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SUBJECT CLASSIFICATION

A. PRIMARY
Serials

Y-AS00-0000-G518

B. SECONDARY
Food production and nutrition--Human nutrition--Colombia

2. TITLE AND SUBTITLE
Community experiments in the reduction of malnourishment in Colombia; progress report, 1975/1976

3. AUTHOR(S)
(101) Community Sytems Foundation,Ann Arbor,Mich.; Fundacion para la Educacion Superior,Cali,Colombia

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1976	169p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
CSF

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAD-447

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Community development
Nutrition
Colombia

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-C-1121 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

COMMUNITY EXPERIMENTS
IN THE REDUCTION OF MALNOURISHMENT
IN COLOMBIA

SECOND YEAR PROGRESS REPORT

June 30, 1975 - June 30, 1976

This project is being undertaken by:

FUNDACION PARA LA EDUCACION SUPERIOR
Cali, Colombia

and

COMMUNITY SYSTEMS FOUNDATION
Ann Arbor, Michigan, U.S.A.

Under a three-year contract from:

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

OFFICE OF NUTRITION

U.S.A.I.D. Project No. 931-17-560-558

U.S.A.I.D. Contract No. AID/ta-C-1121

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	DATA PROCESSING	
	A. The Computer System	10
	B. The Software	10
	Appendix A	12
III.	DATA GATHERED	25
	A. Location	26
	B. The Data	
	1. Villa Rica	
	a. Anthropometric Survey	28
	b. Relative Gap Distribution	29
	c. Habits	30
	2. Piendamo	
	a. Anthropometric Survey	31
	b. Relative Gap Distribution	32
	c. Habits	33
	3. Balboa	
	a. Anthropometric Survey	34
	b. Relative Gap Distribution	35
	c. Habits	36
	4. Rosas	
	a. Anthropometric Survey	37
	b. Relative Gap Distribution	38
	c. Habits	39
	5. Morales	
	a. Anthropometric Survey	40
	b. Relative Gap Distribution	41
	c. Habits	42
	6. Coconuco	
	a. Anthropometric Survey	43
	b. Relative Gap Distribution	44
	c. Habits	45

TABLE OF CONTENTS (continued)

		Page
	7. Ortigal	
	a. Anthropometric Survey	46
	b. Relative Gap Distribution	47
	c. Habits	48
IV.	INSTRUMENTS FOR THE APPLICATION OF THE MODEL	
	THE DIAGNOSIS OF MALNUTRITION-ANTHROPOMETRIC MEASUREMENTS	49
	A. Materials and Methodology	51
	B. Performance Characteristics	51
	C. Correlation Analysis	55
	THE COMMUNITY GAP	
	A. Definition of Community and Its Limits	59
	B. The Community Gap Definition	60
	C. Interfamily Food Distribution	62
	D. The Community Gap Analysis	65
	THE FAMILY GAP AND ENVIRONMENTAL SANITATION	77
V.	THE VILLA RICA RESULTS	88
VI.	INSTRUMENTS FOR INTERVENTIONS	90
	A. Screening for Malnutrition	90
	B. Food Habits	101
	C. Food Production	109
	D. Health - The Effect of the Promotora Program in Candelaria	103
	E. Sanitation - Ortigal and El Turco	160
VII.	PLANS FOR THE FUTURE	165

I. INTRODUCTION

This is a report of progress during the second year of the contract. The purpose of the contract is to develop and test a nutrition planning methodology. Briefly, this methodology includes the following:

A Theory. This theory--the Nutrient Flow Theory--is a statement concerning the relationships among a set of factors thought to effect the prevalence of malnutrition in a community. Among the factors considered are agricultural production (land area, choice of crops, technology of production, etc.), the market (imports and exports of food), food losses before and after harvesting (rats, mice, birds, spoilage, etc.), distribution among families (local markets, income distribution, etc.), distribution within a family (eating habits), environmental sanitation and health services.

A Diagnostic Procedure. With the Nutrient Flow Theory as a point of reference, a sequential procedure has been developed for diagnosing the cause(s) of malnutrition within a community. This procedure prescribes not only what and how information is to be collected, but also when it is to be collected, how it is to be analyzed and what conclusions may be drawn relative to the Nutrient Flow Theory and possible interventions. The output of this procedure is a series of performance specifications for the implementation of interventions.

Design of Interventions. Based upon the performance specifications, this stage analyzes specific intervention alternatives for:

- their potential for meeting the performance specifications;
- their cost in meeting the performance specification; and,
- their time required to meet the performance specifications.

In this manner, an implementation procedure is designed for the proposed intervention(s).

Implementation of Interventions. A constant monitoring procedure is developed and conducted at the time of implementation to insure that the intervention specifications are being fulfilled.

Evaluation of Intervention(s). Once implemented, a procedure is developed for comparing the nutrition effects predicted in the design phase with the observed outcome of the intervention. The evaluation includes effectiveness, cost of the intervention, and/or cost of a set of interventions.

The current contract does not include funds for implementing major interventions. Thus, only the diagnostic procedure can be tested

for feasibility of field implementation. Some evidence as to the validity of the planning methodology may be obtained by using the theory and diagnostic procedure to predict the nutritional effects of the proposed interventions in the state of Cauca, Colombia*.

The first progress report (1974-1975) described many of the details of the field work: the method of field measurements, parts of the analysis, descriptions of the communities in which the diagnostic methodology was used, and examples of participation from residents of the communities. Little was said about the underlying theory as this had appeared in reports written prior to this contract. This theory--the Nutrient Flow Theory--and its potential uses are briefly described below.

The Theory is presented in model form. The model can be described in sections, the first of which consists of three variables: Nutritional Status, Health Status, and Nutrition Gap. These three variables are related as shown in Figure 1:

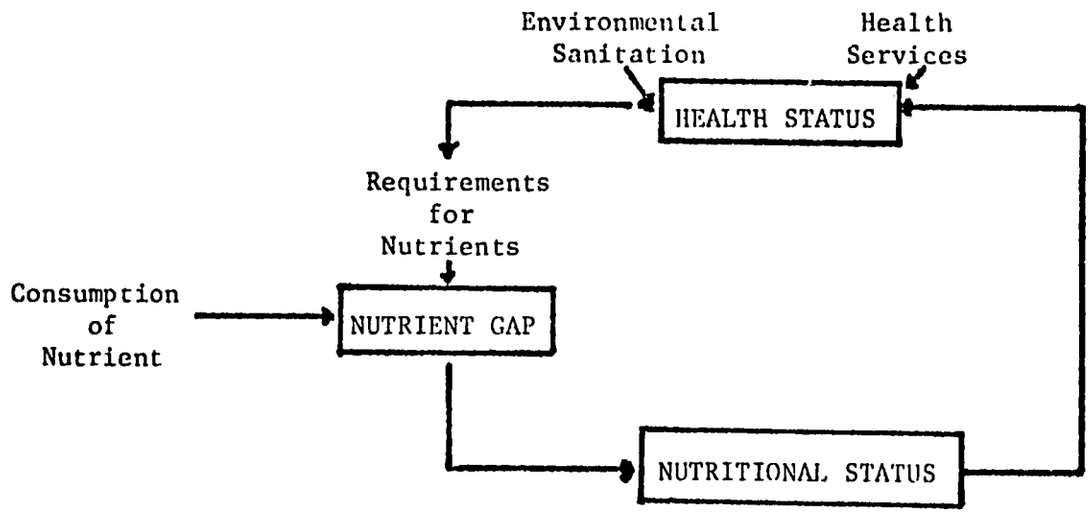


FIG #1

*The Department of National Planning of Colombia has designated the State of Cauca as a location for implementation and testing of major nutrition planning projects. During 1976-77 various major interventions are to be implemented in three pilot areas within Cauca. This national program is supported by a USAID nutrition loan to Colombia.

This section of the theory simply states that Nutritional Status is a function of the Nutrient Gap (the difference between requirements for nutrients and consumption of nutrients), and Health Status. In theory, a reduction in the Nutrient Gap will improve Nutritional Status, an improvement in Nutritional Status will improve Health Status, and improved Health Status will reduce overall nutrient requirements. The reduction in nutrient requirements for one cycle leads to a further reduction in Nutritional Gap, etc. for another cycle

Several statements can be made about this section of the model:

1. The cycle is reversible. For example, an increase in the Nutrition Gap can adversely affect Nutritional Status and Health Status, which in turn can lead to an even greater increase in the Gap by an increase in requirements.

2. There exist bounds for each of the variables. For example, the model does not account for large over-consumption of nutrients which can lead to no further improvement in Nutritional Status but a worsening in Health Status.

3. The Theory states that the three variables are interdependent. Thus, the effect of a change in Health Status on Nutrition Status can not be determined without knowledge of the value of the Nutrient Gap, nor can the effect of a change in consumption of nutrients on Nutritional Status be determined without knowledge of the value of Health Status.

4. Very little is known about the dynamic behavior of the model, and this knowledge has important implications for planning nutrition interventions. For example, for a community which has implemented a measles vaccination program and thereby reduced the incidence of measles by 75%, what new value is expected for the Nutritional Status of the population, and what is the time period expected for the Nutritional Status of the population to reach that new value?

   Although analysis of the intervention of environmental sanitation and the control of diarrhea by health promoters in Candalaria, Colombia* has produced some insight into the dynamic behavior of the model, much more experimentation is needed.

*Reference: The Promotora Program in Candelaria: A Colombian Attempt to Control Malnutrition and Disease, 1968-74, William D. Drake and Luis F. Fajardo, Community Systems Foundation, Cali, Colombia, June, 1976.

5. Interventions can be classified into those primarily designed to increase nutrient consumption and those designed to reduce nutrient requirements. Agricultural production, food storage and preservation, food distribution, food stamps and some nutrition education programs are aimed directly at increasing the consumption of nutrients. However, the effect of increasing consumption can lead to a decrease in nutritional requirements through the interdependence of the variables and cyclical nature of the model.

   Environmental sanitation interventions such as potable water, sewage disposal, education to modify sanitary behavior, and health programs (vaccination and disease control) are designed to effect a reduction in requirements for nutrients, and only very indirectly (following discussion) can such interventions effect consumption.

6. Interventions which improve Health Status reduce requirements for nutrients within the community in the short run; however, if the mortality rate is lowered by these interventions, then the population of the community can increase, and this again increases the community requirements for nutrients.

Many experiments need to be conducted in the field and in the laboratory to test hypotheses about the dynamic relationships among the variables in the Nutrient Flow Theory. Our hope is that research funds (USAID TA/N and others) can be directed toward these investigations.

The second section of the model could be labeled the "consumption section" (see Figure 2). It is similar to the food-balance sheets for nations which have been used by FAO of the United Nations for several years:

$$N_c = N_p - N_e + N_i - N_l$$

nutrients available for consumption	=	nutrients produced	-	nutrients exported	+	nutrients imported	-	nutrient losses

The nutrients available for consumption by a population depend upon the nutrients produced (all sources of production), plus the nutrients imported, minus the nutrients exported, minus the losses. The losses of nutrients are in various forms: harvesting losses, losses in storage and transport (from rodents, insects, birds, spoilage, etc.), losses in the market, losses due to unequal distribution among families of

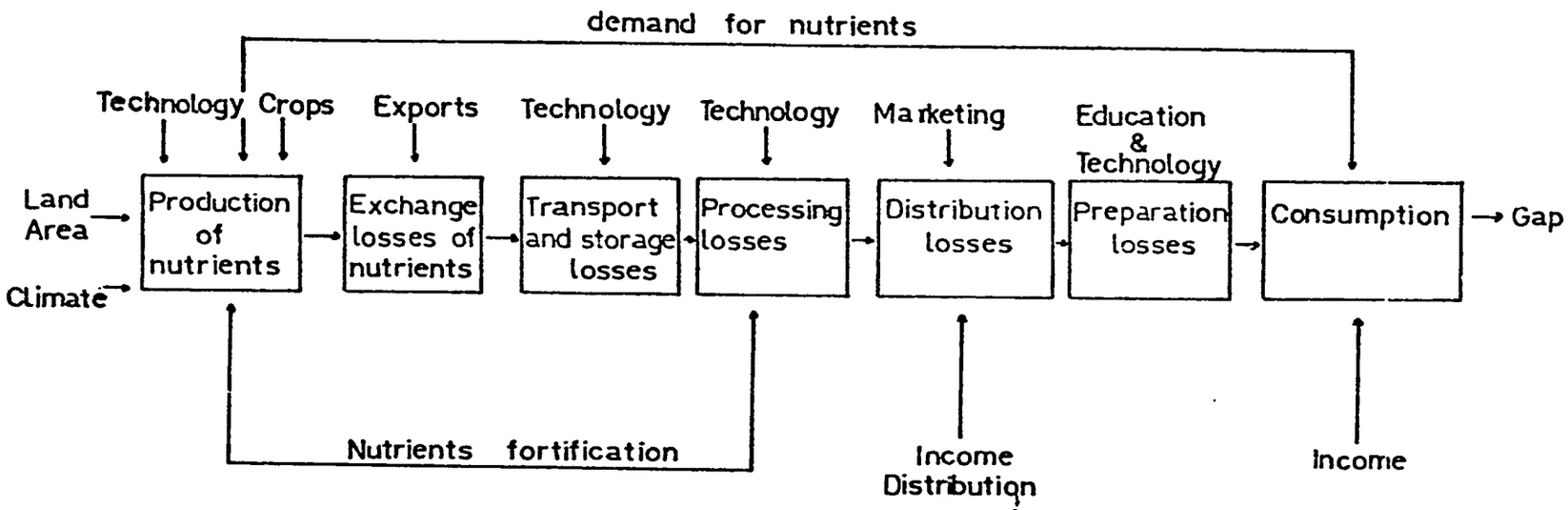

demand for nutrients
Technology
Crops
Exports
Technology
Technology
Marketing
Education & Technology
Land Area
Climate
Production of nutrients
Exchange losses of nutrients
Transport and storage losses
Processing losses
Distribution losses
Preparation losses
Consumption
Gap
Nutrients fortification
Income Distribution
Income

Fig. 2

the community, food preparation losses (both home and commercial), and losses due to unequal distribution among members of a family.

