NUTRITION SURVEY METHODS: EXPERIENCE FROM ETHIOPIA AND FIELD METHODOLOGY TO ASSESS VITAMIN A STATUS

by

Girma Seyoum

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
Master of Science
in
Foods and Nutrition

Winnipeg, Manitoba

ISBN 0-315-47920-5

NUTRITION SURVEY METHODS:
EXPERIENCE FROM ETHIOPIA AND FIELD METHODOLOGY TO ASSESS VITAMIN A STATUS

BY

GIRMA SEYOUM

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

ABSTRACT

An anthropometric survey on a representative sample of 3,000 children under the age of 5 years was carried out, in order to determine underlying causes of PEM, in a rural area of Ethiopia. Anthropometric indicators were used as dependent variables and socio-economic and health factors as independent variables. Mean Weight-for-Height, Height-for-Age and Weight-for-Age percent of standard were 92.4, 92.7 and 80.5, respectively. The proportion of children identified as malnourished according to the Weight-for-Age parameter was (75.8%) greater than that indicated by either Height-for-Age (63.8%) or Weight-for-Height (40.5%). Independent variables such as age, additional food, breast-feeding and ownership of livestock were observed to have a highly significant effect on Height-for-Age and they were also significantly correlated ($p < 0.0001$) with Height-for-Age, respectively. Frequency of diarrhea had a significant effect on Weight-for-Height and was significantly correlated ($p < 0.0001$) with Weight-for-Height. However, the proportion of explainable variation in anthropometric status of children surveyed was generally low.

Anthropometric measurements can not be used to assess individual nutrient deficiencies. Hence, development of field methods to assess specific nutrient deficiencies is needed. Vitamin A deficiency is a prevalent nutritional problem in pre-school and school-age children. However, there is no suitable and applicable method of screening for early Vitamin A deficiency in young children. A study was conducted to

standardize a 10-Second Dark Adaptation Test intended to measure dark adaptation in young children. The relationship of test results from the 10-Second Test and the Rapid Dark Adaptation Test (RDAT) were examined together with applicability of RDAT in children 7-10 years old and fluctuations in the perception of the Purkinje-shift in adults. The 10-Second Test was observed to be applicable for both 7-10 and under 5 year-old children. Mean test times for 7-10 and under 5 years children were 13 and 16.3 seconds respectively compared to 16.2 seconds for adults. A significant relationship ($r= 0.91$, $p < 0.02$) was observed between test times of the 10-Second Test and RDAT. Similar increases and decreases in test times were found and the same subjects were above the mean and below the mean test times in both tests. Test times for the 10-Second Test and RDAT were significantly dependent ($p < 0.0001$) on test day. The RDAT was applicable in children 7-10 years old. A significant subject effect was observed for both 7-10 year old children and adults in the RDAT. The validity of the 10-Second Test,however, needs to be evaluated in vitamin A deficient subjects. Whether or not the fluctuation in the perception of the Purkinje shift was cyclical could not be determined from the data.

ACKNOWLEDGEMENT

The author wishes to thank Dr.Gustaaf Sevenhuysen, the thesis advisor, for his guidance and support. Appreciation is expressed to Dr.Vivian Bruce and Dr.Lois Brockman for gallantly serving in the thesis committee.

Thanks are extended to Dr.Ted Rosenberg & Liza Zacharias for their support and encouragement, to Dr.John Bond for his help in finding subjects for the study, and to Leesa Chan for her technical assistance in the typing of the thesis.

Appriciation and thanks go to Abdullah Hassen, a friend, for his emotional support and encouragement, especially during the bad times.

Gratitude is expressed to fellow graduate students, particularly, to Brenda Rios, Carolina Lodinez, Cheryl McClure and Valerie Siemens for their emotional support.

Research for this thesis was supported through funds from CIDA (Canadian International Development Agency). The author wishes to thank also the ENI (Ethiopian Nutrition Ins titute) for supplying important information on the Nutritional S tatus Assessment Survey presented in part-I of the thesis.

Finally, I wish to thank my wife, Sara Abebe, for her invaluable support and encouragement throughout. Thank you for being there for me when I needed you.

INTRODUCTION

Hundreds of millions of people throughout the world are malnourished. The population groups at greatest risk, particularly in deprived socio-economic areas, are infants and young children, and pregnant and lactating women (Stewart et al., 1977). In developing countries of the world malnutrition has its major effect on young children (Jelliffe, 1966). On a global scale, about 100,000 million children under 5 years of age were seriously affected by malnutrition (Morrow et al., 1977).

Protein-Energy Malnutrition (PEM), which frequently occurs in developing countries, is the most frequent and devastating nutritional problem in children in areas where the overall nutritional environment is poor; that is, where the availability of foods is limited, where the typical diet is inadequate in quantity and quality and where poor sanitation leads to an increased frequency of infectious diseases (Jelliffe, 1966). The adverse consequences of PEM both for individuals and society as a whole, include increased childhood morbidity and mortality, diminished resistance to infection and impairement of psychomotor development (Rosenfield et al., 1977).

The degree of Protein-Energy Malnutrition or protein-energy status of children can be determined using anthropometric measurements, Weight-for-Age, Height-for-Age and Weight-for-Height (Jelliffe, 1966; Stewart et al., 1977; and Robbins and Trowbridge, 1984), and hence, nutritional anthropometry is used as a screening method for PEM.

Vitamin A deficiency, a prevalent nutritional problem in many developing countries (McLaren, 1965 ; Sommer, A., 1982) occurs in conjunction with Protein-Energy Malnutrition (Jelliffe, 1966); that is, increased prevalence of PEM could usually be followed by increased prevalence of Vitamin A deficiency. This is because, insufficient Retinol Binding protein (Serum Vitamin A binding protein) is biosynthesized in the liver. Since retinol-binding protein is the means of transport of retinol from the liver to the blood, the blood retinol level will consequently fall, regardless of the retinol status (Muhilal and Glover, 1974), and hence tissue supply of retinol will decrease. Night-blindness or poor dark adaptation, is the primary sign of Vitamin A deficiency.

Hypovitaminosis A (Vitamin A deficiency) is a highly prevalent nutritional problem in pre-school and school age children. Identifying of children with one of the earliest form of the deficiency (poor dark adaptation) could help to implement of interventions and hence limit the progress of Vitamin a deficiency disease. However, there is no suitable and applicable method of screening for early hypovitaminosis A in children, especially very young children.

Part I of the thesis describes the relationship found of certain socio-economic and health variables to protein-energy status in a selected geographical area of Ethiopia. The protein-energy status (nutritional status) was assessed using anthropometric indicators such as Weight-for-Age, Height-for-Age, and Weight-for-Height. Part II of the thesis describes the development of a simple method of measuring dark adaptation function and its use to measure dark adaptation in children, including young children.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

PART I

RELATIONSHIP OF SOCIO-ECONOMIC, HEALTH FACTORS AND NUTRITIONAL STATUS OF CHILDREN IN AN ETHIOPIAN RURAL AREA

Chapter 1

INTRODUCTION

Malnutrition, particularly Protein-Energy Malnutrition (PEM), is a prevalent nutritional problem of children in the world, especially in developing countries. Based on the data provided by large-scale surveys carried out between 1963 and 1972, Bengoa (1974) estimated that in Latin America the proportion of children with either severe or moderate malnutrition was about 19%, in Africa about 26% , and in Asia about 31%. Economic, agricultural, medical, geographical, educational, social and cultural factors could play a role in the etiology of PEM, that is, national poverty, and family poverty, inadequate food production and concentration of cash crops, high prevalence of infections (diarrhea, measles, tuberculosis, whooping cough, malaria, intestinal parasites) and inadequate health facilities, unproductive soil, ignorance or illiteracy, poor food distribution and absence of family planning, and faulty feeding habits of young children and inequable intrafamilial food distribution (Jelliffe, 1968).

A number of nutritional status assessment surveys have been carried out in developing countries in order to investigate the underlying causes of PEM in children (De Walt, 1983; Bhuiya et al., 1986; Hernandez et al., 1974; Morley, 1968).

An anthropometric survey of children under five years of age was carried out in Sidama Awraja, a sub-province in the Southern part of

Ethiopia. Characteristics of the households in which the children lived were also recorded. The principal objective of the survey was to determine the nature, and severity of nutritional problems in children and also to obtain data on possible underlying factors of malnutrition in Sidama Awraja.

The first part of this thesis focuses on the data collected from rural areas of Sidama Awraja and it describes the associations of social, economic and health factors and the nutritional status of children less than five years old. The data was collected by the Ethiopian Nutrition Institute (ENI) and the results described in the first part of the thesis are based on secondary analysis of this data.

Chapter 2

REVIEW OF THE LITERATURE

2.1 NUTRITIONAL STATUS ASSESSMENT

Nutritional status assessment is a comprehensive process of identifying individuals and population groups at nutritional risk and of planning, implementing and evaluating a course of action (Simko et al., 1980). Nutritional status assessment could be carried out by using anthropometric techniques, clinical examination, dietary methodologies, and laboratory (biochemical) methods. Anthropometric techniques of nutritional status assessment involve the measurement of weight, height, head circumference, mid-upper arm circumference and triceps skinfold thickness (Robbins and Trowbridge, 1984). Anthropometric techniques are easy to use, inexpensive, and are not time consuming.They are frequently used to assess nutritional status under field conditions. Nutritional status assessment using clinical (physical) examination involves identifying indicator changes on external parts of the body, such as, hair, face, eyes, lips, tongue, gums and skin (Owen, 1984). This method requires a well trained professional in order to identify the various signs and symptoms of PEM and could be time consuming. Dietary methodologies of nutritional status assessment include twenty-four hour recall, food frequencies, food records and food history (Wright and Guthrie, 1984). Dietary methodologies are not expensive and could be used under field conditions.They are, however, time consuming. Laboratory techniques for assessing nutritional status measure the nutrient levels in the blood, the urinary excretion rate of the nutrient, urinary metabolites of the nutrients, abnormal metabolic products in blood, and changes in blood components or enzyme activities that can be related to intakes of the nutrient (Pi-Sunyer and Woo, 1984). Laboratory methods of nutritional status assessment are time consuming, expensive, may require the use of sophisticated instruments and chemicals and hence, may not be suitable for use under field conditions. Laboratory methods are usually used under hospital or laboratory settings.

2.1.1 Anthropometric Measurements

Anthropometric measurements describe body dimensions. They are frequently used in surveys for assessing nutritional status. The physical growth of children is regarded as a good indicator of nutritional status and thus careful measurement of total height or length and weight, provide information that can be interpreted nutritionally (Robbins and Trowbridge, 1984). Anthropometric indicators, such as Weight-for-Height, Height-for-Age, Weight-for-Age, head circumference, mid-upper arm circumference and triceps skinfold thickness have been suggested to group children who are adequately nourished from those who are malnourished and in need of preventive or therapeutic services.

Weight-for-Height is an anthropometric indicator that relates body mass to stature. Acute malnutrition is generally characterized by low weight-for-height, also known as 'wasting', which indicates failure of individuals to reach the potential weight for their height (Tripp, 1981; Robbins and Trowbridge, 1984). Height-for-Age is a measure of linear growth. Measurable growth retardation does not occur during a short-term nutritional deprivation, but frequent periods of acute food deprivation or infection over a prolonged period may cause a child to be short for his/her age. This condition is also called 'stunting' (Tripp, 1981; Robbins and Trowbridge, 1984). This effect is particularly noticeable during the first two years of life when growth is most rapid.

Weight-for-Age has been used as a general indicator of nutritional status. However, Weight-for-age does not distinguish between present and past or current malnutrition. A low Weight-for-Age value could mean either that the child has been malnourished in the past so that his height is retarded, but adequately nourished at present. Alternatively, the child was adequately nourished previously but is currently malnourished (Tripp, 1981). Weight-for-Age is sensitive to both current and long-term malnutrition. Weight-for-Age is particularly useful in regard to infants under one year of age when length measurements cannot be performed accurately (Robbins and Trowbridge, 1984).

In order to interpret anthropometric data involving Weight-for-height, height-for-age, and Weight-for-age, the weight and height values need to be expressed both in relation to each other and to reference population values. Thus, height-for-age is the relationship of observed height to expected height for a specific age and sex; weight-for-height is the relationship of observed weight to expected weight for a specific height and sex; and weight-for-age is the relationship of observed weight to expected weight for a specific age and sex (Trowbridge and Robbins, 1984) A weight-for-height proportion of less than the 5th percentile for a given population indicates that the

Wt/Ht of at least 95% of the standard population is better than the average Wt/Ht of the given population (Roy and Roy, 1969). While Weight-for-height is generally considered as an indicator of present nutritional status, height-for-age is considered an indicator of past nutritional adequacy (Jelliffe and Jelliffe, 1979; Waterlow et al., 1977). If a child's height-for-age is at the 5th percentile or below, that child may be exhibiting linear growth retardation or 'stunting' and needs to be evaluated further (Robbins and Trowbridge, 1984).

2.2 FACTORS THAT ARE KNOWN TO INFLUENCE NUTRITIONAL STATUS

Nutritional status of an individual is influenced by inadequate intake, inadequate absorption, and defective utilization of nutrients (Gilbride et al., 1984). Intake of nutrients could be influenced by availability of food and health status and inadequate absorption and defective utilization of nutrients could be the result of poor health status (Cowell et al., 1984). Food availability and food use could be affected by socio-economic factors such as agricultural production, economic standing (income) and food-ideology or education (DeWalt, 1983). The quality and quantity of land owned by a family influences agriculture (food production) and this, in turn, affects food availability to the family. Economic standing or income affects food availability to a family through increasing or decreasing purchasing capacity of the family. Food availability and knowledge about nutrition could affect food use or nutrition strategy and this, in turn, may affect food intake which ultimately affects nutritional status (DeWalt, 1983). The theoretical relationship of food availability, knowledge about nutrition and dietary food intake is represented in Figure 1.

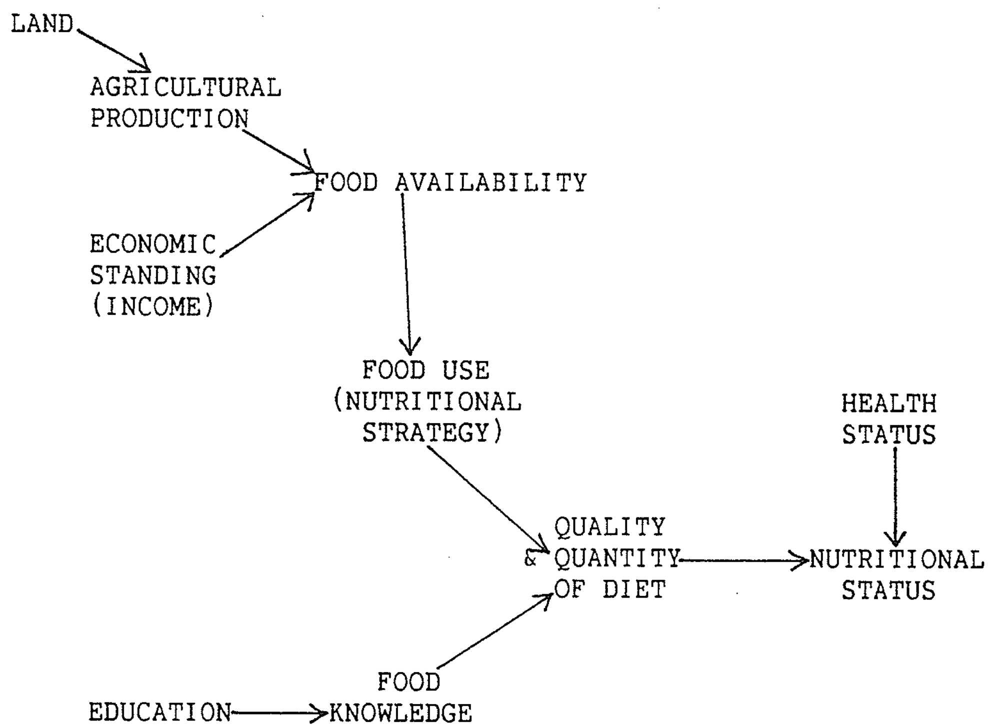

Figure 1: Relationship of food availability, food knowledge and diet (DeWalt, 1983).

2.2.1 Relationship of Economic Standing and Nutritional Status

Income is one of the factors that could affect nutritional status of individuals. Income directly influences the food purchasing capacity of a family and hence, the quantity and quality of food available for consumption (DeWalt, 1983). DeWalt (1983) studied the effect of economic status of households on purchased food and the quality and quantity of food consumed (food use) in a rural Mazehua Indian population in Mexico. The results indicated that there was a positive significant correlation ($r=0.51$, $p<0.001$) between economic standing and amount of expenditure on food. The amount of expenditure on food was positively correlated with meat consumption ($r=0.65$), amount of milk purchased ($r=0.67$; $p<0.001$) and amount of eggs purchased ($r=0.37$; $p<0.01$). The amount of milk purchased was significantly correlated with milk consumption as were egg purchases with egg consumption. Richer households were found to consume more animal protein. Since foods of animal sources are good sources of complete proteins, the use of these foods could affect the growth or nutritional status of children. Similar findings have been reported by others. The quantity of food consumed and the adequacy of energy intake were observed to increase with increasing income in Ceylonese villages (Gunasakera, 1958).

Children from low income families were more likely to have inadequate intakes of energy and protein compared to children from high income families. Hakim and Solimano (1978) reported a linear increase in the consumption of energy and protein in a rural community in Chile, with higher income families consuming higher amount of energy and protein compared to lower income families. For families earning less that two-minimum salaries (indicator of low income level) intakes of energy and protein were estimated to be 1600 kcals per day and 39 grams per day, respectively, compared to intakes of 2,650 kcals and 8 grams protein per day reported for families earning more than eight-minimum salaries, which indicated high income level. According to these observations, it appears that children of low income families are more vulnerable to Protein Energy Malnutrition (PEM).

Income of a family has been observed to influence nutritional status as determined by anthropometric measurements. DeWalt (1983) reported that there was a significant correlation between economic standing and height-for-age of children ($r=0.44$; $p<0.05$) and food expenditure was significantly correlated with height-for-age ($r=0.53$; $p<0.05$). Differences in weights and heights of children between low and high socio-economic classes have been documented. Hakim and Solimano (1978) measuring the weights and heights of pre-school Chilean children, between 3-1/2 to 6-1/2 years of age, found that children from higher socio-economic classes were taller and heavier than children from lower socio-economic classes, with an average weight difference of 2-3 kg for each 6 month age group. The average height differences were between 5 cm and 6 cm. These findings suggest that economic standing plays a direct role in determining variations in physical growth. Also, high income people were found to have a higher level of medical attention compared to low income people (de Kadt, 1974 ; Hakim and Solimano, 1978).

2.2.2 The Relationship of Agricultural Variables to Nutritional Status

The amount of food available for consumption is one of the major factors which could determine nutritional status of children (DeWalt, 1983). The lower the amount of food available for consumption, the greater the chance of inadequate dietary intake of food and poor nutritional status (Simko et al., 1984). Agricultural factors such as: quality and quantity of land, food crops produced, cash crop, livestock (milk animals) owned, household gardening (backyard gardening) and eggs produced could affect food available for consumption. For example, quantity and quality of land owned can limit food available for consumption by affecting agricultural strategies and production. De Walt (1983) studied the relationship of food crop production and consumption in a Mexican rural community. The results of this study revealed a significant positive correlation ($r=0.67$, $p<0.01$) between maize production and its consumption by the community. There was an increase in maize consumption when production increased.

Cash crop production could increase income. Families growing cash crops may have higher incomes than families growing food crops. Increased income from the sale of cash crops was reported to have no significant effect on nutritional status of children (Seyoum et al., 1986), since the income could be spent on items other than food. Relying on the production and sale of cash crops for increased income may lead to a great dependency on the market and this could have an adverse effect on food consumption (Dewey, 1981; Smith et al., 1981). Families producing food for their own consumption are more likely to have greater diversity in their diets and to consume more food than families producing primarily for sale (Dewey, 1979).

Possession of livestock (milk animals), household gardening, and poultry raising could affect food consumption. Milk and eggs being rich sources of protein, their availability and increased consumption by children could enhance physical growth of children as food intake influences nutritional status. Increase in production of milk and eggs could lead to an increase in their consumption, as reported by De Walt (1983) quoted earlier.

Household gardens provide fruits and vegetables which add variety, as well as vitamins and minerals to the staple foods regularly consumed. The sale of fruits and vegetables could also provide a source of income (Smith, 1986). The production and consumption of fruits and vegetables by children coupled with increased income could improve nutritional status of children.

2.2.3 Relationship of infant and child feeding practices and nutritional status

Breast feeding is considered the best way to feed infants since it provides the infant with all the necessary nutrients in the right amounts for the first 4-6 months of life. Breast milk has anti-infective properties and it is free of contamination (Vahlquist, 1981).

Breast-feeding is a common way of feeding infants in Ethiopia, especially in rural areas. The same is true for other Third World Countries, such as Nigeria, Zaire and India (WHO Colaborative Study on Breast-feeding, 1981). According to the WHO Colaborative Study on Breast-feeding (1981), 97 percent of mothers in one of the rural areas maintained breast-feeding up to the age of 18 months. Poor nutritionl status of infants due to failure of breast-feeding does not seem to be a problem. However, the frequency of breast-feeding by day and night could possibly contribute to the variations in nutritional status among breast-fed infants. The day-time breast-feeding frequency of mothers in one of the rural areas of the central region of Ethiopia was observed to be lower than that of a rural area in Nigeria, Zaire and Guatemala (WHO Colaborative Study on Breast-feeding, 1981).

The infant does not need food other than breast milk up to the age of 4-6 months to satisfy requirements on the condition that the mother has adequate supply of milk. However, if additional food is not given to an infant after the age of 4-6 months, the nutritional status of the infant may possibly deteriorate. It has been documented that growth rate of infants in under-developed countries in the tropical and sub-tropical regions of the world fall sharply at the time of weaning and continue at a low level in the post-weaning stages. WHO/FAO (1965) have reported that in underdeveloped countries, protein-energy deficiency may occur at all stages but in the weaning and immediate post-weaning stages its incidence is the highest. Roy and Roy (1969) studied the diet and growth of infants in Midnapore (rural West Bengal). Results of this study (Roy and Roy, 1969) indicated that the weight and height curves of Midnapore infants rose nearly parallel to the corresponding curve of the 50th percentile for U.S.A. infants up to the ages of 3 and 5 months, respectively. At about the age of 5 months, the weight curves of Midnapore infants were below the 3rd percentile of weight curves for U.S. infants, and after 15 months the slope of the height curves began to diverge from the corresponding 50th percentile curves and fell below the 3rd percentile at about 7 to 8 months (Roy and Roy, 1969). Similar trends in weight curves have been reported in other underdeveloped countries. Welbourn (1954) reported that the mean weights of Baganda (Uganda) infants were close to the corresponding 50th percentile at about one to three months of age and from nine months the mean weights were below the 10th percentile of the corresponding weights of American children. The quality and amount of nutrients, especially protein, supplied by the supplementary food could contribute to the falling-off in growth of infants in Third World countries. Roy and Roy (1969) concluded that the low protein content of the supplementary foods (Arrowroot and Sago - washed starch) were at least partially responsible for the reduced rate of the growth rate of Midnapore infants during supplementary feeding period. Children are also more likely to be infected with diarrheal diseases during the weaning period due to the poor sanitary conditions in which additional food is prepared.

