5-1987

Vitamin A Status, Anthropometric Measurements, and Food Practices of Women of Childbearing Age and Their Preschool Children in Northeast Brazil

Susan Ahlstrom Henderson
Utah State University

VITAMIN A STATUS, ANTHROPOMETRIC MEASUREMENTS, AND FOOD PRACTICES OF WOMEN OF CHILDBEARING AGE AND THEIR PRESCHOOL CHILDREN IN NORTHEAST BRAZIL

by

Susan Ahlstrom Henderson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Nutrition and Food Sciences

UTAH STATE UNIVERSITY
Logan, Utah
1987

ACKNOWLEDGEMENTS

Many people have contributed their time and effort to the completion of this study. My deepest appreciation is extended to my major professors, Dr. Carol T. Windham and Dr. Bonita W. Wyse, for their professional expertise, direction, encouragement, and support throughout my graduate school studies. The extra effort given by Dr. Windham will always be remembered. Additional thanks go to the others who served on my graduate committee: Dr. R. Gaurth Hansen for his wealth of experience and insight into nutrition research, Dr. John C. Malechek for his help in connecting me with the Small Ruminant Collaborative Research Support Program (SR-CRSP) in Sobral, Brazil, and Dr. Warren C. Foote for his willingness to advise on short notice. I wish to express my gratitude Mary Farley for running statistical analyses on the data.

I gratefully acknowledge the support of the Consortium for International Development/Women in Development (CID/WID) office in providing the fellowship funding and encouragement that made this research possible, and to Nancy O'Rourke, formerly of that office. Much appreciation is expressed to Dr. Hernando Flores of the Laboratorio de Bioquemica da Nutriciao at the Universidade Federal de Pernambuco for providing valuable experience in vitamin A research, laboratory facilities, technicians, and other assistance. Special thanks are extended to the laboratory nutrition faculty, graduate students, and staff. This study would have been impossible without the help of these talented professionals.

Finally, I wish to express my appreciation to my family for their love and support: to my mother, Anne T. Ahlstrom, for the many hours that she has spent typing and editing papers for me and for the encouragment that she gives to her daughters to become well educated; to my father, C. Blythe Ahlstrom, for his love and guidance throughout my formal edcuation and life in general; and to my husband, Joseph R. Henderson, for the love and encouragment given me to complete my thesis.

Susan Ahlstrom Henderson

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

ABSTRACT

Vitamin A Status, Anthropometric Measurements, and Food Practices of Women of Childbearing Age and Their Preschool Children in Northeast Brazil

by

Susan Ahlstrom Henderson, Master of Science

Utah State University, 1987

Major Professors: Carol T. Windham, Ph.D. and Bonita W. Wyse, Ph.D., R.D.
Department: Nutrition and Food Sciences

Vitamin A nutrition status was evaluated in 110 pairs of women and their preschool children at rural health posts in two different ecological regions of Northeast Brazil. Serum retinol and carotene, weight, height, tricep skinfold and mid-arm circumference were measured from each mother and child. Nutrition knowledge of mothers, socioeconomic living conditions and consumption of retinol and carotene food sources were assessed.

Nine children (8 percent) and one mother had less than acceptable serum retinol (less than 20 μg/dl). Additionally, 21 percent of the children and six percent of the mothers had "low" serum carotene levels. Thirty-seven percent and 57 percent of the children were at or below the tenth percentile for height and weight, respectively, when compared to Brazilian standard tables, and 30 percent were below the tenth percentile of weight for height. When compared to NCHS standard tables, 34 percent were below the tenth percentile for weight/height. Nutrition knowledge was very limited, but opportunities for nutrition education are great as mothers wanted more nutrition and feeding information. Squash, carrots and mangoes were more common sources of vitamin A than were animal sources.

Multiple regression models indicated statistical significance among mothers' serum retinol, survey site, and mothers' weight/height percentile and among mothers' vitamin A intake, survey site, and mothers' ages. The data indicate that vitamin A nutrition status is suboptimal in Northeast Brazil, but appropriate food sources exist. Long-term intervention projects need to focus on increasing the production, distribution, and consumption of preformed vitamin A- and carotene-rich foods.

(149 pages)

STATEMENT OF THESIS PROBLEM

The ultimate goal of nutrition research is to develop the means of improving the nutrition status, and thus the health and well-being, of individuals and groups at risk for malnutrition. Although not recognized as a nutrition problem of public health significance until the 1960s (Oomen, et al., 1964), vitamin A deficiency has long been the leading cause of blindness, especially among young children, in developing areas of the world. Recently, emphasis has been placed on research into the roles of vitamin A in the body, the detection of vitamin A deficiency, cultural food practices, dietary intakes of vitamin A, and intervention programs for the purpose of eradicating hypovitaminosis A by the year 2000.

Nature and Origin of the Study

Northeast Brazil is one of the most poverty-stricken and underdeveloped regions of Latin America. Poverty and underdevelopment contribute to poor nutrition, including vitamin A deficiency, in the population. Vitamin A deficiency was first identified as a severe nutrition problem in Northeast Brazil by the Interdepartmental Committee for Nutrition for National Defense (ICNND, 1965); it continues to be a major nutrition problem in all three ecological regions of the Northeast (Gomes, et al., 1970; Olson, 1979; Simmons, 1976; Santos, et al., 1983; Flores and Araujo, 1984; Dorea, et al., 1984).

The acute manifestation of hypovitaminosis A is ocular lesions known as xerophthalmia. Under extreme deficiency, the symptoms may advance quickly to keratomalacia, liquefaction of the cornea of the eye, and irreversible blindness; this is the major cause of blindness in developing countries of the world.

Research on the deficiency state in animals now indicates that even subclinical levels of vitamin A deficiency can negatively affect growth, differentiation and integrity of epithelial cells, reproduction, fetal development, cerebralspinal fluid pressure, resistance to infection, and vestibular balance (McLaren, et al., 1981).

Requirements for vitamin A increase during periods of rapid growth; this makes young children, who require relatively large amounts of vitamin A for proper growth and development, especially susceptible to deficiency. Although infants are born with low liver stores of vitamin A, xerophthalmia is rarely reported in breastfed infants and children who continue breastfeeding into their second year (Underwood, 1984). Early weaning of infants to diets inadequate in vitamin A is believed to correspond to a higher prevalence of vitamin A deficiency signs and symptoms. The highest incidence of xerophthalmia is reported in preschool children between two and five years of age (Sommer, 1982; Chandra, et al., 1960).

Women of childbearing age constitute another high risk group for vitamin A deficiency. Requirements for vitamin A are increased slightly during pregnancy and substantially during lactation (WHO, 1974). Night blindness (Dixit, 1966) and low serum retinol levels (Venkatachalam, et al., 1962) were reported in India among pregnant women from poor communities. Night blindness symptoms disappeared spontaneously a few days after delivery, but low serum levels of vitamin A remained (Venkatachalam, et al., 1962).

Higher animal species are not capable of synthesizing active forms of vitamin A from smaller molecules. Vitamin A must be obtained through the diet from pro-vitamin sources or larger carotenoid precursors. Preformed retinoids are found mainly in the livers of mammals, fish, and poultry. Other sources include organ meats and dairy products. Good sources of pro-vitamin A carotenoids include green leafy vegetables and yellow-orange fruits and vegetables.

Although much is known about the cause of and the cure for hypovitaminosis A, more research is needed to explore the extent of the problem in specific regions of the world and to develop intervention programs, where needed, that will improve the vitamin A status of populations at risk.

Statement of the Problem

Vitamin A deficiency has been documented in the three ecological regions of Northeast Brazil, but few intervention projects, other than occasional prophylactic supplementation programs aimed at increasing the vitamin A status of populations at risk, have been implemented. Study of local food sources of vitamin A, socioeconomic status, and nutrition knowledge and their relationship to vitamin A status, of the populations at risk for vitamin A deficiency is needed. This information would be useful in developing appropriate and culturally specific, long-term intervention programs to improve the nutrition status of young children and women of childbearing age.

Purpose of the Study

The purpose of this project was to the evaluate vitamin A and general nutrition status, identify food practices and food sources of vitamin A for women and their preschool children in two ecological regions in rural settings of Northeast Brazil. Relationships among nutrition status, dietary intake of vitamin A-containing foods, availability of vitamin A-containing foods, and socioeconomic status of the project participants were explored. Intervention measures to improve the nutrition status of these two vulnerable population groups were proposed.

Objectives of the Study

The objectives of this study were to:

1. Assess vitamin A status of women of childbearing age and and their preschool children using serum retinol and serum carotenoid levels;

2. Assess the general nutrition status of these two population groups using anthropometric measurements;

3. Assess dietary intake of a) vitamin A-containing foods, including organ meats, goat's and cow's milk, and dairy products, and b) carotenoid-containing foods, including green leafy vegetables and yellow-orange fruits and vegetables;

4. Make a qualitative assessment of the food supply, in season;

5. Assess general nutrition knowledge and practices of mothers with respect to appropriate diets for pregnancy, lactation, and weaning;

6. Assess socioeconomic status of the families;

7. Determine relationships among vitamin A status and general nutrition status, dietary intake, nutrition knowledge and practices of the mothers, and socioeconomic status;

8. Suggest methods of intervention for improving the vitamin A status of these two vulnerable population groups.

Significance of the Study

Evaluation of nutrition status, dietary intake of vitamin A-active foods, nutrition knowledge of mothers, and socioeconomic status of families is necessary to identify determinants and prevalence of hypovitaminosis A in Northeast Brazil. Information from this study can be used to identify vitamin A-active foods that are culturally acceptable and available for consumption by the populations at risk.

Information gathered in this study will also be useful in developing and implementing intervention programs that encourage increased home production and intake of vitamin A-active foods, especially during weaning, pregnancy, and lactation. Intervention programs should build upon the current nutrition knowledge and food practices of the mothers in order to develop regionally specific programs for the elimination of hypovitaminosis A in Northeast Brazil.

Research Design

Data for this study were gathered at four rural community health posts, two in the municipal district of Vitoria de Santo Antão in the "Mata" zone and two in the municipal district of Caruaru of the "Agreste" zone, in the state of Pernambuco, Brazil. One hundred ten women and their preschool children donated blood samples for vitamin A and carotenoid analysis. Participants were measured anthropometrically. Nutritionists from the Laboratorio de Bioquimica da Nutricão of the Departamento de Nutricão at the Universidade Federal de Pernambuco (UFPe, Recife, Brazil) interviewed the women using a questionnaire prepared at Utah State University (USU) and revised at UFPe. The women were queried about their nutrition knowledge, diets, child feeding practices, intake of vitamin A-active foods, living conditions, and home cultivation of gardens and animals. In addition, local markets were visited to identify vitamin A-active foods and the cost and availability of these foods.

At local health posts, blood serum was separated from the packed cells and frozen immediately for transport to the UFPe laboratory for analysis using spectrophotometric method by ultraviolet inactivation. The children were each given a capsule containing 200,000 IU vitamin A and 40 mg vitamin E, supplied by (UNICEF). The children were given breakfast and a toy, and photographed so that pictures could be distributed during a second visit.

A second visit was a made to the health posts a month later. The children were again measured, weighed, and blood samples taken.

Serum retinol and carotene levels were compared to ICNND standards. The mothers' anthropometric measurements were compared to United States National Center for Health Statistics (NCHS) standards. The children's anthropometric measurements were compared to both Brazilian and United States NCHS standards. Descriptive statistics were computed for all variables of interest. Multiple linear regression models were developed to determine the affect of selected variables on the vitamin A intake and status of the women and children.

Limitations

A much more expansive survey is needed to determine the extent of vitamin A deficiency in Northeast Brazil. The data collected, at best, can only represent the extent of hypovitaminosis A in the two municipal districts where samples were taken. A better approximation of the extent of the deficiency would have been obtained from a randomized sample of participants. In addition, the unbalanced number of participants from each survey site made statistical analysis difficult.

Vitamin A deficiency is presumed to be more prevalent in the Sertão, the poorest ecological region of the Northeast. Originally, samples were to be gathered in the city of Sobral in the Sertão, but sampling in this region was prevented by logistical considerations: lack of functioning health posts from which to gather samples, lack of support personnel to draw blood and to interview participants, and absence of laboratory facilities for vitamin A and carotene analysis.

The timing involved in gathering the samples may also be an important factor in determining the extent of vitamin A deficiency. Samples for this study were gathered during the rainy season when fruit and vegetable sources or pro-vitamin A are most readily available. In addition, 1985 was a year of unusually abundant rainfall preceded by approximately five years of drought.

There are numerous constraints involved with working outside of one's native country. Language and cultural differences made communication with the research team and survey participants difficult. It was necessary for native interviewers to collect much of the data and, therefore, there was less control over the final design of the survey instrument, interpretation of the responses, and coding of the responses.

At the time of this study there were no widely accepted, valid clinical or biochemical methods for evaluating subclinical vitamin A deficiency. The analytical approach using relative dose response (RDR) developed by Loerch, et al. (1979) and implemented at the University of Pernambuco was the research team's method of choice. In the established procedure for measuring RDR (Flores, et al., 1984) the participant donated a fasting blood sample, was given a standard dose of 450 RE vitamin A, and donated a second blood sample, five hours later. In this study, the participants were given a large dose of vitamin A, 200,000 IU immediately following the first blood draw and the second blood sample was drawn after thirty days. This modified RDR may not be as reliable as the true RDR procedure.

Since the study was conducted, impression cytology has been developed as a more reliable indicator of subclinical vitamin A deficiency. If the study were to be repeated, an effort would be made to use impression cytology, and perhaps evaluate the RDR data with reference to impression cytology to determine the validity of the RDR approach for determining subclinical vitamin A deficiency.

REVIEW OF LITERATURE

Introduction

Vitamin A deficiency with xerophthalmia, the ocular manifestation of the deficiency, continues to be the leading cause of blindness in young children, especially in the lesser-developed countries of the world. An estimated five million children develop clinically detectable xerophthalmia each year in four major Asian countries alone. Of these, at least 500,000 preschool children develop potentially blinding lesions, of which 50 percent, 250,000, are blinded in both eyes (Sommer, et al., 1981; McLaren, 1986a).

Xerophthalmia is believed to be most prevalent in Asia, especially in India, Indonesia, Bangladesh, and the Philippines (Helen Keller International, 1983; McLaren, et al., 1981). The deficiency is common in parts of China, Thailand, Malaysia, and Southeast Asia (Helen Keller International, 1983), and is frequently encountered in Middle Eastern, African, and Latin American countries (Oomen, 1976; HKI, 1983; McLaren, 1986a). In all, vitamin A deficiency is considered a public health problem in an estimated 73 countries and territories around the world (Protein Advisory Group, 1976).

In the past few years, researchers have become increasingly aware of the many functions of vitamin A in the body. As well as being essential to the proper functioning of the rods in the eye, retinol is needed for normal growth and development, tissue differentiation, and in the body's immune system for defense against infections (McLaren, et al., 1981). The Xerophthalmia Club (1986) expressed its concern about "mild" vitamin A deficiency,

> Now it appears that vitamin A may also have a key role in preventing deaths from diarrhoea and acute respiratory infection. Indeed, the eyes may be the last organ affected, not the first (Xerophthalmia Club, 1986, p. 5).

Vitamin A Deficiency in Brazil

The problem of hypovitaminosis A in Brazil is unique in that Brazil itself, because of economic development in the South, is considered a graduate of the lesser-developed world. However, northeastern Brazil, where vitamin A deficiency most commonly occurs, remains one of the most poverty-stricken and underdeveloped areas of Latin America.

In 1965 the Interdepartmental Committee on Nutrition for National Defense (ICNND) survey revealed a number of nutrition problems in Northeast Brazil and identified vitamin A deficiency as one of the most serious (ICNND, 1965). According to the ICNND report,

> A greater percentage of values fell within the "deficient" range for vitamin A than [for] any other nutrient in this survey. Approximately 10 percent of all subjects over six years old and 30 percent of the children under five had less than 10 µg vitamin A per 100 ml plasma. (ICNND, 1965, p. 246)

The ICNND suggested that serum vitamin A levels less than 10 µg per 100 ml indicated a vitamin A-deficient state. Individuals with blood serum levels between 10 µg and 19 µg per 100 ml were considered to have low vitamin A stores. Normal serum vitamin A levels were considered to range between 20 µg and 50 µg per 100 ml (ICNND, 1963). The report attributed the deficiency to "low consumption of milk, butterfat, and eggs," and only seasonal consumption of carotenes from fruits and vegetables (ICNND, 1965).

More recent Brazilian studies continue to report low blood serum levels of vitamin A (Gomes, et al., 1970; Flores, et al., 1984; Roncada, et al., 1978b; Favaro, et al., 1985), as well as low hepatic stores of the vitamin in children (Flores and Araujo, 1984; Dorea, et al., 1984; Olson, 1979). Additional studies have focused on the clinical signs of xerophthalmia in several states of the Brazilian Northeast (Santos, et al., 1983; Simmons, 1976). Vitamin A intake was found to be poor in low income populations of the Northeasr (Jansen, et al., 1977), among urban northeastern migrant workers (Ward and Amoni, 1980), and in Manaus (Horner, et al., 1981).

Since vitamin A is stored largely in the liver, hepatic concentration of vitamin A is considered the best biochemical indicator of body reserves (Olson, 1979). Liver stores of vitamin A have been used by several researchers in Brazil as a means of estimating the prevalence of hypovitaminosis A within a given population (Olson, 1979; Dorea, et al., 1984; Flores and Araujo, 1984).

Olson (1979) used this method in Salvador, Bahia and found that 3 percent of the premature, stillborn or short-lived infants were at risk ($\leq$ 5 µg retinol per 100 ml of serum) for hypovitaminosis A. Children at high risk increased to 30 percent for those between the ages of three months and two years. Olson estimated the number of children, birth to four years, with inadequate vitamin A stores to be 3 percent, with approximately 1 percent at high risk for hypovitaminosis A.

Flores and Araujo (1984) conducted similar studies in Recife, Pernambuco, and found that 3 percent of necropsy samples of children from birth through four years old were at high risk; 17 percent were at moderate risk. Another study, involving the liver stores of fetuses and infants, taken at autopsy, in Brasilia (Dorea, et al., 1984), concluded that none of the infants were at high risk, but 12 percent had insufficient reserves.

In a clinical study, Simmons (1976) estimated that 1000 children were blinded yearly from xerophthalmia in Northeast Brazil. The greatest numbers were found in the state of Ceará.

> Five hundred eighty-one were recorded with blindness from vitamin A deficiency. Six hundred ninety-six children were treated and cured for xerophthalmia and 141 children were recorded with follicular hyperkeratinosis. (Simmons, 1976, p. 118)

Simmons found the state of Ceará to have the highest incidence of xerophthalmia. In the same study (Simmons, 1976), an ophthalmologist from Pirambu Clinic, commented that the cases of xerophthalmia had decreased in the city, but were still common in the interior rural and less developed areas. In Ceará a seasonal difference was noted. The cases of xerophthalmia increased at the end of the dry season, from October to December; gastrointestinal disease also increased during this season.

A clinical study in the state of Paraiba concluded that vitamin A deficiency occurs more frequently in the Sertão, the semi-arid inland regions, than in the coastal (Litoral/Mata) or transitional (Brejo/Agreste) regions of the Northeast (Santos, et al., 1983). This difference may be explained by the scanty rainfall, and hence limited food supply, of the Sertão.

In contrast, a 1978 investigation into the prevalence of xerophthalmia in Brazil concluded that xerophthalmia was not a major public health concern (Roncada, et al., 1978a). The survey was conducted by mail to Brazilian ophthalmologists; of the 300 questionnaires sent, 79 were returned with usable information. The ophthalmologists who responded verified only six cases of xerophthalmic blindness. Roncada and Szarfac (1975) found normal serum vitamin A concentrations in pregnant women in São Paulo state.

Regardless of inadequate statistical records available from ophthalmologists concerning the extent of xerophthalmia in Brazil, many nutrition surveys have identified hypovitaminosis A as a public health problem in various states of the country, not solely the Northeast. Vitamin A deficiency has been reported in Pernambuco (Gomes, et al., 1970; Flores and Araujo, 1984; Simmons, 1976), Ceará (Gomes, et al., 1970; Simmons, 1976; Ward and Amoni, 1980), and Paraiba (Gomes, et al., 1970; Santos, et al., 1983) states of the Northeast. Vitamin A deficiency has also been reported in Manaus

(Giugliano, et al., 1978), Bahia (Olson, 1979; Horner, et al., 1981), and among migrant workers living in the South (Roncada, et al., 1978b, 1981).

Human Dietary Requirements

Estimates of human dietary requirements for vitamin A are primarily based upon evidence of need from animal experimentation (Food and Nutrition Board, 1980; FAO/WHO, 1967). Actual human requirements are somewhat uncertain, as ethical considerations do not permit experimentation on populations most at risk for deficiency, i.e., infants, children, and pregnant women.

Information is limited on the amount of dietary vitamin A needed to provide adequate liver storage in infants (Rodriguez and Irwin, 1972). Newborns have limited vitamin A reserves because of placental controls (Underwood, 1984). The majority of the world's infants depend upon breastmilk, and therefore, on the vitamin A status of their mothers, to build stores in the first months of life. Breastmilk contains approximately 1898 IU/liter (Worthington-Roberts, et al., 1985) which converts to 570 RE/liter. An intake of 420 RE per day is recommended for infants during the first six months by the Food and Agriculture Organization, the World Health Organization of the United Nations (FAO/WHO, 1967), and the Food and Nutrition Board, National Research Council, National Academy of Sciences (1980).

Clinical evidence of deficiency is rare among infants who are breastfed, even when the breastmilk is considered low in vitamin A (FAO/WHO, 1967). However, the incidence of clinical vitamin A deficiency increases in developing countries as children are weaned. In general, their weaning diets are low in sources of vitamin A (Underwood, 1984).

Requirements for vitamin A, based upon body weight, are believed to decline through the first years of life and increase slightly during the adolescent years. FAO/WHO (1967) recommends approximately 300 μg/day for preschool children and 750 μg/day for adults (WHO, 1974). The Food and Nutrition Board (1980) recommends 400 RE/day for preschool children, 800 RE/day for women, and 1000 RE/day for men. In the United States, recommendations for vitamin A during pregnancy and lactation increase by 200 RE and 400 RE, respectively. Recommendations are set considerably above the requirement because of individual variability and because a substantial number of individuals, even in developed countries, have reduced liver stores (Underwood, 1984).

Vitamin A Absorption, Transport, and Metabolism

Food Sources of Vitamin A

The major dietary sources of preformed vitamin A are long-chained fatty acid retinyl esters found in animals. From plants, carotenoids, sources of provitamin A, can be converted to active forms of vitamin A in the body. Vitamin A occurs naturally only in animals; however, higher species cannot synthesize the vitamin from smaller molecules. The higher animal species must be supplied with preformed vitamin A or the carotenoid precursors, which are produced by photosynthesis in plants (Pitt, 1985).

The best sources of preformed vitamin A are found in liver and fish liver oils (Olson, 1986). Significant amounts of preformed vitamin A are found in dairy products, kidney, and eggs (Pitt, 1985; Olson, 1986). Animal livers are the richest sources because of the role of liver in the uptake, storage and conversion of carotenoids to vitamin A, and control of vitamin A circulation (Underwood, 1984).

Carotenoid precursors of vitamin A are widely found in plants. High amounts are found in many of the yellow-orange fruits and vegetables and green leafy vegetables. Carrots, yellow squashes, spinach, kale, chard and beet greens are excellent sources. Lesser amounts are found in tomatoes, lettuce, and peaches.

For a carotenoid to be an active provitamin, it must have at least half of its molecule as retinol. Since both halves of ß-carotene correspond to retinol, it is the most active of the provitamins. Other less-active provitamins include ∂-carotene, gamma-carotene, ß-crytoxanthin, and ß-carotene-5,6-epoxide (Pitt, 1985). It is difficult to predict with confidence the availability of ß-carotene since absorption of carotenes from different foods varies widely.

Conversion factors used to determine the vitamin A-activity of carotenoids, underestimate the vitamin A provided from some food sources and overestimate the vitamin A-activity of others, depending upon the types of carotenes found in the food, and the degree of conversion and absorption (Pitt, 1985). This may partly explain the differences found in the vitamin A status of communities having seemingly similar intakes of carotene-containing foods. Vitamin A deficiency is a public health problem primarily in areas of the world where carotenes comprise the major source of dietary vitamin A. The deficiency is rare in regions where preformed vitamin A food sources provide more than 50 percent of the vitamin (McLaren, 1963).

<u>Absorption</u>

Dietary vitamin A and carotenoids are released from food particles by the action of pepsin in the stomach and proteolytic enzymes in the small intestine to form fatty globules. In the small intestine, these globules are dispersed by bile salts (De Luca, et al., 1979).

Most dietary, preformed vitamin A is in the form of retinyl esters which are hydrolyzed to retinol before being incorporated into the chylomicra in the intestinal lumen and absorbed into mucosal cells. The enzyme responsible for this hydrolysis is believed to be situated on the brush border (Pitt, 1985).

The most common and effective provitamin is ß-carotene, which can be split in the middle by ß-carotene 15,15'-dioxygenase (a soluble enzyme found in the intestine and liver) to yield two molecules of retinaldehyde. Molecular oxygen reacts across the central double bond with the 15 and 15' carbon atoms to form a peroxide of ß-carotene that rapidly cleaves to form two molecules of retinaldehyde (Pitt, 1985). Most of the retinaldehyde formed is reduced to retinol by retinaldehyde reductase for use in the body. However, small amounts are oxidized to retinoic acid and pass into the portal vein. Conversion of the carotenoids to vitamin A is well regulated, so excessive vitamin A will not be produced from carotenoids.

Approximately 75 percent of the retinol, obtained by hydrolysis of retinyl esters or by reduction of carotenoids, is re-esterified inside the mucosal cells with long-chain fatty acids (Helgerund, et al., 1983). The predominant ester formed is retinyl palmitate; smaller quantities of oleate, stearate, and other fatty acyl esters are also formed (Pitt, 1985; Olson, 1986). These retinyl esters are incorporated into lymph chylomicra and taken to the liver. Retinol is absorbed with 80 to 90 percent efficiency; absorption is somewhat decreased when large doses are consumed (Olson, 1986).

The conversion of carotenoids to vitamin A is incomplete; some carotenoids are absorbed intact and travels in the blood stream as part of lipoproteins. Total blood carotene levels reflect dietary carotene, not the storage of vitamin A. Their significance as indicators of vitamin A status has not been defined.

Bile salts, pancreatic lipase and fat aid in the absorption of vitamin A and carotene by the body (Williams, 1985). Bile salts serve as a vehicle of transport through the intestinal wall. Clinical conditions affecting the biliary system, such as obstruction of bile ducts, infectious hepatitis and cirrhosis of the liver hinder vitamin A absorption. The fat-splitting enzyme, pancreatic lipase, is necessary for initial hydrolysis in the upper intestine of fat emulsions of vitamin A. Therefore, in conditions where secretion of pancreatic lipase is curtailed, such as cystic fibrosis, vitamin A absorption is impaired. Some dietary fat in the intestine is needed for effective absorption of both provitamin A and the preformed vitamin. In the absence of dietary fat, absorption efficiency decreases significantly.

The absorption of ß-carotene is affected by other components in the diet, primarily fat, which facilitates absorption. Protein deficiency impairs carotene absorption due to decreased levels of the cleavage enzymes (Arroyave, et al., 1961). ß-catorene is absorbed with approximately 50 to 60 percent efficiency (Goodman, 1984a) while the efficiency of total carotenoid absorption is between 20 and 50 percent (Olson, 1986). Carotenoids are best utilized at low dietary levels; absorption appears to be down regulated on consumption or administration of large doses of the provitamin (Brown, et al., 1987).

Storage

Retinyl esters in chylomicra are transported to the liver, where they are hydrolyzed to retinol, possibly by esterases on the cell membrane, and enter the parenchymal cells (Goodman, 1984a). Within the cell, retinol is associated with cellular retinol binding protein (CRBP) in a lipoglycoprotein complex, then transported to fat-storing liver cells. Fatty acyl coenzyme A derivatives or other acyl donors re-esterify retinol for storage. Within the storage complex, about 96 percent of the vitamin A is in the form of retinyl esters and 4 percent is unesterified retinol (Goodman, 1984a).

Normally, over 90 percent of vitamin A is stored in the liver, with the parenchymal cells having the major role in vitamin A storage. In addition, there is evidence that the fat-storing, non-parenchymal cells also have an important role in vitamin A storage (Goodman, 1984b). Lesser amounts of the vitamin can be found in the kidney and adrenal glands, and small amounts are found in all tissues of the body.

Retinyl esters in liver cells serve as the body's vitamin A reserve, and are used to maintain a steady concentration of vitamin A in blood. As vitamin A is filtered from blood plasma for use by the various non-hepatic organs of the body, storage vitamin A from liver enters plasma.

Unconverted carotene is stored primarily in fat tissue and thus is more evenly distributed throughout the body. Massive doses of carotene are not converted to vitamin A rapidly enough to induce toxicity, but excess carotenes do accumulate in the body and result in a yellowish tinge to the skin. Unlike vitamin A, excessive intakes of carotenoids do not produce toxic effects or clinical symptoms, other than yellow skin, which disappears when excessive ingestion of carotenoids is discontinued (Lui and Roels, 1980).

Transport in Plasma

Retinyl esters, the storage form of vitamin A, must be hydrolyzed to retinol and the retinol attached to a specific carrier protein, plasma retinol-binding protein (RBP), for transport in the bloodstream to the target cells of the body.