In effect, the output of this section becomes the input for the first section of the model (Figure 1): the nutrients consumed are subtracted from the nutrient requirements to calculate the gaps for communities, families or individuals.

There is also a feedback loop from Health Status to the "consumption section" of the model. That is, if Health Status is improved, productivity should increase. Increased productivity can increase income which could effect consumption. For subsistence farmers, increased productivity could directly increase nutrient production and, in turn, increase nutrients available to be consumed or increase income to purchase more nutrients, or both.

The diagnosis and analysis of the causes of malnourishment in a community requires less effort when based upon a theory. In practice, less data needs to be collected and analyzed to determine the priorities for nutrition intervention(s) if the diagnosis of a community proceeds in a sequential manner (as a physician would do when examining a patient). An example of the sequential nature of the diagnosis of Colombian communities is as follows:

1. Measure Nutritional Status. If there is no malnourishment, then no nutrition interventions are necessary and no other variables need to be measured or analyzed. In the field work in Colombia, we have established an arbitrary cut-off point of 50% malnourishment among children age 0-6. If there is less than 50% malnourishment another community is selected. Since the national average is 60%, this seems to be a reasonable procedure.

   If malnourishment rate of 50% or more is observed, then the Nutrient Gap at the family level is analyzed.

2. Analyze Family Gaps. If families are consuming more nutrients than are normally required (considering age structure of the family, pregnant and lactating women, physical activities, etc.) and still these families have malnourished members, then the actual nutrient requirements must be substantially higher than normal, or the distribution of nutrients among family

members is not in proportion to the requirements of the family members, or both. Measurements would then be made of:

- consumption of individual members of families;
- diarrhea rates (to test the need for environmental sanitation interventions); and
- mortality levels (to test the need for health service interventions).

If any combination of the above measures can explain the malnourishment observed in the community, no other measures need be made.

3. Analyze Community Gap. If, on the average, the families of a community have a nutritional deficit, then redistribution of the available nutrients can not solve their problem (although it may lessen the problem in severe cases). There simply aren't enough nutrients to go around. In this case, nutrient production, nutrient imports, and nutrient exports would be analyzed to seek ways to make more nutrients available to the families of the community.

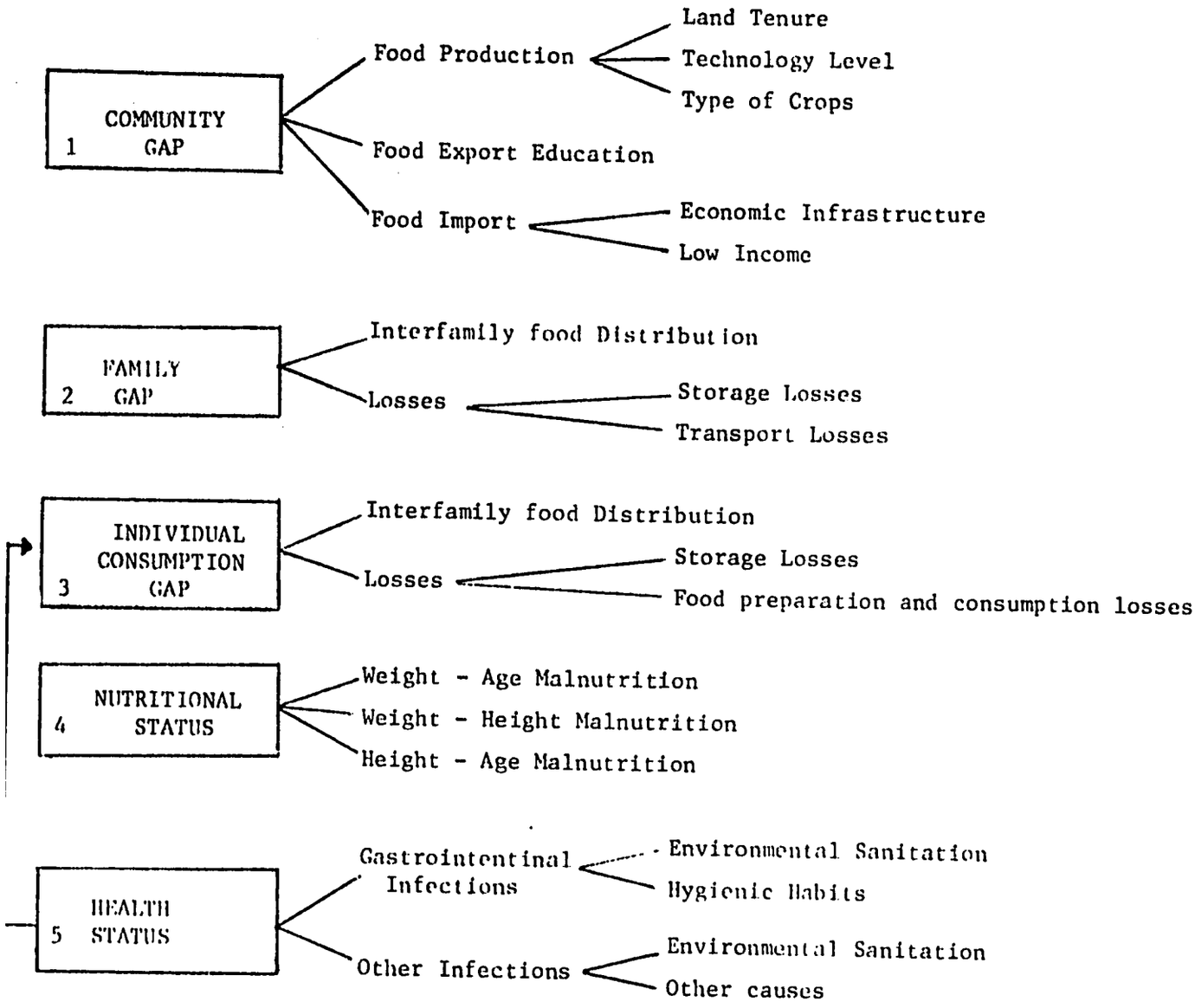
   Production of nutrients, minus exports, plus imports yields the amount of nutrients available to the community. If the nutrient availability is greater than consumption, losses within the community exist. In this case, the measurement and analysis of marketing and within-the-family losses of nutrients is indicated.

   If availability of nutrients is nearly equal to consumption--and the average family experiences a deficit--then interventions in production and/or import are indicated.

Figure 3 illustrates the sequential diagnostic procedure, appropriate measurements, and analyses within the context of the Nutrient Flow Theory. (See page , for complete set of logical comparisons used in the diagnostic procedure).

OTHER USES OF THE MODEL

Planning is more than determining the performance specifications for interventions. For example, in Villa Rica, Colombia, the diagnostic procedure indicates a need for a potable water intervention. There exist at least three alternatives for providing potable water to the community:



Diagnosis - analysis and field measurements

FIG 3

1. Purify the existing water system.
2. Extend the aqueduct from Puerto Tejada.
3. Extend the aqueduct from Caloto to Villa Rica.

The design question is: Which of these three alternatives is the most cost-effective in reducing malnourishment? The model can estimate the effectiveness for each intervention and the long-run stability for the proposed solution. If the alternatives are not yet known, the model can then be utilized to state the performance specifications for the intervention. This latter step is a great advantage when searching for appropriate alternatives.

The model can also be utilized as an evaluation tool to assess the performance of interventions once they have been implemented, for it predicts the expected new values of the variables (e.g., Nutritional Status, Nutrition Gap, consumption, losses, agricultural production, Health Status, morbidity, sanitary conditions, etc.). The model should also predict the time for the stated variables to reach those new values, and a separate cost model will predict the cost of the implemented interventions. Evaluation, then, is simply comparing these predicted values with the observed values. The project work of the first two years has addressed many, but not all, of the difficulties of developing a science-based methodology for nutrition planning.

II. DATA PROCESSING

A. The Computer System

For almost all of our computation processing needs, we used a small computer system, the WANG 2200 equipped with a card reader, a printer, a disk and cassette unit, and a CPU with a core memory of 32 K bytes and a CRT display. The system is programmed through the console in BASIC language.

For each community the procedure relative to data storage and retrieval is as follows:

1. Data are coded and punched in a card file.
2. By a "sort and merge" procedure data are organized in a master file, in which each family is assigned a record with all the information gathered from the various surveys.
3. The master file is stored in the disk unit and periodically updated. As each record starts with a meaningful code, or address, it is easy to retrieve or to modify the information relative to each family. "Auxiliary" files, like the file relative to the list of commodities, are organized in the same way and stored in the disk or cassette units. The cassette can be used to store software or as a "working storage unit".

Therefore, a maximum of three files can be processed at the same time: a disk, cassette and card file. This makes the whole system quite versatile and competitive with larger data processing systems, at a lower cost. Of course the trade-off is time, which for this unit is quite large.

B. The Software Logic

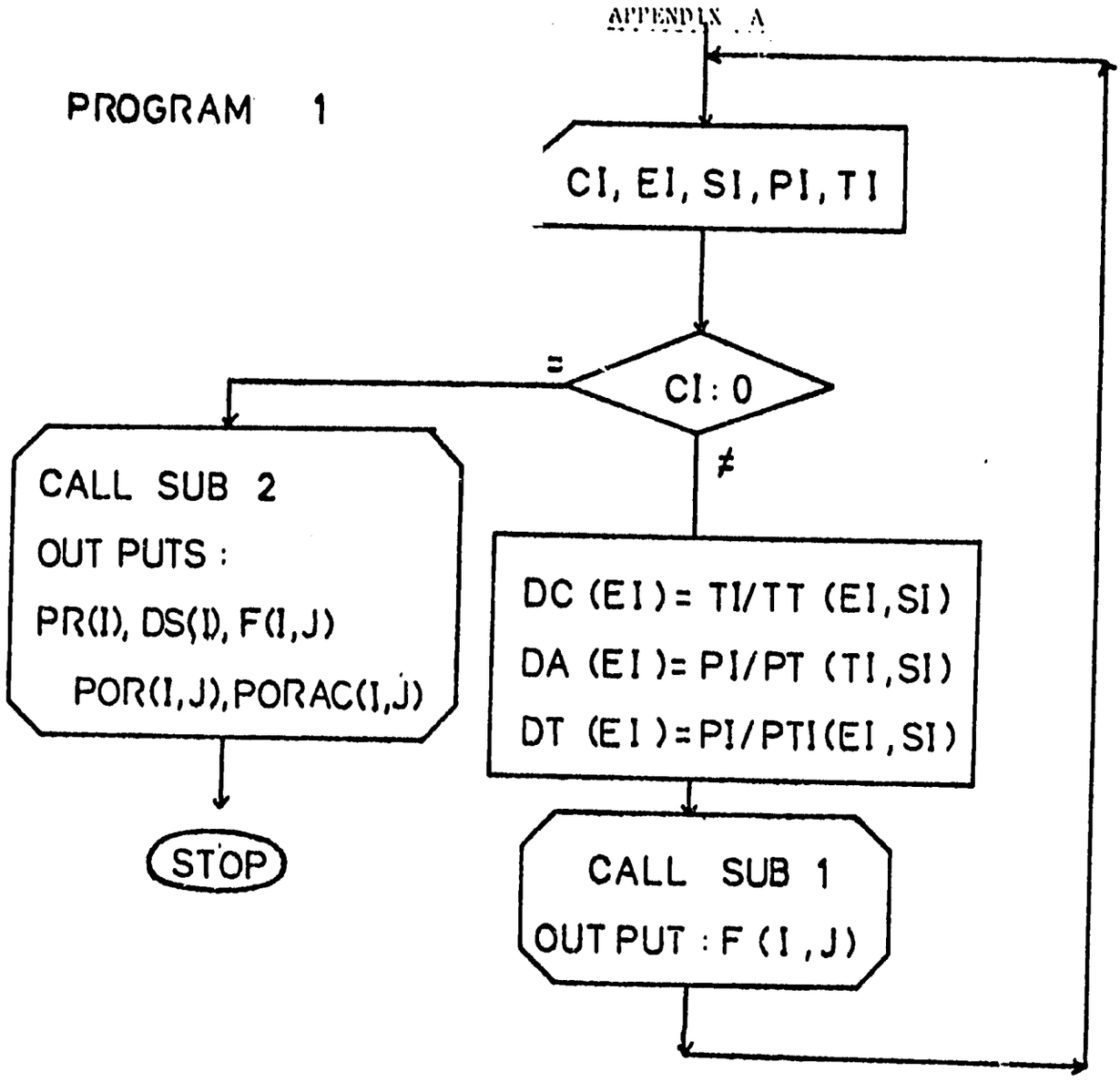
Our software library is very bulky and a detailed description of each program with its own flow-chart is almost impossible. Appendix A shows the flow diagram of the most important computer programs, and in Fig. 4 a synoptic view of the software logic.

Our computer programs are basically of a statistical nature.

