias the summary estimates in favor of those children with multiple observations. In the cases where this multiple-period summary estimate is used, primarily in graphs, discussion in the text includes the range of corresponding monthly values, calculated confidence intervals for the estimate or reports on the significance of the monthly differences using ANOVA or a chi-square test.[10]

Given the preliminary nature of the results, statistical estimates (means, variance and confidence intervals) presented in this report have not been corrected for the complex sample design. These corrections will affect the standard deviations and may change some of the significance tests, but the mean values will not change. These corrections will be made after the data are completely verified and cleaned.

[10] $P < 0.05$ (difference between groups considered statistically significant)

3 Anthropometric Results for Children: Overall, by Sex, and by Age

This section presents the preliminary results for the first six months (May – October 2001) of anthropometric data for children in the sample under five years of age (<60 months). The discussion starts with an overview of the sample height-for-age (HAZ) scores and weight-for-height (WHZ) scores. As explained in Section 2.4.1, HAZ scores are indicators of long-term cumulative inadequacies of health or nutrition commonly referred to as "stunting". WHZ scores are indicators of "wasting" or acute episodes of malnutrition, which may be a contributing factor leading to stunting in the long-run if the nutritional situation is not redressed.

Following the overview, which includes a comparison of the sample HAZ and WHZ scores to the 1978 CDC/WHO reference population, the distribution of scores by sex and age is discussed. The section concludes with a discussion of the relationships between HAZ and WHZ scores by age group and what these relationships suggest about the overall nutritional and health status of Malian children.

3.1 Overall Prevalence of Malnutrition in the Sample

Results from the first six months of data collection in the sample sub-regions show that the prevalence of malnutrition among children under five years old is high. We arrive at this conclusion by comparing the results of our sample to the 1978 CDC/WHO internationally accepted reference population. This international standard is based on the heights and weights of children at a given age in a well-nourished population. The Z-scores, or standard deviation unit, in this reference population has a normal distribution with a mean of zero and a standard deviation of one. Children whose HAZ and/or WHZ score falls two or more standard deviations below the mean are considered "stunted" and/or "wasted" by international standards (Dean et al. 2000, WHO 1995).

Survey results show that the mean HAZ score for sample children is -1.4 (SD of 1.52) and the mean WHZ score is -0.77 (SD of 1.05). This low mean HAZ score (-1.4) indicates that the average nutritional status of children in this survey is considerably lower than that of children in the reference population (where the mean HAZ=0). The higher standard deviation (1.52 in this sample versus 1 for the reference group) reflects the greater variability of HAZ scores in this study relative to the well-nourished group.[11]

[11] These figures represent the survey results after application of the WHO-recommended exclusion criteria for anthropometric values that are most likely to represent errors. While there were no patterns detected in the standard deviations of the HAZ scores (e.g., more variability in the scores of younger children due to the greater difficulty of measuring them properly), data continue to be checked and verified, particularly height measurements and age. In his analysis of DHS data from 14 Sub-Saharan African countries, Sahn (2001) estimated mean HAZ scores of -1.503 and standard deviations of 1.357. The LICNAG study's results for Mali are similar to these averages.

Table 3.1. HAZ and WHZ scores relative to reference group

Score Range	Sample Children				Reference Group	
	HAZ		WHZ		HAZ and WHZ	
	%	Cumul.%	%	Cumul.%	%	Cumul.%
<-2	36	36	12	12	2	2
-2 to -1	26	62	29	41	14	16
-1 to 0	21	83	35	76	34	50
>0	17	100	24	100	50	100

Source: Calculated by authors from survey data (8554 monthly observations) and reference group information in WHO 1995 and Dean et al 2000.
Note: Cumul. % refers to the cumulative percentage of children affected by stunting (case of HAZ) or wasting (case of WHZ) as one moves down the rows of the table.

Survey results for the May through October 2001 period shown in the first row of Table 3.1 indicate that 36 percent of sample children under four years of age had HAZ scores <2 (indicating stunting) and 12 percent had WHZ scores <2 (indicating wasting). In a well-nourished population such as the reference group, only 2.3 percent of the children would be expected to fall below the cutoff and thus be classified as stunted or wasted. At the other extreme of the distribution for sample children, only 17 percent of HAZ scores and 24 percent of WHZ scores exceeded zero (an indicator of good nutritional status), compared to 50 percent for the reference population.

Results for the two intermediate categories (scores ranging from -2 to 0) further confirm the high prevalence of malnutrition among sample children. The column showing the cumulative prevalence for HAZ and WHZ is sobering: 83 percent of children exhibit low height for age and 76 percent exhibit low weight for age. The equivalent share of the reference population having scores indicating nutritional inadequacies (i.e., scores <0) is only 50 percent. WHO has developed a malnutrition "severity index" based on WHZ scores. This four-level index of nutritional status (acceptable, poor, serious, critical) is used to assess children under five years of age in emergency situations such as refugee camps. Using the average WHZ score (-0.77) and sample prevalence (12 percent), we find that Malian children would be classified at the lower end of the "serious" nutritional situation category. This category represents a prevalence from 10-14 percent and a WHZ score between -0.70 and -0.99 (WHO 1995, pg. 212).

Since any child with HAZ or WHZ scores <-2 has serious health or nutritional problems, most studies do not discuss the distribution of scores below <-2. In the LICNAG study, however, 42 percent of the stunted children were severely stunted with HAZ scores <-3; this represents15 percent of all the sample children. Approximately 17 percent of those who were wasted were severely wasted; this represents 2 percent of the total sample.

Monthly variability (from May to October 2001) for these indicators of malnutrition was not particularly high, ranging from 35 to 39 percent for HAZ scores <-2 and from 10 to 13 for WHZ scores <-2. In other words, the high prevalence of stunting and wasting was apparent throughout the entire six months covered by this analysis.

In sum, survey results show that when the data are aggregated across all three cropping systems studied (cotton in the Sikasso Region, irrigated rice in the Ségou Region, and rainfed coarse grains in the Mopti Region), sample children have higher

rates of both stunting and wasting than the reference population. The extremely high prevalence of stunting (36 percent) is of particular concern because it represents children's failure to grow and is likely to have long-term impacts on both children's physical and mental development. This pattern of higher rates of stunting and lower rates of wasting is common throughout sub-Saharan Africa (Sahn and Stifel 2001, Martorell and Habicht 1986), but a cross-country comparison of various DHS studies suggests that Malian stunting rates are among the highest in the Sahel.[12]

3.2 Prevalence of Malnutrition by Sex

Although most studies of nutritional indicators report comparisons of results for male and female children, there is no consistent and statistically significant evidence for Sub-Saharan Africa (SSA) that malnutrition is more prevalent in one sex than the other. For example, Svedberg's 1990 review of the literature found that female children tend to have slightly less malnutrition (i.e., better HAZ and WHZ scores) than male children, but the differences were not statistically significant. A recent analysis of 14 DHS studies in SSA also found that boys are "slightly more likely to be stunted" than girls (Sahn and Stifel 2001).

Interestingly, our preliminary survey results do show a lower prevalence of stunting for girls (33 percent) than for boys (39 percent) and this result is statistically significant (Table 3.2). The strength of the finding is reinforced by the fact that the results were comparable when each month was analyzed individually. On a month-to-month basis the percent of stunting for boys ranged from 37 to 42 percent and that for girls ranged from 32 to 36 percent. This result not only contributes to the general literature reviewed by Svedberg and Sahn and Stifel, but also suggests that Malian caregivers are probably not being partial to male children--a behavior that is often attributed to mothers in societies where male children are sometimes considered a greater asset than female children because of customs concerning inheritance and marriage.[13]

There is no similar difference in WHZ scores across sexes. Average WHZ scores for both genders are almost identical (-0.76 for girls and -0.77 for boys), and the prevalence of wasting is not statistically different for the two groups (12 percent for both girls and boys).

[12] For example, DHS results for the early 1990s show Senegal with 19% stunting, Burkina Faso with 25%, and Niger with 27% compared to Mali's 1995 result of 30% (Haggerty et al. 1998 cited in Tefft et al. 2000).

[13] Mortality data presented in Section 5, however, show more girls dying than boys. Both of these results together make it difficult to draw any conclusions at this time concerning the absence or presence of preferential treatment to children of a particular sex.

Table 3.2: Wasting and stunting by sex

	Height-for-Age Z-score Indicating Stunting				Weight-for-Height Z-score Indicating Wasting			
Gender	% <-2	Mean HAZ	SD	No. monthly observations	% <-2	Mean WHZ	SD*	No. monthly observations
Boy	39*	-1.54	1.53	4201	12	-0.77	1.04	4357
Girls	33*	-1.33	1.50	3990	12	-0.76	1.05	4197

Source: Estimated from LICNAG Survey data using 8191monthly HAZ observations and 8554 monthly WHZ observations for May-October 2001.
Notes:
SD – Standard Deviation; larger SD indicates more variability in data.
Monthly Ranges: Boys: HAZ: -1.65 to -1.47; 37 to 42%; WHZ: -0.83 to-0.68; 9 to 13%
Girls: HAZ: -1.44 to -1.25; 32 to 36%; WHZ: -084 to -0.67; 11to 14%
Number of observations for individual monthly analyses ranged from a low of 642 (girls HAZ) to a high of 864 (boys WHZ).
* Indicates the two rates of prevalence are different (statistically significant at .05 level).

3.3 Stunting, Wasting, and Growth by Age Group

Looking at the distribution of nutritional status indicators by age group permits us to identify the age groups most at risk and in need of priority programs. We begin with a discussion of the prevalence of stunting and wasting by age group for sample children under five years old. This is followed by a comparison of sample and CDC/WHO reference group results for stunting, wasting, and growth rates by age group. The section concludes with a discussion of the relationship between stunting and wasting at different ages and a summary highlighting the salient findings of the age-group analyses.

3.3.1 Stunting and wasting among sample children by age group

Are some age groups more prone to stunting and/or wasting than others? Preliminary survey results suggest similar patterns of wasting and stunting for children aged 1 to 17 months. This pattern is characterized by rapid growth in the prevalence of both stunting and wasting, particularly for children from 4 to 17 months. Following the 18th month, however, the prevalence of wasting declines while that of stunting continues to increase (Table 3.3).

The prevalence of wasting reaches a peak of 25 percent for the 12-17 month age group and then declines. The largest decline in wasting is observed in moving from the 18-23 month group to the 24-35 month group, suggesting that a child's second birthday marks an important change in his/her ability to deal with nutritional deficits and/or disease leading to wasting. Qualitative studies have found that after age two, children are better able to fend for themselves (milking animals, killing birds and lizards, gathering wild foods) and compete with siblings for food. They are also less dependent on parents and can move up off the ground further away from environmental contaminants (Castle, Konaté, Yoder 2000, Dettwyler 1991).

By contrast, the prevalence continues to climb after 18 months until it reaches 49 percent among children in the 36-47 month group. The largest single increase in stunting is observed when moving from the 6-11 month-olds (20 percent prevalence)

to the 12-17 month-olds (40 percent prevalence). The literature on childhood nutrition suggests that the large jump during this period is related to the introduction of solid foods and also morbidity as children become more exposed to disease vectors as they begin crawling and walking (Dettwyler 1991). This constant rise in the prevalence of stunting underscores the difficulty that children have in catching up after exposure to poor nutrition and/or illness early in life, particularly during the formative growth period of the first year. Almost half of the children in the survey (49 percent) between 3 and 4 years of age suffer from stunting, a sign of chronic health and nutritional problems.

Table 3.3 reports the mean Z-scores, standard deviations, and percent of children stunted or wasted for the six age-group categories used by WHO for children under four years of age. These details show that average HAZ and WHZ scores for all age groups are negative, and all are also significantly different from zero. One notes, however, that the HAZ scores are generally much lower than the WHZ scores, regardless of age group, and the prevalence of stunting is consistently higher than the prevalence of wasting. Among 3 to 4 year olds, differences in stunting (about 50 percent prevalence) and wasting (<4 percent prevalence) are particularly large.

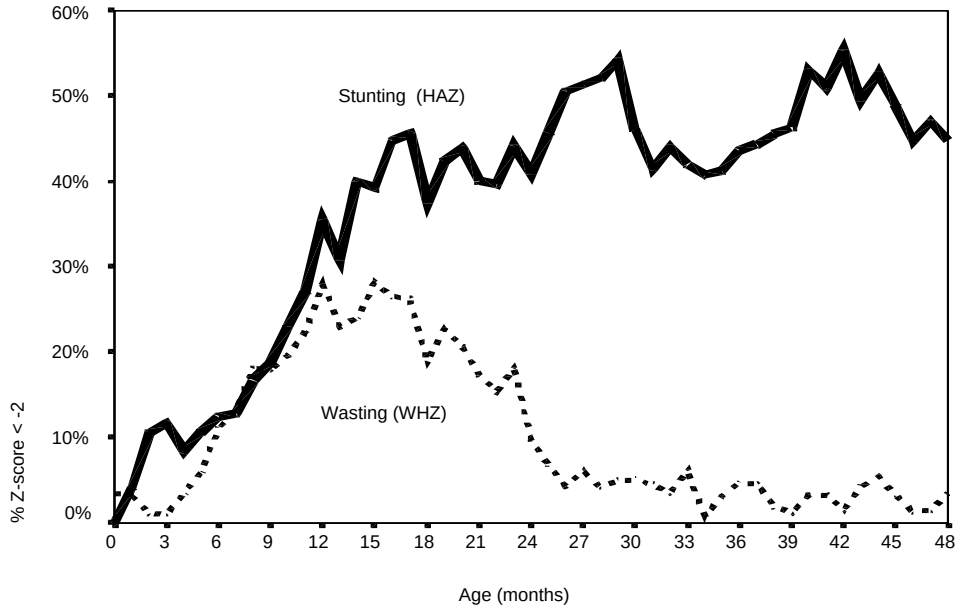
Table 3.3. Prevalence of wasting and stunting by age group

Age Group	Height-for-Age Z-score Indicating Stunting			Weight-for-Height Z-score Indicating Wasting		
	Mean[1]	SD[2]	% < -2.00[3]	Mean	SD	% < -2.00
0-5	-0.40	1.24	10.1	-0.17	1.05	4.7
6-11	-0.89	1.34	19.7	-1.07	1.07	18.5
12-17	-1.53	1.39	39.7	-1.36	0.95	25.0
18-23	-1.53	1.54	41.1	-1.09	1.04	18.3
24-35	-1.79	1.52	46.8	-0.60	0.88	5.0
36-47	-2.03	1.41	49.4	-0.37	0.85	3.5
Total	-1.43	1.52	36.4	-0.77	1.05	11.9

Source: Survey data for May through October 2001 covering 8191 monthly HAZ and 8554 monthly WHZ observations representing 2011 children.
[1]All mean HAZ and WHZ scores were statistically different from zero.
[2]SD – standard deviation; indicates the variability of the underlying data used in estimating the mean for the age group.
[3]Analysis is based on the entire set of monthly observations for May through October.

Figure 3.1illustrates these patterns by graphically comparing changes in the prevalence of stunting and wasting across children of different ages (age is shown as a continuous variable from month 1 through month 48).

Figure 3.1. Comparison of stunting and wasting patterns by age



Source: Survey data for May through October 2001.