Human apo-RBP, a single polypeptide chain with a molecular weight of approximately 21,000 daltons, is synthesized in the liver and modified by microsomal membranes of rough endoplasmic reticulum. The apo-protein contains a hydrophobid-binding site for one molecule of retinol. Apo-RBP and retinol bind in cytoplasm with a 1:1 ratio to form holo-RBP (De Luca, et al., 1979; Goodman, 1984a). Holo-RBP is then secreted by the Golgi apparatus into the blood.

In the blood, holo-RBP reacts with another plasma protein, transthyretin (prealbumin or TTR) in a 1:1 complex. This large complex is believed to play a significant role in preventing the loss of RBP, and thus retinol, from glomerular ultrafiltration in the kidney.

In the absence of retinol, apo-RBP continues to be synthesized by the liver, but is not released, as retinol is required to complete the holo form. However, some apo-protein emerges from the liver in a denatured form. Repletion of the animal with retinol causes a rapid release of holo-RBP into the plasma, temporarily elevating the normal plasma concentrations (Pitt, 1985).

Since retinol is normally secreted complexed with RBP, its plasma concentration depends upon the adequate production of carrier protein. If dietary protein is deficient, insufficient RBP is synthesized by the liver, causing plasma retinol concentrations to fall, regardless of liver retinol reserves.

Uptake by Target Cells

Plasma RBP delivers retinol to specific target cells. Surface receptors for RBP have been found in monkey, bovine, and chicken target cells (Pitt, 1985). Holo-RBP delivers retinol to specific cell surface receptors that recognize RBP and simultaneously release retinol to the cell (Rask, et al., 1979). The apo-RBP is released immediately from the receptor and remains in circulation.

Once released from the cell receptor, the apo-RBP has a slightly modified form which carries a negative charge . The modified apo-RBP no longer associates, as readily, with prealbumin and tends to be filtered by the glomeruli and degraded in the kidney (Pitt, 1985).

Intracellular Metabolism

Within the cell, retinol is not free in solution, but is associated with another binding protein: cellular retinol-binding protein (CRBP). CRBP differs from plasma RBP in molecular weight, only 14,600 daltons, and in amino acid sequence (Rask, et al., 1979). It, too, is a single-chain polypeptide with a single site for binding retinol.

In many cells, such as in the intestinal mucosa and liver, retinol is readily esterified for storage and retinyl esters hydrolyzed for release. Retinol may be involved in the synthesis of glycoproteins in a process involving the phosphorylation of retinol to retinyl phosphate (Pitt, 1985).

Retinol can also be reversibly oxidized to retinaldehyde, and then irreversibly oxidized to retinoic acid (Olson, 1986). For use in the visual cycle of the eye, all-trans-retinaldehyde is reversibly isomerized to 11-cis-retinaldehyde via a series of reactions and multiple enzyme systems.

Questions have been raised about the biological activity of retinoic acid. While retinol and retinaldehyde can be used by all target cells, retinoic acid does not fulfill all vitamin A functions and needs of the organism. Some investigators suggest that retinoic acid is metabolically similar to the retinoid responsible for supporting growth and differentiation (Frolik, 1984). This has led to the theory that different retinoids are responsible for different vitamin A activities.

Other retinoic acid reactions, such as conjugation with glucuronic acid, decarboxylation, further oxidation, epoxidation, and isomerization, result in inactivation.

Excretion

A portion of ingested vitamin A ($\leq$ 20 percent) is not absorbed, but directly excreted in the feces. Twenty to 50 percent is conjugated or oxidized and then excreted within several days via the urine or feces. A significant portion of ingested vitamin A (30-60 percent) is stored in the liver (De Luca, et al., 1979). Therefore, in a given dose of vitamin A, 40-70 percent is excreted within a week, while the remainder is stored, mainly in the liver.

Stored vitamin A is metabolized relatively slowly through two major routes: 1) after retinol is released from the liver, complexed with RBP, it is ultimately dissociated or degraded in epithelial tissue and kidney, and 2) stored retinyl esters are conjugated with glucuronic acid and released via bile in feces or oxidized and excreted in urine (De Luca, et al., 1979).

The rate of vitamin A metabolism depends upon release of retinol complexed with RBP to replace that utilized by cells, liver concentration of vitamin A, and recycled vitamin A (De Luca, et al., 1979). While retinol-RBP complex is released at a relatively constant rate, liver concentration of vitamin A and recycling of the vitamin depend greatly upon the animal's or individual's nutrition status.

Vitamin A Deficiency

Nearly 75 years ago, Osborne and Mendel (1913) and McCollum and Davis (1913), in independent studies, first showed that some natural fats promoted growth in rats, while other fats did not. Since then, vitamin A has been isolated, characterized, synthesized, and extensive experimentation performed on its various forms to determine its metabolic roles and the pathophysiology of inadequate and excessive intakes.

Despite extensive scientific knowledge about vitamin A, human vitamin A deficiency (hypovitaminosis A) is a major public health problem in many developing countries of the world. Hypovitaminosis A is responsible for the majority of preventable blindness, especially in young children; it greatly increases morbidity and mortality of those who suffer from deficiency.

History

In the 1950s many researchers felt that vitamin A deficiency was an unlikely major nutrition problem. Dairy products, a good source of vitamin A, were believed to be consumed by most of the public. It was believed that individuals with limited resources could supplement diets with green leafy vegetables and yellow-orange fruits and vegetables for minimal cost (Pitt, 1985). Results of studies, carried out in various countries using postmortem liver samples to determine body reserves of vitamin A, were interpreted to indicate that most people had adequate stores of vitamin A (Moore, 1957).

In the early 1960s this opinion began to change as numerous surveys revealed vitamin A deficiency in developing countries (McLaren, 1963; McLaren, et al., 1966; Oomen, 1961; Oomen, et al., 1964). Some researchers now claim that after protein-calorie malnutrition (PCM), hypovitaminosis A is the most common nutrition deficiency in the world (Sauberlich, et al., 1974).

Etiology

The primary cause of vitamin A deficiency is simply inadequate intake of vitamin A and its precursor carotenoids. In developing countries, populations with limited economic resources view animal sources of preformed vitamin A (dairy products, liver, and some other organ meats) as luxury items, rather than necessity foods. Families with limited incomes commonly raise animals for sale and use the funds for purchasing staples, such as rice and beans, rather than consuming the animals or milk within the family unit.

While fruit and vegetable sources of vitamin A precursors are less expensive and more widely consumed than animal sources of preformed vitamin A, many underprivileged individuals do not eat these foods. Many are unaware of the body's need for specific nutrients, such as vitamin A. In addition, a higher priority is placed on "filling the belly" than consuming a balanced diet which includes vitamin A foods. Further, many of the high carotenoid fruits and vegetables are available only seasonally.

Risk Factors for Vitamin A Deficiency

Risk factors for hypovitaminosis A influence metabolic need for vitamin A or consumption, absorption, storage, or transport in the body. Environmental risk factors are usually associated with social and economic circumstances of households or the disease state. The risks of vitamin A deficiency are increased in households and neighborhoods characterized by poverty, illiteracy, poor sanitation, social isolation, and inadequate health, medical, and social services. Xerophthalmia tends to "cluster" in particular neighborhoods (Sommer, 1982), which probably reflects poor environmental conditions and chronic low dietary intake of vitamin A by individuals in these neighborhoods.

Such risk factors also influence distribution of vitamin A foods to individuals within households and body utilization of nutrients from foods. Young children, in particular, often consume less varied diets, generally low in vitamin A sources. These same children often suffer from infectious diseases and parasitism, which decrease vitamin A utilization.

Young children. Young children constitute the group most vulnerable to hypovitaminosis A, because of their increased vitamin A requirement for growth, increased need caused by frequent infectious diseases, low liver stores of vitamin A, and diets low in vitamin A-rich and carotenoid-rich foods. Liver stores of vitamin A are low at birth, causing young children to be more susceptible to deficiency syndrome (McLaren, 1975). In adults, liver stores are sufficient to prevent signs of deficiency for many months.

Xerophthalmia, ocular manifestations of vitamin A deficiency, can occur at any age, but is most common among preschool children. This is particularly true of severe forms, including keratomalacia. Xerophthalmia in adults and older children is usually associated with an unusual dietary pattern, such as in alcoholism and self-induced dietary vitamin A deficiency, or as a secondary consequence of a malabsorptive disorder or chronic liver failure (Underwood, 1984).

Keratomalacia is uncommon in children before the age of one year. It is usually associated with an absence or early termination of breastfeeding and an inadequate alternate diet resulting in kwashiorkor. Sommer (1982) reported that the proportion of cases with severe corneal diseases was much higher in children younger than two years than in older children. He found no cases of pure corneal xerosis or active conjunctival xerosis in children studied who were in the first year of life. Unfortunately, Sommer did not investigate the relationship for children under two among severity of xerophthalmia, duration of breastfeeding, and supplementary feeding practices. Younger children were reported to have significantly more corneal lesions than night blindness alone in a Bangladesh hospital study (Brown, et al., 1979).

In general, the age-specific peak prevalence of ocular manifestations of hypovitaminosis A appears to be between the ages of two and five years, although active disease can be found in both younger and older children (Underwood, 1984).

Weaning practices. Early childhood feeding practices play a major role in the development of vitamin A deficiency. Xerophthalmia is rarely reported in breastfed infants and children who continue to breastfeed after one year (Underwood, 1984). Infants are born with limited tissue vitamin A reserves; predominantly breastfed infants are, therefore, dependent upon maternal vitamin A status to maintain or increase their vitamin A reserves. In general, women with low concentrations of vitamin A in their breastmilk tend to be undernourished generally and may also have limited breastmilk production (Underwood, 1984). As a means of satisfying their infants' hunger, these women often wean their infants from breastmilk to a watery gruel of rice flour, other grain flours, or tuber flours.

Early weaning to inadequate diets is believed to increase the incidence of vitamin A deficiency (Underwood, 1984). In many developing societies, the underprivileged do not commonly feed vitamin A-rich or carotenoid-rich foods to infants and small children as supplements to breastmilk. Infants' diets usually advance from breastmilk to watery gruel and then to selected items from the family food pot. These items seldom include green, leafy vegetables and orange-yellow fruits and vegetables. Until the children are old enough to select a larger variety of foods for themselves and are less diet restricted, their diets are generally low in good sources of vitamin A and carotenoids.

Gender. Studies conflict in reporting that xerophthalmia is more common among males than females (Oomen, 1969; Chandra, et al., 1960; Solon, et al., 1978) and that there is no difference (Patwardhan and Kamel, 1967). Sommer (1982) reported a sex difference for vitamin A-responsive Bitot's spots, but not corneal disease, among preschool children in Indonesia.

No physiological mechanism has been determined for a gender difference in susceptibility in young children. The difference may be related to growth and mortality rates, which tend to be higher in males (Underwood, 1984).

Protein-calorie malnutrition. Xerophthalmia has been associated with protein-calorie malnutrition (PCM). Keratomalacia is usually associated with kwashiorkor (severe protein deficiency) rather than marasmus (severe calorie deficiency) (Sommer, 1982). In children suffering from less severe forms of PCM, signs of xerophthalmia are manifested only after growth is stimulated by diets adequate in protein and calories, but deficient in vitamin A sources (Underwood, 1984). Conversely, when kwashiorkor victims with liver stores of vitamin A were treated with diets adequate in protein and calories without vitamin A, a rise in serum retinol was observed (Arroyave, et al., 1961).

In severe protein deficiency, RBP is not produced by the liver, which results in a marked depression of serum retinol. Serum retinol levels of marasmus victims closely resemble those of less severely malnourished children (Large, et al., 1980). Liver retinol stores may be equally low in kwashiorkor and marasmas patients (McLaren, et al., 1965). The initial response to an exogenous dose of vitamin A is a rise in serum retinol level (Large, et al., 1980; Sommer, 1982). Sommer (1982) found that the magnitude of this response is less as protein status decreases.

PCM is associated with less efficient retinol and carotenoid absorption due to protein insufficiencies for the formation of chylomicra (Underwood, 1984). It may also be related to decreased mucosal enzymes for converting caroteinods to retinaldehyde (Ahuja and Wagle, 1980). Vitamin A deficiency, rather than protein deficiency, is believed to be the primary cause of xerophthalmia symptoms associated with mild cases of PCM.

Seasonality. Conflicting reports about the seasonal effect on the incidence of xerophthalmia have appeared in the literature. When observed, seasonal variation has been attributed to the amount of exposure to ultraviolet light (pertinent to the production of carotenoids) (Oomen and ten Dosschate, 1973), to availability and price of food sources of vitamin A and carotenoids, and to prevalence of infectious diseases, particularly diarrhea (Underwood, 1984).

The incidence of xerophthalmia, diarrheal diseases, and PCM frequently peak during the hot, dry season when fruit and vegetable sources of carotenoids are scarce (Oomen and ten Dosschate, 1973; Sommer, 1982)

Secondary Causes of Vitamin A Deficiency

While dietary inadequacy is the primary cause of vitamin A deficiency, depletion of vitamin A stores can occur secondary to disease. Disorders that affect the body's ability to absorb, transport, metabolize, and recycle used vitamin A, or increase the need for the vitamin, can all affect vitamin A status.

Malabsorptive disorders. Malabsorptive disorders include intraluminal dysfunctions, such as pancreatic and biliary insufficiency, which interfere with absorption of lipids and fat-soluble vitamins (Underwood, 1984). Vitamin A deficiency has been associated with the malabsorptive diseases of cystic fibrosis and celiac disease in children. Diets of these individual's diets are usually augmented with vitamin A supplements (Williams, 1985). Hypovitaminosis A may also occur in patients with reduced absorptive surface area, such as in short bowel syndrome, jejuno-ileal bypass surgery, and sprue (Williams, 1985; Rogers, et al., 1980).

Measles. Researchers have reported blindness in children during or following episodes of measles in African countries (Ayanru, 1978; Sanford-Smith and Whittle, 1979) and other developing countries (Oomen, 1961; McLaren, et al., 1966; Sommer, et al., 1976). Measles in better developed countries has not been reported to cause blindness. The association between malnutrition and xerophthalmia has led to controversy about the primary cause of keratomalacia. Some researchers (Oomen, 1961) propose vitamin A deficiency, with measles as a precipitating factor, to be the cause of blinding corneal disease. Others believe that measles may cause keratomalacia in malnourished children in the absence of vitamin A deficiency.

A study by Sommer (1982) supports the hypothesis that hypovitaminosis A is the underlying cause of keratomalacia associated with measles. Children seen in an Indonesian hospital and those in the same community with severe corneal disease reported a history of measles within the preceding one to two months in a higher proportion than those who had milder forms of corneal disease. In a country-wide survey, 64 percent of all corneal cases claimed that measles had preceded the onset of corneal disease.

It is not surprising that circulating vitamin A levels and holo-RBP levels, in particular, have been reported to be especially low during measles (Sommer, 1982; Laditan and Fafuso, 1981), as serum levels of vitamin A decrease during infections. Measles in undernourished children combined with subclinical vitamin A deficiency could increase mortality rates, possibly before corneal disease can develop, and further deplete vitamin A stores in survivors. The survivors could, therefore, have a greater risk for developing severe corneal lesions and resulting blindness when anabolism and "catch-up growth" resume.

Research is needed to determine why measles, as opposed to other infectious diseases associated with childhood (chicken pox, whooping cough, dyptheria), commonly precedes keratomalacia. Seng, et al., (1982) suggest that measles produce ocular lesions that cause corneal irritation and microphage infiltration. Conversely, in India and Africa the incidence of measles peaked at a younger age, when children are most susceptible to the severe blinding forms of xerophthalmia, than in the United States and other more developed countries (Langmuir, 1962; Morley, 1962; Underwood, 1984).

Other infectious diseases, diarrhea, and intestinal parasites. There is a definite relationship between the occurrence of infectious diseases and xerophthalmia. It is postulated that infectious diseases influence vitamin A metabolism by affecting the efficiency of vitamin A absorption and by increasing catabolic rate (Mansour, et al., 1979; Sivakumar and Reddy, 1972).

Vitamin A malabsorption has been associated with diarrhea and intestinal infections (Mansour, et al., 1979). Children with recent histories of diarrhea were reported to be at higher risk for developing clinical signs of hypovitaminosis A than children without histories of diarrhea (Sommer, 1982; Sivakumar and Reddy, 1978). Decreased intestinal transit time is believed to cause decreased vitamin A absorption in diarrheal cases, especially when a large portion of dietary vitamin A comes from carotenoids. The combination of a diet marginal in vitamin A foods and frequent diarrheal episodes leads to a greatly increased incidence of vitamin A deficiency. In a case-control study, Sommer (1982) found that children with recent histories of diarrhea were 13 times more likely to have corneal disease than control children without histories of diarrhea.

Respiratory and urinary tract infections commonly accompany symptoms of clinical vitamin A deficiency. Vitamin A deficiency may alter epithelial integrity or alter t immune response to infections, though the mechanism is still unclear. Respiratory tract infections are also common in PCM, and varying grades of PCM are often associated with xerophthalmia. Both vitamin A deficiency and PCM are involved in cell integrity and cell construction. It is, therefore, difficult to determine a specific vitamin A-related cause of epithelial tissue infections (Underwood, 1984). The general effect of increasing metabolic rate and hence vitamin A requirement may be the best explanation for the increased incidence of respiratory infections in patients with xerophthalmia.

Vitamin A malabsorption has also been associated with intestinal parasites (Sivakumar and Reddy, 1975; Mahalanabis, et al., 1979). The malabsorption seen in Ascaris lumbricoides infections is associated with altered mucosal morphology that reverts to normal after the patient is dewormed (Tripathy, et al., 1972).

Giardia lambia infestations may also impair vitamin A absorption. Additionally, toxic irritants secreted by the parasites may cause inflamatory reactions in the submucosa (Sheehy, et al.,1962).

Other disorders. Alterations in vitamin A absorption may also be seen in kidney diseases, hepatic diseases including alcoholism, thyroid diseases, septic diseases and stress, and others (Underwood, 1984).

Manifestations of Vitamin A Deficiency

Since the body is capable of storing large amounts of vitamin A in the liver, clinical deficiency is manifested only under extreme conditions when liver stores are depleted or blocked and serum levels are low (Oomen, 1976). It is not clear why deficiency symptoms appear earlier in some individuals than others. In many adults, chronic dietary restrictions of vitamin A must be observed over a two-year period before symptoms appear. In rapidly growing children with little vitamin A reserves, severe corneal destruction may occur in a few days or weeks.

Signs and symptoms of hypovitaminosis A have been categorized into three groups, two of which affect the eye: 1) anterior segment eye manifestations, 2) posterior segment eye manifestations, and 3) non-ocular manifestations (McLaren, et al., 1981).

Anterior segment eye manifestations. A relatively large amount of vitamin A in the body is associated with epithelial tissue; this includes conjunctival and corneal epithelia. Lack of vitamin A causes epithelia to become dry, excessively thick, and horny. This structural change in body membranes is referred to as xerosis or keratinization. The lesions of xerophthalmia are examples of this aberration.

The earliest manifestation of xerophthalmia is conjunctival xerosis, one or more dry, nonwettable patches of conjunctiva. Xerosis most often affects the interpalpebral area of the temporal quadrant, but may affect the nasal quadrant as well (McLaren, et al., 1981). In advanced cases, the entire bulbar conjunctiva may be affected. Bitot's spots, bubbly or cheesy-looking material consisting of desquamated conjunctival epithelial cells, may cover all or some of the xerotic area. Bitot's spots are an extension of xerosis, and are often recorded separately for clinical purposes. In prevalence field studies, only Bitot's spots are recorded in order to avoid overdiagnosis (McLaren, et al., 1981).

In areas where vitamin A deficiency is widespread, xerosis and Bitot's spots in preschool children are manifestations of active vitamin A deficiency and will respond to vitamin A therapy. Similar lesions are sometimes found in individuals with normal vitamin A status and have other causes. These are usually older children or young adults; these lesions do not respond to vitamin A treatment. Active lesions can be distinguished from inactive lesions by their positive response to vitamin A thearapy (McLaren, et al., 1981).

Studies in Indonesia (Sommer, et al., 1979) indicated that the cornea is affected by hypovitaminosis A much earlier and at higher concentrations of serum vitamin A than previously believed. Slit lamp examination of florescein-stained cornea revealed that punctate epithelial keratopathy was already present in 70 percent of the children with conjunctival xerosis and apparently normal cornea.

In more severe vitamin A deficiency, the punctate lesions become denser and spread to eventually include the entire cornea. On hand light examination, the cornea has a dry, hazy appearance, termed corneal xerosis. Corneal ulceration with xerosis results in more severe progression causing a loss of epithelial tissue and stromal ulceration. This may affect either part or all of the corneal thickness. Perforating lesions may become plugged with iris and heal as leukomas. Large lesions may cause the anterior segment of the eye to be lost and occasionally the loss of intra-ocular contents. When a protion of normal cornea exists, the eye may heal if given proper vitamin A therapy (Oomen, 1976, McLaren, et al., 1981).

Keratomalacia involving greater than one-third of the cornea and full thickness, edge-to-edge corneal melting, usually occurs in the presence of protein-calorie malnutrition and hypovitaminosis A. Vitamin A therapy will not heal the lesion, but will prevent further deterioration of the other eye. In extreme cases, progression to keratomalacia does not necessarily involve all stages of xerophthalmia (McLaren, et al., 1981).

Secondary bacterial infestations frequently accompany corneal xerophthalmia and may lead to neglect of the underlying vitamin deficiency (McLaren, et al., 1981). The role of secondary infections in progression of xerophthalmia is unclear.

Posterior segment eye manifestations. A relatively small amount of vitamin A is required for use in the specialized rhodopsin mechanism, found only in the eye's retina. In rods, vitamin A in the form of 11-cis-retinaldehyde is involved in transmission of visual stimuli to the optic nerve. Lack of vitamin A results in defective dark adaption or night blindness. Unless complications ensue, this manifestation of vitamin A deficiency may be regarded as biochemical rather than structural in nature (Moore, 1960). Treatment with vitamin A results in rapid reversal of the symptom. Vitamin A has a very different role in other tissues of the body.

In areas where vitamin A deficiency is prevalent, young children, in whom objective testing is impracticable, are the most likely to be affected by night blindness. Pregnant and lactating women also frequently suffer from night blindness (Underwood, 1984).

Differentiation and integrity of epithelial and mesenchymal tissue. The effects of vitamin A deficiency on keratiniziation of mucus-secreting epithelial cells was observed in rats in 1937 by Wolbach (McLaren, et al., 1981). This sign of vitamin deficiency does not occur equally in all epithelial cells (Oomen, 1961). Non-goblet cell-containing epithelium, such as skin, becomes hyperkeratinized, or thickened, dry, and scaly, when compared to normally keratinized tissue (Underwood, 1984). Goblet cell-containing epithelial tissue, such as cornea and conjunctiva, respiratory, urinary, and genital tracts, and salivary glands and trachea respond to vitamin A deficiency by the loss of goblet cells; the remaining cells lose their columnar-like appearance (Underwood, 1984).

Tissues compromised by these morphological changes become less resistant to infections. When a keratinized layer forms on the tissue, it may be initially more resistant to infection, until wounded (Underwood, 1984). Studies on germ-free animals have confirmed that these morphological changes are caused by vitamin A deficiency, rather than being secondary to infection (Beaver, 1961, Rogers, et al., 1969). Morphological changes can be prevented by feeding retinoic acid, retinol, or retinol precursors (Underwood, 1984).

Reproduction and fetal development. Vitamin A-active substance is required in the reproductive system for maintaining normally differentiated epithelium, for functions supporting spermatogenesis in males (Underwood, 1984) and full gestation in females, embryonic development, and delivery in females (Takahashi, et al., 1975). Retinoic acid fulfills the role of epithelial maintenance, but retinol is required for other functions.

The placenta delivers retinol from mother to developing fetus for normal organogenesis and development. When sources of vitamin A drop below a critical level, a wide variety of teratogenic effects can occur, mostly affecting ocular and urogenital tissue (O'Toole, et al., 1974). Similar teratologic effects occur when excessive amounts of retinol are fed early in pregnancy (Greelen, 1979).

Growth and development. Under natural conditions, vitamin A deficiency occurs primarily during periods of growth, such as early life and pregnancy. Weanling animals fed deficient diets decrease their rate of weight gain when their body stores of vitamin A become inadequate (Underwood, 1984). Data derived from conventionally reared rats fed vitamin A-deficient diets suggest that the initial decline in weight gain is a consequence of inefficient utilization of nutrients needed for cell proliferation (Zile, et al., 1979, 1981). Studies under germ-free conditions demonstrate that depression in weight gain is not secondary to infection (Underwood, 1984). Such studies indicate that vitamin A is essential for growth. In children, lack of growth is suspected to be associated with vitamin A deficiency. Vitamin A deficiency has also been linked to anorexia, which may further compromise growth by decreasing food intake (Anzano, et al., 1979) .

Chronic vitamin A deficiency in growing animals results in the laying down of bone where it normally does not appear, and in thickened, less dense bones. These effects are believed to result from an altered balance in the number and activity of osteoblast and osteoclast cells (Underwood, 1984).

Cerebrospinal fluid pressure. Elevated cerebrospinal fluid (CSF) pressure is the first physiological change specific to vitamin A deficiency in many animals. In humans, evidence for elevation in CSF pressure has been reported in hypovitaminosis A. Symptoms include headaches in adults and bulging fontanels in three- to eight-month-old infants (Underwood, 1984).

Resistance to infection. Lack of vitamin A has been associated with increased susceptibility to infections, especially of the respiratory and digestive tracts. When immune mechanisms become impaired, mechanical barriers disintegrate and a state of cachexia may develop. In vitamin A deficiency, synthesis of antibodies is diminished (Ludovici and Axelrod, 1951); cell-mediated immunity is also impaired. Further, digestive and respiratory tract tissues may be more easily penetrated by microorganisms as a result of alterations in epithelial cilia and mucus secretions (Underwood, 1984).

Impaired vestibular balance. Metabolic change in the vestibular apparatus of vitamin A-deficient guinea pigs was shown by Cakirer and Lachance (1974). Impairment of vestibular balance has been reported in both children and adults (McLaren, et al., 1981).

Treatment

Considering the extreme circumstances which lead to manifestations of vitamin A deficiency, individuals with clinical symptoms are in a relatively advanced state of deficiency requiring immediate therapy. Therapy usually consists of high doses of water-miscible vitamin A given either intramuscularly or orally.

In a clinical trial, Sommer (1982) found that intramuscular administration of vitamin A was no more effective than oral administration. Sommer recommends oral administration, as it is more acceptable to target populations. When patients experience vomiting and diarrhea and accompanying protein-calorie malnutrition, initial administration intramuscularly with water-miscible vitamin A is considered to be preferable to oral doses (Underwood, 1984).

The World Health Organization (WHO) recommendations for treatment of children under one year, suffering from vitamin A deficiency, were revised in 1982. WHO recommends that upon diagnosis preschool children be given an initial dose of 200,000 IU of retinyl palmitate or retinyl acetate orally or a 100,000 IU injection intramuscularly. A second dose of 200,000 IU should be given the following day, with a final dose prior to discharge or if clinical deterioration occurs (WHO, 1982). Infants with clinical symptoms should receive treatments of half the dosage given to preschool children. Older children and adults may receive the same dosage. Treating pregnant women with multiple low-dose oral supplements is preferable, since animal studies suggest teratogenic effects of high doses of vitamin A (Greelen, 1979). WHO recommends doses above 10,000 IU daily not be given during pregnancy (1982).

Prevention and Control

Increased dietary intake of vitamin A-rich food is the only long-term solution for the prevention and control of vitamin A deficiency. While measures to control the incidence of deficiency have been successful in countries with many resources, finding effective means to eliminate the deficiency is more difficult in underdeveloped countries with depressed economies and primitive marketing, distribution, and communications. Intervention programs which make vitamin A-active foods available to individuals with limited resources are necessary in countries where poor vitamin A status is a public health problem.

Several methods of providing vitamin A to those at risk for deficiency have been proposed and used with varying degrees of success. These methods include: 1) providing vulnerable groups with periodic large doses of vitamin A, 2) fortifying widely used, inexpensive foods with vitamin A, 3) promoting agricultural activities to improve the availability and decrease the cost of green leafy vegetables and yellow-orange fruits and vegetables, and 4) promoting, through nutrition education, the consumption of inexpensive sources of vitamin A, especially in young children (IVACG, 1977; Underwood, 1984).

Long-term solutions will require a multidimensional approach, usually involving several of the above strategies.

Periodic, large doses of vitamin A. Several countries have developed programs to distribute large, prophylactic doses of vitamin A to preschool children. In the early 1970s, India adopted such a program which provides preschool children with oral doses of 200,000 IU of vitamin A every six months (Underwood, 1984). The program has proven to be effective (Sinha and Bang, 1976). Bangladesh, Indonesia, Haiti, and Sri Lanka adopted similar programs that distribute large doses of vitamin A to preschool children. The cost and complex logistics of maintaining a program that provides prophylactic doses of vitamin A to all children at risk make this type of intervention only a short-term solution to the problem.

Fortification. Fortifying inexpensive, commonly consumed foods with vitamin A has been used successfully in many Western countries. Milk, cheese, butter, and margarine are examples of food vehicles commonly fortified. Although xerophthalmia has not been prevalent in these countries, marginal hypovitaminosis A was and continues to a lesser extent today (Underwood, 1984).

Alternative food vehicles, which are more appropriate for economic situation and culture of target populations, should be sought in lesser-developed countries. An appropriate food vehicle for fortification would be inexpensive and commonly consumed by the vast majority of the target population. It should have a central location for processing and distribution, a stage of processing that would permit uniform incorporation of the nutrient, and acceptable performance regarding nutrient stability and bioavailability of the nutrient. Ideally, the fortified food would not have a significant change in color, odor, texture, or taste (IVACG, 1977).

