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SRI LANKA NUTRITION STATUS SURVEY

(September 1975 - March 1976)

Prepared by
U.S. Department of Health, Education and Welfare
Public Health Service
Center for Disease Control
in Cooperation with
Ministry of Health, Government of Sri Lanka
CARE/Sri Lanka
and
U.S. Agency for International Development

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"The aim of a nutrition status survey is to obtain the maximum of useful information, using a minimum of staff, inexpensive equipment and uncomplicated techniques that can be analyzed easily." (D.B. Jelliffe, The Assessment of the Nutritional Status of the Community, 1966, World Health Organization, Monograph Series, 53.)

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SRI LANKA NUTRITION STATUS REPORT

I. Objectives

The objectives of the Sri Lanka Nutrition Status Survey were threefold: (1) The survey was to provide a statistically valid assessment of the nutritional status of the preschool population of health districts in Sri Lanka by measuring certain key indicators of nutrition status in preschool children 6-71 months of age selected by an acceptable survey sampling technique. The data should allow for estimation and comparison of undernutrition, anemia, and vitamin A deficiency among health districts (SHS areas), if the prevalence of each condition is approximately five percent or greater. (2) The survey was to fulfill the need expressed by the Sri Lanka Ministry of Health for a reliable reference data base to be used in planning intervention programs in nutrition and monitoring possible changes in nutritional status resulting from such programs. (3) The survey was to help develop the capability of Sri Lankan personnel, through training and field experience, to conduct a survey and make nutritional assessments by selected anthropometric, biochemical and clinical means. Such capabilities should be helpful in nutrition surveillance in the future.

The degree of undernutrition in the preschool child (ages 6-71 months) is related to the probable level of the nutritional

status of that child's community[1]. Probability sampling techniques must be used in the selection of preschool children so that statistically valid estimates can be made of the nutritional status of the health districts in which they reside[2]. Anthropometric measurements, selected clinical data and hemoglobin levels are acceptable key indicators of nutritional status in preschool children[3,4].

Baseline data on nutritional status are needed for decision making as to the type and location of possible intervention programs in nutrition[5]. If change of sufficient magnitude occurs as a result of such programs or other activities, it should be detectable by comparison of contemporary data with this baseline data.

II. Background Information

There is evidence that protein-calorie undernutrition, anemia, and vitamin A deficiency may constitute significant nutritional problems in Sri Lanka.

An early study by Cullumbine found clinical undernutrition among people in different economic levels and diverse ethnic groups, but did not make comparisons among different health districts[6]. Admission data from the Children's Hospital, Colombo, show an increase in the proportion of admissions

showing evidence of kwashiorkor from 1950 to 1954 and again from 1967 to 1974[7,8]. In the latter period there was a stable trend in the percentage of admissions showing evidence of marasmus but a slight increase in the proportion of those showing a deficit in weight-for-age according to the Gomez classification[9]. A recent survey conducted by CARE, Sri Lanka, in which approximately 3,700 preschool children were examined in nine health districts, showed an overall prevalence of approximately 2% with clinical marasmus and 0.5% with clinical kwashiorkor[10].

A study by De Silva in 1950 showed a high proportion of low hemoglobins among children hospitalized in Colombo[11]. More recent studies by de Mel have pointed to a possible increase in the prevalence of anemia among preschool children[12].

Information about vitamin A deficiency in Sri Lanka is inconclusive. A review of cases of blindness in the Civil Hospital in Kandy from 1939 to 1942 showed a high proportion of blindness in children to be due to kerotamalacia[13]. A later review of cases of blindness at the eye clinic in Jaffna from 1950 to 1952 showed a strikingly lower proportion of blindness in children due to kerotamalacia[14]. More recent data from the Colombo eye clinic show a decrease in the percentage of children manifesting signs of kerotamalacia and Bitot's spots during the period 1964 to 1974[15].

In summary, data do not exist which permit the estimation of the nutritional status of preschool children for the comparison of the nutritional status of health districts within Sri Lanka.

III. Survey Design and Methodology

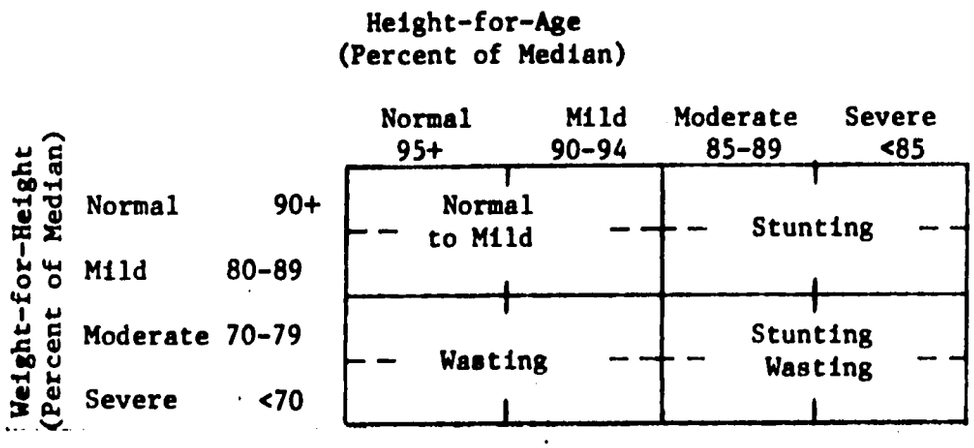
A. Data Items

In a field survey the data items should be easily measurable with acceptable accuracy and reliability, should adequately assess the nutritional conditions under consideration, and must remain within the practical constraints of time, money, equipment, and personnel. With these criteria in mind, data items were chosen which were thought by CDC, USAID, CARE and Sri Lankan officials to adequately reflect a child's status with regard to undernutrition, anemia, and vitamin A deficiency.

Anthropometry allows one to assess protein energy undernutrition by using the simple body measurements of weight and height (and perhaps arm circumference)[3,16]. Some measurements rely on accompanying accurate age information for interpretation and to permit comparison with a reference population[17]. The accuracy of age data in Sri Lanka appears quite acceptable according to published studies[18]. The possible contribution of ethnic and racial differences in distorting anthropometric data comparisons between Sri Lanka and western reference populations is at a minimum

within the age group 6-71 months[19] and should not bias comparisons between health districts. (Additional comments on reference populations are in Appendix A.)

With accurate height, weight and age determinations and an acceptable reference population available, it is possible to estimate the phenomena of stunting (i.e., a deficit in height-for-age) and wasting (i.e., a deficit in weight-for-height)[3]. The distribution of weight-for-age measurements can be examined, but this does not distinguish between long-term stunting due to retarded linear growth of bones and short-term wasting of muscle and fat[9]. Waterlow has suggested a classification, diagrammed below, to classify nutritional status by combining these two measurements[20].



The measurement of hemoglobin by the photometric determination of cyanmethemoglobin is preferred in the assessment of anemia since it is a direct reflection of the oxygen carrying capacity of the blood and can be performed with satisfactory accuracy[21]. It offers the additional advantages that specimens can be relatively easily handled in the field and transported to a central laboratory for photometric determinations.

In assessing vitamin A deficiency, one has to choose specific signs and symptoms which can be easily recognized by field personnel, and whose estimated prevalence is large enough to permit statistical significance testing. Oomen and others have commented on these difficulties in conducting vitamin A deficiency surveys[22]. Bitot's spots and corneal scars are easily recognizable signs of vitamin A deficiency[23], and it is feasible to instruct field personnel in their accurate identification. Night blindness is an early symptom of vitamin A deficiency[24]. While the accuracy of establishing the presence of night blindness by questioning parents is not well known, the question was considered feasible for the survey in children over 2 years of age.

In summary, then, the following data items were selected with regard to the three conditions under consideration:

a) undernutrition - weight, stature, length (and arm circumference)

b) anemia - hemoglobin

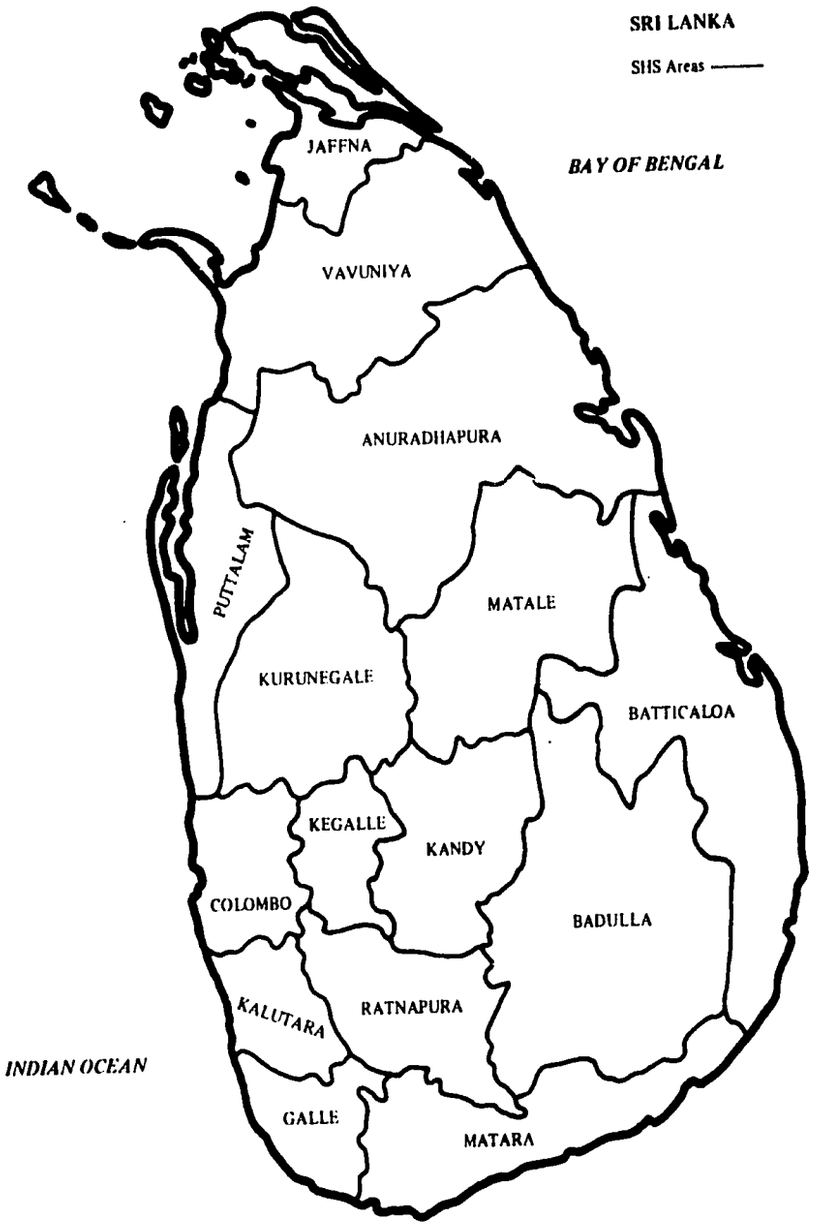
c) vitamin A deficiency - Bitot's spots, corneal scars, and night blindness.

These items meet the criteria of ease of measurability with acceptable accuracy and reliability, and adequate assessment of the nutritional conditions under consideration, while remaining within practical resource constraints.

B. Selection of Survey Universe(s)

Having decided on the data items to be collected in the survey, the survey universe(s) and the sample areas in which the survey would be conducted were delineated by CDC and Sri Lankan officials. The total population of Sri Lanka is approximately 12.7 million. The primary survey universe was defined as the rural population of Sri Lanka which constitutes 75.6% of the population. The SHS area (or health district) was considered the most meaningful area for within country comparisons. Thus, there were 15 sample areas or subuniverses in the survey since there are 15 SHS areas in Sri Lanka. (Figure 1). Samples of equal size were drawn from each SHS area, so

FIGURE I


SRI LANKA
SHS Areas
BAY OF BENGAL
JAFFNA
VAVUNIYA
ANURADHAPURA
PUTTALAM
MATALE
KURUNEGALE
BATTICALOA
KEGALLE
KANDY
COLOMBO
BADULLA
KALUTARA
RATNAPURA
INDIAN OCEAN
GALLE
MATARA

that the prevalence estimates would be approximately the same precision allowing preliminary SHS comparisons from simple inspection of the data. Significance testing could then be performed (using, for example, the t-test or chi-square) to determine if significant differences in nutritional status existed between SHS areas[25].

C. Sampling Methods

Because of the constraints of time, money, equipment and personnel the sample was drawn in two stages. Each health district or sample area would consist of 30 clusters or sample sites in order to permit the estimation of health district characteristics in the areas of protein-calorie undernutrition, anemia, and vitamin A deficiency[26]. Details for these calculations are in Appendix B. Statistical testing could then determine if significant differences existed between districts with regard to the nutrition parameters.

In the first stage a sample of 30 villages was selected within each SHS area using census data. The probability of inclusion of a village in the sample was proportional to its population. Within each village a household was selected as a starting point as explained in Appendix C.

One then proceeded to adjacent households in order to examine 30 children age 6-71 months in each cluster.

D. Special Group

The need for an international reference population to standardize data presentation, to allow numerical comparisons between surveys and to facilitate comparisons within a given survey justifies the use of the NAS reference. Another aid in the analysis and interpretation of survey data is a nutrition status description of an elite population or special group of a country. The results for the special group are compared with results obtained for the survey rural population and with the NAS references. The special group in Sri Lanka was drawn from the private pregrade schools of Colombo and is composed of the children of the socioeconomically advantaged classes. Results obtained for this special group represent the present highest levels of nutritional health that one can find in a country. Therefore, simplistically, they may be regarded as target values potentially obtainable by the same age groups of the entire population of Sri Lanka.

IV. Field Methodology

A. Equipment

Stature or length was measured in centimeters using a sturdy

portable wooden board, which allowed values to be read to the nearest 0.1 centimeter. Weight was measured in kilograms using a Salter hanging scale, which allowed values to be read to the nearest 0.1 kilogram. Boards and scales were checked periodically to insure their measurement accuracy. Arm circumference was measured with a Zerfas slotted tape, which could be read to the nearest 0.1 centimeter.