3.3.2 Malnutrition and growth by age group: Sample vs. Reference group

Having ascertained that wasting peaks for Malian children in the 12-17 month group and stunting increases in prevalence as one moves from younger to older children, we now turn to three approaches to comparing sample and reference group results by age group.

One way of making this comparison is to examine the correlation between the sample children's age in months and their Z-scores; if the correlation is not significantly different from zero (i.e., mean Z-scores across age groups do not change) we can conclude that Malian children in the age group are growing (either gaining weight, in the case of the WHZ, or increasing height, in the case of the HAZ) at approximately the same rate as the reference group. In Table 3.4 the negative and statistically significant correlations for the first three age groups indicate that Malian children under 18 months of age are increasing their height

Table 3.4. Correlation between sample children's age and Z-scores

Age Group→	0-5	6-11	12-17	18-23	24-35	36-47
HAZ/age correlation	-0.093*	-0.138*	-0.069*	0.083	0.030	0.041
No. HAZ observations	1077	1239	1298	1238	1851	1488
WHZ/age correlation	-0.043	-0.184*	0.052	0.143*	0.133*	0.082*
No. WZH observatons	1117	1308	1355	1299	1909	1566

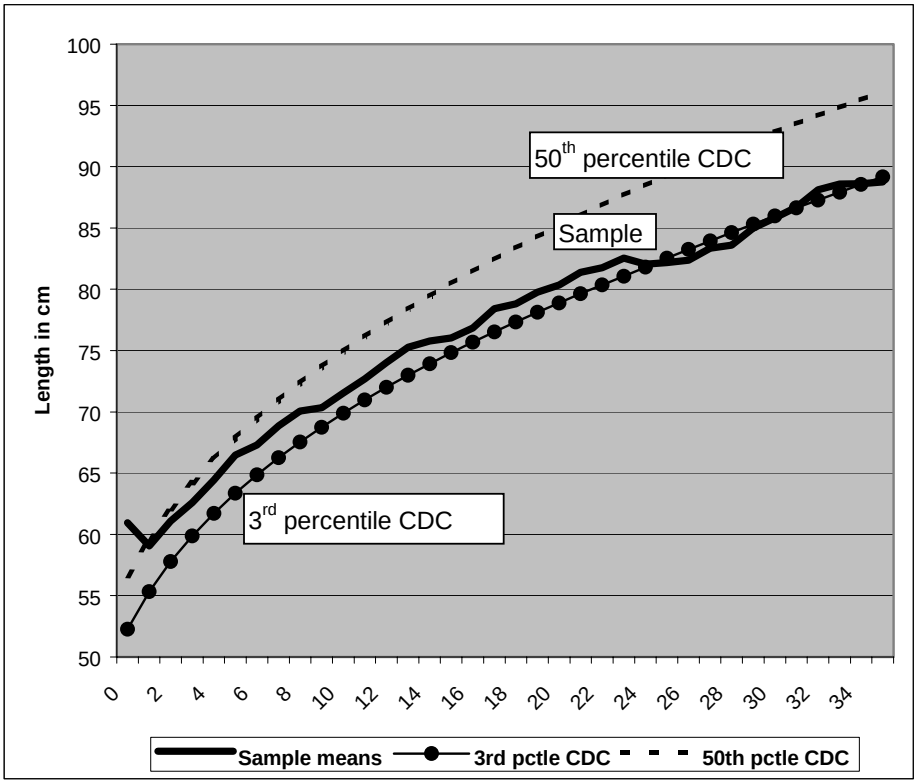
Source: Estimated by authors from survey data for May - October 2001, covering 8191 HAZ and 8554 WHZ observations for 2011 children.
Notes: Numbers represent the Pearson's correlation coefficient between the age (in months) and the Z-scores. Positive correlations indicate sample children are growing faster than the reference group, negative correlations indicate they are growing more slowly.
* Indicates the correlation is significant at the .05 level.

more slowly for a given age than the reference population. Although the correlations for the HAZ scores turn positive after 18 months, indicating that Malians are starting to grow faster than the reference population, the lack of statistical significance for all positive correlations, except that for the 18-23 month group, suggests that after 24 months Malian children are growing at approximately the same rate as the reference population. In other words, Malian children do not manage to compensate for slow growth before 18 months of age with a consistent pattern of more rapid growth in the subsequent periods examined (i.e., through the age of four years).

The only negative and significant correlation for the WHZ scores occurs at 6-11 months of age; this is the only period when Malian children are increasing their weight more slowly per unit of height than the children in the reference population. The positive and significant reversal of the WHZ scores between 18 and 48 months indicates that Malian children in these three age groups are increasing their weight per unit of height faster than children in the reference group. This result suggests that Malian children may be compensating for slower weight gain per unit of height during the 6-11 month period even if they are unable to compensate for slower growth in height as described in the previous paragraph.

Figure 3.2 illustrates a second way to compare Malian growth patterns to those of a reference group. The figure plots the sample and reference group results for HAZ

Figure 3.2. Height-for-age growth charts : Sample and reference group plots



Source : Prepared by authors using sample data for May through October 2001 and CDC growth charts and data (CDC/NCHS 2000).

scores on the CDC growth chart for children from 0 to 36 months.[14] The solid line on the graph represents the overall sample average height-for-age, with age shown in months on the horizontal axis and height in centimeters on the vertical axis. The graph shows how the sample mean height-for-age begins at approximately the 50th percentile of the reference group (dashed line) in the first few months of life but steadily declines toward the 3rd percentile (dotted line) through the first two years of life and remains at the level of the 3rd percentile through the 36th month. As was indicated in Table 3.3, almost 50 percent of three-year olds in the sample are stunted, and the mean HAZ for this age group is –2.03, equivalent to approximately the 2nd CDC percentile. The fact that the sample averages after 3-4 months of age are consistently below the dashed line representing the 50th percentile of the CDC reference group (with the gap increasing as age increases) and approximately the same as the 3rd percentile of the CDC reference group (the dotted line) after 24 months, highlights the seriousness of the stunting problem in Mali.

A third method of evaluating the growth patterns of sample children is to compare average daily weight gain to (1) pediatrician recommended weight gain and to (2) weight gain of the CDC reference group. Weight gain is affected by numerous factors, both dietary and non-dietary. Among the more important non-dietary factors are an infant's body type, metabolism, temperament, and the frequency of breast feeding (Dewey 1992). Among the dietary factors are the adequacy of food intake from complementary foods and micronutrient deficiencies. Also important is illness, which can reduce children's appetite and cause their growth to falter. In this preliminary report we estimate the sample average weight gain by age group and compare it to selected norms; in future reports we will examine the relative importance of the different factors influencing the weight gain patterns of Malian children.

Table 3.5. Average daily weight gain comparisons

Age (months)	Pediatrician-recommended daily weight gain[1] (grams/day)	Average daily weight gain of reference group[2] (grams/day)		Average daily weight gain of sample children (grams/day)	
	Boys and Girls	Boys	Girls	Boys	Girls
0-5	16-32	21	18	16	15
6-11	15	14	13	5	5
12-17	7	8	8	6	6
18-23	6	5	6	6	5
24-35	6	4	4	6	6

[1] Average daily weight gain in grams recommended by pediatricians in numerous publications. (Hohenbrink 1993, Larson 2000, Dewey 1992).
[2] Estimated by authors from CDC/WHO growth chart data base (CDC/NCHS 2000) using cases at or below the 50th percentile.

Using the monthly weight data from the survey, we calculated an average monthly weight gain by age group for children <3 years old (last columns of Table 3.5). This sample average can be compared to pediatrician recommended growth rates and individual averages for boys and girls in the reference group, shown to the left of the sample averages in Table 3.5. Since the sample average WHZ scores by age group range between the 3rd and 50th percentile of the reference group during the first three

[14] We use the unadjusted standards here from the CDC growth chart for children in the United States because we did not have the adjusted data underlying the CDC/WHO charts. We note that in using the unadjusted CDC standards for the U.S., the differences between Malian children and the reference group are probably greater than when we are using the WHO adjusted reference group (as is done in other analyses using the HAZ and WHZ scores).

years of life (a pattern similar to that shown for HAZ scores in Figure 3.2), the numbers calculated for the reference group represent the average daily weight gain of children at or below the 50th percentile in the CDC growth charts. In using this average, we have eliminated the weight gain observations for the top 50 percent of the reference population in an effort to compensate for the unadjusted nature of the CDC numbers and to reduce the possibility of overestimating malnutrition in Malian children. Table 3.5 shows that for the 0-5 month-old boys, weight gain is only 76 percent of the reference group's weight gain and the girls' gain is only slightly better at 83 percent. We compared the 0-5 month sample weight gains to a "ballpark" indicator of recommended weight gain, set equal to 20 grams per day. A t-test confirmed that sample weight gains are statistically different from 20 grams.

Moving up to the next age group (6-11 months), the situation regresses. Sample boys gain only 36 percent and girls 38 percent of the reference group's average gain. From 12-17 months boys and girls gain weight at rates that are comparable to the reference group, but the sample children remain at only 75 percent of desired levels. By 18-23 months, weight gain for boys exceeds that of the reference group (20 percent higher) but girls remain below (83 percent). These results are consistent with the reduction of wasting for 18-23 month children shown in Table 3.3 and further support the characterization of this age as a catch-up period for sample children. During the second year of life, Malians exceed the reference group (50 percent higher for both boys and girls), but at a rate that is not likely to compensate for the extremely low weight gain during earlier periods. The high prevalence of stunting among children in the 2nd and 3rd year (Table 3.3) supports the hypothesis that improved growth between the ages of 18 and 36 months is not sufficient to overcome the extremely poor growth during the first 18 months of life.

The extremely depressed rate of average weight gain for the 6-11 month-old group suggests again that programs to reduce malnutrition among Malian children will need to target these very young children in order to reduce levels of both stunting and wasting in the older age groups.

3.3.3 Evaluating HAZ and WHZ scores simultaneously by age group

Up to this point we have been discussing the HAZ and WHZ results separately, but the health and nutritional status of each child can also be evaluated by combining the results of the two indicators. The Waterlow method, used to produce Table 3.6, classifies children into four categories based on the results of both HAZ and WHZ scores. The categories are presented in order of the increasing severity

Table 3.6. Prevalence of Stunted and Wasted Children (Waterlow)

	Waterlow Classification			
Age Group	Neither Stunted nor Wasted	Wasted, Not Stunted	Stunted, Not Wasted	Stunted and Wasted
	(Percent of children)			
0-5	87	4	9	1
6-11	65	12	18	6
12-17	46	14	29	12
18-23	55	8	26	11
24-35	52	1	43	4
36-47	52	2	44	2
Overall Total	56	7	31	6

Source: Estimated by authors from survey data for the month of July 2001.

of the nutritional problems: (1) neither wasted nor stunted, (2) wasted but not stunted, (3) stunted but not wasted, and (4) both wasted and stunted (Waterlow 1976).

Across all ages, 56 percent of children in the sample suffered from neither stunting nor wasting in July 2001. Moving to the three Waterlow categories associated with varying degrees of malnutrition, we find that 7 percent of all children 0-47 months were wasted but not stunted, indicating that they were of correct height but thin and suffering from acute but episodic malnutrition. Thirty-one percent suffered from stunting (i.e., they were short for their age), but they were not wasted. Six percent were both stunted and wasted.

Although data for only July 2001 are presented in Table 3.6, the classification for all other months between May and August 2001 resulted in similar distributions of children across the four categories (i.e., there were no statistically significant differences across months).

The breakdown of malnutrition by age group in Table 3.6 corroborates that children between six months and two years suffer the most relative to other groups. Children between 6 and 18 months exhibit the highest prevalence of wasting, while those from one to two years old have the largest proportion of cases where stunting and wasting both occur.

3.3.4 Summary of results by age group

The salient findings in the analysis of malnutrition by age group are:

- Prevalence of stunting increases with age (Table 3.3); it is lowest in the 0-5 month age group (10 percent) and highest in the 36-47 month age group (49 percent);
- Prevalence of wasting (Table 3.3) is relatively low (#5 percent) between 24 and 37 months of age and highest (25 percent) among children 12-17 months old;
- Daily weight gain is most depressed *vis à vis* the reference group for children in the 6-11 month age group, followed by those 12-17 months.
- Children from 12-17 months are most vulnerable to some form of malnutrition;
- Children from 12-23 months are most vulnerable to being both stunted and wasted;
- Children from 24 to 47 months are most vulnerable to being stunted.

These findings suggest that programs to reduce malnutrition in rural Mali need to focus on children in the lower age groups (6-11 in particular) and follow through for children in the 12-17 month age group if they are to redress the health and nutritional problems causing the low HAZ and WHZ scores that become apparent after 12 months of age. It would be an error to target age groups with the highest prevalence before dealing with the younger children exhibiting lower prevalence of stunting and wasting. Since preliminary results appear to indicate that children do not fully recover from early exposure to malnutrition despite above average growth in later periods, it will be important for health and nutrition programs to focus on improving nutrition and health status at an early age.

4 Child Anthropometrics by Sample Sub-Regions

A key objective of the LICNAG research is to understand better the relationship between child nutrition and health status, on the one hand, and economic growth associated with increases in agricultural production, on the other hand. The choice of three study regions includes:

- Sikasso, representing a cotton-based production system that also produces about 30 percent percent of Mali's coarse grains;
- Ségou, representing an irrigated rice system with an important dry-season horticultural component; and
- Mopti, representing rainfed coarse grains with onion production during the dry season.

We selected these regions because they provide an opportunity to evaluate differences in nutritional and health status across different types of cropping systems. Furthermore, having selected households from two different sub-regions (*cercles*) within each cropping system permits us to go beyond the cropping system in search of other factors that might influence nutritional and health status. For example, the two districts selected for each cropping system generally have different levels of access to physical infrastructure (roads, communications, markets) and services such as health and education--factors thought to influence income and the general level of well-being in rural communities.

Section 4 includes an overview of malnutrition by sub-region, a description of stunting, wasting, and average daily weight gain by sub-region and age group, some preliminary observations on the seasonal variability in the prevalence of wasting by sub-region, and a discussion of the potentially positive links between irrigated rice production and child nutritional status.

4.1 Prevalence of Malnutrition by Sub-Region

Data presented in Table 4.1 reveal that the prevalence of stunting among sample children is significantly lower in Ségou's irrigated rice sub-regions of Macina and

Table 4.1. Prevalence of malnutrition among children by agricultural production system

Production System	Sub-region	Stunted (HAZ score < -2)		Wasted (WHZ score < -2)	
		%	CI	%	CI
Cotton	Kolondieba	47.9	45.5 - 50.3	9.9	8.5 – 11.4
	Koutiala	39.3	37.3 - 41.3	10.2	8.9 – 11.4
Irrigated Rice	Macina	25.0	22.6 – 27.5	8.0	6.5 – 9.5
	Niono	19.2	16.4 – 22.0	9.9	7.8 – 12.0
Coarse Grains	Bandiagara	34.7	32.1 – 37.4	15.6	13.5 –17.6
	Koro	42.0	39.3 – 44.8	16.4	14.3 – 18.5
TOTAL		36.8	35.8 – 37.9	11.5	10.8 –12.2

Source: Survey data for May through October 2001, for 8462 monthly HAZ and 9515 monthly WHZ scores covering approximately 2000 children, depending on month.
Note: « CI » represents the 95 percent confidence interval; results not corrected for design effect (see Section 2).