In Central America, sugar has been a successful vehicle for vitamin A fortification (Arroyave, et al., 1979). Sugar fortification has been somewhat less effective in Brazil (Araujo, et al., 1978). These and similar programs are in jeopardy because of high cost of imported, synthetic vitamin A (Underwood, 1984). Other food vehicles are being explored for vitamin A fortification in Asia. Monosodium glutamate appears to be a viable vehicle in the Philippines and Indonesia (Solon, et al., 1978), as does tea in India.

Fortification may be a long-term, relatively low-cost solution for some countries. Success depends upon the ability to find an appropriate food vehicle and the political and economic constraints to enforce nationwide fortification and distribution (Underwood, 1984).

Agricultural approaches. The goal of agricultural approaches to vitamin A deficiency is to make provitamin A-rich foods available, at a low cost, to populations at risk. Two different approaches have been proposed to increase agricultural production: 1) use of large-scale production, dealing with agricultural policies, incentives for developing specific crops, modification of distribution and marketing systems, and subsidizing of foods for specific target groups, and 2) use of small scale production to initiate family and community gardens for raising specific high nutrient foods (IVACG, 1977).

Constraints on using large-scale agricultural production are high in many developing countries. Where economic conditions are poor, it may be difficult to unite government officials in a large-scale, multifaceted project (IVACG, 1977). However, in areas where water and land are in short supply, large-scale production and distribution may be the only alternative for supplying food to the public.

Small-scale production allows those who will benefit directly from the project to participate fully in planning, planting, harvesting, and consuming the foods. These projects are relatively inexpensive and require only a few highly trained personnel; entire communities and families can be instructed in the need for specific foods and nutrients for a balanced diet (IVACG, 1977). However, implementation of backyard or community garden strategy is limited in areas where resources are in short supply (Underwood, 1984). This is frequently the case during the dry season when xerophthalmia peaks.

Nutrition education. Educational programs to increase the consumption of vitamin A-containing foods should be implemented concurrently with other intervention programs. It is important to determine local customs and attitudes towards foods, before attempting to implement a change that may not be culturally acceptable. Much has yet to be learned about the reasons why families do not feed vitamin A-containing foods to preschool children. Many educational programs should be aimed at pregnant and lactating women who have immediate and direct influence over the diets of small children, vulnerable to nutrient deficiencies (IVACG, 1977). Perhaps one of the greatest constraints to an educational approach to increased consumption is that children, in general, simply do not like to eat green leafy vegetables or yellow squash (Underwood, 1984).

Assessment of Vitamin A Status

Underwood states that vitamin A status is the sum product over time of the dynamic processes involving intake, storage, mobilization, utilization, and excretion. Primary deficiency results from chronic inadequate intake of vitamin A in relation to need for body function. Over time, this depletes the liver reserves and results in hypovitaminosis A. Conversely, toxicity results from excessive intake, either chronic or acute. Clinical and biochemical manifestations of deficiency or excess, with the exception of acute toxicity, appear only after liver reserves have been depleted or saturated, respectively. The time required to deplete or saturate the liver depends upon the initial liver reserve, dietary intake of vitamin A, and factors that may influence the body's utilization of vitamin A.

Measurement of hepatic stores is the best indicator of vitamin A status. However, liver biopsies in living human populations for the purpose of assessing vitamin A status are unethical, necessitating the use of other methods to approximate vitamin A status. Until recently, there have been no satisfactory methods to approximate vitamin A status when clinical signs are not apparent.

Nutrition Surveys

A nutrition survey is the primary means of providing information for planning of appropriate and realistic nutrition programs consistent with the needs and cultural practices of a given community. Surveys are also used for evaluating the effectiveness of nutrition programs already in place and provide quantitative data useful for convincing governments to encourage and support nutrition action programs for improving public health. The classic survey methods for determining nutrition status include four types of evaluative data: clinical, biochemical, anthropometric and dietary. Each of these measures different states of nutriture, and therefore, do not necessarily correlate with each other (Pike and Brown, 1984).

Clinical Assessment

Whereas dietary data are indicative of current food intake and biochemical analysis of relatively recent food intake, clinical examinations are more likely reflect the result of long-term nutrition status. However, clinical lesions may be the result of other factors, such as intestinal parasites or infection, which may influence absorption and metabolism of nutrients independent of dietary intake.

Symptoms and signs of vitamin A deficiency have been classified by WHO (1982) and include xerosis of the skin, follicular hyperkeratosis, xerosis conjunctivae, keratomalacia and Bitot's spots. Clinical assessment in this study is based upon WHO (1982) classifications of xerophthalmia. These range in severity from night blindness to the blinding keratomalacia. Conjunctival xerosis is the least severe lesion affecting the eye. Bitot's spots are a bubbly- or cheesy-appearing material on the conjunctiva.

Corneal xerosis, in which the cornea begins to turn hazy, is usually the first sign of corneal involvement in the disease process. When treated properly, before extensive ulceration can occur, the eye can be saved, but a resulting corneal scar will remain. Proper treatment will prevent the unaffected eye from developing lesions, but will not reverse the process in an extensively affected eye.

WHO (1982) has suggested prevalence criteria using the incidence of xerophthalmia, at different stages of disease development, to determine if a given population is at risk. Public health significance is reached when night blindness is found in greater than 1 percent, Bitot's spots are found in greater that 0.5 percent, corneal xerosis corneal ulcerations, and keratomalacia are found in greater than 0.01 percent, or corneal scars are found in greater than 0.05 percent of the population between six months and six years of age.

Recently the technique of impression cytology has been proposed as a clinical method of detecting less severe vitamin A deficiency. The technique involves the removal or epithelial cells from the conjunctiva, staining the cells, and observing these stained epithelial cells under a microscope. Individuals at risk for vitamin A deficiency will have a deficient number of goblet cells.

Biochemical Assessment

Data collected on human response to diet in metabolic studies have been used to establish standards for evaluation of nutrition status in population groups. Biochemical tests for appraisal of nutrition status, however, have usually been selected on the basis of simplicity of the analytical procedure, with sensitivity of the method as a secondary concern (Pike and Brown, 1984).

When the objective of a study is to identify nutrition problems of health significance, emphasis is on the group rather than on the individual. Under these circumstances, the approach is to select the most practical method that will yield useful data. The measurement of serum or plasma levels of vitamin A has been one of the most widely used and practical means of determining vitamin A status. Limitations of this technique include sensitivity and specificity. Serum levels of vitamin A remain relatively stable until liver reserves become dangerously low or high. Only then will serum vitamin A reflect liver vitamin A reserves.

Serum and plasma vitamin A levels have been useful in population surveys to determine the extent of vitamin A deficiency and as a measurement of dietary adequacy (Underwood, 1984). A broad range in plasma levels of vitamin A is encountered among apparently healthy, relatively affluent populations consuming adequate levels of vitamin A-active foods (Underwood, 1984). Serum vitamin A levels generally follow a normal distribution curve for serum levels from 20-80 μg/dl, and there is little evidence of an abnormal vitamin A status within this range (ICNND, 1963).

Serum levels ranging from 10-19.9 μg/dl are considered marginal, and levels below 10 μg/dl put the individual at extreme risk for vitamin A deficiency (ICNND, 1963; WHO, 1982). Vitamin A deficiency is considered a public health problem when greater than 5 percent of the population of six-month to six-year-olds have serum levels of vitamin A below 10 μg/dl or greater than 15 percent have serum levels below 20 μg/ml (ICNND, 1963; Underwood, 1984; De Luca, et al.,1979).

Since over 90 percent of the total body vitamin A reserve is found in the liver, hepatic levels of vitamin A are considered to be good approximations of body stores. However, liver biopsy in living individuals for the purpose of assessing vitamin A status is not justified. Postmortem liver samples have been used to estimate the vitamin A status of populations (Olson, 1979) and to evaluate vitamin A intervention programs (Arroyave, et al., 1979).

There is considerable variation in the distribution of vitamin A between the two lobes of the liver and sites within the lobes (Olson, 1979). The technique for evaluating liver stores has been standardized so that only one sample from the central lobe is necessary. Samples taken from this portion are reported to approximate the overall mean (Olson, 1979).

Olson (1979) suggested that 20 μg retinol/per gram of liver be set as a minimal acceptable vitamin A reserve. This figure was proposed because it theoretically provided enough vitamin A to support a 15 kg child for 100 days on a vitamin A-free diet.

An alternative method for estimating liver stores of vitamin A was first proposed by Loerch, et al. (1979). In theory, the pattern of response to a small dose of vitamin A over a five-hour period differentiated liver concentrations under 10 μg retinol/dl liver from those with values above this limit. The procedure is termed relative dose response (RDR).

> The RDR is based on the laboratory observations that: 1) Liver reserves approximate total reserves; 2) Liver reserves increase with increase dietary intake but not linearly; 3) Plasma holo-Retinol Binding Protein (RBP) is under homeostatic control, largely independent of stores when these are above threshold level; 4) Rate of hepatic synthesis of RBP is largely independent of availability of retinol; 5) Accumulation of RBP is dependent upon retinol from dietary or endogenous sources; 6) In fasting the preferred pathway for at least part of the newly ingested vitamin A is the liver where it complexes with apo-RBP and enters circulation; and 7) The extent and duration of the postprandial rise in serum holo-RBP is determined by the level of preformed hepatic apo-RBP (IVACG, 1985, p. 21-22).

A fasting sample of serum is taken, the subject is given a small oral dose of vitamin A, and a serum sample is again taken at five hours. RDR is the calculated difference between the five-hour and fasting plasma level of vitamin A divided by the absolute value at five hours.

Anthropometric Assessment

Growth, as represented by height and weight for age, is believed to be one of the most definitive indicators of nutrition status of young children (Pike and Brown, 1984). Simple anthropometric measurements, in addition to clinical examination, provide more information at low cost than other more extensive survey techniques. When the age of the child is not known, weight/height ratio for young children is a useful indicator of nutrition status. Dugdale (1971) showed that the weight/height ratio for children one to five years of age is independent of age, but correlates with nutrition status. Normal weight for height has been observed in young children below height norms for their ages (Downs, 1964). These children evidently suffered from malnutrition early in life with resultant lowered height for age. That is, even though weight was proportional to height, both were similar to that expected in younger children.

Vitamin A deficiency, either directly or indirectly, adversely affects many physiological functions of organisms, including growth. Animals on a vitamin A deficient diet grow less well than controls; the first sign of deficiency is a reduction in food intake (Olson, 1986). In experimental animals these changes are often expressed early, long before histological changes occur.

Vitamin A requirements for humans are closely related to growth rate (FAO/WHO, 1967), and thus are relatively large during childhood. Breastmilk or cow's milk are not rich sources of vitamin A (FAO/WHO, 1967) and infants receiving milk may not have their requirements met (McLaren, 1986b). In addition, weaning diets are often low in provitamin A carotenoids, as dark green leafy vegetables are not frequently fed.

Infectious diseases, which are common in early childhood in developing countries, significantly increase metabolism, and thus requirement for vitamin A; gastroenteritis causes decreased intake and inefficient absorption. Protein-calorie malnutrition has its highest incidence during childhood, most commonly manifested as marasmus and kwashiokor which are not infrequently accompanied by xerophthalmia (McLaren, 1986b).

Dietary Assessment

Dietary surveys can be planned to determine food consumption of families or individuals. Household or family consumption estimates the amount of food consumed by the family unit for a fixed time period, usually one week. The most commonly used methods for collecting household intake data are food lists and food records, whereas methods for determining individual food intake include the dietary recall, food record, dietary history, food frequency and weighed intake.

Since all known methods for obtaining dietary data have certain advantages as well as limitations, the choice of methods should depend upon the population sample to be surveyed and the particular use for which the data are intended. In addition to the choice of method, how the collected data will be handled must be considered. It may be necessary to only know the general pattern of food intake or the range of nutrient intake for a population and the specific foods from which nutrients are obtained.

According to Christakis (1973), dietary histories provide the most valid information on the usual dietary intake of a variety of nutrients for individuals (Christakis, 1973). However, they are time consuming, costly, and difficult to administer to children and some individuals of low socioeconomic standing. A 24-hour recall is more easily administered, may be more appropriate for underdeveloped societies, and can be valid for populations in situations where monotonous diets are consumed year round. A one- to seven-day food weighing of foods actually eaten may also provide valid information in underdeveloped societies, but again is very costly and time consuming to administer. Neither the 24-hour recall or food weighing detect variations in the diet caused by seasonal changes in food supply (Underwood, 1984). This is of great concern in developing countries where food supply is dependent upon immediate local food production and preservation techniques are not usually practiced.

Food frequency techniques are easily administered and can provide quantitative information by including an estimation of portion sizes (Hanklin, et al., 1975). Care must be taken to develop an accurate list of all possible sources of vitamin A-containing foods or appropriate categories of such foods. The validity of the method and reliability of the data are improved when food models or pictures of appropriate portion sizes of foods in the recall list are used by the interviewer.

Summary

Nutrition assessment surveys are valuable in grossly defining nutrition status. However, interpretation of survey data should be made with recognition of the limitations of current assessment methodologies and of variability of population groups. Clearly, there is a need for improved methodology for assessing vitamin A status of population groups and for standardized methods of evaluating assessment data.

MATERIALS AND METHODS

Selection of the Survey Sites

Ecology of the Northeast

The Brazilian Northeast consists of three ecologically different regions: the coastal "Zona Mata" ("Litoral"), the transitional "Zona Agreste" ("Brejo"), and the semiarid "Sertão". The Sertão is the innermost region of the Northeast and, like the other two zones, extends through several states. Precipitation is most abundant along the coast and decreases inland toward the Sertão. The Mata has the most evenly distributed rainfall; total precipitation on the coast averages about 1,000 mm per year. Rainfall is unevenly distributed in the Sertão, and accounts for approximately 300 mm per year (Neumaier, 1984). During periods of drought, some parts of the Sertão receive no rain for years.

Prior to 1985, the Northeast had experienced approximately five years of drought. During drought periods, many residents of the Northeast migrate, from the inlands (Agreste and Sertão) to the coastal cities (Mata) and to the more prosperous cities in the South, looking for work. The year 1985 was extraordinary in that extra rain fell in the Northeast and caused flooding in many areas. This provided more water than usual for crop production.

Because of consistent rainfall, the Mata is the best region in the Northeast for growing food crops, but much of the farmland has been zoned for raising sugar cane. The Mata was originally settled by plantation owners who planted sugar cane for export. Sugar cane continues to be an important export crop and in Brazil is also used to make alcohol for automobile fuel. Consequently, food crops and animals are cultivated in the other two regions of the Northeast. Most food for the people of the Northeast is cultivated in the

Agreste. Subsistence farming is practiced in the Sertão, because of the scarcity of water.

Survey Sites

Four rural survey sites were selected from two municipal districts of Pernambuco State, Vitoria de Santo Antão in the Zona Mata and Caruaru in the Zona Agreste. These communities represented two of the three ecological regions of Northeast Brazil. A city in the Sertão was visited, but no samples were collected.

The municipal district of Vitoria de Santo Antão was selected primarily because of its proximity to Recife and its functioning health posts. The research team visited several health posts with which personnel from the Departamento de Nutricão, UFPe, had previously worked, before selecting two sites, São José and Cajá, in the rural outskirts of town. Each selected site had a functioning health post from which to work.

Caruaru municipal district was selected because of its favorable political climate. The mayor of Caruaru was interested in promoting development and health programs to benefit his district. The local government was, therefore, very interested in the nutrition status of the people and in implementing a nutrition program. In Caruaru, local government health workers helped select the project sites.

At one site, Alto do Moura, most of the community was involved in making and marketing fired clay figures. These figures were sold in a local artisans' market and in the large, coastal cities of the Northeast. The other site, Lagoa de Pedra, was typical of a rural, agricultural community. Those involved in planning the project were interested in determining if the nutrition status of the women and children differed between the two communities.

In the Sertão, the third ecological region of Northeast Brazil, the potential for promoting goat milk as a source of vitamin A was assessed. Sobral lies in the interior of the state of Ceará. There the federal government has established the Centro Nacional Pesquisa de Caprinos (CNPC) to research goat management. Utah State University (USU) and other U.S. institutions have U.S. Agency for International Development (AID) grants to work with CNPC on the Small Ruminant-Collaborative Research Support Program (SR-CRSP).

Description of the Subjects

The target populations included women of childbearing age and their preschool children. A statement of the proposed research describing the use of human subjects is filed in the Office of the Vice President for Research at USU. Informed consent for this joint UFPe/USU project was arranged by the UFPe research team and pertinent data housed at the Laboratorio de Bioquemica da Nutricão in Recife.

The women and children surveyed lived in the areas surrounding the selected health posts, on the outskirts of Vitoria de Santo Antão and Caruaru. The health post workers, at each survey site, contacted mothers to participate with their children in the survey. The children were required to be between two and five years of age; the mothers were generally 20 to 40 years of age. Both mothers and children were requested to come fasting to the health post on the sampling days.

The families who participated in the survey received limited medical and health care services from the health posts. Services provided by health posts included prenatal education, birth control information and supplies, nutrition information, and immunizations.

Development of the Survey Instrument

Before travel to Northeast Brazil, a preliminary survey instrument was designed at Utah State University. This instrument was translated and modified in Recife, Brazil, with the assistance of Brazilian nutrition faculty and graduate students at the Laboratorio de Bioquemica da Nutricão, Universidade Federal de Pernambuco (UFPe). The modified survey instrument was field tested, using participants at the Vitoria de Santo Antão sites, and modified again for use at Caruaru and on a second sampling in Vitoria de Santo Antão.

The questionnaire was designed for interviewing rural women to estimate their nutrition knowledge, their consumption and their children's consumption of vitamin A-active foods, resources from family gardens and livestock, and socioeconomic status. The survey instrument is included, in English (Appendix A) and Portuguese (Appendix B).

The survey instrument was administered by Brazilian nutritionists to rural women at the survey sites. Initial questions provided identification and statistical information including project location, name, age, birthdate and gender. A second section on family and maternal information provided information on the size of the household and pregnancy status. As a means of determining basic education level, mothers were asked if they could read.

Survey Procedure

Two sampling visits were made by the research team to each survey site. To solicit help from health-post workers, the study sites were visited a week before the first sampling. The workers arranged for women of child-bearing age, with children between two and five years old, to come to the health post on sampling days. Women and children were instructed to arrive fasting so that blood samples could be drawn. Mothers were interviewed to determine their nutrition knowledge, living conditions as proxy for socioeconomic status, use of home gardens and animals, and consumption of foods rich in vitamin A and pro-vitamin A. Body weight, height, tricep skinfold, and mid-arm circumference measurements were taken from each mother and child.

Beginning July 22, 1985, the research team took equipment and traveled in the morning to Vitoria de Santo Antão. The field research team consisted of three to five Brazilian nutritionists, two lab technicians, and the author. Using the modified questionnaire, the nutritionists interviewed the mothers. Lab technicians drew blood samples, and the author made the anthropometric measurements.

A second sampling was taken at study sites a month later to collect blood samples to compute modified RDR and anthropometric data from the children. At the Vitoria de Santo Antão sites, the mothers were interviewed to gather data for the revised questionnaire. Children again received a toy and breakfast. Photographs, taken on the previous sampling, were distributed to the children.

The study procedure in Caruaru was similar to that of Vitoria de Santo Antão and began on August 6, 1985. Local government health workers assisted the research team in Caruaru. The distance from Recife to Caruaru was further than from Recife to Vitoria; so the team stayed overnight and gathered data from both sites in two days. The research team returned a month later for a second sampling.

During the first visit to Caruaru, a project was initiated by the local government with the help of the field research team to distribute prophylactic doses of vitamin A to preschool children in the entire community. This project began in September, 1985.

In the third ecological region of the Northeast, CNPC/SR-CRSP project researchers were queried about the potential for promoting increased production of goat's milk, which contains appreciable amounts of vitamin A, as a means of increasing vitamin A consumption in the Northeast. The contributions that women make in caring for and milking the goats were also discussed.

In Sobral, an ophthalmologist and a pediatrician were interviewed concerning the incidence of vitamin A deficiency in the area. Other visits were made to the Secretary of Health and to rural women who lived near the CNCP/SR-CRSP research facility. The women responded to informal questions about their family's consumption of vitamin A foods. The local market was also surveyed.

Descriptive Analysis of the Data

Means and standard deviations were computed for serum retinol, serum carotene and modified dose response, averaged over all children and all mothers in the survey. The distribution within and across survey sites and the percentage of participants with acceptable and unacceptable levels of serum retinol, RDR and serum carotene were computed separately for women and children. Mean ages, anthropometric measures and standard deviations were also determined for mothers and children separately. The distributions and percentages of mothers' and children's weight percentiles were averaged within and across survey sites. Weight/height ratios of children were computed and compared with both Brazilian and U.S. standards. Percentiles of arm anthropometry were computed for mothers and for male and female children separately. Other descriptive data computations include 1) average preformed and pro-vitamin A consumed and the percent adequacy for women and children 2) vitamin A-rich foods commonly consumed, 3) distribution and percentage of women at each survey site who cultivated gardens and/or raised animals, and 4) distribution and percentage with various levels of nutrition knowledge, socioeconomic status and adequate dwellings and sanitation facilities.

Vitamin A Status

Vitamin A status of the women and children was determined by serum retinol and carotene, using a spectrophotometric technique first developed by Bessey, et al (1946). Araujo and Flores (1978) modified the method and use it for analysis in Recife.

Each mother and child donated a blood sample. After the blood draw, children received a 200,000 IU oral dose of vitamin A in oil (with 40 mg of vitamin E, donated by UNICEF). Mothers and children received breakfast consisting of a carton of fortified chocolate milk, cookies, and corn chips. As a reward for donating blood and to encourage further cooperation, children were given toys and photographed.

Approximately 10 cc of blood was drawn from each participant. Serum was separated from packed cells by centrifugation and frozen immediately over dry ice. Samples were transported to the Laboratorio de Bioquemica da Nutricão and analyzed later for vitamin A and carotene, using the spectrophotometric method by ultraviolet inactivation.

The assay method is based upon 1) saponification and extraction of vitamin A and carotene from the serum, 2) measurement of light absorption, 3) destruction of the vitamin A with ultraviolet irradiation, and 4) remeasurement of the absorption (Bessey, et al., 1946). Vitamin A absorption was read at 328 nm and carotene at 460 nm.

Other techniques have been developed and are widely used, but instrumentation was unavailable. This technique was sufficiently accurate to meet the needs of the laboratory.

A second sampling was taken a month later to measure a modified relative dose response (RDR). To determine relative dose response (RDR), 1) a fasting blood sample is drawn from the participant, 2) the participant is given a small dose of vitamin A (450 RE), and 3) a second blood sample is taken five hours later (Flores, et al., 1984). RDR is calculated from the fasting serum retinol (A_0) and the serum retinol after five hours (A_5) using the following formula:

$$RDR = \frac{A_5 - A_0}{A_5} \times 100$$

In this study a modified RDR rather that the standard RDR was used: 1) fasting blood was drawn from the children, 2) a large dose of vitamin A (200,000 IU) was given, and 3) a second blood sample was taken after 30 days.

Anthropometric Measurements

The general nutrition status of the women and children was assessed anthropometrically using height, weight, tricep skinfold (TSF), mid-arm circumference (MAC), and calculated mid-arm muscle circumference (MAMC). Measurements were taken on the children during both samplings, and on the women at the first sampling only.

Mid-arm muscle circumference was calculated from tricep skinfold and mid-arm circumference using the following equation:

$$MAMC\ (mm) = MAC\ (mm) - \{\pi \times TSF\ (mm)\}$$

Standard procedures were used to measure the children and mothers. Balances were available at the health posts in Vitoria de Santo Antão for weighing the participants. A portable, bathroom-type scale was used at the Caruaru health posts. Heights were taken with a non-stretch measuring tape attached to the wall in the health posts. Lange Skinfold Calipers (Cambridge Scientific Industries, Inc.) and a flexible non-stretch measuring tape were used to measure arm anthropometry.

United States National Center for Health Statistics (NCHS) anthropometric standards (Abraham, et al., 1979) were used to evaluate the height, weight, and weight for height of mothers. Brazilian (Marques, et al., 1982) and NCHS (Hamill, et al.,1977) standard tables were used to assess the height, weight, and weight for height of children. Weight for height standards were computed from both Brazilian and NCHS weight and height standards by dividing the weight standards by the height standards. Brazilian tables were not available for evaluating TSF, MAC, and MAMC, therefore, NCHS standards (Frisancho, 1981) were used to assess these measurements in women and children. Percentiles for all measurements were interpolated from standard percentiles.

Food Sources of Vitamin A

Indigenous food sources of vitamin A were identified by visiting a Recife market. Local markets were also visited in Vitoria de Santo Antão, Cauraru, and Sobral to determine the relative availability and cost of vitamin A-rich foods. Vendors in the market place were asked the prices of animal products, vegetables, and fruits which contain vitamin A and pro-vitamin A. The vendors commented on the availability of the foods and the foods most commonly purchased by the rural and semirural poor.

During interviews with the survey participants, dietary intake of vitamin A and pro-vitamin A-containing foods was assessed using a modified food frequency questionnaire. The mothers were asked how often they consumed specific foods or types of food and how much they consumed. Foods were named specifically, except in the case of green-leafy vegetables; the mothers were asked to identify the green-leafy vegetables consumed. The mothers responded to the same questions about their children's diets. It was assumed that the mothers could adequately estimate portion sizes in grams, as rural women purchase most of their foods by the kilogram.

The amount of vitamin A, from animal and plant sources, consumed by the mothers and children was estimated from the food frequency section of the survey. The amount of preformed or pro-vitamin A in 100 gm servings of each food was included on the surveys. These composition values were taken from the Instituto de Nutricíon de Centro America y Panama-International Committee of Nutrition for National Defense (INCAP-ICNND,1961) tables, with the exception of the values for beef liver, jerimun (a pumpkin-like, yellow squash) and carrots. Composition values determined by the Laboratorio de Bioquemica da Nutricão were used for these three foods. Vitamin A content was recorded in retinol equivalents (RE).

The amount of vitamin A consumed from plant and animal sources per month were estimated from the information given by the mothers and the vitamin A content of the foods. These values were then divided by 30 to approximate the total vitamin A, vitamin A from plant sources, and vitamin A from animal sources consumed per day. The estimated vitamin A intake could then be judged as adequate or inadequate when compared to the FAO/WHO (1967) recommended intakes for vitamin A.

The FAO/WHO recommendations for vitamin A intake are given in µg/day. Vitamin A content of diets was calculated using the following equivalencies:

1 retinol equivalent (RE) = 1 µg retinol
= 6 µg ß-carotene
= 12 µg other pro-vitamin A carotenoids
= 13.33 IU vitamin A activity from retinol
= 10 IU vitamin A activity from ß-carotene

Vitamin A Sources from Gardens and Animals

The women were questioned about vitamin A sources from cultivation of fruits and vegetables in household garden or raising domestic animals. Women who had a garden or animals were asked to identify the fruits and vegetables grown in the garden, the animals they raised, and their use of the products. Women who did not have gardens or animals were asked to give reasons for not cultivating a garden or raising animals.

Nutrition Knowledge of the Mothers

The nutrition knowledge of the mothers was evaluated by Brazilian nutritionists from responses to questions on foods that the mothers thought should and should not be eaten 1) generally, 2) during periods of pregnancy and lactation, 3) by infants and 4) by young children. Immediately after interviewing the participant, the nutritionists assessed each woman's level of nutrition knowledge as good, reasonable, no knowledge, or undeterminable (prejudiced, i.e., the participant was trying to answer as she perceived the nutritionist wanted her to answer). The "good" category was removed from the survey when none of the women were assessed as having good knowledge of basic nutrition concepts. Since the rural women generally had little formal education in Portuguese and used local figures of speech, the Brazilian nutritionists were better able than the author to assess each participant's nutrition knowledge.

Socioeconomic Status

Socioeconomic status was determined by measures of housing adequacy and basic sanitation. Participants answered questions about physical characteristics of their dwellings, including information about the materials used for roofing, walls, floors, and lighting. Questions on sanitation included source of water, disposal of human excrement, trash disposal, and number of persons per bedroom. The participants were then judged, on a scale of zero to eight, to have either adequate or inadequate housing and sanitation.

Statistical Analysis of the Data

Descriptive Analysis of the Data

Means and standard deviations were computed for serum retinol, serum carotene and modified dose response averaged over all children and all mothers in the survey. The distribution within and across survey sites and the percentage of participants with acceptable and unacceptable levels of serum retinol, RDR and serum carotene were computed separately for women and children. Mean ages, anthropometric measures and standard deviations were also determined for mothers and children separately. The distributions and percentages of mothers' and children's weight percentiles were averaged within and across survey sites. Weight/height ratios of children were computed and compared with both Brazilian and U.S. standards. Percentiles of arm anthropometry were computed for mothers and for male and female children separately. Other descriptive data computations include 1) average preformed and pro-vitamin A consumed and the percent adequacy for women and children, 2) vitamin A-rich foods commonly consumed, 3) distribution and percentage of women at each survey site who cultivated gardens and/or raised animals and 4) distribution and percentage with various levels of nutrition knowledge, socioeconomic status and adequate dwellings and sanitation facilities.

Inferential Statistics

Multiple regression analysis was used to evaluate the effect of selected anthropometric, dietary, demographic, and socioeconomic independent variables on five dependent variables, namely: 1) mothers' retinol, 2) mothers' vitamin A intake, 3) children's retinol at the first sampling, 4) children's modified RDR and 5) children's vitamin A intake (Table 1).

Models for each dependent variable were developed based upon the independent variables hypothesized to be significantly related to the dependent variables. Anthropometric and physiological independent variables included percentile of weight for height by age, percentile of mid-arm muscle circumference (MAMC) by age (both computed from NCHS tables), age, and child's gender. Demographic, socioeconomic and dietary independent variables were survey site, mother's ability to read, mother's nutrition knowledge, socioeconomic score, family gardens and animals, and vitamin A intake.