Blood was collected by finger or heel prick on approximately every fifth child in the survey. Blood was drawn into capillary tubes which were calibrated to collect the same quantity of blood on each child, and the blood was then dissolved in Drabkin's solution of known concentration and quantity. These specimens were then taken to a laboratory where the same experienced technician performed all assays by the cyanmethemoglobin method using a Bausch and Lomb Minispec 20 TM Spectrophotometer[27]. Detailed procedures for anthropometric measurements and collection of blood samples are provided in Appendices D and E.

B. Personnel

A staff of 24 individuals received an intensive 3-week training course prior to the initiation of field work. The staff consisted of 18 public health inspectors, 2 laboratory technicians, and 4 CARE staff members. Each

of these individuals had previous experience in working under field conditions, and most had worked with children in a public health capacity. The training course consisted of intensive instruction in the techniques of adequately obtaining and recording data for undernutrition, anemia and vitamin A deficiency. The staff worked in teams consisting of 2 individuals each. While only 10 teams were required for the field work, 2 additional teams were trained to serve as replacements in the event that staff members might be rendered unavailable for field work.

Teams were carefully instructed in the measuring and recording of weight, height, and arm circumference to insure acceptable accuracy and reliability. Team performance was evaluated at the end of the training session through the use of standardization tests adapted from those utilized by Habicht[28]. There were two subsequent standardization exercises during the course of the field work.

Team members were carefully instructed in the identification of Bitot's spots and corneal scars, using slides depicting these signs, and patients manifesting them. They were standardized at the end of the training session and on two subsequent occasions during the course of the field work, again using slides and clinical cases with Bitot's spots, and corneal scars, and other normal and abnormal eye

findings. Team performance in all instances was satisfactory.

Teams were instructed in the proper techniques of asking questions and obtaining responses necessary for completion of other items on the data form. The recording of all items was reviewed by supervisory personnel throughout the course of the field work.

During the field work at least three CDC and Sri Lankan Ministry of Health supervisors remained full time in the field traveling with the teams, and observing and correcting team work in the sample sites.

C. Data Collection

A sample questionnaire is presented in Appendix F. Two items were deleted after its preparation; availability status of the CARE Thriposha Program and the income level of the child's family. The exact details of the proper administration of the data form are included in the field manual for the Sri Lanka Nutrition Status Survey.

The survey design and sampling methodology were structured so that estimates could be made by SHS areas of selected nutrition parameters. The design and methodology allow for SHS area estimates on demographic and descriptive factors also collected in the survey. These factors are

size and location of the child's household, child's birth order and the child's registration status with midwife and CARE Thriposha programs. They are considered auxiliary information. The survey was designed to estimate the extent and location of specific nutrition problems throughout Sri Lanka and not to identify causal factors for these problems.

Completed questionnaires were edited for legibility, completeness, and accuracy at the sample site by the team, and thereafter by supervisory personnel in Colombo. The forms were then airmailed to the Center for Disease Control for keypunching, computer editing, and tabulation by an IBM 370/145 computer.

Field work began in October 1975 and was completed in March 1976.

V. Survey Results and Analysis

A. Analytic Methodology

Since the primary objective of the survey was to assess the nutritional status of SHS areas, a format for data presentation and analysis was chosen which allowed meaningful comparisons of SHS areas on various nutrition indices as in the following categories suggested by Waterlow and Rutishauser[20]:

Nutritional Status	Height-for-Age	Weight-for-Height
Normal Nutrition	normal	normal
Acute Undernutrition ("wasting")	normal	low*
Chronic Undernutrition ("stunting")	low**	normal
Concurrent acute and chronic undernutrition ("stunting & wasting")	low**	low*

* Defined as less than 80% of reference median weight-for-height[20].
** Defined as less than 90% of reference median height-for-age[20].

The anthropometric parameters of height-for-age and weight-for-height allow the identification of three different categories of undernutrition. With the percentage of preschool children in these categories identified for each SHS area, the SHS areas are compared as follows:

B. Age and Sex Distribution

The sample distribution by sex and age is shown in Table 1. The age and sex distribution for the total survey population and the age and sex differences between SHS areas are not likely to have biased the survey results.

Table 1

Distribution of Sample by Age and Sex

Age (Months)	Males		Females		Total	
	Actual[a] No.	Weighted[b] Percent	Actual No.	Weighted Percent	Actual No.	Weighted Percent
6-11	641	9.4	589	8.8	1230	9.1
12-23	1306	19.4	1292	19.3	2598	19.3
24-35	1262	18.1	1163	18.0	2425	18.0
36-47	1301	18.8	1210	18.1	2511	18.5
48-59	1281	18.8	1222	19.0	2503	18.9
60-71	1072	15.5	1111	16.9	2183	16.2
Total	6863	100.0	6587	100.0	13450	100.0

[a] Actual number of children in age group.

[b] Weighted percentages calculated to correct for the influence of unequal SHS populations.

Of the 13,500 preschool children selected for the survey, 50 were not included in the analysis because of omitted or suspected erroneous age or anthropometric data. Deletions

were not concentrated in any particular SHS area.

Of those selected for analysis, 90.8% (12,189) had a birth registration form (or certified copy thereof) as proof of date of birth. Among the SHS areas, this value ranged from 87.4% to 96.0% of children accepted for analysis. Significant survey bias resulting from inaccurate age data is not likely because of this high percentage of reliable written age information.

C. Acute Undernutrition

Table 2 shows the percentage of children who had evidence of acute undernutrition ("wasting") in each SHS area and the average percentage of such children for Sri Lanka as a whole. The individual SHS prevalence figures vary significantly from the country average (chi-square = 42.4, $p < .001$). Practically, the differences between the high and low values for wasting when related to an average prevalence of 6.6% may be of little useful value for developing and targeting remedial programs.

Table 2

Acute Undernutrition[a] by SHS Area

SHS Area	% Acutely Undernourished
Ratnapura	8.8
Kandy	8.5
Batticaloa	8.4
Galle	8.2
Matale	7.2
Kegalle	7.1
Anuradhapura	6.9
Kalutara	6.2
Matara	6.0
Vavuniya	5.8
Badulla	5.8
Kuranegale	5.7
Puttalam	5.1
Colombo	4.9
Jaffna	3.7
Weighted Average - Sri Lanka	6.6

[a] Weight-for-height <80% of reference median

Table 3 shows the pattern of acute undernutrition by age groups for rural Sri Lanka.

Table 3

Acute Undernutrition (Wasting) by Age

Age (Months)	% Acutely Undernourished (weighted percent)
6-11	5.0
12-23	10.8
24-35	6.9
36-47	4.8
48-59	5.0
60-71	6.2
Average - Sri Lanka	6.6

Acute undernutrition in Sri Lanka is age dependent and is significantly higher in the 12-23 month age group (chi-square = 67.7, $p < .001$).

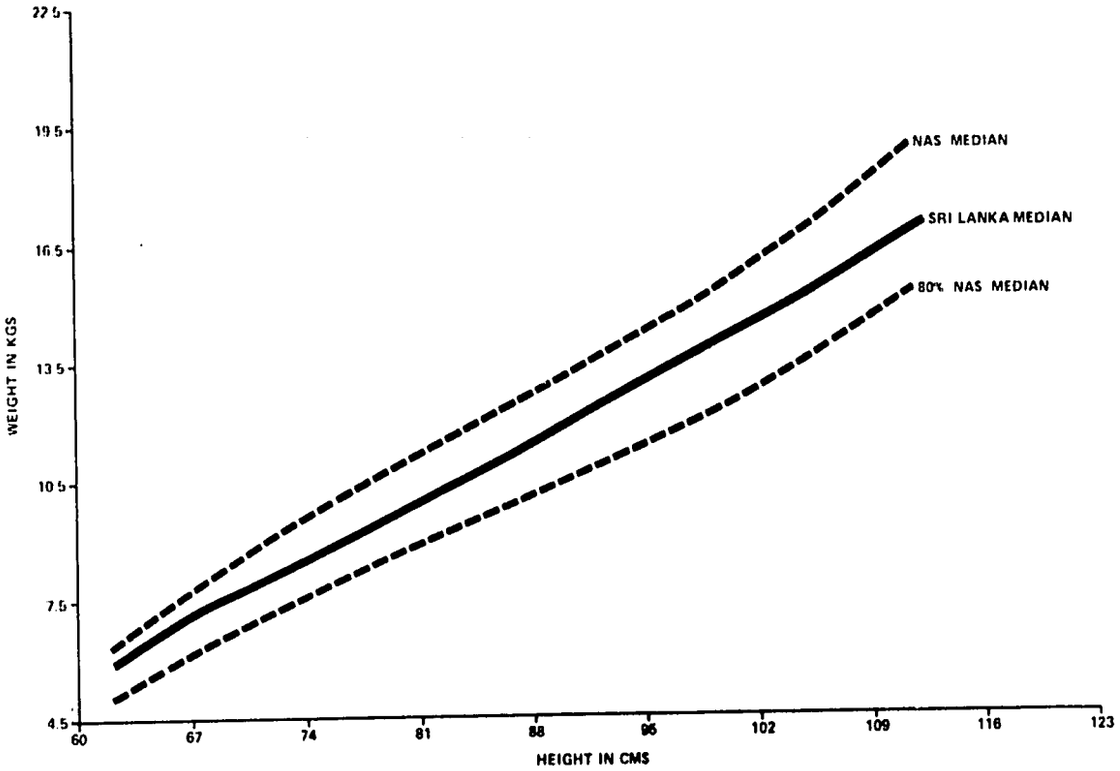
Figure 2 displays the rural Sri Lanka median weight-for-height by sex as curves compared with the NAS reference population median and 80% of median weight-for-height curves.

D. Chronic Undernutrition

Table 4 shows the percentage of children who had evidence of chronic undernutrition ("stunting") in each SHS area and the average percentage of such children for rural Sri Lanka.

FIGURE 2

COMPARISON OF RURAL SRI LANKA SURVEY POPULATION MEDIAN WEIGHT – FOR – HEIGHT
WITH NAS REFERENCE POPULATION – BOYS



COMPARISON OF RURAL SRI LANKA SURVEY POPULATION MEDIAN WEIGHT – FOR – HEIGHT
WITH NAS REFERENCE POPULATION – GIRLS

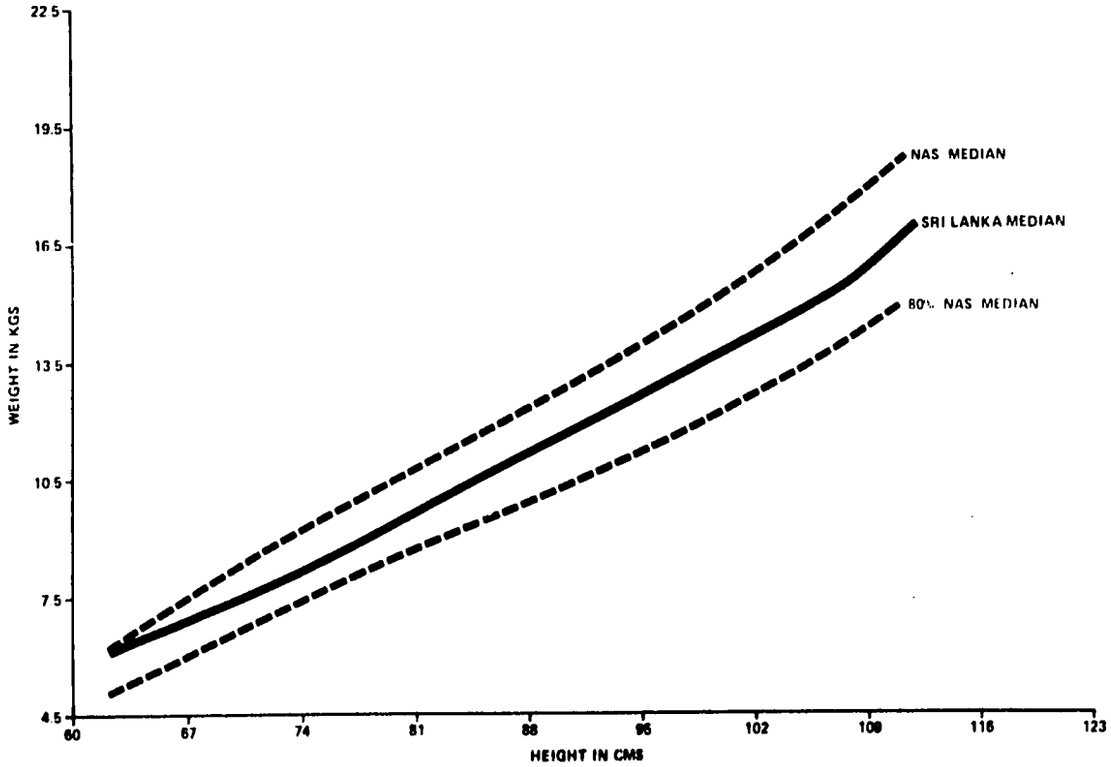


Table 4

Chronic Undernutrition[a] by SHS Area

SHS Area	% Chronically Undernourished
Kandy	49.6
Badulla	49.4
Kegalle	39.6
Matale	38.9
Ratnapura	37.3
Batticaloa	36.5
Galle	33.3
Anuradhapura	30.7
Kuranegale	30.4
Matara	29.7
Vavuniya	29.6
Jaffna	28.4
Kalutara	26.8
Puttalam	24.4
Colombo	20.7
Weighted Average - Sri Lanka	34.7

[a] Height-for-age <90% of reference median.

The total rural survey prevalence of stunting is high. Significant variation exists between the 15 SHS areas (chi-square = 94.7, $p < .001$). Besides there being

statistical variation, practical differences in the prevalences of stunting exist especially between the high and low extremes. Stunting effects fully one-third of the preschool rural children of Sri Lanka with approximately a twofold difference in prevalence separating a lower and higher grouping of SHS's. Planning for nutrition intervention should consider this is selection and targeting remedial programs.

Table 5 shows the pattern of chronic undernutrition, by age, for rural Sri Lanka as a whole.

Table 5

Chronic Undernutrition (Stunting) by Age

Age (Months)	% Chronically Undernourished (weighted percent)
6-11	11.8
12-23	24.8
24-35	33.1
36-47	40.8
48-59	41.9
60-71	46.2
Average - Sri Lanka	34.7

The pattern shows a consistent increase in stunting with increase in age.

Figure 3 compares by sex the rural Sri Lanka median height-for-age curve with the NAS reference population median and 80% of median weight-for-height curves by age.