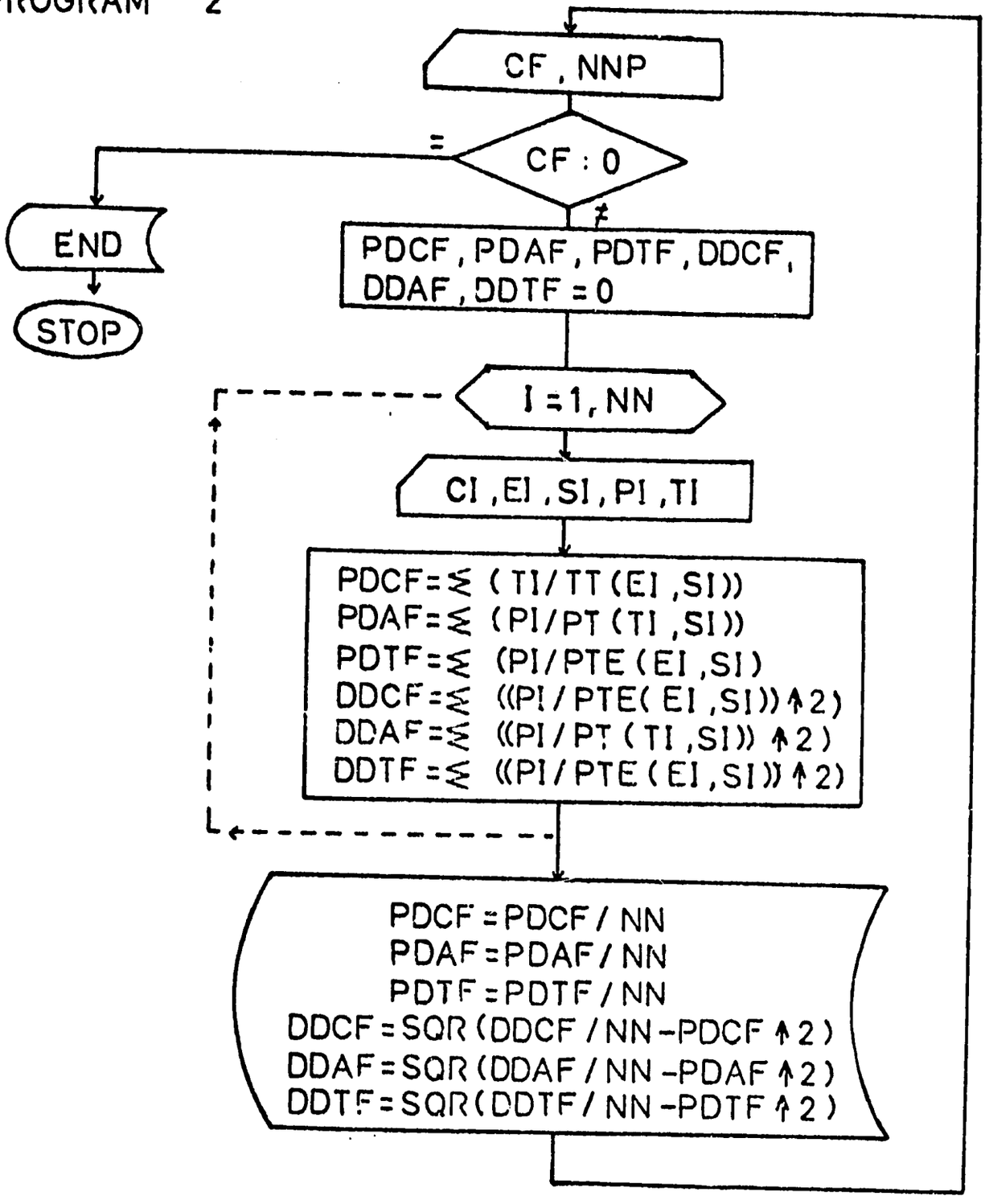
From family information concerning food production and purchasing, number of persons, age, sex, nutritional and health status, etc., we derive essentially two kinds to statistical information:

1. Mean values and distributions around mean values. In this way, we calculate the community, family and individual nutrient gaps, their standard deviation, the percentage of families with a given characteristic, etc.
2. Type and strength of association between two or more variables. We can investigate for example how a particular anthropometric parameter is related to age, how food distribution patterns within the family can change when the family gap tends to increase, etc. We can investigate the association among families, between families and categories of individuals, within families, and between individuals and families. Fig. 4 shows the flow diagram of the programs which are used for the calculation of the community, family and individual gaps. The last part relative to survey 9 has not been worked out yet because of some difficulties in the laboratory methodology. We can see that this flow diagram constitutes the core of the diagnostic procedure for a community. Its output represents the input to the model of analysis in Fig. 3

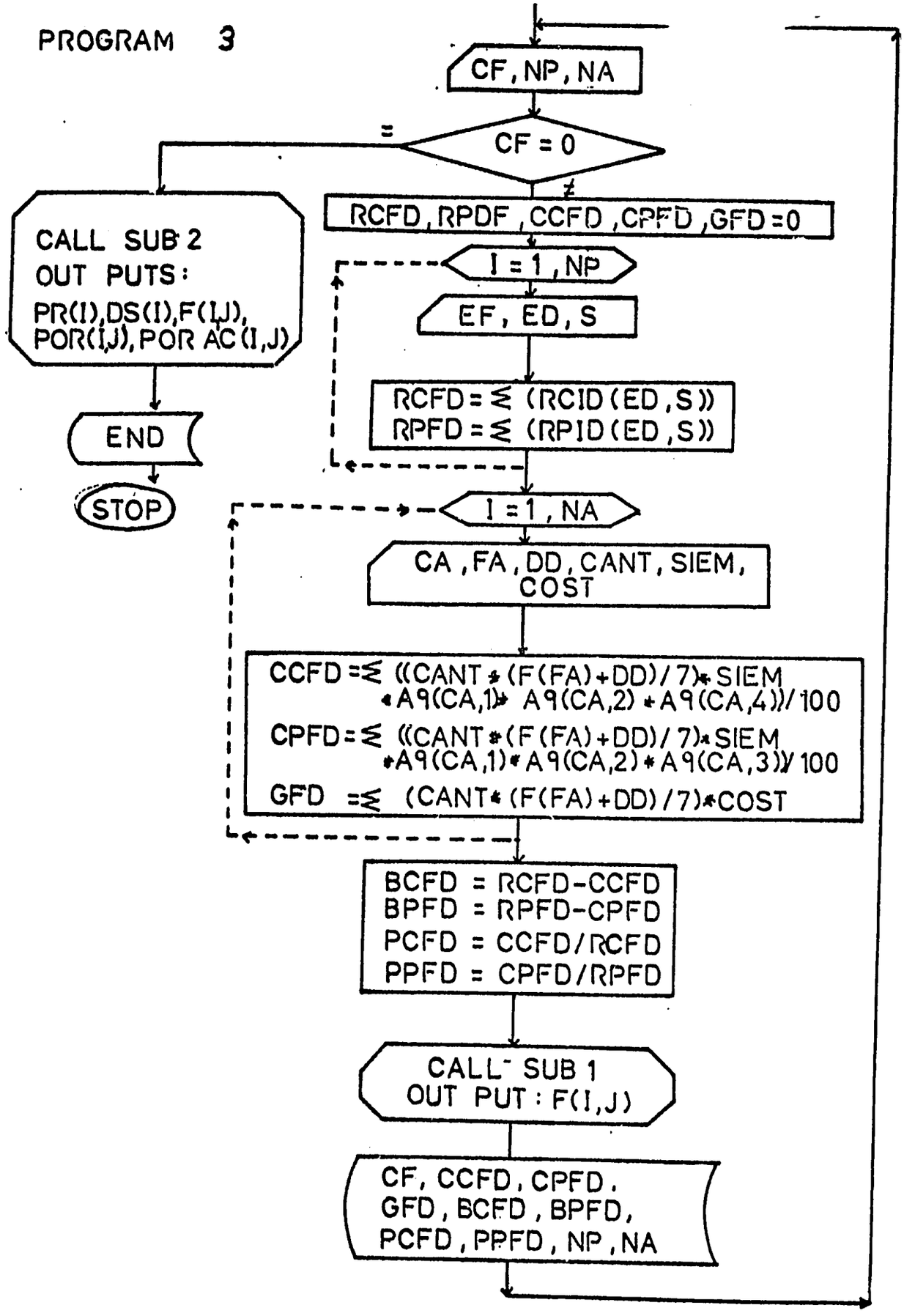
PROGRAM 1


CI, EI, SI, PI, TI
CI : 0
=
≠
CALL SUB 2
OUT PUTS :
PR(I), DS(I), F(I,J)
POR(I,J), PORAC(I,J)
STOP
DC (EI) = TI/TT (EI,SI)
DA (EI) = PI/PT (TI,SI)
DT (EI) = PI/PTI (EI,SI)
CALL SUB 1
OUT PUT : F (I,J)

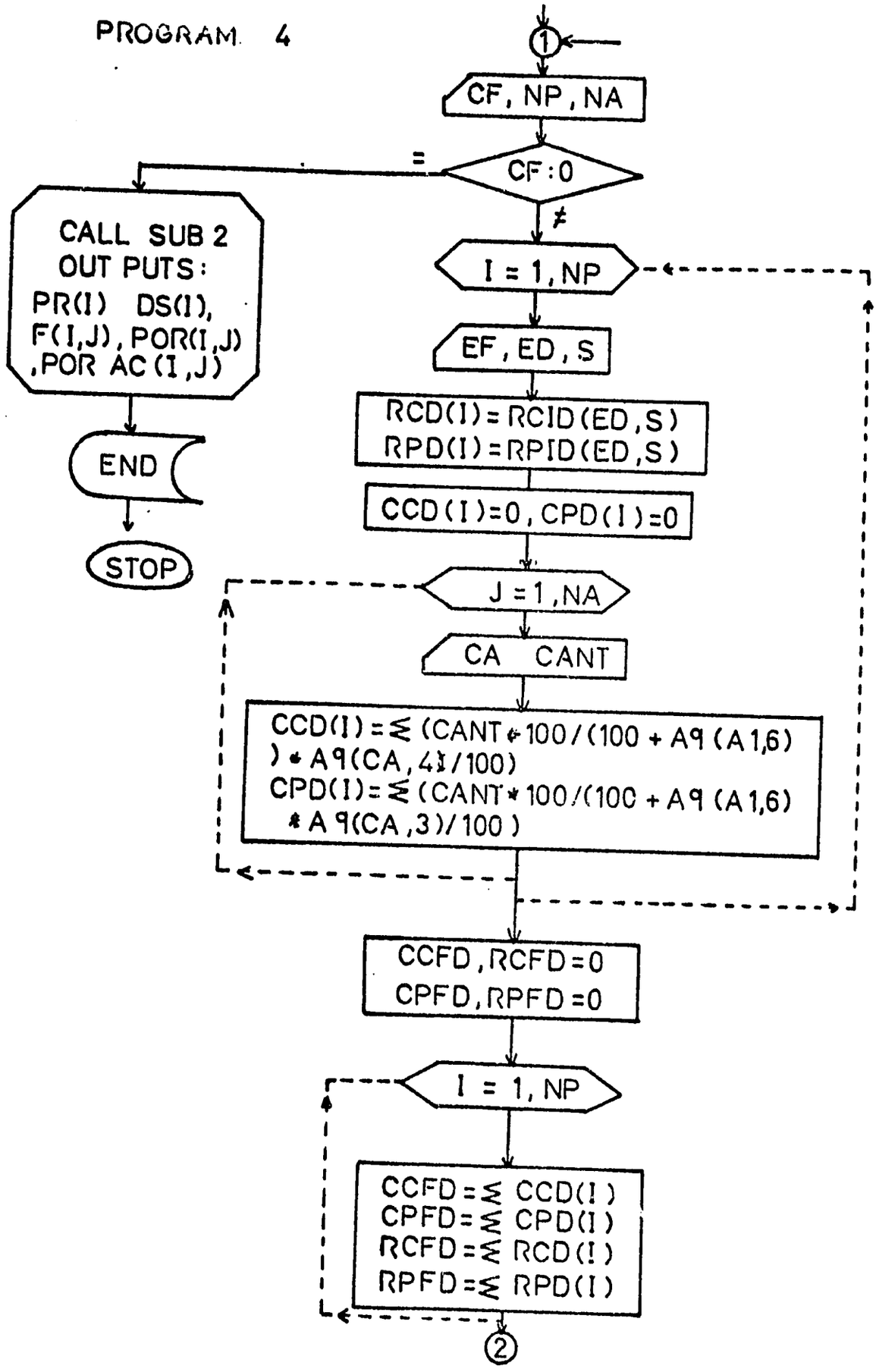
PROGRAM 2


CF , NNP
CF : 0
=
≠
END
STOP
PDCF , PDAF , PDTF , DDCF ,
DDAF , DDTF = 0
I = 1, NN
CI , EI , SI , PI , TI
PDCF = Σ (TI / TT (EI , SI))
PDAF = Σ (PI / PT (TI , SI))
PDTF = Σ (PI / PTE (EI , SI)
DDCF = Σ ((PI / PTE(EI , SI)) ↑ 2)
DDAF = Σ ((PI / PT (TI , SI)) ↑ 2)
DDTF = Σ ((PI / PTE (EI , SI)) ↑ 2)
PDCF = PDCF / NN
PDAF = PDAF / NN
PDTF = PDTF / NN
DDCF = SQR (DDCF / NN - PDCF ↑ 2)
DDAF = SQR (DDAF / NN - PDAF ↑ 2)
DDTF = SQR (DDTF / NN - PDTF ↑ 2)