2.2.4 Relationship of health status and nutritional status of children

Several health variables could play a role in predicting nutritional status of children. For instance, poor environmental sanitation could lead to drinking water pollution or contamination with disease causing microorganisms. This may cause diarrheal and infectious diseases. These diseases could affect food intake, increase nutrient requirements, disrupt the normal absorption and utilization of nutrients, and increase excretion of nutrients (Wellman, 1978). Morley et al. (1968) investigated the effects of measles, whooping cough and diarrhea on weight gains of two groups (Group A and Group B) of very young children in a Nigerian village. The number of children in both groups, A and B, was the same, 52 children in each group. Group A was characterized by higher incidences of measles, whooping cough and diarrhea at 0-12 months of age than that of group B at the corresponding ages. Results indicated that on 87 occasions children in group A and in only 22 occasions children in group B gained less than 1 pound per month in the first 3 months of life and less than 0.5 pounds per month in the second 3 months of life. Morley et al. (1968) concluded that the child who was underweight at 6-12 months of life was more likely to have suffered from measles, whooping cough, or particularly, diarrhea in the first year of life. Trowbridge and Stetler (1982) have also reported that seasonal peaks in malnutrition consistently followed 1-2 months after 1 major seasonal peak in diarrhea in 1-4 year old children in El Salvador, and concluded that diarrhea may play a role in the etiology of malnutrition.

2.2.5 Relationship of education and nutritional status of children

Knowledge about nutritional basics and child health care of the mother, could be an important factor in the nutritional status of children. Inappropriate cultural child feeding practices ,for example, weaning infants with washed starch , (Roy and Roy, 1969)) may affect the physical growth of children. In a community, cultural nutrition misconceptions could be exchanged by mothers and this could result in general ignorance of nutritional basics among mothers. Ignorance of nutritional basics may lead to poor food purchasing practices and poor use of available foods and this in turn, could result in inappropropriate weaning foods for offspring. Inappropriate weaning of a child may result in poor nutritional status of the child (Lazarus and Bhana, 1984).

Chavez and Ramirez (1963) also stated that culture is the basis for food habits, and education is the most powerful instrument of improving food habits. De Walt (1983) found a positive relationship (r=0.30) between the mother's education and total protein from animal sources in a rural Mexican community. This relationship was unaffected when data analysis was controlled for economic status. As women are the principal purchasers and preparers of food, educational effects could be reflected on food use. Bhuiya et al. (1986) reported that mother's education had a significant positive ($p<0.001$) effect on boys nutritional status and education of household head had a significant ($p<0.01$) effect on girls nutritional status as measured by weight-for-age, in a Bangladesh village. Burgess (1970) also reported significantly less protein-energy malnutrition in the group of Malawi children whose mothers had received some education. However, it was not indicated whether or not literate mothers were economically better off than illiterate mothers.

2.2.6 Relationship of household size and nutritional status of children

Family size constitutes an important factor to nutritional status of children. Large family size aggravates almost all other factors affecting nutritional status. Family size could affect the food share of members of a household provided that the quality and quantity of food available for consumption does not significantly vary. The more children in the family, the lower the per capita food intakes since the amount of disposable income and volume of food decreases with each additional family member (Schofield, 1979). Rao and Gopalan (1971) studied the energy and protein intakes of 500 Indian families from one socio-economic group whose family income was below Rs 250 per month. They found that families with three or less children were observed to have better energy and protein intakes. Families with three or less children consumed 300 kcals and 10 grams protein more daily than did families with three or more children. In a large-sized family, it is usually the new members who suffer most, and hence what is important is not only total family size but the total number of children, especially the number of under five year old children (Schofield, 1979). Thus, if under five years children, who are already vulnerable group, have to compete within the family for scarce food, care and attention, their vulnerability will increase as family size increases. Wojtyniak et al. (1986) reported a significant negative effect ($p<0.05$) of household size on nutritional status (weight-for-age) of boys in a Bangladesh village, indicating that weight-for-age decreased as household size increased. De Walt (1983) also reported significant negative correlations between the number of people in the household and maize consumption ($r=-0.39$; $p<0.001$), milk consumption ($r=-0.48$, $p<0.05$) and egg consumption ($r=-0.48$, $p<0.001$) in a Mexican rural community. These significant negative correlations suggest a significantly lower per person consumption of maize, milk and egg for larger families.

The survey described in the first part of the thesis was carried out in a rural community in Ethiopia covering 3,000 households. The objectives of the survey were to assess the overall nutritional status of children under 5 years, identify underlying causes of malnutrition and to collect baseline information for possible intervention.

Chapter 3

MATERIALS AND METHODS

3.1 DESIGN

3.1.1 Sample selection and data collection

A representative sample of households was selected from rural population of Sidama awraja, which is organized into Farmers Associations (FAs). A three stage stratified sampling technique was used to obtain a representative sample. For the first stage, 19 sub-strata were used , which were identified by administrative area and by ecological zones. Sidama Awraja had 7 woredas and 3 ecological zones. The latter was identified by altitude and production of staple crops. The highland zone was characterized by crops such as barley and enset(false-banana), the middle-land by coffee, teff, and pulses, and the lowland by sorghum, maize, and teff. The respective altitudes were: above 2000 m, between 500 and 2000 m, and less than 500 m. In Sidama Awraja, 5 of the woredas represent all the three ecological-zones (15 sub-strata), and the remaining 2 represent 2 ecological-zones each (4 sub strata). For the second stage, Farmers Associations were randomly selected from each of the 19 sub-strata proportionally based on the number of households in each stratum. One hundred Farmers' Associations were sampled from a total of 492. For the third stage, 30 households with children under 5 years of age were randomly selected from each Farmers' Association (FA). From each of the selected FA, 30 households were surveyed covering a total of 3000 households out of the estimated total of 209,000. The distribution of FAs and households from each stratum in all the woredas are given in Appendix A.

The respective values of the dependent variables: Weight/Height (Wt/Ht), Height/Age (Ht/Age), and Weight/Age (Wt/Age), which are indicators of anthropometric status (nutritional status), were calculated from collected data on weights, heights, and ages of children. Data on independent variables, that is, social, economic, agricultural, and health factors, were collected from each household to explain differences in nutritional status of children. One hundred twenty seven variables were included in the survey. The survey variables are presented in appendix B as questions 1-127. The survey variables which had incomplete records and wrong values were dropped and only 73 variables were included in the study. The study variables are presented in Appendix C as questions 1-41 and in Appendix D in coded format.

3.1.2 Theoretical model

A theoretical model was developed to represent independent variables (socio-economic and health factors) and their possible links with the dependent variable (nutritional status). The theoretical model is represented by Figures 2 to Figure 5. Selection and grouping of the factors were based on information from the literature. The factors considered in the model and their respective indicator variables included the following:

3.1.3 Food Production

The size of land owned, quantity of food crops produced, quantity of cash crops rpoduced, number of livestock owned, backyard gardening (quantity of fruits and vegetables produced), number of poultry raised, and number of milk animals owned were included in the theoretical model as indicator variable of food production.

3.1.4 Income (Total income)

Income from the sale of agricultural products, income from income generating activities and other income sources were considered as indicator variables of total income.

3.1.5 Child Feeding

Breast-feeding (duration and frequency of breast-feeding), additional food (type and starting age of additional food), weaning food (type, frequency and starting age of weaning food), food taboos and maternal feeding were considered as indicator variables of child-feeding practices in the theoretical model.

3.1.6 Education of Mother

Knowledge of the mother about basic principles of child nutrition, knowledge of the mother about basic child health care, reading and writing capability of the mother, and formal education already achieved by the mother were considered as indicator variables of maternal education.

3.1.7 Health Status

Environmental sanitation (use of pit-laterine and proper waste disposal system), source of drinking water, vaccination, diarrheal diseases, and infectious diseases were considered as indicators of health status in the theoretical model.

3.1.8 Family Size

The number of children in a family (number of <5 years and > 5 year old children), number of adults and total number of family members were considered as indicators of family size.

(A) Agricultural Variables (Food Production):

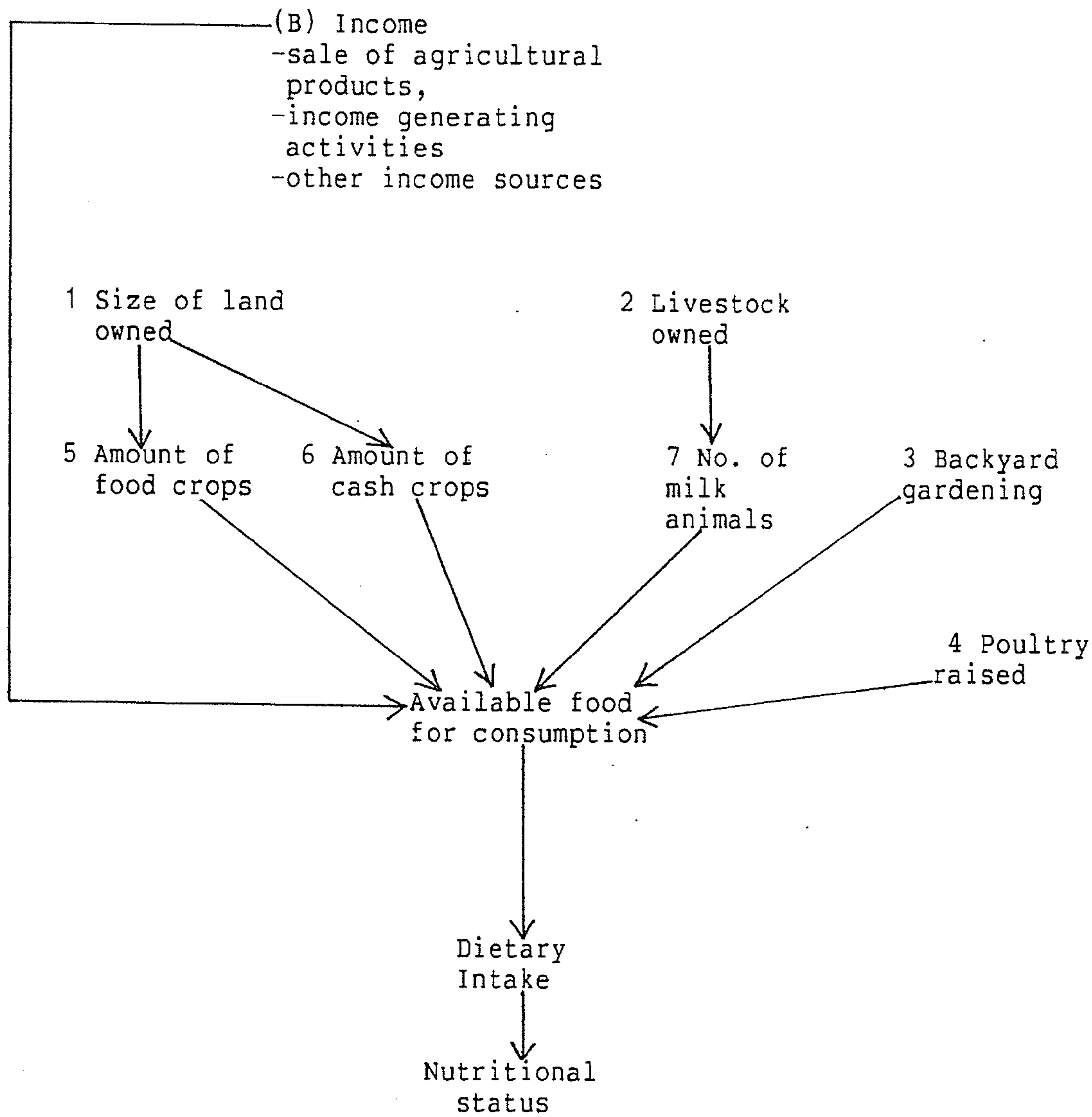

Figure 2: The theoretical model.

(C) Child Feeding

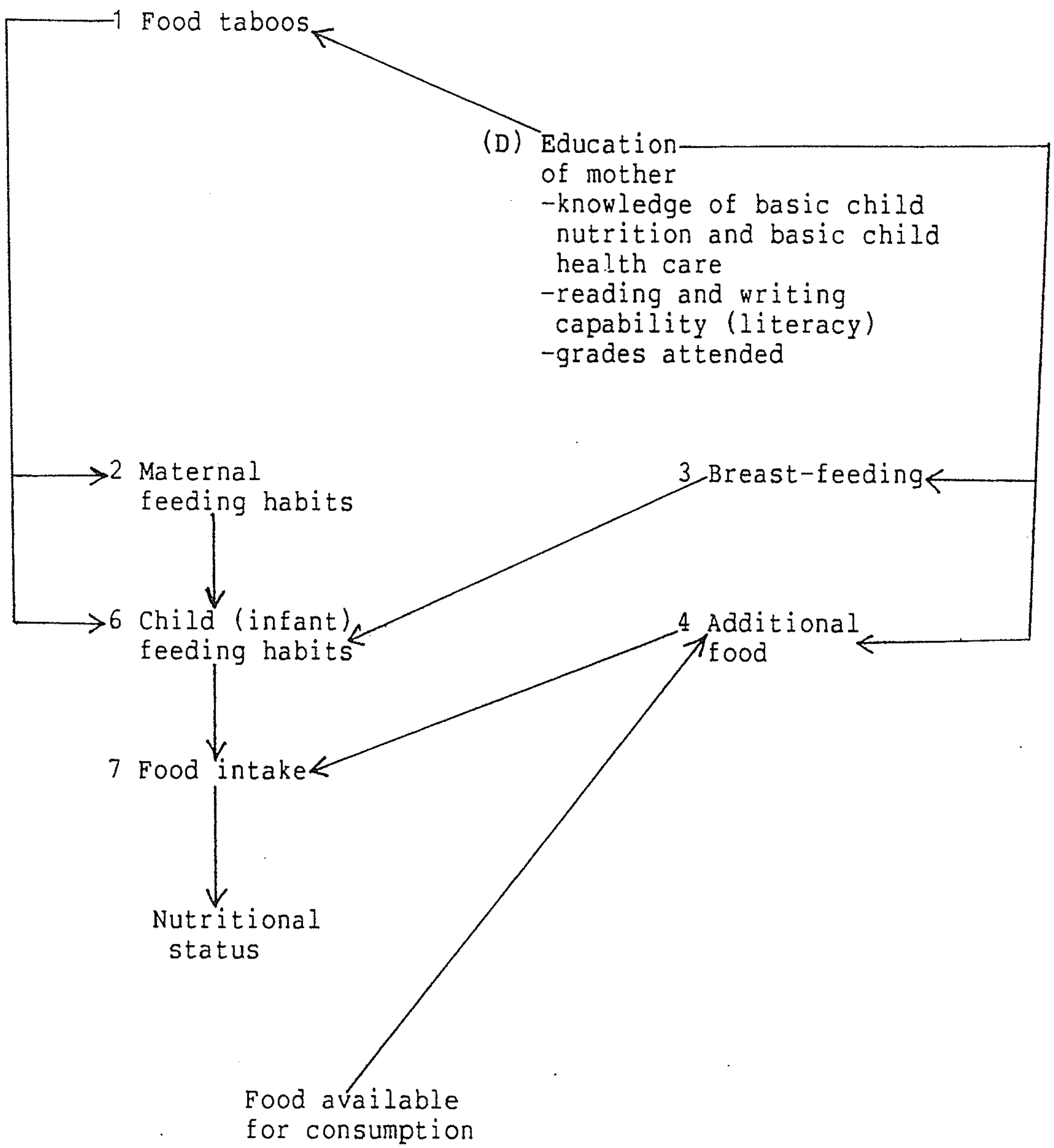

Figure 3: The theoretical model continued

(E) Health Variables (Health Status)

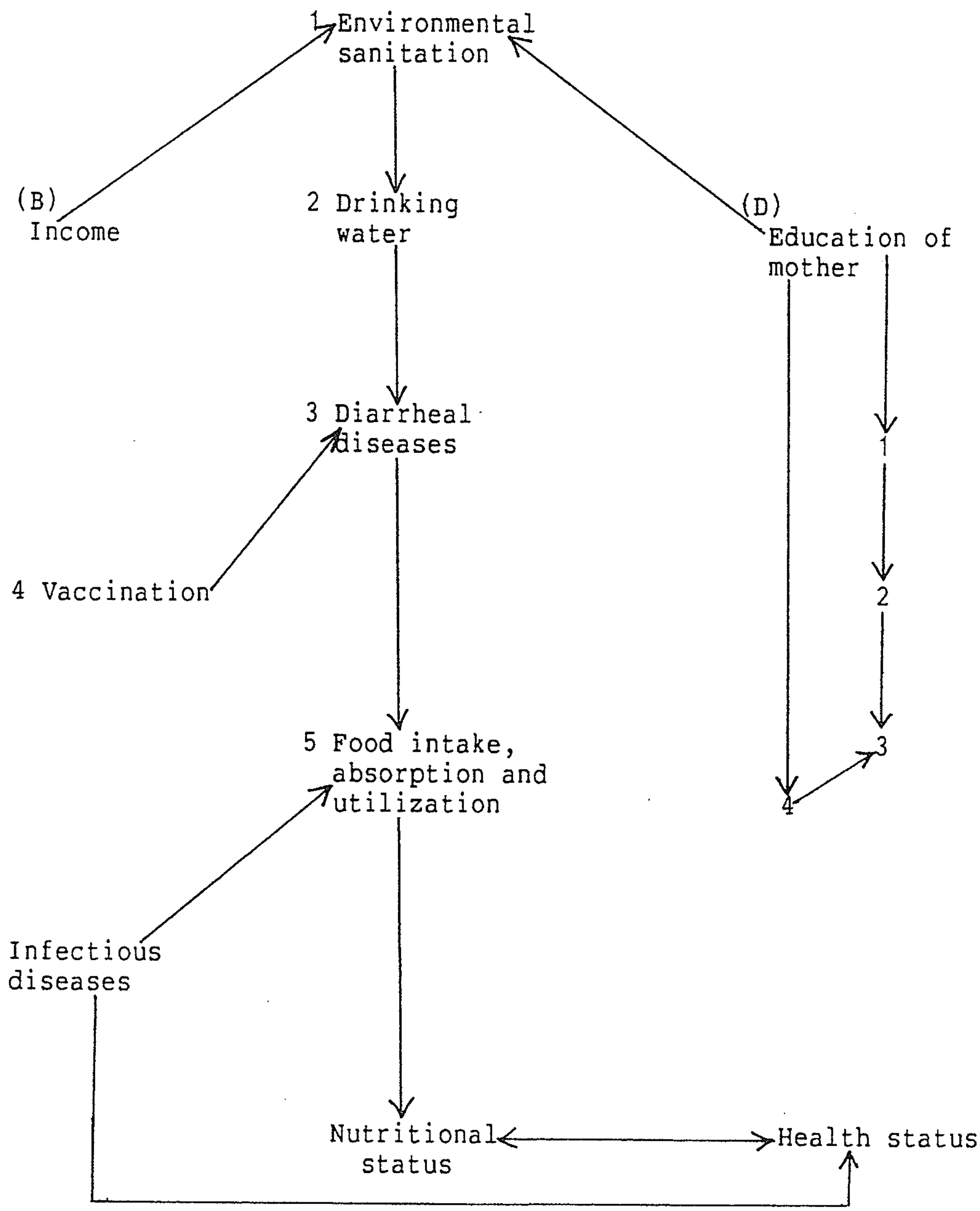

Figure 4: The theoretical model continued

(F) Family Size

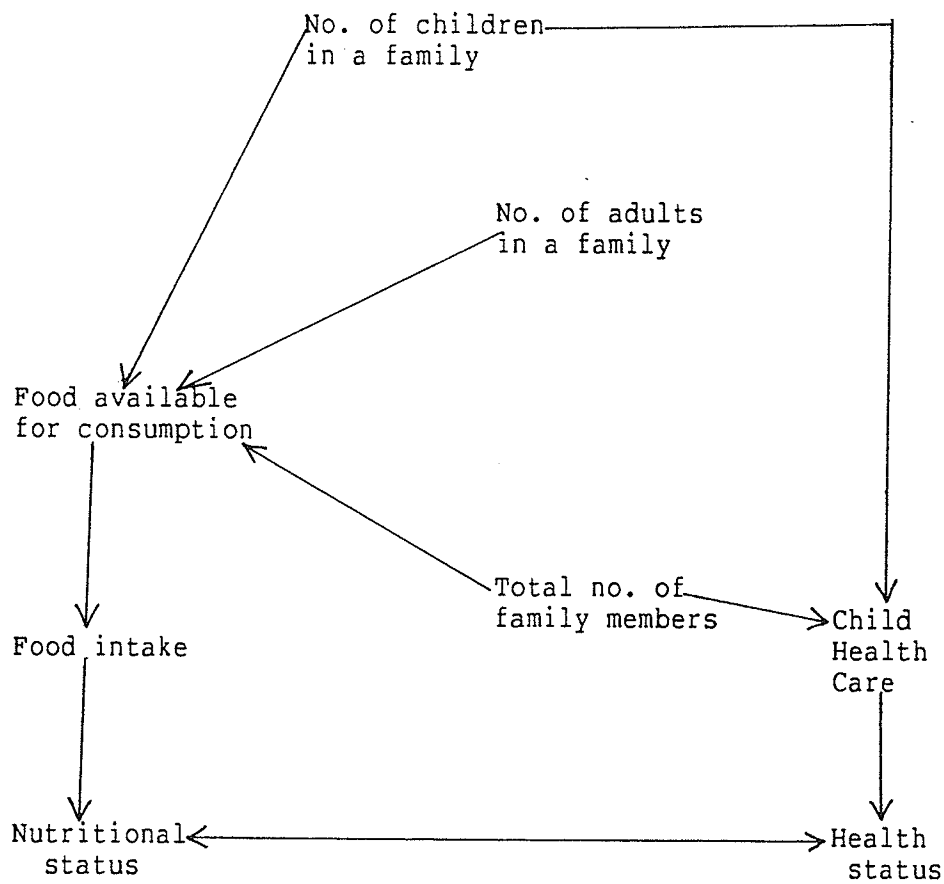

Figure 5: The theoretical model continued

3.2 METHODS

3.2.1 Data collection

Weights and heights of each child under 5 years of age were collected together with age and sex. Data on health and socio-economic status of respective households were collected using a household questionnaire. The questionnaire was completed by enumerators through personal interview in the home with the mother or head of household. The household questionnaire which included the survey variables is presented in Appendix B.

Weight of each child was measured using Salter scales (25 x 0.1 Kg) and was recorded to the nearest 100 g. The scales were checked against a 10 Kg weight twice daily. Standing height of children greater than 2 years of age was measured using a vertical wooden rod with a graduated tape attached to it. Children between the ages of 2 and 5 years stood bare-foot on a flat surface with heels, buttocks and back of head touching the vertical rod. With the head errect and eyes directed horizontally, a wooden bar, at right angle with the vertical rod, was lowered flattening the hair until a firm contact with the crown of the head was reached. Measurement was recorded to the nearest centimeter. In children less than two years of age , length was measured using a locally made wooden infantometer. The infant was placed horizontally on the measuring board and the head was held in such a way that it contacted the fixed portion of the measuring board. Both knees were held straight while moving a sliding foot-piece until it reached the soles of both feet. Length was then recorded to the nearest centimeter while the feet and legs were at right angle to each other. Age was recorded from documents kept by respective FAs, or reported by parents with the use of local calendars. Local events were used to construct a calendar, for example, how many months before or after national holydays such as New-year, Christmas, or Easter did the birth of the child take place.