Niono relative to the other sub regions studied (i.e., the confidence intervals for the prevalence of stunting in the rice zones is lower and does not overlap with the confidence intervals for other zones). Wasting is more widespread in the coarse grain producing sub-regions of Bandiagara and Koro in the Mopti region (i.e., the confidence intervals are higher and do not overlap).

A disturbing characteristic of the high prevalence of stunting shown in Table 4.1 is that a large share of sample children with HAZ scores <-2 are severely stunted (i.e., exhibiting HAZ scores <-3). In Bandiagara, 50 percent of the stunted children have HAZ scores <-3; in Kolondieba and Koutialla, 43 and 41 percent fall into the same category. In Niono, the sub-region exhibiting the lowest overall prevalence of stunting, the children who are severely stunted represent 47 percent of those with HAZ scores <-2. This result suggests that malnutrition in the Niono sample may be most common in a small group of households that are extremely poor (e.g., those without access to irrigated land or with very small farms in the irrigated perimeters).[15] The percent of wasted children with WHZ scores <-3 ranged from 10 percent in Macina to 21 percent in Niono. The WHZ scores <-3 show the same sub-region pattern as the HAZ scores; Niono has a surprisingly large percent of wasted children falling into the category of severe wasting.

Table 4.2 provides a bit more detail on the nutritional situation across sub-regions, presenting the mean HAZ and WHZ scores, standard deviations for those scores, and the number of observations used in the analysis. The number of observations represents the number of individual monthly anthropometric measures available from May-October; the total number of children represented in the analysis is approximately 2000, depending on month.

Table 4.2 Mean anthropometric measurements of children by sub-region

Crop System	Sub-region	Height-for-age Z-score			Weight-for-height Z-score		
		Mean	SD	Number	Mean	SD	Number
Cotton	Kolondieba	-1.83	(1.40)	1703	-0.68	(1.04)	1810
	Koutiala	-1.54	(1.50)	2278	-0.64	(1.06)	2443
Rice	Macina	-0.99	(1.45)	1228	-0.54	(1.00)	1494
	Niono	-1.00	(1.38)	764	-0.90	(0.92)	820
Coarse Grains	Bandiagara	-1.30	(1.71)	1256	-0.90	(1.10)	1489
	Koro	-1.62	(1.44)	1233	-0.94	(1.02)	1459
	Total	-1.45	(1.52)	8462	-0.74	(1.04)	9515

Source: Survey data for May through October 2001 for approximately 2000 children, depending on month.
Note: The 'Number' column represents the number of individual monthly observations on weight and height available for sample children.

Results in Table 4.1 also draw attention to the higher percentage of children with low WHZ scores in the coarse grain production areas of Bandiagara and Koro (16 percent) relative to the levels in the rice and cotton areas (9-11 percent). As discussed earlier, WHZ is an indicator of acute, episodic malnutrition. Higher levels of wasted children may indicate relatively greater short-term difficulty in satisfying children's food

[15] Mariko et al. 2001 noted that very small farms (less than four hectares) located in the rehabilitated areas of the *Office du Niger* did not realize the positive income benefits of the devaluation.

needs. These preliminary results fall in line with the results of a 2001 Public Attitude Survey in which 62 percent of all respondents in the Mopti Region, where Bandiagara and Koro are located, mentioned hunger as a personal problem compared to 39 percent for the rest of the country (Bratton 2001). Recent analyses of per capita food production by administrative region also support the conclusion that the availability and access to food is a bigger problem in Mopti than in Ségou and Sikasso (Tefft et al., 2000).

It is useful to recall from Table 2.2 that the PCUs in Niono tend to be small, nuclear households (11 people on average) rather than large, extended families (16-21 people) as in the other sub-regions. As a result, there are fewer children in the Niono sample and fewer monthly Z-score observations (e.g., 764 HAZ scores vs. more than 1000 for each of the other sub-regions). Whether there is any statistically significant relationship between nutritional outcomes and family structure is a topic that we will examine in-depth once the full data set is available. The smaller family size (11 persons including 2 children <48 months of age) and relatively good Z-scores for the Niono sub-region lead us to ask if there might be a negative relationship between PCU size and Z-scores, resulting in a decline in children's nutritional status as PCU size increases. The presently available descriptive statistics do not provide a clear indication of this, however, as Macina (in the same cropping system) also has relatively good Z-scores but a larger average PCU size (16 persons including 3.1 children <48 months of age).[16]

4.2 Indicators of Malnutrition by Sub-Region and Age Group

4.2.1 Stunting by sub-region and age group

Table 4.3 shows the prevalence of stunting by age group and sub-region. The stunting pattern presented in the "total" column serves to remind us of the general pattern reported for the full sample in Table 3.3--continuously increasing rates of stunting as age increases, with the most rapid increases occurring between 0 and 17 months of age. (e.g., prevalence doubles between 0-5 and 6-11 months and then doubles again

Table 4.3. Prevalence of stunting by age group and sub-region

Age Group	Cotton Zones		Rice Zones		Coarse Grain Zones		Total
	Kolondieba	Koutiala	Macina	Niono	Bandiagara	Koro	
	(percent of sample children)						
0-5	10	6	13	7	16	11	10
6-11	26	20	19	13	20	17	20
12-17	53	48	29	20	29	35	40
18-23	57	48	25	23	36	39	41
24-35	60	53	29	23	45	56	47
36-47	64	46	26	20	64	67	49
Total	48	39	25	19	35	42	37

Source: Survey data for May through October 2001, for 8462 monthly observations (approximately 2000 children, depending on month).
Notes: The numbers shown are the percent of the children in each age group with HAZ scores <-2 standard deviations below the reference group average scores.

[16] Although PCU size in Macina is larger than in Niono, it is still smaller than average PCU size in other zones, which range from 18 to 21 persons.

when moving from the 6-11 group to the 12-17 month group). This rapid increase in stunting among infants contributes to a total prevalence of 40 percent for children in the 12-17 month age group and a slightly higher prevalence of 49 percent for children in the 36-47 month group.

The sub-regional breakdowns show that the prevalence of stunting during the 0-17 month period is variable across sub-regions. The two cotton sub-regions of Koutiala and Kolondieba have prevalence rates (48 and 53 percent, respectively) for 12-17 month-old children exceeding the 40 percent average prevalence. The rates of increase in prevalence when moving from one age group to the next are also unusually high in these two sub-regions. For example, in Koutiala prevalence increases 250 percent in moving from the first to the second age group and again 150 percent in moving to the third age group. The rice sub-regions, as well as Bandiagara in the coarse grain zone, fall well below the average prevalence for 12-17 month-olds, with rates in the 20-29 percent range. Increases in prevalence when moving from one age group to the next are also relatively low (ranging from 20 to 90 percent).

The sub-region breakdown also shows that there is not a consistent increase in the prevalence of stunting through 48 months of age as exhibited in the overall sample results. In Koutiala, Macina, and Niono the prevalence of stunting is approximately 5 percent lower among 36-47 month-olds than it is among 24-36 month-olds, suggesting that it may be possible in some cases to compensate for poor nutrition and health in the first two years of life through better nutrition and health after age three. A final observation on the sub-regional breakdown is that in the coarse grain zones of Bandiagara and Koro, the rate of increase in the prevalence of stunting remains quite high for children 24 months and over (20 to 47 percent depending on sub-region and age group) compared to the other sub-regions, where prevalence either decreases or increases at less than 10 percent from age group to age group.

These sub-region/age-group analyses are preliminary. Once the data for the full survey year are available and we have more observations in the older age groups, we will be able to look at these apparent age-group differences across sub-regions in a more statistically sound manner. If the differences in patterns of stunting that we report here are confirmed by an analysis of the full set of data we will be looking for answers to the following questions:

- Why does stunting increase more rapidly in the cotton zones of the Sikasso Region, where cereal production per capita is higher than in any other region?[17]
- Why is it that stunting increases more slowly in the coarse grain zones of Mopti but ends up at approximately the same very high level among children between 3 and 4 years of age?
- Why is stunting prevalence lower in the irrigated rice zones?
- Why does stunting decrease between 3 and 4 years of age in three of the six sub-regions but not in the others?

[17] From 1986 to 1999 the Sikasso Region produced an average of 312 kg of cereal per capita with an average annual surplus of 103 kg/capita and not a single year of deficit production (Tefft et al. 2000).

4.2.2 Wasting by sub-region and age group

Table 4.4 presents the sub-region and age group breakdown for the prevalence of wasting, showing the percent of children in each category with WHZ scores more than two standard deviations below the reference group mean score. In every sub-region but the coarse grain zone of Koro, there is a consistent pattern of wasting rates increasing through the 17th month and then decreasing from the 18th through the 47th month. These general patterns are also consistent with wasting prevalence by age group based on the aggregate analyses done for 0-47 month-olds (Section 3.3.1, Table 3.3).

Table 4.4. Prevalence of wasting by age group and sub-region

Age Group*	Cotton Zones		Rice Zones		Coarse Grain Zones		Total
	Kolondieba	Koutiala	Macina	Niono	Bandiagara	Koro	
0-5	3	2	3	11	6	11	5
6-11	17	13	13	15	26	25	19
12-17	18	25	23	19	30	37	25
18-23	18	21	15	17	18	21	18
24-35	4	6	3	4	5	8	5
36-47	2	3	<1	3	1	10	4
Total	10	10	8	10	15	16	12

Source: Survey data for May through October 2001, for 9515 monthly observations (approximately 2000 children, depending on month).
Notes: The numbers shown are the percent of the children in each age group with WHZ scores <-2 standard deviations below the reference group average scores.

In Koro, however, wasting prevalence is not only higher than all other sub-regions after 2 years of age, but it also increases during the fourth year (36-47 month period). If this pattern holds up after additional verification of existing data and inclusion of data for the second six months, information currently being collected on household food consumption levels and on childcare and feeding practices should permit us to understand better the reasons behind Koro's atypical wasting patterns.

4.2.3 Average daily weight gain by sub-region and age group

Table 4.5 presents average daily weight gain results by production zone, sub-region and age group. The overall picture confirms that children in the rice zones are generally doing better than those in the cotton and coarse grain zones, although the relative performance varies across age groups.

Weight gain for 0-5 month-old children across all zones is statistically lower than 20 grams per day (a "ballpark" value selected from information in Table 3.5 to represent recommended weight gain for this age group). Although the weight gain for the 0-5 months group is lower in the coarse grain zones, it is not statistically different from the averages for the other two zones.

The cotton zones have the lowest weight gain at the critical growth period of 6-11 months of age (4.2 grams), followed by the coarse grain zones (5.2 grams) and then the rice zones (6.5 grams). These results are statistically different across all zones. Differences across zones are not significant for the 12-17 month group. The coarse

grain zones have a statistically lower weight gain for the 18-23 month-olds than the other two zones. For the 24-35 month-olds all zones are statistically different, with

Table 4.5. Average daily weight gain by age group and sub-region

Age Group	Cotton Zones			Rice Zones			Coarse Grain Zones			Total	
	Kolondieba	Koutiala	Zone	Macina	Niono	Zone	Bandiagara	Koro	Zone	Gain	No. of obs.
	(average grams per day)										
0-5[a]	14.5	16.8	15.8	17.1	11.1	15.8	14.5	15.2	14.9	15.6	673
6-11[b]	5.1	3.3	4.2	7.6	4.7	6.5	4.8	5.4	5.2	5.0	946
12-17	7.3	5.5	6.2	8.7	6.8	7.9	5.4	3.2	4.4	6.1	953
18-23	6.4	5.6	6.0	6.0	7.6	6.6	5.2	4.0	4.7[c]	5.8	982
24-35[b]	6.5	5.3	5.7	6.5	9.0	7.5	3.1	4.8	3.9	5.7	1412
36-47	5.5	6.1	5.8	8.7	7.2	8.2	6.4	4.0	4.8	6.1	1223
No. obs.	1284	1726	3010	898	514	1412	908	859	1767		6189

Source: Survey data for May through October 2001, for 5694 monthly observations (approximately 2000 children, depending on month).

[a] Indicates that there is no significant difference across zones, however, all average weight gains are statistically lower than 20 grams per day (indicator of recommended weight gains shown on Table 3.5).

[b] Indicates that average weight gain in each zone column is different from weight gain in other zones for this age group.

[c] Indicates that weight gain in zone with superscript is significantly different from each of other zones for this age group.

Note: all tests of significance are at .05 level or better.

the rice zones doing the best (8.2 grams per day), followed by the cotton zones (5.7) and the coarse grain zones (3.9). For the 36-47 month-olds there is again no statistically significant differences across zones.

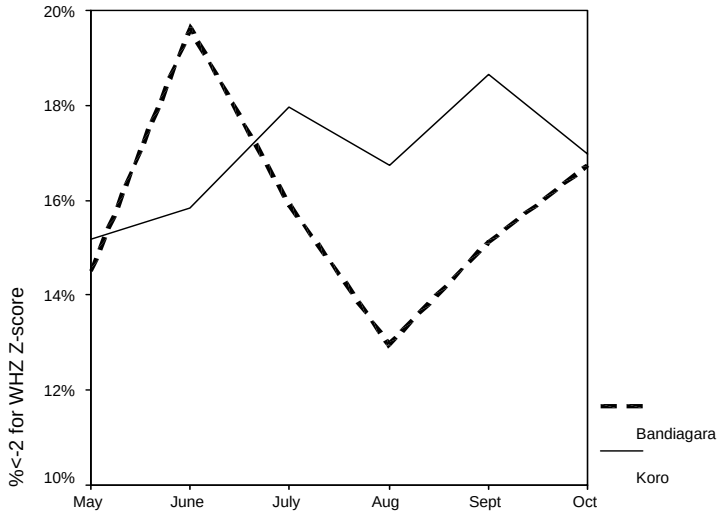
If the rice zone continues to have better results when the rest of the data are added and the coarse grain zones poorer ones, the next step will be to correlate the weight gain data with height changes during the year to get a fuller picture of the nutritional situation. This should permit us to describe more precisely the differences in nutritional outcomes across zones and improve our ability identify the determinants of more rapid growth in the rice zone.

4.3 Seasonality of Wasting by Sub-Region

The numbers presented in Tables 4.1 through 4.5 represent results aggregated over the entire six-month period from May to October 2001. Because WHZ scores measure acute episodes of malnutrition that have a short-run impact on the relationship between a child's weight and height, it is the indicator that one would expect to show seasonality effects.[18] In an effort to verify if there were any seasonality effects on child nutrition we calculated WHZ scores by sub-region for each month from May to October. Preliminary results suggest an increase in the percentage of wasted children (WHZ <-2) in the coarse grain production zone of Bandiagara during the month of June. This is illustrated in Figure 4.1, which plots the proportion of children in both

[18] Future analysis will also include use of the weight-for-age indicator.

Figure 4.1. Monthly prevalence of wasting in coarse grain production systems



Source: Analysis of May through October 2001 survey data.

the Koro and Bandiagara sub-regions of Mopti exhibiting WHZ scores <–2.00 during the six month period. The figure shows much greater variability in the Bandiagara data than the Koro data and a different monthly pattern. In Bandiagara, the peak month for wasting is June, whereas in Koro, it is September. Although these monthly differences are not statistically different from each other (t-tests), the graph does suggest that the topic warrants further investigation.

Analysis of the monthly data for WHZ scores in the cotton and irrigated rice systems revealed relatively stable levels of wasting across months, leading us to conclude that May to October seasonality in consumption in these zones during 2001 did not have a measurable impact on the weight of children less than five years old.