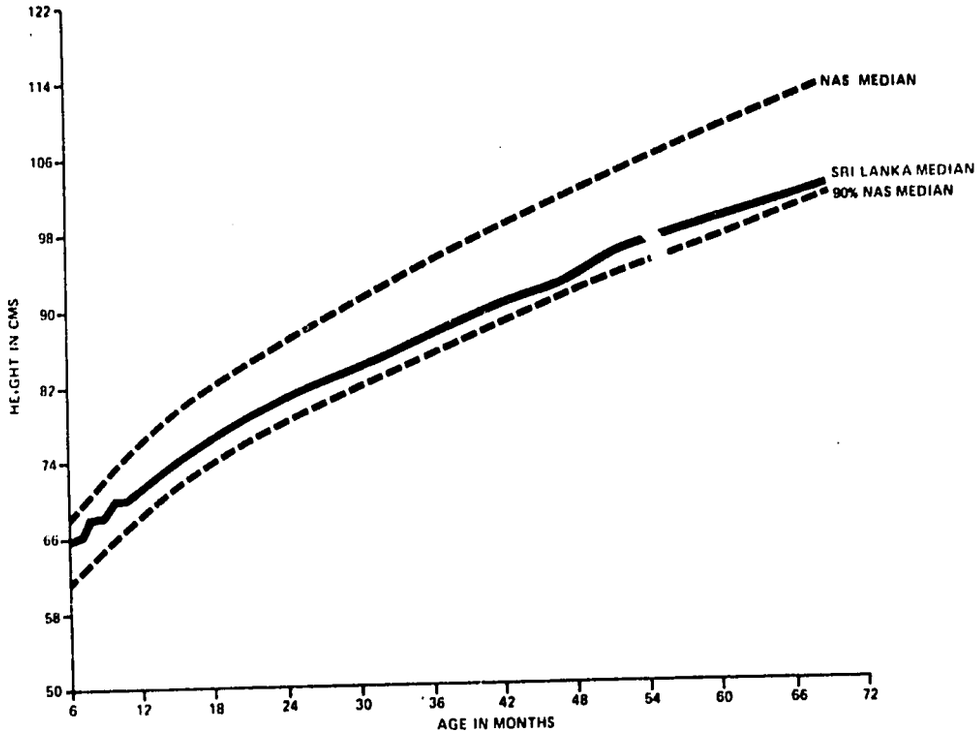
E. Concurrent Acute and Chronic Undernutrition

Table 6 shows the percentage of children who had evidence of concurrent acute and chronic undernutrition ("stunting and wasting") in each SHS area and the average percentage of such children for rural Sri Lanka.

Statistically there is significant variation between SHS prevalences (chi-square = 48.8, $p < .001$). In practical terms the numbers of children for the entire country with concurrent wasting and stunting may not justify the construction of a remedial program specifically limited to this group. An action program, which targets one SHS to receive the benefits and ignores another on the basis of a 3-4% difference in prevalence may not be justified by these data.

FIGURE 3

COMPARISON OF RURAL SRI LANKA SURVEY POPULATION MEDIAN HEIGHT – FOR – AGE WITH NAS REFERENCE POPULATION – BOYS 6 – 71 MONTHS



COMPARISON OF RURAL SRI LANKA SURVEY POPULATION MEDIAN HEIGHT – FOR – AGE WITH NAS REFERENCE POPULATION – GIRLS 6 – 71 MONTHS

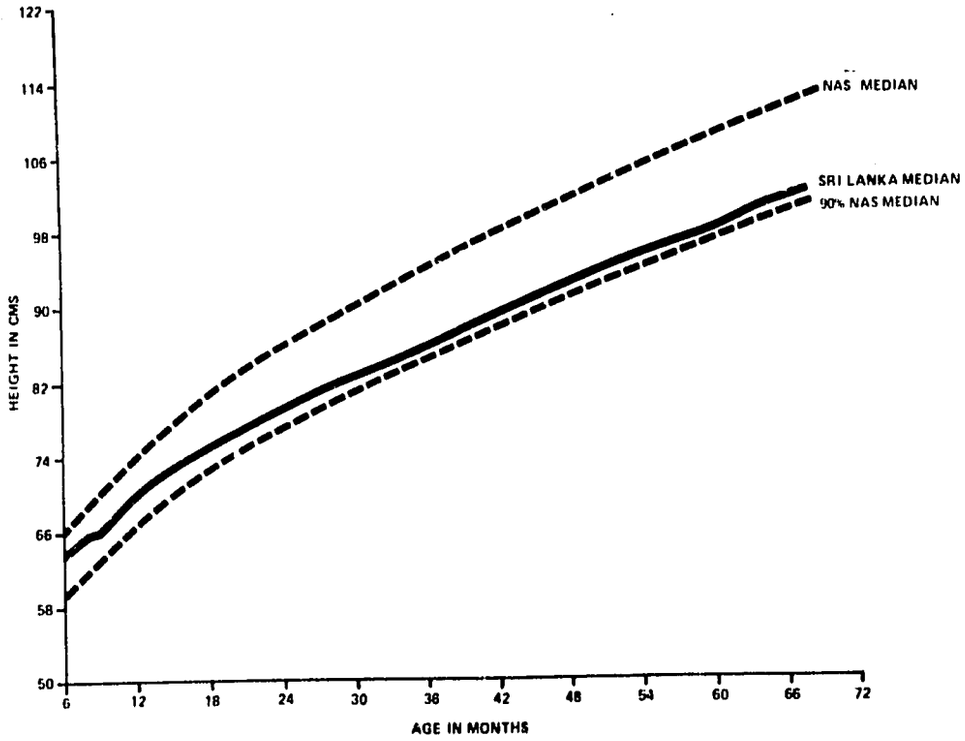


Table 6

Concurrent Acute and Chronic Undernutrition[a] by SHS Area

SHS Area	% Acutely and Chronically Undernourished
Kandy	5.5
Galle	4.1
Ratnapura	4.1
Batticaloa	4.0
Badulla	4.0
Kegalle	4.0
Matale	3.8
Kalutara	3.4
Anuradhapura	2.9
Kurunegale	2.3
Vavuniya	2.3
Matara	2.2
Colombo	1.9
Puttalam	1.9
Jaffna	1.6
Weighted Average - Sri Lanka	3.4

[a] Height-for-age <90% of reference median and weight-for-height <80% of reference median.

Table 7 shows the pattern of concurrent acute and chronic undernutrition by age groups for rural Sri Lanka.

Table 7

Concurrent Acute and Chronic Undernutrition by Age

Age (Months)	% Acutely and Chronically Undernourished (weighted percent)
6-11	1.6
12-23	3.8
24-35	4.0
36-47	3.4
48-59	2.6
60-71	3.9
Average - Sri Lanka	3.4

The pattern shows a low prevalence in the 6-11 month age group and a moderate prevalence of concurrent acute and chronic undernutrition among the other age groups.

F. Gomez Classification

While the Gomez classification[9], a weight-for-age index, does not allow one to distinguish between acute and chronic undernutrition, analyses based on weight-for-age are presented here since they may prove useful for comparison with existing data in Sri Lanka.

Table 8 presents the percent of children in combined second and third degree malnutrition by SHS area according to the Gomez classification.

Table 8

Gomez Classification:
Second and Third Degree Malnutrition by SHS Area
(weight-for-age <75% of NAS reference median)

SHS Area	% Gomez Second and Third Degree (combined)
Kandy	54.6
Badulla	50.6
Ratnapura	49.7
Matale	45.9
Kegalle	45.4
Galle	44.6
Batticaloa	42.3
Kurunegale	39.6
Anuradhapura	38.4
Matara	37.2
Vavuniya	36.4
Kalutara	35.7
Puttalam	34.6
Jaffna	32.5
Colombo	29.1
Weighted Average - Sri Lanka	42.0

There is significant variation among SHS prevalences (chi-square = 160.2, $p < .001$).

Table 9 shows the age distribution of children with second and third degree malnutrition on a weight-for-age basis.

Table 9

Gomez Classification:
Second and Third Degree Malnutrition by Age Groups
(weight-for-age <75% of NAS reference median)

Age (Months)	% Gomez Second and Third Degree (combined) (weighted percent)
6-11	26.2
12-23	39.2
24-35	36.3
36-47	40.2
48-59	46.6
60-71	57.3
Average - Sri Lanka	42.0

A more detailed presentation of weight-for-age data, including the Indian Academy for Pediatrics' modification of the Gomez classification, is presented in Appendix G. Even though variation among SHS areas can be demonstrated using such data, the interpretation of the results does not allow objective diverted program planning to the degree possible when using height-for-age and weight-for-height data. These latter two indices help separate chronic and acute undernutrition, and help

to determine whether long or short-term intervention programs are indicated.

Arm circumference data are presented in Appendix G. The relation of arm circumference-for-height potentially provides information similar to the relation of weight-for-height. However, the reliability of arm circumference measurements are probably less than for measurements of weight. In addition acceptable arm circumference reference data are not available as are such data for weight and height. Finally, as is shown in Appendix H, arm circumference has a low correlation with age, height, and weight data obtained in the survey.

As a final note on undernutrition in rural Sri Lanka, only 0.2% of all survey children were found to have bilateral pedal edema, probably attributable to severe undernutrition. The prevalence of pedal edema in survey children in the concurrent "wasting and stunting" category is 1.9%. Overall there is a very low prevalence of pedal edema for Sri Lanka and for practical purposes there is no difference between SHS areas.

G. Anemia

A great disparity of anemia prevalences between SHS areas

suggests the real possibility of technical errors in hemoglobin value determinations. The SHS areas in which the errors occurred cannot be identified. A high prevalence of anemia was determined in Jaffna (25.3%), Vavuniya (11.2%), Anuradhapura (9.9%), and Puttalam (7.3%), and yet these SHS areas are the best SHS areas by anthropometric indices. On the other hand, the average anemia prevalence of 3.8% for the remaining 11 SHS areas is unexpectedly low. Tables 10 and 11 show these 11 SHS areas ranked for anemia prevalence and the age group anemia prevalences for these SHS areas.

Because of the unreliability of hemoglobin data extremely cautious judgement must be exercised when utilizing the hemoglobin data of the survey. Therefore, the true prevalence of anemia in rural Sri Lanka can not be determined. The strongest indication that can be obtained from the survey results is that no practical difference in anemia prevalences occur between age groups.

Table 10

Percent of Children with Anemia[a] for Eleven SHS areas

SHS Area	% Anemic
Galle	6.7
Ratnapura	6.6
Matale	4.4
Colombo	4.4
Kalutara	4.4
Kandy	3.6
Badulla	3.3
Batticaloa	2.8
Kurunegale	2.8
Kegalle	2.5
Matara	1.1
Weighted Average - 11 SHS Areas	3.8

[a] Hemoglobin <10.0 for children under 2 years of age.

Hemoglobin <11.0 for children 2 years of age and older[29].

Table 11

Percent of Children with Anemia by Age Groups for Eleven SHS areas

Age (Months)	% Anemic (weighted percent)
6-11	3.3
12-23	3.4
24-35	4.0
36-47	3.2
48-59	5.1
60-71	3.3
Average - 11 SHS Areas	3.8

H. Clinical Vitamin A Deficiency

Seven children (0.05%) of all those surveyed had unilateral or bilateral corneal scarring possibly attributable to vitamin A deficiency. This is a very low prevalence and is one-half the percentage prevalence considered significant by recent WHO guidelines[32]. In addition, only 0.1% of all survey children had monocular or binocular blindness (due primarily to congenital causes).

The percent of children identified with unilateral or bilateral Bitot's spots in each SHS is shown in Table 12. The mean prevalence is quite low and is approximately one-half the percentage prevalence considered significant

by recent WHO guidelines[32]. Statistical testing demonstrates differences among the SHS areas and indicates that Kegalle and Matara have a prevalence of Bitot's spots exceeding the WHO minimum criteria of 2% ($p < .05$). Table 13 shows for rural Sri Lanka an increasing prevalence of Bitot's spots with increasing age.

Only 1.0% of all survey children older than 24 months had symptoms suggestive of night blindness (Table 12). Preschool children in Kegalle and Matara have a prevalence of night blindness greater than the WHO minimal criteria of 2% ($p < .05$). None of the age groups from 24-71 months had prevalences exceeding 2%.

Table 12

Percent of Children with Bitot's Spots and with Night Blindness by SHS Area

SHS Area	% Bitot's Spots	% Night Blindness
Kegalle	2.3	2.6
Matara	2.2	2.3
Ratnapura	2.0	0.9
Galle	1.4	1.1
Badulla	1.0	0.8
Kandy	1.0	1.1
Kurunegale	1.0	0.5
Kalutara	0.9	0.3
Batticaloa	0.7	1.3
Anuradhapura	0.7	0.5
Matale	0.7	0.8
Vavuniya	0.7	0.5
Jaffna	0.4	0.6
Puttalam	0.3	0.6
Colombo	-	1.2
Weighted Average - Sri Lanka	1.1	1.0

Table 13

Percent of Children in Age Groups with Bitot's Spots

Age (Months)	Bitot's Spots (weighted %)
6-11	0.1
12-23	0.2
24-35	0.8
36-47	1.4
48-59	1.4
60-71	2.1
Total	1.1

I. Village and Estate Sectors

The rural Sri Lanka population is primarily located within the village sector (88.2%) and secondarily within an estate sector (11.8%). The population of the estate sector is predominantly Indian Tamal, who were brought to Sri Lanka from India as laborers over several generations by concessionaires to meet the intensive labor requirements of the tea, rubber and coconut agricultural industries. The health care and economic status of the estate workers are primarily dependent upon these industries.

The survey sampling methods do not allow for rigid

statistical handling of data in comparing the village and estate sectors as survey sampling was population based, i.e., SHS total population by SHS total population, and did not take into consideration the estates as a separate sampling entity. However, the survey questionnaire differentiates between the two sectors and some liberty will be taken in comparing the results by sector.

Of 13,431 survey children categorized by sector, 91.6% inhabited the village sector and 8.4% inhabited the estate sector. Table 14 compares the prevalence of wasting for the two sectors.

Table 14

Comparison of Village and Estate Sectors

Percent of Children Weight-for-Height Less than 80% of NAS Reference

Sector	Percent Acute Undernutrition	Number Survey Children in Sector
Village	6.3	12,301
Estate	8.6	1,130
Total Rural Sri Lanka (weighted)	6.6	13,450

Table 15 presents the prevalence of wasting by sector for age groups.