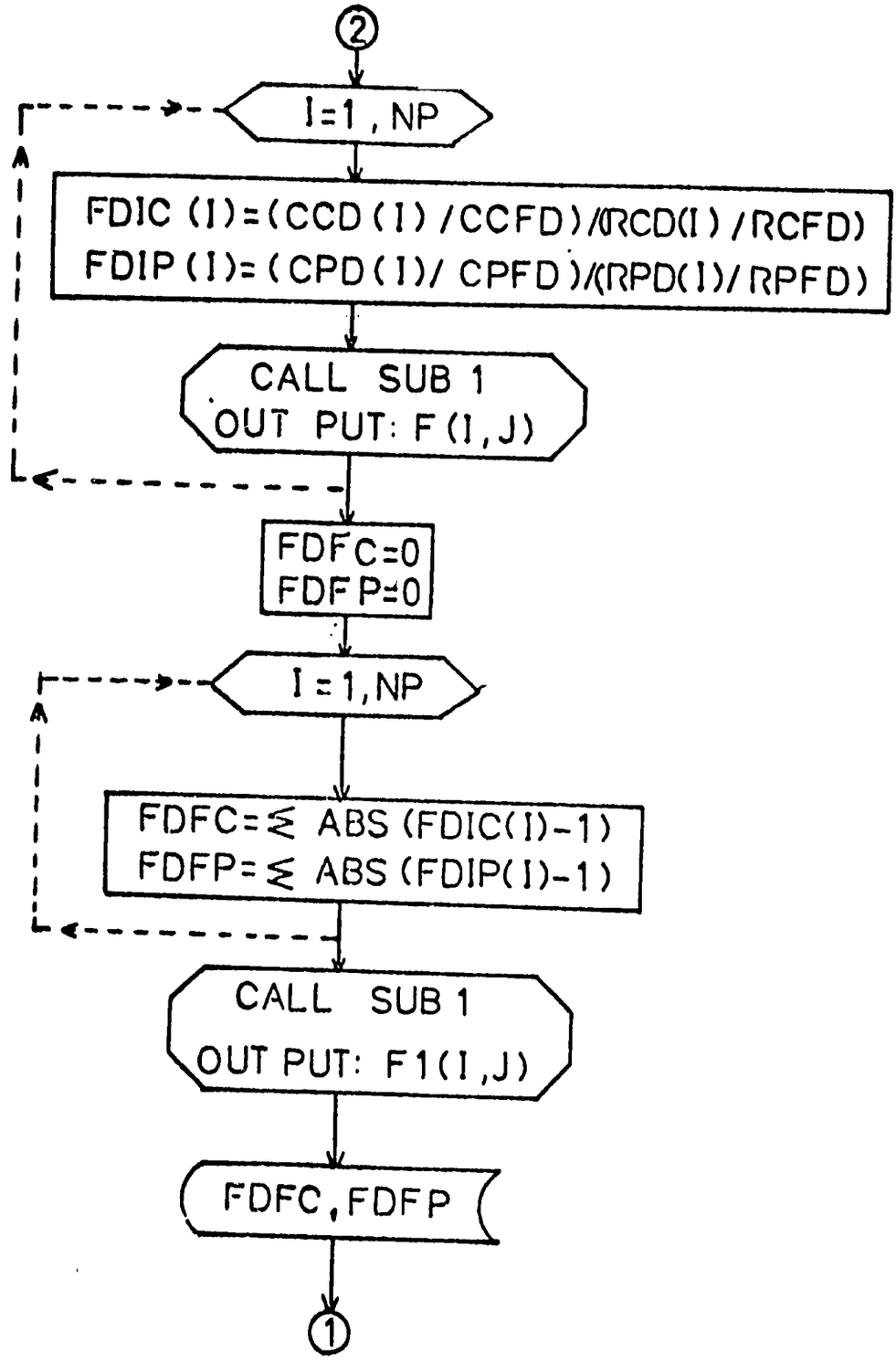
PROGRAM 3


CF, NP, NA
CF = 0
=
≠
CALL SUB 2
OUT PUTS:
PR(I),DS(I),F(I,J),
POR(I,J), POR AC(I,J)
END
STOP
RCFD, RPDF, CCFD, CPFD, GFD = 0
I = 1, NP
EF, ED, S
RCFD = ≤ (RCID(ED,S))
RPFD = ≤ (RPID(ED,S))
I = 1, NA
CA, FA, DD, CANT, SIEM, COST
CCFD = ≤ ((CANT * (F(FA) + DD)/7) * SIEM * A9(CA,1) * A9(CA,2) * A9(CA,4))/100
CPFD = ≤ ((CANT * (F(FA) + DD)/7) * SIEM * A9(CA,1) * A9(CA,2) * A9(CA,3))/100
GFD = ≤ (CANT * (F(FA) + DD)/7) * COST
BCFD = RCFD - CCFD
BPFD = RPFD - CPFD
PCFD = CCFD/RCFD
PPFD = CPFD/RPFD
CALL SUB 1
OUT PUT: F(I,J)
CF, CCFD, CPFD,
GFD, BCFD, BPFD,
PCFD, PPFD, NP, NA

PROGRAM 4


1
CF, NP, NA
CF:0
=
≠
CALL SUB 2
OUT PUTS:
PR(I) DS(I),
F(I,J), POR(I,J)
,POR AC(I,J)
END
STOP
I = 1, NP
EF, ED, S
RCD(I) = RCID(ED,S)
RPD(I) = RPID(ED,S)
CCD(I)=0, CPD(I)=0
J = 1, NA
CA CANT
CCD(I) = Σ (CANT * 100/(100 + A9 (A1,6)
) * A9(CA,4)/100)
CPD(I) = Σ (CANT * 100/(100 + A9 (A1,6)
* A9(CA,3)/100)
CCFD, RCFD = 0
CPFD, RPFD = 0
I = 1, NP
CCFD = Σ CCD(I)
CPFD = Σ CPD(I)
RCFD = Σ RCD(I)
RPFD = Σ RPD(I)
2

PROGRAM 4
(Contin)



PROGRAM 1

CI: Individual code

EI: Individual age (months)

SI: Individual sex

PI: Individual weight (grams)

TI: Individual Height (centimeters)

TT(EI, SI): Table of Height for normal children of EI months and SI sex

PT(TI, SI): Table of Weight for normal children of TI centimeters and SI sex

PTE (EI, SI): Table of Weight for normal children of EI months and SI sex

DC(EI): Degree of chronic malnourishment

Ratio between actual height and normal height for age of children of EI months

DA (EI): Degree of acute malnourishment

Ratio between actual weight and normal weight for height of EI months

DT(EI): Degree of total malnourishment

Ratio between actual weight and normal weight for age of children of EI months

F (I, J): Frequency of variable I in interval J. The variables are the differents types of degree of malnourishment for differents ages.

PR(I): Average of variable I

DS(I): Standard deviation of variable I

POR(I, J): Percentage of variable I in interval J.

PORAC(I, J): Accumulated percentage of variable I in interval J.

PROGRAM 2

CF: Family code

NN: Number of children in the family

PDCF: Average value of degree of chronic malnutrition for all children in the family

PDTF: Average value of degree of total malnourishment for all children in the family

DDCF: Standard deviation value of degree of chronic malnourishment for all children in the family

DDAF: Standard deviation value of degree of acute malnourishment for all children in the family

DDTF: Standard deviation value of degree of total malnourishment for all children in the family.

CI: Individual code

EI: Individual age (months)

SI: Individual sex

PI: Individual weight (grams)

TI: Individual Height (centimeters)

TT (EI, SI) : Table of Height for normal children of EI months and SI sex

PT (TI,SI) : Table of weight for normal children of TI centimeters and SI sex

PTE (EI,SI) : Table of weight for normal children of EI months and SI sex.

PROGRAM 3

CF: Family code

NP: Number of individuals in the family

NA: Number of commodities in the family diets.

RCFD: Daily requirements of calories by family

RPFD: Daily Requirements of proteins by family

CCFD: Daily consumption of calories by family

CPFD: Daily consumption of proteins by family

EF: Physiological states of the individual

ED: Age of the individual

S: Sex of the individual

GFD: Daily expenditure of food by family

RCID(ED,S): Daily requirements of calories for a person of a given age (ED) and sex (S)

RPID(ED,S): Daily requirements of proteins for a person of a given age (ED) and sex (S)

CA: Food code

FA: Purchasing frequency

DD: Days of the week assigned to food purchasing

CANT: Amount of food purchased

COST: Unit cost of commodities

SIEM: Quantity for standard package

F(FA): Factor for the standardization of the purchasing frequency FA

A9 (CA,1): Edible percentage of food CA

A9 (CA,2): Conversion factor from the standard weight unit used to grams

A9 (CA,3): Percentage of proteins in food CA

A9 (CA,4): Percentage of calories in food CA

BCFD: Average daily family gap for calories

BPFD: Average daily family gap for proteins

PCFD: Average daily adequacy of calories

PPFD: Average daily adequacy of proteins

PROGRAM 4

CF: Family code

NP: Number of individuals in the family

NA: Number of commodities in the familiar diets.

EF: Physiological states of the individual

ED: Age of the individual

S: Sex of the individual

RCD (I): Daily requirements of calories for the person I in the family

RPD (I): Daily requirements of proteins for the person I in the family.

RCID (ED,S): Daily requirements of calories for a person of a given age (ED) and sex (S)

RPID (ED,S): Daily requirements of proteins for a person of a given age (ED) and sex (S)

CCD(I): Daily consumption of calories for the person I in the family

CPD(I) : Daily consumption of proteins for the person I in the family

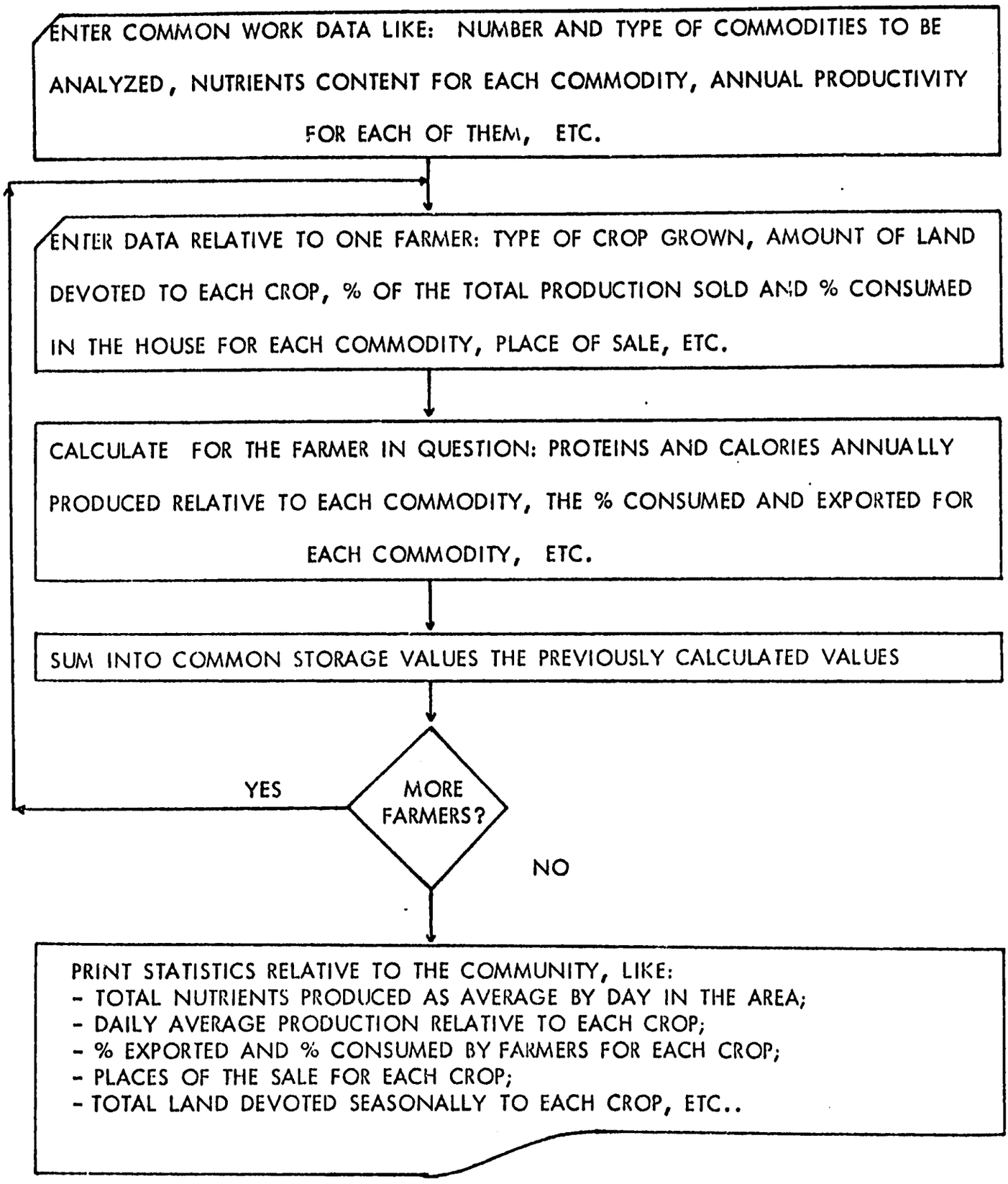
FDIC(I): Distribution factor of calories for the person I in the family