The regression approach to this study required definition of dummy or indicator variables to incorporate the categorical data, eg., survey site, into the regression model. Dummy variables were coded using the usual constraints format (1,0, -1) such that statistical significance of each level within a categorical variable was measured relative to the overall mean for the variable.

Table 1. Statistical models derived to estimate the mothers' serum retinol, mothers' dietary vitamin A, children's serum retinol, children's modified RDR, and children's dietary vitamin A.

	Mothers' Serum Retinol	Mothers' Dietary Vitamin A	Children's Serum Retinol	Children's Modified RDR	Children's Dietary Vitamin A
Mothers'					
Dietary vitamin A	*				
Age	*	*			
Wt/ht %	*	*			
MAMC %	*	*			
Nutrition knowledge	*	*	*		*
Literacy	*	*	*		*
Survey site	*	*	*		*
Socioeconomic score	*	*	*		*
Family garden	*	*	*		*
Family animals	*	*	*		*
Children's					
Dietary vitamin A			*	*	
Age			*	*	*
Wt/ht %			*	*	*
MAMC %			*	*	*
Gender			*	*	*

* Used in the model.

The F test was used to determine the statistical significance of independent variables on the five models. Significance was determined at the 0.05 probability level. Fisher's Least Significant Difference (LSD) was used to make pairwise comparisons between means within categorical variables judged by the F test to be significant by the least squares regression analysis (Snedecor and Cochran, 1980). Beta coefficients were used to determine signficant linear relationships between dependent and continuous independent variables in each model.

The Statistical Package for Social Sciences (SPSS, 1986) was used for all satistical analyses.

RESULTS

Vitamin A Status

Serum Retinol

Serum retinol and carotene levels were used to evaluate the vitamin A nutrition status of mothers and children. Mean serum retinol and carotene of the mothers and children, and children's modified relative dose response (RDR) are presented in Table 2. Sample sizes were unbalanced because 1) unequal numbers of mothers and children from each survey site participated in the study, 2) serum samples were broken during transport for laboratory analysis, 3) participants refused to have blood drawn or did not return for the second sampling, and 4) carotene analysis was not performed on the serum samples of the first 22 mothers and children .

Table 2. Mean serum retinol, serum carotene and modified relative dose response (RDR) of the mothers and children.

	n	Mean	Standard Deviation
Mothers			
Retinol (μg/dl)	106	68.3	23.6
Carotene (μg/dl)	86	98.6	48.1
Children			
Retinol 1 (μg/dl)	106	48.7	19.5
Retinol 2 (μg/dl)	102	65.1	12.1
Modified RDR (%)	99	120.3	583.2
Carotene 1 (μg/dl)	87	73.1	40.1
Carotene 2 (μg/dl)	102	67.7	30.8

Hypovitaminosis A is said to reach public health significance when greater than 5 percent of the population has "critical" serum retinol levels of less than 10 μg/dl (ICNND, 1963; WHO, 1982) or greater than 15 percent of the population has "marginal" serum retinol levels less than 20 µg/dl (ICNND, 1963).

None of the mothers had critical serum retinol levels (Table 3) as defined by the ICNND (1963) standards for "critical," "marginal," and "acceptable" levels. One mother from the São José site, in the municipal district of Vitoria de Santo Antão, had marginal serum retinol. In this case, the woman's daughter, also, had a critical serum retinol level (see Table 4). All other mothers had acceptable serum retinol levels.

Table 3. Distribution and percentage of mothers' serum retinol at each survey site by ICNND standards* for critical, marginal, and acceptable levels.

	Vitoria de Santo Antão		Caruaru		
µg/dl	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Critical (n) 0-9.9	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Marginal (n) 10-19.9	1 (3.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
Acceptable (n) >20.0	26 (96.3%)	28 (100.0%)	21 (100.0%)	30 (100.0%)	105 (99.1%)
Sample Size (Percent of total)	27 (25.5%)	28 (26.4%)	21 (19.8%)	30 (28.3%)	106 (100.0%)

* Hypovitaminosis A is considered a public health problem when > 15% of the population has serum retinol levels < 20 µg/dl or > 5% of the population has serum retinol levels < 10µg/dl (ICNND, 1963 p. 242).

Two girls (1.9 percent; Table 4), one each from São José and Cajá, in the Vitoria de Santo Antão municipal district, had critical levels of serum retinol. Six other children, four boys and two girls, had marginal levels of serum retinol; five of these were from Vitoria de Santo Antão and one was from Lagoa de Pedra in Caruaru district. Thus, a total of eight children (7.5 percent) had less than acceptable serum retinol levels, indicating that they were at high risk for vitamin A deficiency.

Table 4. Distribution and percentage of children's serum retinol from each survey site by ICNND standards* for critical, marginal, and acceptable levels.

	Vitoria de Santo Antão		Caruaru		
µg/dl	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Critical (n) 0-9.9	1[f] (3.7%)	1[f] (3.6%)	0 (0.0%)	0 (0.0%)	2 (1.9%)
Marginal (n) 10-19.9	2[m] (7.4%)	3[b] (10.7%)	0 (0.0%)	1[m] (3.3%)	6 (5.7%)
Acceptable (n) ≥20.0	24 (88.9%)	24 (85.7%)	20 (100.0%)	30 (96.8%)	98 (92.5%)
Sample Size (Percent of total sample)	27 (25.5%)	28 (26.4%)	20 (18.9%)	31 (29.2%)	106 (100.0%)

* Hypovitaminosis A is considered a public health problem when > 15% of the population has serum retinol levels < 20 µg/dl or > 5% of the population has serum retinol levels < 10 µg/dl (ICNND, 1963 p. 242).
[m] Males, [f] females, [b] one male and two females.

Modified RDR

RDR of greater than 20 percent is defined as being "negative," while RDR of less than 20 percent is defined as "positive" (Flores, et al., 1984). Thirty-eight (34.8 percent) of the children had negative modified RDR percentages as determined using the criteria described by Flores, et al. (1984). See Table 5. In Vitoria de Santo Antão, 23 (44.2 percent) of the 52 children had negative RDR percentages, compared to 15 (31.9 percent) of the 47 children from Caruaru. A smaller percentage (22.2 percent; n = 6) of the children 27 from Lagoa de Pedra site had negative RDR percentages than from the other three survey sites (Table 5).

Table 5. Distribution and percentage of modified retinol dose response (RDR) values of the children from each survey site by positive and negative RDR.*

	Vitoria de Santo Antão		Caruaru		
RDR	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Positive (n) ≥20%	14 (53.8%)	15 (57.7%)	11 (55.0%)	21 (77.8%)	61 (69.6%)
Negative (n) <20%	12 (42.6%)	11 (42.3%)	9 (45.0%)	6 (22.2%)	38 (34.8%)
Sample size (Percent of total)	26 (26.3%)	26 (26.3%)	20 (20.2%)	27 (27.3%)	99 (100.0%)

* Flores, et al., 1984.

Serum Carotene

Serum carotene was evaluated according to ICNND (1963) standards for "critical," "marginal," and "acceptable" levels (Tables 6-8). Four mothers (4.7 percent) had less than acceptable levels of serum carotene, one with critical and three with marginal levels. Three of these mothers were from Vitoria de Santo Antão district, and the other from Caruaru. In the critical case, no carotene was found in the mother's blood and she had a marginal level of serum retinol. The three mothers with marginal serum carotene had relatively low, though not critical or marginal levels of serum retinol.

Table 6. Serum carotene levels of mothers from each survey site compared to ICNND standards* for critical, marginal, and acceptable levels.

	Vitoria de Santo Antão		Caruaru		
μg/100ml	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Critical (n) 0-19.9	1 (4.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.2%)
Marginal (n) 20-39.9	1 (4.8%)	1 (7.1%)	0 (0.0%)	1 (3.2%)	3 (3.5%)
Acceptable (n) ≥ 40.0	19 (90.5%)	13 (92.9%)	20 (100.0%)	30 (96.8%)	82 (95.3%)
Sample Size (Percent of total sample)	21 (24.4%)	14 (16.3%)	20 (23.3%)	31 (36.0%)	86 (100.0%)

* ICNND, 1963.

Fourteen children (16.1 percent) had less than acceptable levels of serum carotene at the first sampling (Table 7). Two girls and two boys (4.6 percent) had critical serum carotene levels. Of these, one girl was from São José, and a boy and a girl were from Cajá in Vitoria de Santo Antão district. In Caruaru, one boy from Alto do Moura had critical serum carotene levels; no children from Lagoa de Pedra had critical levels.

No retinol or carotene was detected in the serum of the girl from São José; she was the daughter of the woman with marginal serum retinol and critical serum carotene. Two children with low serum carotene also had less than acceptable levels of serum retinol. Five children with less than acceptable serum retinol were not tested for serum carotene at the first sampling (one of these had low serum carotene on the second sampling). The remaining children had acceptable serum retinol levels, although four of these were only marginally acceptable.

Table 7. Children's serum carotene levels from each survey site, at the first sampling, compared to ICNND standards* for critical, marginal, and acceptable levels.

	Vitoria de Santo Antão		Caruaru		
µg/100ml	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Critical (n) 0-19.9	1[f] (4.5%)	2[a] (14.3%)	1[m] (4.8%)	0 (0.0%)	4 (4.6%)
Marginal (n) 20-39.9	3[b] (13.6%)	4[c] (28.6%)	3[b] (14.3%)	0 (0.0%)	10 (11.5%)
Acceptable (n) ≥ 40.0	18 (81.8%)	8 (57.1%)	17 (81.0%)	30 (100.0%)	73 (83.9%)
Sample Size (Percent of total sample)	22 (25.3%)	14 (16.1%)	21 (24.1%)	30 (34.5%)	87 (100.0%)

* ICNND, 1963.
[m] male, [f] female, [a] 1 male and 1 female, [b] 2 males and 1 female, [c] 2 males and 2 females.

At the second sampling, 13 children (12.8 percent; Table 8), nine boys and four girls, had less than acceptable levels of serum carotene. Four of these children had not been tested for serum carotene at the first sampling. One child, a boy from Cajá, had critical levels of serum carotene at both samplings. Four children had less than acceptable serum carotene levels at both samplings.

Table 8. Children's serum carotene levels from each survey site, at the second sampling, compared to ICNND standards* for critical, marginal, and acceptable levels.

	Vitoria de Santo Antão		Caruaru		
µg/100ml	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Critical 0-19.9	0 (0.0%)	1[m] (3.8%)	0 (0.0%)	0 (0.0%)	1 (1.0%)
Marginal 20-39.9	8[b] (27.6%)	2[a] (7.7%)	2[a] (10.0%)	0 (0.0%)	12 (11.8%)
Acceptable ≥ 40.0	21 (72.4%)	23 (88.5%)	18 (90.0%)	27 (100.0%)	89 (87.3%)
Sample Size (Percent of total sample)	29 (28.4%)	26 (25.5%)	20 (19.6%)	27 (26.5%)	102 (100.0%)

* ICNND, 1963.
[m] male, [a] 1 male and 1 female, [b] 6 males and 2 females.

Anthropometric Measurements

Anthropometric data provide a valuable component for nutrition status evaluation of individuals or groups from which the measurements are collected. In adults, this information reflects nutrition status over a long period of time. In children, when anthropometric data indicate growth as being below the 10th percentile or above the 90th percentile, or when interviews reveal dietary intake patterns that indicate that an essential nutrient is in short supply, the children are considered to be at nutritional risk (Pipes, et al., 1985).

Anthropometric Measurements of the Mothers

Descriptive statistics of age and anthropometric measurements of mothers in the study sample are presented in Table 9. Mothers had a mean age of 31.1 years and ranged in age from 19 to 47 years old. Mean height of the mothers was 153.3 cm (60.4"), with a mean weight of 56.1 kg (123.2 lb). Mean weight for height by age percentile, compared to NCHS tables (Abraham, et al., 1979), was at the 38.8 percentile. Mean tricep skinfold (TSF) for the mothers was 17.8 mm, with a mid-arm circumference (MAC) of 275.8 mm. Mean mid-arm muscle circumference (MAMC), calculated from the TSF and MAC, was 22.0 mm. When compared to NCHS tables (Frisancho, 1981), mean MAMC for the mothers was at the 56.7 percentile.

Table 9. Mothers' mean age and anthropometric measurements: weight, height, weight/height , mid-arm circumference (MAC), tricep skinfold (TSF), and mid-arm muscle circumference (MAMC).

	n	Mean	Standard Deviation
Age (years)	109	31.1	7.3
Weight (kg)	110	56.1	11.1
Height (cm)	110	153.3	7.1
Weight/Height (kg/cm)	110	0.37	0.069
Percentile Wt/Ht[a]	109	38.8	30.5
MAC (mm)	110	275.8	35.6
TSF (mm)	110	17.8	6.8
MAMC (mm)	110	22.0	2.3
Percentile MAMC[b]	109	56.7	25.0

[a] Percentile of weight/height adapted from NCHS tables (Abraham, et al., 1979).
[b] Percentile of MAMC from NCHS tables (Frisancho, 1981).

Weights and heights. Mothers' heights ranged from the 107 cm (42.1") to 171 cm (67.3"), with a mode of 152 cm (59.8") for 13 mothers. Mean height of the mothers was 153.3 cm (60.4"), which indicated that the mothers tended to be of small stature compared to average height of 63.7 inches for U.S. women in the National Health and Nutrition Examination Survey (NHANES I)

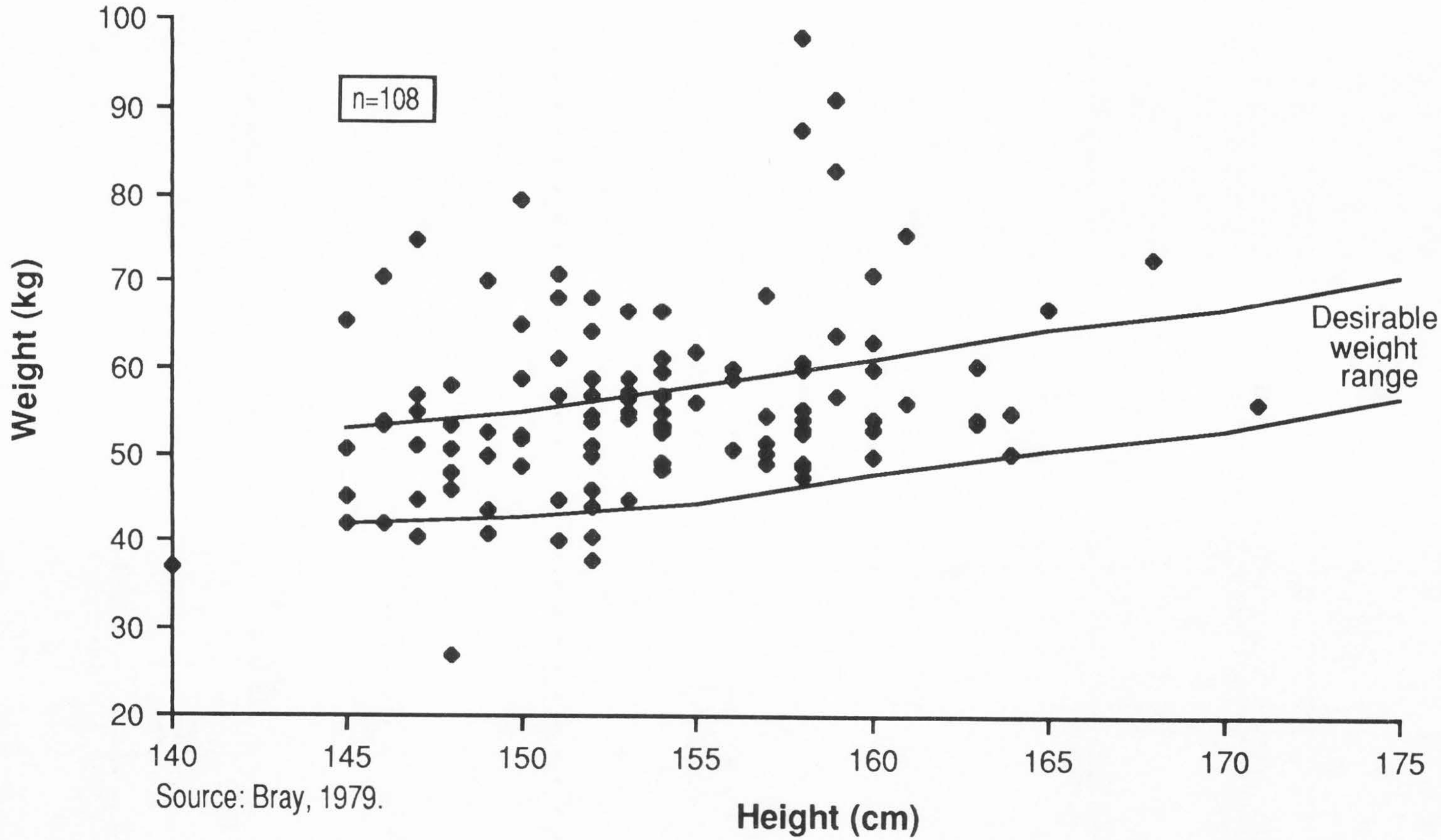
(Abraham, et al., 1979). Only 10 (9.1 percent) of the 110 women were taller than 162 cm (64"). Table 10 presents the heights, in centimeters and percentages, of the 110 women surveyed.

Table 10. Heights of the 110 mothers.

Height (cm)	n	Percent
<140	1	0.9
140-144	1	0.9
145-149	25	22.7
150-154	42	38.2
155-159	25	22.7
160-164	15	13.6
165-169	2	1.8
≥170	1	0.9

When compared to the suggested desirable ranges of weights for height, using National Institute of Health (NIH) standard tables (Bray, 1979), six (5.5 percent) of the women had weights below the desirable weight range and 36 (32.7 percent) had weights above the desirable weight range (Figure 1). Fifty-nine percent (n = 65) weighed in the desirable range for their heights. Two of the women were shorter than the heights for which NIH standards are available. One of the women was extremely short, 107 cm (42").

Weight for height. The women's weights for heights were compared to the NCHS data (Abraham, et al, 1979) which estimates the percent distribution of heights and weights of women in the United States. See Figure 2. The weight for height by age graph in Figure 2 was derived by dividing the NCHS values for weight for age at the 10th, 50th, and 90th percentiles by the corresponding values for height for age. Twenty-two (20 percent) of the women



Source: Bray, 1979.

Figure 1. Weight for height of the mothers compared to NIH suggested desirable weight ranges for height.

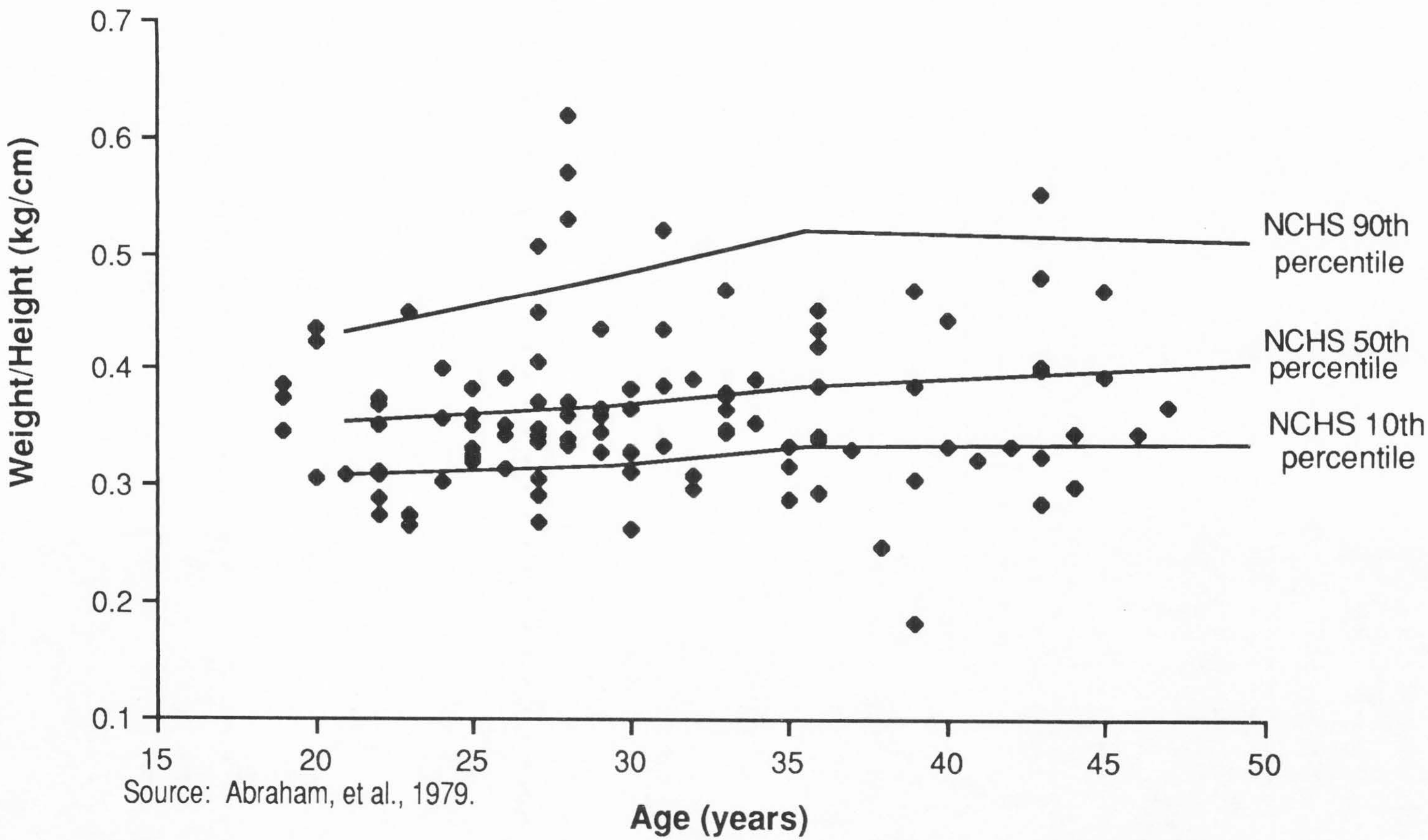


Figure 2. Weight for height for age of the mothers compared to NCHS weight tables divided by height tables.

fell below the 10th percentile of weight for height compared to the NCHS tables and seven (6.4 percent) women were above the 90th percentile (Figure 2).

Arm anthropometry. The mid-arm circumferences (MAC) of the mothers ranged from 193 mm to 376 mm with a mean of 276 mm. Six (5.5 percent) of the mothers fell at approximately the 10th percentile or below for MAC compared to NCHS data (Frisancho, 1981); another six were at or above the 90th percentile (Table 11). The majority of the mothers had MAC between the 50th and 90th percentiles.

Table 11. Mid-arm muscle circumferences (MAC) of the 110 mothers.

MAC (mm)	n	Percent
< 230	6	5.5
230-259	33	30.0
260-289	42	38.2
290-339	23	20.9
≥ 340	6	5.5

Tricep skinfold measurements are indicators of body fat stores. Approximately 17 percent (Table 12) of the mothers had TSF below the 10th percentile when compared to NCHS tables (Frisancho, 1981). Eight (7.3 percent) were near or above the 90th percentile.

Table 12. Tricep skinfold (TSF) measurements of the 110 mothers.

TSF (mm)	n	Percent
<12	19	17.3
12-17.9	39	35.5
18-23.9	32	29.1
24-29.9	12	10.9
≥30	8	7.3

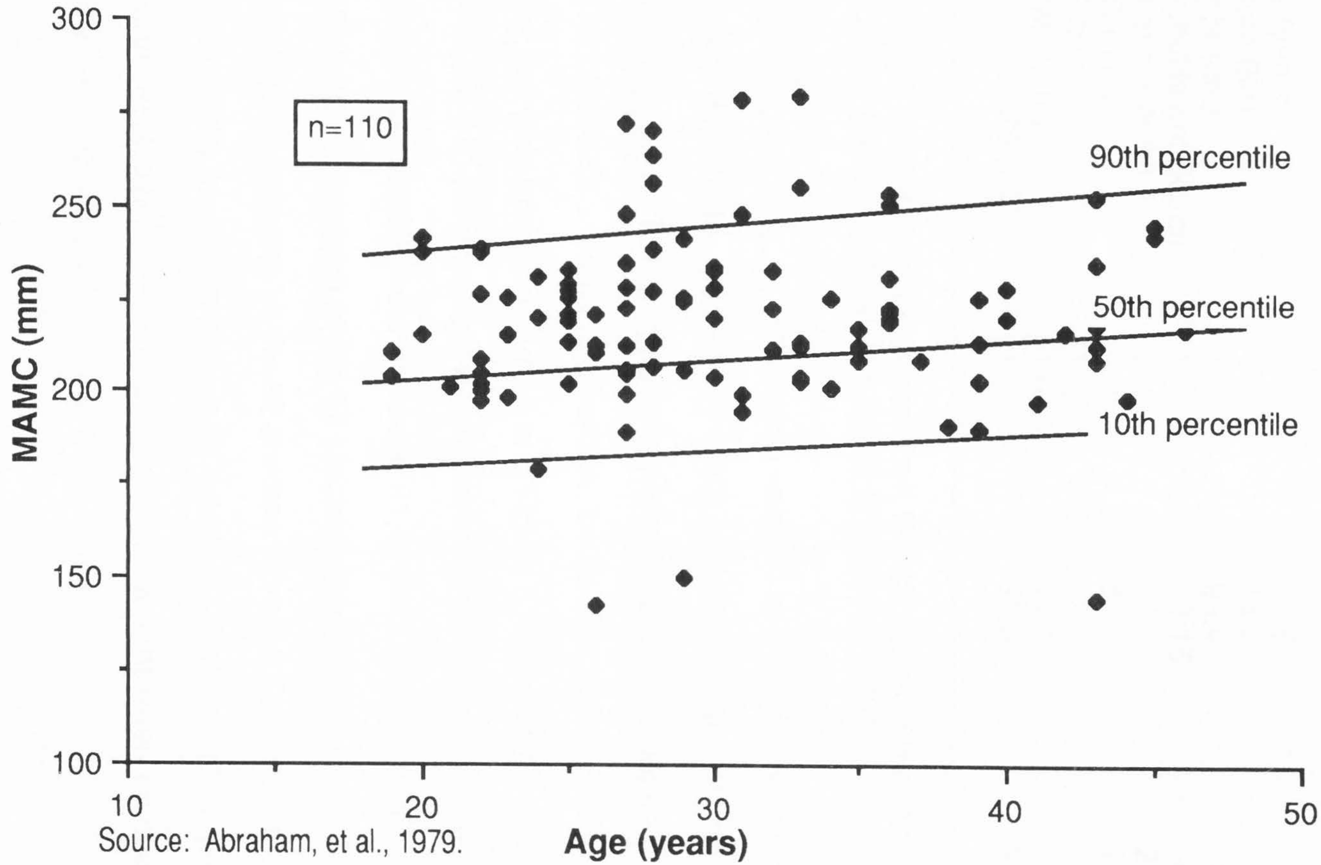
Mid-arm muscle circumference (MAMC) is an indication of lean body mass and was calculated from the mid-arm circumference and the tricep skinfold. Four mothers had MAMC at or below the 10th percentile (Table 13) compared to NCHS data (Frisancho, 1981). Seventeen (15.5 percent) had MAMC measurements at or above the 90th percentile (Table 13; Figure 3). Figure 3 is a scatter plot of the mothers MAMC for age, with the 90th, 50th, and 10th percentiles for MAMC (Frisancho, 1981) superimposed.

Table 13. Mid-arm muscle circumference (MAMC) of the 110 mothers.

MAMC (mm)	n	Percent
<180	4	3.6
180-199.9	10	9.1
200-219.9	44	40.0
220-239.9	35	31.8
≥240	17	15.5

Anthropometric Measurements of the Children

Descriptive statistics of anthropometric measurements of the children in the sample are listed in Table 14. Mean age of the children was 3.6 years (Table 14), with a range of 1.6 to 5.8 years. Mean height was 95.4 cm (37.6"), and mean weight was 14.2 kg (31.2 lb). When compared to the derived NCHS weight for height by age tables (Hamill, et al., 1977), the mean of the sample of children was at the 62.3 percentile. Mean TSF for the children was 8.9 mm and mean MAC of 167.8 mm. MAMC, calculated for each child from the TSF and MAC, was 14.0 mm, or the 33.8 percentile of the NCHS tables (Frisancho, 1981).



Source: Abraham, et al., 1979.

Figure 3. Mid-arm muscle circumferences (MAMC) by age for the mothers compared to NCHS tables for whites.

Table 14. Children's mean age and anthropometric measurements: weight, height, weight/height, mid-arm circumference (MAC), tricep ski fold (TSF), and mid-arm muscle circumference (MAMC).

	n	Mean	Standard Deviation
Age (years)	110	3.6	1.0
Weight (kg)	110	14.2	2.6
Height (cm)	110	95.4	8.2
Weight/Height (kg/cm)	110	0.15	0.017
Percentile Wt/Ht [a]	110	62.3	25.7
MAC (mm)	110	167.8	12.4
TSF (mm)	110	8.9	2.2
MAMC (mm)	110	14.0	1.0
Percentile MAMC [b]	110	33.8	29.4

[a] Percentile of weight/height adapted from NCHS tables (Abraham, et al., 1979).
[b] Percentile of MAMC from NCHS tables (Frisancho, 1981).

Weights and heights. Children's weights and heights were compared to Brazilian standards (Marques, et al., 1982). Brazilian tables of arm anthropometry, MAC, TSF and MAMC, have not been developed.