3.2.2 Data Analysis

Three anthropometric indicators: Weight-for-Height (Wt/Ht), Height-for-Age (Ht/Age), and Weight-for-Age (Wt/Age) were derived from measured weight,height and estimated age. The indicators were expressed interms of the WHO standard for weight and height. Weight-for-Age was expressed as a percentage of the 50th percentile (median) by sex: %Wt/Age = Wo/Wst x 100, where Wo was the observed weight and Wst the median for the age and sex of the child. Height-for-Age was expressed as percentage of the median in a similar manner. Percentage Weight-for-Height was calculated according to the formula: % Wt/Ht = Wo/Wh x 100, where Wo was the observed weight and Wh the median for the weight of a child of the same height and sex.

The respective values of age, sex, health, and socio-economic factors (independent variables) were either recorded as continuous variables or descrete variables in coded format.

Four statistical procedures were used: 1. Univariate analysis of survey variables was performed to determine the frequency distribution of the data. 2. The stepwise regression analysis was carried out for dependent variables (Wt/Ht, Ht/Age, and Wt/Age) against independent variables (study variables) to determine significant regressors of the dependent variables. A significance level of 0.15 was set for each independent variable for entry and stay in the regression model. Independent variables which were significant at least at 0.05 level were generally considered significant. 3. The GLM procedure was performed for Wt/Ht, Ht/Age and Wt/Age using groups of independent variables identified for each major factor indicated in the theoretical model.

This procedure was run for each group of variables separately, that is: (1) Agriculture (Food Production) involving the variables: size of land cultivated for food crops, size of land cultivated for cash crop, produce fruits, produce vegetables, raise poultry, own livestock and use fertilizer; (2) Child feeding: involving the variables breast-feed, duration of breast-feeding, give additional food, additional food at what age, and frequency of weaning food; (3) Health status: involving the variables diarrheal rate (incidence of diarrhea), vaccination, mortality rate, prevalence of diarrhea, and distance of health institute; (4) Income: participation in income generating activities; and (5) Family size: number of people in a family. The purpose of carrying-out the GLM procedure for each group of variables separately was to evaluate the independent effect of each group on Wt/Ht, Ht/Age, and Wt/Age.

The GLM procedure was also used with variables identified by stepwise regression analysis as common regressors of Wt/Ht, Ht/Age and Wt/Age in order to evaluate the combined effect of the common regressor variables on anthropometric status.

4. Correlation analysis of significant regressors of Wt/Ht, Ht/Age, and Wt/Age was carried out to estimate the strength of relation- ships

between the independent variables (significant regressors) and anthropometric status (nutritional status) of children.

Chapter 4

RESULTS

4.1 DATA CLEANING

During data cleaning, some subjects were left out from the study because of the fact that the weight, or height, or age data for these subjects was either missing or wrong values of the variables were recorded. Some survey variables were also eliminated from the study because they were found to have incomplete records. The independent variables included in the study were: 1. Agricultural variables: size of land for food crop cultivation, size of land for cash crop cultivation, livestock ownership, use of fertilizer, poultry raising, main staple foods (15 variables), and growing fruits and vegetables; 2. Feeding habits: breast-feeding, duration of breast-feeding, child receives additional food, starting age for additional food, frequency of additional food, source of food for consumption (4 variables), pregnancy taboos (10 variables) and lactation taboos. 3. Health variables: diarrhea, diarrheal rate, number of live births, number of deaths before 1 year of age, fertility rate, mortality rate, total number of deaths among children, drinking water source (5 variables), and distance of health institute; 4. Household size: number of children under 5 years of age (4 variables) and total number of household members; 5. Income: participation in income generating activities; 6. Knowledge (education): whether mother reads and writes, knowledge about duration of breast-feeding and type of treatment for sick family members; 7. Ecozone: highland, midland, and lowland; 8. Crop zone: food crops, cash crops, and food and cash crops; 9. Age and sex of children. Significant variables are presented in Tables 11, 12, and 13.

4.2 DESCRIPTION OF ANTHROPOMETRIC AND ASSOCIATED VARIABLES

The frequency distribution of age,sex,socio-economic,and health variables are given in Tables 1 to 9. The number of children between the ages of 0-12 months was 1106 (39%) and that of children between the ages of 13-36 months was 1300 (45.9%) out of a total of 2833 children surveyed. Nutritional marasmus is commonly seen in the first 12 months of life and kwashiorkor occurs mainly in the age group of 12-36 months (Jelliffe, 1966). Thus, the proportion of children vulnerable to either nutritional marasmus or kwashiorkor was high, 84.9% (Table 1). The number of children who came from households having more than 3 children were 112 (4%), out of a total of 2831 and the mean household size was 5.6 (Table 2). The Weight-for-Height, Height-for-Age and Weight-for-Age distribution of the children in rural Sidama Awraja is given in Tables 8, 9, and 10. Children were classified as mild, moderate and severe cases of malnutrition according to Waterlow's (1976) classification for Wt/Ht and Ht/Age and based on Jelliffe's (1966) classification for Wt/Age. The Wt/Ht, Ht/Age, and Wt/Age percentages of the standard were calculated for 2,833 children. The proportion of children who were considered malnourished in the Wt/Age parameter (75.8%) was greater than that indicated by either Wt/Ht or Ht/Age (40.5% and 63.8% respectively). The mean Wt/Age, Wt/Ht and Ht/Age percentages of children studied were 80.5±14, 92.4±10 and 92.7±6, respectively.

TABLE 1

Age and sex distribution of children surveyed.

Variable	N	Mean and S.D.	Age in months				
			0-12	13-24	25-36	37-48	49-59
Age of Child	2833	20.2 ±14.4	1106 (39%)	760 (26.8%)	540 (19.1%)	305 (10.8%)	122 (4.3%)
			Male		Female		
Sex of Child	2832		1424 (50.3%)		1408 (49.7%)		

TABLE 2

Household size and number of under 5 year old children .

Variable	N	Mean and S.D.	Minimum	Maximum	Median
Household size	2832	5.6 ±1.9	2	14	5
No. of under 5 year old children	2831	1.5 ±0.6	1	4	1

TABLE 3

Number of children by presence or absence of Breast-feeding, Additional food and Ownership of Livestock (Milk animals).

Variable	N	No. of children by responses Present	Absent	Mean	S.D.
Breast-feeding	2831	2060 (72.8%)	771 (27.2%)	1.3	0.4
Child receives additional food	2833	1748 (61.7%)	1085 (38.3%)	1.6	0.9
Own milk animals (livestock)	2811	2214 (78.8%)	597 (21.2%)	1.2	0.4

TABLE 4

Frequency of additional food given to children in survey area.

Variable	N	Mean and S.D.	Minimum value	Maximum value	Median	% of children receiving additional times per day
Frequency of Additional food	2832	3.8 ±1.3	0	10	4	35.8

TABLE 5

Size of land cultivated for food crops in survey area.

Variable	N	Mean and S.D.	Minimum value	Maximum value	Median	% of households cultivating less than 0.22 hectares
Size of land cultivated for food crops (in hectares)	2831	0.22† ±0.23	0†	4.5†	0.15	63.8

† (size of land is relative to household size)

TABLE 6

Income and Education Levels of the Mother in rural Sidama Awraja (survey area).

Variable	N	No. of cases by responses		Mean	S.D.
		Yes	No		
Mother participates in income-generating activities	2816	408 (14.5%)	2408 (85.5%)	1.8	0.3
writes		(4.8%)	(95.2%)		

TABLE 7

Frequency prevalence of diarrhea in under 5 year old children two weeks prior to the survey.

Variable	N†	Mean and S.D.	Minimum value	Maximum value	Median	% of children with diarrhea
Frequency of diarrhea	2831	0.6 ±0.7	0	5	1	50.4

† N=number of children in the survey.

TABLE 8

Classification of children by Weight-for-Height (Wt/Ht) percentages of Harvard Standard (Waterlow, 1976) and mean Wt/Ht of children.

% Wt/Ht	No. and percentages of children	Degree of Malnutrition (wasting)
>90	1,685 (59.5%)	No wasting
90 - 80	880 (31.1%)	Mild (First degree)
80 - 70	233 (8.2%)	Moderate (Second degree)
Under 70	35 (1.2%)	Severe (Third degree)
Total	2,833	
Mean (% Wt/Ht) = 92.4 ± 10		

TABLE 9

Classification of children by Height-for-Age (Ht/Age) percentages of Harvard Standard (Waterlow, 1976) and mean Ht/Age of children.

% Ht/Age	No. and percentages of children	Degree of Malnutrition (stunting)
>95	1,025 (36.2%)	No stunting
95 - 90	926 (32.7%)	Mild (First degree)
90 - 85	545 (19.2%)	Moderate (Second degree)
Under 85	337 (11.9%)	Severe (Third degree)
Total	2,833	

Mean (% Ht/Age) = 92.7 ± 6

TABLE 10

Classification of children by Weight-for-Age (Wt/Age) percentages of Harvard Standard (Jelliffe, 1966) and mean Wt/Age of children.

% Wt/Age	No. and percentages of children	Degree of Malnutrition (PEM)
>90	685 (24.2%)	No acute or chronic malnutrition
90 - 80	733 (25.9%)	Mild - moderate
80 - 70	799 (28.2%)	Mild - moderate
70 - 60	436 (15.4%)	Mild -moderate
<60	180 (6.4%)	Severe
Total	2,833	
Mean (% Wt/Age) = 80.5 ± 14		

4.3 ASSOCIATION OF SOCIO-ECONOMIC AND HEALTH VARIABLES WITH ANTHROPOMETRIC INDICATORS

The Stepwise Regression Analysis was performed with 73 independent variables together with three indicators (Wt/Ht, Ht/Age and Wt/Age) of the dependent variable (nutritional status) which were considered as study variables. The variables that met the 0.15 significance level were included in the regression model and the variables that fitted best were selected based on the R-Square value. The 1.5 significance level was an arbitrary cut-off point chosen by the computer program commonly used in this type of analysis. The association of regressor variables on Wt/Ht, Ht/Age and Wt/Age are given in Tables 11, 12, and 13, respectively.

Whether or not a child receives additional food, whether or not a child is breast fed, diarrheal rate, ownership of livestock, size of land for food crops cultivation and age of the child were observed to be the best fits of the regression model and had significant impacts on all the three anthropometric indicators (Table 11, 12, and 13). The variables: whether or not a child is vaccinated, total number of live births and foods avoided during pregnancy (not eating eggs) were among the best fits of the regression models for Wt/Age and Wt/Ht, Ht/Age and Wt/Ht, and for Wt/Age and Ht/Age, respectively (Tables 11, 12, and 13). Frequency of additional food and poultry raising also were among the best fits of the models for Ht/Age and Wt/Ht, respectively (Tables 11 and 12). Other variables included in the initial regression analysis, including income, household size, number of under 5 year old children and education or knowledge of the mother which other investigators have reported as factors closely related to nutritional status, were not

TABLE 11

Effect of socio-economic and health (medical) factors on Weight-for-Height of children.

Factors	Weight-for-Height			
	DF	B value	Prob>F	R-Square
	2717			0.05
Livestock ownership		-1.2	0.0108	
Number of live births		-0.2	0.0010	
Child receives additional food		0.2	0.0117	
Starting age of additional food		3.1	0.0001	
Age of child		-0.01	0.0041	
Poultry raising		-1.1	0.0212	
Vaccination		-3.3	0.0135	
Presence of breast-feeding		-4.6	0.0012	
Size of land for food crop cultivation		2.1	0.0168	
Frequency of diarrhea		-2.6	0.0001	

TABLE 12

Effect of socio-economic and health (medical) factors on Height-for-Age of children.

Factors	Height-for-Age			
	DF	B value	Prob>F	R-Square
	2717			0.24
Livestock ownership		-1.8	0.0001	
Frequency of diarhea		-0.6	0.0002	
Number of live births		0.2	0.0001	
Frequency of additional food		0.2	0.0409	
Child receives additional food		-2.21	0.0001	
Age of child		-0.2	0.0001	
Presence of breast-feeding		-2.0	0.0118	
Staple cereal (Enset)		-0.6	0.0456	
Staple cereals (Enset and maize)		-1.0	0.0003	
Taboos in pregnancy (avoiding eggs)		15.5	0.0065	

TABLE 13

Effect of socio-economic and health (medical) factors on Weight-for-Age of children.

Factors	Weight-for-Age			
	DF	B value	Prob>F	R-Square
	2717			0.17
Livestock ownership		-4.4	0.0001	
Frequency of diarrhea		-2.5	0.0001	
Child receives additional food		7.1	0.0001	
Age of child		-0.3	0.0001	
Sex of child		1.1	0.0223	
Vaccination		-4.3	0.0100	
Presence of breast-feeding		-9.3	0.0001	
Size of land cultivated for food crop		3.5	0.0015	
Staple cereals (maize and teff)		9.9	0.0406	
Taboos in pregnancy (avoiding eggs)		37.0	0.0037	

important (in the current survey), to the observed variations in Wt/Ht, Ht/Age and Wt/Age.

The impact of whether or not a child receives additional food and prevalence of diarrhea in children were highly significant ($p<0.0001$) on all the three anthropometric indicators (Table 11, 12, and 13). The effects of livestock ownership and age of the child on Ht/Age and Wt/Age also were highly significant ($p<0.0001$). Breast-feeding and total number of live births also had highly significant effects ($p<0.0001$) on Wt/age and Ht/Age, respectively. The effects of age of the child, diarrheal prevalence, livestock ownership, breast-feeding and vaccination on the respective anthropometric indicators were negative.

The R-Square value which indicates the percentage of explainable variation in the Wt/Ht parameter was only 5% (Table 11). The proportion of explainable variation in the Ht/Age was about 24% (Table 12) and that in Wt/Age was only 17% (Table 13).

The independent effects of agricultural, child feeding habits and health variables on Wt/Ht, Ht/Age and Wt/Age are given in Tables 14, 15, and 16, respectively. The proportions of variability in Wt/Ht, Ht/Age and Wt/Age, due to agricultural variables, were about 1%, 3% and 3%, respectively (Table 14). The proportions of variations in Wt/Ht, Ht/Age and Wt/Age due to child feeding habit variables were about 2%, 9% and 7%, respectively (Table 15) and variations due to health variables were about 3%, 2% and 3%, respectively (Table 16). Child feeding practices were more important to the variations in Ht/Age and Wt/Age than agricultural or health variables. Health variables were more important to the variation in Wt/Ht, indicator of acute malnutrition.

TABLE 14

Effects of agricultural variables on anthropometric indicators.

Independent Variables	Anthropometric Indicators (Dependent Variables)					
	Weight-for-Height		Height-for-Age		Weight-for-Age	
	P	R-Square	P	R-Square	P	R-Square
Ownership of livestock	0.0317	0.0093	0.0001	0.0293	0.0001	0.0280
Size of land for food crop cultivation	0.0466		0.1485		0.0149	
Size of land for cash crop cultivation	0.3058		0.1016		0.1776	
Staple cereals	0.6406		0.0450		0.2058	
Vegetable growing	0.4478		0.3667		0.7575	
Fruits growing	0.2330		0.4610		0.1651	
Poultry raising	0.0489		0.3626		0.1142	
Fertilizer use	0.2175		0.1213		0.0783	

Whether or not the child receives additional food, prevalence of diarrhea, age of child, livestock ownership, size of land for food crops cultivation and breast-feeding were observed to be common regressors of Wt/Ht, Ht/Age and Wt/Age (Tables 11, 12 and 13). In the current survey, about 87%, 96% and 94% of the variations in Wt/Ht, Ht/Age and Wt/Age, respectively, were due to the above 6 common regressor variables (Table 17).

TABLE 15

Effects of child-feeding practices on anthropometric indicators.

Independent Variables	Anthropometric Indicators (Dependent Variables)					
	Weight-for-Height		Height-for-Age		Weight-for-Age	
	P	R-Square	P	R-Square	P	R-Square
Presence of breast-feeding	0.3770	0.0194	0.0168	0.0927	0.0314	0.0751
Duration of breast-feeding	0.2300		0.0001		0.0019	
Child receives additional food	0.0001		0.0001		0.0001	
Starting age for additional food	0.0088		0.4655		0.2590	
Frequency of additional food	0.8020		0.0001		0.0255	

Correlation coefficients of correlation analysis of common regressor variables and anthropometric indicators is given in Table 18. There was a significant negative correlation ($r=-0.13$, $p<0.0001$) between presence of diarrhea in children and Wt/Ht of children, which is an indicator of acute malutrition. Feeding habit factors such as receiving additional food and breast-feeding were observed to have significant relationships ($r=-0.09$, $p<0.0001$; and $r=-0.19$, $p<0.0001$, respectively) with Ht/Age, (indicator of chronic malnutrition), and their relationship with Wt/Ht, however, was not significant. Whether or not households owned livestock had a significant negative relationship ($r=-0.13$, $p<0.0001$) with Ht/Age

TABLE 16

Effects of health-related variables on anthropometric indicators.

Independent Variables	Anthropometric Indicators (Dependent Variables)					
	Weight-for-Height		Height-for-Age		Weight-for-Age	
	P	R-Square	P	R-Square	P	R-Square
Diarrheal rate	0.0014	0.0296	0.0001	0.0265	0.0001	0.0300
Vaccination cultivation	0.0203		0.6300		0.0877	
Health institute distance	0.3980		0.1003		0.0366	
Number of live births	0.0392		0.0043		0.1754	
Mortality rate	0.9005		0.8202		0.7666	
No. of children died	0.7292		0.2407		0.4568	
Drinking water source	0.1764		0.6570		0.4829	

of children. The relationship of size of land for food crop cultivation and Wt/Ht was positive and significant ($r=0.04$, $p<0.0194$). Age of child was observed to have highly significant negative relationship with all the three anthropometric indicators and the relationships were relatively stronger than those observed between each of the three anthropometric indicators and each of the other regressor variables (Table 18).

TABLE 17

Age, health and socio-economic factors, as common regressors of anthropometric indicators.

Independent Variables	Anthropometric Indicators (Dependent Variables)					
	Weight-for-Height		Height-for-Age		Weight-for-Age	
	P	R-Square	P	R-Square	P	R-Square
Ownership of livestock	0.0181	0.0408	0.0001	0.2254	0.0001	0.1637
Child receives additional food	0.0001		0.0001		0.0001	
Presence of diarrhea	0.0001		0.0004		0.0001	
Age of child	0.0003		0.0001		0.0001	
Size of land for food crop cultivation	0.0156		0.0517		0.0013	
Presence of breast-feeding	0.6142		0.8023		0.5013	

TABLE 18

Correlation coefficients showing relationship of common regressor variables and anthropometric indicators.

Independent Variables	N	Mean and S.D.	Anthropometric Indicators Wt/Ht	Ht/Age	Wt/Age
Presence of diarrhea	2718	0.6±0.6	-0.13 p<0.0001	-0.02 p<0.2320	-0.11 p<0.0001
Receive additional food		1.6±0.9	0.04 p<0.0185	-0.10 p<0.0001	-0.00 p<0.8920
Age of child		20.3±14	-0.07 p<0.0002	-0.42 p<0.0001	-0.29 p<0.0001
Breast-feeding		1.3±0.4	-0.00 p<0.9618	-0.19 p<0.0001	-0.09 p<0.0001
Livestock ownership		1.2±0.4	-0.05 p<0.0164	-0.13 p<0.0001	-0.13 p<0.0001
Size of land for food crop cultivation		0.22±0.2	0.04 p<0.0194	0.03 p<0.0848	0.06 p<0.0028

Chapter 5

DISCUSSION

More children were identified as malnourished by the Ht/Age parameter than those identified by the Wt/Ht, suggesting that the proportion of children suffering from chronic malnutrition, resulting in stunting were higher than that of children with acute malnutrition, resulting in wasting. This implied that chronic malnutrition was more prevalent than acute malnutrition in the children surveyed and more children could, possibly, have been exposed to long term unfavorable nutritional environment in the past. Deficit in Wt/Ht is an indicator of acute or current malnutrition and deficit in Ht/Age indicates chronic or past malnutrition (Tripp, 1981). Wasting of the body is a chracteristic of Wt/Ht deficits and a deficit in Ht/Age is characterized by stunting or height retardation (Waterlow, 1976).

The number of children identified as malnourished by the Wt/Age parameter was almost two times greater than that identified by Wt/Ht. This observation could be explained by the fact that Wt/Age does not distinguish between current or acute and past or chronic malnutrition and since it is sensitive to both forms of malnutrition. Thus, children that were malnourished in the past (retarded height) but adequately nourished currently and those adequately nourished in the past but with current malnutrition could have been identified as malnourished by the Wt/Age parameter.

Variations in nutritional status (protein-energy status) were observed in the children included in the current survey. Almost all the variations Wt/Ht, Ht/Age and Wt/Age were observed to be due to prevalence of diarrhea, whether or not child received additional food, age of the child, livestock ownership, size of land for food crop production, and whether or not a child was breast-fed. These factors were also identified as common significant regressors of Wt/Ht, Ht/Age and Wt/Age. Prevalence of diarrhea in children and whether or not a child received additional food, showed highly significant effects ($p<0.0001$) for the three anthropometric indicators. Diarrheal diseases are common health problems in developing countries and are more frequent in rural than urban areas (Trowbridge and Stetler, 1982). In the current survey, of 2830 children, 1426 (50.4%) had diarrhea during the two weeks prior to the survey. Due to the fact that diarrheal diseases could disrupt the intake and absorption of nutrients, it was expected that difference in presence of diarrhea would have an effect on nutritional status. Trowbridge and Stetler (1982) reported that a peak in diarrhea incidence was followed (1-2 months after) by a peak in clinically diagnosed malnutrition among preschool children in El Salvador. Low weight gains in children with higher incidence of diarrhea were documented in a Nigerian village (Morley et al., 1968). In this survey significant negative correlations ($r=-0.141$, $p<0.0001$, and $r=-0.140$, $p<0.0001$) were found between diarrheal rate and Wt/Ht and diarrheal rate and Wt/Age, respectively. These correlations appeared to imply that an increase in diarrheal rate could lead to a decrease in Wt/Ht (indicator of acute malnutrition) and Wt/Age.

Whether or not the child was receiving additional food also was observed to have highly significant effects ($p<0.0001$)on Wt/Age, Ht/Age and Wt/Ht. A significant negative correlation ($r=-0.1$; $p<0.0001$) was found between child receiving additional food and Ht/Age of the child, which is a measure of chronic malnutrition. It appears that chronic or long-term inadequate food intake was experienced by children in the weaning or supplementary feeding period. Roy and Roy (1969) have also reported that the height curves of West Bengal children began to diverge from the 50th percentile for American children at 5 months of age and fell below the 3rd percentile at about 7 to 8 months of age and this decrease in height increments occured in the first 2-4 months of supplementary feeding period. The additional food given to children in West Bengal was exclusively starch and did not contain protein (Roy and Roy, 1969). The frequency at which additional food is given to children could also contribute to the negative effect of supplementary feeding on Ht/Age of children. Frequency of additional food given to children was one of the best regressors of Ht/Age in the regression model and had a weak but significant positive correlation ($r=0.05$; $p<0.01$) with Ht/Age. In children between the ages of 6 and 13 months occasional supplementary feeding is common in Ethiopia, particularly in rural parts (WHO Collaborative Study, 1981). It is also likely that the poor sanitary conditions (in the area) in which additional food is prepared could expose the child to diarrheal and infectious diseases which, in turn, could affect nutritional status of the child.