Table 15

Comparison of Village and Estate Sectors

Percent of Children Weight-for-Height less than 80%

of NAS Reference by Age Groups

Age (months)	Village	Estate	Total Rural Sri Lanka (weighted)
6-11	4.8	6.7	5.0
12-23	10.5	13.5	10.8
24-35	6.6	9.2	6.9
36-47	4.2	9.1	4.8
48-59	4.6	7.1	5.0
60-71	6.4	4.9	6.2
6-71	6.3	8.6	6.6

Table 16 presents the average prevalence of stunting in the village and estate sectors.

Table 16

Comparison of Village and Estate Sectors

Percent of Children Height-for-Age less than 90%

of NAS Reference

Sector	Percent Chronically Undernourished	Number Survey Children in Sector
Village	30.8	12,301
Estate	62.4	1,130
Total Rural Sri Lanka (weighted)	34.7	13,450

Table 17 gives the stunting prevalence by sector for age groups.

Table 17

Comparison of Village and Estate Sectors

Percent of Children Height-for-Age less than 90%

of NAS Reference by Age Groups

Age (Months)	Village	Estate	Total Rural Sri Lanka (weighted)
6-11	9.3	27.4	11.8
12-23	21.5	47.2	24.8
24-35	29.4	62.6	33.1
36-47	36.5	71.5	40.8
48-59	37.4	73.1	41.9
60-71	41.4	77.4	46.2
6-71	30.8	62.4	34.7

Although for each sector the population base of these prevalences is very different and the biases of disproportionate sampling cannot be measured, there seems to be a real difference in the prevalence of stunting between village and estate children in the survey. The overall chronic undernutrition prevalence in the village sector is 30.8% and in the estate sector 62.4%, a twofold difference. Appendix G presents the weight-for-height and height-for-age data distributions in each sector.

Table 18 combines all age groups for each sector to present a comparison of the village and estate survey children by the Gomez classification (weight-for-age).

Table 18

Gomez Classification of Malnutrition:

Village and Estate Sector Survey Children

(Percent of NAS reference median weight-for-age)

Sector	Normal (90.0+)	1° (75.0-89.9)	2° (60.0-74.9)	3° (60.0)	No. of Survey Children in Sector
Village	10.1	51.0	35.8	3.1	12,301
Estate	2.9	33.3	54.7	9.1	1,130
Total Rural Sri Lanka (weighted)	9.2	48.8	38.2	3.9	13,450

Severe malnutrition characterized by combining 2° and 3° Gomez categories affects 38.9% of village survey children and 63.8% of estate survey children, again suggesting a more severe problem in the estate sector.

Within the reservations stated earlier on the quality of survey hemoglobin data a comparison of village and estate anemia prevalence can be at best only suggestive. Table 19 compares estate data with village data obtained from the 11 SHS areas for which low anemia prevalences were determined.

Table 19

Prevalence of Anemia in Villages and Estates for All Age Groups

Sector	Percent With Anemia
Village	4.1
Estate	2.1

Even though the village sector anemia prevalence is twice that of the estate sector, the difference may not be practically useful in terms of establishing remedial priorities as both prevalences are low.

For practical purposes there are no differences between the estate and rural sectors in the prevalences of the clinical vitamin A deficiency sign of Bitot's spots and symptoms of night blindness.

J. Special Group

Anthropometric and age data were collected on 438 children age 48-71 months in several private schools within the capitol city of Colombo. These children are generally from a higher socioeconomic category than the children of the rural population. Table 20 compares this special group of children with the survey children of rural Sri Lanka for growth parameters only in the two age groups, 48-59 months and 60-71 months for which data on sufficient numbers of private school children are available.

The private school children in Colombo are remarkably better off than the rural survey children and, in fact, their growth parameter medians approach the NAS reference group medians for both height-for-age and weight-for-height in the above age groups (Figures 4-5).

Hemoglobin values were determined on 124 of these children and only 2 (1.6%) were below 11 gms Hgb/100 cc as compared to the 5.7% of the rural survey children of the same age groups. The children's eyes were examined for evidence of clinical vitamin A deficiency and none was found.

Table 20

Growth Comparisons
Special Groups and Rural Sri Lankan Children 48-71 Months Old

Age (Months)	Special Group	Rural Survey Children[a]
	Height-for-Age (percent below 90% of NAS reference median)	
48-59	1.1	49.9
60-71	3.4	46.2
No. children 48-71	438	4686
	Weight-for-Height (percent below 80% of NAS reference median)	
48-59	1.6	5.0
60-71	3.6	6.2
No. children 48-71	438	4686
	Weight-for-Age (percent below 75% of NAS reference median)	
48-59	6.5	46.6
60-71	11.9	57.3
No. children 48-71	438	4686

[a] Percents calculated from weighted data.

FIGURE 4

COMPARISON OF WEIGHT - FOR - HEIGHT DATA IN AGE GROUP 48 - 71 MONTHS
RURAL SRI LANKA SURVEY, SRI LANKA SPECIAL GROUP AND NAS REFERENCE MEDIANS

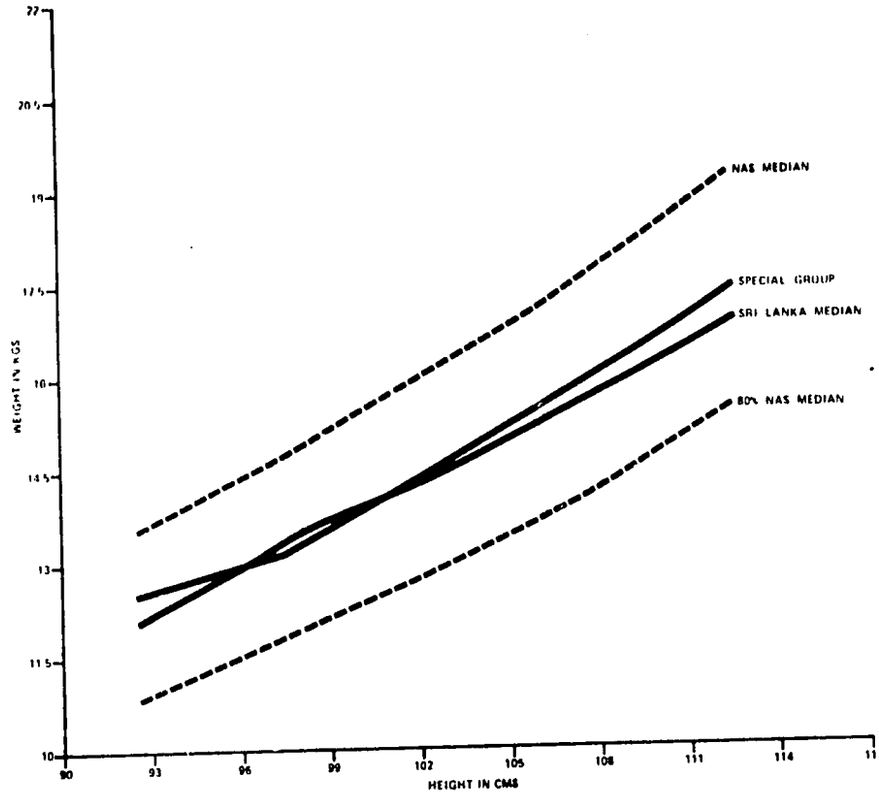
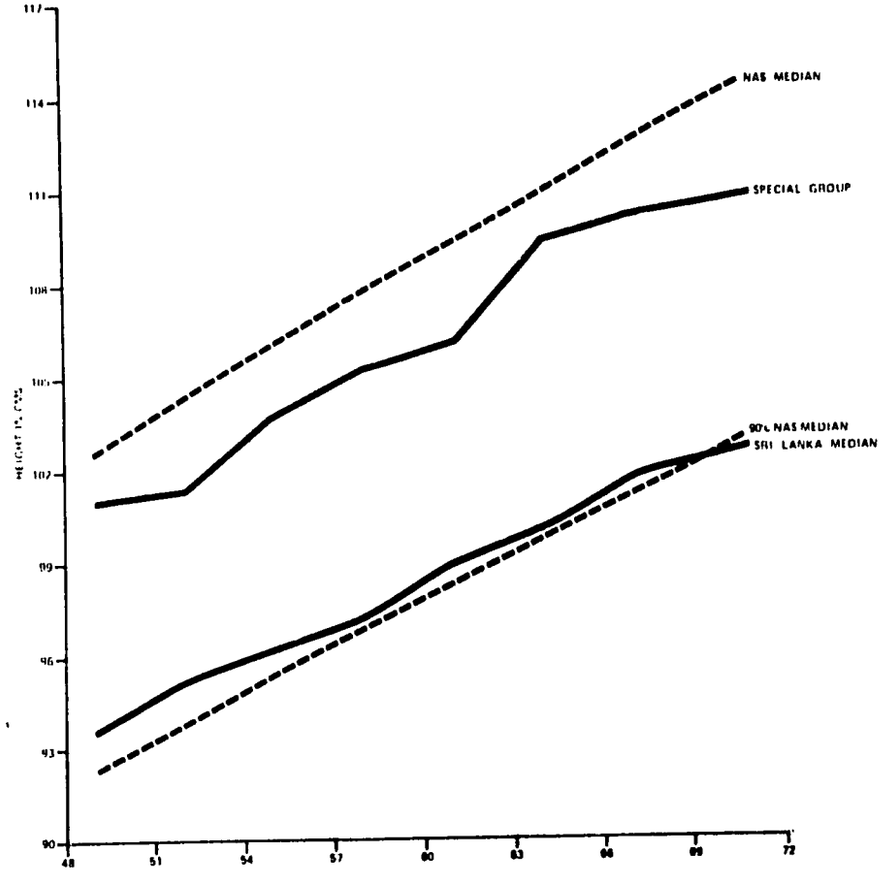


FIGURE 5

COMPARISON OF HEIGHT - FOR - AGE DATA IN AGE GROUP 48 - 71 MONTHS
RURAL SRI LANKA SURVEY, SRI LANKA SPECIAL GROUP AND NAS REFERENCE MEDIANS



K. Other Demographic and Descriptive Data

To obtain the following results the survey data for each factor were not weighted for SHS population differences.

1. Household size. The average household size of the participant in the rural Sri Lanka survey was 6.5. Table 21 shows the average household size of the survey members in each Waterlow category of nutrition status.

Table 21

Average Household Size of 13,447 Survey Children for Waterlow Categories

	Normal	Stunting	Wasting	Wasting and Stunting
Average household size	6.3	6.8	6.4	6.7

Statistical testing suggests that the average household size of the stunting and normal categories differs and that of the wasting and normal categories does not. A statistical difference exists for the average house size of the village and estate sector participants.

2. Birth order of survey participants. The average birth order of the participants in the rural Sri Lanka survey was 3.7. Table 22 shows the average birth order position of the survey members in each Waterlow category of nutrition status.

Table 22

Average Birth Order of 13,437 Survey Children for Waterlow Categories

	Normal	Stunting	Wasting	Wasting and Stunting
Average Birth Order	3.4	4.1	3.6	4.1

Statistically the average birth order in the stunting category differs from that of the normal category. There is no difference in average birth order between the estate and village sectors.

3. Participation in CARE-Sri Lanka Thriposha program. Of 13,331 survey children, 13.1% were participants in the CARE-Sri Lanka Thriposha program at the time of the survey. Table 23 shows the percent of the survey children in each of the four Waterlow categories for the participants.

Table 23

Percent of Survey Children Participating in Thriposha Program by Waterlow Categories

	Normal	Stunting	Wasting	Wasting and Stunting
Receiving Thriposha	11.9	13.1	15.3	15.8

The percent participation of survey children in each SHS ranges from a high of 27.1% to a low of 4.6% as seen in Table 24.

Table 24

Percent Participation in Thriposha Program and Percent Registration with Midwife in Health Facility by SHS Area

SHS Area	% Participation	Midwife or Health Facility % Registered
Colombo	27.1	86.0
Vavuniya	27.1	48.2
Jaffna	26.1	77.1
Kandy	18.7	67.1
Anuradhapura	17.6	38.1
Badulla	9.3	46.2
Kurunegale	9.2	68.4
Kalutara	9.1	80.8
Kegalle	8.3	71.6
Puttalam	7.3	57.5
Matale	6.9	63.9
Galle	6.7	77.3
Matara	5.2	68.9
Batticaloa	5.1	44.8
Ratnapura	4.6	69.6

4. Participants registered with midwife or health facility. Of 13,350 survey children, 67.3% were registered with a midwife or health facility. For purposes of this survey having received immunizations also implied being registered with a health facility. Table 23 lists by SHS area the percent of survey children who were registered. Table 25 shows the percent of survey children in each of the Waterlow nutrition categories who were registered.

Table 25

Percent of Survey Children Registered with Midwife or Health Facility by Waterlow Category

	Normal	Stunting	Wasting	Wasting and Stunting
Registered Children	66.5	59.7	68.2	62.1

VI. Discussion

The Sri Lanka Nutrition Status Survey was a cross-sectional study of the Sri Lanka rural population. The ideal requirements of the statistician and the realities of field logistics, time and available funding were carefully considered in determining the survey data content, sampling methods and procedures for assessing the quality of the data. Surveys utilizing this methodology have been done in the Sahel[30] and in Nepal[31].

Knowledge of the existing nutrition status of a population provides a base on which to build effective nutrition policy directed at improving the nutritional status of the population. A well designed study of the nutritional status of a statistical sample of the population would provide information on the nature of the nutritional problems, on localization of the problems and definition of "risk" groups and on the severity of the problem[32].

The degree of usefulness of a cross-sectional nutrition status survey in forming nutrition policy depends on knowledge of other nutrition indicators and the practicality of gathering other data. Initially, the results of a nutrition status survey may provide the bulk of useful baseline material. With the identification of other indicators and their incorporation into an ongoing surveillance system and with causal information obtained from well designed studies the value of a cross-sectional nutrition survey then would be to assess change resulting from instituted remedial programs.

Repeated status surveys would permit valid data comparisons at different points in time provided the survey methods remain the same.