The children's weights and heights, by gender, compared to Brazilian standards, are illustrated in Figure 4 and Figure 5, respectively. Forty-one (37.3 percent) of the 110 children had weights below the 10th percentile. Of these, 20, or 31.7 percent of 63, were boys and 21, or 44.7 percent of 47, were girls. Twenty-three (39.7 percent) of the 58 children from the Vitoria de Santo Antão sites and 18 (34.6 percent) of the 52 children from the Caruaru sites fell below the 10th percentile for weight (Figure 6; Table15). In all, 97 (88.2 percent) of the 110 children were below the 50th percentile for weight when compared to Brazilian weight standards (Figure 4; Table 15).

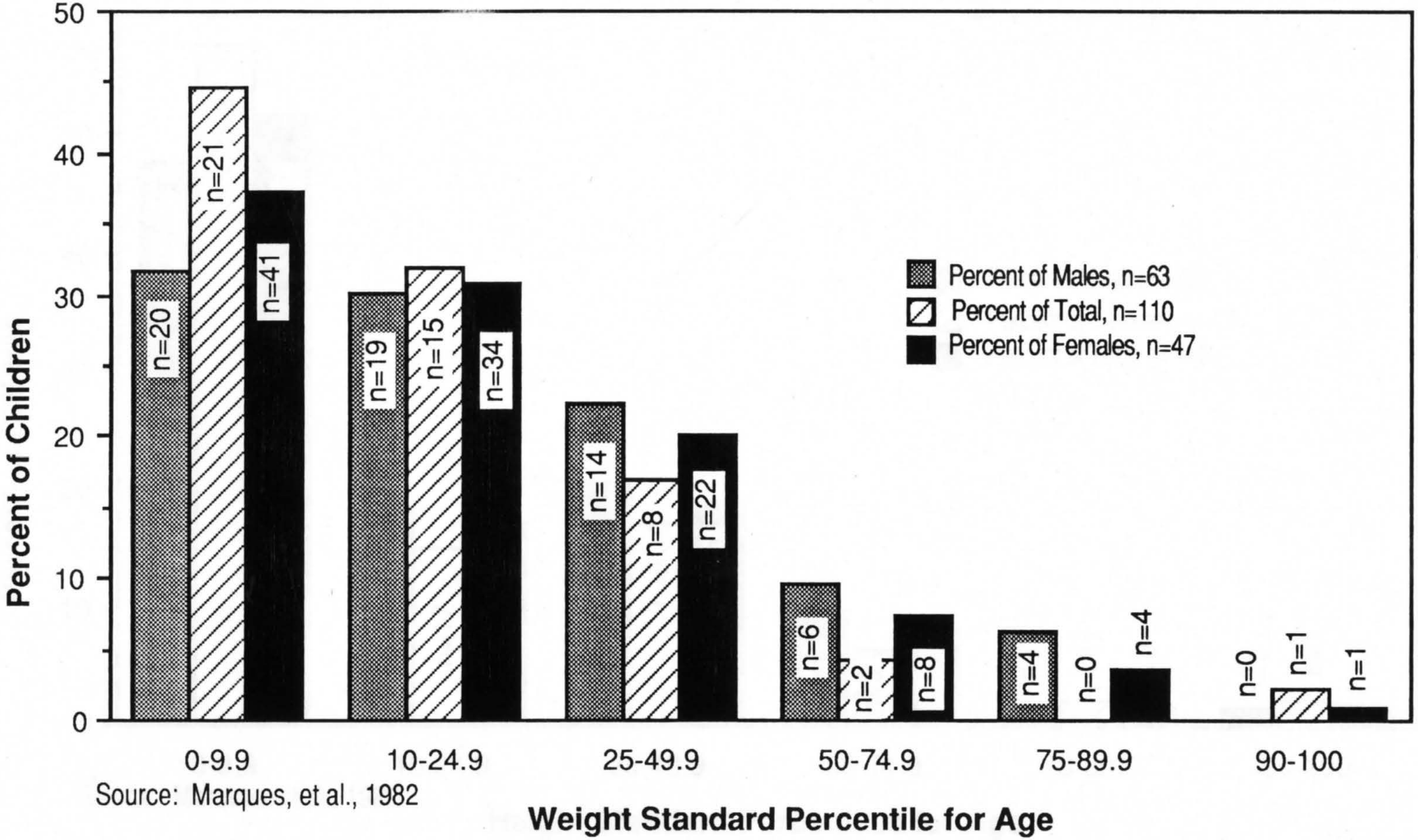
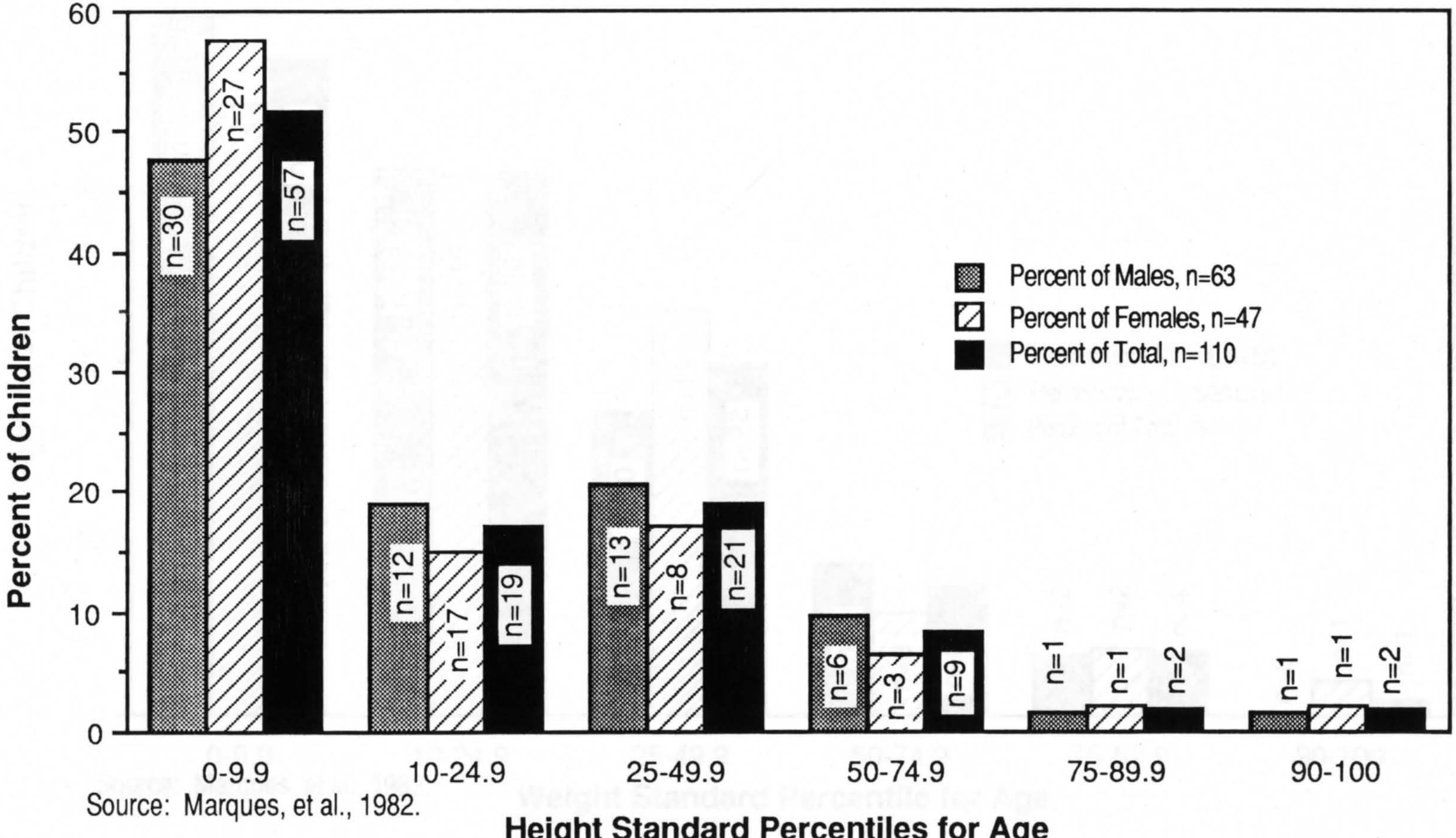
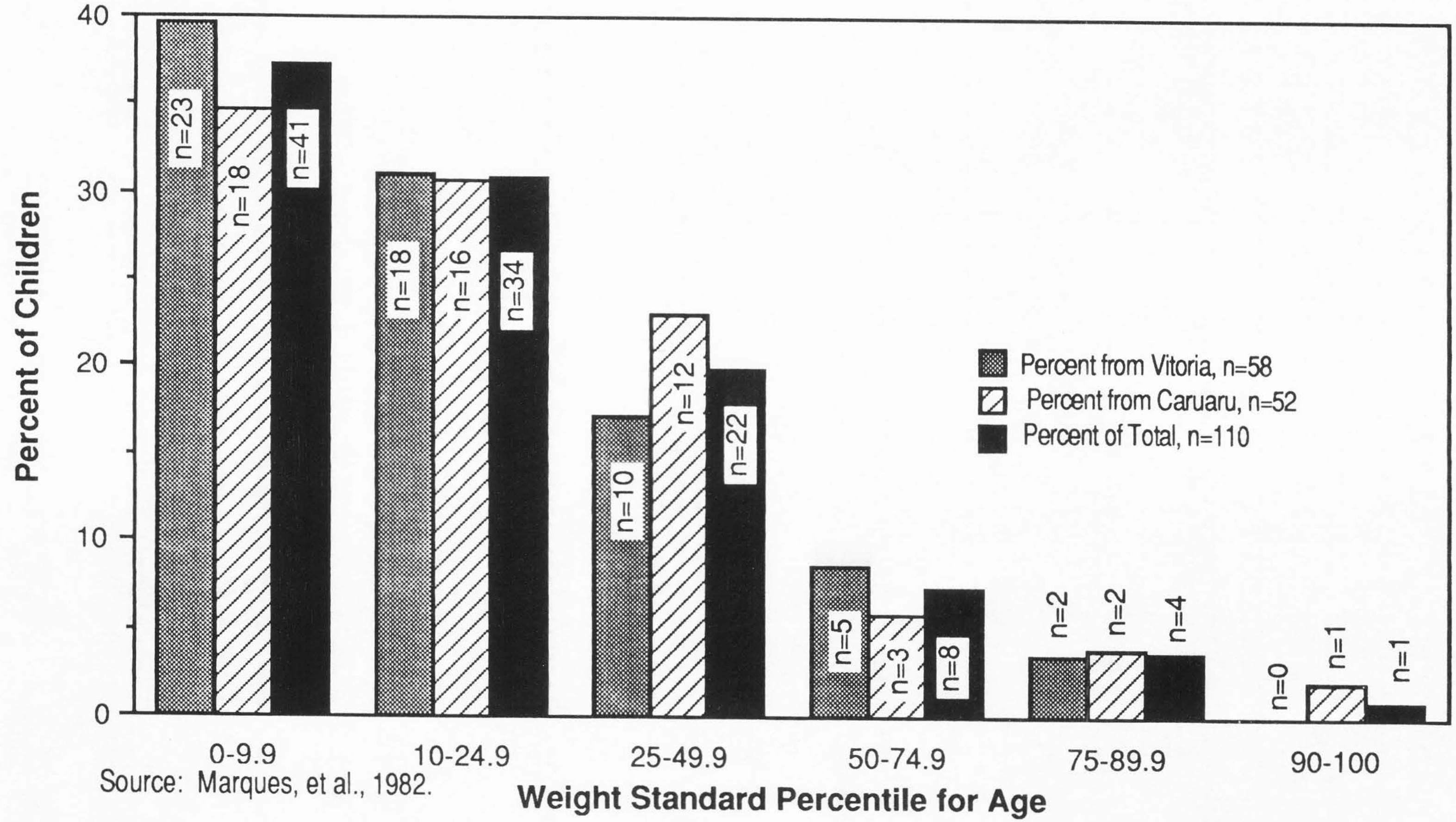


Figure 4. Percentiles of weight for age and gender of the children compared to Brazilian tables.



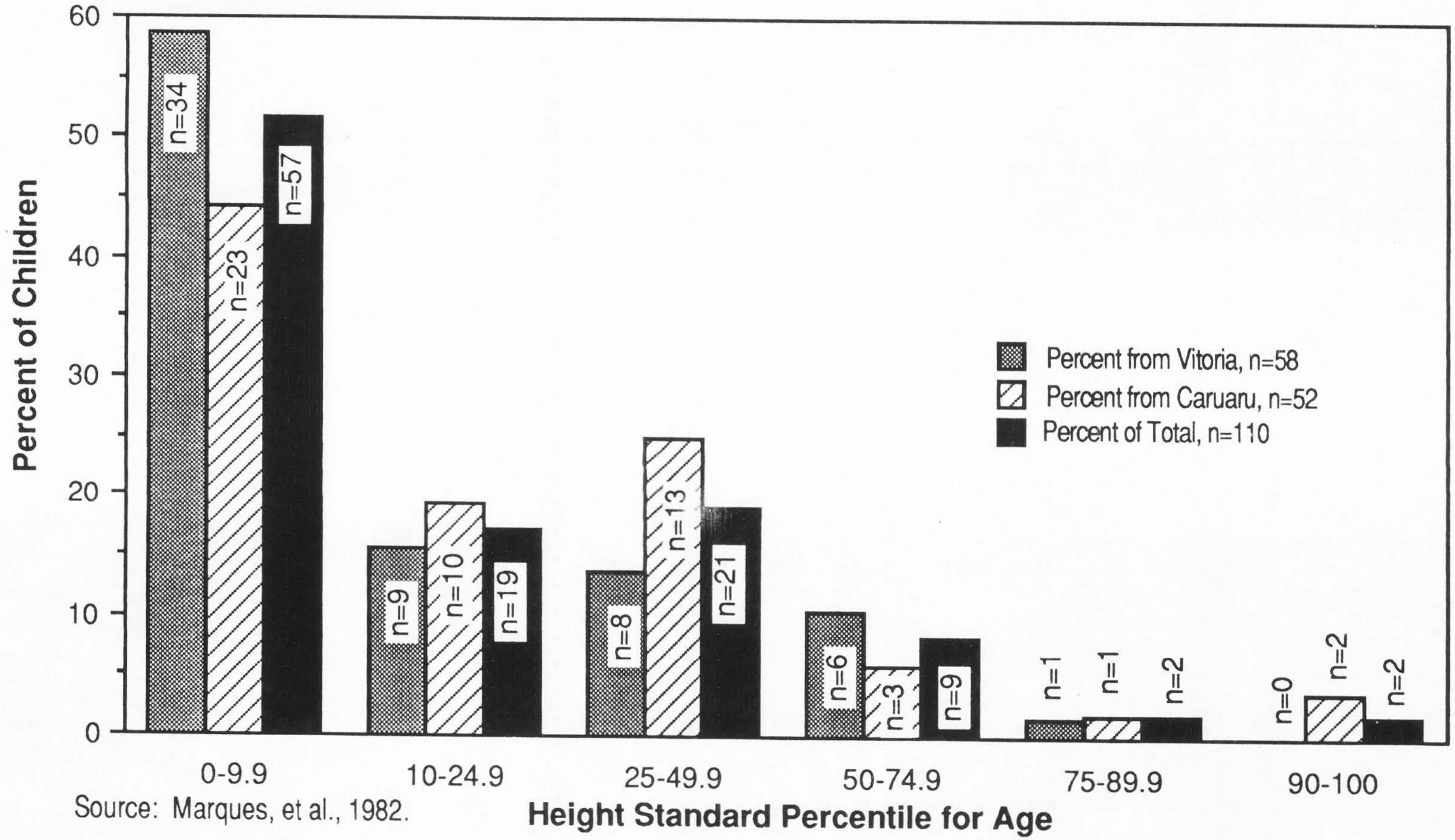
Source: Marques, et al., 1982.

Figure 5. Height for age and gender of the children compared to Brazilian tables.



Source: Marques, et al., 1982.

Figure 6. Percentiles of weight for age and gender of the children from Vitoria de Santo Antão and Caruaru, compared to Brazilian standards.



Source: Marques, et al., 1982.

Figure 7. Percentiles of height for age and gender of the children from Vitoria de Santo Antão and Caruaru, compared to Brazilian standards.

Table 15. Distribution and percentage of children's weight percentiles from the survey sites using Brazilian tables.*

	Vitoria de Santo Antão		Caruaru		
Percentile	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
0-9.9	12	11	4	14	41
(Percent)	(40.0)	(39.3)	(19.0)	(45.2)	(37.3)
10-49.9	12	16	15	13	56
(Percent)	(40.0)	(57.1)	(71.4)	(41.9)	(50.9)
50-89.9	6	1	2	3	12
(Percent)	(20.0)	(3.6)	(9.5)	(9.7)	(10.9)
90-100	0	0	0	1	1
(Percent)	(0.0)	(0.0)	(0.0)	(3.2)	(0.9)
Sample Size	30	28	21	31	110
(Percent of total sample)	(25.5)	(27.3)	(19.1)	(28.2)	(100.0)

* Marques, et al., 1982.

More children were below the 10th percentile for height than for weight when compared to the Brazilian tables. Fifty-seven (51.8 percent) of the children were below the 10th percentile, 30, or 47.6 percent, of the 63 boys and 27, or 57.4 percent, of the 47 girls (Figure 5). Thirty-four (58.6 percent) of the children from Vitoria de Santo Antão and 23 (44.2 percent) from Caruaru were below the 10th percentile (Figure 7; Table 16). A total of 97 (88.2 percent) children were below the 50th percentile for height.

Table 16. Distribution and percentage of children's height percentiles from the survey sites using Brazilian tables.*

	Vitoria de Santo Antão		Caruaru		
Percentile	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
0-9.9	16	18	9	14	57
(percent)	(53.3)	(64.3)	(42.9)	(45.2)	(51.8)
10-49.9	8	9	10	13	40
(percent)	(26.7)	(32.1)	(47.6)	(41.9)	(30.9)
50-89.9	6	1	2	2	11
(percent)	(20.0)	(3.6)	(9.5)	(6.5)	(14.5)
90-100	0	0	0	2	2
(percent)	(0.0)	(0.0)	(0.0)	(6.5)	(1.8)
Sample Size	30	28	21	31	110
(Percent of total sample)	(25.5)	(27.3)	(19.1)	(28.2)	(100.0)

* Marques, et al., 1982.

Weight/height ratios. Weight for height ratios are preferable to either height or weight measurements alone in determining nutrition status of children (Pipes, et al., 1985). Weight for height by age standards for children were calculated from Brazilian (Marques, et al., 1982) and NCHS (Hamill, et al., 1977) tables by dividing the weight data at the 90th, 50th and 10th percentiles by the corresponding values from the height by age standard tables. Weight/height standards by age were superimposed over a scatter plot of the children's weight/height by age (Figures 8-11).

Compared to Brazilian standards, 15 (23.8 percent; Figure 8) of the boys and 18 (38.3 percent; Figure 9) of the girls were at or below the 10th percentile of weight/height by age. Thus, a total of 33 (30 percent) children were below the 10th percentile. Fifty-three (84.1 percent) of the boys and 44 (93.6 percent)

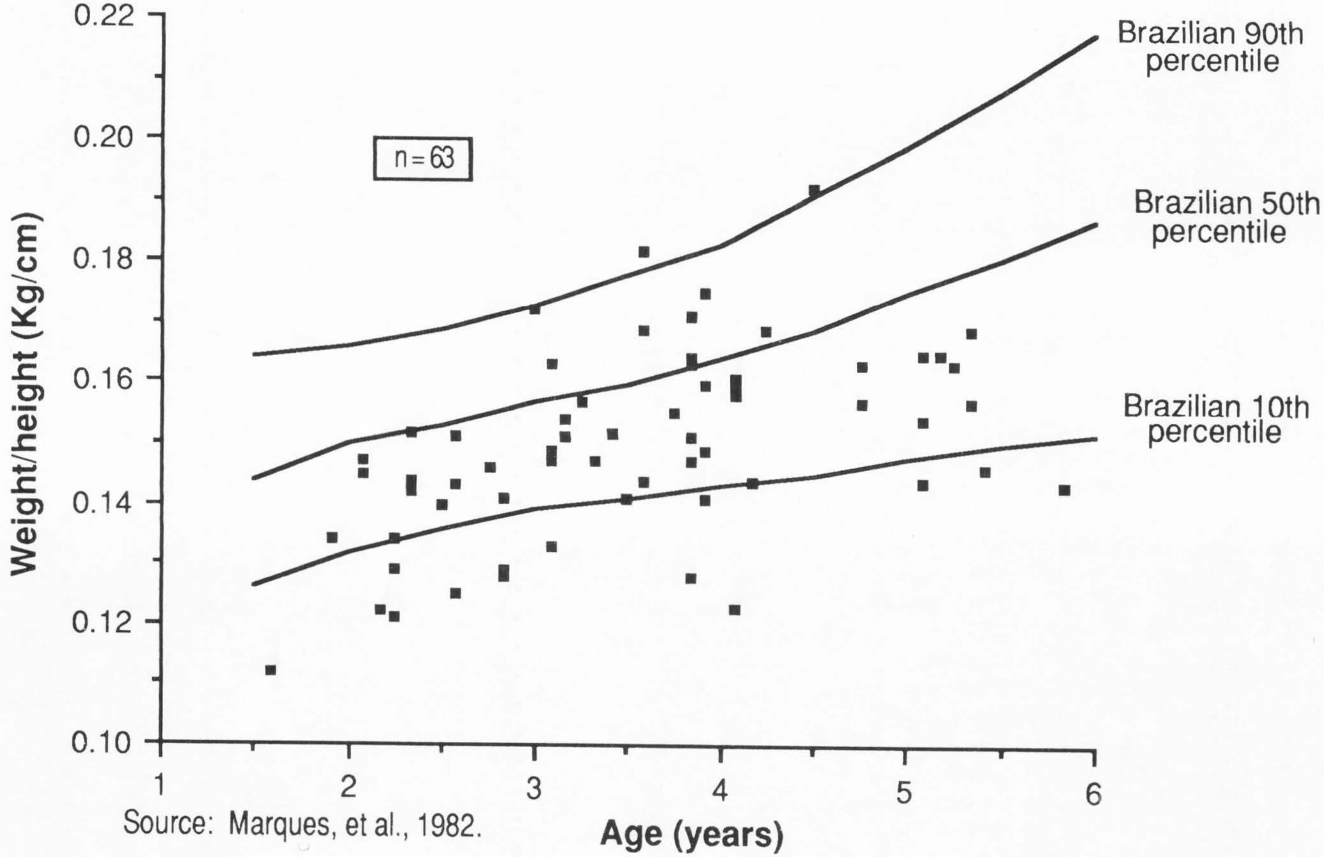
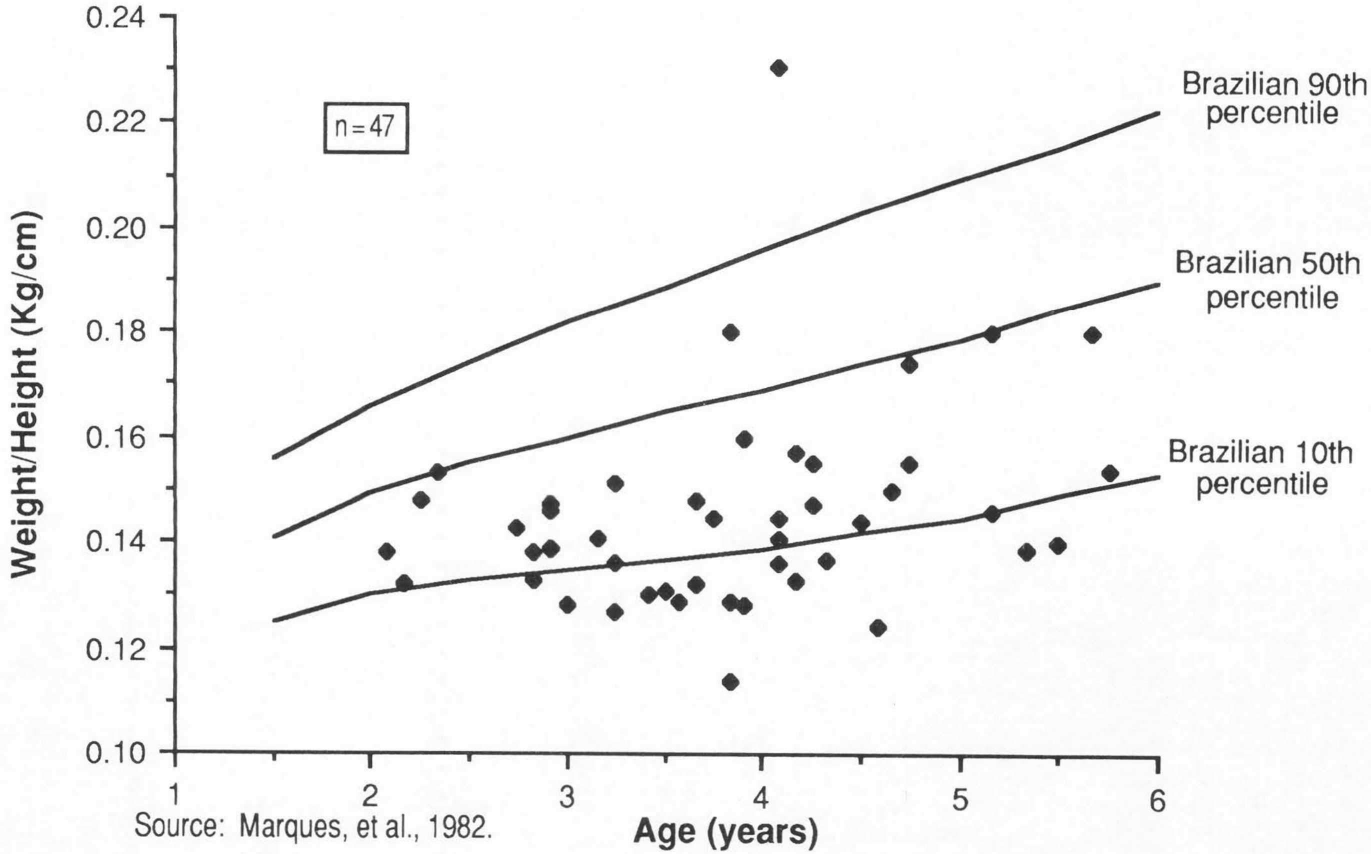
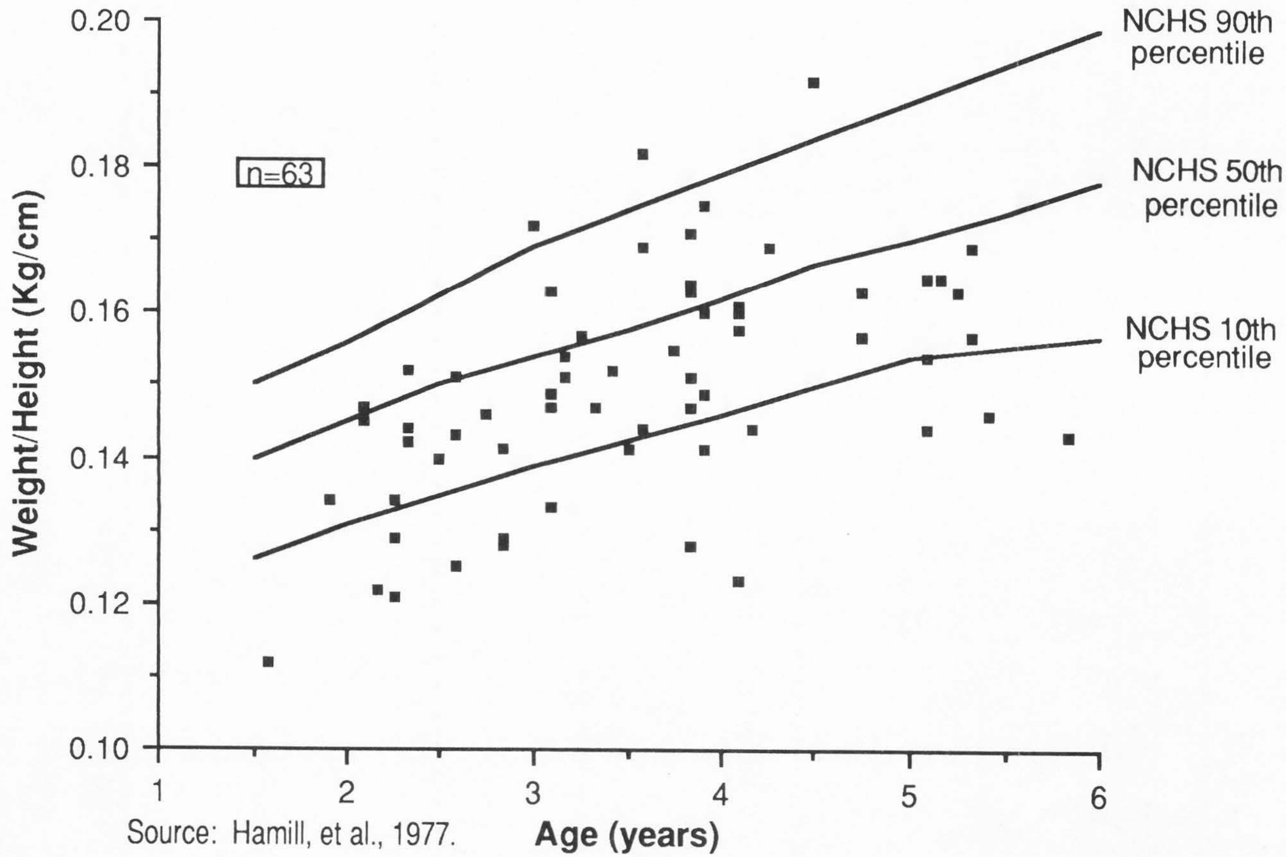


Figure 8. Weight for height by age of the male children compared to Brazilian weight tables divided by height tables.