Ownership of milk animals (livestock) was found to be one of the best regressors of Wt/Age ($p<0.0001$), Ht/Age ($p<0.0001$), and Wt/Ht ($p<0.0076$)

of children in Sidama Awraja, indicating that whether or not a household owns livestock influences the anthropometric status of children. Since milk is a good source of protein, intake of milk is expected to make a difference in growth of children. Significant correlation between milk production and consumption (r=0.58, p<0.001) was also reported by De Walt (1983). Intake or consumption of food could have a direct effect on nutritional status of children provided that absorption and utilization of nutrients are not disrupted. In the current survey, it was found that a majority of households (79%) owned livestock (milk animals) and 75% of them used the milk for entirely child feeding. However, despite these facts, significant negative correlations (Table 18) were found between livestock ownership and anthropometric indicators, implying that as livestock ownership increases, nutritional status of children decreases. This negative relationship between livestock ownership and nutritional status could have been due to the frequency and quantity of milk given to children as supplementary food. A significant negative correlation (r=-0.06, p<0.0031) was observed between livestock and frequency of additional food. Owning livestock alone, does not necessarily mean that children would consume milk (as supplementary food) more frequently and adequately. On the other hand it is possible that the nutritional status of children, from household owning livestock, could be poor if the milk supply is inadequate and especially, if other types of additional foods are not given in addition.

Age of the child was the most important regressor of Wt/Age and Ht/Age, and it had a highly significant (p<0.0001) contribution to the variation in Ht/Age and Wt/Age. Significant negative correlations, (r=-0.42; p<0.0001 and r=-0.29; P<0.0001) were observed between Age of child and Ht/Age and Age of child and Wt/Age, respectively. The results indicate that older children are more likely to be malnourished. A child breast-fed is less likely to be malnourished in the first 4-6 months of life provided that other health factors do not affect intake, absorption and utilization of breast milk. However, children face a greater risk of malnutrition in the supplementary feeding or weaning period. Children mildly malnourished during the earlier stages of supplementary feeding period are more likely to reflect long term or chronic forms of malnutrition as age increases. In addition, as a child's age increases, the child is more likely to be exposed to increased number of unfavourable health factors, such as, diarrheal and infectious diseases which could affect nutritional status of the child. In the current survey, the majority of children (61%) were between the ages of 2 and 5 years, and the association of age of child with nutritional status was as expected.

The size of land cultivated for food crops had a significant association on Wt/Age (p<0.0026), Wt/Ht (p<0.0162) and Ht/Age (p<0.0866). Significant positive correlations were observed between size of land cultivated for food crops and Wt/Age (r=0.06, p<0.0028), Wt/Ht (r=0.04, p<0.01) and Ht/Age (r=0.03, p<0.08) suggesting that as size of land for food crop cultivation increases, nutritional status of children also improves. The size of land cultivated for food crops plays a role in determining especially the quantity of food produced and made available for consumption. The quantity and quality of land owned could predict agricultural strategies and agricultural strategies could influence the size of land cultivated for food crops (De Walt, 1983). In the current survey, the range of land size for food crop production was 0-4.5 hectares and the average was 0.22 hectares. The percentage of households cultivating food crops on less than 0.22 hectares of land was 63.8. Because of variations among households in the size of land cultivated for food crops, variability in nutritional status of children from different households could be expected.

Factors that were indicators of child feeding habits, such as whether the child was breast fed, received additional food and frequency of additional food, affected Ht/Age of children more than either agricultural or health factors, as indicated by a relatively high R-Square value and highly significant relationship with Ht/Age (Table 15 and 18). Thus, it appears that the chronic malnutrition (height-retardation) observed in the children surveyed was mostly due to child feeding habits of households in the survey area. Health or medical factors, such as presence of diarrhea, were observed to be more important in the etiology of acute malnutrition than in chronic malnutrition (Table 16 and 18). Acute malnutrition is more likely to occur, when children suffer from with diarrheal diseases. During an acute attack of diarrhea, mothers often restrict the food intake of the child and thus aggravate any malnutrition that is already present, thereby precipitating kwashiorkor or other nutritional deficiency diseases Jelliffe and Jelliffe, 1979).

Chapter 6

CONCLUSION

In this study, almost all of the variations in Wt/Ht, Ht/Age, and Wt/Age of children appeared to be due to age of the child, prevalence of diarrhea, whether or not the child received additional food, whether or not the child was breast-fed, livestock ownership, and size of land for food crop production.

The factors that were closely linked to nutritional status of children by other investigators, such as income, household size, and education of the mother, did not appear to be important to the observed variations in anthropometric status of the children in the current survey. The proportions of explainable variation, in the three anthropometric indicators used, were low. The maximum proportion of explainable variation was only about 24% and was observed in Ht/Age parameters. The fact that the explainable variations in nutritional status was low and that other factors that were reported to be related to nutritional status were not significant could be explained in part by the methodology of the survey. The wording of the questions included in the survey questionnaire could influence the response of subjects and this consequently could affect the response of outcome variables to respective factors. The responses of the survey population to some questions, such as "how many hectares of land do you cultivate for food crops or cash crops?", may not be accurate estimates. Income of a household, which was reported to be related to nutritional status by other investigators, did not appear to have an effect on nutritional status in the current survey. However, the question asked about income did not allow for differences in income level among households. The question asked was "do you participate in income generating activities?". A "yes" or "no" answer to this question does not appear to tell differences in income levels among households. Similarly, education of the mother was not important to the variation in nutritional status of children in the survey. The question asked was "do you read and write?". A "yes" or "no" answer to this question may not show variations among households in nutritional care given to children. In the current survey, face-to-face or person-to-person questionnaire interviewing was used. This type of interviewing may lead to gathering false data, especially on sensitive issues, such as income, landholding, family size and education. Factors that may have direct effects on nutritional status such as actual food intakes (protein and energy intakes) of children were not estimated in the current survey, and hence, possible variability in nutritional status of the children surveyed was not determined. Data was collected by non-professional high school students who received a minimum training regarding collection of data. The sample size and number of study variables were considerably large. Thus, errors in recording questionnaire data and also measurement and recording errors in anthropometric data were possible.

The current survey has shown that age of the child, prevalence of diarrhea, whether or not a child received additional food, breastfeeding, ownership of livestock and size of land cultviated for food crops had significant effects on anthropometric status of children surveyed. The proportions of explainable variations in the anthropometric indicators was generally low, which was in part due to the methodology of the survey. Therefore, improving the survey methodology, including improving the wording of questions, minimizing measurement and recording errors, would increase the proportions of explainable varations in anthropometric status of children and would assist in a better identification of factors related to nutritional status.

PART II

MODIFICATION OF THORNTON'S (1977) DARK ADAPTATION TEST AND MEASUREMENT OF DARK ADAPTATION

Chapter 7

INTRODUCTION

Vitamin A deficiency is a major cause of preventable blindness in the world, especially in the third world countries. The problem is common in pre-school and school-age children. It has been estimated that up to 100,000 children become blind from vitamin A deficiency every year (McLaren, 1965). Nutrition intervention programs, which include activites to detect hypovitaminosis A (vitamin A deficiency) among children, could reduce the prevalence of xerophthalmia and blindness among populations at risk.

The earliest clinical sign of hypovitaminosis A is night blindness. Night blindness is a decrease in the retinal sensitivity to light under dim light condition (a decrease in dark adaptation ability). External symptoms of hypovitaminosis A, such as corneal, and conjunctival xerosis and Bitot's spots, can not be used to detect early hypovitaminosis A, since these symptoms are not reflected during the early stages of development of the deficiency. Serum retinol (the active form of Vitamin A in the blood) level is not a reliable measure of early hypovitaminosis A in individual subjects because of the wide range of border-line values where vitamin A dependent rod function may or may not be affected (Carney and Russell, 1980). Moreover, serum retinol levels could be affected by a lack of Retinol Binding Protein even when liver retinol stores are adequate (Pitt, 1981). A culturally based history of dark adaptation ability from parents may verify night blindness (Sommer et al., 1980). However, Vinton and Russell (1981) suggest that verification of night blindness using a culturally based history may not be an effective technique, as parents might not recognize night blindness in their own children.

A decrease in dark adaptation ability (night blindness) is an indicator of early hypovitaminosis A. This condition can be quantified by dark adaptation testing. A Rapid Dark Adaptation Test for adults, which is inexpensive and easy to use under field conditions was described by Thornton (1977). This Rapid Dark-Adaptation Test, however, may not be suitable for use with children, especially young children, since the test requires cognitive skills. A co-operative and attentive subject is also required.

The focus of the current study is on the modification of the Rapid Dark-Adaptation Test (Thornton, 1977) and the development of a suitable dark adaptation test for use with children, including young children who are less than 5 year old.

Chapter 8

REVIEW OF LITERATURE

8.1 BIOCHEMICAL AND PHYSIOLOGICAL BASIS OF DARK ADAPTATION TESTING

The retina of the eye contains a number of specialized cells known as rods and cones. The rods are specialized for scotopic vision (night time vision), and the cones for photopic (day light) vision. Both rods and cones contain photosensitive chemicals, which assist in scotopic and photopic vision, respectively. The photosensitive chemical in the rods is known as rhodopsin. Scotopic vision (dark adaptation) is dependent on the concentration of rhodopsin in the retina. Low rhodopsin concentration results in night blindness (poor dark adaptation). This is because the sensitivity of the rods to light can be altered tremendously by only slight changes in rhodopsin level (Guyton, 1976).

During photopic vision, if the retina remains exposed to intense light for a long time, most of the stored rhodopsin will be converted into retinene and eventually, into retinol (Figure 6). Therefore, the concentration of rhodopsin in the rods decreases greatly. This condition is also true in the cones in that the photosensitive chemical of the cones decreases during dark-adaptation. The reconversion of retinol into retinene and then to rhodopsin is a slow process and the sensitivity of the retina to light is reduced for a period of time.

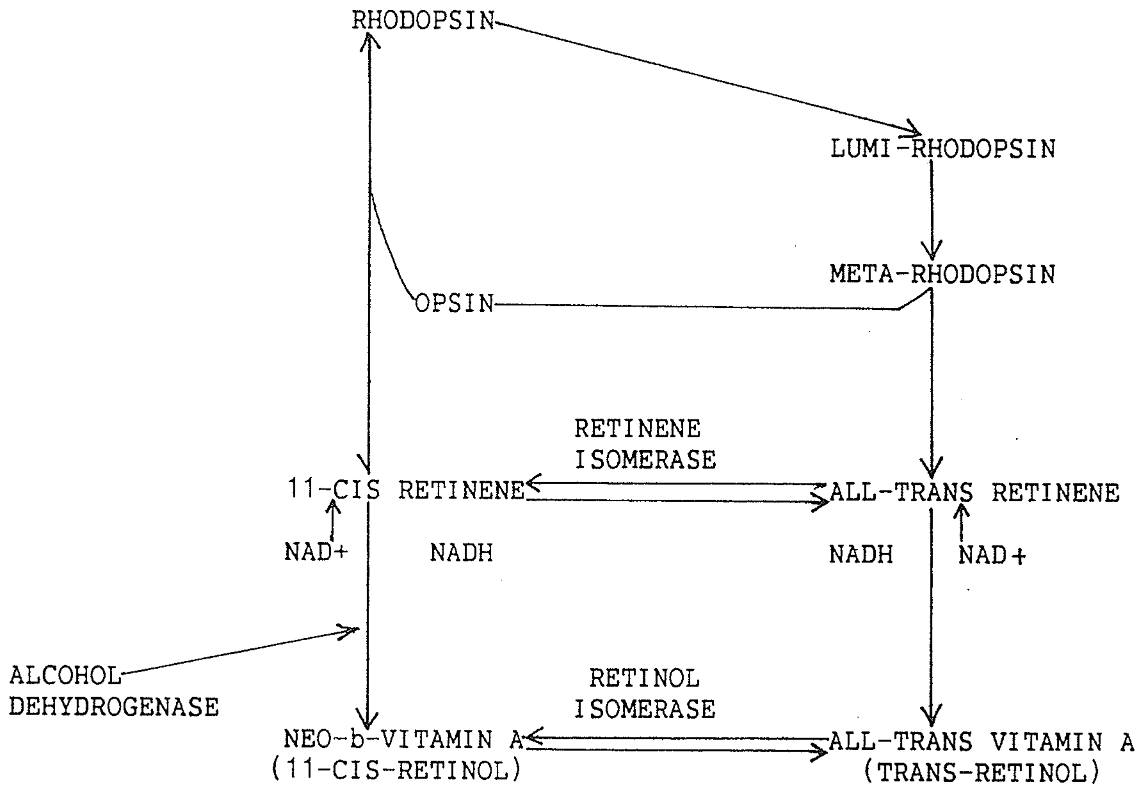

Figure 6: Photochemistry of the visual cycle.
(Adapted from Guyton, 1976).

During dark adaptation, a large amount of Vitamin A (retinol) is converted into rhodopsin and reconversion of retinene and opsin into rhodopsin also takes place. Because of these reconversions, the visual receptors (rods) become so sensitive that even a minute amount of light causes excitation. The regeneration of rhodopsin in the retina is dependent on Vitamin A (Figure 6). In night blindness, the retina contains less rhodopsin than a normal retina and the rate of regeneration of rhodopsin is much slower, and this condition could be reflected on dark adaptation ability of individuals (Guyton, 1976).

The relationship between the ability to see in the dark and Vitamin A status was demonstrated by Dowling and Wald (1958). Rats were maintained on Vitamin A deficient diet. The liver Vitamin A level began to fall steadily within the first week of the start of the Vitamin A deficient diet, within three weeks reached about 5% of the normal value. Then the blood Vitamin A level was depleted and reached 0% which was followed by a depletion in the rhodopsin concentration of the retina. These conditions, finally, resulted in an increase in the visual threshold (final dark adapted threshold), marking the onset of night blindness. Final dark adapted threshold is the minimum amount of light which illuminates a given surface in order to render it visible (Hecht and Mandelbaum, 1939). Final dark adaptation threshold was defined as the average of three ascending and three descending thresholds obtained after 35-40 minutes in the dark (Russell et al., 1973).

8.2 DARK ADAPTATION TESTING

Dark adaptation describes the process of increasing retinal sensitivity to light under dim light conditions. The subject of dark adaptation testing was first brought to the attention of the medical world through the work of Aubert in 1862. Since then the test attained a more scientific level of standardization of the light intensity in the testing device as well as its calibration. The subject of dark-adaptation became increasingly important, owing to the work of Wald (1934), who observed that the regeneration of rhodopsin in the eyes of animals bleached out by light is assisted by Vitamin A. The ability of human subjects to adapt to dim light has been shown to be dependent on their Vitamin A status (Vinton and Russell, 1981). Dark adaptation ability of individuals can be measured using the Classical Dark Adaptation Test (Vinton and Russell, 1981) or the Rapid Dark Adaptation Test described by Thornton (1977).

8.2.1 The Classical Dark Adaptation Test

The Classical Dark Adaptation Test is based on the measurement of the final dark adapted threshold, using an instrument known as dark adaptometer, such as the Goldman-Weekers Adaptometer. The classical dark adaptation curve is presented in Figure 7. Goldman-Weekers Adaptometer is a sophisticated instrument used to measure dark adaptation ability. This adaptometer has control over the standard conditions, such as the test light intensity. The final dark adapted threshold is the minimum amount of light capable of stimulating the retinal receptors after 35 minutes in an environment without light. The rod-cone breakpoint in the

Classical Dark Adaptation Test has also been shown to be useful for the diagnoses of sub-clinical Vitamin A deficiency. The rod-cone breakpoint is a transition point at which onset of rod-vision takes place during dark adaptation. Normally, the rod-cone breakpoint is observed in about 4 minutes after the start of dark adaptation. Both the final dark-adapted threshold and rod-cone breakpoint have been shown to be related to Vitamin A status (Vinton and Russell, 1981). In Vitamin A deficiency, the time taken to observe the rod-cone breakpoint becomes prolonged indicating delayed onset of rod-vision; the final dark adapted threshold of retinal sensitivity is elevated. This is because, Vitamin A is involved in the regeneration of rhodopsin. Rhodopsin is the photosensitive chemical of the rods and is responsible for rod vision (dark adaptation). In the presence of Vitamin A, 11-cis-retinene and all-trans retinene are formed. Rhodopsin is then regenerated from '11-cis retinene' and 'all-trans' retinene. Because of this interrelationship of Vitamin A and rhodopsin, dark adaptation ability decreases in Vitamin A deficiency.

The Classical Dark Adaptation Test is said to be reliable, reproducible and valid as a functional measure of early hypovitaminosis A (Vinton and Russell, 1981; Carney and Russell, 1980; Van Graan et al., 1975; Russell et al. 1973). However, this dark adaptation test is expensive, tedious, impractical and not easily available making it unsuitable for use, especially under field conditions (Vinton and Russell, 1981; Thornton, 1977). The testing device and procedure may not be suited for young children since an attentive and cooperative subject is required. The subject is kept in the dark for at least 35 minutes and has to con-

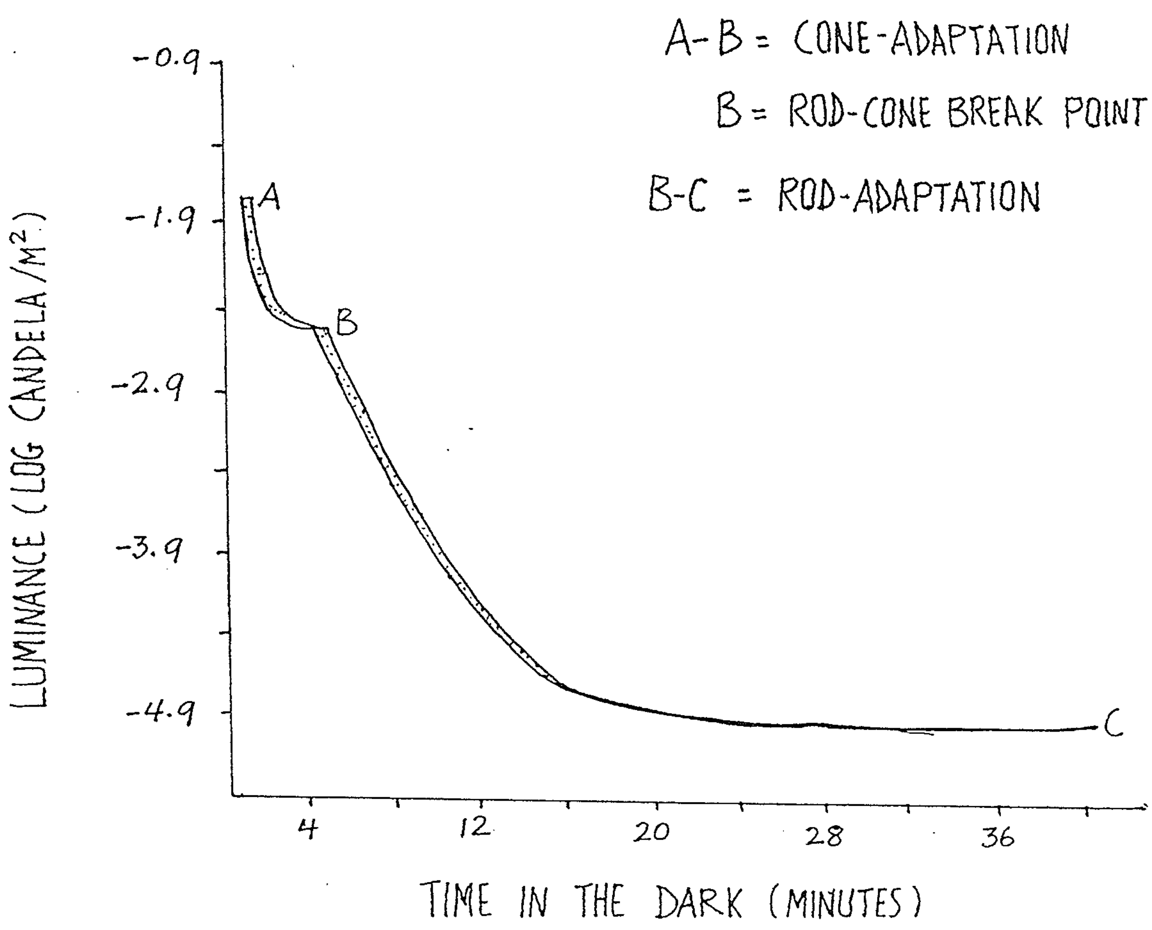

Figure 7: Classical dark adaptation curve.

(VINTON AND RUSSELL, 1981)

centrate on the test light as it is dimmed and increased continuously throughout the test.

8.2.2 Rapid Dark Adaptation Test (RDAT)

The Rapid Dark Adaptation Test described by Thornton (1977) is based on separating white, blue and red plastic discs from a randomly mixed pile under scotopic conditions, a dark condition where color vision (cone function) is non-functional. The time taken to complete the test with 100% accuracy determines the individual's dark adaptation ability and hence, Vitamin A status, since dark adaptation ability is influenced by Vitamin A status.

The physiological basis for the Rapid Dark Adaptation Test is the measurement of the time of occurrence of the purkinje-shift. The purkinje-shift is a phenomenon whereby the peak wave length sensitivity of the retina shifts from the red towards the blue end of the visual spectrum during the transition from day vision (photopic or cone mediated) to night vision (scotopic or rod-mediated). This shift causes the intensity of blue color to appear brighter than that of red under dim scoptic lighting condition where color vision is non-functional. Therefore, a blue object is seen as a brighter shade of gray than a red object.

The Rapid Dark Adaptation Test described by Thornton (1977) is simple, inexpensive and easy to used with adults under field conditions. This test has also been shown to correlate with other reliable and valid measures of dark adaptation and has been validated as a screening method for Vitamin A deficiency in adults (Vinton and Russell, 1981). The test, however, may not be practical for use with children, especially young children, since it requires cognitive skills and subjects have to be attentive and cooperative throughout the testing procedure. That is, subjects need to develop a criteria that enables them to distinguish different test objects (blue discs from red discs) and remember the criteria when performing the test. Subjects should also concentrate on test objects without a break and continue sorting test objects according to specific color groups.

8.3 USE OF DARK ADAPTATION TESTS FOR ADULTS

The relationship between Vitamin A status and dark adaptation ability of adults was demonstrated by Vinton and Russel (1981). The subjects included in this study were 32 normal controls, 11 patients hospitalized with a variety of diseases not resulting in Vitamin A deficiency and 19 Vitamin A deficient patients. Vitamin A deficiency was defined as the presence of an abnormal dark adaptation curve (i.e., a final dark adapted threshold more than 2 standard deviation greater than the age-specific mean) and a fasting serum Vitamin A level less than 40 ug/dl (Carney and Russell, 1980). All subjects were screened for evidence of eye disease. All had normal ophthalmoscopic exam (no evidence of eye disease). Subjects were tested by both the Classical and Rapid Dark Adaptation Test. In the Classical Dark Adaptation Test, a Goldman-Weekers Adaptometer was used. Each subject was initially light adapted to a diffuse white light of 3.13 millilamberts luminance for 10 minutes, after which threshold measurements were started immediately. The subject fixated on a 2 mm red light located above the center of the test light. The stimulus consisted of light flashed of 1 second duration separated by 1 second intervals of darkness. The luminance of the test light was increased or decreased depending on the response of the subject. (An "ascending threshold" was the intensity at which the subject first saw the test light as its luminance was increased; a "descending threshold" was the intensity at which the subject ceased to see the test light as its luminance was lowered). Each threshold intensity was mechanically plotted versus time, and the values were read off the graph at the end of the session. Testing was continued until the thresholds stabilized, i.e., until the final dark adapted threshold was achieved.