The simple division of children into well nourished and malnourished on the basis of any single anthropometric parameter can be misleading. No single anthropometric parameter identifies the acuteness or chronicity of the malnutrition problem in a population. The deficient weight of a child in comparison to the ideal weight for his height provides an indication of acute malnutrition. Height deficits in children are nearly always an indication of the duration of malnutrition. The Waterlow classification outlines these components of protein-energy undernutrition[20].

The separation of undernutrition into acute and chronic components is important in that each has different implications for the design and evaluation of appropriate remedial programs. Acute undernutrition or wasting suggests current or recent deficiency in food intake reflecting either actual food unavailability or impaired absorption resulting from diarrhea or other acute disease. While it may be difficult to rapidly change the prevalence of the latter situation, the former may respond to a quickly-instituted short-term remedial program. This is particularly true in famine situations where emergency food distribution can remedy the situation until the acute environmental situations normalize.

Chronic undernutrition or stunting implies past and long-term nutritional inadequacies of food supplies, a more subtle nutritional deprivation that retards linear growth. An unknown part of the prevalence of stunting relates to the prevalence of chronic diseases which influence stature growth. Mortality and morbidity from chronic undernutrition is not likely to be as measurable or as impressive as that of acute undernutrition. Furthermore, the implications of a moderate deficit in height potential on a child's health are not known. To improve the chronic situation one would envisage the need for longer term and multidisciplined approaches to remedial intervention. The benefits of such programs may take several years to become apparent.

Protein-energy undernutrition in rural Sri Lanka is a general problem, the magnitude and composition of which differ in various SHS areas and sectors as summarized in Table 26. The usefulness of survey results is enhanced by data on the Special Group composed of Sri Lankan private pregrade school children age 48-71 months from Colombo which show growth potential to be markedly increased in a better socioeconomic situation.

Table 26

Sri Lanka Nutrition Status Survey Summary:

Percentage Distribution of Children 6-71 Months

of Age by Waterlow Categories

Population	Percentage				Sample Sizes
	Normal	Stunting	Wasting	Wasting and Stunting	
Total Rural Sri Lanka (weighted)	62.0	31.4	3.3	3.4	13450
Village	65.8	27.8	3.4	3.0	12301
Estate	35.0	56.3	2.6	6.1	1130
Special Group (48-71 Months)	95.2	2.2	2.6	-	438
NAS Reference Population	98.7	0.4	0.8	-	4947

Acute undernutrition or wasting as measured by the weight-for-height index varies in prevalence among the SHS areas of Sri Lanka. The weighted rural country average prevalence of 6.6% (obtained by combining percent wasting and percent concurrent wasting and stunting) represents the combined result of food unavailability and physiological nutrient misutilization resulting primarily from acute infectious disease. The individual contribution of these two factors is unknown overall and probably varies among SHS areas. Further specific studies are required to quantitate the contribution of infectious disease. In addition the contribution of each factor varies with the seasons of the year. By the weight-for-height index

the SHS areas of Ratnapura, Kandy, Batticaloa and Galle are the worse off while the SHS areas of Jaffna, Colombo and Puttalam seem to have little acute undernutrition. While the statistical differences between SHS areas are significant, a practical interpretation of the differences must consider that overall the rural country average is only 6.6%; that only an arbitrary decision on the level of acute undernutrition requiring intervention can be made; and that there is no reason to believe that an acute famine or disaster existed in Sri Lanka concurrently with or immediately before the survey data collection.

In rural Sri Lanka the distribution of acute undernutrition or wasting by age groups indicates that children age 12-23 months are most seriously affected. This could indicate inadequacy of weaning foods, the young child's inability to compete successfully in the family food chain, and the high risk of infectious diseases. Because other uncontrolled factors such as an acute famine would be common to all age groups the identification of an age group with increased severity, both statistically and practically, suggests children 12-23 months of age in rural Sri Lanka are the high risk group to be considered in designing a remedial program.

There is a wide range of prevalence means for chronic undernutrition or stunting among the SHS areas of Sri Lanka (20.7% to 49.6%). Puttalam, Colombo and Jaffna are among the superior SHS areas and

Badulla and Kandy are substantially inferior by this nutrition status index. Given that the effect of moderate stunting on the health or well being of a child is not known, the practical importance of these findings is hard to interpret. Regardless, the prevalence of stunting in the sample from some SHS areas is two and one-half times that of others showing marked relative differences of chronic undernutrition within rural Sri Lanka. This suggests disproportionate food intake over a long period of time among SHS areas perhaps because of differences in actual availability to the SHS populations. This may be related to agricultural production, food distribution, food subsidies and market prices. Other more subtle considerations may include drought cycles, importance of cash crops and socioeconomic divisions. Data on the contribution of each factor to the prevalences of stunting are not available from the nutrition status survey. Information on the importance of individual factors in the light of the prevalence data of this survey may be obtainable from the records of various ministries.

In rural Sri Lanka, as a whole, stunting begins at an early age. Whatever the causes of chronic undernutrition in Sri Lanka they appear to effect all age groups. Those initially stunted tend to fall further behind in linear growth. With each succeeding year, others who fail to obtain adequate nourishment to provide for both day-to-day nutrition and linear growth needs slip into the stunting category.

If, as Waterlow suggests, children suffering from concurrent wasting and stunting require a priority remedial response then 3.4% of Sri Lanka's approximately 2.1 million rural children 6-71 months of age have priority needs[20]. These children are suffering the effect of long-term protein-calorie undernutrition - a retardation in linear growth - and the effect of an acute deficit in nutrients - a weight loss creating a disproportionately low body weight-for-height situation. When this category of undernutrition is analyzed statistical differences are evident among SHS areas and among age groups.

A commitment to improving countrywide the status of affected children has the initial practical problem of identifying the maximum number of affected children. In all SHS areas and all age groups the high priority child is a relatively uncommon occurrence. A methodical countrywide screening program using weight-for-height and height-for-age measurements implies a major expense in terms of personnel and equipment. Practically, a goal for screening may include all preschool children attending any health unit. A corollary to this is that the participating health units must be capable of providing curative nutritional education and aid to the families with children found to be in the priority category.

Pedal edema of nutritional origin is diagnostic of kwashiorkor. In rural Sri Lanka the survey identified a prevalence of 0.2% in the 6-71 month age group. In the survey children with concurrent

wasting and stunting the prevalence of pedal edema is 1.9%. Pedal edema is not a general problem in preschool rural Sri Lankan children but, as it is a simple clinical sign to examine for, all children attending clinics should be examined for it and when found appropriate acute therapy provided.

Weight-for-age is the most commonly used index of undernutrition. This parameter does not identify the separate contributions of acute and chronic protein-calorie deprivations. In rural Sri Lanka 42.1% of the children 6-71 months of age are in the combined second and third degree Gomez classification. The SHS areas of Kandy, Badulla and Ratnapura have the highest prevalences and Colombo, Jaffna and Puttalam the lowest prevalences of undernutrition by this criteria. The prevalence of undernutrition by this criteria and by height-for-age criteria increases with age. In a country like Sri Lanka where there is a high prevalence of chronic undernutrition as defined by height-for-age criteria it is probable that a large component of undernutrition as defined by the Gomez system of weight-for-age measurements is related also to chronic food inadequacies. In Sri Lanka weight-for-age measurements have a correlation coefficient of .79 with height-for-age measurements. The correlation probably would increase with increasing duration of food insufficiency.

In Sri Lanka, where the major undernutrition problem is primarily a result of chronic food deprivation, the weight-for-age measurement

for identifying undernutrition and height-for-age measurement for chronic undernutrition both identify a large number of the same people.

In an attempt to summarize the SHS differences for protein-calorie undernutrition Table 27 presents a combined ranking of SHS areas as determined by totalling the SHS rankings for the three commonly used growth indices of weight-for-height, height-for-age and weight-for-age. These results indicate that rural Colombo, Jaffna and Puttalam have the least undernutrition and Kandy and Ratnapura have the most. These latter two SHS areas also have the largest estate populations.

Table 27

Summary SHS Ranking for Undernutrition:

A Combination of SHS Growth Rankings

for Weight-for-Height, Height-for-Age, and Weight-for-Age

SHS Area	Total Ranking Value
1 Colombo	4
2 Jaffna	7
3 Puttalam	8
4 Kalutara	15
5 Vavuniya	16
6 Kurunegale	19
7 Matara	19
8 Anuradhapura	24
9 Galle	31
10 Batticaloa	32
11 Badulla	33
12 Kegalle	34
13 Matale	35
14 Ratnapura	39
15 Kandy	44

Anemia levels as determined by hemoglobin measurements in a population of preschool children are predominantly a reflection of long-term nonavailability of an adequate dietary intake. In most countries iron deficiency is the most important cause of anemia in children. Assuming any technical error in hemoglobin determination to be age-independent the survey hemoglobin results suggest an inconsequential difference between age groups. Because of the questionable reliability of the survey hemoglobin data, a limited repeat hemoglobin survey is indicated. Initially, this should be done in the 4 SHS areas in which high prevalences were obtained and in 2 SHS areas in which low prevalences were obtained. If the repeat survey verifies the high prevalences, then it follows that further hemoglobin data should be collected in the remaining 11 SHS in which a low average anemia prevalence was obtained. If the high prevalences are not verified and the results for the 4 SHS areas are in the range of the remaining SHS areas, then if one assumes these latter SHS area prevalences to be correct they could be spared a repeat hemoglobin data collection.

The survey results indicate some real differences in nutrition status between the estate and village sectors of rural Sri Lanka. The preschool population of the estate sector is statistically and practically worse off by the anthropometric indices of height-for-age and weight-for-age. Although representing only 8.4% of the survey population, the results obtained for the estate sector produce a marked influence on the overall rural Sri Lanka weighted averages

because of the magnitude of the difference in prevalences between the estate and village sectors. Therefore, when considering weighted averages for these parameters in rural Sri Lanka, the impact of the 8.4% of the population composed of estate preschool children influences these parameter results for all rural preschool children by increasing the overall rural prevalences by 2-4%.

The differences between the two sectors for acute protein-calorie undernutrition defined as a weight-for-height deficit may be too small to be useful. The same statement can be made for sector comparisons of vitamin A deficiency signs and symptoms.

The questionable hemoglobin data available indicates no major difference in anemia prevalence between the estate and village sectors.

Anthropometric, clinical and anemia nutrition parameters of the advantaged Special Group children are in all instances superior to those of the rural survey preschool children and suggest a nutrition status obtainable in the next few generations by the entire preschool population of Sri Lanka. Figures 4 and 5 compare both the weight-for-height and height-for-age medians of the Sri Lanka survey population, the Sri Lanka Special Group and the NAS reference population.

Recently the World Health Organization published criteria for determining if vitamin A deficiency is a significant public health problem in a country[32]. The signs and symptoms to be clinically assessed are:

Primary signs:

Conjunctival xerosis

Bitot's spots with conjunctival xerosis

Corneal xerosis

Corneal ulceration with xerosis

Keratomalacia

Secondary signs:

Night blindness

Xeropthalmia fundus

Corneal scars

In a representative population of children up to 6 years of age, anyone of the following specific prevalences is acceptable as a criteria for establishing vitamin A deficiency as a problem of public health importance:

Bitot's spots with conjunctival xerosis in more than 2% of the population

A combined prevalence of corneal xerosis-corneal ulceration with xerosis and keratomalacia of greater than 0.01% of the population at risk

Corneal scars (attributable to vitamin A deficiency) in more than 0.1% of the population at risk

The clinical examination to establish vitamin A deficiency in the Sri Lanka survey children was simplified and includes only the following signs and symptoms:

Corneal scarring

Bitot's spots

Night blindness

Personnel collecting the data were public health inspectors who were considered qualified as a result of intensive presurvey training and testing during the survey.

Overall in rural Sri Lanka, vitamin A deficiency does not appear to be a significant public health problem by WHO guidelines.

The survey data identifies two SHS areas, Kegalle and Matara, which meet or exceed the WHO minimum criteria of 2% prevalence of Bitot's spots. Data was collected on night blindness as a symptom in survey participants older than 24 months. In Kegalle and Matara the prevalence of night blindness exceeded 2%.

The prevalence of night blindness supports the hypothesis that vitamin A deficiency is a public health problem in these two SHS areas.

The analysis of Bitot's spots prevalence by age group suggests increasing prevalence with age. Sinha suggests that Bitot's spots may remain as a residual of vitamin A deficiency even in instances of adequate vitamin A therapy[36].

The relationships of nutrition status to family size, position in live birth order, participation in the CARE-Sri Lanka Thriposha feeding

program and being registered with a midwife or health facility were examined individually. The average family size of a survey participant was 6.5. There were no practical relationships found between family size and nutrition in either the village or estate sectors. The average birth order of the survey participant was 3.7. Birth order of a participant also could not be shown to have a practical influence on his nutrition status. Furthermore, when these same factors were considered for estate and rural sectors, no practical differences could be demonstrated.

Taken as isolated factors participation of a survey member in the CARE/Sri Lanka feeding program or his being registered with a midwife or health facility were statistically related to his nutrition status with chi-square test values of 10.8 and 64.0, respectively. The practical value of these differences are questionable when each is looked at by the percent of total children in each Waterlow quadrant, i.e., normal, wasted, stunted, concurrent wasting and stunting who are in the first instance, Thriposha participants or, in the second instance, registered with a midwife or health facility. Thriposha participants compose 11.9% of the children in the Waterlow category of normal and 15.8% of those children in the concurrent wasting and stunting action priority category. Survey children registered with a midwife or health facility compose 66.5% of the survey children who are normal by growth standards, 59.7% who are stunted only by these standards, 68.2% who are wasted only by these

standards and 62.1% who are concurrently wasted and stunted. The actual number of Thriposha participants or registered children of the survey group in the Waterlow normal group is larger than the total numbers located in the three remaining Waterlow categories for each of the two factors. Therefore, the relationships shown for each Waterlow category have little practical value for identifying rural preschool children with low nutrition status.

The true value of Thriposha particpation or registration with a midwife or health unit cannot be assessed by this data. For example, survey results on Thriposha participation can mean either that the greatest percent of participation occurs in the priority group or that despite participation these children are in the priority group. The Thriposha participation in the normal group can mean either that many recipients do not need this supplement or that children are in this category only because of the extra nourishment received from Thriposha. Further details such as length of participation, availability of Thriposha and the quantity that a child receives are necessary to allow for objective evaluation of the Thriposha program. Likewise, the benefits made available through the midwife or health facility either in quantity or quality were not asked for. Such information requirements were not appropriate to this survey. The answers to these questions can more suitably be researched in well designed longitudinal surveys using a control population.