Information collected to date on consumption and expenditure patterns reveals that in the Bandiagara sub-region, households tend to save their cereal stocks for the cropping season so that they will be able to eat well when physical work demands are at a peak. Because the 2000 cereal harvest was not good for many Bandiagara households, they tended to eat less than their normal consumption levels during May and the first half of June, prior to the rains. In late June and early July, most households increased the daily ration of cereal. We do not yet know if households in the Koro sub-region have similar traditions concerning adjustments in cereal consumption levels. The plotted line on the graph for Koro suggests that households may follow the more typical Malian pattern of eating home-produced stocks until they run out and then resorting to the market to purchase cereals; this type of pattern results in lower consumption levels during the cropping season, often getting very low just before harvest in September. Such a consumption pattern would be consistent with the increased prevalence of wasting from August to September shown in Figure 4.1 for Koro.

The extent to which the seasonal economizing on cereal consumption is affecting the nutritional status of young children on a month-to-month basis will be studied more carefully in the second phase of the data analysis after we have a more complete picture of food purchase and consumption patterns. [19]

4.5 Are children better off in irrigated rice zones?

When results are grouped together on a regional basis (Kolondiéba and Koutiala in the cotton zone of Sikasso, Macina and Niono in the irrigated rice zone of Ségou, and Bandiagara and Koro in the coarse grains zone of Mopti) one sees that the differences across cropping systems are sharper than those across sub-regions. While 42 percent of children under five are stunted in the cotton zone and 39 percent are stunted in the coarse grain zone, only 23 percent are stunted in the irrigated rice zone. Although these LICNAG estimates are not representative of the administrative regions within which they are located (e.g., Sikasso, Ségou, and Mopti) because the sample only includes two sub-regions or *cercles* per region, a comparison with the regionally representative estimates of the 2001 DHS III survey is nevertheless informative.[20]

In Sikasso and Mopti, the sample stunting rates of 42 and 39 percent are lower but still relatively close to the 48 and 41 percent regional rates estimated by the recent DHS III. In the Ségou region, however, the percentage of sample children with HAZ scores less than –2.00 (23 percent) is significantly lower than the regionally representative DHS III estimate of 41 percent. The LICNAG sample includes primarily households in the irrigated rice-growing sub-regions of Niono and Macina, while the DHS III sample includes households from other sub-regions in Ségou, where the cropping system is based on coarse grain production rather than irrigated rice.

In an effort to test the hypothesis that PCUs with good access to well-controlled irrigation infrastructure have better nutritional outcomes than others, we divided the sample for the rice production zones into PCUs living in villages having good access to the irrigated rice perimeters[21] and those who were living in villages outside the perimeters.[22] PCUs outside the perimeters include some members of the Bozo ethnic group, whose primary income-generating activity is fishing, and other families whose farming systems are not as closely tied to irrigated rice production as those living within the perimeters. Many of these households grow rice, but some grow only coarse grains.

Table 4.6 summarizes the results, which do not provide a consistent picture across sub-regions. In Niono, the non-irrigated zones have much higher prevalence of both wasting and stunting; the differences are highly significant. In Macina, the irrigated zones have a higher prevalence of wasting (highly significant), but there is no statistically significant difference in stunting.

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[19] The weight-for-age Z-score, not discussed in this report, may be a useful indicator for this type of longitudinal monitoring.

[20] Information on DHS III results comes from a Ministry of Health report on preliminary DHS III findings (2001).

[21] *Zones amenagées* inside official limits of the *Office du Niger*.

[22] *Zones non-amenagées* outside the official limits of the *Office du Niger*.

Table 4.6. Child malnutrition by access to irrigation in the rice production zone

Sub-region and production system	HAZ				WHZ			
	Z	SD	Obs.	%	Z	SD	Obs.	%
Niono	Irrigated does better				Irrigated does better			
Irrigated	-0.89*	1.4	603	16 *	-0.83*	0.09	631	8*
Non-irrigated	-1.50*	1.4	135	35 *	-1.23*	0.80	140	19*
Macina	No significant differences				Non-irrigated does better			
Irrigated	-1.10	1.3	308	23	-0.77*	1.00	322	13*
Non-irrigated	-0.91	1.5	869	24	-0.47*	1.00	923	7*

Source: Estimated from survey data for May through October 2001.
* Significantly different across irrigated and non-irrigated villages at 1% level

It is surprising that results for Macina are reversed with the non-irrigated zones looking a bit better. Understanding why stunting and wasting rates are significantly lower for PCUs located within the irrigated perimeters of Niono but not for those in the irrigated perimeters of Macina will require additional analyses.

Research conducted in the *Office du Niger* irrigated rice system following the 1994 devaluation of the CFA franc found that (1) aggregate household incomes of an important share of producers increased in real terms following the devaluation and (2) women's access to income-generating activities (e.g., rice transplanting and onion production) also improved (Mariko et al. 2001). Although farmers in both Niono and Macina benefited from growth after the devaluation, there were important differences across the two zones.[23] Since the beginning of irrigation rehabilitation investments, Niono has always been a few steps ahead of Macina in terms of irrigation infrastructure, access to markets, and access to transportation infrastructure. When the devaluation took place, rice farmers in Macina were not as well placed as those in Niono to take advantage of it. For example, Macina farmers had higher levels of indebtedness following years of poor performance by village associations, making it difficult for them to get input credit and increase yields. This resulted in lower post-devaluation fertilizer application rates and yields for Macina's than for Niono's farmers. Furthermore, the boom in horticultural production that took place in Niono (area cultivated more than doubling) was not evident in Macina where onion area cultivated actually declined from 310 hectares in the early 1990s to 213 in the late 1990s. Since much of the horticultural income in Niono went to women, the failure of horticulture to thrive in Macina following devaluation suggests that women's income probably did not increase as much there as it did in Niono. If these differences between Macina and Niono still exist at present, they could provide a possible explanation for poorer nutritional outcomes in irrigated zones of Macina compared to irrigated zones of Niono.

The analysis of the crop production data collected by the LICNAG study will provide an opportunity to compare the income and productivity situations in the two rice-

[23] Information on differences between Niono and Macina come from an unpublished IER report by Markio et al. 1998.

producing sub-regions and to test various hypotheses concerning the link between agricultural incomes and nutritional outcomes. These zones present an excellent opportunity to compare the nutritional impacts of increases in household vs. increases in women's income. It will also be possible to examine the role of non-income or non-agricultural factors such as differences in access to nutrition programs or health centers in the two zones. Future analysis will center on better understanding the relative importance of the numerous factors underlying differences in children's nutritional and health status.

5 Child Morbidity and Mortality

As noted earlier, HAZ and WHZ scores are indicators of both health and nutritional status. If children are ill, they may not be eating correctly or their bodies may not be using the food they consume efficiently. Consequently, any effort to improve HAZ and WHZ scores will need to address both health and nutrition problems. In this section of the report, we focus on data concerning children's illnesses: percent of children falling ill, types of illnesses, types of diagnoses and treatments, and the financial aspects of who pays for children's health care. The discussion of illness and treatment are based on a series of questions asked of caregivers (usually mothers) concerning the health of their children during the two weeks preceding each of the six monthly anthropometric measurements of children younger than five years. Because illnesses reported cover approximately one-half of the time interval between anthropometric measurements, they do not describe the complete picture of illness for the entire six months. The illness data is combined with some preliminary analyses of expenditure data showing how households handle the costs of healthcare for their children.

We begin with an overview of the salient findings concerning morbidity and mortality before turning to a more detailed discussion of the (1) diagnosis and treatment of children's illnesses, (2) links between morbidity, growth, and malnutrition, and (3) child mortality.

Tables 5.1 and 5.2 present data on morbidity by sub-region and age group.

Table 5.1. Incidence of Morbidity by Sub-region

	Children who were sick at least once from May through October 2001	
Sub-region	Percent	Number
Kolondieba	43	145
Koutiala	62	431
Macina	58	173
Niono	48	104
Bandiagara	39	112
Koro	53	185
Total	51	1150

Source: Survey data, May-October 2001.

Table 5.2. Illness by age-group

	Illness	
Age Group	Percent of all sample children in each age-group who were ill at least once	Percent of all ill children represented by the age-group
0-5	47	11
6-11	64	21
12-17	66	18
18-23	58	16
24-35	57	21
36-47	46	11
Total		98

Source: Survey data for May-October 2001.

The salient findings concerning child morbidity and mortality follow:

- Fifty-one percent of all children had at least one illness during the six two-week periods covered by the data;
- Illness was both most and least reported in the cotton zones: 62 percent were ill in Koutiala but only 43 percent in Kolondieba;
- Illness affected more children in the 6-11 month and 12-17 month age groups (64 and 65 percent, respectively) than in the 0-5 month and 36-47 month groups (47 and 46 percent, respectively);

- Seasonal variability in illness appears to exist only in the 12-17 month age group where the percent of sick children increased from 57 in May to 71 in the August-October period;
- Sixty-one children (approximately 3 percent of the sample children less than four years old) died during the six-month period covered by this report.

5.1 Diagnosis and Treatment of Children's Illnesses

Caregivers rather than medical personnel provided information about diagnoses and treatments (Tables 5.3 and 5.4). Consequently, the results presented in this section provide a reasonably accurate picture of overall levels of morbidity and mortality, while the particular categorizations of illnesses and types of treatments reflect the perceptions of the caregivers rather than the opinion of medically trained personnel. Understanding these perceptions is an important first step in building stronger health education and health delivery services in rural areas as it provides information that can be used to target educational programs, not only in terms of messages, but also in terms of whom to target with the messages.

The key findings concerning children's illnesses are:

- Fever/malaria (48 percent of all episodes of illness) and diarrhea (21 percent) are the two most common illnesses reported by caregivers;
- Primary caregivers (usually mothers) were the persons most likely to diagnose a child's illness (67 percent of illnesses), followed by nurses (15 percent), family/friends (11 percent), and traditional healers (6 percent).

Table 5.3. Morbidity by Caregiver Diagnosis

Caregiver Diagnosis	Number of episodes reported	Percent of total episodes
Diarrhea	506	21
Cough	213	9
Fever/Malaria	1150	48
Vomiting	104	4
Eye problems	156	6
Skin	129	5
Cold	71	3
Other	92	4
Total	2421	100

Source: Survey data May through October 2001.

Interestingly, malnutrition is not mentioned or diagnosed as a problem, although the preliminary results reported in sections 2-4 above show that it affects a large number of children less than five years old. This could be due to difficulties with translation of responses from local languages to French, but it is more likely because caregivers do not recognize nutritional deficiencies as the source of the problem.

Table 5.4. Person Making Diagnosis

Category of Person	Different Diagnoses	
	Number	Percent
Mother	1624	67.1
Nurse	368	15.2
Traditional Healer	147	6.1
Family/friend	273	11.3
Pharmacist	9	0.4
Total Diagnoses	2421	100.0

Source: Survey data May through October 2001.

With almost 70 percent of the diagnoses being made by mothers, the need to ensure that they have a good comprehension of the life threatening potential of the two most common illnesses (fever/malaria and

diarrhea) and the appropriate treatments is evident. The current level of mothers' knowledge about children's illnesses is a topic being covered by a knowledge, attitude, and practices survey (KAP), which the project is implementing. Results of the KAP will help us recommend concrete actions for improving family diagnoses and treatments, including increasing awareness of the role that poor nutrition plays in determining a child's general health status.

Table 5.5 shows the frequency with which different treatment options were used for various illnesses. In 19 percent of all episodes, no treatment was administered, while either modern (41 percent) or traditional (38 percent) medication was given in slightly more than three-quarters of all cases. With the exception of vomiting and the "other" category, the percentage of children receiving modern medication was equal to or slightly higher than those receiving traditional treatments. For eye problems, however, there was a strong preference for modern medicines (41 percent vs. 14 percent).

Table 5.5. Treatment options used for different illnesses

Type of illness	Type of treatment					
	Nothing	ORT*	Modern Medication	Traditional Medication	Water	Total
	(percent)					
Diarrhea	18	1	42	38	0.2	100
Cough	32	1	37	29	0.5	100
Fever/Malaria	13	1	43	43	0.3	100
Vomiting	20	4	34	42		100
Eye	42		41	14	3.0	100
Skin	23	1	43	34		100
Cold	31		38	31		100
Other	20		35	46		100
Treatment averages	19	1	41	38	0.4	100

Source: Survey data for May - October 2001.
*ORT: Oral Rehydration Therapy

Although only 19 percent of diagnosed illness were untreated for the entire sample, Table 5.6 shows that there is a much higher rate of non-treatment for diagnoses made by mothers (27 percent) and by family/friends (8 percent) than when the diagnosis is made by modern or traditional healers (no treatment recommended for only 1 percent of patients in each group). This is as one would anticipate, if we assume that mothers diagnose all problems first and only consult health specialists for cases that they believe need treatment.

Mothers making the diagnosis treated their children with both modern (33 percent of illnesses) and traditional medication (38 percent). Although health center personnel favored modern medicines (87 percent of treatments recommended) and traditional healers favored traditional medications (92 percent of treatments), there was some use of traditional medicines by modern health professionals (9 percent of cases) and some modern medicine used by traditional healers (8 percent).

For cases where no treatment was administered, we need to probe further to understand if they were really cases of not needing treatment, a failure to recognize the need for treatment, a financial constraint, or lack of access to medicines or health services. We will attempt to answer these types of questions in the final report.

Table 5.6. Treatments by type of person performing diagnosis

	Person who performed diagnosis			
	Mother	Health Professional	Traditional Healer	Family Friend
Treatments	(percent of diagnoses)			
Nothing	27	1	1	8
SRO	1	3		1
Modern Medication	33	87	8	43
Traditional Medication	38	9	92	47
Water	1			<1
Total percent	100	100	100	100
Total diagnoses	1624	368	147	273

Source: Survey data for May - October 2001, covering a total of 2412 different diagnoses.
Note: Pharmacists represent 0.4% of cases diagnosed; they are not shown in table.

What factors drive decisions to use modern over traditional treatments? Is it a matter of cost? Or a matter of perceived efficacy of one treatment over the other? Or a question of availability? Although the LICNAG survey will not provide definitive answers to all of these questions, the combination of expenditure data with information from the KAP survey should improve our understanding of the reasoning behind these choices. Improved information in this area will be of use to Malian health planners as they continue their efforts to foster complementarities between traditional and modern health care systems.

Although we do not yet have enough expenditure data to fully analyze the role of income in shaping the use of health services and different types of treatments, we do have some preliminary results on who is paying for different types of treatments (Table 5.7). The conventional wisdom in Mali holds that women have traditionally been responsible for childcare costs such as supplementary foods, health care, clothing, etc. Data available thus far suggest that men and women are sharing the costs of health care; fathers and heads of the PCU (who are all male) are actually paying for more treatments (48 percent and 16 percent, respectively, (i.e., a total of 64 percent) than are mothers (30 percent).

Table 5.7. Who pays for a treatment and what type of medication?

	Categories of Persons Paying for a treatment					
Who pays?→	Mother	Father	PCU Head	Other Family Member	Friend	Total
	(percent of treatments)					
	30	48	16	4	3	101
↓Type of medication?	(percent of treatments)					
Modern	74	78	76	49	34	74
Traditional	26	22	24	52	66	26

Source: Survey data for May-October 2001.
Notes: Pharmacists and SRO 17 cases are not included in this table.