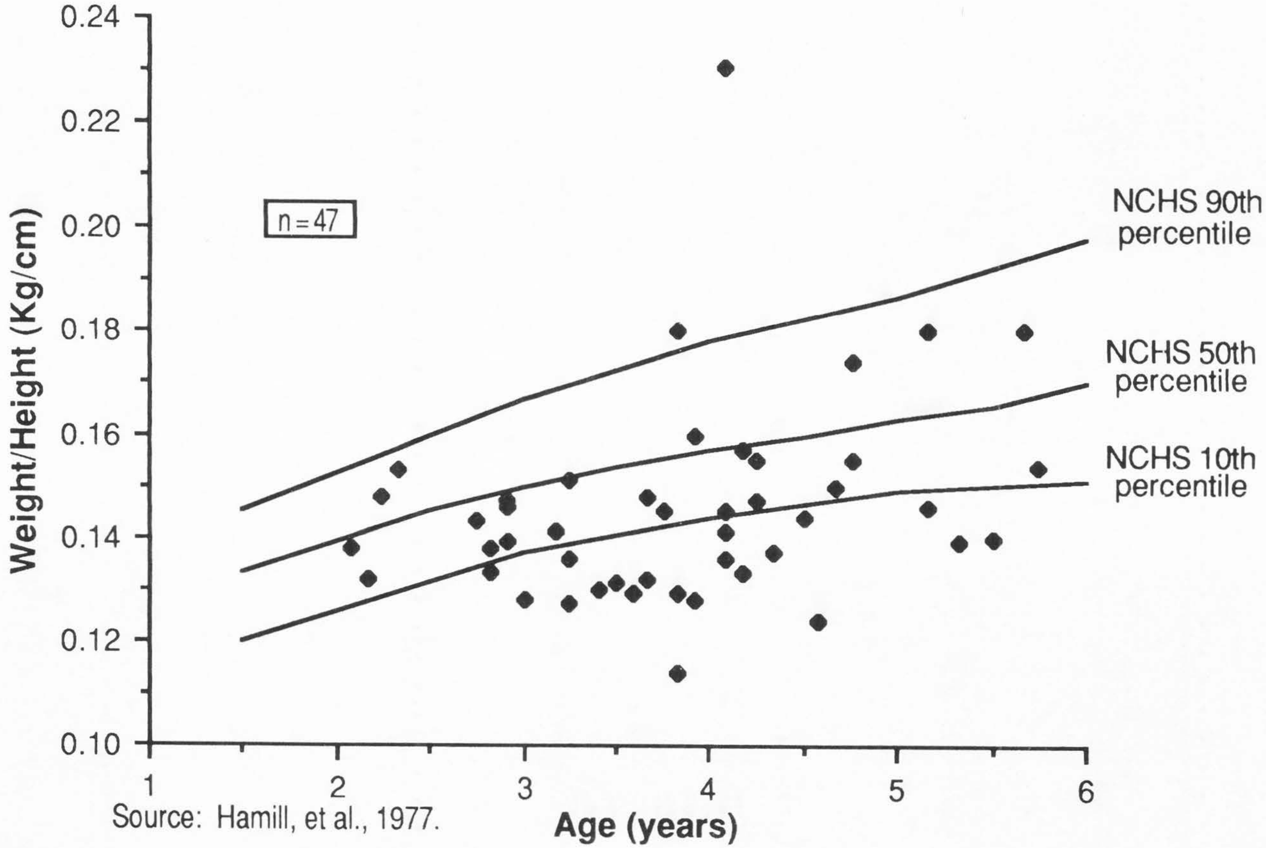
Source: Marques, et al., 1982.

Figure 9. Weight for height by age of the female children compared to Brazilian weight tables divided by height tables.



Source: Hamill, et al., 1977.

Figure 10. Weight for height by age of the male children compared to smoothed NCHS weight tables divided by height tables.



Source: Hamill, et al., 1977.

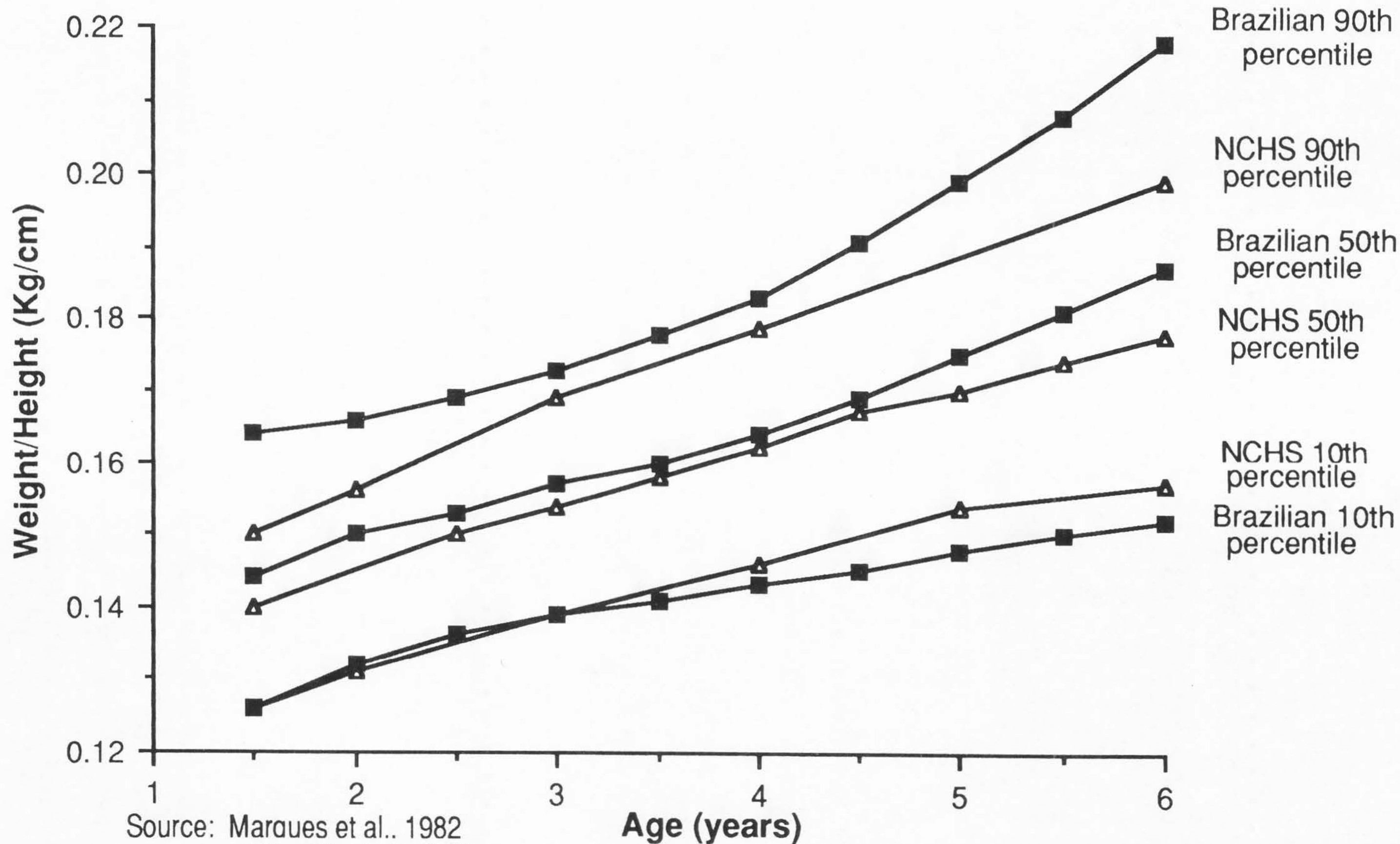
Figure 11. Weight for height by age of female children compared to smoothed NCHS weight tables divided by height tables (Hamill, et al., 1977).

of the girls were below the 50th percentile. Two boys and one girl were above the 90th percentile.

When the NCHS weight/height by age data were superimposed over the children's weight/height by ages, the children's data were more evenly distributed (Figures 10 and 11). However, 17 (27 percent) boys and 20 (42.6 percent) girls, or 33.6 percent of the sample, had weight/height values below the 10th percentile of the NCHS standards. Three boys and two girls were above the 90th percentile. Forty-nine or 77.8 percent of the boys and 39 or 83 percent of the girls were below the 50th percentile (Figures 10 and 11). Eighty percent (n = 88) of the children sampled fell below the 50th percentile of weight/height by age.

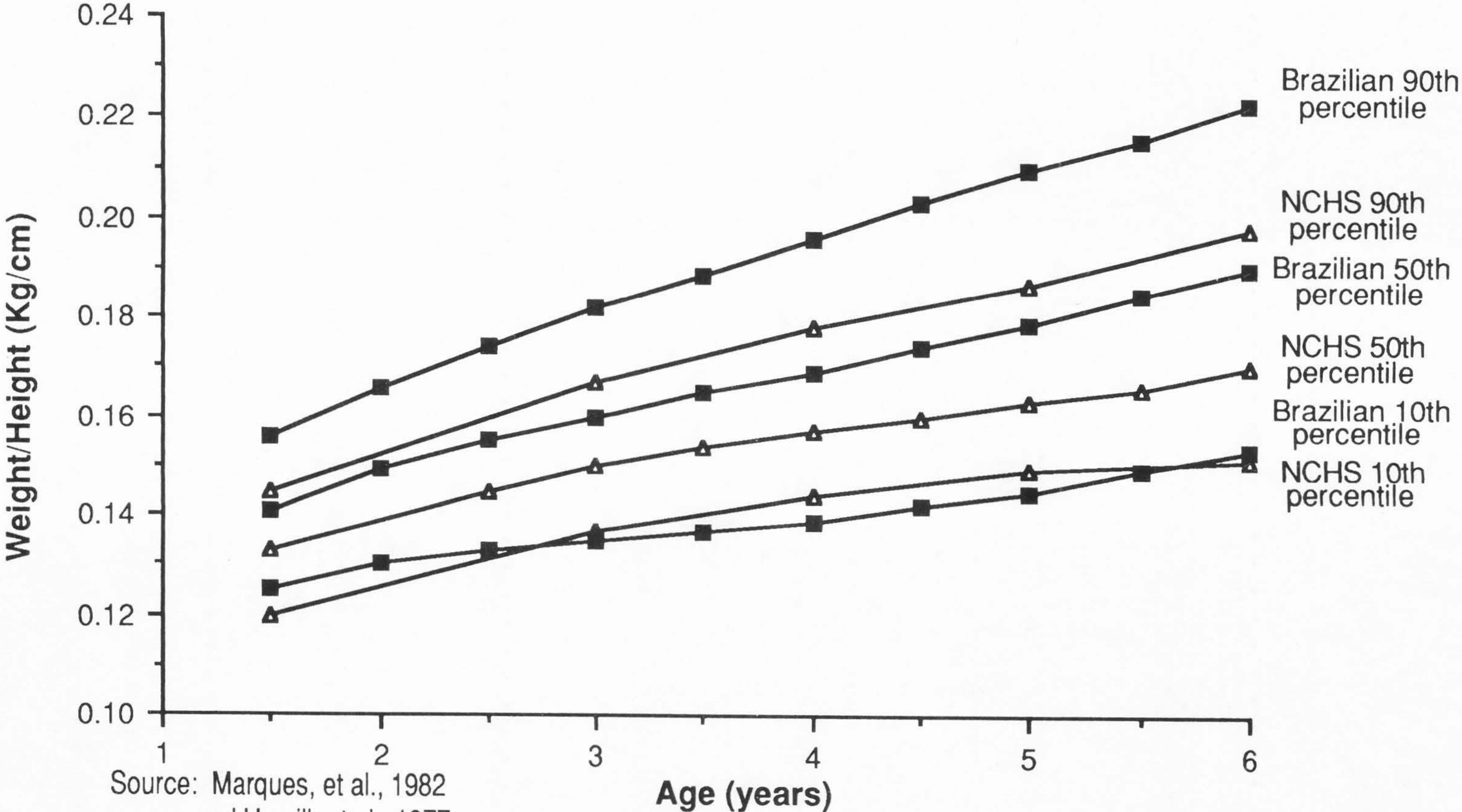
Figures 12 and 13 illustrate the comparison of derived Brazilian weight/height by age standards (Marques, et al., 1982) to derived NCHS weight/height by age standards (Hamill, et al., 1977). The 50th percentile on the Brazilian tables is higher for both males (Figure 12) and females (Figure 13), with females having a higher standard than for males. The distance between the extremes (10th to 90th percentiles) of the standards is greater for the Brazilian than for the NCHS standards.

The sample sizes used to develop the NCHS standards were very large (n > 4,500) for children from birth to six years. While the sample size used to derive the Brazilian tables is unknown, it is undoubtably smaller than the NCHS sample size. It may be inappropriate to compare extreme percentiles in different standard charts because of differences in 1) sample sizes used to generate the charts, 2) class intervals according to age, and 3) methods used to derive the percentiles. The use of relatively small samples may decrease the validity of standard percentiles, particularly at the extremes, resulting in



Source: Marques et al.. 1982 and Hamill, et al., 1977.

Figure 12. Comparison of Brazilian and NCHS weight tables divided by height tables for male children.



Source: Marques, et al., 1982
and Hamill, et al., 1977.

Figure 13. Comparison of Brazilian and NCHS weight tables divided by height tables for female children.

decreased validity in estimating numbers of individuals with high and low values (Frankle and Owen, 1978).

Arm anthropometry. The children's mid-arm circumferences ranged from 137 mm to 223 mm with a mean of 168 mm. Four children (3.6 percent), two boys and two girls, had MAC less than 150 mm which is below the 10th percentile for MAC when compared to the NCHS tables (Table 17) (Frisancho, 1981). Ten (15.5 percent) boys and seven (14.9 percent) girls had MAC near or above the 90th percentile of 180 mm.

Table 17. Mid-arm circumference (MAC) of the 63 male and 47 female children.

	Males		Females		Total	
MAC (mm)	n	Percent	n	Percent	n	Percent
<150	2	3.6	2	4.3	4	3.6
150-159.9	13	9.1	9	19.1	22	20.0
160-169.9	20	40.0	20	42.6	40	36.4
170-179.9	18	31.8	9	19.1	27	24.5
≥180	10	15.5	7	14.9	17	15.5

More children had low tricep skinfold measurements than low mid-arm circumferences. Eight boys (12.7 percent; Table 18) and four girls (8.5 percent) had TSF below the 10th percentile of 7 mm when compared to the NCHS tables (Frisancho, 1981). Five (4.5 percent) children had TSF near 14 mm or the 90th percentile.

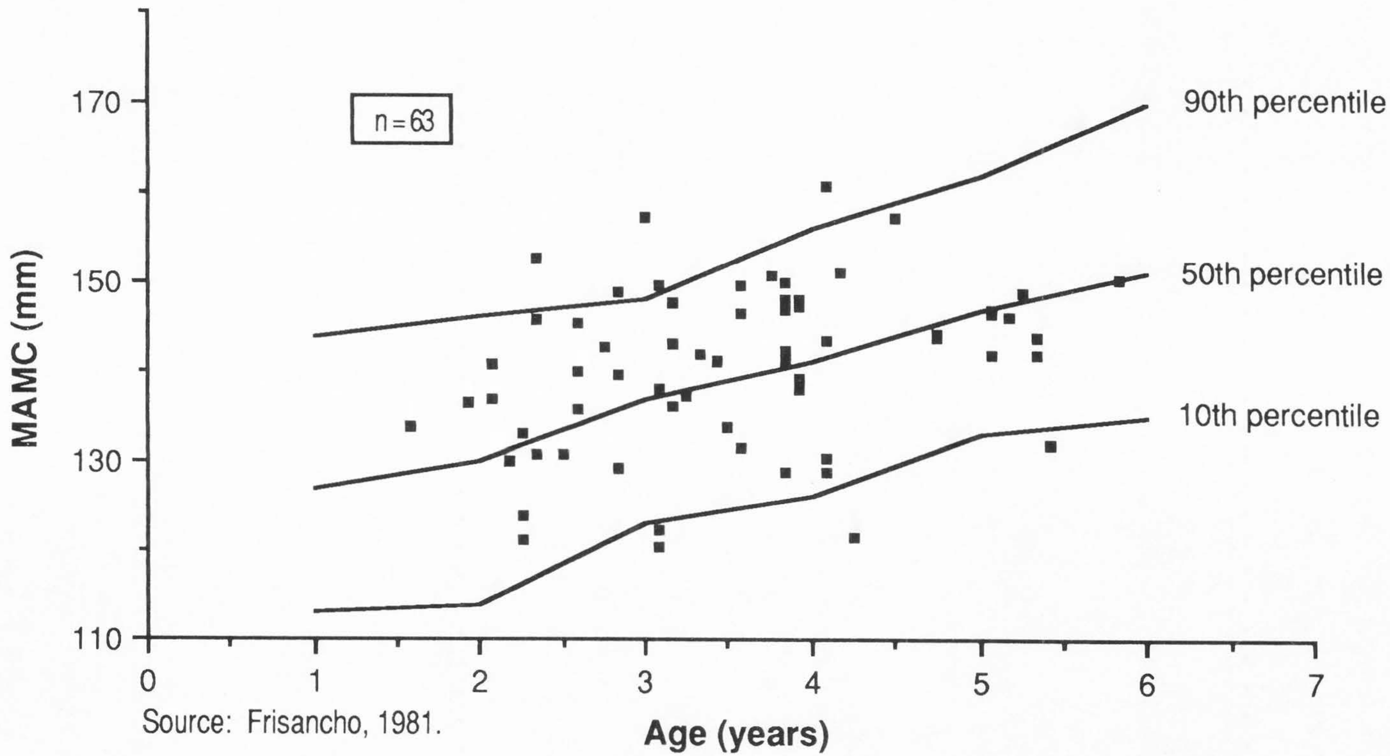
Table 18. Tricep skinfolds (TSF) of the 63 male and 47 female children.

	Males		Females		Total	
TSF (mm)	n	Percent	n	Percent	n	Percent
<7	8	12.7	4	8.5	12	10.9
7-10	43	68.3	34	72.3	77	70.0
11-13	10	15.9	6	12.8	16	14.5
≥14	2	3.2	3	6.4	5	4.5

The children's MAMC are presented in Table 19. These values were plotted against ages, and are presented in Figures 14 and 15 with standards for the 90th, 50th and 10th percentiles superimposed (Frisancho, 1981). Four (6.3 percent) of the boys had MAMC below the 10th percentile while five (7.9 percent) were above the 90th percentile (Figure 14). Two (4.3 percent) of the girls were below the 10th percentile and four (8.5 percent) were above the 90th percentile (Figure 15).

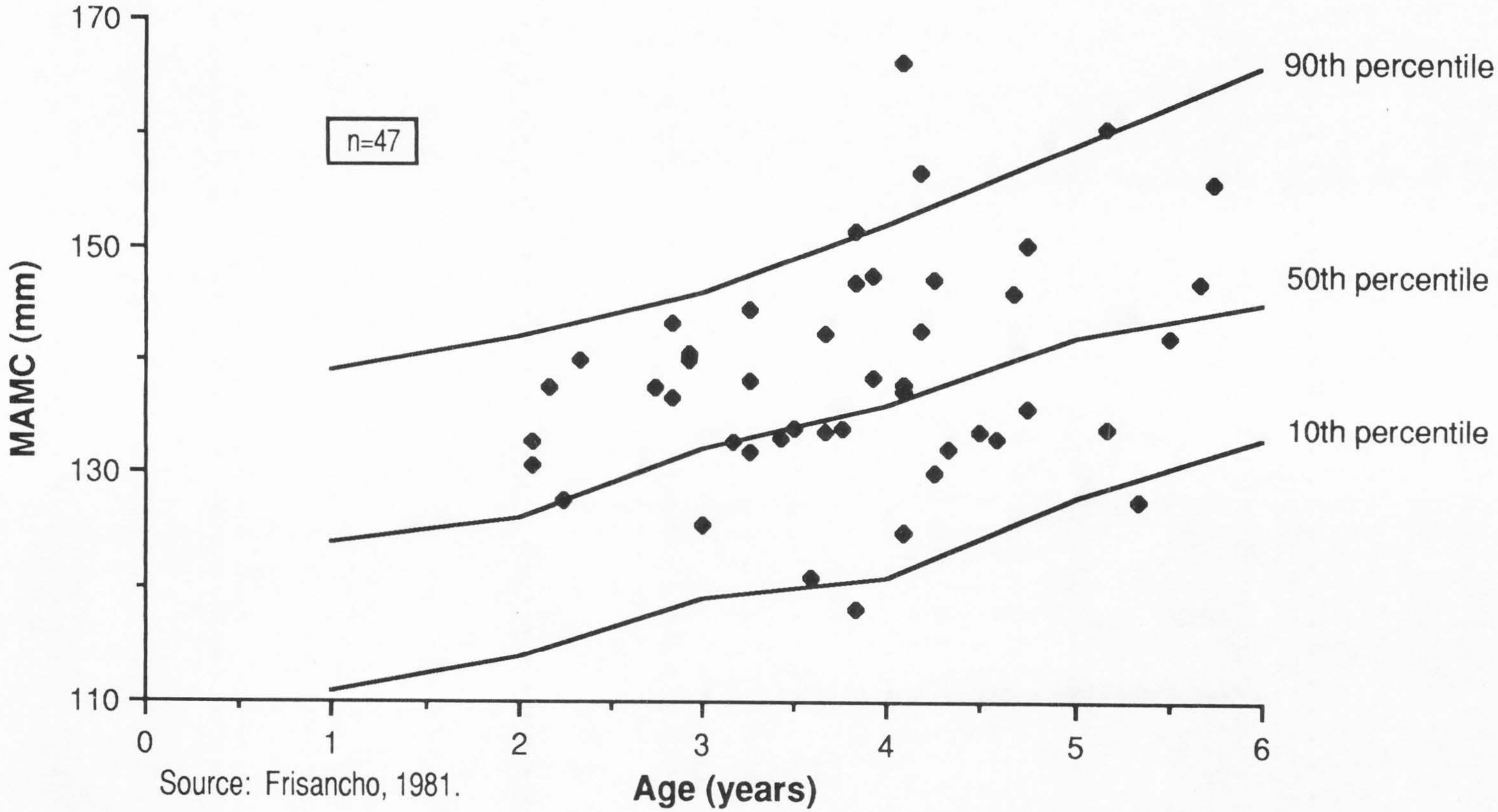
Table 19. Mid-arm muscle circumference (MAMC) of the 63 male and 47 female children.

	Males		Females		Total	
MAMC (mm)	n	Percent	n	Percent	n	Percent
<125	5	7.9	3	6.4	8	7.3
125-139.9	22	34.9	26	57.4	48	43.6
140-154.9	33	52.4	14	29.8	47	42.7
≥155	3	4.8	4	8.5	7	6.4



Source: Frisancho, 1981.

Figure 14. Mid-arm muscle circumference (MAMC) by age of males compared to NCHS tables for whites.



Source: Frisancho, 1981.

Figure 15. Mid-arm muscle circumference (MAMC) by age of females compared to NCHS tables for whites.

Food Sources of Vitamin A

The mothers and children consumed vitamin A from both preformed and provitamin A sources, although generally more vitamin A was consumed from provitamin A, i.e., carotenoid, sources. Table 20 lists mean levels of preformed, pro- and total vitamin A consumed by mothers and children.

Table 20. Mean and percent of total vitamin A intake from preformed vitamin A and provitamin A by mothers and children.

	n	Mean	Standard Deviation
Mothers			
Preformed (RE)	107	481	1242
Pro- (RE)	107	797	1106
Total (RE)	107	1277	1750
Children			
Preformed (RE)	107	474	696
Pro- (RE)	107	447	754
Total (RE)	107	921	1141

The amount of vitamin A consumed by each mother and child was determined by interview with the mothers. Mothers indicated quantities of specific vitamin A foods, in grams, that they and their children consumed daily, weekly, or monthly. The quantity was multiplied by the level of vitamin A content in RE of that food per 100 gm, and the average amount of preformed, pro- and total vitamin A per day was computed. Vitamin A food composition data came from the INCAP-ICNND tables (1961), except for the vitamin A content of beef liver, carrots, and jerimun, a local pumpkin-like winter squash. Vitamin A content of these foods was analyzed from local samples at the Laboratorio de Bioquémica da Nutricão of the Universidade Federal de Pernambuco.

Food composition tables report the vitamin A content of food in retinol equivalents (RE) to correct for the difference in vitamin A activity of performed and provitamin A sources. By definition a retinol equivalent is equal to one μg retinol, 6 μg ß-carotene, or 12 μg other provitamin A carotene. The amount of vitamin A consumed in retinol equivalents can, therefore, be compared to the World Health Organization (WHO) standards for "adequate" and "inadequate" vitamin A intake in μg retinol per day (FAO/WHO, 1967, WHO, 1974).

Forty-nine (45.8 percent) of the 107 mothers reported consuming less than adequate daily amounts of dietary vitamin A compared to WHO standard of adequacy of 750 μg/day (FAO/WHO, 1967; WHO, 1974) (Table 21). Sixteen or 76.2 percent of the women from Alto de Moura reported consuming adequate dietary vitamin A. A lower percentage from each of the other survey sites reported adequate vitamin A intake.

Sixty-two (57.9 percent) of all the children in the sample were reported by their mothers to consume adequate dietary vitamin A when compared to the FAO/WHO (1967, 1974) recommendation of 400 μg retinol per day for children (Table 21). More children, that is 71.4 percent, of those in São José were reported to have adequate vitamin A intakes when compared to children in other survey sites.

Table 21. Distribution and percent of mothers and children with adequate and inadequate dietary vitamin A, as estimated* compared to WHO standards.†

	Vitoria de Santo Antão		Caruaru		
	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Mothers					
Adequate (n)	14	11	16	17	58
≥ 750 μg/day	(50.0%)	(40.7%)	(76.2%)	(54.8%)	(54.2%)
Inadequate (n)	14	16	5	14	49
< 750 μg/day	(50.0%)	(59.3%)	(23.8%)	(45.2%)	(45.8%)
Sample Size (Percent of) total sample)	28 (26.2%)	27 (25.2%)	21 (19.6%)	31 (29.0%)	107 (100.0%)
Children					
Adequate (n)	20	16	12	14	62
≥ 400 μg/day	(71.4%)	(59.3%)	(57.1%)	(45.2%)	(57.9%)
Inadequate (n)	8	11	9	17	45
< 400 Mg/day	(28.6%)	(40.7%)	(42.9%)	(54.8%)	(42.1%)
Sample Size (Percent of) total sample)	28 (26.2%)	27 (25.2%)	21 (19.6%)	31 (29.0%)	107 (100.0%)

* Computed using INCAP-ICNND food composition tables (1961) and composition values analyzed at UFPe, Laboratorio de Bioquémica da Nutricão.
† WHO, 1974.

Mothers generally reported dietary consumption of the same foods for themselves and their children, though the children consumed smaller quantities. Preformed sources of vitamin A most commonly eaten by the mothers and children were milk and liver (Table 22). The amount of vitamin A consumed from liver may be overstated as composition tables did not contain dried, salted liver. The vitamin A content of fresh liver was used for computation.

Table 22. Northeast Brazilian food sources of preformed and provitamin A, and consumption of these foods by mothers and children.

Food	RE/100 gm*	Intake by Mothers and Children
Preformed Vitamin A		
Liver		
Beef	4,441[a]	Occasional.
Dried salted beef	4,441	Common.
Pork	8,660	Very rare.
Dried salted pork	8,660	Very rare.
Goat	15,000	Only when a goat is slaughtered.
Chicken	4,200	Often one weekly for the whole family.
Milk		
Cow's fresh	30	Daily when a cow is owned by the family, otherwise occasionally.
Goat's fresh	25	During the rainy season, when the family owns a goat.
Fortified powdered	255	Daily by children and weekly by mothers.
Cheese		
Cow's	310	Very rare.
Goat's	40	Never.
Provitamin A		
Vegetables		
Jerimun (local yellow squash)	15,26[a]	Small amounts weekly, when available.
Carrots	3,530[a]	Small amounts weekly, when available.
Leaf Lettuce	260	Two leaves daily, when available.
Cabbage	30	Small amounts weekly, when available.
Kale	2,015	Small amounts weekly, when available.
Spinach	1,080	Very rare.
Beet greens	1,575	Never, only the roots are consumed.
Other greens		Very rare.
Fruits		
Mango	630	Two to three daily, Feb.-May.
Papaya	11	Small amounts weekly, as available.
Herbs and Spices		
Parsley	1,820	Very small amounts daily.
Coriander	1,291[a]	Very small amounts daily.

* INCAP-ICNND food composition tables, 1961.

[a] Analysis from Laboratorio de Bioquémica da Nutricão of Universidade Federal de Pernambuco.

The most commonly eaten high carotenoid fruits and vegetables were jerimun, a local pumpkin-like yellow squash, carrots, and mangoes (Table 22). Mangoes were available only during their harvest months of February to May. During this period, the mothers and children often ate between two and five mangoes per day. Leaf lettuce was the most commonly consumed green leafy vegetable, followed by cabbage and then kale. Lettuce and cabbage added only a small amount of vitamin A to the diet. Kale was a good source of vitamin A, but was not as commonly consumed.

Family Gardens and Animal Raising

Families who cultivate gardens and raise animals potentially have less expensive sources of food, including those high in preformed and provitamin A. Twenty-eight (25.7 percent) of the women surveyed cultivated gardens, and 44 (41.1 percent) raised animals (Table 23). More women cultivated gardens and raised animals at the Lagoa de Pedra survey site than at other sites combined. Nineteen, or 63.3 percent of the women, cultivated gardens and 27, or 90 percent of those at this site, raised animals.