In the Rapid Dark Adaptation Test, each subject was light adapted for one minute immediately before the actual test began. Only distance of light source for light adaptation was recorded. Timing by stopwatch started when the test light was dimmed to 0.0068 candela/m^2. The subject then sorted 5 white, 6 blue and 7 red discs until 100% accuracy of sorting was achieved. Errors were reflected in the total amount of time taken to complete the test. Fasting serum Vitamin A (retinol) levels were measured.

The results of this study indicated that in the Classical Dark Adaptation Test, there was an elevated final dark adapted threshold and an increased rod-cone break time in Vitamin A deficient subjects compared to normal controls. The other interesting observation was that Vitamin A deficient subjects had consistently increased test times in all the three parameters: in rapid test time (in the Rapid Dark Adaptation Test), final dark adapted threshold and rod-cone break time compared to normal controls and Vitamin A sufficient patients. When the scores of Vitamin A deficient subjects were compared to either the scores of controls or Vitamin A sufficient patients, there was a significant difference ($p<0.0001$). For the Rapid Dark Adaptation Test, there was a significant ($p<0.0001$) difference when scores of Vitamin A deficient subjects were compared to either the scores of controls or Vitamin A sufficient patients. However, there was no significant difference between normal controls and Vitamin A sufficient patients for any of the dark adaptation parameters. Rapid test time was 4.41±0.83, 4.59±0.97, and 7.63±1.79 minutes for normal controls, Vitamin A sufficient patients and Vitamin A deficient subjects, respectively. Rod-cone break time was 8.0±0.7, 5.7±1.1, and 9.6±1.8 minutes for controls, vitamin A sufficient patients and Vitamin A deficient subjects, respectively. Final dark adapted threshold was -4.9±0.2, -4.9±0.2, and -4.4±0.4 log/candela/m^2 for controls, Vitamin A sufficient patients and Vitamin A deficient subjects, respectively (Table 19). There was a positive relationship between the Rapid Dark Adaptation Test time and the final dark adapted threshold ($r=0.71$), between Rapid Dark Adaptation Test time and rod-cone break time ($r=0.79$) and between final dark adapted threshold and rod-cone break time ($r=0.72$). In this study (Vinton and Russell, 1981), evaluation of the Rapid Dark Adaptation Test as a screening test for Vitamin A deficiency in adults has shown that the test was both sensitive (95%) and specific (91%) to limit the number of false negatives and false positives.

The Classical Dark Adaptation Test has been shown to correlate with serum Vitamin A levels in that a decrease in serum Vitamin A level was followed by a decrease in dark adaptation ability (Carney and Russell,

TABLE 19

Comparison of scores of dark adaptation test parameters and serum Vitamin A level.

Dark Adaptation Test Parameters	Subjects		
	Controls	Vitamin A sufficient patients	Vitamin A deficient patients
Rapid Dark Adaptation Test Time (in minutes)	4.41±0.83	4.59±0.97	7.63±1.79
Rod-cone Break Time (in minutes)	8.0±0.7	5.7±1.1	9.6±1.8
Final Dark Adapted Threshold ($log/Cd/m^2$)	-4.9±0.2	-4.9±0.2	-4.4±0.4
Serum Vitamin A (in ug/dl)	45±11	44±13	26±8

(Vinton and Russell, 1981)

1980). Subjects for this study were adult patients with liver disease, gastro-intestinal disease and chronic alcoholism. Each subject had a normal ophthalmoscopic exam. Blood samples were collected and serum Vitamin A levels were determined. Dark adaptation ability was measured using the Classical Dark Adaptation Test. Comparison of serum Vitamin A levels and the final dark adapted threshold revealed that a serum Vitamin A level of >40 ug/dl predicted normal dark adaptation 95% of the time. A serum Vitamin a level of >30 ug/dl predicted normal dark adaptation 68% of the time and a level of >20 ug/dl predicted normal dark adaptation 27% of the time (Carney and Russell, 1980).

8.4 RAPID DARK ADAPTATION TEST FOR USE WITH CHILDREN

Although Vitamin A deficiency disease is a problem in adults (Sabrell and Harris, 1967), particular victims of the deficiency are children. The most susceptible age group is from 9 months to 4 years (Sabrell and Harris, 1967). In a review of xeropathalmia and keratomalacia, (Sommer et al., 1981) it was reported that over 60,000 Indonesian children become xerophthalmic every year and by extrapolation of these findings about 500,000 new cases of xerophthalmia, half of which lead to blindness occur each year in India, Bangladesh, Phillipines and Indonesia combined. Sommer and Nuhilal (1982) studied the nutritional factors in the same group of Indonesian children. They observed that the serum Vitamin A levels were depressed in all subjects, and that the level was proportional to the severity of corneal changes. Solomons et al. (1982) have studied the applicability of Thornton's Rapid Dark Adaptation Test in children. The study population was 14 males and 13 females (aged 5-12 years) in Guatemala and 11 males and 7 females (aged 4-5 years) in Baltimore, USA. The study in Guatemala City was carried out at the Institute of Nutrition of Central America and Panama (INCAP). The study in Baltimore was carried out in a day-school setting. All children had normal ophthalmoscopic examination and a visual acuity of at least 20/100.

The test administered in both Guatemala and Baltimore were modifications of Thornton's (1977) RDAT. They were based on the retinal purkinje shift and involved the timed, sequential separation of white, blue and red discs from a black surface in dim illumination. In Guatemala, the procedure was identical to that originally described by Thornton

(1977). RDAT using poker chips, except that the light adaptation period was 2 minutes and that subjects were light adapted by starring at a lighted x-ray view box at a distance of 45 cm. In the Baltimore series, the procedure was identical to the one used in adults by Vinton and Russell (1981). Red and blue Munsell color discs were used. Illumination was set to emit at the work surface 0.0068 candela/m^2. Pretest retinal bleaching was accomplished by having the test subject stare at a lighted portable x-ray view box at a distance of 0.05 cm for one minute.

In Baltimore, a food frequency history based on customary intake of Vitamin A rich foods and Vitamin supplements was taken from parents. The Vitamin A and provitamin contents of the diets were estimated using tables of food composition. In Guatemala, a 4 ml sample of whole blood was taken. Vitamin A levels and plasma zinc concentration were determined. However, a blood test, involving determination of blood vitamin A level, was not done in Baltimore.

The 5-12 year old children in Guatemala were able to understand the instructions, manipulate the discs and cooperate throughout the testing procedure. Of the 18 , 4-5 year old children enrolled in Baltimore, 16 (89%) successfully completed the test. One subject in Baltimore (a boy aged 5) played with the chips but did not understand the mission of the test; another, (a girl aged 4), asked to be excused to return to the playroom.

For the Guatemalan group, the mean time taken to complete the test was 144 seconds, and for the Baltimore group, the mean time was 171 seconds. Rapid-dark adaptation test performance was significantly correlated to the Vitamin A dietary intake ($p<0.05$). Based on the results of this study, Solomons et al. (1982) concluded that the RDAT appears to be acceptable for use in children, even as young as 4 year old, and could complement biochemical determination of Vitamin A in clinical settings, field surveys and research. Correlation of Vitamin A intake and dark adaptation performance was observed for only the Baltimore group and not for Guatemalan group. Dark Adaptation performance was not shown to correlate with serum retinol in Guatemalan group.

There were, however, some criticisms regarding the observations of Solomons et al. (1982). The correlation observed between dark adaptation and Vitamin A intake in Baltimore subjects was not demonstrated in the Guatemalan group. Moreover, the Baltimore group (4-5 year olds) was constituted by American children, who could have been more sophisticated in the art of responding to tests. The children at risk of Vitamin A deficiency disease are usually found in severely socio-economically depressed areas. The level of skill of children in such areas in responding to tests is not likely to equal that of American children, especially if general malnutrition is also present.

Dhanamitta et al. (1983) studied the relationship between a Rapid Dark Adaptation Test and plasma Vitamin A levels. The dark adaptation test used in this study was simpler than the Rapid Dark Adaptation Test described by Thornton (1977) and could be completed in less than 15 second by normal individuals. In this study, mothers were asked initially about symptoms in the child which might indicate night blindness. One pair of siblings was selected from each of 30 households in which there was a complaint related to night blindness; this group was designated as the night blind group. The control group consisted of 10 pairs of siblings from families in which there were no complaints. Subjects were males and females from 3-12 years of age. There were no ocular signs of Vitamin A deficiency in all groups of subjects.

Subjects were tested for defective dark adaptation using a simple dark adaptation test. At night, the child was exposed to a bright flash light for one minute and was immediately put into a dark room and asked to locate an object (a bag of cookies) which was silently moved from one location to another one meter in front of the subject. The light level in the dark room was not specified. Time taken to locate the test object was recorded. The time taken to comolete the dark adaptation test by the night-blind group was 38 seconds compared to only 9 seconds in the non-nightblind group. Blood samples were collected from each subject. Half of the night blind group and half of the control group were given Vitamin A supplement (100,000 IU in the form of retinyl-palmitate) and the rest were given a placebo. Eighteen days after the Vitamin A supplement or placebo, blood samples were again collected and the dark adaptation test was repeated.

After 18 days all of (100%) the Vitamin A supplemented night blind subjects had dark adaptation times less than 15 seconds. Only 50% of the night blind subjects had dark adaptation times less than 15 seconds before Vitamin A supplementation. Thirty percent of the placebo group had dark adaptation times of less than 15 seconds. All of the children (100%) in the control group, who were given Vitamin A supplement had dark adaptation times less than 15 seconds. Mean plasma Vitamin A levels of the Vitamin A supplemented night blind group increased significantly ($p<0.05$) while the plasma Vitamin A levels of the placebo night blind group did not.

The dark adaptation test used by Dhanamitta et al. (1983) is different from that described by Thornton (1977). The test used by Dhanamitta et al. (1983) was not based on the purkinje shift and utilized simpler procedures so it is easy to use with children, especially with young children. However, the test seems to lack control over the testing light condition and subjects are likely to locate the test object just by chance. More stray light was possible in the darkened room due to field condition . Subjects could sense the location of the test object as it was moved from one location to another.

Chapter 9

MATERIALS AND METHODS

9.1 HYPOTHESES

1. There is a relationship between the responses of individuals to Thornton's (1977) Rapid Dark Adaptation Test and a 10-Second Test.
2. The variation in the perception of the purkinje shift occurs at a fixed interval.
3. There is a relationship in the performance (test times) of adults and 7-10 year old children in Thornton's (1977) Rapid Dark Adaptation Test.
4. The test times of adults and children in the 10-Second Test are related.

9.2 DESIGN

A total of 4 separate experiments were carried out. Experiment I was designed to see if there was a relationship between the response of subjects in the Rapid Dark Adaptation Test (Thornton, 1977) and in a 10-Second Test (modification of the Rapid Dark Adaptation Test). Experiment II was designed to quantitate fluctuations in the perception of the purkinje shift during dark adaptation; Experiment III was designed to test the application of the Rapid Dark Adaptation Test and the 10-Second Test in children between the ages of 7 and 10; and Experiment IV assessed the application of the 10-Second Test in pre-school children. The 10-Second Test differs from Thornton's (1977) Rapid Dark Adaptation Test in that the test light illuminance on the surface was 0.087 uW, whereas the illuminance in Thornton's RDAT was 0.02 uW. Moreover, for the 10-Second Test, the subject had to identify only a white plastic disc from a pile of 4 red, 4 blue and 1 white discs. For Thornton's RDAT, however, the subject had to sort 5 white, 6 blue, and 7 red discs. The 10-Second Test and Thornton's RDAT were similar in that the intensity of light for light adaptation and light adaptation period were the same.

Three different dark adaptation test procedures were used in the process of collecting data:

1. Rapid Dark Adaptation (Thornton, 1977)
2. Multiple Decision Test (Sevenhuysen, 1984)
3. A 10-Second Test

In experiment I, the Rapid Dark Adaptation Test and the 10-Second Test and in experiment II the Multiple Decision Test were used with five adult subjects. Five replicates of each of these tests were performed by each of the five subjects on five different days. Three consecutive trials were conducted for each replicate of each of the three dark adaptation tests. The three dark adaptation tests (Rapid Dark Adaptation Test, Multiple Decision Test and 10-Second Test) were performed by each subject one after the other each day until five replicates were completed. In experiment III both the Rapid Dark Adaptation Test and

10-Second Test were used. In experiment IV only the 10-Second Test was used. In both experiments, III and IV, unlike experiments I and II, the respective tests were performed on a single day and three consecutive trials were completed by each subject. In Experiment III, 5 children between the ages of 7 and 10 years performed both the Rapid Dark Adaptation Test and 10-Second Test. In Experiment IV, 5 children between 3-1/2 to 5 years of age performed the 10-Second Test only.

In all experiments subjects were light adapted before the actual testing. The purpose was to standardize the level of bleaching of the retinal photosensitive chemical, rhodopsin. If subjects were exposed to various levels of light intensities for different periods of time, then the responses of subjects to the dark adaptation tests would vary greatly and the variation could not be explained by their Vitamin A status. Those exposed to lower levels of light intensities for a relatively shorter time would have a faster dark adaptation time than those exposed to higher light intensities for a longer period of time. This is because, rhodopsin decomposes into retinene and opsin when the eye is exposed to bright light. In order to regain normal dark adaptation, rhodopsin must be regenerated from retinene and opsin and from Vitamin A (retinol). The regeneration of rhodopsin is a time-consuming process and hence results in an increased dark adaptation time. Prolonged exposure of the eye to strong light could result in the further conversion of rhodopsin to retinol. Retinol should first be converted to retinene before being converted to rhodopsin and hence the regeneration process would further be delayed and this would result in a prolonged dark adaptation. Therefore, a standard pre-dark adaptation light adaptation period is necessary.

The first trial, in all the 4 series of experiments, was used for further standardization of the level of concentration of the photosensitive chemicals of the retina and to familiarize subjects with the tests and the testing procedures involved.

9.3 PROCEDURES OR METHODS

9.3.1 Experiment I

Five adult subjects between the ages of 25 and 29 (graduate students from the Faculty of Human Ecology) participated in experiment I. Subjects were tested for dark adaptation using Thornton's rapid adaptation test and a 10-Second Test (modification of Thornton's RDAT).

Each subject was light adapted for one minute by fixating on a white paper (65x50 cm) placed on the work surface. The only light source for light adaptation were two 60 watt light bulbs placed perpendicular to the work surface at a height of 74 cm from the work surface. These light bulbs were placed adjacent to each other and about 20 cm apart. In the Rapid Dark Adaptation Test, the lighting was dimmed to 0.02 uWatt which is equivalent to 0.002 foot lambert, and the subject began sorting white, blue and red discs (poker chips) from a pile of 5 white, 6 blue and 7 red discs. For the blue discs, the hue, chroma and value were 7.5 purple blue, 12 and 4, respectively. For the red discs, the hue, chroma and value were 5R, 14 and 5, respectively. Each subject signaled as soon as the white discs were separated. The test was stopped when the blue and red discs were separated. In the meantime, any discs mistakenly separated by the subject were returned to the original pile by the investigator and the subject continued to sort until 100% of the disks were identified. Errors were reflected in the total amount of time taken to complete the test.

In the 10-second, the light was dimmed 0.087 u Watt and the subject had to pick out a white disc from a random pile of 1 white, 4 blue and 4 red discs. Four red and 4 blue discs were included so that the white disc was not identified by chance alone. In the 10-Second Test, the light sources for light adaptation and the light adaptation period were the same as in Thornton's Test. However, the 10-Second Test was different from Thornton's Test in test light illuminance and test object. In the 10-Second Test, the test light was dimmed to 0.087 u Watts and the subject had to pick out a white disc from a pile of 1 white, 4 blue and 4 red discs. The white, blue and red discs used in the 10-Second Test were the same as those used in Thornton's RDAT. The purpose of using a white disc as the test object in the 10-Second Test was to simplify Thornton's Test procedure and shorten the dark adaptation test time. In Thornton's Test, the subject had to sort 5 white, 6 blue and 7 red discs and sort them according to their respective colors. The time taken to sort white discs was much shorter (25 to 35 seconds) than the time for sorting the blue discs from the red, 150 to 180 seconds (Thornton, 1977).

9.3.2 Experiment II

Five graduate students in the Faculty of Human Ecology participated in experiment II. All of the five subjects were females between the ages of 25 and 28. All subjects reported no history of eye disease or problems related to vision. Subjects were also screened for evidence of colour-blindness.

A non-reflective black turntable of 15 cm diameter, with 3 red and 1 blue discs (poker chips) mounted at equidistant positions, was used to test the fluctuation in the perception of the purkinje-shift during dark adaptation. A circular gray spot was placed at the center of the turntable and the sides of the turntable had different luminous symbols, visible only to the investigator, to indicate the position of the odd disc (i.e., the blue disc). Experiment II was carried out 10 minutes after completing experiment I (Thornton's and 10-Second Tests). Each subject was light adapted for one minute by fixating on a white, 65x50 cm paper placed on the work surface. The set up of the light source for light-adaptation for experiment II was the same as that for experiment I.

Each subject was light adapted, just before the actual testing began, for one minute by fixating on a white hard paper (65 x 50 cm) placed on the work surface. Immediately after one minute of light adaptation, the lighting was dimmed to 0.02 u Watt (scotopic range). Recording of time using a stopwatch started when the subject was able to identify the gray spot on the center of the turntable. At this time the turntable was spun every 4.88 seconds, and the subject was forced to make a decision, i.e., to point out the blue disc. The 4.88 second mark was determined by a tape recorded sound which was heard every 4.88 seconds. All correct and incorrect decisions were recorded until 7 correct consecutive decisions were achieved. The time of the last correct decision was used to determine the test time. If the subject couldn't identify the disc or was not sure of the location of the test disc, he/she was allowed to guess.

9.3.3 Experiment III

Five children between the ages of 7 and 10 were involved in experiment III. These 5 children were sons (3) and daughters (2) of professors in the Faculty of Human Ecology. Both Thornton's RDAT and 10-Second Test were used, and the testing procedures and the standard conditions were the same as those described in experiment I.

9.3.4 Experiment IV

The participants in this experiment were five children under the age of 5 from the Child Development Center of the Faculty of Human Ecology. None of the five children had any history of eye disease. A slightly modified 10-Second Test was used. The testing procedure involved picking out a candy wrapped in a white piece of paper under a standardized dim-light condition.

Four circular white candies, three of them wrapped in brown pieces of paper and the remaining one (the test object) was wrapped in a white piece of paper, were mounted on a plate covered with a black non-reflective cloth. For the brown wrapping paper, the hue, chroma and value were 2.5 YR, 6, and 4, respectively. Each subject was light adapted for one minute. Then the lighting was dimmed to 0.087 u Watt and the subject started to pick out the candy wrapped in a white piece of paper. Three trials were made by each subject and the times taken to identify the candy were recorded. In Thornton's (1977) RDAT, red and blue discs reflecting the same light energy were used, since the RDAT was based on differences in perception of the peak wave lengths of colours (red and blue discs). In the 10-Second Test, however, since it was not based on perception of wave lengths , colours of test objects were not regarded as important. Instead, in the 10-Second Test, differences in light energy reflection of test objects were considered more important since the 10-Second Test was based on cone adaptation. The cones of the retina are more stimulated by a colour with higher reflected energy than a colour with lower reflected energy. For instance, white reflects more energy than brown and hence, a white object is expected to be identified faster than a brown object under dim illumination in the photopic range.

Chapter 10

RESULTS AND DISCUSSION

10.1 EXPERIMENT I: COMPARISON OF THE RAPID DARK ADAPTATION TEST (THORNTON, 1977) AND A 10-SECOND TEST

10.1.1 The Rapid Dark Adaptation Test (Thornton, 1977 RDAT)

The Rapid Dark Adaptation Test results are summarized in Table 20. Comparison of results of Thornton (1977) and the 10-Second dark adaptation tests are summarized in Table 21. Thornton's RDAT was performed by subjects three times each day for five days. All of the subjects completed the test. The mean time taken to complete the Rapid Dark Adaptation Test was 226±65 second (3.76 minutes) which was the average of the 5 subejcts for 5 days. However, consistent higher test times were observed for subject 2 over the 5 days (mean test time of the 5 days was 285 seconds) compared to the rest of the subjects (Table 20). The mean test time of the 5 subjects for day I was observed to be higher (307 seconds) than the rest of the days and the lowest mean test time was recorded on day-V (192 seconds). The decline in test time from day-I to day-II and from day-II to day-III was continuous. However, this decline in test-time decreased after the third day and almost leveled-off from day-IV to day-V (Figure 8). This observation indicated that there was a learning-effect in the testing procedure in the first two days of the test and the effect diminished as subjects became more familiar with the test. Therefore, it appears that the observed variation in the performance of subjects over the five days was due to the learning-effect involved rather than the lack of reproducability of the test. The test was replicated regardless of what day the test was performed, as shown by the absence of significant day-order interaction ($p<0.2510$). Sources of variability in the test are summarized in Table 21. There was no significant difference between trial-II and trial-III in the Rapid Dark Adaptation Test ($p<0.0590$) indicating that the Rapid Dark Adaptation Test (Thornton, 1977) was reproducible over trials. However, there was a statistically significant day-effect on the performance of subjects ($p<0.0001$). The time taken to complete the test was dependent on what day the test was performed when the average time of all subjects over the five days was taken (Table 21). A significant inter-subject variability was also observed ($p<0.0001$), indicating that test times were dependent on the subject. There was no significant intra-subject variability over the 5 day test period as shown by the absence of significant subject-day interaction ($p<0.4238$). This indicated that the time taken to complete the test did not change significantly when the same subject performed the test at different times, and thus, the Rapid Dark Adaptation Test was reproducible in the same subject over a period of 5 days.

Reproducibility of the Rapid Dark Adaptation Test (Thornton, 1977) was also reported by Vinton and Russell (1981). The test was reproduced over a two week period and the sensitivity and specificity of the test was reported to be 95% and 91%, respectively. Thirty-two healthy individuals (controls), fourteen vitamin A sufficient patients and eleven Vitamin A deficient patients were included in the study. In the healthy individuals, the mean time taken to complete the Rapid Dark Adaptation

TABLE 20

Test times of adult subjects for 5 days in the Rapid Dark Adaptation Test (Thornton, 1977).