The lower half of Table 5.7 shows that there is no differentiation among mothers, fathers, and PCU heads in the share of modern versus traditional treatments. Each

category of provider purchases modern medicines in about three-quarters of the cases and traditional medicines in about one-quarter. When other family members or friends pay, however, the treatment is likely to be a traditional one at least 50 percent of the time. One hypothesis here is that the assistance is coming from extended family members of an older generation who may be more accustomed to traditional treatments; the data are not disaggregated enough for us to verify this hypothesis.

We have also been able to do some preliminary analyses on the cost of medical treatments during the first six months of the survey (Table 5.8). Average expenditure per treatment, regardless of type, falls between 900 and 1000 FCFA, suggesting that the choice of traditional versus modern treatment may not be driven by cost (as hypothesized above). Also of note is the magnitude of this expenditure. For a rural household, an unexpected expenditure of almost 1000 FCFA on a single family member is an important sum given that 73 percent of the population lives on <700 FCFA per day and 91 percent on less than 1400 FCFA per day (Tyner et al. 2001).[24]

Table 5.8. Average child health expenditures per illness by treatment and person paying

	Modern Treatment		Traditional Treatment		Overall Results	
Person Paying	Average Expenditure (FCFA)	Number of Observations	Average Expenditure (FCFA)	Number of Observations	Average Expenditure (FCFA)	Number of Observations
Mother	638	280	1133	93	755	373
Father	1053	442	889	124	1028	566
PCU head	1427	154	1087	44	1370	198
Other Family Member	917	21	227	15	630	36
Friend	321	14	593	25	496	39
Overall Results by treatment						
Mean costs	974		936		965	
Total Observations		911		301		1212

Source: Survey data for May-October 2001 covering all treatments of childhood illness for which an expenditure was made.

PCU heads, fathers and mothers spent on average 1370, 1028 and 755 FCFA per treatment. In comparing the results of Tables 5.7 and 5.8, we find that there is no difference in the frequency of paying for modern versus traditional treatments among mothers, fathers, and PCU heads (Table 5.7) although fathers and PCU heads pay more of the actual expenditures on modern medicines. On average, a father's expenditure on modern treatments is 18 percent greater than on traditional treatments (percent calculated from data in Table 5.8). The equivalent difference for a PCU head is 31 percent. For mothers, the direction of the difference is reversed, and the effect is much stronger. Mothers spend 78 percent more on traditional treatments than on modern treatments, even though 75 percent of the individual treatments for which mothers pay are modern treatments. This suggests that mothers may be purchasing inexpensive modern medicines such as aspirin and chloroquine, while fathers and PCU heads may be paying for more expensive modern treatments involving antibiotics or chloroquin injections for malaria. Future analysis will examine the

[24] The Tyner et al. document is referring to results of the poverty assessment and reports that 73% live on less than US$1.00 and 91% on less than US$2.00 per day; we converted to FCFA at a US$1.00=700 FCFA rate.

sequencing in treatment options used during a given illness and the reasons for using a given healthcare provider.

Although the data now available on non-health expenditures is still in the very early stages of being verified and cleaned, comparing the level of health versus non-health expenditures on children under four years of age is a first step toward better understanding patterns of household resource allocation. Table 5.9 reports expenditures made between May and October 2001 in which a child under four years old was the intended beneficiary. The table compares expenditures made by fathers to those made by mothers.

Table 5.9. Average total May-Oct expenditure directly benefiting children <4

Production System	Sub-region	Fathers		Mothers		Total	
		Health	Non-health	Health	Non-health	Health	Non-health
		(FCFA)					
Cotton	Kolondieba	2,004	2,127	246	840	1,254	1,314
	Koutiala	3,669	2,705	450	2,179	2,628	2,482
Rice	Macina	1,482	1,713	798	1,521	1,142	1,594
	Niono	3,673	2,375	1,193	2,312	2,521	2,335
Coarse Grains	Bandiagara	1,901	1,084	884	1,117	1,284	1,107
	Koro	1,885	1,617	717	1,032	1,313	1,233
All combined	All	2,529	2,069	696	1,461	1,703	1,698

Source: Survey data for May - October 2001 covering a subset of expenditures on items purchased by parents for their children < 4 years of age.

The table reports the average total expenditure for the period on health items and non-health items (all other items, but primarily food and clothing). Not included at the present time is the value of home-produced foods (e.g., cereals, fruits). The level of health expenditures is more variable than those for non-health items. This is expected because not all children fell ill within the period so there are many zero observations for health but few zero observations for other types of expenditures. Fathers' expenditures show a relatively high level of variation within each sub region, probably because their expenditures on children under four are more determined by health costs (see below) than by other needs.

Although these results are preliminary and need to be combined with additional data yet to be completely verified, several interesting issues appear:

- Total parent expenditures are approximately 100 percent greater in the Koutiala and Niono sub-regions than the other zones. These are the zones where there is the strongest evidence of agricultural productivity and income growth, suggesting that increased household income may result in increased expenditure on children.
- Fathers' average expenditures on health are higher than their non-health expenditures while mothers' non-health expenditures on children are over double the amount spent on health. These results suggest that fathers accept responsibility for major curative expenditures but not for day-to-day child maintenance.
- Mothers' average total expenditures on health are lowest in the Kolondieba and Koutiala sub-regions of Sikasso. These results may be a reflection of lower personal income for women in these zones and therefore a greater need for men to cover curative costs.

- Mothers in the Niono sub-region have the highest level of expenditures on health and non-health items compared to mothers in the other sub regions while those in the Kolondieba sub-region spend the least amount on their children. Again, this may be due to differences in women's access to money.

We anticipate verifying these results and testing various hypotheses about what is behind the differences across sub-regions once the full data set is available.

5.2 Morbidity, Growth, and Malnutrition

Summary results from an analysis of the change in children's weight following a reported illness are shown in Table 5.10 for eight categories of illnesses, listed from smallest to largest weight gain. Although pediatrician-recommended weight gain (Table 3.5) never falls below 6 grams per day, regardless of age group, results in Table 5.10 show that weight gain is below 6 grams per day following all illnesses except skin problems.

Table 5.10. Average weight gain following episodes of illness

Caregiver Diagnosed Type of Illness	Average Weight Gain	
	Grams per day	Number of Observations
Fever/malaria	0.1	543
Diarrhea	1.2	318
Vomiting	1.8	18
Others	3.6	31
Cough	3.8	87
Cold	4.4	31
Eye problems	4.5	59
Skin problems	7.0	49
Total	1.5	1131

Source: Survey data for May through October 2001.
Note: The weight gain per child is calculated as the difference between the weights for two successive months divided by the number of days between the weighing sessions; only cases for which a child was ill during the month are included.

When children were reported to be sick with fever or malaria (48 percent of the episodes reported in Table 5.3), their average weight gain for that month was only 0.13 grams/day. Diarrhea and vomiting are associated with the next smallest weight gains (1.2 and 1.8 grams per day). While these preliminary results are based on a relatively small percentage of cases for which both anthropometric and morbidity data have been cleaned and verified, they confirm the logical conclusion that children's growth is hindered by episodes of illness.

Table 5.11 provides another way of looking at the relationship between malnutrition and morbidity. The table reports HAZ and WHZ scores and the prevalence of

Table 5.11. Relationship between HAZ and WHZ scores and morbidity

Frequency of illness during 6-month period	Height-for-Age Results (Stunting)			Weight-for-Height Results (Wasting)		
	Mean Score	% < -2.00	Range	Mean Score	% < -2.00	Range
Not ill	-1.44	37	36-40	-0.59	8	7-11
Ill once	-1.37	34	32-35	-0.75	11*	10-14
Ill twice	-1.55	38	34-42	-0.96	16*	16-18
Ill ≥ three times	-1.69	44*	38-49	-1.26	25*	20-33
Overall average	-1.45	37		-0.74	12	

Source: Survey data for May through October 2001.
*Significantly different from prevalence for those with no episodes of illness.

stunting and wasting for groups of children who differ by the frequency of their illness episodes. These results corroborate the link between illness, weight-for-height, and height-for-age. For both stunting and wasting, the results presented in Table 5.11 reveal that the nutritional status is significantly worse for children plagued by frequent episodes of illness. Children with three or more illness episodes were more likely to be stunted (44 percent) compared to those who were not sick (37 percent). The effect of repeated bouts of sickness is logically more apparent in the rates of wasting because weight gain is more susceptible to short-term bouts of illness than height. While average WHZ scores were significantly different from well children for all categories of illness, only children who were sick three or more times had HAZ scores (indicating stunting) that were significantly different than those who were not sick. This is logical to the extent that only when children suffer from reoccurring bouts of illness would one expect there to be an effect on height. These results reflect both the aggregate six-month situation and the monthly results, as we did not find any statistically significant variation across months in the relationship between illness and HAZ or WHZ scores.

The relationship between malnutrition and illness is mutually reinforcing. Malnourished children with weaker immune systems are potentially more susceptible to disease and likely to experience more severe disease symptoms for a longer duration. Malnutrition, in the form of protein-energy deficiencies, increases the duration of diarrhea, while sufficient vitamin A is important for fighting illnesses including measles, respiratory track infections and diarrhea. Repeated bouts of illness worsen children's nutritional status. Table 5.5 shows that in 19 percent of the illness episodes, no treatment was given, and children were left to rely on their own defenses. While well-nourished children are better able to fend off illnesses and develop immunities, they are still at significant risk from diseases such as malaria and measles.

5.3 Child Morbidity and Mortality

Child mortality is the direst consequence of high rates of malnutrition and repeated exposure to illness. The most sobering result to date is that during the first six months of the LICNAG study, sixty-one of the sample children less than 4 years of age have died; 19 children in the cotton zones of the Sikasso Region, 23 in coarse grain zones of the Mopti Region and 19 in the rice production zones of the Ségou Region.[25] Seventy percent of the children who died were less than 2 years old; 61 percent were girls and 39 percent boys. In looking at deaths by sub-region, the same pattern of more female (from 58 to 71 percent, depending on sub-region) than male deaths applies in all cases but that of Koro, where slightly more boys died (56 percent) than girls (44 percent).

Prior to their deaths, 43 percent of the children were stunted, 17 percent severely with HAZ < -3.00; 38 percent were wasted, 15 percent severely wasted with WHZ < -3.00. The high prevalence of wasting (38 percent) indicates that children's weight had dropped in the period preceding their death (prevalence of wasting in the overall population is only 12 percent). While there is no information presently available on the cause of death, caregivers for over 90 percent of the children who died had

[25] This includes deaths of children originally in the sample and those born between May and October.

reported at least one episode of illness during the five-month period preceding their death.

These mortality figures, when viewed in the context of the high prevalence of malnutrition and morbidity described above, show that children who are sick and malnourished with low Z-scores often do not make it through the first two years of life. This is one factor that may contribute to the lower wasting rates in the sample of children between 3-5 years old. By the time a child is three or four years old, they have survived the major childhood diseases like measles that can also contribute to wasting (Dettwyler 1991). Higher mortality rates among girls might also have an impact on the relative prevalence of stunting for boys versus girls; if more girls are dying at an early age, this could be contributing to the lower overall prevalence of stunting found among girls (34 percent) versus boys (40 percent). If these tendencies are confirmed after the full year of data is analyzed, an effort will be made to unravel the impact that different rates of mortality for boys and girls might be having on the overall statistics for the remaining sample.

6 Preliminary Findings on Factors Hypothesized to Influence Health and Nutrition

The research proposal for the second phase of the project (LICNAG 2000) identified a number of hypotheses concerning the determinants of children's health and nutritional status in Mali that were drawn from a review of the literature and discussions with members of the multi-disciplinary advisory committee. Testing most of these hypotheses in a statistically correct manner will not be possible until the full year of data on household consumption, expenditures, non-farm income, and agricultural production are entered and verified. In the interim, we discuss some preliminary results using the small portion of the data that are currently available. We limit the discussion to the relationship between child nutritional levels and parents' education, household assets, and income levels.

6.1 Parents' Level of Education

Maternal education is widely recognized as an important factor in determining the health and nutritional status of young children (Behrman and Deolalikar 1988). There is considerable speculation about how maternal education influences nutrition (e.g., through increased income, more control over household resources, better understanding of appropriate health and hygiene practices). Pender's 1999 analysis of DHS II data for Mali (reported in Tefft et al. 2000) found that the positive relationship between maternal education and WHZ scores was stronger than that for HAZ scores. Part of the difficulty of examining this relationship in rural Mali, as well as that for paternal education, is the limited number of educated parents.

The number of parents of sample children under four years old who have received some form of schooling is very low. Parents who have never gone to school account for more than half the sample: 68 percent of the fathers and 87 percent of the mothers. Table 6.1 shows that only 4 percent of mothers and 11 percent of fathers attended either a public or private school; 9 percent of mothers and 22 percent of fathers have received some type of Koranic education. Of the 13 percent of mothers who had some schooling, all had studied six years or less. Among the fathers with some

Table 6.1. Prevalence of malnutrition by parent's education level

Mother	Education		Stunting		Wasting	
	%	Number	Ave.	CI	Ave.	CI
No schooling	86.7	1542	38.7	38-40	11.8	11-13
Public/private	4.4	79	33.7	29-38	8.7	6-12
Koranic/literacy	8.8	157	26.7	24-30	10.0	8-12
Total		1778				
Father	**Education**		**Stunting**		**Wasting**	
	%	Number	Ave.	CI	Ave.	CI
No schooling	67.7	938	40.5	39-42	12.3	12-13
Public/private	10.5	145	31.0	28-34	9.0	8-11
Koranic/literacy	21.9	303	31.4	29-34	10.0	9-12
Total		1386				

Source: Survey data for May through October 2001.
Note: There is incomplete information for 69 mothers and 128 fathers who are not included in the analysis.

schooling, only18 percent studied between 7 and 12 years.

Despite a very small sample of educated parents, the preliminary results show that the children of parents who attended school have lower rates of stunting and wasting. Mothers with some formal education had a lower prevalence of stunted children (33 percent) than mothers with no schooling (39 percent). Stunting is more prevalent among children of fathers with no schooling (41 percent) than fathers with some schooling (31 percent). The average HAZ scores for both mothers and fathers are significantly different across levels of education, but the WHZ scores are not. These results are the reverse of those obtained by Penders using the DHS II data.

Previous research has found that the effect of education is often influenced by other variables such as a household's relative well-being, the sex of the child, and the sex of the parent. In an analysis of DHS data for sub-Saharan Africa, fathers' education proves to be more important to children's nutritional status in lower income countries like Mali. In wealthier countries, where households may have attained a certain level of welfare, mothers' education was found to be a more important determinant (Penders et al. 2001). Using similar data, fathers' education was found to have a greater effect on male children's health and nutritional status while mothers' education level had greater impact on daughters' status (Sahn and Stifel 2001).

Experiences outside Mali have found that children's nutritional status can be improved through the use of targeted behavioral change interventions that use "highly specific messages, appropriately tailored and delivered" to improve caregiver practices, irrespective of the level of family income or mother's education (Berg 1999). These results suggest that even with Mali's low levels of education it is possible to improve children's health and nutritional status.