FDIP (I): Distribution factor of proteins for the person I in the family

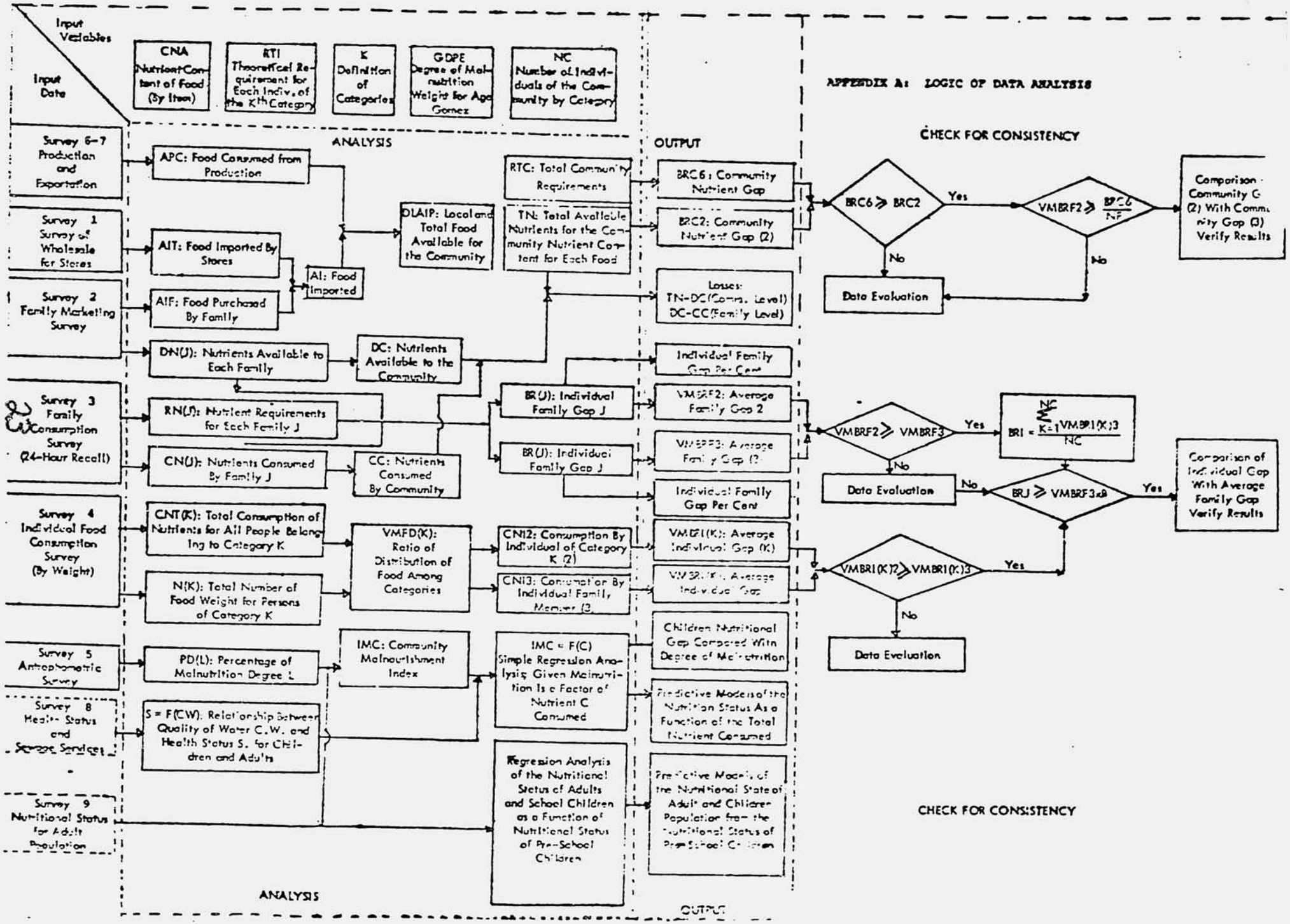
FDFC: Indirect intrafamily distribution factor of calories

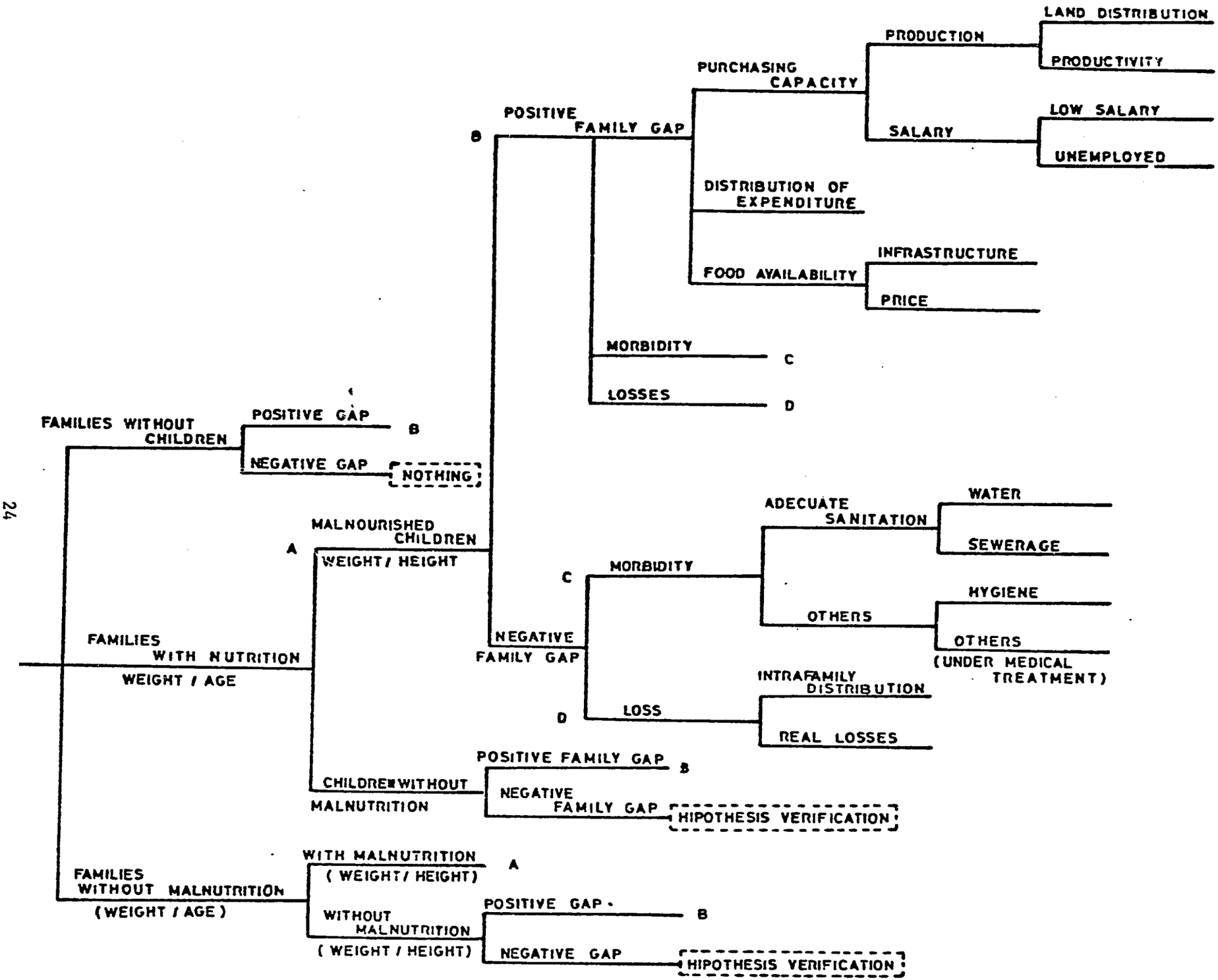
FDFP: Indirect intrafamily distribution factor of proteins.

FLOW DIAGRAM RELATIVE TO AGRICULTURAL PRODUCTION



APPENDIX A: LOGIC OF DATA ANALYSIS

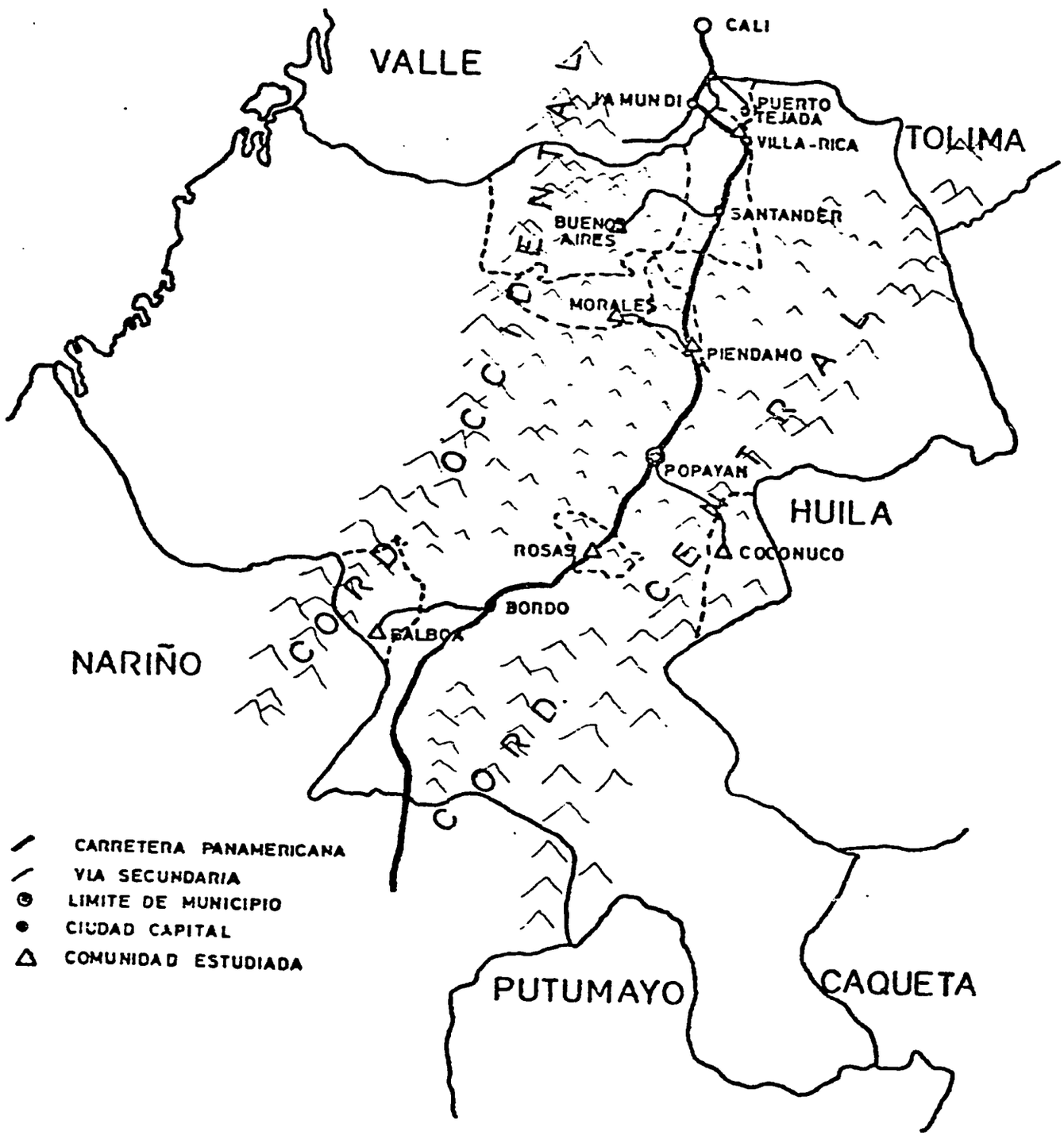



FAMILIES WITHOUT CHILDREN
POSITIVE GAP
B
NEGATIVE GAP
NOTHING
FAMILIES WITH NUTRITION WEIGHT / AGE
MALNOURISHED CHILDREN
A
WEIGHT / HEIGHT
B
POSITIVE FAMILY GAP
PURCHASING CAPACITY
PRODUCTION
LAND DISTRIBUTION
PRODUCTIVITY
SALARY
LOW SALARY
UNEMPLOYED
DISTRIBUTION OF EXPENDITURE
FOOD AVAILABILITY
INFRASTRUCTURE
PRICE
MORBIDITY
C
LOSSES
D
NEGATIVE FAMILY GAP
C
MORBIDITY
ADECUATE SANITATION
WATER
SEWERAGE
OTHERS
HYGIENE
OTHERS
(UNDER MEDICAL TREATMENT)
D
LOSS
INTRAFAMILY DISTRIBUTION
REAL LOSSES
CHILDREN WITHOUT MALNUTRITION
POSITIVE FAMILY GAP
B
NEGATIVE FAMILY GAP
HIPOTHESIS VERIFICATION
FAMILIES WITHOUT MALNUTRITION (WEIGHT / AGE)
WITH MALNUTRITION (WEIGHT / HEIGHT)
A
WITHOUT MALNUTRITION (WEIGHT / HEIGHT)
POSITIVE GAP
B
NEGATIVE GAP
HIPOTHESIS VERIFICATION

III. DATA GATHERED

A. Location

B. The Data


CALI
VALLE
LA MUNDI
PUERTO TEJADA
VILLA-RICA
TOLIMA
SANTANDER
BUENOS AIRES
MORALES
PIENDAMO
POPAYAN
HUILA
ROSAS
COCONUCO
BORDO
PALBOA
NARIÑO
PUTUMAYO
CAQUETA
CORDILLERA OCCIDENTAL
CORDILLERA CENTRAL
CORDILLERA ORIENTAL
CARRETERA PANAMERICANA
VIA SECUNDARIA
LIMITE DE MUNICIPIO
CIUDAD CAPITAL
COMUNIDAD ESTUDIADA

	VILLA RICA	PIENDAMO	BUENOS AIRES	ROSAS	COCONUCO	BALBOA	MORALES
Extension (Km^2)	30	197	1,124	197	707	360	265
Total Population	8,000	13,064	26,240	7,984	7,722	12,360	11,788
Urban	3,000	5,046	3,000	1,009	661	1,783	804
Rural	5,000	8,018	23,240	6,975	7,001	10,577	10,984
Altitude over the sea level (Meters)	1,071	1,864	1,225	1,714	2,360	1,630	1,635
Mean Temperature °C	27	18	22	19	16	19	19
Ethnic Composition	Black	Mestizo	Black 80%	Mestizo	Mestizo	Mestizo	Mestiz