Table 23. Distribution and percentage of women, at each survey site, who cultivated gardens and/or raised animals.

	Vitoria de Santo Antão		Caruaru		
	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Garden (n)	3	2	4	19	28
(Percent)	(10.0)	(7.1)	(19.0)	(63.3)	(25.7)
Animals (n)	4	6	7	27	44
(Percent)	(13.0)	(21.4)	(33.3)	(90.0)	(41.1)
Sample size	30	28	21	30	109
(Percent of total sample)	(27.5)	(25.7)	(19.1)	(27.5)	(100.0)

Nutrition Knowledge of Mothers

None of the women surveyed had a good knowledge of basic nutrition as judged by the nutritionists from the Universidade Federal de Pernambuco. Forty-six (42.2 percent) were judged as having a "reasonable" knowledge of nutrition (Table 24). The nutritionists judged 37 (33.9 percent) of the mothers as having a "poor" knowledge of nutrition. The remaining 26 women were "prejudiced," that is, the interviewer felt that the mothers had preconceived ideas of what the interviewer wanted to hear, and answered accordingly. The interviewer was, therefore, unable to determine the level of nutrition knowledge of these women.

Table 24. Distribution and percentage of mothers, from the survey sites, who have a reasonable, poor, or prejudiced knowledge of basic nutrition principles as judged by Brazilian interviewers.

Nutrition Knowledge	Vitoria de Santo Antão: São José	Vitoria de Santo Antão: Cajá	Caruaru: Alto do Moura	Caruaru: Lagoa de Pedra	Total
Reasonable (n)	14	14	9	9	46
(Percent)	(46.7)	(51.9)	(42.9)	(29.0)	(42.2)
Poor (n)	12	11	3	11	37
(Percent)	(40.0)	(40.7)	(14.3)	(35.5)	(33.9)
Prejudiced (n)	4	2	9	11	26
(Percent)	(13.3)	(7.4)	(42.9)	(35.5)	(23.9)
Sample Size	30	27	21	31	109
(Percent of total sample)	(27.5)	(24.8)	(19.3)	(28.4)	(100.0)

Socioeconomic Status

Illiteracy was high among the women. Sixty-one (56.5 percent) stated that they could not read, while 47 (42.7 percent) claimed the ability to read (Table 25). No attempt was made to determine the extent of the literacy of those who could read.

Table 25. Number and percentage of mothers, from the four survey sites, who stated that they could read.

	Vitoria de Santo Antão		Caruaru		
	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Literate (n)	12	11	11	13	47
(Percent)	(40.0)	(39.3)	(52.4)	(41.9)	(42.7)
Illiterate(n)	18	17	10	16	61
(Percent)	(60.0)	(60.7)	(47.6)	(51.6)	(56.5)
Sample Size	30	28	21	29	108
(Percent of total sample)	(27.8)	(25.9)	(19.4)	(26.9)	(100.0)

Table 26 presents the mean of the socioeconomic score used as an indicator of the socioeconomic status of the families.

Table 26. Mean socioeconomic score (0-8) based on physical characteristics and sanitation of family dwellings.

	n	Mean	Standard Deviation
Socioeconomic status	110	4.6	1.7

A socioeconomic score of zero to eight was given to each family based upon the physical characteristics and sanitation of the assigned home. Mothers were queried about materials used to provide roofing, walls, flooring, lighting and number of persons per bedroom in their dwellings. Means of water delivery and disposal of human waste and trash were also determined. A one-point score was given for having a minimal requirement for each physical and sanitary characteristic. The number of dwellings that met these minimal requirements for each characteristic are listed in Table 27. The majority of homes, 108 or 98.2 percent, had tile roofing. Few families (7.3 percent) had adequate trash removal.

Table 27. Distribution and percentage of families, from the four survey sites, with adequate physical characteristics and sanitation of their family dwellings.

	Vitoria de Santo Antão		Caruaru		
	São José	Cajá	Alto do Moura	Lagoa de Pedra	Total
Physical Characteristics of Dwelling					
Roofing (n)	28	28	21	31	108
(percent)	(93.3)	(100)	(100)	(100)	(98.2)
Walls (n)	17	19	21	29	86
(percent)	(56.7)	(67.9)	(100)	(93.5)	(78.2)
Floors (n)	23	19	17	22	81
(percent)	(76.7)	(67.9)	(81.0)	(71.0)	(73.6)
Lighting (n)	23	22	15	9	69
(percent)	(76.7)	(78.6)	(71.4)	(29.0)	(62.7)
Sanitation					
Water (n)	22	10	18	1	51
(percent)	(73.3)	(35.7)	(85.7)	(3.2)	(46.4)
Disposal of human excrements (n)	25	20	8	9	62
(percent)	(83.3)	(71.4)	(38.1)	(29.0)	(56.4)
Trash removal (n)	3	1	1	3	8
(percent)	(10.0)	(3.6)	(4.8)	(9.7)	(7.3)
Persons/room (n)	13	8	14	14	49
(percent)	(43.3)	(28.6)	(66.7)	(45.2)	(44.5)
Sample Size	30	28	21	31	110
(Percent of total sample)	(25.5)	(27.3)	(19.1)	(28.2)	(100.0)

Interrelationships Among Indicators of Nutrition Status

The statistical models developed to predict the effect of the selected physiological, anthropometric, socioeconomic, and demographic variables on children's serum retinol ($r^2 = 0.074$, $p = 0.93$), modified RDR ($r^2 = 0.037$, $p = 0.61$), and dietary vitamin A ($r^2 = 0.16$, $p = 0.23$) were not significant. None of the independent variables, when considered together in the multiple regression models, significantly explained the variance in the children's serum retinol levels, modified RDR, or vitamin A intakes.

The regression models for mothers' serum retinol and vitamin A intake were statistically significant at the 0.05 level (Table 28). The values of r^2 for the models of mothers' serum retinol and the mothers' dietary vitamin A were 0.24 (p = 0.029) and 0.20 (p=0.044), respectively.

Table 28. Estimated means and ß values of significant independent variables of regression on mothers' serum retinol and dietary vitamin A.

	Significant Regression Models					
	Mothers' Serum Retinol			Mothers' Dietary Vitamin A		
Variables	Estimated Mean	p	ß	Estimated Mean	p	ß
Overall adjusted mean		69 µg/dl			1292 RE	
Categorical (Indicator)						
Survey Site		0.003			0.026	
São José	80[a]			973[b]		
Cajá	61[b]			704[b]		
Alto do Moura	76[a]			2367[a]		
Lagoa da Pedra	61[b]			1350[b]		
Covariate						
Mothers' wt/ht percentile		0.031	0.21		NS	NS
Mothers' age		NS	NS		0.077	- 43

NS Not significant.
[a b] Values with different superscript in vertical columns denote significant differences at the p = 0.05 level.

Independent variables with significant effects on mothers' serum retinol were the survey site ($p = 0.003$) and the mothers' weight/height percentile ($p = 0.031$). Table 28 presents the results of the LSD test on the categorical or indicator variable, survey site, and the ß value for the covariate, weight/height percentile. Mothers' estimated mean serum retinol of 80 µg/dl in São José and 76 µg/dl in Alto do Moura were significantly ($p = 0.003$) higher than those at Cajá (61 µg/dl) and Lagoa de Pedra (61 µg/dl). Estimated mean serum retinol for individuals from São José and Alto da Moura did not differ significantly from each other, nor did those from Cajá and Lagoa de Pedra. Mothers' weight/height percentile had a statistically significant ($p = 0.031$) linear relationship with mothers' serum retinol ($\beta = 0.21$). This implies that for every unit increased in mothers' weight/height percentile, serum retinol increases by 0.21 µg/dl.

The model hypothesized to explain the mothers' dietary intake of vitamin A was also significant with an r^2 of 0.20 ($p = 0.044$). Again, survey site was significant ($p = 0.026$) as was the independent variable for mothers' ages ($p = 0.077$). Estimated averages of mothers' dietary vitamin A of 973 RE in São José, 704 RE in Cajá, and 1350 RE in Lagoa da Pedra did not differ significantly from each other, but did differ significantly from the relatively high estimated average of 2368 RE, in Alto do Moura. Mothers' ages were significantly correlated with dietary intake of vitamin A ($p = 0.077$) in a negative linear regression relationship ($\beta = -43$). This implies that for a given one year increase in the mothers' age, vitamin A intake decreased by 43 RE.

DISCUSSION

Restatement of Purpose

The purpose of this study was to assess vitamin A and general nutrition status, and dietary intake of vitamin A-active foods of women of childbearing age and their preschool children in Northeast Brazil. The availability of local indigenous vitamin A food sources, extent of mothers' nutrition knowledge, and socioeconomic status were also determined. Multiple linear regression analysis was used to define the relationships of selected independent variables on parameters of vitamin A nutrition status. Recommendations for appropriate intervention methods and nutrition policy implementations for decreasing vitamin A deficiency were also explored.

Discussion

Vitamin A Status

Critical and marginal serum retinol levels have long been used to identify individuals or groups at high risk for vitamin A deficiency. Most mothers and children sampled had acceptable serum retinol and carotene levels. For mothers, 0.9 percent (n =1) of the sample population had marginal serum retinol, between 10 and 19.9 μg/dl. Among children, 1.9 percent (n = 2) of the sample population had critical serum retinol, less than 10 μg/dl, and 5.7 percent (n = 6) of the sample had serum retinol between 10 and 19.9 μg/dl. Thus, only one mother and eight children were at high risk for clinical vitamin A deficiency.

When compared to the ICNND (1963) definition for determining public health significance, using serum retinol, vitamin A deficiency would not be of public health significance for the target populations studied. However, because serum retinol is not a sensitive indicator of vitamin A status, since levels remain constant until hepatic stores are depleted, individuals with subclinical deficiency could not be detected. It is presumed that some mothers and children suffered from subclinical deficiency, not detectable from serum retinol levels.

Modified retinol dose response (RDR) was used to identify children at risk for subclinical vitamin A deficiency. If modified RDR accurately identifies individuals at risk for subclinical deficiency, then nearly 70 percent of the children suffered from some degree of vitamin A deficiency. Of these, eight (7.6 percent) were at risk for clinical deficiency, because of their concomitant critical and marginal serum retinol levels. RDR and serum retinol were highly associated in that every child with marginal or critical serum retinol had a positive RDR. There was a highly significant correlation between children's serum retinol 1 and modified RDR ($r = -0.915$, $p < 0.001$).

Only one mother had an unacceptable serum retinol level at the first sampling, so modified RDR tests were not performed on mothers. Adults have more time to accumulate vitamin A stores and are, therefore, less likely than children to be deficient. However, some mothers would be expected to have negative RDR percentiles, indicating subclinical deficiency. RDR data might have been useful in determining subclinical deficiency of mothers.

Although data from the modified RDR appeared to identify subclinical deficiency in a large proportion of the study sample, modified RDR has not been validated. The research conditions and priorities of co-investigators from the Universidade Federal de Pernambuco precluded using RDR in this study. The modified method should definitely be tested against RDR, as the modified method, if valid, would save time, resources, and participant burden in conducting vitamin A evaluations.

RDR is a relative indicator of vitamin A status based on current, but limited knowledge about vitamin A metabolism and mobilization during depletion and repletion. During vitamin A deficiency, retinol-binding protein (RBP) accumulates in the hepatic cells when retinol is unavailable for binding and transport to target tissues. When a small dose of vitamin A is introduced, the retinol binds with RBP and enters the blood stream, thus increasing serum retinol levels.

Since the time this study was conducted, a more definitive method, impression cytology, has been developed for identifying subclinical vitamin A status. This method is based on the fact that epithelial tissues in the eye are affected during vitamin A deficiency, and corneal goblet cells appear to atrophy early in vitamin A depletion. Impression cytology assesses subclinical deficiency by quantifying the loss of goblet cells. A small piece of filter paper is applied to the eye to remove epithelial cells, which are fixed and dyed, then examined for relative number of goblet cells under a microscope.

Impression cytology may be the method of choice in the future for detecting vitamin A deficiency in live subjects. However, RDR and modified RDR may be equally useful, and the extent to which they correlate with each other and with impression cytology should be determined.

Serum levels of total carotene can be useful in conjunction with serum retinol for evaluating vitamin A status in populations, especially children, where malnutrition is prevalent and essentially all dietary vitamin A comes from carotenoid sources (Underwood, 1984; Olson, 1981). In this special case, when dietary intake of vitamin A, both preformed and provitamin A, is limited, a low serum carotene level is evidence of poor vitamin A status.

Children's serum retinol correlated highly with children's serum carotene ($r = 0.472$, $p < 0.001$), implying that serum carotene may also have indicated poor vitamin A status. Sixteen children had less than acceptable serum carotene at one or both samplings, and four mothers had less than acceptable serum carotene. Three children and one mother had less than acceptable serum levels of retinol and carotene at the first sampling, possibly indicating an even poorer vitamin A status than previously supposed. In these individuals, unacceptable serum retinol levels indicated low vitamin A stores and unacceptable serum carotene levels indicated that little carotene was available for conversion to vitamin A.

In cases where serum retinol levels were less than acceptable, less acceptablity of serum carotene appeared to be further indication of poor vitamin A status in children. Mothers and children with acceptable serum retinol and unacceptable serum carotene may consume much of their vitamin A from preformed sources.

<u>General Nutrition Status</u>

Body weight and length are important indicators of nutrition status, especially in young children. The mothers were generally short of stature, when compared to U.S. population, and many were overweight for their heights. Children's heights, weights, and weights for height were generally low in comparison to Brazilian and NCHS standards for children.

Christakis (1973) states that if 45 percent of the children's heights fall below the 25th percentile of the reference chart, it may be assumed that nutrition problems exist. In this study, 52 percent of the children fell below the 10th percentile for height, and 69 percent below the 25th percentile when compared to Brazilian standards. Thirty percent of the children were below the 10th percentile of height for weight by age. When compared to NCHS standards, 33 percent of the children were below the 10th percentile of weight for height by age.

It is uncertain whether short stature is attributable to genetics, previous dietary deficiencies, protein-calorie malnutrition (PCM), diarrhea, disease, infections, parasites, or some combination of the above. Poor vitamin A status increases the incidence of PCM, diarrhea, intestinal and respiratory infections, and measles (Underwood, 1984), and any one or combination of these conditions could contribute to growth stunting. Vitamin A deficiency in itself is associated with growth retardation, and a decline in weight gain is one of the first signs of nutrition deficiency (Underwood, 1984). Further, vitamin A is associated with proper growth, so much so that FAO/WHO standards (1967) are closely related to growth rate (McLaren, 1986a). Though vitamin A deficiency may not be the sole cause of growth stunting seen in study women and children, it may explain, in part, the low anthropometric measurements found in the sample populations.

This study might have been improved by investigating the prevalence and severity of vitamin A-related diseases and their effects on growth and stature. However, the process of gathering this information was prevented because of the language barrier, high illiteracy of mothers, time restraints, and questionable reliability of responses to retrospective questioning on weaning children, severity and timing of previous illnesses, and so forth.

There are limitations to assessing general nutrition status of the target populations using anthropometric measurements: 1) anthropometric standards have not been developed for use specifically with Northeast Brazil populations, 2) the origin of the Brazilian standards is uncertain, and sample size used to derive the standards seemed relatively small, and 3) NCHS standards were not developed for evaluating anthropometric measurements of children from countries outside of the United States.

Despite objections of applying U.S. standards to various racial groups, children of different racial backgrounds of high economic status tend to fall within the standards (Bohdal and Simmons,1969). These findings suggest that nutrition status may be a more significant factor in promoting growth than genetic makeup, but the controversy of "nurture" and "nature" is far from being resolved. What is needed are long-term studies of children of different racial groups, but similar socioeconomic background, in order to determine the relative effects of nutriture and genetics on growth.

The Brazilian and NCHS standards provide valuable information on nutrition status that can be used 1) to establish that mothers and children were small in comparison with defined populations, 2) to assess the success of intervention programs aimed at improving general and vitamin A nutrition status in children, and 3) as a baseline for future comparisons. It is possible that Brazilian standards present a clearer picture, at least in comparison with the middle quartiles (25th to 75th percentiles), of the sample population's weight, height and weight/height ratio relative to a genetically similar population.

Indigenous Food Sources for Vitamin A Intake

Appropriate interpretation of dietary data requires sound knowledge of dietary standards and requirements, and understanding of the validity of methods for collecting and analyzing the data. In addition, people are extremely different and variable, which has a significant effect on reliability of data collected from survey participants.

Mean vitamin A intake of mothers and children reached the WHO recommendations, however, the variance in vitamin A intake was very large. At one extreme, eight mothers and 10 children were reported to have no vitamin A intake. At the other, one mother reported consuming an average of almost 9000 RE per day.

Preformed sources. Milk was more often consumed in larger quantities by the children than the mothers. Children often drank several cups of milk per day while the mothers consumed only one cup per day or week. Many mothers reserved milk for the children rather than consuming any themselves. The mothers commonly reported that they and their children drank the less expensive powdered milk, which was vitamin A-fortified. Those mothers in the Caruaru municipal district who had dairy animals reported that they and their children consumed fresh milk. Some mothers in Caruaru purchased fresh milk. Fresh and most brands of liquid milk, except "Cilpe," were not vitamin A fortified.

Many of the mothers and children consumed dried, salted liver (most often beef, but occasionally pork) once a week. This liver was less expensive than fresh liver. Another liver source of vitamin A came from chickens. It was common for families to consume one chicken per week. The liver was often either divided among the family members or eaten by the mothers. Many mothers reported that they or their children did not like liver, and therefore did not consume it.

Provitamin A sources. Most fruits and vegetables consumed by the mothers and children were either raised by the family, purchased from neighbors, or received as gifts from family or friends. Jerimun (a native yellow squash), carrots and mangoes were the most commonly consumed, high provitamin A foods. Mothers often reported that they and their children used approximately 100 gm of jerimun or carrots a week. Mangoes were eaten in large quantities during harvest season, from February to May. Mothers often reported that they and their children ate two to five mangoes per day during the harvest. Intake of vitamin A from green, leafy vegetables was relatively low.

Leaf lettuce was eaten most and cabbage second, neither is high in provitamin A content. A few mothers and children ate kale, an excellent source of provitamin A.

Beet roots are a commonly used vegetable, but contain no carotenoids. However, beet leaves are an excellent source of dietary provitamin A. Beet greens are not consumed by the human population, but fed to domestic animals. These could be a valuable source of dietary provitamin A.

Corn is eaten in large amounts during the harvest festival of June in northeastern Brazil. Although corn contains a large amount of carotene, the particular carotenoid involved is not biologically very active, and thus adds little provitamin A to the diet.

Cost of vitamin A foods. Information about foods purchased by the rural and semirural poor was obtained from merchants in open markets of Recife, Caruaru and Sobral. Preformed sources of vitamin A were quite expensive for people from rural and semirural areas, and provitamin A sources were generally not purchased in large quantities. When money was available to purchase food, parents preferred to buy staples such as noodles, dried beans, and rice. Noodles were very economical because wheat was heavily subsidized by the government. Noodles were seldom enriched or fortified.

Home Production. The idea of promoting family gardening is supported by UNICEF and other international development agencies. Recently, emphasis has been placed on promoting traditional mixed gardens which provide families with a variety of foods and nutrients (Teply, 1986).

For those studied who did cultivate gardens or raise animals, most of the produce, animals, and animal products were used by the family for food. This was especially true of the fruits and vegetables. Small animals, such as chickens, were eaten by the families or provided eggs for the diet. Dairy animals in the Caruaru district produced milk for family consumption. Many larger animals were sold for profit.

When asked why they did not cultivate gardens, mothers from all survey sites usually gave one of the following responses: 1) they did not have land on which to plant a garden, 2) they did not know how to plant, care for, and harvest produce, 3) they had no money to buy seed, or 4) they had no time to work in a garden. Reasons given by the mothers for not raising animals were: 1) lack of space, 2) lack of money to purchase young animals, and 3) insufficient knowledge to raise animals.

Mothers' Nutrition Knowledge

The mothers' level of nutrition knowledge was difficult to assess. The Brazilian nutritionists who interviewed the mothers judged 46 percent as having a reasonable and 37 percent as having less than reasonable knowledge of basic nutrition principles. No mothers were judged as having good knowledge of nutrition. The interviewers were unable to determine nutrition knowledge of the remaining mothers.

Answers provided by the mothers in response to questions on foods that should and should not be eaten generally, during pregnancy and lactation, and by infants and children, revealed common nutrition misconceptions. For example, many mothers felt that infants should be fed breastmilk for only 15 days and then be given a milk and rice or cassava mixture. Mothers also felt that some foods, including vegetables, should not be given to young children.

Infants were generally weaned early, but mothers often avoided giving the children good food sources of vitamin A. It may be that young children in Brazil, as in other parts of the world, simply refuse to consume high-carotenoid vegetables. Mothers, despite whatever knowledge they do have, may choose not to force the children to eat foods that they dislike.

Socioeconomic Status of the Families

The majority of the mothers (56 percent) stated that they could not read. A higher percentage of the mothers from Alto do Moura (52 percent) could read than from the other survey sites. Certainly, this high rate of illiteracy affected their socioeconomic status by preventing them from obtaining well-paying employment and furthering their education on their own.

Only two of the families had adequate housing and sanitation facilities. Families lacked proper sanitation more than adequate physical housing. Such poor conditions lead to increased incidence of disease and parasites, especially in young children, thus increasing their vitamin A requirement.

Dietary, Biochemical, Anthropometric, and Clinical Relationships

The multiple regression model for mothers' serum retinol indicated that serum retinol varied significantly with the different survey sites from which the samples were collected and with the mothers' weight for height percentile. A second multiple regression model to explain mothers' intake of diet and modified relative dose response was significant with survey site and mothers' ages.

The effect of survey sites on mothers' serum retinol and vitamin A intake might be explained by the differences from site to site and in municipal districts. The Mata region of Northeast Brazil, the region in which Vitoria de Santo Antão lies, has been traditionally zoned for sugar cane, which undoubtedly influences the extent to which families are allowed to cultivate gardens and raise animals. The Agreste region, where Caruaru lies, has been the traditional "bread basket" of the Northeast. The rural and semirural population of Caruaru are more accustomed to having greater opportunity for small agricultural endeavors.

The lower prevalence for maintaining gardens and domestic animals in Alto do Moura was related to the occupation of most of the survey village population. Most were artisans who produced clay pottery and colorful figures for sale in the local markets and in the larger cities of the Northeast. The income from this small industry may preclude the need for home-produced food to meet estimated nutrient, or at least energy needs.

Mothers' ages had a negative effect on their vitamin A intake. Older mothers may have larger families with less income per capita to spend on food. In this situation the mothers may choose to consume less food, including vitamin A -rich foods. Mothers may be more concerned about the diets of other family members and sacrifice high vitamin foods in order to provide better diets to children and husbands.

Summary and Conclusions

Vitamin A deficiency is one of the most widespread nutrition deficiencies in many parts of the world and contributes to a considerable portion of preventable blindness in children. The most important etiological factor is, in fact, inadequate dietary intake of the vitamin, although there are other contributing factors which aggravate the situation. Malnutrition, including vitamin A malnutrition, is a multifactorial problem involving much more than a simple lack of "food on the table" or a lack of the nutrient at the cellular level. Rather, malnutrition is intimately involved in the overall economic and social conditions of a country, people, family, or individual. To understand vitamin A deficiency as it exists, one must look at the entire scope of environmental conditions: economic development, purchasing power, educational level, sanitation and medical facilities, dietary practices and taboos and religion. In considering a single nutrient deficiency, such as vitamin A deficiency, one must put the causes of this preventable disease into the perspective of the larger social context.

Even though every effort was made in this study to collect data on factors which might have important effects on vitamin A status, time and monetary constraints precluded collection of all potentially relevant data. The lack of significance for any of the models to explain children's vitamin A parameters is puzzling. It may be that the models could have been improved by the addition of key independent variables which could provide important additional descriptive or predictive power to the model. For example, perhaps a mother's nutrition knowledge was not as important in determining children's intake as what she told the child to eat, or what food taboos existed for weaning foods or feeding during diarrheal disease.

This study was conducted during the rainy season following several years of drought. It is possible that vitamin A intake, status and stores were better than usual because of one good season of local production, or because of seasonal availability of vitamin A foods. These factors may have been more influential than other factors in determining vitamin A status during the particular time period in which the study was conducted.

Only a few of the variables operating on any indicator of vitamin status can be included explicitly in a numerical procedure, such as regression analysis, for the purpose of identifying situations or factors which may significantly impinge on the etiology or incidence of vitamin A deficiency. Thus the models developed, based upon available data for hypothesizing relationships among dietary, anthropometric, physiological, demographic, and socioeconomic factors and vitamin A nutrition status are not necessarily "wrong." However, they could have undoubtedly been improved materially by the collection and inclusion of different or additional variables.

There is no question that interpretation of results becomes more difficult as the number of evaluative criteria and environmental factors increase. Surveys, more than any other kind of nutrition studies, help to remind investigators of the limitations of procedures currently available for evaluation of human nutrition status and of the variability inherent within the human race (Pike and Brown, 1984).

Recommendations

Further investigation is needed to determine the utility of modified RDR in identifying subclinical vitamin A deficiency. Though this method appeared to have identified children at risk for subclinical deficiency, the technique was not validated against more definitive methods nor used with an adult population that might also be at risk.

While the degree of clinical vitamin A deficiency in the population at risk was not of public health significance, the fact that nine (8 percent of the children and 1 percent of the mothers) individuals were biochemically deficient, and as many as 70 percent (n = 38) of the children were subclinically deficient, implies that intakes of vitamin A may be marginal or inadequate in some individuals or groups. Children may not be at great risk for blinding xerophthalmia, but are at increased risk for other manifestations of deficiency, including growth stunting and increased infectious diseases.

Carefully planned multifactorial intervention projects should be aimed at increasing the management, availability, and consumption of vitamin A-containing foods, especially high carotenoid sources. Horticulture projects may include providing seeds, information, and technical assistance for community and family gardening projects. A nutrition component may include nutrition classes on proper infant feeding and weaning, supplementing children's diets with vitamin A-rich foods, and recipes for cooking with vegetables. Local institutions of higher learning, such as the Universidade Federal de Pernambuco, may be involved with extension programs and the training of para-professionals to provide community technical and educational assistance.

In less developed areas, where economical resources are scarce, intervention projects should stress the importance of communities working together to better their own situation. Caruaru was a particularly good candidate for self-help projects, as the local government expressed interest in community nutrition. As local governments target economical resources for improving health care programs under their jurisdiction, successful programs may be developed, adopted and implemented by state and federal governments.

LITERATURE CITED

Abraham, S., Johnson, C. L. and Najjar, M. F. 1979. Weight and height of adults 18-74 years of age: United States, 1971-74. DHEW Publication; (PHS) 79-1659, Hyattsville, Md.

Ahuja, B. S. and Wagle, D. S. 1980. The effect of dietary protein on the conversion of ß-carotene into vitamin A in rats. Indian J. Nutr. Diet. 17:123.

Anzano, M. A., Lamb, A. J. and Olson, J. A. 1979. Growth, appetite, sequence of pathological signs and survival following the induction of rapid sychronous vitamin A deficiency in rats. J. Nutr. 109:1419.

Araujo, C.R.C. and Flores, H. 1978. Improved spectrophometric vitamin A assay. Clin. Chem. 24:386.

Araujo, R. L., Borges, E. L., Silva, J. D. B., Palhares, R. D. and Vieira, E. C. l978. Effect of the intake of vitamin A fortified sugar by pre-school children. Nutr. Rep. Internat. l8:429.

Arroyave, G., Wilson, D., Méndez, J., Behar, M. and Schrimshaw, N. S. 1961. Serum and liver vitamin A and lipids in children with severe protein malnutrition. Am. J. Clin. Nutr. 9:180.

Arroyave, G., Aguilar, J. R., Flores, M. and Guzman, M.A. 1979. Evaluation of sugar fortification with vitamin A at the national level. PAHO Sci. Publ. No. 384. Pan Am. Health Organ., Washington, D.C.

Ayanru, J. O. 1978. Infections of conjunctiva and cornea in Bengal State of Nigeria. Trop. Geogr. Med. 30:69.

Beaver, D. L. 1961. Vitamin A deficiency in the germ-free rat. Am. J. Pathol. 38:335.

Bessey, O. A., Lowry, O. H., Brooks, M. J. and Lopez, J. A. 1946. The determination of vitamin A and carotene in small quantities of blood serum. J. Biol. Chem. 166:177.

Bohdal, M. and Simmons, W. K. 1969. A comparison of the nutritional indicies in health: African, Asian, and European children. Bull. WHO. 40:166.

Bray, G. A., ed. 1979. Obesity in America. DHEW Publication No. (NIH) 79-359. U.S. Govt. Printing Office, Washington D. C.

Brown, E. D., Bieri, J. G., Micozzi, M., Rose, A., Caraft, N., Schuman, P., Beeker, G. and Smith, J. S., Jr. 1987. Plasma response in normal men to various carotenoid sources. Fed. Proc. Fed. Am. Soc. Exp. Biol. 46:1189.

Brown, K. H., Gaffar, A. and Alamgir, S. M. 1979. Xerophthalmia, protein-calorie malnutrition and infections in children. J. Pediatr. 95:651.

Cakirer, O. M. and Lachance, P. A. 1974. The effect of avitaminosis A on the inner ear of the guinea-pig. Nutr. Rep. Internat. 9:383.

Chandra, H., Venkatachalam, P. S., Belavady, B., Reddy, V. and Gopalan, C. 1960. Some observations on vitamin A deficiency in Indian children. Indian J. Child Health. 9:589.

Christakis, G. 1973. Nutritional assessment in health programs. American Public Health Association, Inc., Washington D. C.