6.2 Household Assets

A key question guiding the LICNAG project is what can be done to strengthen the positive effects of growth in agricultural production and farm incomes on children's health and nutritional status. One hypothesis is that improved agricultural productivity can have a direct effect on the well-being of children in households that increase their income, if the income goes to improved nutrition and health care. A second, complementary hypothesis is that agricultural growth can raise the level of community resources available for investments to improve health and nutrition (health centers, schools, cereal banks, reliable sources of potable water, etc.), assuming that the community organizes in a way that permits it to tap some of the higher individual incomes.

Most analyses of the links between income and nutrition have used easily collected data on household assets as a proxy for income. During the first phase of this project, it was determined that household assets (used to proxy income) and nutritional outcomes had a weak but statistically significant correlation (Penders 1999 cited in Tefft et al. 2000).

> …analysis of DHS I and II data finds that income, approximated by the ownership of various assets, has a positive but statistically weak effect on weight-for-height and height-for-age Z-scores in children. This

finding is similar to evidence presented by many other studies throughout developing countries (for a review see Behrman and Deolalikar 1988).

The difficulty with this and other similar analyses is the lack of data accurately reflecting the relative value of assets across households. In the DHS surveys the number of radios, bicycles, motorcycles, televisions, refrigerators and cars owned by the household were used to represent household assets. These indicators of wealth miss a large share of rural savings held in the form of livestock. Also, counting the number of assets with no attempt to quantify the current value may lead to inaccurate comparisons across households. These possessions might also be a poor proxy for income in any given year, since they reflect purchases of durable goods that may have

Table 6.2. Prevalence of stunting and HAZ scores by level of household assets

Production System	Asset Level						Total Sample	
	Highest[a]		Middle[b]		Lowest[c]			
	Percent Stunted	HAZ Score	Percent Stunted	HAZ Score	Percent Stunted	HAZ Score	Percent Stunted	HAZ Score
Cotton	41	-1.62	47	-1.79	*39	-1.51	43	-1.67
Rice	21	-0.93	21	-0.86	*27	-1.22	23	-1.0
Coarse Grains	40	-1.59	36	-1.36	38	-1.36	38	-1.44
Total	37	-1.47	38	-1.47	34	-1.34	37	-1.44
No. of cases	203		271		257		731	

Source: Calculated by authors from LICNAG survey data May-October 2001.
Notes: * Statistically different from prevalence for highest and/or middle asset groups.
a. Own at least one radio, bicycle, and motorcycle or moped.
b. Own at least one radio and bicycle.
c. Own none of the aforementioned assets.

taken place years earlier (Tefft et al.2000). Furthermore, households that choose to consume health services rather than purchasing a bicycle will confound the relationship between "asset ownership" and nutrition because these households would appear to be less wealthy, yet may have better health and nutrition.

6.2.1 Durable goods as assets

Keeping in mind the disadvantages of using household assets (a measure of wealth) as proxies for income, we used LICNAG survey data to analyze the link between assets and children's nutritional status. The results thus far are ambiguous. Table 6.2 reveals that the rice zone is the only one exhibiting the anticipated relationship; households in the lowest asset group exhibit a statistically higher prevalence of stunting (27 percent) than those in the other two asset groups (21 percent). In the cotton zone, the prevalence of stunting is statistically different across asset groups, but we find the lowest prevalence of stunting in the households with fewer assets (a result of the confounding relationship mentioned in the previous paragraph?). In the coarse grain zones, households appear to have equally poor nutritional outcomes regardless of asset level. Similar analyses were done using WHZ scores and the results were even more inconclusive; there were no statistically significant differences across asset levels identified, regardless of zone. Given that assets reflect wealth or long-term income trends rather than current income levels, it is not surprising to find no link

between assets and an indicator of short-run, episodic nutritional problems such as wasting.

6.2.2 Productive assets

Table 6.3. Agricultural Equipment Levels of Sample PCUs

Production Systems and Sub-Regions	Agricultural Equipment Asset Levels				Total Sample	
	2 Full teams[a]	1 Full team[b]	Partial team[c]	Manual[d]		
	(Percent of PCU in each asset level, by zone)				N	%
Cotton	**38**	**48**	**9**	**6**	248	100
Kolondiéba	22	57	11	10		
Koutiala	53	39	7	2		
Irrigated Rice	**18**	**40**	**25**	**17**	244	100
Macina	21	47	20	11		
Niono	14	33	30	23		
Coarse Grains	**1**	**14**	**47**	**38**	239	100
Bandiagara	1	12	22	65		
Koro	2	17	74	8		
Total	**19**	**34**	**27**	**20**	731	100

Source: Calculated from survey data for May through October 2001.

Notes:

a. Two sets of draft oxen and ≥ two plows
b. One set of draft oxen and ≥one plow
c. Complete set minus one oxen or one plow
d. No oxen or plow

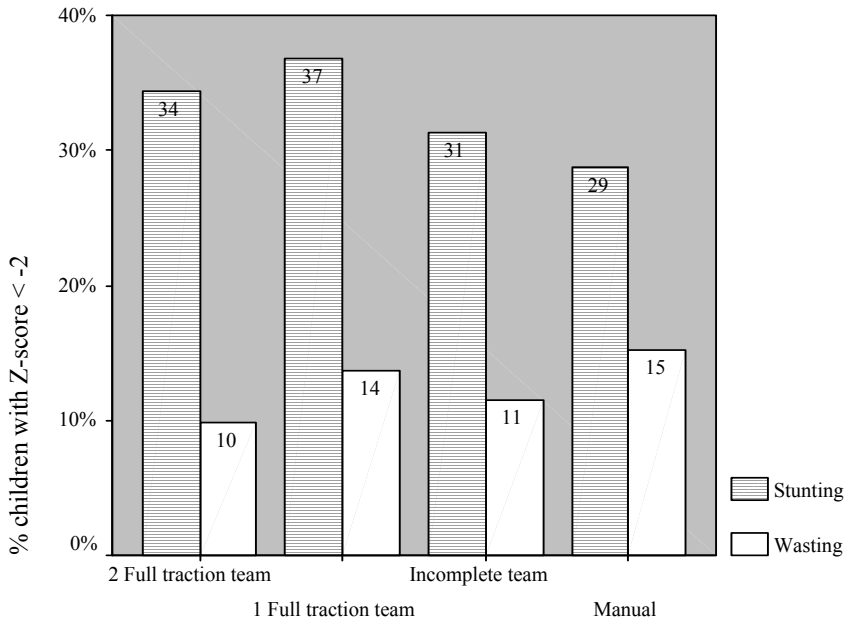
Collaborators working in the agricultural sector have found that farm income is correlated with higher levels of productive assets such as animal traction equipment. Equipment allows households to plow, plant, and weed quickly and at the appropriate times. Farms with their own traction team can plow and plant most of their land after the first rain, while households that seek to rent equipment are often unable to find something during the peak demand periods. Households relying on manual cultivation often finish planting their fields several days (or even weeks) later than equipped households. Numerous studies by IER, the CMDT and others have shown that rural households owning and using animal traction equipment are the more productive farmers who obtain higher yields and subsequently earn higher incomes (e.g., Kébé et al. 1998).

As these results suggest that levels of animal traction equipment owned by a household might better reflect income than consumer assets typically used to proxy income, we used LICNAG data to examine the hypothesis that children in households with more animal traction equipment had better health and nutritional outcomes. Table 6.3 shows equipment levels for sample households according to the equipment classifications used by the CMDT. This classification is based on an animal traction team composed of a pair of draft oxen and a plow. There are large differences across cropping systems. In the cotton zones, 86 percent of farm households (PCU) have at least one complete traction team and only 6 percent of the PCUs are classified as manual (possessing no equipment). In the rice areas, 58 percent of the sample households own at least one full traction team; 17 percent do not own any equipment, the larger share being in the Niono sub-region. In the coarse grain zones of the Mopti Region, only 15 percent own at least one full team of traction equipment. Overall,

these farmers rely heavily on manual cultivation techniques (38 percent of the PCUs), but there are sharp differences between the Bandiagara sub-region (65 percent manual) and the Koro sub-region (only 8 percent).

The greater number of fully equipped teams in the cotton and rice regions is due to the history of programs there that have promoted the use of, provided the credit for and developed the supply of traction equipment (CMDT, *Office du Niger*). There have been few, if any, such programs in the coarse grain production zones of the Mopti region (in large part because coarse grain production has not been profitable enough to cover the costs of animal traction equipment). In addition, many fields in

Figure 6.1. Prevalence of child malnutrition by levels of productive assets



Source: Survey data for May through October 2001.
Note: There is not statistically significant difference in stunting and wasting across equipment levels.

Bandiagara (but not in Koro) are extremely rocky or otherwise inappropriate for plowing with animal traction equipment.

The data do not confirm our hypothesis about the potential links between productive assets and children's nutritional status (Figure 6.1). Although the prevalence of wasting is somewhat higher among households with the lowest equipment levels (15 percent) than among households in other groups (9-12 percent), differences across all equipment levels are small and not statistically significant.

We anticipate that the agricultural input/output and landholding data that have been collected will allow a more detailed analysis of this question. One reason for the lack of statistical significance in the present analysis could be that we have not yet looked at the equipment/land ratios in classifying households.

Another category of productive assets frequently used as an indicator of wealth and potential income in Africa is livestock holdings. Livestock can be sold to purchase food when there are shortfalls in production, they are also used or exchanged for social occasions (baptisms, weddings, and funerals), and animal by-products such as milk and eggs often provide small amounts of income for women. In addition, farmers owning more animals often have access to more manure which can be used to improve soil fertility and crop productivity. Given the important role of the livestock sector in rural areas, one might anticipate that PCUs with larger livestock holdings are wealthier and therefore better able to provide adequate health care and nutrition for the children.

Preliminary cross-tab analyses using a four-category variable for livestock holdings and a two-category variable for nutrition status (HAZ- or WHZ-scores above or below -2) does not support this hypothesis. The livestock variable classified PCU as having large (> 5 animals), average (3-5), below average (1-2) or zero animal assets for each major type of animal (cattle, sheep, and goats). The cross-tab was done individually for each type of animal. Each analysis revealed that households owning no animals were more likely to have a lower prevalence of stunting and wasting than the sample average; these results were particularly strong for goats and sheep. At the other end of the distribution, households with the largest number of animals were more likely to have a higher prevalence of stunting and wasting than the sample average; this result was particularly strong for cattle and weak for goats. Results for the intermediate groups (1-5 animals) were mixed with prevalence sometimes being higher than the sample average and sometimes lower. Analyses looking at the relationship of wasting to goat and sheep ownership were similar, but the analysis for cattle showed no statistically significant relationship. These preliminary results suggest that larger livestock holdings per se are not being used as a source of income or food to improve child health care and nutrition.

Future analyses will examine different ways of representing the value of livestock holdings (e.g., conversion to standard livestock units or valuation in monetary terms) to make sure that these preliminary results do not change when the method of valuation changes. We will also attempt to look at the contribution of poultry to child health and nutritional status, as this is an asset that is usually controlled by women and might be more likely to be used to pay for child care expenses.

6.3 Do higher incomes contribute to better nutritional outcomes?

As mentioned above, our hypothesis is that higher farm incomes can contribute to better nutritional outcomes at both the household and the community level. In this section of the report we focus on the relationship between household income and nutritional outcomes, examining how children's nutritional status varies with the level of income for the entire household as well as for individual members of the household (particularly mothers). In future reports we will be looking at evidence on the ability of communities to mobilize increased household incomes for community actions that contribute to improved health and nutrition.

For all income analyses, LICNAG will be estimating total household income by the expenditure method. This is the most common way of estimating income in large

surveys as it is easier to collect accurate data on expenditures than to collect accurate data on net income from a multitude of different activities.[26] Expenditures include all goods and services purchased as well as those received as gifts. In addition, consumption of items produced by some households but purchased by others (e.g., firewood, soap, cereals) is valued and treated as expenditure. To collect this information, every adult member of the household making expenditures is interviewed at least twice a month to record all purchases, in-kind transfers, consumption of goods and services produced by members of the PCU, and animal and agricultural transactions.[27]

With data continuing to be collected, cleaned and verified, this section reports a first attempt to classify households based on monetary expenditures. We include all goods and services recorded between May and October 2001, except livestock and cereals.[28] Due to the difficulty of collecting information on consumption of non-purchased items (e.g. firewood collected rather than purchased), the current estimate tends to understate the expenditures of households with heavy consumption of non-purchased items.

Table 6.4. Average value of purchased goods and services*

	Value of purchases			Average	Average Monthly
	6-month Average	6-month Median	Monthly Average	No. PCU Members	Purchases Per Capita
Sub-region	(FCFA)				
Kolondieba	116,428	81,023	25,507	19.84	1217
Koutiala	200,084	114,800	41,113	20.23	1502
Macina	154,313	126,000	27,129	15.72	1874
Niono	205,055	105,350	44,070	11.31	3051
Bandiagara	57,075	40,980	13,091	20.65	632
Koro	53,381	37,310	10,875	18.36	592
Total	133,236	71,715	27,480	17.71	1505

Source: Very rough estimate from survey data on purchased goods and services for May through October.
*Note: estimate does NOT include cereals and livestock either purchased or consumed from home produced stocks.

Table 6.4 summarizes our rough estimates of average PCU expenditures by sub-region for the entire May through October period. Also shown for each sub-region are average monthly expenditures and average monthly expenditures per capita. It is important to remember that food tends to represent 50 to 75 percent of total expenditure in Sahelian rural households (e.g., Kelly et al. 1996 for Senegal). Because the numbers in table 6.4 do not include a large part of the food expenditures (cereals and animals slaughtered for home consumption), final estimates of total PCU expenditures are expected to be at least double the values reported here. At present, the numbers in Table 6.4 are best thought of as discretionary spending over and above basic foods.

[26] For a discussion of different approaches to collecting income data, see Deaton 1997.
[27] Additional data collected on income earned in farm and off-farm activities will be used as a check on the expenditure-based income estimate and to examine the relative profitability of different income generating activities.
[28] The analysis of these products is more complicated than that for other expenditures as we need to include the consumption of home produced livestock, cereals, and pulses.

Looking at the last column of the table, we note that the level of per capita purchases is lowest in the coarse grain production areas of Bandiagara and Koro and highest in Niono. If we assume that these estimates of discretionary spending are reasonable proxies for differences in average per capita PCU income across the different sub-regions, the results for the coarse grain zones and for Niono suggest that there may a positive correlation between income levels and children's nutritional status described in Sections 3 and 4 of this report.

Another way of looking at these results is to compare the two sub-regions within each zone in terms of nutritional outcomes and discretionary income. Recall that within each cropping system we selected one sub-zone to represent a more economically dynamic agricultural economy (more infrastructure, better developed markets, more evidence of investments to improve agricultural productivity). As anticipated, for each cropping system the average income results for the more economically dynamic sub-regions (Koutiala, Niono, and Bandiagara) are better. In each of the more economically dynamic sub-regions the prevalence of stunting is statistically lower than in the less dynamic sub-region of the same zone (Table 6.5). This result suggests a positive correlation between general indicators of economic development and nutritional outcomes.