Subject	Day I	Test times (in seconds) Day II	Day III	Day IV	Day V	Mean of 5 days
1	284	210	205	175	173	209.6
2	432	253	249	255	236	285.2
3	258	193	164	161	163	188.0
4	290	228	238	235	232	244.9
5	273	235	180	162	159	202.0
Mean of 5 Subjects	307.6	224.1	207.6	197.7	192.7	226±65

Test was 3.03±1.00 and 4.41±0.83 minutes in the 20-39 and 40-60 year old groups, respectively. The mean test time for healthy subjects (3.03 minutes) which was more or less similar to the mean test time in the current study (3.76 minutes). The slight variation in test times observed between the sutdy by Vinton and Russell (1981) and the current study could be explained by inter-subject variability. A significant ($p<0.0001$) inter-subject variability was also observed in the current study. The fact that the test objects (colored discs) used in the two studies were different could also have contributed to the difference in test times between the two studies. In the study reported by Vinton and Russell (1981), Munsell color discs were used, where as in the current study ASO (Advanced Soft Optics) discs were used. The physical characteristics of the ASO discs, such as reflective surfaces of the discs and

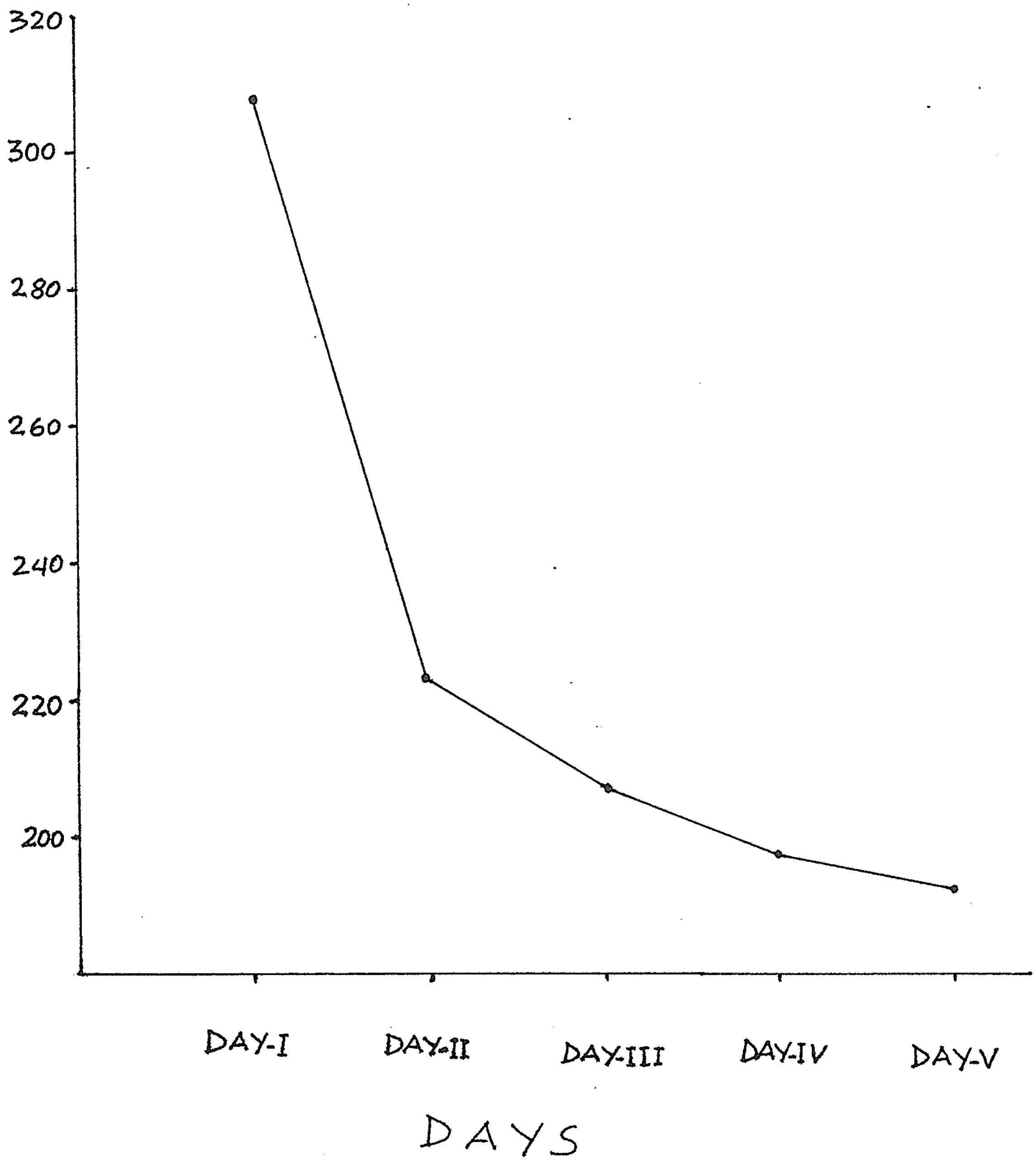

Figure 8: A plot of test times of five subjects for Thornton's (1977) Rapid Dark Adaptation Test.

TABLE 21

Sources of variability in Dark-Adaptation test times of Thornton's (1977) and 10-Second Tests in adults.

Variable	Thornton's Test		10-Second Test	
	F-value	Pr>F	F-value	Pr>F
Person	13.00	0.0001	9.22	0.0002
Day	18.83	0.0001	152.88	0.0001
Order	4.01	0.0590	47.01	0.0001
Person/Day	1.09	0.4238	4.70	0.0007
Day/Order	1.46	0.2510	5.47	0.0039

Person=subject; Day=test day; Order=trial.

percent purity of their color, make them more time-consuming to be identified under scotopic conditions.

The effect of difference in physical characteristics of test objects on dark adaptation times was reported by Sevenhuysen (1984). Subjects were five healthy adult women between the ages of 19 and 30. None showed evidence of any type of color-blindness or a history of night-blindness. The test objects used were ASO and Munsell disc , with dominant wavelengths of the blue disc of 463 u and 475 u and purity of 70% and 45%, respectively. The test was performed in a light proof room under scotopic condition. Each subject was light adapted for 60 seconds just before the light was dimmed and when the light was dimmed subjects sorted 5 white, 6 blue and 7 red ASO or Munsell discs. The results indicated that the reflective characteristics of ASO discs influenced the test times significantly. The mean time taken to complete the test, when ASO discs were used, was 4.63±0.37 minutes compared to 2.58±0.23 minutes when Munsell discs were used.

10.1.2 The 10-Second Test

The 10-Second Test was performed by five adult subjects, immediately after Thornton's Rapid Dark Adaptation Test, five different times. Results are summarized in Table 22. Subjects did not have any difficulty in following the test procedure. The mean time taken to complete the test was 9.94±3.7 seconds. As in the Thornton Rapid Dark Adaptation Test, there was a significant day-effect ($p<.0001$) as shown in Table 21. This indicated that the time taken to complete the 10-Second Test was dependent on the day on which the test was performed . The consistent decrease in the amount of time taken to complete Thornton's RDAT from day 1 to day 2, was also observed in the 10-Second Test. This steady decline in test time diminished after the second day and remained constant at the end of the test period (Figure 9). These observations indicated that there was a similar pattern in the response of subjects to Thornton's Rapid Dark Adaptation Test and the 10-Second Test. Also, there was a significant subject effect ($p<.0002$) which indicates that the time taken to complete the 10-Second Test was dependent on the ability of the subject. There were differences between the 10-Second Tests and Thornton's RDAT. A significant subject-day interaction ($p<0.0007$) was observed in the 10-Second Test which has not been observed for Thornton's RDAT. This indicates that the time taken to complete the 10-Second Test was not consistent for individuals who performed the test at different times . There was also a significant order effect (p<0.0001), indicating that trial II and trial III were significantly different from each other. However, the times for trial II were not consistently higher than those of trial III nor were the times for trial III were consistently higher than those for trial II. It was observed that the time taken to complete the 10-Second Test was greater for the first day of the test for all subjects. The mean test time on day-1 was 16.2 seconds compared to 9.6, 9.0, 7.5 and 7.4 seconds on days 2, 3, 4 and 5, respectively. Therefore, it appears that the significant day-effect observed in this 10-Second Test was due to the increased amount of time taken to complete the test on day 1 rather than due to day to day variability in the response of subjects over the test period. The sources of variability in both the Rapid Dark Adaptation Test (Thornton, 1977) and the 10-Second Test weere not observed to be consistently similar. All the variables involved (subject, day, order, subject-day and day-order interactions) were observed to be significant factors for the variability in the 10-Second Test, while only subject and day were important for the variability in the Rapid Dark Adaptation Test (Table 21). However, there was a similar pattern in the response of subjects to both tests suggesting a relationship between the two dark adaptation tests (Figures 8 and 9). The decrease in test times from test day 1 to test day 5 for the RDAT was similar to that for the 10-Second Test. Moreover, Pearson's Correlation Coefficients between scores of Thornton's and 10-Second Tests were observed to be significant, (r=0.91, p<0.02) suggesting that subjects responded to the two tests similarly and that there is a relationship between the two tests with regard to responses of subjects to these tests.

TABLE 22

Test times of adult subjects for 5 days in the 10-Second Test.

Subject	Day I	Test times (in seconds) Day II	Day III	Day IV	Day V	Mean of 5 days
1	16	7	7	6	7	9.0
2	21	10	8	8	8	11.2
3	15	9	9	7	7	9.5
4	15	10	10	8	8	10.5
5	13	10	9	7	7	9.5
Mean of 5 Subjects	16.2	9.6	9.0	7.5	7.4	9.9

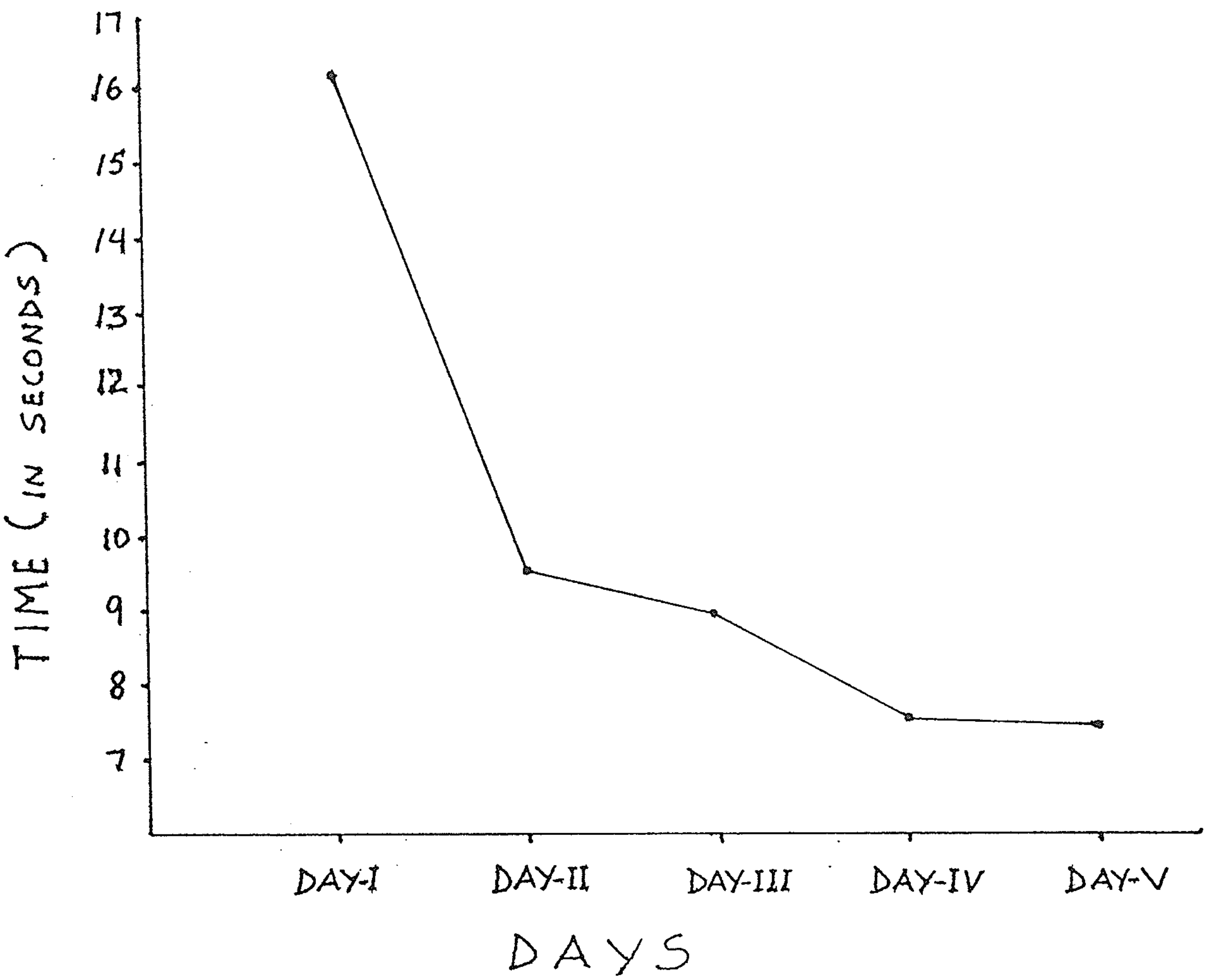

Figure 9: A plot of test times of five adult subjects for the 10-Second Test.

10.2 EXPERIMENT II: APPLICATION OF THE MULTIPLE DECISION PROCEDURE IN ADULT SUBJECTS.

Experiment II was designed to determine: 1. whether or not there was a fluctuation in the perception of the purkinje shift; 2. whether the response of subjects to the purkinje shift in the Rapid Dark Adaptation Test (Thornton, 1977) had a cyclical nature.

Subjects for this experiment were the same adult subjects involved in experiment I. The test used was the Multiple Decision Procedure and the testing procedure is described under Methods.

Results of experiment II are given in Table 23 and 24. All subjects, except one (subject 2), successfully completed the test over the entire testing days. Subject 2 failed to complete the test in less than 10 minutes during the first two days of the test. Each of the test times recorded for subject 2 during the last three days of the test were higher than that recorded for any of the other subjects on any of the five testing days. The mean test times for subject 2, in Thornton's Rapid Dark Adaptation Test (Experiment I), was also observed to be higher than that recorded for any of the other 4 subjects. The mean times for Trials II and III for 4 of the 5 subjects for completion of the Multiple Decision Procedure on days I,II,III,IV,and V were 300, 208.6, 188.6, 189,and 173.5 seconds,respectively. The mean test time for the four subjects over the five days was 207.9 seconds. A mean time of 173.2 seconds was reported for 5 subjects for 4 tests (Sevenhuysen, 1984). Sources of variability in the Multiple Decision procedure are given in Table 24. Significant subject-effect ($p<0.0181$) and day-effect ($p<0.0002$) were observed in the response of subjects to the Multiple

Decision Procedure, indicating that time taken to complete the test was dependent on the subject and on what day the test was performed. Significant day and person effects were also observed for Thornton's Rapid Dark Adaptation Test. In contrast to the absence of significant order-effect, subject-day and day-order interactions in Thornton's RDAT (Experiment I), however, significant order-effect ($p<0.0001$), subject-day ($p<0.0024$) and day-order interactions ($p<0.0011$) were observed in the Multiple Decision Procedure.

In this experiment, the probability of perceiving the purkinje shift appeared to increase and reached the peak after a short exposure of subjects to scotopic conditions. This was reflected by subjects making four consecutive correct decisions (which was the maximum probability of making correct responses). However, the increase in probability of making correct responses did not stabilize even after the maximum probability was achieved. Increases in probability were followed by decreases until a breaking point where the test object became continuously visible to the subject. This appears to suggest that there is a fluctuation in the perception of the purkinje shift during the process of dark adaptation. If perception of the purkinje shift had not been a fluctuating phenomenon, at least, the peak (of the first four consecutive correct responses) would have stabilized at the maximum probability. However, whether or not this fluctuation occurred at a fixed interval and whether the response of subjects to the purkinje shift had a cyclical nature could not be determined due to the lack of enough repetitions of correct and incorrect responses. This was because subjects completed the Multiple Decision Procedure in short periods which did not allow enough repetitions to determine cycles.

TABLE 23

Test times of adult subjects for 5 days in the Multiple Decision Procedure (Sevenhuysen, 1984).

Subject	Day I	Test times (in seconds) Day II	Day III	Day IV	Day V	Mean of 5 days of subjects 1, 3, 4 & 5
1	287	179	165	170	161	192.8
2	>629	>629	464	418	396	--
3	341	191	172	168	145	203.6
4	354	276	229	176	231	253.3
5	217	204	187	162	156	185.5
Mean of subjects 1,3,4&5	300.0	212.8	188.6	169.0	173.5	261.0

TABLE 24

Sources of variability in Dark Adaptation Test times of the Multiple Decision Procedure (Sevenhuysen, 1984).

Variable	F-value	Pr>F
Person	4.97	0.0181
Day	13.87	0.0002
Order	29.94	0.0001
Person/Day	4.93	0.0024
Day/Order	8.10	0.0011

10.3 EXPERIMENT III: APPLICATION OF THORNTON'S RAPID DARK ADAPTATION TEST AND THE 10-SECOND TEST TO 7-10 YEAR-OLD CHILDREN

All of the children were able to understand the instructions involved in both Thornton's and the 10-second dark adaptation tests and cooperated throughout the testing procedures.

Results are summarized in Tables 25 and 26 for Thornton's (1977) Rapid Dark Adaptation Test and the 10-Second Test. The mean time taken to complete Thornton's RDAT was 366±62 second (6.1 minutes). This test time was increased by about one minute compared to that of adults (307.6 second) reported in day-1 of Experiment I. The difference in time could have been due to differences in understanding and applying the series of testing instructions involved in the testing procedure. The instructions appeared to be better understood by adults compared to the children.

As observed in adults, there were no significant differences between trial II and trial III. Test times were not dependent on the trial which indicated that Thornton's RDAT was replicated over the two trials by these children. There was a significant person effect observed for children. The time taken to complete the test was dependent on which child completed the test ($P<0.0024$). A significant ($p<0.0001$) person effect was also observed when this same rapid dark adaptation test was administered in adults. The test, however, was only carried out on a single day with the children whereas it was repeated over a period of five days with adults. This makes comparison of the results for children with that of adults difficult.

TABLE 25

Test times of adults and 7-10 year old children on day-I for the Rapid Dark Adaptation Test (Thornton, 1977) and the 10-Second Test.

Subject	Rapid Dark Adaptation Test (Times: in seconds)		10-Second Test (Times: in seconds)	
	Adults	Children	Adults	Children
1	284	322	16	12
2	242	358	21	13
3	258	436	15	13
4	290	424	15	14
5	273	288	13	14
Mean	269.6	366±62	16.2	13.5

TABLE 26

Sources of variability in Dark Adaptation Test times of Thornton's (1977) and 10-Second Test in 7-10 year old old children.

Variable	Thornton's Test		10-Second Test	
	F	Pr<F	F	Pr<F
Person	33.99	0.0024	1.86	0.2818
Order	3.66	0.1281	4.57	0.0993

Thornton's Rapid Dark Adaptation Test has been used with children, as young as 4 years of age by (Solomons et al. 1982). Two groups of children, 4-5 year old and 5-12 year old in Baltimore and Guatemala, respectively, participated in the study.

The results indicated that the mean test time for the 4-5 year old group was 171 seconds (2.85 minutes). For the 5-12 year old group, the mean test time was only 144 seconds (2.4 minutes). In the 4-5 year old children in Baltimore, the Rapid Dark Adaptation Test time ranged from 101 to 300 seconds, compared to 93 to 284 seconds for healthy adults aged 20-39 years at the same center in Baltimore (Vinton and Russell, 1981). The Rapid Dark Adaptation Test time ranged from 87-278 seconds in the 5-12 year old children in Guatemala, compared to a range of 71-426 seconds for 75 healthy adults aged 13-39 years in the same center. In the present study, Rapid Dark Adaptation Test time ranged from 289-437 seconds for 7-10 year old children. In Solomons et al. (1982) study, the mean score for the 5-12 year old Guatemalan children was 144 seconds (2.4 minutes) compared to 366 seconds (6.1 minutes) in the present study,with 7-10 year old children. The testing procedure of the present study was identical to that used in Solomons et al. (1982) study with Guatemalan children except that the light adaptation period was 60 seconds in the present study compared to the 120 seconds in Solomons et al. (1982) study. In two groups of healthy adult subjects, the longer light adaptation period results in a longer time to complete the RDAT, provided that the intensity of light is the same (Sevenhuysen, 1984). Despite this fact, however, the mean RDAT time was shorter (144 seconds) for subjects studied by Solomons et al. (1982) than that observed in the current study (366 seconds). Subjects were light adapted for 120 seconds by fixating on an x-ray view box at 45 cm (Solomons et al., 1982). The light intensity, for light adaptation, of the x-ray view box, however, was not specified. Factors which are known to influence dark adaptation time were controlled. All of the subjects had a normal opthalmoscopic examination. Fourteen of the 24 subjects (58.3%) had serum Vitamin A levels above 40 ug/dl and none of the Vitamin A levels were below 30 ug/dl. In the present study, subjects were light adapted for 60 seconds by fixating on a 65x50 cm white paper reflecting a light emitted by two 60 watt bulbs suspended at 74 cm from the work surface. No opthalmoscopic examination of subjects was carried out. However, none of the five subjects had complaints related to vision. Serum Vitamin A and zinc levels were not determined. Since the objective of this experiment was to determine whether or not the Rapid Dark Adaptation Test procedure could be modified for children.

For the 7-10 year old group, the mean time taken to complete the 10-Second Test was 13±0.78 seconds. This test time was shorter compared to 16 seconds recorded for adults on day-I of experiment II. There was no significant subject effect ($p<0.2818$); test scores were not dependent on which person did the test. There was also no significant order effect ($p<0.0993$) which indicated that the test was replicated over trials completed the same day.

A study similar to the 10-Second Test which was not based on the retinal purkinje-shift, was reported by Dhanamitta et al. (1983). Subjects were males and females from 3-12 years of age, and had no occular signs of vitamin A deficiency. In this study, initial dark adaptation time was observed to be higher in children with complaints related to night blindness, (38 seconds), than in those without complaints (9 seconds). Children were randomly selected from both the night blind group and control group and were given 100,000 I.U. retinyl palmitate in oil in capsules. Overall dark adaptation time decreased after the treatment. The mean dark adaptation time declined from 38±14 seconds to 5±t seconds in the treated night blind group and this decrease was significant ($p<0.01$).

Although this dark adaptation test used by Dhanamitta et al. (1983) was not based on the retinal purkinje-shift (unlike Thornton's Rapid Dark Adaptation Test), the test appeared to be capable of detecting differences in dark adaptation ability between a night blind group and a control group. This test also detected improvements in dark adaptation performance in the night blind group after Vitamin A supplementation, due to the consequent increase in serum Vitamin A level from 23-31 ug/dl. Therefore, it appears that dark adaptation tests based on cone adaptation (not based on rod adaptation or purkinje-shift) could be developed and used for screening poor dark adapting or night blind individuals in a given population.

This dark adaptation test used by Dhanamitta (1983) is similar to the 10-Second Test used in the current study in that it was simple, easy to use, inexpensive and does not require cumbersome instrumentation and thus is appropriate for field condition. The testing instruction and procedure are not complicated and hence appropriate for use with children. However, the test had inherent sources of measurement variability. Light adaptation of subjects prior to dark adaptation was uneven since there was no control over total light. The lighting condition in the dark room during the dark adaptation process was not fully controlled as more stray light was possible. Moreover, there was the likelihood of subjects locating the test object (placed one meter from the subject) by chance alone. In the case of the 10-Second Test used in the current study, however, subjects were light adapted for a fixed (1 minute) period of time, the light intensities for light adaptation and dark adaptation were standardized. In general, the 10-Second Test was carried out in a more standardized and controlled setting than the dark adaptation test used by Dhanamitta et al. (1983).