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Appendix A - References and Data Comparisons

1. Choosing a Reference Population

Data have to be organized before they can be interpreted. For practical purposes the distribution of characteristics is most important. Values to be useful must be categorized into normal or abnormal or similar classifications. In a survey using anthropometric measurements, distribution cutoffs for category inclusion can be arbitrarily based on the survey range or can be arbitrarily decided on by utilizing experience gained from similar surveys as a reference.

Reference populations used in anthropometry are frequently critized as not being applicable to developing areas of the world. Because of this, problems arise in methods of assessing the deficits in height and weight on a survey population in order to quantitate the size of the problem. In preschool growth studies, the influences of environment, such as nutrition and infectious disease, are of much greater importance than those of race or ethnicity. The differences in growth of preschool children associated with social class are many times those attributable to ethnic factors alone. The probable degrees of the genetic effect on height-for-age and weight-for age growth indices are approximately 3% and 6%, respectively, among children from different ethnic backgrounds but similar socio-economic class[19]. In pre-pubertal children, weight-for-height indices are relatively independent of age and race and chiefly reflect nutritional status.

Waterlow suggests that a reference be used as a basis for a value judgment - normal or deficient[5]. The reference values are correctly used as a basis for the interpretation of survey results and not as a set of restrictive diagnostic criteria. They are not to be used as a standard or target to be sought after by a country.

Two or more studied populations or repeated studies on one population can be compared if a reference for comparison is decided on and if the criteria for subject inclusion, age determination and measurement methodology are the same. Although several reference populations are available for anthropometry, the so-called Stuart-Meredith populations, based on data collected on a relatively small number of children in Iowa and Boston during the 1930's and early 1940's, are most commonly utilized as a reference.

Specific limitations of the Stuart-Meredith data base are the small numbers of children involved, the longitudinal rather than cross-sectional gathering of data, the limited socio-economic and ethnic representation, and the age of the data itself. The 10th and 90th percentile were based on such a small number of people as to severely limit statistical precision in these ranges. In developing areas, a great majority of individuals may fall below the 10th percentile, the very area where the Stuart-Meredith data base is statistically the weakest.

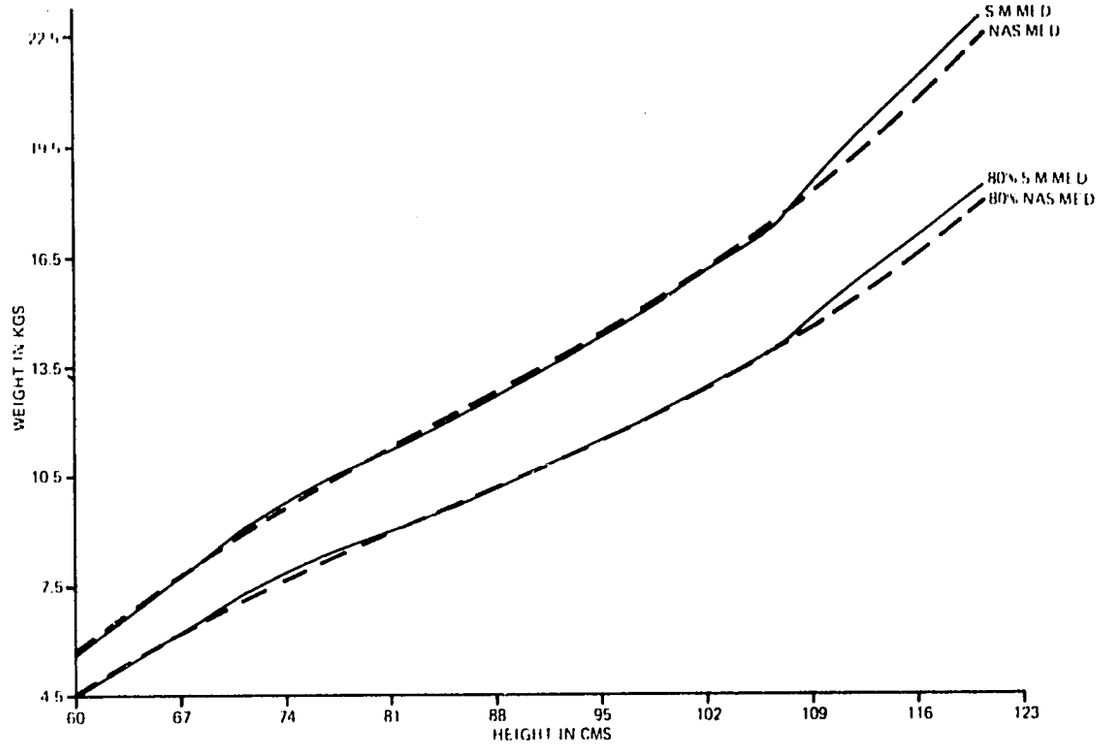
The recent availability of data from large-scale and more representative studies in the U.S. has resulted in more appropriate references for use in population comparisons, known as the National Academy of Sciences (NAS) reference populations for anthropometry. Specifically, the larger number of individuals characterizing the NAS reference population improves the statistical precision of outlying percentiles.

The general acceptance of a reference population for anthropometry is an international need. The choice of which reference to use for a single survey is probably unimportant. However, if multiple surveys are to be compared, it would seem reasonable that a single reference be agreed upon. Again, which reference is decided on for international use is unimportant. We have chosen to describe the Sri Lanka survey findings using the NAS reference population.

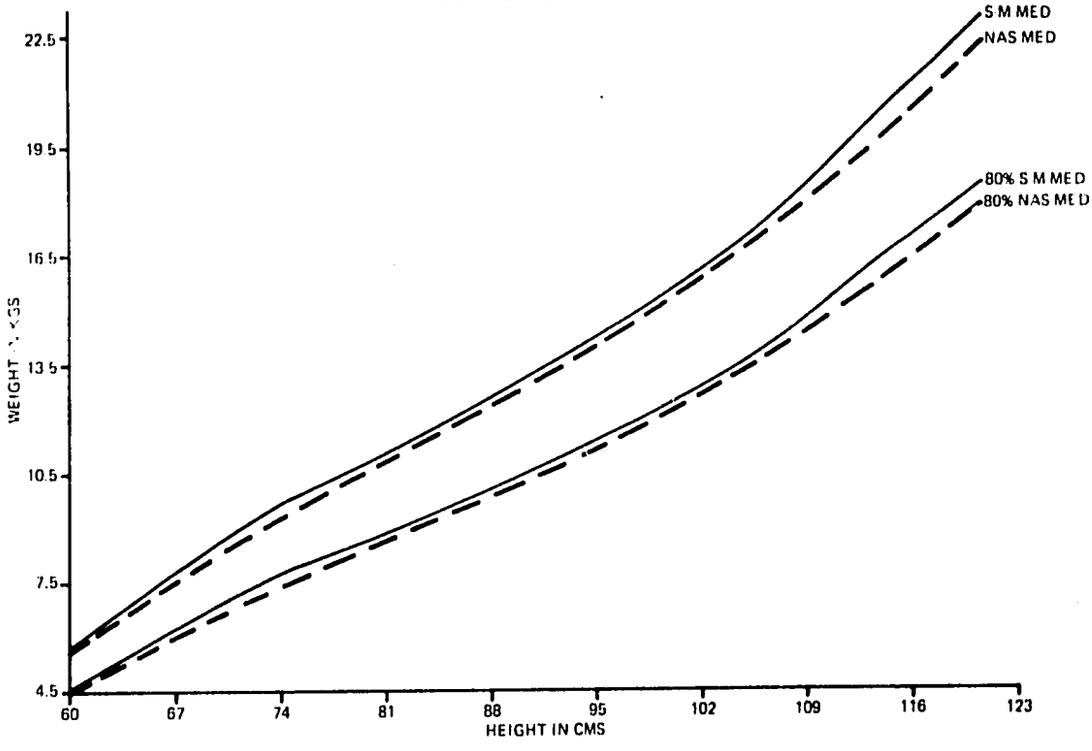
2. Graphic Comparison of NAS and Stuart-Meredith References for Percent of Median for Weight-for-Height and Height-for-Age Indices. (Appendix A - Figure 1 and Figure 2.)

Appendix A - Figure 1

COMPARISON OF NAS AND STUART MEREDITH REFERENCE POPULATION
WEIGHT FOR HEIGHT - BOYS

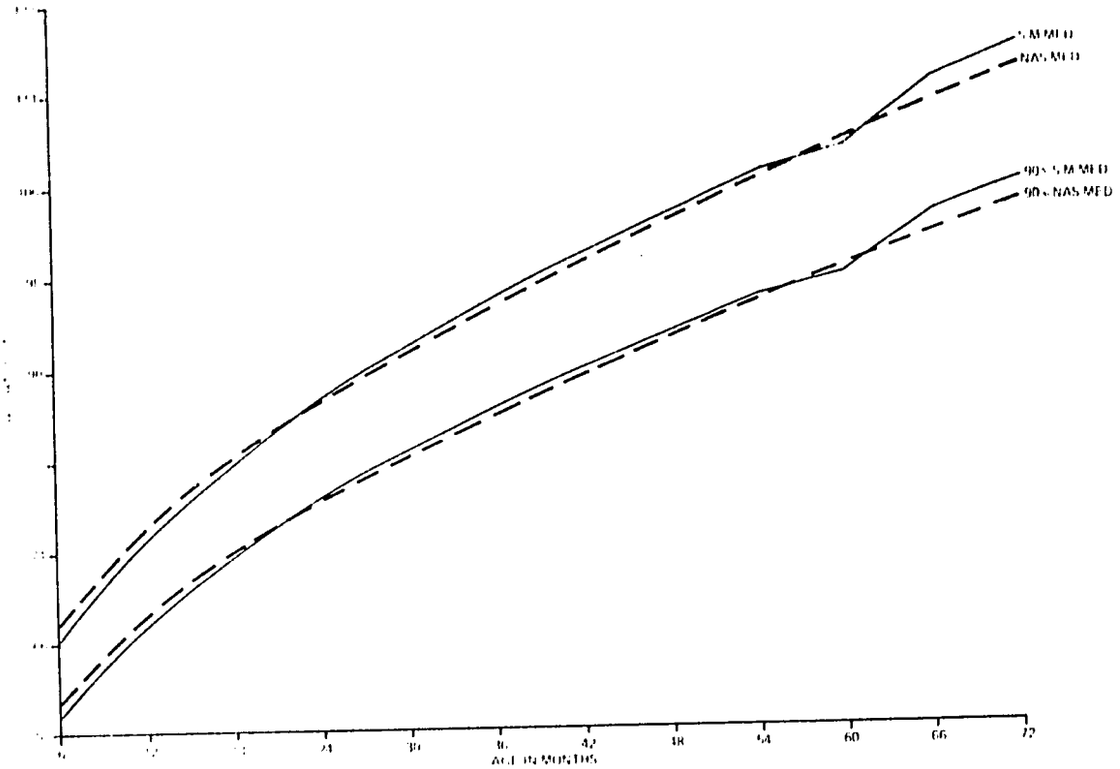


COMPARISON OF NAS AND STUART MEREDITH REFERENCE POPULATION
WEIGHT-FOR-HEIGHT - GIRLS

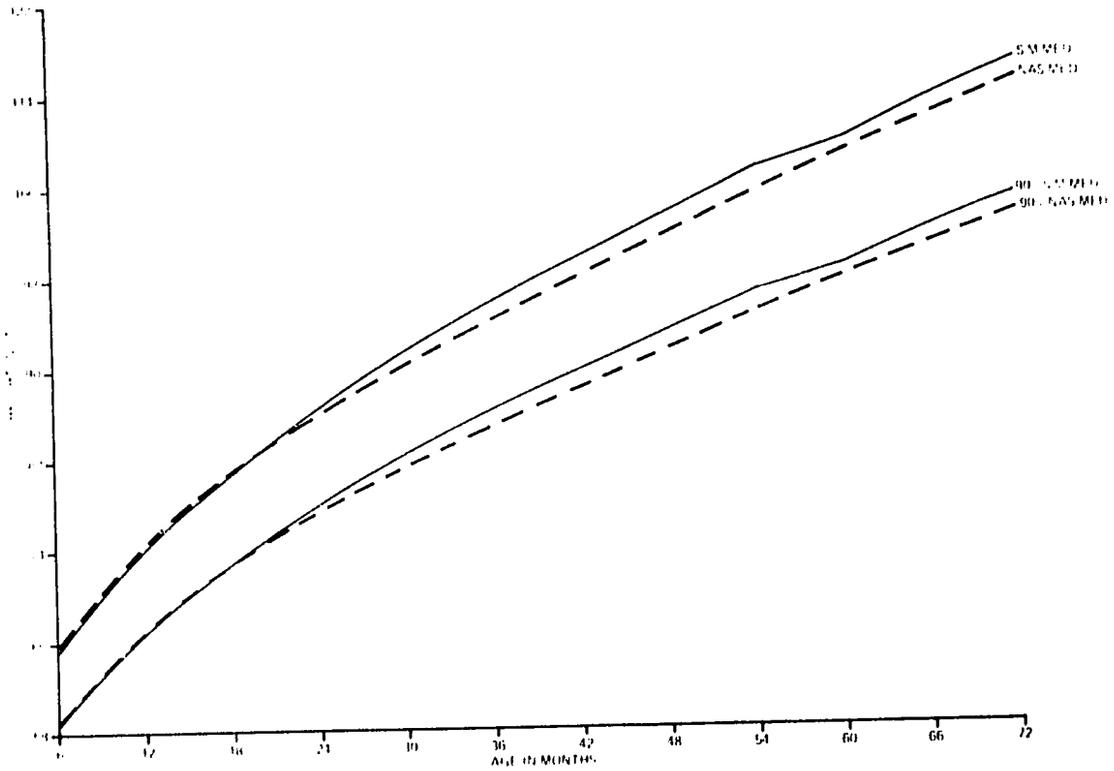


Appendix A - Figure 2

COMPARISON OF NAS AND STUART-MEREDITH REFERENCE POPULATION
HEIGHT-FOR-AGE -- BOYS 6-72 MONTHS



COMPARISON OF NAS AND STUART-MEREDITH REFERENCE POPULATION
HEIGHT-FOR-AGE -- GIRLS 6-72 MONTHS



Appendix B - Determination of Survey Sample Size

The universe to be sampled included the rural and estate sectors of Sri Lanka and excluded the urban sector (in accordance with the Department of Census and Statistics definitions of these sectors). Separate samples were drawn for each SHS area to allow comparison of these areas on various nutrition parameters.