Once all the expenditure data are cleaned and analyzed, we will be in a better position to test the relationship between income and nutritional status at both the sub-region and the household level. At present, preliminary analyses do suggest that levels of income may be influencing nutritional outcomes. As noted in Section 6.2, most prior studies examining income/nutrition linkages have relied on relatively poor proxies for income (e.g., household assets) rather than income/expenditure data. Although logic suggests that children in households with higher incomes should be better-off, most of these earlier analyses have found weak, if any, correlation between income (proxied by household assets) and nutritional status. We anticipate that the LICNAG effort to collect both expenditure and anthropometric information on the same sample will provide a better basis for analyzing the income/nutritional linkages than that offered by the earlier studies.

Table 6.6. Average value of monthly purchases by gender *

Sub-region	Male		Female	
	All men	Fathers	All females	Mothers
	(FCFA/month)			
Kolondieba	6076	1332	1543	1357
Koutiala	11680	1832	2541	1972
Macina	5887	4286	3580	4133
Niono	10809	5476	5188	5686
Bandiagara	3927	3179	2695	3008
Koro	2742	1075	1031	1115
Total	7033	2793	2709	2755

Source: Estimated by authors from data on purchases for May through October 2001.
* Note: Estimates exclude the value of cereals and livestock from both purchases and consumption of PCU-produced items.

Table 6.6 breaks down the monthly purchase data by gender (all men and all women) and by family status (all fathers and all mothers of children <4 years of age).

Three key points are illustrated by the information in the table:

- Overall discretionary spending by men is more than double that of women;

- Discretionary spending by all men is much higher than that by fathers of children <4.
- Discretionary spending by fathers and mothers is approximately the same within each zone.

Higher expenditures by men than by women are anticipated as men are the heads of the PCUs and they are responsible for many purchases that benefit the entire PCU (taxes, buildings and building maintenance, clothing for celebrations, and the costs of major social events such as baptisms). Women's expenditures tend to benefit their immediate nuclear family rather than the entire PCU.

The average total expenditure of fathers of children under four years of age is lower than the average for all males (including men who do not have children under four years old). This occurs because many fathers in the sample are not the head of the PCU (the large extended family), but head of "dependent" families within the larger PCU. As the heads of "dependent" families, these men have less discretionary income (e.g., cotton income goes to the PCU head) and few financial responsibilities. Although the pattern of overall male expenditure exceeding that of fathers is consistent across sub-regions, the magnitude of the differences varies considerably. In the cotton zones, male expenditure ranges from 4.5 times greater than fathers' expenditure in Kolondieba to 6 times greater in Koutialla. These differences are in stark contrast to the situation in the rice production zones (Niono and especially Macina) and the coarse grain zones (Bandiagara and Koro) where the expenditure for all men is 1.4 to 2.5 times greater than that by fathers.

The large regional difference in fathers' level of expenditures can be explained, in part, by the manner in which household resources, production and income are managed and controlled. In the Sikasso zone, where cotton production predominates, cotton revenues are controlled by the PCU head in large extended households.[29] In Ségou, where there are smaller production units that more closely resemble nuclear families, fathers of young children appear to have greater access to and control of productive assets (primarily land) and the returns to their use.

It is also interesting to note the substantial variation in average female expenditures between the zones. Average monthly expenditures of women in the Macina, Niono and Bandiagara sub-regions are 50 to 400 percent higher than those of women in Kolondieba, Koutiala and Koro. Although in-depth analysis of expenditure, income and agricultural data will provide specific information to better understand this question, income earned in horticultural production in the Macina, Niono and Bandiagara sub-regions would appear to be the primary factor differentiating expenditure levels between zones. In the Niono sub-region where mothers' expenditures average 5686 FCFA per month, double the sample average and 4 to 5 times the levels in Kolondieba and Koro, access to irrigation water in the *Office du Niger* perimeter allows women to earn income from both rice transplanting and dry season onion production.

[29] Kébé et al. 1998 discusses the evolving nature of the situation, with an increasing number of "dependent" families breaking away from the large extended family to set up their own PCU.

Table 6.7 reports the results of a first attempt to quantify the relationship between children's nutritional status and the level of income both for the entire household (PCU) and for mothers. It shows a Pearson's correlation coefficient which is a measure of the degree of linear association between income (estimated by "discretionary spending levels" explained above) and children's' HAZ and WHZ scores. The correlation coefficient is positive and statistically significant between (1) PCU expenditures per capita and both Z-scores and between (2) mothers' total expenditures and their children's HAZ scores; these results indicate that higher levels of income are associated with higher or improved nutrition. Similarly, lower incomes are associated with lower Z-scores.[30]

Table 6.7. Correlation between discretionary expenditures and children's health and nutritional status

	Expenditures for May through October 2001	
Z -scores	PCU expenditure per capita	Total expenditures made by mothers
HAZ	0.087**	0.130**
WHZ	0.051**	0.014 --

Source: Estimated from survey data for 701 PCUs and 1566 different mothers.
Numbers represent the Pearson's correlation coefficient.
** Correlation is significant at the 0.01 level (99 percent probability).
-- Not statistically significant.

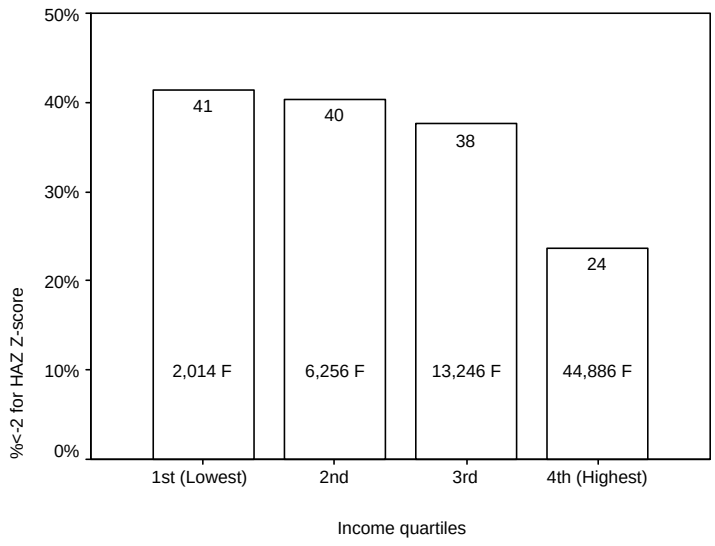
Despite the low absolute value of the correlation coefficients,[31] the higher coefficient for mothers' total expenditures and HAZ scores (0.130) vis-à-vis that for PCU per capita expenditures and HAZ scores (0.087) suggests that an increase in mothers' income (represented by the discretionary spending variable) may have a more positive impact on children's nutritional status than overall PCU income. Comparable coefficients estimated for WHZ scores are smaller than those for HAZ scores, and that for mothers' expenditures is not statistically significant. As one would expect income to be correlated with both HAZ and WHZ scores in a similar manner, we suspect that the differences will diminish once we have completely cleaned the data and added more observations. Also, it will be important to include expenditure data on basic foods.

[30] PCU expenditures are reported on a per capita basis to control for the very variable number of persons across PCUs (from as few as 5 to as many as 90). Mothers' expenditures are not reported on a per capita basis as most of their expenditures are made for members of their immediate family rather than for the entire PCU. An alternative approach that we may try in the future is to look at mothers' expenditures per child to control for the variable number of children for whom each women is responsible.

[31] A perfect linear relationship is indicated by the value of 1.

Figure 6.2 displays the prevalence of stunted children (with HAZ < -2.00) for mothers' income quartiles.[32] The figure shows that the percentage of stunted children decreases as mothers' discretionary spending ("income") increases. Twenty-four percent of children of mothers in the highest income quartile (total expenditures > 20,000 CFAF) are stunted, a statistically significant difference from the 38 to 40 percent levels estimated for the three lower income quartiles.

Figure 6.2. Prevalence of stunting by mothers' expenditure/income quartile



Figures at bottom of box represent average quartile expenditures

Source: Estimated from May through October 2001, survey data for 1676 mothers of sample children less than four years old.

Future analysis will seek to determine whether mother's income has more impact on children's nutritional status than overall PCU income, as implied by these preliminary findings.

[32] Income quartiles are based on mothers' total expenditures between the months of May and October 2001. 1st: < 4.000 CFAF, ave.=2,014; 2nd: 4,000 – 9,000, ave. = 6,256; 3rd: 9,000 – 20,000, ave. = 13,246; 4th: > 20,000, ave. = 44, 886. We used 6097 observations representing 1676 mothers.

7 Overview of Key Findings and Implications

The study of Linkages between Child Nutrition and Agricultural Growth (LICNAG) seeks to better understand the positive and negative repercussions that agricultural-led growth has on children's health and nutritional status and to develop sound recommendations for increasing the positive outcomes.

As the primary goal of the project is to examine possible synergies between agricultural development and improved child health and nutritional status, the study is being conducted in three agricultural production systems--two that have recently shown signs of increased production and one where production has been relatively stagnant. The systems recently increasing production are the cotton zones in the Sikasso Region and the irrigated rice zones of the *Office du Niger* in the Ségou Region. The coarse grain (millet/sorghum) systems in the Mopti region were selected to represent the less dynamic production system.

The objective of this interim report is to present a sub-set of preliminary findings from the analysis of data collected in the first six months of the study (May – October 2001) in order to (1) disseminate the principal empirical findings, (2) inform on-going discussions on policies and programs to improve nutritional outcomes in Mali, and (3) elicit suggestions for future analysis of the LICNAG data base. The report draws primarily on anthropometric, morbidity, and mortality data for children less than four years old and on a very small subset of the socio-economic data. With detailed data on income, consumption, agricultural production, and childcare practices not yet available, the focus is on cross-sectional comparisons across age and gender groups, different types of production zones and a limited number of household characteristics.

7.1 Key Findings

7.1.1 High prevalence of stunting and wasting by 18 months

Across the entire sample, preliminary results show that 36 percent of children less than four years of age are stunted and 12 percent suffer from wasting (Z-scores < -2.00). These prevalence figures are considerably higher than the 2.3 percent level that would be expected in a population of well-nourished children. Of the 36 percent of stunted children, 41 percent (i.e., 15 percent of the total sample) are severely stunted (HAZ < -3.00); of the 12 percent of wasted children, 15 percent (i.e., 2 percent of the total sample) are severely wasted (WHZ < -3.00). Although this pattern of higher rates of stunting and lower rates of wasting is common throughout sub-Saharan Africa, the prevalence of stunting in Mali is among the highest in the Sahel.

The prevalence of stunting among boys in the sample is statistically higher (39 percent) than that among girls (33 percent), but there is no statistically significant difference between sexes in the prevalence of wasting. These results are similar to findings from other studies in sub-Saharan Africa (Sahn 2000).

Analysis of anthropometric data by age group reveals that wasting and stunting set in at an early age. In the first five months of life, 5 percent of sample children are wasted and 10 percent are already stunted. The prevalence of both stunting and wasting increases rapidly through the first 18 months, by which time 40 percent are

stunted and 25 percent are wasted. The 2002 Demographic Health Survey (DHS III) reports that many parents are not following two very important feeding practices for very young children:

- All children should be exclusively breast fed from 0-5 months (i.e., no water, juice, or other foods), yet only 25 percent of mothers interviewed for the DHS III survey follow this advice;
- By 6 months of age all children should be receiving both solid foods and liquids on a regular basis to supplement breast milk, yet only 26 percent of Malian children receive supplementary foods by their 6th month and only 59 percent of children receive regular supplements by one year of age (Ministry of Health, 2002).

We expect that the feeding practices affecting sample children are similar to those reported above; results from LICNAG surveys now underway will provide more information on childcare practices of mothers in the sample.

At 18 months, wasting rates for the sample children begin to decline, dropping to 4 percent for children from 3-4 years of age. The prevalence of stunting, however, increases to 49 percent by age 4. The growing prevalence of stunted children at a time of reduced levels of wasting suggests that children never fully recover from the early growth deficits. The cumulative effects of frequent periods of nutritional and health stress during the first two years leads to a continued deterioration in linear growth relative to age- and gender-standardized norms (Dettwyler 1991, Dewey 1992, Penders and Staatz 2001, Sahn 2000). These growth patterns are fairly consistent with results of other studies in sub-Saharan Africa; they underscore the importance of targeting very young children in efforts to improve the nutritional status of all children.

7.1.2 Lower stunting in the rice zone, higher wasting for coarse grain zones

The prevalence of stunting among sample children is significantly lower in Ségou's irrigated rice sub-regions of Macina and Niono (19 to 25 percent) relative to other sub regions studied (35 to 48 percent). Although sample estimates are not representative of the administrative regions within which they are located, it is nevertheless interesting to note that in the irrigated rice zone of Ségou, the percentage of sample children with HAZ scores less than –2.00 (23 percent) is significantly lower than the regionally representative DHS III estimate of 41 percent. This comparison with DHS III data underlines the contribution of a disaggregated analysis that permits us to identify pockets of lower rates of malnutrition and then test a variety of hypotheses about why the rates are lower in these places.

In addition to the many factors related to hygiene, health care, and feeding practices that affect children's nutritional status, several socioeconomic factors may also explain the relatively lower prevalence of stunting in the rice zone. First, families tend to be small, nuclear households rather than large, extended families as in the other sub-regions. Second, households with access to irrigated land can grow two profitable crops a year, usually rice and a horticultural crop. Third, greater access to water, fertilizer inputs and processing technology for both male and female farmers has fostered high productivity growth and increased real incomes.

In every sub-region but the coarse grain zone of Koro, there is a consistent pattern of wasting rates increasing through the 17th month and then decreasing from the 18th through the 47th month. The higher prevalence of wasting in the coarse grain producing sub-regions of Bandiagara and Koro in the Mopti region (16 percent) compared to levels in the rice and cotton areas (9-11 percent) may indicate relatively greater short-term difficulty in satisfying children's food needs, particularly during the hungry season. These preliminary results fall in line with the results of a 2001 Public Attitude Survey, in which 62 percent of all respondents in the Mopti Region, where Bandiagara and Koro are located, mentioned hunger as a personal problem, compared to 39 percent for the rest of the country (Bratton 2001). Recent analyses of per capita food production by administrative region also support the conclusion that the availability and access to food is a bigger problem in Mopti than in Ségou and Sikasso (Tefft et al., 2000).

Analysis by age group shows that the prevalence of stunted children increases rapidly in the cotton zone, attaining 50 percent for children 12-17 months, compared to 32 percent for the coarse grain zone. Stunting rates continue rising through the 4th year in the coarse grain zone, while rates in other sub-regions remain constant or slightly decline.

Future analysis will use the complete LICNAG data set to examine the complex interaction of different factors in an effort to explain why:

- Stunting increases more rapidly in the cotton zones of the Sikasso Region, where cereal production per capita is higher than in any other region;
- Stunting is generally lower in the rice zones;
- Stunting and wasting rates are significantly lower for households located within the irrigated perimeters of Niono but not for those in the irrigated perimeters of Macina;
- Wasting prevalence is higher in Koro than all other sub-regions after two years of age and increases during the fourth year (36-47 month period).

7.1.3 Better nutrition for children of educated parents

Despite an extremely small sample of parents with some formal schooling (4 percent of mothers and 11 percent of fathers), results show that children of parents who have attended school have lower rates of stunting (34 and 31 percent respectively for mothers and fathers with some formal education versus 39 and 41 percent for parents with no schooling).