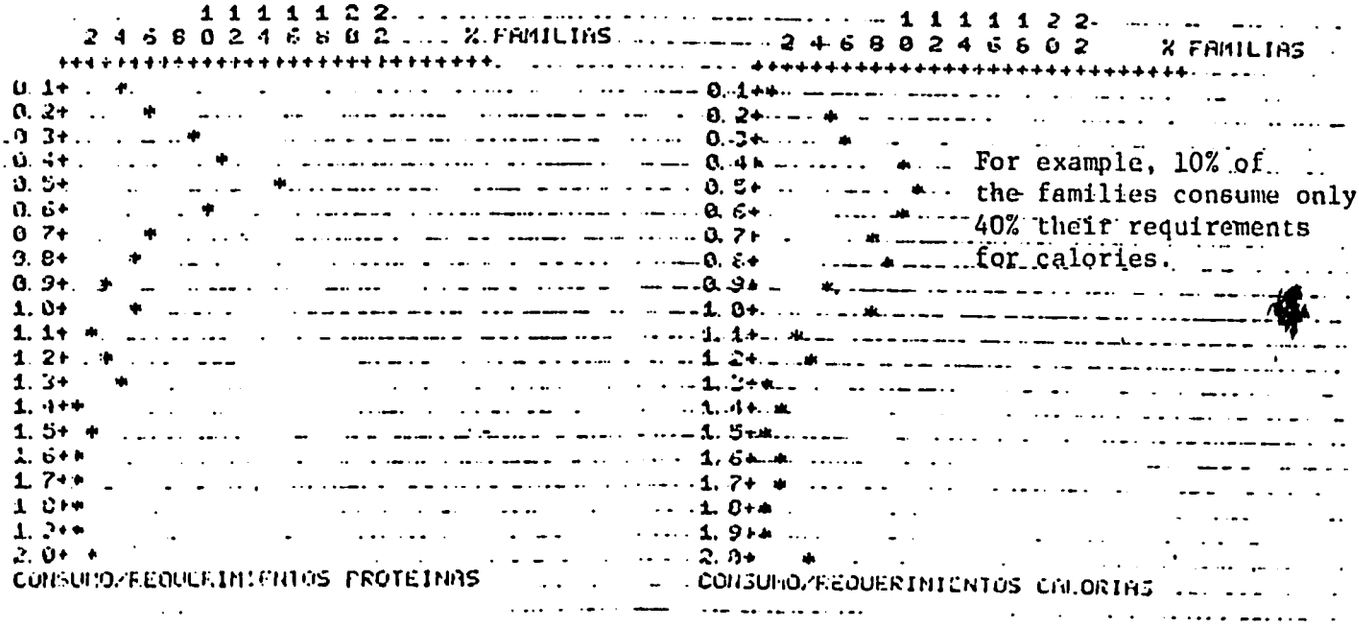
VILLA RICA (URBAN + RURAL)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	459	31%	69%
Height/Standard height for height:	0-6 years	459	48%	52%
Weight/Standard weight for actual height:	0-6 years	64	72%	28%

VILLA RICA (URBAN + RURAL)

Calorie Requirements per family per day	12,838
Protein Requirements per family per day	271 grams
Calorie Consumption per family per day	9,832
Protein Consumption per family per day	184 grams
Absolute Gap of calories per family per day	2,510
Absolute Gap of proteins per family per day	80 grams



For example, 10% of the families consume only 40% their requirements for calories.

Distribution of Nutrients Among Families

VILLA RICA (URBAN + RURAL)

	Variable % Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	18.2	27.0	6.4	19.0	5.2
Plantain	12.7	9.9	22.4	6.9	18.0
Rice	11.5	23.0	20.3	16.2	16.3
Fat	7.3	--	9.8	--	7.8
Potatoes	6.2	4.5	4.1	3.1	3.3
Coffee	5.9	0.4	0.2	0.3	0.2
Sugar	4.6	--	13.8	--	11.1
Oil	3.4	--	2.7	--	2.1
Beans	3.0	4.8	1.4	3.4	1.1
Brown Sugar	2.7	0.4	5.1	0.3	4.1
Fish	2.6	2.7	0.3	1.3	0.2
Chocolate	2.2	0.3	0.6	0.2	0.5
Pasta	2.0	2.4	1.5	1.7	1.2
Eggs	1.8	7.0	1.7	4.9	1.4
Corn	1.3	4.0	2.9	2.8	2.4
Wheat Flour	1.2	3.0	1.4	2.1	1.1
Tomatoes	1.2	0.2	--	0.1	--
Milk	1.2	1.6	0.5	1.1	0.4
Onion	1.1	0.1	--	0.1	--
Cassava	1.1	0.3	1.0	0.2	0.8
Carrots	1.0	--	--	--	--
Cheese	0.8	0.9	0.3	0.6	0.2
Powdered Milk	0.7	0.6	0.2	0.4	0.2
Lentils	0.6	1.1	0.3	0.7	0.2
Bread	0.5	0.5	0.4	0.3	0.3
Oats	0.5	0.5	0.3	0.4	0.3
"Mezcla Vegetal"	0.4	1.8	0.5	1.2	0.4
Wheat Corn	0.4	0.7	0.5	0.5	0.4
"Arracacha"	0.4	0.2	0.3	0.1	0.3
Chicken	0.3	0.2	--	0.1	--
Soup Bones	0.3	--	--	--	--
Ullucos	0.3	0.1	--	--	--
Oranges	0.2	--	--	--	--
Banana	0.2	--	--	--	--
Beet Roots	0.2	--	--	--	--
"Tortilla"	0.2	0.2	0.2	0.1	0.1
Salt	0.2	--	--	--	--
Visceras	0.2	0.2	--	--	--
Cabbage	0.1	--	--	--	--
String Bean	0.1	--	--	--	--

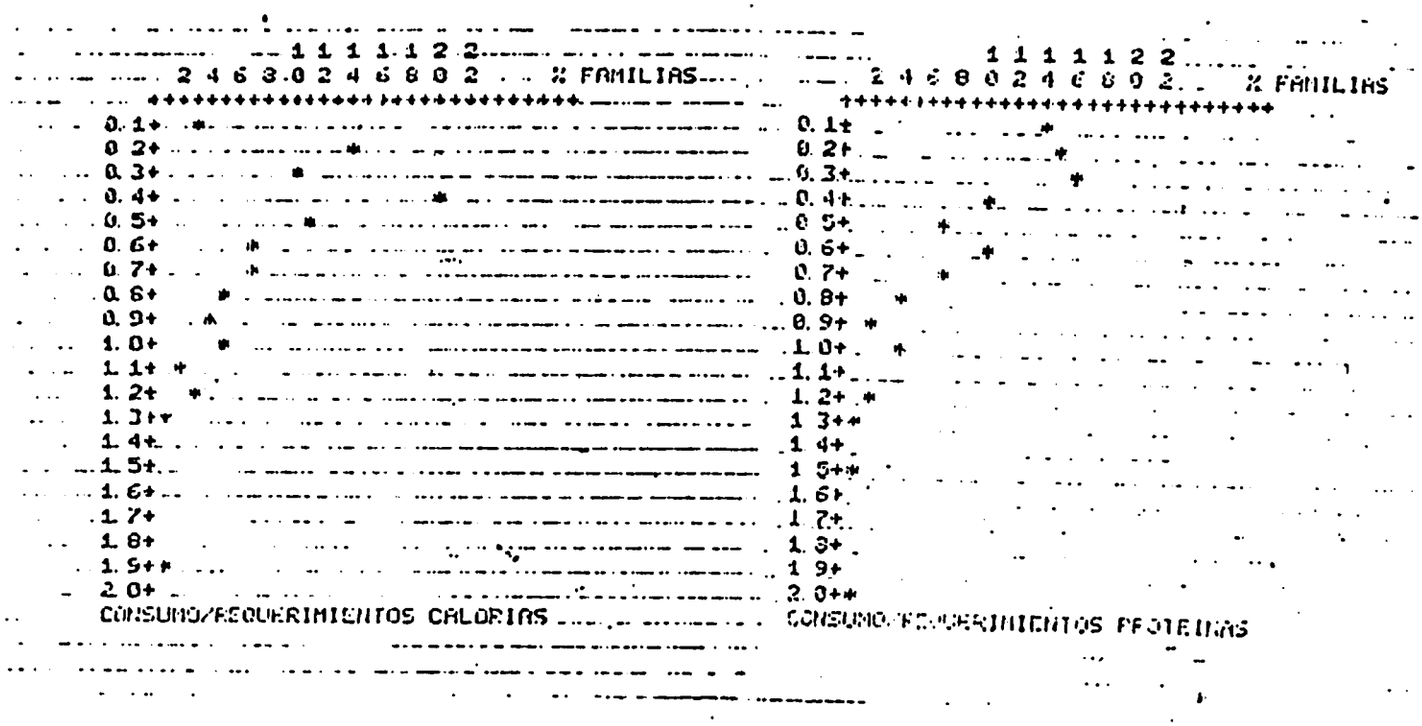
PIENDAMO (URBAN + RURAL)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	99	31%	69%
Height/Standard height for height:	0-6 years	99	41%	59%
Weight/Standard weight for actual height:	0-6 years	99	51%	49%

PIENDAMO (URBAN + RURAL)

Calorie Requirement per family per day	15,464
Protein Requirements per family per day	328 grams
Calorie Consumption per family per day	9,047
Protein Consumption per family per day	171 grams
Absolute Gap of calories per family per day	5,904
Absolute Gap of proteins per family per day	148 grams



Distribution of Nutrients Among Families

PIENDAMO (URBAN + RURAL)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	14	19	4	10	2
Plantain	11	9	20	5	12
Brown Sugar	10	1	13	0	8
Coffee	10	-	-	-	-
Rice	8	17	15	9	9
Corn	8	22	16	12	10
Potatoes	7	7	7	4	4
Fat	4	-	6	-	4
Bread	4	4	2	2	1
Beans	3	6	1	3	1
Eggs	3	2	—	1	-
Sugar	3	-	7	-	4
Pasta	2	2	1	1	1
Milk	2	2	-	1	-
Onion	2	-	-	-	-
Oil	1	-	-	-	-
Cassava	1	-	1	-	-

n = 84 families

Protein requirements: 328 g (Average per family day)

Caloric requirements: 15,464 (Average per family day)

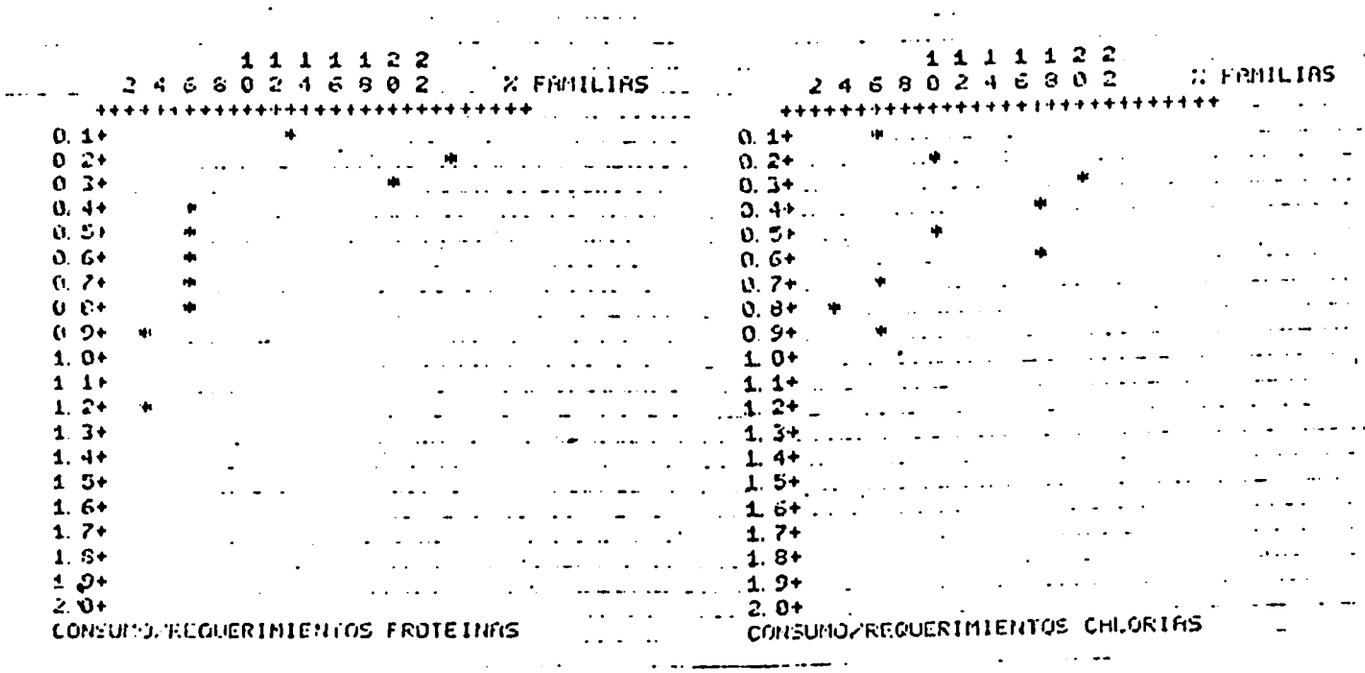
BALBOA (URBAN)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	65	32%	68%
Height/Standard height for height:	0-6 years	65	30%	70%
Weight/Standard weight for actual height:	0-6 years	65	67%	33%

BALBOA (URBAN)

Calorie Requirements per family per day	14,689
Protein Requirements per family per day	303 grams
Calorie Consumption per family per day	6,724
Protein Consumption per family per day	124 grams
Absolute Gap of proteins per family per day	148 grams
Absolute Gap of calories per family per day	7,517



Distribution of Nutrients Among Families

BALBOA (URBAN)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	17.7	29.1	6.7	12.7	3.2
Brown Sugar	10.0	13	16.1	5.6	7.8
Fat	9.5	-	13.6	-	6.5
Plantain	8.4	7.8	17.2	3.4	8.3
Rice	8.0	19.2	16.3	8.3	7.9
Bread	5.9	5.7	4.0	2.4	1.9
Coffee	5.1	-	0.2	-	0.1
Eggs	4.5	3.1	0.7	1.3	0.3
Beans	3.5	8.7	2.4	3.8	1.1
Cassava	2.9	1.0	3.5	0.4	1.7
Arracacha	2.5	1.2	2.2	0.5	1.0
Wheat flour	2.3	3.7	2.4	1.6	1.1
Milk	1.8	3.1	1.0	1.3	0.4
Sugar	1.5	-	4.1	-	2.0
Powdered milk	1.2	1.1	0.3	0.4	0.1
Pasta	1.1	1.5	0.9	0.6	0.4
Onion	1.0	0.3	0.1	0.1	-
Cabbage	0.9	0.7	0.1	0.3	-

n = 29 families

Protein requirements: 303 g (Average per family day)