A number of factors enter into the determination of sampling specifics for a statistical study, including:

a) Resources available, both financial and physical.
b) Constraints such as time and logistical problems affecting the survey in the field.
c) The nature of the sample distribution assumed applicable.
d) The precision desired and the confidence level to be associated with it.

Considering the effect of these factors on the survey, 30 sample sites or clusters in each sample area allowed the use of normal parametric statistical procedures in the estimation of population characteristics* of a sample area and in testing for a significant statistical difference among sampling areas[26]. For survey purposes Sri Lanka was divided into 15 health districts or SHS areas, each being considered as a separate sampling area. With 30 sample sites in each area, the total number of clusters became 450 for the entire country.

*Provided the characteristic is not rare (<5% prevalence).

A random start and a fixed interval method for population proportional sampling were applied to the rural and estate population of each SHS area using the 1971 Sri Lanka census data. Since the census data were tabulated by administrative district for each of 22 such districts, it was necessary in some instances to combine two administrative districts to obtain the census of a given SHS area; in other cases, this was not necessary since the administrative district and the SHS area were one and the same.

To determine the appropriate survey sample size for a geographic area the applicability of binomial theory was assumed. Using binomial theory modified for cluster sampling there were four variables affecting sample size, ('n')[35].

Z = normal deviate for confidence level desired (1.96 for 95% confidence and 1.64 for 90% confidence).

p = proportion of population having the attribute measured.

D = deviation from 'p' due to sampling with confidence level chosen; the confidence limits for p would be p ± D.

K = adjustment for "clustering effect."

The formula for 'n' is:

$$n = \frac{K\ Z^2}{D^2} \quad (p) \quad (1 - p)$$

Past experience with Stuart-Meredith percent of standard weight for height has shown that K = 2 should provide at

least the desired precision. The Z score is generally chosen for 95% confidence (Z = 1.96).

While the value of D can be predetermined, it depends on the value of 'p' and may or may not be acceptable; for example, 50% $\pm$ 5% might be considered acceptable but 10% $\pm$ 5% might not.

The value of 'p' yielding the largest 'n' is 0.5; therefore, if a number of different proportions are to be measured for the universe, it is safest to assume p = 0.5. After fixing K, Z, and p, n and D were the only values not determined.

By determining maximum deviation tolerable (D), 'n' for any sample area was solved for as follows:

K = 2 (cluster effect)

Z = 1.96 (95% confidence)

p = 0.5 (50%)

D = .046 (4.6%)

$$n = \frac{2\ (1.96\ )^2}{(\ .046)^2} \quad (.5)\ (.5)$$

n = 900

Thirty children were drawn using a random start technique within each selected sample unit. A total sample of 900 children (30 sample units x 30 children) was drawn for each of the 15 SHS areas, giving a total of 13,500 sample children for the entire country. An SHS sample of 900 children with

proportions having a characteristic varying as follows would have the following approximate precisions:

% Having Characteristics (p)	95% Confidence Limits (d)	Difference Required for Significance with 95% Confidence Level (p1 - p2)
50.0%	±4.6%	6.5%
20.0%	±3.8%	5.4%
10.0%	±2.8%	3.9%
5.0%	±2.0%	2.8%

If two SHS areas have a statistically significant difference with respect to a given characteristic, then they must differ on that characteristic at least to the extent shown in the last column (p1 - p2)[33].

Predetermination of the sample size did not predetermine the precision of survey estimates. Some parameters had greater precision than predicted and others had less. Computation of precision estimates for every tabulation provided in the report and appendices would have required substantial computer time and was not done.

Appendix C - Selection of Sample Sites and Survey Children

1. The Sri Lanka survey universe was defined as the rural and estate sectors of the population (as defined by the Department of Census and Statistics) for all 15 SHS areas.

2. Survey design required 450 sites or clusters to permit the required estimates and comparisons to be made.

3. Using the 1971 Sri Lanka village and estate line-listing by population and by SHS area, a fixed interval method of population proportionate sampling was applied to the rural and estate population of each SHS area.

   a. The populations of all villages and estates within the sample area were cumulated.

   b. The cumulated total rural and estate population was divided by 30 to obtain a sampling site interval.

   c. A starting number within the bounds of the sampling site interval was randomly selected.

   d. The village including this number in its cumulative population was identified as the first sample site.

   e. The sample site interval was added consecutively to the starting number 30 times.

   f. With each addition the village with the number in its cumulated population was identified as a sample site.

   g. This procedure was repeated in each of the 15 SHS areas, giving the required total of 450 sample sites.

4. In the village or estate chosen as a sample site the first household was selected by one of two methods:
   a. A household list (i.e., tax list or census tract) was obtained, and households were assigned sequential numbers. The first household was identified by selecting a random number on the list.
   b. Geographic groupings of households and the approximate number of households in each group were ascertained from the village or estate leaders. The households in each grouping were assigned sequential numbers, and the numbers cumulated. From among the total, a random number was selected, thus identifying the first household.

5. The first child and all subsequent children included in the survey had to be:
   a. A permanent resident of the household
   b. Between the ages of 6 and 71 months
   c. Made available to the survey team for completion of survey measurements
   d. Allowed to participate in the survey through the consent of a parent or household head.

6. When more than one child in the 6-71 month age group lived in a household, a survey form was completed on each of these children.

7. The second and subsequent households included in the survey were the next geographically closest houses. This procedure was followed until 30 children had been surveyed in each sample site.

8. If, in a selected household group of a village or estate, 30 children were not obtained, the geographically closest village or estate was entered at its geographically closest point and the survey unit completed.
9. If a preselected village or estate were found abandoned, then the geographically closest village or estate was used as a sample site.
10. No household number was assigned to an abandoned or temporarily vacant household, or to a household without children in the 6-71 month age group.

Appendix D. Procedures for Anthropometric Measurements

Principles

Since physical growth is one of the best indicators of the nutritional status of children, its careful measurement is essential for adequate assessment of their nutritional status. Of the many measures of growth, total body length or height, weight and arm circumference are the measurements most frequently carried out to provide useful information. In practice, however, the accuracy and precision of these measurements is often unsatisfactory, so that anthropometric data commonly fail to attain their potential usefulness. Small between-group differences are immensely important but this significance may be obscured if the measurements have not been made with sufficient accuracy or precision.

There is a deceptive simplicity about making height, weight and arm circumference measurements. It seems to some that the recording of height and weight is so straightforward that it can readily be done with little attention or care. Adherence to the procedures which follow will appreciably minimize the most common sources of error.

A. Equipment

1. Measuring Board

   - A combination height/length board with metric scale to 0.1 cm that has been custom made

2. Scale

   - Salter hanging scale 25 or 50 kgm scale with 0.1 and 0.2 kgm divisions, respectively

- Salter pants or seat
- Tripod - quadripod or other system to hang scale from

3. Arm circumference tape - Zerfas tape

B. Procedures

The measurements will be done in the following order:

1. Length/height
2. Weight
3. Arm circumference

1. Length or height

The measurer estimates if the child is less or greater than 80 cms in height. Those actually 80 cms or less will then be accurately measured for length lying down; those actually greater than 80 cms are measured for height standing.

(a) Length measurements

1) The measuring board is laid horizontally on the ground or on a table.

2) With the help of a minimum of two assistants, the baby, barefoot, is placed on the board with the head against the fixed end of the board.

3) An assistant holds the baby's head in the Frankfort plane and applies gentle traction to bring the top of the head into contact with the fixed end.

4) The measurer, with the help of another assistant, holds the child's knees together and the legs extended fully. The measurer uses one hand to insure that the child's feet are perpendicular to the board and brings the moveable

footboard to rest firmly against the child's heels.

5) The measurer reads the value of the length to the nearest 0.1 cm reading to the next higher 0.1 cm when the length falls at or above the midway point of a 0.1 cm graduation.

6) The measurer then records the length clearly in the appropriate blocks on the questionnaire (blocks 43-46).

(b) Height measurement

1) The measuring board is in a vertical position.

2) With the help of a minimum of two assistants the child is positioned barefoot on the horizontal platform with his feet together.

3) One assistant insures that the child stands flat foot with the knees fully extended. The shoulders and buttocks should be in line with the heels and these should all touch the vertical surface of the measuring board.

4) The moveable headboard is then brought to rest firmly on the crown of the child's head. The head is held in the Frankfort plane.

5) As in (a) (5) except substitute "height" for "length."

6) As in (a) (6) except substitute "height" for "length."

2. Weight

(1) The Salter scale is suspended from a tripod, quadripod, or a pole held by two assistants.

(2) The child is undressed by the parent or guardian.

(3) The parent holds the child; the measurer reaches his arms through the leg holes of the Salter pants and draws the legs of the child through the leg holes. He then attaches the Salter pants to the scale.

(4) The child in Salter pants hangs freely from the scale. The scale face is read to the nearest 0.1 kgms, reading up to the next higher 0.1 kgm when the pointer tip is at or beyond the midway point of a 0.1 kgm graduation. The reading is made after the child is reasonably still, and the needle is stationary.

(5) The measurer then records clearly the weight in the appropriate blocks on the questionnaire (blocks 40-42).

(6) The child is then removed from the Salter pants and partially reclothed.

3. Arm Circumference

(1) The child is held by the parent or guardian; the left arm and shoulder is bared.

(2) With the arm flex at the elbow the midpoint between the posterior tip of the acromion process of the scapula and the oleocranon process of the ulna is determined using the reverse side of the Zerfas tape. This point is marked on the skin with a pen.

(3) The Zerfas tape is looped around the upper arm and the distal free end of the tape inserted through the window and slot from behind.

(4) The distal end of the tape is pulled until firm but gentle and uniform contact is made with the arm circumference at the marked midpoint. The soft tissues of the arm are <u>not</u> to be compressed.

(5) The measurer reads the value indicated between the opposing arrows to the nearest 0.1 cm, reading to the next higher 0.1 cm when the arm circumference falls at or beyond the midpoint of a 0.1 cm graduation on the tape.

(6) The measurer then records the arm circumference value clearly in the appropriate blocks on the questionnaire (blocks 49-51).

C. Precautions

1. Assistants are necessary - in measuring children their strength and mobility cannot be overstated.

2. When measuring the arm circumference pulling the tape end tight enough to indent the skin contour produces INACCURATE READINGS.

3. The Frankfort plane is a plane perpendicular to the body constructed in profile by a line between the lowest point on the margin of the orbit of the eye and the highest point on the opening of the ear. As much as 2 cm variation in height or length can be produced by flexing or extending the head out of the Frankfort plane!

4. Children, especially infants, have a tendency to extend their feet while lying or standing. Accurate height or length depends on a measurement from the heel.

Appendix E. Procedures for Collecting Blood Samples

A. Fingerstick Method

1. Take one unopette container from the sealed plastic bag which has been premarked with the village ID code.
2. Clean index finger or middle finger of child's hand by rubbing with alcohol swab. Allow area to dry. Turn hand palm upward.
3. If you are right-handed, use the thumb and forefinger of your left hand to grip the patient's finger. Make a quick, but firm jab to the fleshy part of the fingertip. (Be prepared for a sudden, instinctive withdrawal movement by the child.)
4. If necessary, use a gentle "milking" motion of your fingers to stimulate flow of blood. Be careful to avoid too much pressure; this will cause tissue juices to be mixed with the blood and introduce error.
5. Using a dry gauze swab, wipe away the first two drops of blood.
6. Remove the unopette pipet from its shield. Use the shield to pierce the plastic cover of the bottle containing the diluting solution.
7. Allow a drop of blood to form on the fingertip. Holding the pipet horizontally, touch the pipet to, but not into, this drop, and allow the pipet to fill by capillary action.
8. Contents of the pipet must be mixed thoroughly and quickly with the diluting solution to avoid clotting of the blood (and therefore loss of the sample). After the pipet is filled, wipe off any

excess blood on the outside of the pipet, being careful not to touch the tip which would draw blood out.

9. Loosely insert pipet into the opening of the unopette bottle. Gently squeeze and hold the sides of the container, using your finger to cover the opening of the pipet and then push the pipet down into the neck until it clicks. Release the pressure and remove your finger from the opening. The blood will then be drawn into the container. Squeeze the container several times in order to rinse out the pipet thoroughly, being careful not to let the liquid overflow the neck.

10. Placing your finger over the opening in the top of the bottle (leaving pipet in container), invert the bottle several times to mix the blood with the diluting solution. After mixing, place Critoseal in the opening to avoid leakage.

11. Make sure patient's hand is wiped off, and if desired, apply bandaid.

12. Write ID# of patient on bottom of unopette container with marking pen. Return unopette to premarked plastic bag and place bag in pack.

13. Check "yes" on questionnaire in block, next to "blood specimen collected."

B. Heel Stick Procedure (exterior lower lateral side of the sole)

Heel sticks are essentially the same as fingersticks; a rubbing motion from the toes to the heel on the bottom of the foot will help stimulate the blood flow especially if the baby's foot is cold. Babies may also be stuck in the big toe. Get a firm grasp on the

infant's foot with your hand; babies can display great amounts of resistance. Follow the same procedure for cleaning area and collecting sample. Apply a bandaid when finished.

C. Handling of Unopettes

The premarked plastic bag containing the used and identified unopettes is kept in a pack unexposed to light and delivered to the operations officer or project director.