7.1.4 Higher income associated with better nutrition

One of the LICNAG study objectives is to examine how children's nutritional status varies with the level of income for the entire household as well as for individual members of the household, particularly mothers. We use detailed expenditure data as a proxy for income. This is a major contribution of the study as previous analyses have used a variety of relatively poor proxies for income (e.g., assets owned such as radios and bicycles) and found only weak links between asset ownership and nutritional outcomes. Preliminary LICNAG results based on detailed expenditure

data suggest that there is a positive and statistically significant correlation between expenditure levels and children's nutritional status.

Survey results show that the average monthly household purchases per capita[33] is lowest in the coarse grain production areas of Bandiagara and Koro, where the prevalence of stunting and wasting is high, and highest in the irrigated rice zones of Niono and Macina, where children's nutritional status is better. Average household expenditure in Niono is 2 to 5 times higher than the levels in the cotton and coarse grain zones. Analysis disaggregated by gender and household status shows that:

- Expenditures by men are more than double that of women;
- Expenditures by all men are much higher than those by fathers of children under 4 years;
- Expenditures by fathers and mothers are approximately the same within each zone.

Most striking is the magnitude of the difference across sub-regions between overall male expenditures and fathers' spending. This occurs because many fathers in the sample are not the head of the large extended family but live in "dependent" units within a larger family. In the cotton zones, where cotton income goes to the head of the extended family, male expenditure ranges from 4.5 to 6 times greater than fathers' expenditure. These differences are in stark contrast to the situation in the rice production zones (Niono and especially Macina) and the coarse grain zones (Bandiagara and Koro), where the expenditure for all men is only 1.4 to 2.5 times greater than that by fathers. In Ségou, where there are smaller production units that more closely resemble nuclear families, fathers of young children appear to have greater access to and control of productive assets (primarily land) and the returns to their use.

Average monthly expenditures of women in the rice-growing zone are 2 to 4 times that of women in other sub-regions, while those in the coarse grain zone in Bandiagara are 50 percent higher. Although in-depth analysis of expenditure, income and agricultural data will lead to a better understanding of these differences, income earned in horticultural production in the Macina, Niono and Bandiagara sub-regions would appear to be a primary factor differentiating higher expenditure levels for women in these zones.

When expenditures are matched with anthropometric data, the results show that higher levels of both household and mothers' income are significantly correlated with higher Z-scores or improved nutrition for children. Correspondingly, lower incomes are associated with lower Z-scores. Mothers' income shows a stronger association with children's nutritional status than household income. The prevalence of stunting is significantly lower for children of mothers in the highest income quartile (24 percent) relative to the levels for the three lower income quartiles (38-40 percent).

[33] This estimate represents the average value of purchased goods and services (not including home-produced or purchased cereals and livestock).

7.1.5 Fever and diarrhea are common; modern treatments used most often

Fever/malaria and diarrhea were the two most common illnesses reported by caregivers (respectively 48 and 21 percent of all episodes of illness).[34] Illness is most prevalent for children between the ages of 6 to 17 months. Mothers diagnosed 67 percent of all illnesses, health professionals 15 percent and family or friends 11 percent. Fathers and household heads (who are all males) paid for 64 percent of treatments, while mothers paid for 34 percent. In 19 percent of all episodes, no treatment was sought. For those cases involving treatment, modern medicine was purchased in approximately 75 percent of the cases, while traditional medicines were used in the others.

Average expenditure per treatment, regardless of type, falls between 900 and 1000 FCFA, suggesting that the choice of traditional versus modern treatment may not be driven by cost. Household heads, fathers and mothers spent on average 1370, 1028 and 755 FCFA per treatment. Fathers and household heads spend 18 to 31 percent more on modern than traditional treatments; mothers spend 78 percent more on traditional treatments than on modern treatments even though 75 percent of the individual treatments for which mothers pay are modern treatments. This suggests that mothers may be purchasing inexpensive modern medicines such as aspirin and chloroquine while fathers and PCU heads may be paying for more expensive modern treatments involving antibiotics or chloroquine injections for malaria. Mothers may also cover initial treatments, with fathers or PCU heads intervening only when illness persists. Future analysis of expenditure data along with information from the KAP survey should improve our understanding of the factors (i.e., availability, cost, perceived efficacy of one treatment over the other) driving the decisions to use modern versus traditional treatments.

The analysis of expenditure data for which a child less than 4 years was the intended beneficiary show that total parent expenditures are approximately 100 percent greater in the zones where there is the strongest evidence of agricultural productivity and income growth (Koutiala and Niono), suggesting that increased household income may result in increased expenditure on children. Fathers' average expenditures on health are higher than their non-health expenditures while mothers' non-health expenditures on children are over double the amount spent on health. These results suggest that fathers accept responsibility for major curative expenditures but not for day-to-day child maintenance. Consistent with the income data presented above, mothers in the Niono sub-region have the highest level of expenditures on health and non-health items for their children compared to mothers in the other sub regions; those in the Kolondieba sub-region spend the least amount on their children. These results may be a reflection of lower personal income for women in these zones and therefore a greater need for men need to cover curative costs.

7.1.6 Child morbidity is associated with low weight gain and high mortality

Analysis of data on children's daily weight gain confirms that growth is hindered by episodes of illness. Infants gain on average 1.5 grams per day following episodes of

[34] The particular categorizations of illnesses, and types of treatments reflect the perceptions of the caregivers rather than the opinion of medically trained personnel.

illness (0.13 grams per day following fever or malaria), a rate significantly lower than pediatrician recommended levels. Results show that nutritional status is significantly worse for children plagued by frequent episodes of illness. For example, children with three or more illness episodes in a six-month period have a 25% prevalence of wasting versus an 8 percent prevalence for those who were not ill.

The most sobering result to date is that during the first six months of the study, sixty-one out of approximately 2100 children in the sample died (70 percent of those who died were less than two years old; 61 percent were girls). Prior to their deaths, 43 percent of the children were stunted, 17 percent severely with HAZ < -3.00; 38 percent were wasted, 15 percent severely wasted with WHZ < -3.00. The higher prevalence of wasting (38 percent) indicates that children's weight had dropped substantially in the period preceding their death (prevalence of wasting in the overall population is only 11 percent).

These preliminary results indicate that the combination of inadequate food intake and reoccurring illness hinders weight gain and stunts children's growth. Repeated episodes of diarrhea and malaria reduce consumption, impair digestion and utilization, and alter the metabolism. A malnourished child has a weaker immune system, increased susceptibility to illness and greater difficulty in fighting it off. The high prevalence of micronutrient deficiencies (vitamin A, iron anemia, iodine) in Malian children exacerbates the protein-energy problem (Ministry of Health 2002). Over one quarter of Malian children die before the age of five, the fifth highest level in the world (UNICEF 2000). The combined effect of malnutrition and the widespread incidence of infections and parasitic disease among Malian children contributes to this high death rate.

7.2 Looking Forward: Implications of Preliminary Findings

7.2.1 Need to improve nutrition and health services for children under two years old

Findings on the onset of wasting and stunting in children between the age of 6 to 11 months and rapidly increasing through the 18th month (corroborating results from other studies conducted in Mali and throughout sub-Saharan Africa) point to the need to focus nutritional interventions on children below two years of age. The high prevalence of stunting and wasting reported in this DHS studies indicate that substantial difficulties remain in the effective and sustainable delivery of nutrition and health services for children (e.g., growth monitoring, nutrition education, malaria prevention, diarrhea treatment). These are all services included in the Ministry of Health's minimum package of health services. On-going interviews with community health center personnel in the survey zones will provide valuable information on the operational constraints in implementing these activities.

7.2.2 A more comprehensive multi-sector approach is needed

Interim findings also suggest that nutrition-related interventions included in the Ministry of Health's minimum package of activities may, by themselves, be insufficient to deal with the entire array of factors contributing to malnutrition. Most prominent of these factors is the widespread poverty and hunger throughout Mali that affect the ability of households and caregivers to adequately feed and care for their

children on a regular basis. Many parents find it hard to provide adequate supplementary foods when they do not have the purchasing power to buy nutritionally rich and diverse food products. The high incidence of childhood illnesses suggests that hygiene and access to potable water and mosquito nets, in addition to health services, must be systematically addressed.

The presence of these problems point to the need for a more comprehensive, coordinated, multi-sector approach in which other line ministries are committed to and involved in the efforts to systematically address the entire range of factors influencing the nutritional status of Malian children. Future analyses will attempt to develop a clearer understanding of the relative importance of the numerous interacting factors[35] affecting the health and nutrition status of children. While this information will contribute to more clearly identifying the priority policy and programmatic actions needed in each sector, preliminary results already draw attention to several emerging issues in each zone.

7.3 Different Approaches for Different Cropping Systems

One of the most important insights emerging from the analysis of rural children's health and nutritional status in three different types of cropping systems is that the priority actions needed to improve health and nutrition are likely to differ by cropping system.

7.3.1 Irrigated rice zones

Initial results show that per capita incomes for fathers and mothers of children less than four years old are significantly higher in the rice zone than in cotton and coarse grain zones covered by this study. These findings support research conducted in the *Office du Niger* irrigated rice system following the 1994 devaluation of the CFA franc that found that (1) aggregate household incomes of an important share of producers increased in real terms following the devaluation and (2) women's access to income-generating activities (e.g., rice transplanting and onion production) improved (Mariko et al. 2001). These positive results highlight a few important factors that reduce farmers' exposure to climatic and price risk, thereby allowing them to raise their productivity and incomes: competitive, profitable markets with remunerative prices; regular access to affordable, quality inputs (water, credit, equipment, fertilizer and knowledge); and an evolving mix of effective policies, well-structured institutions and appropriate technology.

While the preliminary findings indicate a lower prevalence of stunting and wasting in the rice zone, results also show that children in a small portion of poorer households in the irrigated zone are severely malnourished. Although this disparity raises many questions regarding access to and control of land and water that will be addressed in further analysis, it also highlights the positive effect that higher income appears to have on children's nutritional status. In a similar vein, future analysis needs to identify the factors determining the better nutritional results of children in households

[35] For example, agricultural and income-related factors relative to the multitude of other cultural, biological, social, behavioral, health, and hygienic determinants.

that are located in the rice zone but not within the irrigated perimeters (i.e., Macina) *vis-à-vis* those in the other non-irrigated cropping systems.

7.3.2 Cotton production systems

The majority of households in the Koutiala and Kolondieba sub-regions depend on the cotton sector for credit, fertilizer and equipment that are used for the production of both cotton and coarse grains. The guaranteed market for their seed cotton also provides a relatively secure source of income that is used by household heads to cover production costs, pay taxes, maintain PCU housing, and finance social ceremonies.Cotton is the cornerstone of the farming system in these zones.

Finding more effective ways to manage the cotton sector and perform critical functions at the lowest possible cost will go a long way to preserving the competitiveness of the industry and subsequently its positive contributions to food security and rural livelihoods in the region. Preliminary results from this study, however, suggest that (1) household heads control a large share of household income, and (2) that access to income is limited for mothers and fathers of children less than four years old. These results call attention to the need for greater crop and income diversification in the zone. This may be particularly important for the non- and partially-equipped farmers in the zone for whom cotton production is not always profitable (Kébé, 1998).

The 2001 regional development plan for the Koutiala sub-region reports that there is a high potential but very low current level of investment in agricultural lowlands that are used primarily by women for rice production (Deyoko 2000). Future analysis of agricultural input/output data will help determine whether the feasibility of intensifying production in lowlands may be constrained by competing labor demands in cotton fields. The large disparity in income between household heads and parents (both mothers and fathers) of children under 4 years of age also suggest the need for more effective rural taxation systems whereby the income going to household heads might be taxed and invested in rural health and education infrastructure.

7.3.3 Coarse grain zones

In the coarse grain-producing sub-regions of Bandiagara and Koro in the Mopti region, the higher prevalence of wasting through the 3rd and 4th year points toward a problem of availability and access to food. Lower per capita food production together with the relatively high percentage of residents in the Mopti region who mentioned hunger as a personal problem suggests that adults as well as children are not getting enough to eat. Widespread involvement in onion production by households in the Bandiagara sub-region may be contributing to Bandiagara's higher income levels (for households and mothers) and the relatively lower prevalence of stunting and wasting when compared to the Koro sub-region, yet malnutrition rates in Bandiagara are still very high.

Increasing access to food and income will depend on more systematic efforts to reduce price and climatic risk through investment in appropriate water management and transport infrastructure and expanded development of other commodity subsectors (e.g., livestock, onions). Even in the best case scenario, households in

these sub-regions will probably still depend heavily on off-farm income to meet their food needs, particularly remittances from young women working as domestic help in Mali's urban centers and from both men and women working as temporary laborers in the *Office du Niger* irrigated rice zone. As Mali moves forward in its efforts to expand the ON's irrigated perimeter, it may be useful from a food security standpoint to consider how the positive spillover effects from the irrigated rice sector can contribute to improved food security of households in zones such as Bandiagara and Koro.

7.3.4 Strengthening the income-nutrition link

Preliminary results from the irrigated rice zone suggest that agricultural productivity growth that generates higher incomes has a positive effect on children's nutrition status. This hypothesis is further supported by the fact that the more economically dynamic sub-regions in each cropping system have higher incomes and better nutritional outcomes than the sub-regions with less developed markets, poorer infrastructure, and less agricultural investment. We believe that further analysis will corroborate the preliminary findings that higher incomes improve access to food and increase effective demand for health care services that are critical to children's health. On-going KAP surveys and focus group discussions will help confirm results from other studies that have found that mothers find it difficult to effectively take and implement health care decisions when they do not have their own income (Maiga, 1995).

In the aggregate, broad-based income growth that increases the effective demand for health care services is also critical to the financial viability of community health centers. To the extent that the systematic delivery of nutrition and health services included in community health centers' minimum package of health activities cannot be financed by the existing cost-recovery based system, higher agricultural incomes channeled through a variety of mechanisms (e.g., monies from village associations or commune fiscal revenues) could serve as another potential source of funding. Additional income could help finance hiring additional health personnel (e.g., village-based agents) or expand the frequency and type of visits (e.g., nutrition demonstrations) that health center personnel make to villages in their health zone, thereby expanding in a sustainable way the nutritional outreach actions needed to more closely monitor the growth and health of children.

Developing mechanisms to finance nutrition and health interventions will, however, be difficult to sustain without an economic base capable of increasing incomes and economic gains for productive reinvestment. Initial results indicate that this economic base does not yet exist in the Mopti region. Being able to expand the tax base by tapping this growth will be difficult if incomes are not growing. In rural Mali, where livelihoods are intimately tied to the agricultural sector, incomes will not rise unless renewed efforts are made to increase investment that is required to drive productivity growth, and subsequently generate the broad-based income growth that is prerequisite for an expanded tax base. Information from on-going interviews with mayors and commune councils will provide information on the feasibility of mobilizing fiscal revenues and using them to financing nutrition-related interventions.

To researcher, policy maker and practitioner alike, the magnitude and complexity of malnutrition can be overwhelming. It is easy to get bogged down in assessing the importance of the variety of different family and individual circumstances affecting children's health and nutrition. The challenge lies in determining which strands of the complex web of factors affect the largest number of children and families, constitute the biggest priority, and are amenable to improvement through direct and indirect interventions. There is no single magic bullet. While none of the solutions will be sustainable without ongoing rural economic growth, growth is not enough. It needs to be tapped effectively and reinvested in the rural health and education facilities needed for making long-term impacts on child health and nutritional status. Thus, understanding the linkages between rural agricultural-based economic growth and children's health and nutritional status is critical for the future of Mali's children.

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