Calorie requirements: 14,690 (Average per family day)

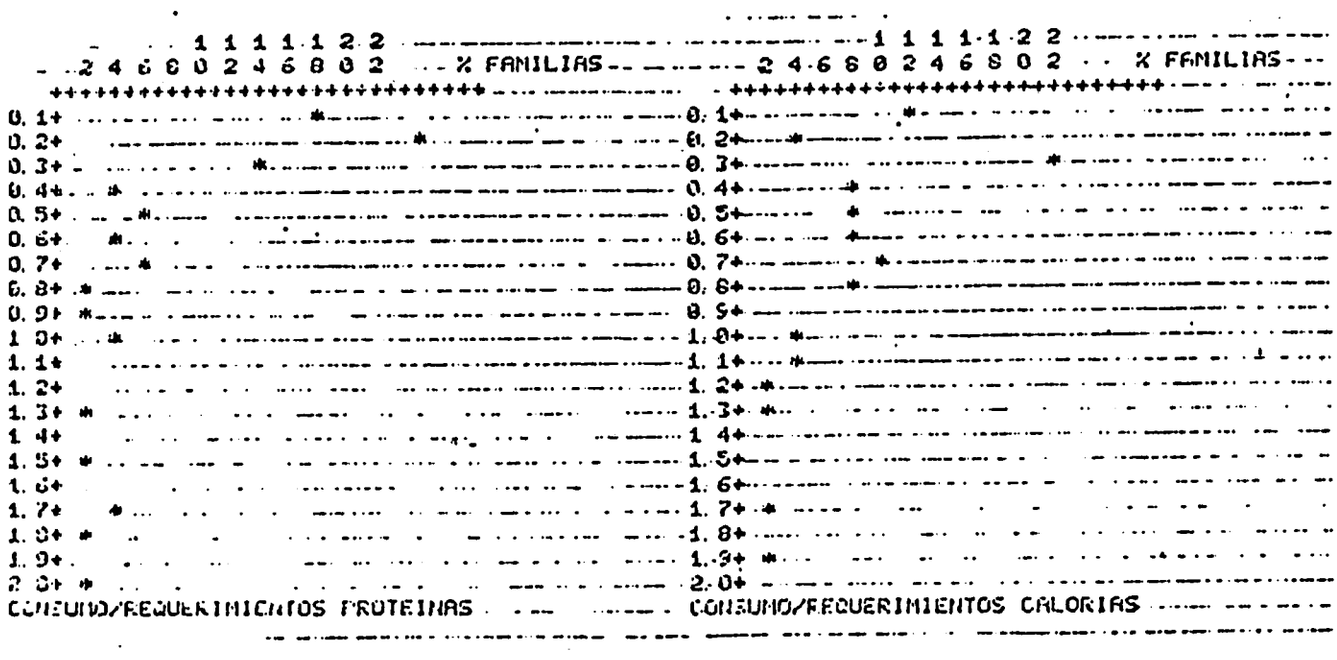
ROSAS (URBAN + RURAL)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	40	50%	50%
Height/Standard height for height:	0-6 years	40	48%	52%
Weight/Standard weight for actual height:	0-6 years	40	80%	20%

ROSAS (URBAN + RURAL)

Calorie Requirements per family per day	16,541
Protein Requirements per family per day	343 grams
Calorie Consumption per family per day	8,770
Protein Consumption per family per day	165 grams
Absolute Gap of calories per family per day	7,145
Absolute Gap of proteins per family per day	149 grams



Distribution of Nutrients Among Families

ROSAS (URBAN + RURAL)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	22	14	20	11	11
Rice	16	8	14	8	8
Milk	13	7	4	7	2
Plantain	9	9	20	4	11
Bread	7	6	5	4	3
Beans	6	2	2	3	1
Potatoes	5	4	5	2	3
Corn	4	1	3	2	2
Eggs	2	3	0	1	0
Lentils	2	0	0	1	0
Wheat flour	2	0	7	1	4
Banana	2	2	2	1	1
Brown sugar	1	11	17	0.5	10
Cassava	1	3	4	0.5	2

n = 48 families

Protein requirements: 343g (Average per family day)

Calorie requirements: 16,541 (Average per family day)

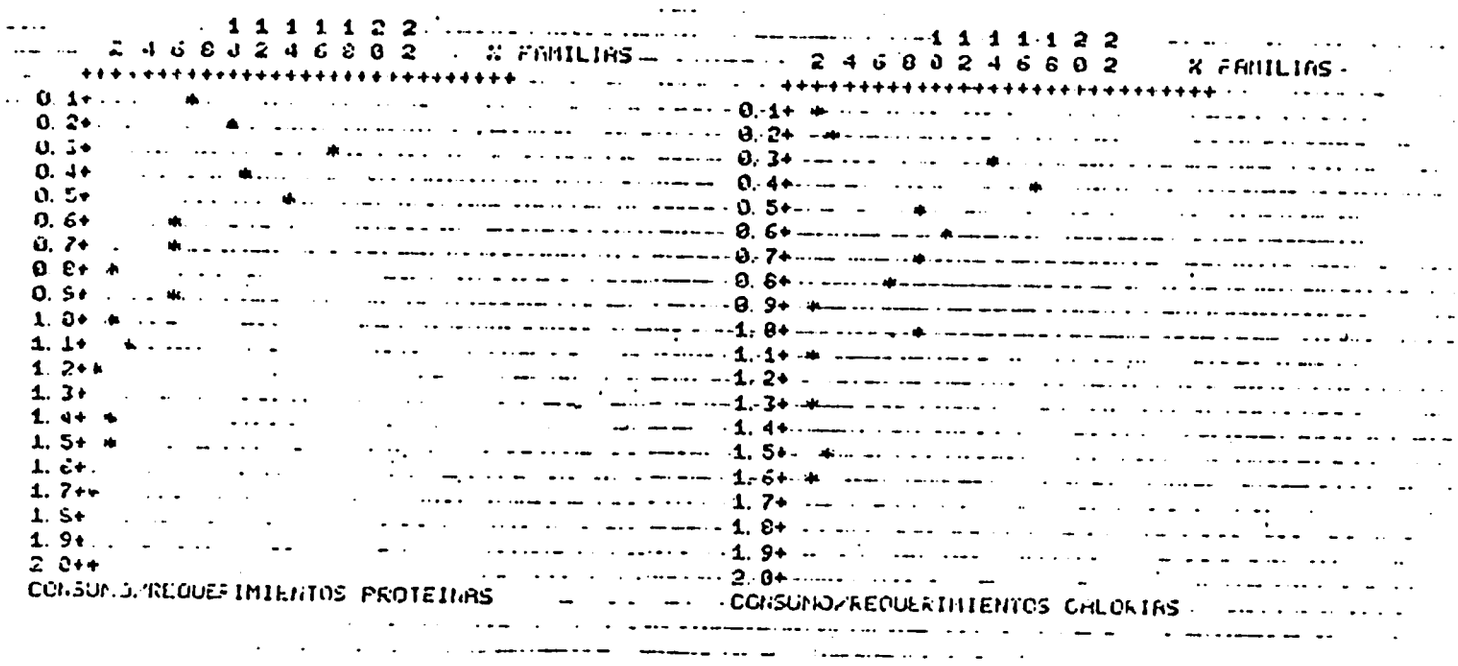
MORALES (URBAN + RURAL)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	64	45%	55%
Height/Standard height for height:	0-6 years	64	44%	56%
Weight/Standard weight for actual height:	0-6 years	64	72%	28%

MORALES (URBAN + RURAL)

Calorie Requirements per family per day	14,342
Protein Requirements per family per day	305 grams
Calorie Consumption per family per day	9,947
Protein Consumption per family per day	177 grams
Absolute Gap of calories per family per day	3,894
Absolute Gap of proteins per family per day	144 grams



Distribution of Nutrients Among Families

MORALES (URBAN + RURAL)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	17	26	6	17	4
Brown Sugar	10	1	15	1	11
Plantain	9	9	20	6	15
Milk	8	4	1	3	1
Rice	7	16	14	10	10
Potatoes	6	6	6	4	4
Coffee	5	1	0.3	1	-
Corn	5	16	12	10	9
Fat	4	-	7	-	5
Eggs	3	2	0.5	1	-
Bread	2	3	2	2	1
Cassava	2	0.8	3	1	1
Soup bones	2	-	-	-	-
Powdered milk	2	1	0.4	1	-
Oil	2	-	2	-	1
Sugar	2	-	6	-	4
Onion	1	-	-	-	-
Pasta	1	2	1	1	1
Chicken	1	0.5	-	-	-

n = 76 families

Protein requirements: 305 g (Average per family day)

Calorie requirements: 14,343 (Average per family day)

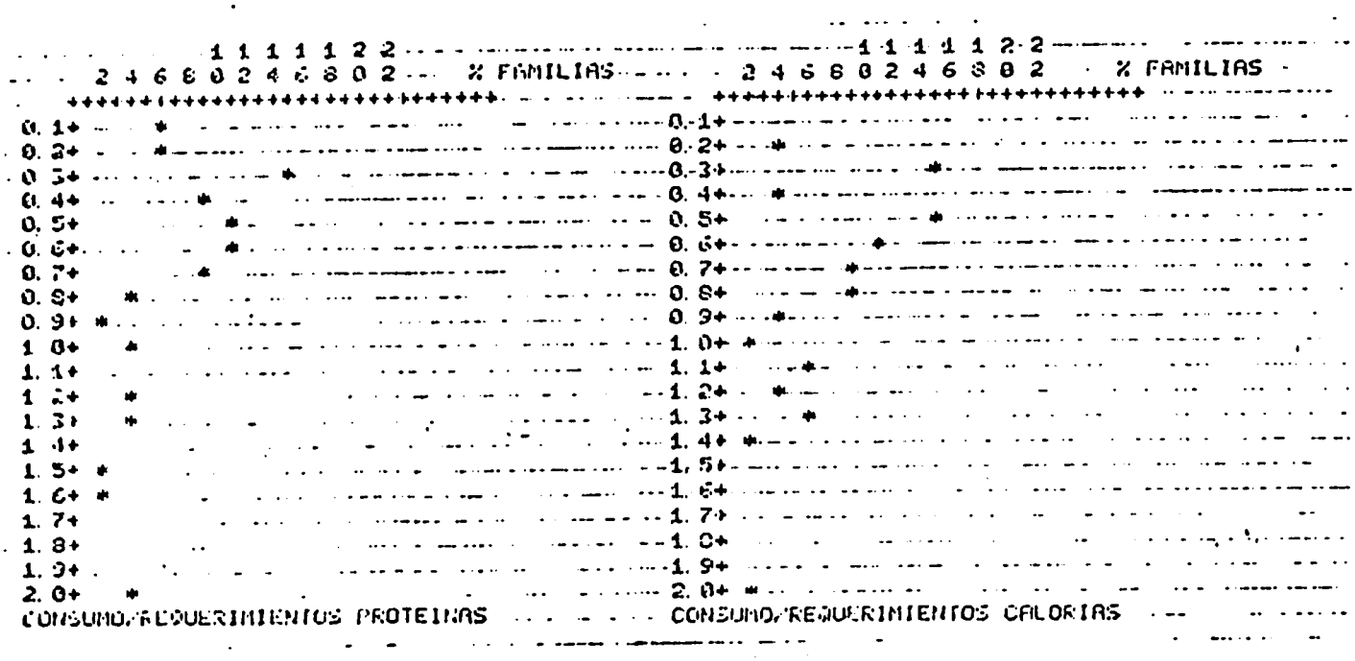
COCONUCO (URBAN + RURAL)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	57	40%	60%
Height/Standard height for height:	0-6 years	57	43%	57%
Weight/Standard weight for actual height:	0-6 years	57	78%	22%

COCONUCO (URBAN + RURAL)

Calorie Requirements per family per day	13,977
Protein Requirements per family per day	295 grams
Calorie Consumption per family per day	9,750
Protein Consumptt ion per family per day	192 grams
Absolute Gap of calories per family per day	3,727
Absolute Gap of proteins per family per day	97 grams



Distribution of Nutrients Among Families

COCONUCO (URBAN + RURAL)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Potatoes	17	18	17	12	12
Coffee	15	1	-	1	-
Brown Sugar	10	1	16	1	12
Corn	10	27	20	18	15
Milk	7	12	4	8	3
Fat	6	-	8	-	6
Rice	6	10	9	7	7
Meat	5	5	1	3	1
Eggs	4	2	-	1	-
Plantain	3	3	6	2	4
Sugar	3	-	7	-	5
Bread	2	2	1	1	1
Ullucos	2	2	1	1	1
Wheat flour	2	5	2	3	1
Pasta	1	2	1	1	1
Cabbage	1	-	-	-	-
Beans	0.9	2	-	1	-

n = 44

Protein requirements: 295 g (Average per family day)

Calorie requirements: 13,977 (Average per family day)