10.4 EXPERIMENT IV: APPLICATION OF A 10-SECOND TEST IN CHILDREN UNDER THE AGE OF FIVE

The subjects for experiment IV were children who were 3-1/2 to 5 year old. The dark adaptation test used in this group of children was similar to the 10-Second Test used in the 7-10 year old children (experiment III) in that the standard testing conditions were the same. However, a slight modification was made on the 10-Second Test used with 7-10 year old children to make it simpler for use with under 5 year old children as described under methods for experiment IV. All of the five under five year old children were able to understand the testing instructions and had no difficulty in performing the test.

Test times of <5 years and 7-10 year old children and adults for the 10-Second Test are given in Table 27 and Table 28. Sources of variability in adults and the two groups of children are compared. The mean dark adaptation time for under five year old children was 16.30 ± 1.30 seconds. This test time was similar to that of adults (16.20 seconds) but longer than that recorded for 7-10 year old (13.50 seconds). The time of 7-10 year olds for trial-2 was significantly shorter ($p<0.0087$) than that of <5 year olds and adults. However, there was no significant difference ($p<0.05$) among the three groups of subjects with respect to the times for trial-3. There was also no significant difference in test time for trial-2 between <5 year olds and adults. There was no significant subject-effect ($p<0.4019$), indicating that dark adaptation test time was not influenced by inter-subject variability in responding to the test. There was also no signficant order effect ($p<0.5012$) for trials replicated over the same day period. Similar observation was obtained when the 10-Second Test was used with 7-10 year olds (Table 28). However, significant inter-subject variability ($p<0.0002$) and significant order effect ($p<0.001$) were observed when the 10-Second Test was used with adults on day-1 of the test.

TABLE 27

Test times of day-I for adults, 7-10 years and <5 year old children for the 10-Second Test.

Subject	Adults	Test Times (in seconds) 7-10 year old children	<5 year old children
1	16	12	16
2	21	13	15
3	15	13	17
4	15	14	17
5	13	14	15
Mean	16.2	13.5±0.78	16.3±1.3

TABLE 28

Sources of variability in Dark Adaptation Test times for the 10-Second Test in adults, 7-10 year and <5 year old children.

Variable	Adults	7-10 year old children	<5 year old children
	Pr<F	Pr<F	Pr<F
Person	0.0002	0.2818	0.4019
Order	0.0001	0.0993	0.5012

Chapter 11

CONCLUSION

This study showed that the 10-Second Test was significantly influenced by subject, day and order effects and also by subject-day interaction while only subject and day significantly influenced Thornton's (1977) RDAT when both tests were performed by adults. The variability in test scores between subjects, days, and trials was greater for the 10-Second Test than for Thornton's Test. There was, however, a similar pattern in the response of subjects to Thornton's and the 10-Second Test, which might suggest a relationship between these two tests. That is, decreases in test times for Thornton's Test from day-I to day-V was followed by similar decreases in the 10-Second Test.

The probability of perceiving the purkinje shift was observed to increase and decrease at intervals during the process of dark adaptation. This observation appears to suggest that there was a fluctuation in the perception of the purkinje shift. However, the periodical increases and decreases in perception did not appear to occur at fixed intervals as the time intervals between each two adjacent peaks were different from each other. Whether or not the responses of subjects to the purkinje shift had a cyclical nature could not be determined statistically due to number of repetitions of correct and incorrect responses to the purkinje shift.

In the current study, the 10-Second Test appeared to be appropriate for use with children as young as 3-1/2 years of age. The children tested had no difficulty in understanding the testing instructions and manipulating test objects. Test times of children under five years of age for the 10-Second Test were similar to that of adults in a similar 10-Second Test. There were no significant differences between trials II and III for children under five years of age and adults. Trial III of the 10-Second Test for under five year olds and adults was not significantly different from trial III for children between the ages of 7 and 10. The 10-Second Test was reproducible over two trials and test times were not influenced by inter-subject variability when the test was performed by children (under five and 7-10 year old) twice on a single day.

Thornton's RDAT appeared to be applicable in 7-10 year old children. This group of children was able to understand and follow the testing instructions and had no difficulty in manipulating test objects. Test scores were reproducible over two trials. Test scores were not dependent on which trial was performed and this same observation was also noted for adult subjects in the same test. There was, however, a difference of about one minute in test times, for Thornton's Test, between children and adults.

In general, this study indicated that sources of variability for both Thornton's and 10-Second Tests were not identical. However, sources of variability common to both tests were observed and similar patterns of responses for both tests were also noted. The variabilities observed in these two tests could have been brought about partly by the small sample size.

In conclusion, Thornton's (1977) RDAT appeared applicable in children 7-10 year old. The 10-Second Test procedure appeared suitable for use with children as young as 3-1/2 years of age. However, whether or not the 10-Second Test could be used for screening vitamin A deficient individuals from a given population, needs further investigation.

PART I - BIBLIOGRAPHY

Ashworth, A., 1969, Growth Rates in Children Recoving from Protein-Calorie Malnutrition, Br. J. Nutr. 23:835.

Bengoa, J. M., 1974, The Problem of Malnutrition, WHO Chron. 28:3.

Bengoa, J. M., 1970, Recent Trends in the Public-Health Aspects of Protein-Calorie Malnutrition, WHO Chron. 24:552.

Bhuiya, A., Wojtytiak, B., D'Souza, S. and Zimicki, S., 1986, Socio-Economic Determinants of Child Nutritional Status: Boys Versus Girls, Food and Nutr. Bull., 8:3.

Blackburn, G. L., Bistrian, B. R., Maini, B. S., Schlamm, H. F., and Smith, M. F., 1977, Nutritional and Metabolic Assessment of the Hospitalized Patient, J. Parenteral and Enteral Nutrition 1:11.

Chavez, A., and Ramirez, J., 1963, Nutrition and Economic Development, Rev.Health Publ. 5:827.

De Kadt, E., 1974, "Aspectos Distributivos de la Salud en Chile", in Centro de Estudios de Planificacion, Bienestar y Pobrezo (Santiago: Ediciones Nueva Universidad).

De Walt, K. M., 1983, Nutritional Strategies and Agricultural Change in a Mexican Community, UMI Research Press.

Dewey, K. G., 1979, "Agricultural Development, Diet and Nutrition", Ecology of Food and Nutrition, 8:265.

Dewey, K. G., 1981, "Nutritional Consequences of the Transformation from Subsistence to Commercial Agriculture in Tabasco, Mexico", Human Ecology, 9:151.

Dugdale, E. E., 1971, An Age Independent Anthropometric Index of Nutritional Status, Am. J. Clin. Nutr. 24:174.

Gunasakera, D. B., 1958, Nutrition Surveys of Some Rural Areas in Ceylon, J. Ceylon Med. Sci. 9:107.

Guthrie, H. A., and Wright, H. S., 1984, Dietary Methodologies, In: Nutrition Assessment, pp. 119, Aspen System Corp., Maryland.

Habicht, J. P., 1974, Height and Weight Standards for Preschool Children: How Important are Ethnic Differences in Growth Potential? Lancet 1:611.

Hakim, P., and Solimano, G., 1978, Development, Reform, and Malnutrition in Chile.

Harfouche, J. K., 1970, The Importance of Breast-feeding. J. Trop. Pediatr. 16:133.

Hernandez, M., Hidalgo, C. P., Hernandez, J. R., Madrigal, H., and Chavez, A., 1974, Effect of Economic Growth on Nutrition in a Tropical Community, Ecol. Food and Nutr. 3:283.

International Union of Nutritional Sciences, 1977, Guidelines on the At-risk Concept and the Health and Nutrition of Young Children, Am. J. Clin. Nutr. 30:242.

International Union of Nutritional Sciences, 1972, The Creation of Growth Standards, A Committee Report, Am. J. Clin. Nutr. 25:218.

Jelliffe, D. B., 1966, The Assessment of Nutritional Status of the Community. Geneva: WHO. Monograph Series.

Jelliffe, D. B., 1968, Infant Nutrition in the Tropics and Subtropics. Geneva: WHO. Monograhp Series No. 29.

Jelliffe, D. B. and Jelliffe, E. F. P. 1973. The At-risk Concept as Related to Young Children Nutrition Programs, Clin. Pediatr. 12:65.

Jellife, D. B., and Jelliffe, E. F. P., 1979, Nutrition and Growth, Human Nutrition, Plenum Press, New York.

Joint FAO, UNICEF, WHO Expert Committee, 1976, Methodology of Nutritional Surveillance, Technical Report Series, No. 53, pp. 20-60, WHO Geneva.

Kanawati, A. A., and McLaren, D. S., 1970, Assessment of Marginal Malnutrition, Nature 228:573.

Keilmann, A. A., 1977, Weight Fluctuations after Immunization in a Rural Preschool Child Community, Am. J. Clin. Nutr. 30:592.

Lazarus, T., and Bhana, K., 1984, Protein-Energy Malnutrition and Associated Variables Among Indian Pre-School Children in a Selected Area of Natal, S. Afr. Med. J. 65:381.

McLaren, D. S., and Read, W. W. C., 1972, Classification of Nutritional Status in Early Childhood, Lancet 2:146.

Mason, M., Wenberg, B. G., and Welsch, P. K., 1982, The Dynamics of Clinical Dietetics, 2nd Ed. pp. 10-11, New York: John Wiley & Sons.

Mason, J. B., and Mitchell, J. T., 1983, Nutritional Surveillance, Bull. WHO 61:745.

Massel, E. L., 1951, Research on Food and Nutrition. 5th Report, South Pacific Commission, Noumea.

Morley, D., Bicknell, J., and Woodland, M., 1968, Factors Influencing the Growth and Nutritional Status of Infants and Young Children in a Nigerian Village, Trans. Royal Soc. Trop. Med. and Hygiene, 62:164.

Muhilal, H., and Glover, J., 1974, Effects of Dietary Deficiencies of Protein and Retinol on the Plasma Level of Retinol-Binding Protein in Rats, Br. J. Nutr. 32:549.

Neumann, C. G., Shanker, H., and Uberoi, I. S., 1969, Nutritional and Anthropometric Profile of Young Rural Punjabi Children, Indian J. Med. Res. 57:1122.

Owen, G. M., 1984, Physical Examination As an Assessment Tool, In: Nutrition Assessment, pp. 57-66, Aspen Systems Corp., Maryland.

Pi-Sunyer, F. X., and Woo, R., 1984, Laboratory Assessment of Nutritional Status, In: Nutrition Assessment, pp. 139-174, Aspen Systems Corp., Maryland.

Pitt, G. A. J., 1981, The Assessment of Vitamin A Status, Proc. Nutr. Soc. 40:173.

Rao, K. V., and Gopalan, C., 1971, Family Size and Nutritional Status, in Proceedings of the First Asian Congress of Nutrition (Hyderabad: National Institute of Nutrition, pp. 339-48).

Robbins, G. E., and Trowbridge, F. L., 1984, Anthropometrric Techniques and Their Application, In: Nutrition Assessment: pp. 69-89, Aspen Systems Corp., Maryland.

Rosa, F. W., and Turshen, M., 1970, Fetal Nutrition, Bull. WHO 43:783.

Roy, J. K., and Roy, B. C., 1969, Nutritional Background and Growth of Infants: A major District of West Bengal, Calcutta: An Anthropometric Survey of India, Govt. of India, Memoir No. 28.

Rutishauser, I. H. E., 1965, Heights and Weights of Middle-Class Baganda Children, Lancet 2:565.

Schofield, S., 1979, Development and the Problems of Village Nutrition, Croom Helm Ltd., London.

Scrimshaw, N. W., 1964, Ecological Factors in Nutritional Diseases. Amer. J. Clin. Nutr. 14:112.

Seyoum, E., Kidane, Y., Gebru, H., and Sevenhuysen, G. P., 1986, Preliminary Study of Income and Nutritional Status Indicators in Two Ethiopian Communities, Food and Nutrition Bulletin, UNU, 8:37.

Shakir, A., 1972, Pattern of Protein-Calorie Malnutrition in Young Children Attending an Out-patient Clinic in Baghdad, Lancet 2:143.

Simko, M. D., Cowell, C., and Gilbride, J. A., 1984, The Nutrition Profile As a Tool for Identifying Who Needs Nutritional Care, In: Nutrition Assessment, pp. 37, Aspen Systems Corp.

Simko, M. D., Cowell, C. and Gilbride, J. A., 1980, Assessing the Nutritional Needs of Groups, pp. 3-8, New York University, Department of Home Economics and Nutrition, New York.

Smith, V. E., Kolasa, K., Strauss, J., Whelan, W., and Bingen, L. 1981, "Development and Food Consumption Patterns in Rural Sierra Leone", Food and Nutrition, 7:24.

Smith, M. F., 1986, The Impact of Changing Agricultural Systems on the Nutritional Status of Farm Households in Developing Countries, Food and Nutrition Bulletin, UNU, 8:25.

Statistical Analysis System (SAS) Institute, 1986, Cary, NC., U.S.A.

Stewart, M. M., Reilly, T. A., Morrow, R. H., Rosenfield, A. G., and Suskind, R. M., 1977, Ecologic Determinants of Health Problems, Springer Pub. Comp., New York.

Tripp, R. B., 1981, Farmers and Traders: Some Economic Determinants of Nutritional Status in Northern Ghana, J. Trop. Pediatr., 27:15.

Trowbridge, F. L., and Stetler, H. C., 1982, Results of Nutritional Status Surveillance in El Salvador, Bull. WHO, 60:433.

Walker, A. R. P., and Richardson, B. D., 1973, International and Local Growth Standards, Am. J. Clin. Nutr. 26:897.

Waterlow, J. C., 1972, Classification and Definition of Protein-Calorie Malnutrition. Br. Med. Journal. 3:566.

Waterlow, J. C., 1976, Classification and Definition of Protein-Energy Malnutrition, In: Nutrition in Preventive Medicine, pp. 530, WHO, Geneva.

Waterlow, J. C., Buzina, R., Keller, W., Lane, J. M., Nichaman, M. Z., and Tanner, J. M., 1977, The Presentation and Use of Height and Weight Data for Comparing the Nutritional Status of Groups of Children Under the Age of 10 Years, Bull. WHO 55:489.

Welbourn, H., 1954, The Danger Period During Weaning Among Baganda Children. East. Agr. Med. J., 31:147.

Wellcome Trust Working Party, 1970, Classification of Infantile Malnutrition, Lancet 2:302.

Wellman, N. S., 1978, The Evaluation of Nutritional Status, In: Nutrition in Clinical Care, pp. 290-301, New York: McGraw Hill Book Co.

WHO, 1976, Methodology of Nutritional Surveillance. Technical Report Series No. 593. Geneva: WHO.

WHO, 1976, Nutrition in Preventive Medicine, WHO Monograph Series 62.

WHO Colaborative Study on Breastfeeding, 1981, WHO, Geneva.

Wray, J. D., and Aguirre, A., 1969, Protein-Calorie Malnutrition in Candelaria, Colombia. Prevalence; Social and Demographic Causeal Factors; J. Trop. Pediatr., 15:76.

PART II - BIBLIOGRAPHY

Brown, G. C., Felton, S. M., Benson, W. E., 1980, Reversible Night-Blindness Associated with Intestinal by Pass Surgery, Am. J. Ophthalmol. 110:552.

Carney, E. A., and Russell, R. M., 1980, Correlation of Dark Adaptation Test Results With Serum Vitamin A Levels in Diseased Adults, J. Nutr. 110:552.

Dhanamitta, S., Stoecker, B., Maneechine, A., and Valyasevi, A., 1983, Dark Adaptation, Plasma Vitamin A and Urinary Calcium of Vitamin A Supplemented Children in North East Thailand, Nutr. Rep. Inter. 27:67.

Dowling, J. E., and Wald, G., 1958, Vitamin A deficiency and Nightblindness, Proc. Nat. Acad. Sci. 44:648.

Favaro, R. M. D., de Souza, N. V., Vannucchi, H., D Desai, I. and de Oliveira, J. E. D., 1986, Evaluation of Rose-Bengal Staining Test and Rapid Dark Adaptation Test For the Field Assessment of Vitamin A Status of Preschool Children in Southern Brazil, Am. J. Clin. Nutr. 43:940.

Feldman, J. B. 1941, Light Threshold and its Clinical Evaluation, Arch. Opthalmol. pp. 466-471.

Fisher, K. D., Carr, C. J., Huff, J. E., and Huber, T. E., 1970, Dark Adaptation and Night Vision, Fed. Proc. 29:1605.

Guyton, A. C., 1976, Photochemistry of the Visual Cycle, Text Book of Medical Physiology, 5th Edi., p. 800, W.B. Saunders Company.

Guyton, A. C., 1986, Photochemistry of the Visual Cycle, Text Book of Medical Physiology, 7th. Edi., p. 713, W.B. Saunders Company.

Hecht, S., and Mandelbaum, J., 1939, The Relationship Between Vitamin A and Dark Adaptation, J. A. M. A., 112:1910.

Joint WHO/USAID Meeting, 1976, Vitamin A Deficiency and Xerophthalmia, WHO Tech. Rep. Ser. 590, Geneva.

Kim, V., and Solomons, N. W., 1983, Performance of Genetically-Colorblind Individuals on a Rapid Dark Adaptation Test Based on the Purkinje Shift, Perceptual and Motor Skills 56:251.

McLaren, D., Oomen, H., and Escapini, H. 1966, Ocular Manifestations of Vitamin A Deficiency in Man, Bull. WHO 34:357.

McLaren, D. S., Techalian, M., Khoury, G., Shirajian, E., 1965, Xerophthalmia in Jordan, Am. J. Clin. Nutr. 17:117.

Morrison, S. A., Russell, R. M., Carney, E. A., and Oaks, E. V., 1978, Zinc Deficiency: A Cause of Abnormal Dark Adaptation in Cirrhotics, Am. J. Clin. Nutr. 31:276.

Perlman, I., Barzilai, D., Tamarhaim, and Schramek, A. 1983, Night Vision in Case of Vitamin A Deficiency due to Malabsorption, Br. J. Opthalmol. 67:37.

Pitt, G. A. J., 1981, The Assessment of Vitamin A Status, Proc. Nutr. Soc. 40:173.

Ripps, H., and Wheale, A., 1976, Visual Adaptation In: The Eye, 2A, pp. 101, Academic Press Inc. New York, 2nd Ed.

Russell, R., Multack, R., and Smith, V., 1973, Dark Adaptation Testing for Diagnosis of Sub-Clinical Vitamin A Deficiency and Evaluation of Therapy, Lancet 2:1161.

Russell, R. M., Morrison, A., Smith, F. R., Oaks, E. V., and Carney, E. A., 1978, Vitamin A Reversal of Abnormal Dark Adaptation in Cirrhosis, Ann. Intern. Med. 88:622.

Sabrell, W. H. and Harris, R. S., 1967, In: The Vitamins, Vol. I:3, Academic Press Inc.

Sandberg, M. A., Rosen, J. B., and Berson, E. L., 1977, Cone and Rod Function in Vitamin A Deficiency With Chronic Alcoholism and in Retinitis Pigmentosa, Am. J. Ophthalmol. 84:658.

Sauberlich, H. E., Hodges, R. E., Wallace, D. I., Kolder, H., Canham, J. E., Hood, J., Raica, N., Jr., and Lowry, L. K., 1974, Vitamin A Metabolism and Requirements in the Human Studied With the Use of Labeled Retinol, Vit. Horm. 32:251.

Sevenhuysen, G. P., 1984, Sources of Measurement Variation in the Rapid Dark Adaptation Test, Nutr. Rep. Intern. 30:213.

Smith, J. E., and Goodman, D. S., 1979, Retinol Binding Protein and the Regulation of Vitamin A Transport, Fed. Proc. 38:2504.

Solomons, N. W., Russell, R. M., Vinton, N. E., Guerrero, A. M., and Mejia, L., 1982, Application of a Rapid Dark Adaptation Test in Children, J. Ped. Gastr. Nutr. 1:571.

Sommer, A., Hussaini, G., Muhilal, Tarwotjo, I., Susanto, D., and Seroso, J. S., 1980, History of Night Blindness: A Simple Tool for Xerophthalmia Screening, Am. J. Clin. Nutr. 33:887.

Sommer, A., Hussaini, G., Tarwotjo, I., and Susanto, D., 1983, Increased Mortality in Children With Mild Vitamin A Deficiency, The Lancet, 2:585.

Sommer, A., Katz, J., and Tarwotjo, I., 1984, Increased Risk of Respiratory Disease and Diarrhea in Children With Pre-existing Mild Vitamin A Deficiency, Am. J. Clin. Nutr. 40:1090.

Sommer, A., Tarwotjo, I., Hussaini, G., Susanto, D., Soegiharto, T., 1981, Incidence, Prevalence and Scale of Blinding Malnutrition, Lancet 1:1404.

Sommer, A., 1984, Vitamin A Deficiency and Mortality Risk, Lancet 1:347.

Srikantia, S., 1975, Human Vitamin A Deficiency, World Rev. Nutr. Diet. 20:184.

Statistical Analysis System (SAS) Institute, 1986, Cary, NC., U.S.A.

Thornton, S. P., 1977, A Rapid Test for Dark Adaptation, Ann. Ophthalmol. 9:731.

Vinton, N. E., and Russell, R. M., 1981, Evaluation of A Rapid Test of Dark Adaptation, Am. J. Clin. Nutr. 34:1961.

Walt, R. P., Kemp, C. M., Lyness, L., Bird, A. C., and Sherlock, S., 1984, Vitamin A Treatment for Nightblindness, Br. Med. J. 288:1030.

Warth, J. A., Prasad, A. S., Zwas, F., and Frank, R. N., 1981, Abnormal Dark Adaptation in Sickle Cell Anemia, J. Lab. Clin. Med. 98:189.

Yarbrough, M. E., and Dann, W. J., 1941, Dark Adaptometer and Blood Vitamin A Measurements in a North Carolina Nutrition Survey, J. Nutr. 22:597.

Young, D. C., 1980, Dark Adaptation in Five-Year-Old Children and Adults, Vision Research 21:811.

Appendix A

DISTRIBUTION OF FAS AND HOUSEHOLDS BY STRATA AND NUMBER SELECTED

Stratum (worada)	Sub-strat. (eco-zone)	Tot. No. of FAs	No. of selected FAs	Tot. No. of Households	No. of HH in sample
Aleta wondo	H.Land	15	6	12,992	180
	M.Land	34	8	16,978	240
	L. Land	17	5	10,809	150
Arbegona	H.Land	48	6	13,244	180
	M. Land	15	3	6,557	90
	L.Land	-	-	-	-
Awassa	H.Land	36	6	12,546	180
	M.Land	21	6	11,622	180
	L.Land	14	2	3,904	60
Bensa	H.Land	19	3	6,449	90
	M.Land	14	3	6,532	90
	L. Land	4	1	825	30
Dale	H.Land	15	4	7,130	120
	M.Land	43	11	23,449	330
	L.Land	18	2	4,954	60
Hagere Selam	H.Land	73	12	25,777	360
	M.Land	14	3	5,374	90
	L.Land	-	-	-	-
Shebedino	H.Land	15	3	5,371	90
	M.Land	36	9	19,466	270
	L.Land	41	7	15,123	210
Total	-	492	100	209,102	3,000

Appendix B

QUESTIONNAIRE REPRESENTING SURVEY VARIABLES

1. Region

____

2. Awraja (Sub-region)

   No. of allowed replies: 1.