Appendix F. Sri Lanka Nutrition Status Survey Questionnaire

	SHS Area	DRO Div.	GS Div.	Household	ID No.	Team	Interview Date Day	Mo	Yr
ID CODE	(1-2)	(3-4)	(5-7)	(8-9)	(10-11)	(12-13)	(14-15)		

NAME _____

HH HEAD _____

Sex (20)
1 ☐ M
2 ☐ F

HOUSEHOLD INFORMATION

Size ☐☐ (21-22)

Location (23) 1 ☐ Village 2 ☐ Estate

AGE DATA

Date of Birth Day ☐☐ Mo ☐☐ Yr ☐☐ (24-29)

SOURCE FOR AGE DATA (33)
1 ☐ Verifiable Record
2 ☐ Estimate
3 ☐ Other

BIRTH ORDER (enter number) (Unknown - 99) ☐☐ (34-35)

Age – Years ☐ (30) Months ☐☐ (31-32)

SOCIAL DATA

REGISTERED WITH MIDWIFE (36)
1 ☐ Yes
2 ☐ No
9 ☐ Unk

CARE THRIPOSHA PROGRAM (37)
1 ☐ Available
2 ☐ Not Available

Participant (38)
1 ☐ Yes
2 ☐ No
9 ☐ Unk

INCOME (Rs/mo) (39)
1 ☐ 0-199
2 ☐ 200-399
3 ☐ 400-599
4 ☐ 600
9 ☐ Unk

MEASUREMENTS

Weight ☐☐.☐ kg (40-42) Height ☐☐☐.☐ cm (43-46) Measurer ☐☐ (47-48)

Arm Circumference ☐☐ ☐ cm (49-51) Measurer ☐☐ (52-53)

Bilateral Pedal Edema (54) 1 ☐ Yes 2 ☐ No 9 ☐ Unknown

EYE EXAMINATION

Bitot's Spots	(55) Left	1 ☐ Yes	2 ☐ No	9 ☐ Unknown
	(56) Right	1 ☐ Yes	2 ☐ No	9 ☐ Unknown
Corneal Scar	(57) Left	1 ☐ Yes	2 ☐ No	9 ☐ Unknown
	(58) Right	1 ☐ Yes	2 ☐ No	9 ☐ Unknown
Blindness	(59) Left	1 ☐ Yes	2 ☐ No	9 ☐ Unknown
	(60) Right	1 ☐ Yes	2 ☐ No	9 ☐ Unknown

EYE HISTORY

History of Blindness (one or both eyes) (61)
Yes If "yes", cause:
1 ☐ No
6 ☐ Unk
2 ☐ congenital
3 ☐ trauma
4 ☐ other
9 ☐ unknown

Night Blindness (if child has sight in one or both eyes) (62)
1 ☐ Yes
2 ☐ No
9 ☐ Unknown

LAB

Blood Specimen Collected (63)
1 ☐ Yes
2 ☐ No

Hemoglobin Value ☐☐.☐ gm/100 ml (64-66)

Appendix G - Distribution Details of Anthropometric Indices

I. Distribuiton of Sri Lanka Survey Population(s) by the Weight-for Height Index

Table 1 - Appendix G

Weight-for-Height

Percentage Distribution of Survey Population

by NAS Reference Weight-for-Height Median

by Individual SHS Areas

	Percent of NAS Reference Median			
Populations	<80.0	80.0-89.9	90.0-99.9	100.0+
Total Rural Sri Lanka	6.6	46.0	39.8	7.5
SHS				
Ratnapura	8.8	48.1	37.5	5.6
Kandy	8.5	46.6	38.6	6.3
Battiacaloa	8.4	42.9	39.8	8.8
Galle	8.2	49.2	36.5	6.1
Matale	7.2	47.8	37.7	7.2
Kegalle	7.1	46.5	38.9	7.4
Anuradhapura	6.9	45.1	39.4	8.6
Kalatura	6.2	46.4	39.5	7.9
Matara	6.0	45.0	40.8	8.1
Vavuniya	5.8	42.1	42.6	9.5
Badulla	5.8	45.9	40.1	8.2
Kurunegale	5.7	47.8	39.8	6.7
Puttalam	5.1	46.0	41.0	7.9
Colombo	4.9	44.7	43.5	6.9
Jaffna	3.7	41.3	41.5	13.4

II. Distribution of Sri Lanka Survey Population(s) by the Height-for-Age Index

Table 2 - Appendix G

Height-for-Age

Percent of Sri Lanka Survey Population

by NAS Reference Height-for-Age Median

by Individual SHS Areas

Populations	Percent of NAS Reference Median			
	<85	85.0-89.9	90.0-94.9	95.0+
Total Rural Sri Lanka	9.0	25.7	41.7	23.5
SHS				
Badulla	14.9	34.5	35.8	14.9
Kandy	17.2	32.4	35.7	14.7
Kegalle	11.4	28.2	39.3	21.1
Matale	8.1	30.8	40.5	20.6
Ratnapura	9.7	27.6	43.9	18.9
Battiacaloa	8.6	27.9	40.0	23.5
Galle	9.6	23.7	44.1	22.5
Kurunegale	4.8	25.6	45.4	24.2
Anuradhapura	4.9	25.8	45.9	23.4
Matara	8.5	21.2	43.6	26.8
Vavuniya	6.4	23.2	43.9	26.6
Jaffna	4.5	24.0	45.5	26.1
Kalatura	7.3	19.5	42.9	30.3
Puttalam	3.8	20.7	44.4	31.1
Colombo	3.7	17.0	43.9	35.4

Appendix G

III a. Distribution of Sri Lanka Survey Population(s) by Weight-for Age (Gomez Classification)

Table 3 - Appendix G

Gomez Classification of Malnutrition - Sri Lanka - by SHS Area

(Percent of NAS Reference Median Weight-for-Age)

Populations	Normal 90.0+	1° 75.0-89.9	2° 60.0-74.9	3° <60.0
Total Rural Sri Lanka	9.2	48.8	38.2	3.9
Kandy	5.6	39.8	47.6	7.1
Badulla	5.9	43.5	44.8	5.8
Ratnapura	7.0	43.3	46.0	3.7
Matale	8.0	46.1	42.3	3.7
Kegalle	7.3	47.3	40.5	4.9
Galle	7.9	47.5	39.8	4.8
Battiacola	11.4	46.3	38.5	3.8
Kurunegale	8.7	51.7	37.3	2.3
Anuradhapura	7.8	53.8	36.4	2.0
Matara	9.0	53.7	34.0	3.2
Vavuniya	10.8	52.8	34.2	2.2
Kalatura	11.5	52.8	31.1	4.6
Puttalam	12.1	53.3	33.0	1.6
Jaffna	15.0	52.5	31.0	1.5
Colombo	14.5	56.4	27.4	1.8

Appendix G

III b. Distribution of Sri Lanka Total Survey Population by the Weight-for-Age Index for Age Groups

Table 4 - Appendix G

Gomez Classification of Malnutrition

by Age Groups

(Percent[a] of NAS Reference Median Weight-for-Age)

Age Groups	Normal 90+	1° 75.0-89.9	2° 60.0-74.9	3° <60.0
6-11	22.0	51.8	22.8	3.4
12-23	10.8	50.0	35.0	4.2
24-35	9.9	53.8	33.8	2.5
36-47	9.0	50.9	36.9	3.3
48-59	5.8	47.5	43.2	3.5
60-71	3.4	39.3	51.0	6.3
6-71	9.2	48.8	38.2	3.9

[a] Weighted percent

Appendix G

III c. Weight-for-Age Classification of the Indian Academy of Pediatrics (IAP) 1972[36] and Sri Lanka Weight-for-Age Data Using the IAP Classification

Indian Academy of Pediatrics (IAP) 1972 classifications of malnutrition by weight-for-age percent of reference median:

Normal Road to Health 80+% of reference median weight-for-age

First Degree = 70-79.9% of reference median weight-for-age

Second Degree = 60-69.9% of reference median weight-for-age

Third Degree = <60% of reference median weight-for-age

Table 5 - Appendix G

Indian Academy of Pediatrics (IAP) Weight-for-Age Classification by Age Group

(Percent[a] of NAS Reference Median Weight-for-Age)

Age Groups	Normal 80+%	1° 70-79.9%	2° 60-69.9%	3° <60%
6-11	56.5	29.7	10.4	3.4
12-23	40.1	37.8	17.9	4.2
24-35	40.9	41.1	15.5	2.5
36-47	38.8	40.7	17.1	3.3
48-59	31.6	43.0	22.0	3.5
60-71	22.6	42.2	29.0	6.3
6-71	37.0	39.9	19.2	3.9

[a] Weighted percent

Appendix G

Table 6 - Appendix G

Indian Academy of Pediatrics (IAP) Weight-for-Age

Classification by SHS Area

(Percent of NAS Reference Median Weight-for-Age)

Populations	Normal 80+%	1° 70-79.9%	2° 60-69.9%	3° <60%
Total Rural Sri Lanka (Weighted)	37.0	39.9	19.2	3.9
Kandy	25.4	40.4	27.1	7.1
Badulla	28.5	41.1	24.6	5.8
Ratnapura	28.1	44.9	23.3	3.7
Kegalle	34.4	39.4	21.3	4.9
Matale	34.8	39.7	21.8	3.7
Galle	34.3	40.2	20.6	4.8
Batticaloa	37.7	37.7	20.8	3.8
Kurenegale	38.4	41.0	18.3	2.3
Matara	40.5	39.5	16.7	3.2
Kalutara	43.5	37.6	14.3	4.6
Vavuniya	43.1	39.4	15.3	2.2
Anuradhapura	39.1	43.4	15.4	2.0
Puttalam	44.4	38.7	15.3	1.6
Jaffna	47.1	39.0	12.4	1.5
Colombo	50.1	36.7	11.5	1.8

Appendix G

IV a. Distribution of Sri Lanka Survey Population(s) by Arm Circumference-for-Height Index

Table 7 - Appendix G

Arm Circumference-for-Height of Survey Population for Individual SHS Areas

Percent Above & Below 82.5 Percent of Median of 10-State Nutrition Survey as a Reference

Populations	Percent of 10-State Nutrition Survey Reference Median	
	<82.5	82.5+
Total Rural Sri Lanka (weighted)	3.1	96.9
SHS		
Battiacola	5.3	94.7
Kandy	4.9	95.1
Matale	4.4	95.6
Ratnapura	3.8	96.2
Badulla	3.6	96.4
Kegalle	3.1	96.9
Galle	3.0	97.0
Vavuniya	3.0	97.0
Kalatura	2.9	97.1
Anuradhapura	2.5	97.5
Puttalam	2.2	97.8
Matara	2.2	97.8
Colombo	1.9	98.1
Kurunegale	1.6	98.4
Jaffna	1.4	98.6

Appendix G

IV b. Distribution of Sri Lanka Survey Population by Arm Circumference-for Height Index for Age Groups

Table 8 - Appendix G

Arm Circumference-for-Height by Age Group

Percent[a] Above and Below 82.5 Percent of Median of 10-State Nutrition Survey as a Reference

Age Group	<82.5	82.5-94.9	95.0+
6-11	1.2	28.9	69.9
12-23	3.8	52.1	44.2
24-35	2.5	54.0	43.5
36-47	3.1	51.1	45.8
48-59	2.9	54.7	42.4
60-71	4.0	60.7	35.3
6-71	3.1	52.3	44.7

[a] Weighted percent

Appendix H. Correlations Between Anthropometric Measurements in the Sri Lanka Nutritional Status Survey

Data from the Sri Lanka Nutritional Status Survey were used to identify relationships between anthropometric variables and the degree to which anthropometric variables were related in order to (1) assess the accuracy and precision of measurements made, and (2) explore the utility of arm circumference-for-height index in assessing nutritional status and as a surrogate for the weight-for-height index in assessing acute undernutrition. Table 1 presents the matrix of correlation coefficients (r) between age and anthropometric measurement made in the Sri Lanka survey. All correlations are straight lines. No appreciable improvement in r was seen for other variables by using a higher than 1st degree function. Table 1 demonstrates strong relationships between age and height, between age and weight, and between height and weight.

Of these highly significant correlations, that between weight and height is the strongest and demonstrates both a close relationship between these two variables in Sri Lankese children 6-71 months of age and a high degree of accuracy and/or reproducibility in the individual measurements. The coefficient of determination (88.6) shows that almost 90% of the variation in weight is accounted for by its regression on height. The same can be said for the relationships between height and age and weight and age with coefficients of determination of 84.1 and 70.7, respectively. Age, height and weight are all highly interrelated in the Sri Lankese children and the accuracy and/or consistency of measurement of these

variables is apparently of a high degree. Most of the variation in height and weight can be explained by their correlation with each other and with age.

Arm circumference measurements were included in the Sri Lanka survey to assess the value of an arm circumference-for-height index and arm circumference-for-age index in identifying undernutrition.

The correlation coefficient between weight and arm circumference is 0.65 with a coefficient of determination of 42.5 percent. The correlation between arm circumference and height is 0.48 with a coefficient of determination of 22.8 percent. The correlation between arm circumference and age is 0.35 with a coefficient of determination of 12.1 percent. All are relatively low indicating a weak relationship between arm circumference and height, weight and age variables in Sri Lankese children. Because a common reference population for percents of median weight-for-height and arm circumference-for-height does not exist, correlations between these two indices cannot be calculated. However, the individual correlations between actual measurements of arm circumference and weight, height and age suggest that arm circumference is not a good surrogate for weight. The following are possible explanations for this weak relationship.

1. The true relationship between arm circumference and the other variables in Sri Lankese children is weak and arm circumference does not, in fact, reflect nutritional status with the same precision as does weight.

2. Measuring arm circumference requires identifying and measuring the distance between the posterior acromial process and the olecranon process; locating the midpoint between the two processes; positioning the tape perpendicular to the axis of the arm; and estimating the proper degree of tension to apply to the tape. The potential for errors of technique to occur at each measurement step enhances the likelihood of an inaccurate final measurement value. Since the range of normal arm circumferences in children 6-71 months of age is small, slight errors may, in fact, be large percentages of the true value. Weight measurement, in comparison, is a single step mechanical procedure with less chance for the introduction of human error.

In summary the accuracy and/or reproducibility of height and weight measurements in the Sri Lanka survey appear to be extremely good with a high degree of interrelationship between the two as well as with age as shown by the correlation coefficients in Table 1. Arm circumference does not demonstrate a high degree of correlation with age, height and weight.

Appendix H

Table 1 - Appendix H

Correlation Coefficients (r) Between Age and Anthropometric Measurements for Children 6-71 Months of Age
Sri Lanka Nutritional Status Survey

Dependent Variable (Y)	Age	Height	Weight	Arm Circumference
Height	0.9168 (84.1)			
Weight	0.8409 (70.7)	0.9414 (88.6)		
Arm Circumference	0.3472 (12.1)	0.4781 (22.9)	0.6516 (42.5)	

INDEPENDENT VARIABLE (X)

NOTE: Numbers in parentheses show percent of variation in Y explained by the regression of Y on X.