De Luca, L. M., Glover, J., Heller, J., Olson, J. A. and Underwood, B. 1979. VI. Recent advances in the metabolism and function of vitamin A and their relationship to applied nutrition. In: Guidelines for the eradication of vitamin A deficiency and xerophthalmia. Report of International Vitamin A Consultative Group (IVACG). The Nutrition Foundation, Inc., New York and Washington, D.C.

Dixit, D. T. 1966. Night blindness in the third trimester of pregnancy. Indian J. Med. Res. 54:791.

Dorea, J. G., Souza, J. A., Galvão, M. O. and Iunes, M. A. F. 1984. Concentrations of vitamin A in the liver of foetuses and infants dying of various causes in Brazilia, Brazil. Internat. J. Vit. Nutr. Res. 54:119.

Downs, E. F. 1964. Nutritional dwarfing: A syndrome of early protein-calorie malnutrition. Am. J. Clin. Nutr. 15:275.

Dugdale, A. E. 1971. An age-dependent anthropometric index of nutritional status. Am. J. Clin. Nutr. 24:174.

FAO/WHO (Food and Agriculture Organization/World Health Organization). 1967. Requirements of vitamin A, thiamine, riboflavin, and niacin. Report of a joint FAO/WHO Expert Committee. FAO Nutrition Meetings Report Series No. 41; WHO Tech. Rep. Ser. No. 362, Geneva.

Favaro, R. M. D., de Souza, N. V., Batistal, S. M., Ferriani, M. G. C., Desai, I. D. and Dutra de Oliveira, T. E. 1985. Vitamin A status of young children in Southern Brazil. Am. J. Clin. Nutr. 43:852.

Flores, H. and Araujo, C. R. C. 1984. Liver levels of retinol in unselected necropsy specimens: A prevalence survey of vitamin A deficiency in Recife, Brazil. Am. J. Clin. Nutr. 40:146.

Flores, H., Campos, F., Araujo, C. R. C. and Underwood, B. A. 1984. Assessment of marginal vitamin A deficiency in Brazilian children using relative dose response procedure. Am. J. Clin. Nutr. 40:1281.

Food and Nutrition Board. 1980. Recommended dietary allowances, 9th rev. ed., 1980. National Academy Press, Washington, D. C.

Frankle, R. T. and Owen, A. Y. 1978. Nutrition in the community: The art of delivering services. C.V.Mosby Co., Saint Louis, Missouri.

Frisancho, A. R. 1981. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am. J. Clin. Nutr. 34:2540.

Frolik, C. A. l984. Metabolism of retinoids. In: Sporn, M. B., Roberts, A. B. and Goodwin, D. S., eds. l984. The retinoids, vol 2. Academic Press Inc., New York.

Giugliano, R., Albuquerque, H. C. R. and Shrimptom, R. 1978. Estudo antropométrico, clinico e de padrões alimentares em um grupo de escolares de Manaus, 1976. Acta Amazonica. 8:75.

Gomes, S. F., Batista, M., Varela, R. M., Bazante, M. D. and Salzano, A. C. 1970. Plasma retinol levels of pre-school children in the sugar cane areas of Northeast Brazil. Arch. Latinamer. Nutr. 20:445.

Goodman, D. S. 1984a. Overview of current knowledge of metabolism of vitamin A and carotenoids. JNCI. 73:1375.

Goodman, D. S. 1984b. Vitamin A and retinoids in health and disease. N. Engl. J. Med. 310:1023.

Greelen, J. A. G. l979. Hypervitaminosis A induced teratogenesis. CRC Critical Rev. Toxicol. Nov.:351.

Hamill, P. V. V., Drizd, T. A., Johnson, C. L., Reed, R. B. and Roche, A. F. 1977. NCHS growth curves for children, birth-18 years, United States. DHEW Publication No. (PHS) 78-1650, Hyattsville, Maryland.

Hanklin, J. H., Rhoads, G. G. and Gober, G. A. 1975. A dietary method for an epidemiologic study of gastrointestinal cancer. Am. J. Clin. Nutr. 28:1055.

Helen Keller International (HKI). 1983. Research priorities for the prevention of blindness in developing countries. Helen Keller International Inc., New York.

Helgerund, P., Petersen, L. B. and Norum, K. R. 1983. Retinol esterification by microsomes from the mucosa of human small intestine. J. Clin. Invest. 71:747.

Horner, M. R., Dorea, J. G., Pereira, M. G., Bezerra, V. L. and Salomon, J. B. 1981. Inquérito dietético com base no consumo familiar: O caso de Ilheus, Bahia, Brasil em 1979. Arch. Latinamer. Nutr. 31:726.

ICNND (Interdepartmental Committee on Nutrition for National Defense). 1963. Manual for nutrition surveys, 2nd ed., U.S. Govt. Printing Office, Bethesda, Maryland.

ICNND (Interdepartmental Committee on Nutrition for National Defense). 1965. Northeast Brazil: A nutritional survey. U.S. Govt. Printing Office,Washington D. C.

INCAP-ICNND (Instituto de Nutricion de Centro America y Panama-Interdepartmental Committee on Nutrition for National Defense). 1961. Tabla de composicion de alimentos para uso en America Latina. U.S. Govt. Printing Office, Bethesda, Maryland.

IICNND-INCAP (IInterdepartmental Committee on Nutrition for National Defense-nstituto de Nutricion de Centro America y Panama). 1961. Tabla de composicion de alimentos para uso en America Latina. U.S. Govt. Printing Office, Bethesda, Maryland.

IVACG (International Vitamin A Consultative Group). 1977. In: Guidelines for the eradication of vitamin A deficiency and xerophthalmia. A Report of the International Vitamin A Consultative Group (IVACG)., 1977. The Nutrition Foundation, Inc., New York and Washington D. C.

IVACG (International Vitamin A Consultative Group). 1985. Report of the tenth IVACG meeting held at the National Institute of Nutrition Hyderabad, India, October 14-18, 1985. The Nutrition Foundation, Inc., New York and Washington D. C.

Jansen, G. R., Jansen, N. B., Shigetomi, C. T. and Harper, J. M. 1977. Effect of income and geographic region on nutritional value of diets in Brazil. Am. J. Clin. Nutr. 30:955.

Laditan, A. A. O. and Fafuso, M. 1981. Serum levels of vitamin A, beta-carotene and albumin in children with measles. East Afr. Med. J. 58:51.

Langmuir, A. D. 1962. Medical importance of measles. Am. J. Dis. Child. 103:24.

Large, S., Neal, G., Glover, J., Thanangkul, O. and Olson, R. E. 1980. The early changes in retinol-binding protein and prealbumin concentrations in plasma of protein-energy malnourished children after treatment with retinol and improved diet. Br. J. Nutr. 43:393.

Loerch, J. D., Underwood, B. A. and Lewis, K. C. 1979. Response of plasma levels of vitamin A to a dose of vitamin A as an indicator of hepatic vitamin A reserves in rats. J. Nutr. 109:778.

Ludovici, P. P. and Axelrod, A. E. 1951. Circulating antibodies in vitamin-deficiency states. Pteroylglutamic acid, niacin-tryptophan, vitamin B_{12}, A, and D deficiencies. Proc. Soc. Exp. Biol. Med. 77:526.

Lui, N. S. T. and Roels, O. A. 1980. Vitamin A and carotene. In: Goodhart, R. S. and Shils, M.E., eds. Modern nutrition in health and disease. 6th ed., 1980. Lea and Febiger. Philadelphia.

McLaren, D. S. 1963. Malnutrition of the eye. Academic Press, New York.

McLaren, D. S. 1975. Vitamin A. Progress in Food and Nutrition Science. 1:335.

McLaren, D. S. l986a. Global occurrence of vitamin A deficiency. In: Bauernfeind, J. C., ed., Vitamin A deficiency and its control. Academic Press, Inc., Orlando, Florida.

McLaren, D. S. 1986b. Pathogenesis of vitamin A deficiency. In: Bauernfeind, J. C., ed., Vitamin A deficiency and its control. Academic Press, Inc., Orlando, Florida.

McLaren, D. S., Ballintine, E. J., ten Doesschate, J., Hodges, R. E., Pararajasegaram, R., Sommer, A. and Venkataswamy, G. 1981. The symptoms and signs of vitamin A deficiency and their relationship to applied nutrition. A Report of the International Vitamin A Consultative Group (IVACG). The Nutrition Foundation, Inc., New York and Washington D. C.

McLaren, D. S., Oomen, H. A. P. C. and Escapini, H. 1966. Ocular manifestations of vitamin A deficiency in man. Bull WHO. 34:357.

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

Mahalanabis, D. ., Simpson, T. W., Chakraborty, M. L., Ganguli, C., Battacharjee, A. K. and Mukherjee, K. L. 1979. Malabsorption of water miscible vitamin A in children with giardiasis and ascariasis. Am. J. Clin. Nutr. 32:312.

Mansour, M. M., Mikhail, M., Farid, Z. and Bassily, S. 1979. Chronic salmonella septicemia and malabsorption of vitamin A. Am. J. Clin Nutr. 32:319.

Marques, R. M., Marcondes, E., Berqué, E., Prandi, R. and Yunes, J. 1982. Análise anthropométrica: altura e peso. In: Crescimento e Desenvolvimento Pubertário em Crianças e Adolescentes Brasileiros II. Altura e Peso. Editora Brasileira de Ciências Ltda., São Paulo, Brasil.

McCollum, E. V. and Davis, M. D. 1913. The necessity of certain lipids in the diet during growth. J. Bio. Chem. 15:167.

Moore, T. 1957. Vitamin A. Elsevier Publishing Co., New York.

Moore, T. 1960. The pathology of vitamin A deficiency. Vitam. Horm. (N. Y.) 18:499.

Morley, D. C. 1962. Measles in Nigeria. Am. Dis. Child. 103:230.

Neumaier, M. C. 1984. The social organization of peasant goat production in Northeast Brazil. Unpublished Masters Thesis, University of Missouri-Columbia.

Olson, J. A. 1979. Liver vitamin A reserves of neonates, preschool children and adults dying of various causes in Salvador, Brazil. Arch. Latinamer. Nutr. 29:521.

Olson, J. A. 1981. Serum levels of vitamin A and carotenoids as reflectors of nutritional status. JNCI. 73:1439.

Olson, J. A. 1986. Physiological and metabolic basis of major signs of vitamin A deficiency. In: Bauernfeind, J. C., ed., 1986. Vitamin A deficiency and its control. Academic Press, Inc., Orlando, Florida.

Oomen, H. A. P. C. 1961. An outline of xerophthalmia. Int. Res. Trop. Med. 1:131.

Oomen, H. A. P. C. 1969. Clinical epidemiology of xerophthalmia in man. Am. J. Clin. Nutr. 22:1098.

Oomen, H. A. P. C. 1976. Xerophthalmia. Nutrition in preventive medicine WHO (World Health Organization--Monograph Series). 62:94.

Oomen, H. A. P. C., McLaren, D. S. and Escapini, H. 1964. Epidemiology and public health aspects of hypovitaminosis A. A global survey of xerophthalmia. Trop. Geogr. Med. 16:271.

Oomen, H. A. P. C. and ten Dosschate, J. 1973. The periodicity of xerophthalmia in Southeast Asia. J. Ecol. Food Nutr. 2:207.

Osborne, T. B. and Mendel, L. B. 1913. The relation of growth to the chemical constituents of the diet. J. Biol. Chem. 15:311.

O'Toole, B. A., Fradkin, R., Warkany, J., Wilson, J. G. and Mann, G. B. 1974. Vitamin A deficiency and reproduction in rhesus monkeys. J. Nutr. 104:1513.

Protein Advisory Group (PAG). 1976. WHO/FAO/UNICEF. PAG Bull. 6, No. 4.

Patwardhan, V. N. and Kamel, W. W. 1967. Studies on vitamin A deficiency in infants and young children in Jordan. Report to WHO (World Health Organization), Geneva.

Pike, R. L. and Brown, M. L. 1984. Nutrition, an integrated approach. 3rd ed. John Wiley & Son. New York.

Pipes, P. L., Bumbalo, J. and Pritkin, R. 1985. Collecting and assessing food intake information. In: Pipes, P. L., ed., Nutrition in infancy and childhood. Times Mirror/Mosby, St. Louis, Mo.

Pitt, G. T. A. 1985. Vitamin A. In: Diplock, A. T., ed. 1985. Fat soluble vitamins, their biochemistry and applications. Technomic Publishing Co., Inc. Lancaster, Pennsylvania.

Rask, L., Anundi, H. and Peterson, P. A. 1979. Primary structure of the human retinol-binding protein. FEBS. 104:55.

Rodriguez, M. E. and Irwin, M. I. 1972. A conspectus of research on vitamin A requirements in man. J. Nutr. 102:909.

Rogers, E. L., Douglass, W., Russell, R. M., Bushman, L., Hubbard, T. B. and Iber, F. L. 1980. Deficiency of fat soluble vitamins after jejunoiteal bypass surgery for morbid obesity. Am. J. Clin. Nutr. 25:291.

Rogers, W. E., Jr., Bleri, J. G. and McDaniel, E. G. 1969. In: De Luca, H. F. and Suttle, J. W., eds., 1969. The fat soluble vitamins. Univ. of Wisconsin Press, Madison, Wisconsin.

Roncada, M. J. and Szarfarc, S. C. 1975. Hipovitaminose A e anemia ferropriva em gestantes de duas comunidades do vale do Riveira (estado de São Paulo, Brasil). Rev. Saúde Públ., S. Paulo. 9:99.

Roncada, M. J., Wilson, D., Netto, A. L., Netto, O. B. and Kalil, A. C. 1978a. Investigação sobre a prevalência de xeroftalmia, através de inquérito realizado junto oftalmologistas brasileiros. Rev. Saúde Públ., S. Paulo. 12:151.

Roncada, M. J., Wilson, D., Netto, A. L., Netto, O. B., Kalil, A. C., Nunes, M. F. and Okani, E. T. 1978b. Hipovitaminose A em filhos de migrantes nacionais em trânsito pela capital do estado de São Paulo, Brasil. Estudio clínico-bioquemíco. Rev. Saúde Públ., S. Paulo. 12:345.

Roncada, M. J., Wilson, D., Mazzilli, R. N. and Gandra, Y. R. 1981. Hipovitaminose A em comunidades do estado de São Paulo, Brasil. Rev. Saúde Públ., S. Paulo. 15:338.

Sanford-Smith, J. H. and Whittle, H. C. 1979. Corneal ulceration following measles in Nigerian children. Br. J. Ophthalmol. 63:720.

Santos, L. M. P., Dricot, J. M., Asciutti, L. S. and Dricot-d'Ans, C. 1983. Xerophthalmia in the state of Paraiba, northeast of Brazil: Clinical findings. Am. J. Clin. Nutr. 38:139.

Sauberlich, H. E., Hodges, R. E., Wallace, D. L., Kodler, 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 labelled retinol. Vitam. Horm. 32:251.

Seng, W. L, Kenyon, K. R. and Wolf, G. 1982. Studies on the source and release of collagenase in thermally burned corneas of vitamin A-deficient and control rats. Invest Ophthalmol. Visual Sci. 22:62.

Sheehy, T. W., Meroney, W. H., Cox, R. S. , Jr. and Soler, J. E. 1962. Hookworm disease and malabsorption. Gastroenterology 42:148.

Simmons, W. K. 1976. Xerophthalmia and blindness in Northeast Brazil. Am. J. Clin. Nutr. 29:116.

Sinha, D. P. and Bang, F. B. 1976. The effects of massive doses of vitamin A on the signs of vitamin A deficiency in preschool children. Am. J. Clin. Nutr. 29:110.

Sivakumar, B and Reddy, V. 1972. Absorption of labelled vitamin A in children during infection. Br. J. Nutr. 27:299.

Sivakumar, B and Reddy, V. 1975. Absorption of vitamin A in children with ascariasis. J. Trop. Med. Hyg. 78:114.

Sivakumar, B and Reddy, V. 1978. Studies on vitamin A absorption in children. World Rev. Nutr. Diet. 31:125.

Snedecor, G. W. and Cochran, W. G. 1980. Statistical methods. 7th ed. The Iowa State University Press, Ames, Iowa.

Solon, F. S., Popkin, B. M., Fernandez, T. L. and Latham, M. C. 1978. Vitamin A deficiency in the Philippines: A study of xerophthalmia in Cebu. Am. J. Clin. Nutr. 31:360.

Sommer, A. 1982. Nutritional blindness: Xerophthalmia and keratomalacia. Oxford University Press, London and New York.

Sommer, A., Emrin, N. and Tamba, T. 1979. Vitamin A responsive punctate keratolopathy in xerophthalmia. Am. J. Ophthal. 87:330.

Sommer, A., Tarwotjo, I., Hussani, G., Susanto, D. and Soegiharto, T. 1981. Incidence, prevalence and scale of blinding malnutrition. Lancet. 1:1407.

Sommer, A., Toureau, S., Cornet, P., Midy, C. and Pettiss, S. T. 1976. Xerophthalmia and anterior segment blindness. Am. J. Ophthalmol. 80:1073.

SPSS, Inc. 1986. SPSSX user guide, 2nd ed. SPSS, inc., Chicago, Illinois.

Takahashi, Y. I., Smith, J. E., Winick, M. and Goodman, D. S. 1975. Vitamin A and retinol-binding proteins metabolism during fetal development in the rat. J. Nutr. 105:1299.

Teply, L. J. 1986. Control of vitamin A deficiency by the agricultural crop and household food approach. In: Bauernfeind, J. C., ed. Vitamin A deficiency and its control. Academic Press, Inc., Orlando.

Tripathy, K., Duque, E., Bolanos, O., Lotero, H. and Mayoral, L. G. 1972. Malabsorption syndrome in ascariasis. Am. J. Clin. Nutr. 25:169.

Underwood, B. A. 1984. Vitamin A in animal and human nutrition. In: Sporn, M. B., Roberts, A. B. and Goodman, D. S., eds. The retinoids, vol. 1. Academic Press Inc., New York.

Venkatachalam, P. S., Belavady, B. and Gopalan, C. 1962. Studies on vitamin A nutritional status of mothers and infants in poor communities in India. Indian J. Pediatr. 61:262.

Ward, J. O. and Amoni, D. 1980. Diets of urban migrants in Northeast Brazil: An economic analysis. Nutr. Reports Internat. 21:11.

Williams, S. R. 1985. Nutrition and diet therapy. Times Mirror/Mosby College Publishing. St. Louis.

WHO (World Health Organization). 1974. Handbook on human requirements. WHO, Geneva.

WHO (World Health Organization). 1982. Control of vitamin A deficiency and xerophthalmia. WHO Tech. Rep. Ser. No. 672. WHO, Geneva.

Worthington-Roberts, B. S., Vermeersch, J. and Williams, S. R. 1985. Nutrition in Pregnancy and Lactation. C. V. Mosby Co., St. Louis, Missouri.

Xerophthalmia Club. 1986. Extracts from "Child survival action program" Agency for International Development. Xerophthalmia Club, Bull. 32:5.

Zile, M. H., Bunge, E. C. and De Luca, H. F. 1979. On the physiological basis of vitamin A-stimulated growth. J. Nutr. 109:1787.

Zile, M. H., Bunge, E. C. and De Luca, H. F. 1981. DNA labeling of rat epithelial tissue in vitamin A deficiency. J. Nutr. 111:777.

Appendices

Appendix A.

Survey Instrument--English

VITAMIN A SURVEY

Location ______________________________________ Date__________

Name ____ Code M _______

Child ____ Code C _______

Address ______________________________________ _____________

Mother's Birthday __/__/__ Age____/_____ (years/months)

Child's Birthday __/__/__ Age____/_____ (years/months) Sex ____

I. Family data:

1. How many children have you given birth to? ______
2. How many people live in the house? ______
3. How many bedrooms are in the house? ______
4. Do you know how to read? _____
5. Are you pregnant? _____ How many months? _____

II. Nutrition Knowledge:

1. What foods do you think are good for health? Why?

2. What foods do you think you should eat when you are pregnant? Why?

3. What foods do you think you should eat when you are breastfeeding? Why?

4. What foods should we give to babies, at what age, and why? (before 1 yr.)

5. What foods should we give to small children and why?

6. What foods to you think are bad for health and why?

7. What foods do you think should not be eaten when you are pregnant and why?

8. What foods do you think should not be eaten when you are breastfeeding and why?

9. What foods should we not give to babies and at what age? (before 1 yr.)

10. What foods should we not give to small children and why?

11. Do you take vitamins? Which ones, when and why?

12. Do your children take vitamins? Which ones, when and why?

Interviewer:

The mother has which level of knowledge about nutrition and feeding:

Good	___
Reasonable	___
None	___
Prejudice	___

III. Food Sources of Vitamin A:

Mother

	Quantity Daily	Weekly	Monthly	Total/Month
MILK: cow (30)				
goat (25)				
powdered (255)				
CHEESE: cow (240)				
goat (40)				
LIVER: beef (8660)				
pork (4441)				
mutton (15,000)				
chicken (4913)				
salted beef (8660)				
salted pork (4441)				
VEGETABLES: pumpkin (1526)				
carrot (3530)				
green leaves:				
leaf lettuce (260)				
kale (2015)				
cabbage (30)				
FRUITS: oiti				
macaiba				
mangoe (630)				
papaya (11)				

Observation: ( ) µg/day

Vitamin A sources: Adequate ___ >750 µg/day
Poor ___ <750 µg/day

Child

		Quantity			
		Daily	Weekly	Monthly	Total/Month
MILK:	cow (30)				
	goat (25)				
	powdered (255)				
CHEESE:	cow (240)				
	goat (40)				
LIVER:	beef (8660)				
	pork (4441)				
	mutton (15,000)				
	chicken (4913)				
	salted beef (8660)				
	salted pork (4441)				
VEGETABLES:	pumpkin (1526)				
	carrot (3530)				
	green leaves:				
	leaf lettuce (260)				
	kale (2015)				
	cabbage (30)				
FRUITS:	oiti				
	macaiba				
	mangoe (630)				
	papaya (11)				

Observation: (   ) µg/day

Vitamin A sources: Adequate ___ > 400 µg/day
Poor ___ < 400 µg/day

IV. GARDENS AND ANIMALS:

1. Do you have a garden? _____

2. If no, why don't you have a garden?

3. What foods do you have in your garden?

4. What do you do with the foods from your garden?
   a. consume ___
   b. sell ___
   c. trade ___
   d. other ____________________

5. Does your family have any animals? ______
   No.
   a. cattle ________
   b. horses _______
   c. goats _______
   No.
   d. pigs _______
   e. birds _______
   f. other ____________________

6. If no, why don't you raise animals?

7. What do you do with the animals?
   a. consume ___
   b. sell ___
   c. keep ___
   d. trade ___
   e. other____________________

V. Socioeconomic Status:

Classification of housing using basic characteristics and sanitation.

Specification	Value 0		Value 1	
Physical Characteristics of Dwelling:				
Roofing	Straw or similar material	___	Roofing tile	___
Walls	Other	___	Brick with plaster	___
Floor	Other	___	Cement	___
Lighting	Other	___	Electricity	___
Sanitation:				
Water	Other	___	Water system	___
Disposal of human excrements	Other	___	Cesspool or sewerage	___
Trash removal	Elimination < once/week	___	Elimination once/week or more	___
Persons to a bedroom	> 3	___	≤ 3	___

Classification using the points obtained:

Level: Inadequate ≤ 7

Adequate = 8

VI. Anthropometry:

MOTHER

		First Visit
Weight		_______Kg
Height		_______cm
Mid-arm Circumference		_______mm
Triceps Skinfold	1.	_______mm
	2.	_______mm
	3.	_______mm
	TSF average	_______mm
Calculated Mid-arm muscle circumference		_______mm

CHILD

		First Visit		Second Visit
Weight		_______Kg		_______Kg
Height		_______cm		_______cm
Mid-arm Circumference		_______mm		_______mm
Triceps Skinfold	1.	_______mm	1.	_______mm
	2.	_______mm	2.	_______mm
	3.	_______mm	3.	_______mm
	TSF average	_______mm	TSF average	_______mm
Calculated Mid-arm muscle circumference		_______mm		_______mm

VII. Serum Retinol and Carotene:

MOTHER

	First Visit
Retinol	________µg%
Carotene	________µg%

CHILD

	First Visit	Second Visit
Retinol	________µg%	________µg%
Carotene	________µg%	________µg%

Appendix B.

Survey Instrument--Portuguese

PESQUISA--VITAMINA A

Local ____ Data _________

Nome ____ Código M______

Criança ______________________________________ Código C______

Endereço ____

Data de Nacimento Mãe __/__/__ Idade __/__/__ (anos/ mêses)

Data de Nacimento Criança __/__/__ Idade __/__/__ (anos/mêses) Sexo

I. Data da Família:

1. Quantos filhos teve? ______
2. Quantas pessoas moram na casa? ______
3. Quantos dormitórios têm na casa? ______
4. A senhora sabe ler? ______
5. A senhora está grávida? ______ Quantos mêses? _____

II. Conhecimentos sobre Nutrição

1. Que alimentos a senhora acha que fazem bem? Por que?

2. O que a senhora acha que deve comer quando está grávida? Por que?

3. O que a senhora acha que deve comer quando está amamentando? Por que?

4. Quais são os alimentos que devemos dar ão bebê, em que idade, e por que? (até 1 ano).

5. Que alimentos devemos dar as crianças e por que?

6. Que alimentos a senhor acha que fazem mal e por que?

7. O que a senhora ache que não deve comer quando está grávida e por que?

8. O que a senhora acha que não deve comer quando está amamentendo e por que?

9. Quais os alimentos que não devemos dar ão bebê e em que idade? (até 1 ano).

10. Que alimentos não devemos dar as crianças e por que?

11. A senhora costuma tomar vitaminas? Quais? Quando e por que?

12. Seus filhos costumam tomar vitaminas? Qual, quando e por que?

Entrevistador:

A mãe tem un grau de conhecimento sobre nutrição e alimentação:

Bom ___

Razoável ___

Nenhum ___

Prejudicial ___

III. Fontes da Vitamina A:

MAE

	p/dia	p/sem	p/mes	Total p/mes
	Quantidade			
LEITE: de vaca (30)				
de cabra (25)				
em pó integral (255)				
QUEIJO: de vaca (240)				
de cabra (40)				
FIGADO: de boi (8660)				
de porco (4441)				
de carniero (15,000)				
de galinha (4913)				
de alemão de boi (8660)				
de alemão de porco (4441)				
VERDURAL: jerimum (1526)				
cenoura (3530)				
folhas:				
alface (260)				
couve (2015)				
repolho (30)				
FRUTAS: oiti				
macaíba				
manga (630)				
mamão (11)				

Obs: (   ) µg/dia

Fontes de vitamina A: Adequado ___ ≥750 µg/dia
Pobre ___ <750 µg/dia

CRIANÇA

		Quantidade			
		p/dia	p/sem	p/mes	Total p/mes
LEITE:	de vaca (30)				
	de cabra (25)				
	em pó integral (255)				
QUEIJO:	de vaca (240)				
	de cabra (40)				
FIGADO:	de boi (8660)				
	de porco (4441)				
	de carniero (15,000)				
	de galinha (4913)				
	de alemão de boi (8660)				
	de alemão de porco (4441)				
VERDURAS:	Jerimum (1526)				
	cenoura (3530)				
folhas:					
	alface (260)				
	couve (2015)				
	repolho (30)				
FRUTAS:	oiti				
	macaíba				
	manga (630)				
	mamão (11)				

Obs: (   ) µg/dia

Fontes de vitamina A:			
	Adequado	___	≥400 µg/dia
	Pobre	___	<400 µg/dia

IV. Hortas e Animais:

1. Você tem horta? ______

2. Porque não tem horta?

3. Quais os alimentos que tem em sua horta?

4. Que faz você com os alimentos de horta?

   a. consumo ___ c. troca ___
   b. venda ___ d. outro ______________________

5. Sua família possue animais ou criações? ______

	No.		No.
a. bovinos	______	d. suinos	______
b. equinos	______	e. aves	______
c. caprinos	______	f. outros	______________________

6. Porque no tem animais?

7. Que faz você com os animais?

   a. consumo d. troco
   b. venda e. outro______________________
   c. guarda

V. Estado Socioeconomical:

Classificação de moridias segundo características e saneamento básico.

Especificação	Valores 0		1	
Characterísticas Físicas de Moradia:				
Teto	Palha ou similar material	___	Telha/Zn	___
Parede	Outros	___	Tijolo c/reboco	___
Piso	Outros	___	Cimento	___
Iluminação	Outros	___	Eléctrica	___
Saneamento:				
Auga	Outros	___	Rede	___
Dejetos	Outros	___	Fossa	___
Lixo	Outros	___	Eliminação em tiempo hábil	___
Pessoas p/ dormitório	Outros	___	≤ 3	___

Classificação segundo pontos obtidos:

Nível: Inadequado ≤ 7

Adequatdo $= 8$

VI. Anthropometría:

MAE

		Primeira Visita
Peso		_______Kg
Altura		_______cm
P. Branquial		_______mm
P. Cutanea	1.	_______mm
	2.	_______mm
	3.	_______mm
	Média	_______mm

CRIANÇA

		Primeira Visita		Segunda Visita
Peso		_______Kg		_______Kg
Altura		_______cm		_______cm
P. Braquial		_______mm		_______mm
P. Cutanea	1.	_______mm	1.	_______mm
	2.	_______mm	2.	_______mm
	3.	_______mm	3.	_______mm
	Média	_______mm	Média	_______mm

VII. Reteol e Catotene no Soro:

MAE

	Primeira Visita
Retinol	_______µg%
Carotene	_______µg%

CRIANÇA

	Primeira Visita	Segunda Visita
Retinol	_______µg%	_______µg%
Carotene	_______µg%	_______µg%