   ( ) 1. Arero
   ( ) 2. Borena
   ( ) 3. Gedeo
   ( ) 4. Jemjem
   ( ) 5. Sidama
   ( ) 6. Wolaita

3. Woreda (District)

   No. of allowed replies: 1.

   ( ) 1. Aletawondo
   ( ) 2. Arbegona
   ( ) 3. Awassa
   ( ) 4. Bensa
   ( ) 5. Dalle
   ( ) 6. Hagereselam
   ( ) 7. Shebedino

4. Farmers Association

____

5. Town

____

6. Higher

____

7. Kebele

____

8. Selected house number

____

9. Order of household selection

____

10. Month

____

11. Year

____

12. Child number

____

13. Is this the first time data is entered for this mother?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

14. Age of the mother

__________________ years

15. Mother religion

No. of allowed replies: 1.

( ) 1. Orthodox
( ) 2. Other christian
( ) 3. Moslem
( ) 4. Other

16. Mother ethnic

No. of allowed replies: 1.

( ) 1. Amhara
( ) 2. Gurage
( ) 3. Sidama
( ) 4. Oromo/Guji
( ) 5. Tigre
( ) 6. Wolaita
( ) 7. Others

17. Mother's marital status

No. of allowed replies: 1.

( ) 1. Single
( ) 2. Married
( ) 3. Widowed

( ) 4. Divorced

18. Mother read and write

No. of allowed replies: 1.

( ) 1. Reads and writes
( ) 2. Does not read or write

19. Mother's occupation

____

20. Weight of the mother

____________________ Kilograms

21. Height of the mother

____________________ Centimeters

22. Number of months mother is pregnant

____________________ Months

23. Father's age

____________________ Years

24. Father religion

No. of alowed replies: 1.

( ) 1. Orthodox
( ) 2. Moslem
( ) 3. Other christian
( ) 4. Other

25. Father ethnic

No. of allowed replies: 1.

( ) 1. Amhara
( ) 2. Gurage
( ) 3. Sidama
( ) 4. Oromo/Guji
( ) 5. Tigre
( ) 6. Wolaita
( ) 7. Others
( ) 9. Missing

26. Father marital status

No. of allowed replies: 1.

( ) 1. Married
( ) 2. Single
( ) 3. Divorced

27. Father read and write

No. of allowed replies: 1.

( ) 1. Reads and writes
( ) 2. Does not read and write

28. Father's occupation

____

29. Land holding

_____________ Hectares

30. Number of hectares under food crop cultivation

_____________ Hectares

31. Number of hectares under cash crop cultivation

_____________ Hectares

32. Source of major food crops for consumption

No. of allowed replies: 1.

( ) 1. Produced
( ) 2. Purchased
( ) 3. Produced and purchased
( ) 4. Aid

33. What percent of the food consumed annually is produced?

______________ Percent

34. Do you raise poultry?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

35. If yes, what do you do with the eggs you get from you poultry?

No. of allowed replies: 1.

( ) 1. Mainly consume
( ) 2. Mainly sell
( ) 3. Consume and sell

( ) 4. For poultry purposes
( ) 5. Not applicable

36. Do you own milk animals?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

37. If yes, what do you do with the milk and milk products?

No. of allowed replies: 1.

( ) 1. Mainly consume
( ) 2. Mainly sell
( ) 3. Sell and consume
( ) 4. Not applicable

38. Do you grow fruits?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

39. If yes, what do you do with the fruits that you get?

No. of allowed replies: 1.

( ) 1. Mainly consume
( ) 2. Mainly sell
( ) 3. Consume and sell
( ) 4. Not applicable

40. Do you grow vegetables?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

41. If yes, what do you do with the vegetables?

No. of allowed replies: 1.

( ) 1. Mainly consume
( ) 2. Mainly sell
( ) 3. Consume and sell
( ) 4. Not applicable

42. Do you use chemical fertilizers?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

43. Do you use pesticides?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

44. Do you live in the same house with animals?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. NO

45. Source of water for drinking and food preparation

No. of allowed replies: 1.

( ) 1. River
( ) 2. Spring
( ) 3. Lake
( ) 4. Well
( ) 5. Pond
( ) 6. Pipe

46. Distance of water source from household unit

____________________ Kilometers

47. Is water adequate throughout the year?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

48. Do you have a pit latrine?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

49. Do you use your pit latrine?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No
( ) 3. Not applicable

50. How do you dispose of garbage?

No. of allowed replies: 1.

( ) 1. Burn
( ) 2. Dump in running water
( ) 3. Buried
( ) 4. Dump on open field

51. How far do you live from the nearest health institution?

____________________ Kilometers

52. Where do you go first when a family member becomes sick?

No. of allowed replies: 1.

( ) 1. Health instiution
( ) 2. Traditional practitioner
( ) 3. Local injector
( ) 4. Drug vendor shop
( ) 5. Nowhere

53. Why do you take sick to the health care provider you choose?

No. of allowed replies: 1.

( ) 1. Service is easily available
( ) 2. Less distance to travel
( ) 3. Better care
( ) 4. Cheaper payment
( ) 5. Not applicable

54. Who usually attends your deliveries?

No. of allowed replies: 1.

( ) 1. Untrained TBA
( ) 2. Trained TBA
( ) 3. Health worker
( ) 4. Relative or neighbor
( ) 5. Self

55. Do you know what a vaccination is?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

56. If yes, what is it?

No. of allowed replies: 1.

( ) 1. Cures disease
( ) 2. Prevents disease
( ) 3. Prevents and cures diseases

( ) 4. Has no use
( ) 5. Don't know its use
( ) 6. Not applicable

57. Number of children under 5 with diarrhea during the last two weeks prior to the survey

____

58. Number of years married

____

59. Total number of live-births

____

60. Total number of children alive

____

61. Total number of children died

____

62. Number of children who died before one year of age

____

63. How long do you think a child should be breast fed?

_______________ Months

64. How long do you usually breastfeed your children?

_______________ Months

65. At what age do you give additional food to your children?

_______________ Months

66. Do you work outside the home?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

67. Do you take your under 5 children with you when you go out for work?

No. of allowed replies: 1.

( ) 1. Yes

( ) 2. No
( ) 3. Not applicable

68. If yes, do you feed them there?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No
( ) 3. Not applicable

69. If you don't take them with you, who feeds them at home?

No. of allowed replies: 1.

( ) 1. Other members in the household
( ) 2. Neighbors
( ) 3. No food is served
( ) 4. Not applicable

70. How many times do you usually give additional food to your weaning child?

___________________ per day

71. What is the feeding practice of children under 5 in the family?

No. of allowed replies: 1.

( ) 1. Children are served first
( ) 2. Children served after adults
( ) 3. Adults, children eat together
( ) 4. Eat together but diff. dishes

72. What is the feeding practice of the mother?

No. of allowed replies: 1.

( ) 1. Together with other members
( ) 2. With husband only
( ) 3. With children under 5
( ) 4. Last alone

73. Do you participate in any women's income generating activity?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

74. What are the main staple cereals of your family?

____

75. What are the foods that you strictly do not eat when you are pregnant? (First response)

____

76. Why don't you eat this food (food named in previous question) during pregnancy?

____

77. What are the foods that you strictly do not eat when you are pregnant? (Second response)

____

78. Why don't you eat this food (food named in previous question) during pregnancy?

____

79. What are the foods that you strictly do not eat when you are pregnant? (Third response)

____

80. Why don't you eat this food (food named in previous question) during pregnancy?

____

81. What are the foods that you strictly do not eat when you are pregnant? (Fourth response)

____

82. Why don't you this food (food named in previous question) during pregnancy?

____

83. What are the foods that you strictly do not eat when you are lactating? (First response)

____

84. Why don't you eat this food (food named in previous question) during lactation?

____

85. What are the foods that you strictly do not eat when you are lactating? (Second response)

____

86. Why don't you eat this food (food name in previous question) during lactation?

____

87. What are the foods that you strictly do not eat when you are lactating? (Third response)

____

88. Why don't you eat this food (food named in previous question) during lactation?

____

89. What are the foods that you strictly do not eat when you are lactating? (Fourth response)

____

90. Why don't you eat this food (food named in previous question) during lactation?

____

91. What are the foods that you should eat when you are pregnant? (First response)

____

92. What is the reason for eating this food (food name in previous question) while pregnant?

____

93. What are the foods that you should eat when you are pregnant? (Second response)

____

94. What is the reason for eating this food (food named in previous question) while pregnant?

____

95. What are the foods that you should eat when you are pregnant? (Third response)

____

96. What is the reason for eating this food (food named in previous question) while pregnant?

____

97. What are the foods that you should eat when you are pregnant? (Fourth response)

____

98. What is the reason for eating this food (food named in previous question) while pregnant?

____

99. What are the foods that you should eat while you are lactating? (First response)

____

100. Why do you eat this food (food named in previous question) during lactation?

____

101. What are the foods that you should eat while you are lactating? (Second response)

____

102. Why do you eat this food (food named in previous question) during lactation?

____

103. What are the food that you should eat while you are lactating? (Third response)

____

104. Why do you eat this food (food named in previous question) during lactation?

____

105. What are the foods that you should eat while you are lactating? (Fourth response)

____

106. Why do you eat this food (food named in previous question) during lactation?

____

107. What are the foods that the family does not eat at all due to beliefs and habits? (First response)

____

108. What are the foods that the family does not eat at all due to beliefs and habits? (Second response)

____

109. What are the foods that the family does not eat at all due to beliefs and habits? (Third response)

____

sk

110. What are the foods that the family does not eat at all due to beliefs and habits? (Fourth response)

____

111. What do you mostly use for cooking?

No. of allowed replies: 1.

( ) 1. wood
( ) 2. charcoal
( ) 3. cow dung
( ) 4. kerosine
( ) 5. wood + charcoal
( ) 6. wood + cow dung
( ) 7. other

112. Breastfeeding

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

113. Receives food other than breast milk

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No
( ) 3. Adult's food only

114. Vaccinated

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

115. Birth rank of child

No. of allowed replies: 1.

( ) 1. First
( ) 2. Second

( ) 3. Third
( ) 4. Fourth
( ) 5. Fifth
( ) 6. Sixth
( ) 7. Seventh
( ) 8. Eighth
( ) 9. Ninth or more

116. Age of the child

___________ Months

117. Sex of the child

No. of allowed replies: 1.

( ) 1. Male
( ) 2. Female

118. Weight of child

____________ Kilograms

119. Weight-for-age score for the child

____

120. Height of child

____________ Centimeters

121. Height-for-age score for the child

____

122. Weight-for-height score for the child

____

123. Household size (total number of individuals in the household)

_____________ People

124. Number of children under 5

No. of allowed replies: 1.

( ) 1. One
( ) 2. Two
( ) 3. Three
( ) 4. Four

____

125. Number of adults in the household

---

126. Eco-zones

No. of allowed replies: 1.

( ) 1. Highland
( ) 2. Middleland
( ) 3. Lowland

127. Crop zones

No. of allowed replies: 1.

( ) 1. Crop
( ) 2. Cash
( ) 3. Crop + cash

Appendix C

'HOUSEHOLD

ECOZONE

1. Eco-zones

No. of allowed replies: 1.

( ) 1. Highland
( ) 2. Middleland
( ) 3. Lowland
( ) 4. Urban

CROP ZONE

2. Crop zones

No. of allowed replies: 1.

( ) 1. Crop
( ) 2. Cash
( ) 3. Crop+Cash

3. Child number

____

AGE AND SEX OF CHILDREN

4. Age of the child

___________ Months

5. Sex of the child

No. of allowed replies: 1.

( ) 1. Male
( ) 2. Female

6. Weight of child

____________ Kilograms

7. Weight-for-age score for the child

____

8. Height of child

    ____________ Centimeters

9. Height-for-age score for the child

    ____

10. Weight-for-height score for the child

    ____

HOUSEHOLD SIZE

11. Household size (total number of individuals on the form)

    ____________ People

12. Number of children under 5

    No. of allowed replies: 1.

    ( ) 1. One
    ( ) 2. Two
    ( ) 3. Three
    ( ) 4. Four

    ____

AGRICULTURAL VARIABLES

13. Land holding

    ____________ Hectares

14. Number of hectares under food crop cultivation

    ____________ Hectares

15. Number of hectares under cash crop cultivation

    ____________ Hectares

16. Source of major food crops for consumption

    No. of allowed replies: 1.

    ( ) 1. Produced
    ( ) 2. Purchased
    ( ) 3. Produced and purchased
    ( ) 4. Aid

17. What are the main staple cereals of your family?

    ____

18. What percent of the food consumed annually is produced?

    ____________ Percent

20. Do you raise poultry?

    No. of allowed replies: 1.

    ( ) 1. Yes
    ( ) 2. No

20. Do you own milk animals?

    No. of allowed replies: 1.

    ( ) 1. Yes
    ( ) 2. No

21. If yes, what do you do with the milk and milk products?

    No. of allowed replies: 1.

    ( ) 1. Mainly consume
    ( ) 2. Mainly sell
    ( ) 3. Sell and consume
    ( ) 4. Not applicable

22. Do you grow fruits?

    No. of allowed replies: 1.

    ( ) 1. Yes
    ( ) 2. No

23. Do you grow vegetables?

    No. of allowed replies: 1.

    ( ) 1. Yes
    ( ) 2. No

24. Do you use chemical fertilizers?

    No. of allowed replies: 1.

    ( ) 1. Yes
    ( ) 2. No

FEEDING HABITS

25. How long do you usually breastfeed your children?

    ____________ Months

26. At what age do you give additional food to your children?

____________ Months

27. What are the foods that you strictly do not eat when you are pregnant? (First response)

____

28. What are the foods that you strictly do not eat when you are lactating? (First response)

____

29. Breastfeeding

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

30. Receives food other than breast milk

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No
( ) 3. Adult's food only

31. Source of water for drinking and food preparation

No. of allowed replies: 1.

( ) 1. River
( ) 2. Spring
( ) 3. Lake
( ) 4. Well
( ) 5. Pond
( ) 6. Pipe

HEALTH OR MEDICAL

32. How far do you live from the nearest health institution?

______________ Kilometers

33. Number of children under 5 ith diarrhea during the last two weeks prior to the survey

____

34. Total number of live-births

____

35. Total number of children died

____

36. Number of children who died before one year of age

____

37. Vaccinated

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

EDUCATION

38. Mother read and write

No. of allowed replies: 1.

( ) 1. Reads and writes
( ) 2. Does not read or write

39. How long do you think a child should be breast fed?

_______________ Months

40. Where do you go first when a family member becomes sick?

No. of allowed replies: 1.

( ) 1. Health institution
( ) 2. Traditional practitioner
( ) 3. Local injector
( ) 4. Drug vendor shop
( ) 5. Nowhere

INCOME

41. Do you participate in any women's income generating activity?

No. of allowed replies: 1.

( ) 1. Yes
( ) 2. No

Appendix D

LIST AND CODES OF STUDY VARIABLES

Qno.	Varcode	Type	Question		
1	REGION	NUM	Region	Unit:	Limits: 1.00000 to 14.0000
2	AWRAJA	CL/D	Awraja	No of classes: 6.	
3	WOREDA	CL/D	Woreda	No of classes: 7.	
4	YEAR	NUM	Year	Unit:	Limits: 76.00000 to 77.0000
5	MONTH	NUM	Month	Unit:	Limits: 1.00000 to 12.0000
6	FAS	NUM	Farmers Asso	Unit:	Limits: 0.00000 to 87.0000
7	ECOZONE	CL/D	Eco-zones	No of classes: 4.	
8	CROPZON	CL/D	Crop zones	No of classes: 3.	
9	CHILDNO	NUM	Child number	Unit:	Limits: 1.00000 to 5.0000
10	AGECHIL	NUM	Age of the c	Unit: Month	Limits: 0.00000 to 59.00000
11	SEXCHIL	CL/D	Sex of the c	No of classes: 2.	
12	WTCHIL	NUM	Weight of ch	Unit: Kilog	Limits: 2.00000 to 30.0000
13	WACHIL	NUM	Weight-for-a	Unit:	Limits: 50.0000 to 130.000
14	HTCHIL	NUM	Height of ch	Unit: Centi	Limits: 30.0000 to 150.00
15	HACHIL	NUM	Height-for-a	Unit:	Limits: 70.0000 to 130.0000
16	WHCHIL	NUM	Weight-for-h	Unit:	Limits: 60.0000 to 130.0000
17	HOUSIZE	NUM	Household si	Unit: Peopl	Limits: 2.00000 to 18.0000
18	CHIFIVE	CL/D	Number of ch	No of classes: 4.	
19	LANDHOL	NUM	Land holding	Unit: Hecta	Limits: 0.00000 to 10.00000
20	CROPCUL	NUM	Number of he	Unit: Hecta	Limits: 0.00000 to 10.0000

21	CASHCRC	NUM	Number of he	Unit: Hecta Limits: 0.00000 to 10.0000
22	CONSUMP	CL/D	Source of ma	No of classes: 4.
23	STAPLE	NUM	What are the	Unit: Limits: 1.00000 to 15.0000
24	POULTRY	CL/D	Do you raise	No of classes: 2.
25	LIVESTO	CL/D	Do you own m	No of classes: 2.
26	PROLIVE	CL/D	If yes, what	No of classes: 4.
27	FRUITS	CL/D	Do you grow	No of classes: 2.
28	VEGETAB	CL/D	Do you grow	No of classes: 2.
29	FERTILI	CL/D	Do you use c	No of classes: 2.
30	BREAST	NUM	How long do	Unit: Month Limits: 0.00000 to 48.0000
31	ADDFOOD	NUM	At what are	Unit: Month Limits: 0.00000 to 48.0000
32	WEANCHI	NUM	How many tim	Unit: Limits: 0.00000 to 10.0000
33	PRETAB1	NUM	What are the	Unit: Limits: 0.00000 to 12.0000
34	LACTAB1	NUM	What are the	Unit: Limits: 0.00000 to 12.0000
35	BFYORN	CL/D	Breastfeedin	No of classes: 2.
36	RECFOOD	CL/D	Receives foo	No of classes: 3.
37	WATER	CL/D	Source of wa	No of classes: 6.
38	HEAINST	NUM	How far do y	Unit: Kilom Limits: 0.00000 to 30.0000
39	DIARRHA	NUM	Number of ch	Unit: Limits: 0.00000 to 5.0000
40	LIVEBIR	NUM	Total number	Unit: Limits: 0.00000 to 12.0000
41	DIED	NUM	Total number	Unit: Limits: 0.00000 to 12.0000
42	NOCHILD	NUM	Number of ch	Unit: Limits: 0.00000 to 12.0000
43	VACCIN	CL/D	Vaccinated	No of classes: 2.
44	MOREAD	CL/D	Mother read	No of classes: 2.
45	BREASTF	NUM	How long do	Unit: Month Limits: 0.00000 to 48.0000
46	SICK	CL/D	Where do you	No of classes: 5.
47	INCOME	CL/D	Do you parti	No of classes: 2.

Appendix E

LETTER OF PERMISSION

TO: Dr. L. Brockman, Head of Child Development Center, Faculty of Human Ecology

FROM: Girma Seyoum, Grad. Student, Foods & Nutrition Dept.

SUBJECT: Submission For a Request to Involve Children (In the Child Development Center of The Faculty of Human Ecology) In The Proposed Dark Adaptation Study.

I am a graduate student in the Faculty of Human Ecology, Department of Foods and Nutrition. I am currently in the process of undertaking my Thesis research which is on "Modification of the Standard Rapid Dark Adaptation Test and Measurement of Dark Adaptation in Adults and Children".

One of the purposes of this study is to develop a dark adaptation test suitable for use in children as a means of screening poor dark adapting individuals due to poor Vitamin A status. This involves modification of the Standard RDAT described by Thornton (1977). Since this standard test is time-consuming, involves a series of steps which may not be appropriate for children and also requires not only dark adaptation ability but also cognitive skills. Thus, the involvement of children in this study is important to see if the modified dark adaptation test would be applicable for use in children.

- The number of children required for the study is 8, preferably, 4 boys and 4 girls.
- Age group required is: 3-5 year old children
- Preferably, at least one boy and one girl from each age group in the afternoon shift

The study is expected to start in mid-November, 1986 and it is going to be carried out in Room 311 of the Human Ecology Building. The entire test procedure is expected to take about 10 minutes and participating children may have to leave their class for about 15-20 minutes. A member of the family of each participating child is requested to accompany and remain with the child during the entire test procedure.

The test procedure is explained in the request letter which is going to be sent to parents of children, and this request letter is attached here with.

For further information, you are welcome to contact me or Dr. G. P. Sevenhuysen, Dept. of Foods and Nutrition. My phone number is: , Phone Dr. Sevenhuysen at 474-9556.

Appendix F

LETTER OF REQUEST

University of Manitoba
Faculty of Human Ecology
Department of Foods & Nutrition

January,1987

To: Parents
From: Girma Seyoum,Graduate Student,Foods & Nutrition Department
Subject: Request for involvement of your child in a study

Dear Parents:

I am a graduate student in the Department of Foods and Nutrition at the University of Manitoba. I am currently in the process of undertaking my thesis research which includes adapting a procedure for children from one used to assess ability to see in dim light conditions. Such ability is a function of the Vitamin A level of individuals. Measuring dark adaptation is one means of assessing the vitamin A nutritional status of individuals since an initial sign of vitamin A deficiency is a decrease in dark adaptation ability. Vitamin A deficiency disease is one of the most frequently occurring nutritional problems in the world and it is the major cause of blindness in children in third world countries. Early detection of vitamin A deficiency through measurement of dark adaptation ability allows preventive and therapeutic measures to be taken which are easy to administer at a relatively low cost.

The purpose of this study is to develop a dark adaptation test suitable for use with children as a means of screening poor dark adapting inidividuals due to poor vitamin A status. The standard Rapid Dark Adaptation Test has been used successfully with adults and it is our interest to modify it for use with children.

Before using the new dark adaptation test for screening purposes in vitamin A deficient children, it needs to be modified to be suitable for children. I, therefore, wish to invite you with your child to partici_ pate in the development of the procedure for this dark adap_ tation test. Your child's participation will include sorting different colored plastic discs under dim light conditions. Before each child starts the actual sorting of the discs, he or she will be light adapted for 60 seconds by requesting him or her to trace a drawing on a white paper. The entire procedure may take up to 10 minutes. You, or a member of your family, is requested to accompany and remain with the child during the entire procedure.

The study will be carried out in Room 311 of Human Ecology Buil_ ding about the middle of January, 1986. If you are interested in participating, I will call you in advance to arrange a time that is convenient to you and your child.

Children initially participating in the study are also free to withdraw at any time during the study. Data obtained from participating children will be kept confidential. After the study has been completed, I will provide you with a brief summary of the results.

If you have any question regarding this study and your child's participation in the study, you are welcome to contact me or Dr. G. P. Sevenhuysen who is my Thesis advisor.

My telephone number is: Phone 474-9556 to contact Dr. G. P. Sevenhuysen.

Yours truly,

Girma Seyoum

CONSENT FORM

The dark adaptation test has been explained to me. I understand the procedure involved and I agree to let my son or daughter participate in the study.

I understand that my child's participation is voluntary and can withdraw from the study at any time.

Name of Parent: ______________________________

Signature: __________________________________

Date: ______________________________________

Telephone: __________________________________