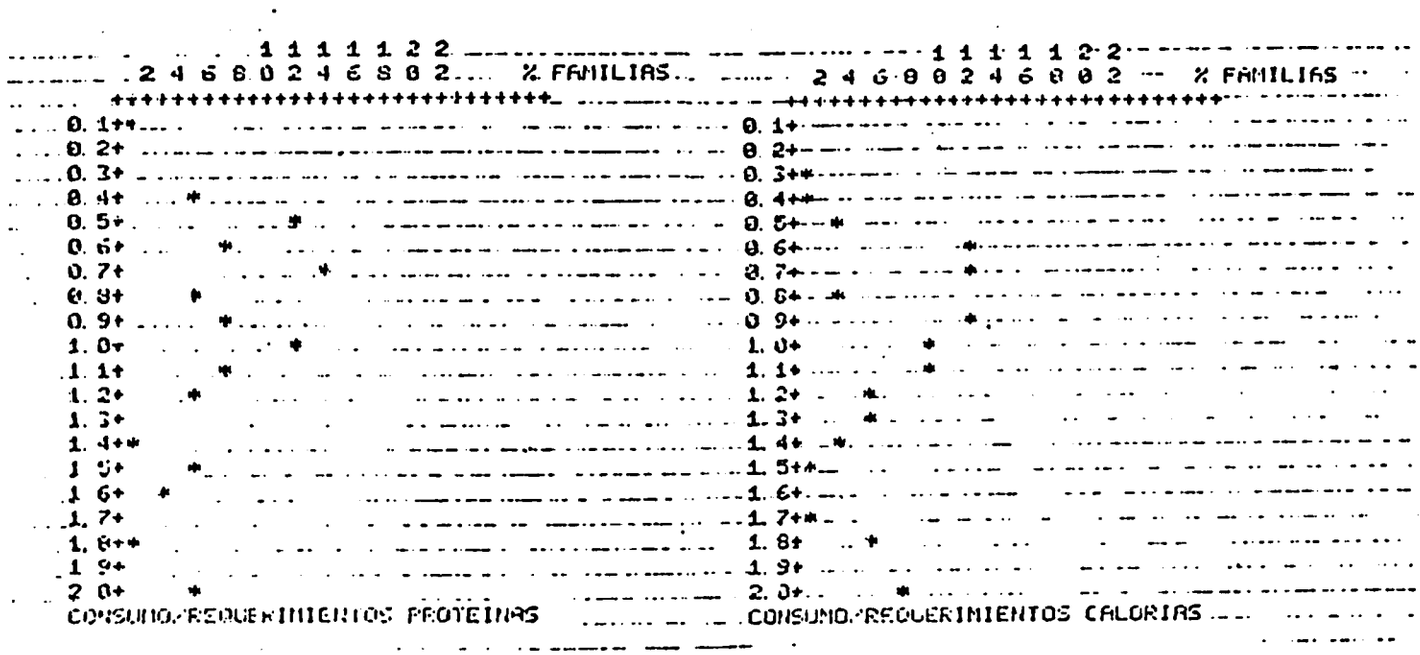
ORTIGAL (URBAN)

ANTHROPOMETRIC SURVEY - PERCENTAGE DISTRIBUTION

	Age	Sample Size n	Well Nourished N	Malnourishment (All Grades)
Weight/Standard weight for age:	0-6 years	85	47%	53%
Height/Standard height for height:	0-6 years	85	38%	62%
Weight/Standard weight for actual height:	0-6 years	85	78%	22%

ORTIGAN (URBAN)

Calorie Requirements per family per day	12,741
Protein Requirements per family per day	269 grams
Calorie Consumption per family per day	12,481
Protein Consumption per family per day	240 grams
Absolute Gap of calories per family per day	241
Absolute Gap of proteins per family per day	22 grams



Distribution of Nutrients Among Families

ORTIGAL (URBAN)

Variable	% Cost	% Proteins	% Calories	Protein / Requirements	Calories / Requirements
Meat	18.1	20.4	4.8	19.2	5.0
Rice	9.7	22.4	19.6	21.0	20.3
Plantain	8.0	8.6	19.3	8.1	20.3
Coffee	7.5	0.7	0.4	0.6	0.4
Powdered Milk	5.3	4.1	1.3	3.9	1.3
Oil	5.2	--	--	--	4.4
Fat	4.9	--	--	--	6.8
Sugar	4.3	--	15.6	--	16.3
Eggs	2.3	2.8	0.7	2.6	0.7
Brown Sugar	3.9	0.5	5.4	0.4	5.6
Beans	3.9	10.0	2.8	9.3	2.9
Potatoes	2.8	5.7	5.2	5.3	5.4
Chocolate	2.7	0.4	0.9	0.4	1.0
Milk	2.1	2.5	0.8	2.3	0.9
Pasta	2.0	2.6	1.6	2.5	1.7
Bread	1.8	2.3	1.6	2.2	1.7
Corn	1.4	4.1	3.0	3.8	3.1
Onion	1.3	0.4	0.2	0.4	0.2
Lentils	1.3	2.5	0.6	2.3	0.7
Tomatoes	1.0	0.2	--	0.2	--
Cheese	1.0	1.2	0.3	1.1	0.4
Wheat flour	1.0	3.0	1.3	2.8	1.4
Fish	0.7	0.6	--	0.5	--
Cassava	0.6	0.3	0.9	0.2	0.9
"Arepa"	0.5	0.9	0.7	0.9	0.8
Carrots	0.5	0.2	0.2	0.2	0.2
Chicken	0.4	0.4	--	0.4	--
Orange	0.4	0.2	0.2	0.2	0.2

N = 54 families

n = 54 surveys

IV. THE INSTRUMENTS

THE DIAGNOSIS OF MALNUTRITION - ANTHROPOMETRIC MEASUREMENTS

The methodology currently used to assess the Nutritional Status of individuals can be grouped under three categories:

1. Comparing the nutrient intake with the nutrient requirement according to age, sex, and physiological state. This method can be used for all individuals in population groups. The problem of the assessment of actual nutrient requirements remains unresolved.
2. Biochemical test involving the analysis of total protein and serum albumin, urine, excretion of creatinine, creatinine/hydroxiproline, index, etc. Although such procedures assess the Nutritional Status, their implementation under field conditions is difficult.
3. Anthropometric measures that detect deviations of growth as related to given standards. As growth occurs only in children and adolescents, anthropometric measurements can only be used for individuals in these age groups. Anthropometric measurements have been used in the project to assess the Nutritional Status of the communities under investigation.

The anthropometric measures used are mid-arm circumference/age, head circumference/age, weight for age, height for age, and weight for height.

The objective is to analyze those anthropometric measures with respect to accuracy, sensitivity, specificity, cost and optimum performance under field conditions.

The relation between deviation of growth and malnutrition is not specific because other diseases could alter the patterns of growth in the same direction as malnutrition. There are two kinds of deviations of growth that anthropometric measures may detect; one is related to age, and the other to body proportions.

It is assumed that a given child may present either Acute (wasting) Malnutrition, Chronic (stunting) Malnutrition, or both.

Acute Malnutrition is defined here as a deficit of the child's weight with respect to the ideal weight for his/her height. Ideal weight is defined as the mean value of weights for a given height of children from a "normal reference" population.

$$P(T) = \frac{\text{Actual weight of child (in Kg.)}}{\text{Standard weight for actual height of child.}}$$

The standard deviation (SD) of this variable for a normal population in all age categories between 0-6 years is 0.1 (10%). The P(T) value of 1-SD = 0.9 is the limit value used to detect malnutrition. P(T) values less than 0.9 indicate acute malnutrition, and represent an actual deficit of either calories or proteins or both.

Chronic Malnutrition is defined as a deficit of the height of the child with respect to the ideal (standard) height for his/her actual age. Ideal height is defined as the mean value of height for a given age of children from a "normal reference" population.

$$T(E) = \frac{\text{Actual height of child (in cm.)}}{\text{Standard height for actual age of child}}$$

The standard deviation of this variable for a normal population is 0.05 (5%). The T(E) value of 1-SD = 0.95 is the limit value below which Chronic Malnutrition is detected. Chronic Malnutrition represents the actual effect on the growth of the child as a result of one or several episodes of Acute Malnutrition suffered in the past. Essentially, this indicates a variable grade of deficit of height with respect to age.

Global Malnutrition. This term is used here to represent one single indicator for either Acute or Chronic malnutrition, or both occurring simultaneously in the same individual. One approximation for the quantification of Global Malnutrition is the use of the product of the variable P(T) and T(E). That is:

$$P(T(E)) = P(T) \times T(E)$$

Because the two variables have different standard deviations, their relative influence should be homogenized. This is done by making the

SD of the two variables about the same. As already noted the SD of the variable P(T) is twice the SD of variable T(E). Hence,

$$P(T(E)) = (2\ T(E) - 1)\ P(T)$$

This relation increases the interval in which the measures of Chronic Malnutrition vary. Similarly, by using the relation

$$P(T(E)) = (0.5\ P(T) + 0.5)\ T(E)$$

the interval for the variable P(T) of acute malnutrition is reduced.

In the first case the value of P(T(E)) below which Global Malnutrition is detected is 0.9; in the second case the limit value of P(T(E)) to detect Global Malnutrition is 0.95.

A. Material and Methodology

Data from two surveys involving 800 preschool children (0-6 years old) from urban and rural populations were used for the analysis. For each child the following data were collected: age, height, weight, sex, mid-arm circumference, head circumference and elbow circumference. The measurements were analyzed by comparing them with the reference values for the Colombian population (derived from measurements of children of high income families from Bogota).

Children for the urban survey were selected from nurseries and outpatient clinics in Cali and were mainly whites. Children for the rural survey were randomly selected from 5 different communities in the Cauca state. They were mainly of black or mestizo origin.

B. Performance Characteristics

Several factors may influence the decision as to what anthropometric method to use when assessing malnutrition. For the purpose of this discussion the following criteria are used: accuracy, sensitivity, specificity, cost and degree of difficulty for implementation under field conditions.

To facilitate the trade-off between these factors in deciding what methodology to use, it was necessary to analyze the characteristics of the instrument for each method, and for the method per se.

The instruments studied were weighing scales, infant meter, arm tape, head tape, and age, for behavior on the following variables;

1. Standard error SE
2. Percent error (error%) = $\frac{\text{Standard error}}{\text{mean value of the range of the instrument readings}}$
3. Field performance: degree of simplicity in the use of the instrument.
4. Transportability: ease with which instrument can be transported.
5. Durability: the half life of the instrument under rough field conditions.
6. Cost of the instrument.
7. Time spent in the use of the instrument for performing its designated activity.

The standard error includes both the random error and the systematic error due to the instrument. The standard error was calculated by performing the anthropometric measures several times on the same group of children.

For the percent error calculation, the range of readings refers to the maximal variation obtained with the instrument when measuring normal children 0-6 years old.

For the other variables, an ordinal scale between 0-10 was constructed, where the 0 corresponds to optimal performance and 10 to worst. For example, in Table I, on the following page, the Cost value for "AGE" is "0", meaning there is no cost; Field Performance values of 4 for the Infant Meter and 2 for the Weighing Scale mean that, under field conditions, it is easier to work with the Weighing Scale than with the Infant Meter.

TABLE I

PERFORMANCE OF THE INSTRUMENTS

(Urban and Rural Settings)

Instrument	Units	Standard Error	Error Percent	Field Performance	Transportability	Durability	Cost	Time
Arm Tape	cms	0.28	0.02	1	1	2	1	1
Head Tape	cms	0.22	0.005	2	1	2	1	2
Infant meter	cms	0.65	0.08	4	4	3	2	3
Weighing scale	Kg.	0.5	0.05	2	2	4	3	4
Age	months	0.5	0.014	1	0	0	0	1

The instrument with the least standard error is the Head Tape, while the measurements taken with the Infant Meter have the greater standard error. It is important to recall that these observations refer to the communities we have studied. In other communities, Age may have the greatest standard error, due probably to cultural or other characteristics.

Once the instrument performance is defined, we can turn our attention to the method performance. Again, a series of characteristics inherent in each method can be analyzed in conjunction with some of the characteristics of the instruments used to carry out the measurement.

The anthropometric measurements to be analyzed are expressed as the relation between the actual measure and the value of such measure taken of a child considered as well nourished. In addition to the variables P(T), T(E), P(T(E)) already defined, the following anthropometric measurements are included:

$$CB(E) = \frac{\text{mid-arm circumference}}{\text{standard mid-circumference for actual age}}$$

$$CC(E) = \frac{\text{head circumference}}{\text{standard head circumference for actual age}}$$

$$P(E) = \frac{\text{actual weight}}{\text{standard weight for actual age}}$$

Appendix A describes the mathematical procedure for the calculation of the standard error of the methods from the standard error of the instrument.

The values for the variables: field performance, transportability, durability, cost and time refer to the instruments used, not to the method per se. The values are in an ordinal scale.

TABLE II

PERFORMANCE OF METHODS

Method	SE	Error Percent	Field Perform-ance	Transport-ability	Durability	Cost	Time
CB(E)	0.02	0.02	1	1	1	2	1
CC(E)	0.007	0.007	1	1	2	1	2
P(T)	0.09	0.09	5	5	5	4	5
T(E)	0.03	0.03	4	4	3	2	3
P(E)	0.06	0.06	2	3	4	3	4
P(T(E))	0.95	0.95	6	6	6	4	4

From Table II we can see that variables CB(E) and CC(E) have the best performance characteristics for all the characteristics studied

It is interesting to note the way in which the measurement error affects the method sensitivity and specificity. Suppose the SE for the measurement of height is 0.65 cms. and that for weight is 0.5 kg.; both are represented in the SE of the variable P(T) with an error of around 9%. If we then define the coefficient of variation for the variable P(T) for a population of normal children 0-6 years to be 10%, the specificity and sensitivity of the weight for height measure may be seriously affected around the value of P(T) = 0.9, i.e., the limit between the two categories of well nourished and malnourished children.

C. Correlation Analysis

In order to study the relations between the different anthropometric methods, regression and correlation analysis was performed for the two samples treated as a single population.

TABLE III

CORRELATION COEFFICIENTS

	P(E)	P(T)	T(E)	P(T(E))	CB(E)	CC(E)
P(E)	1					
P(T)	R=0.6 (F=591)					
T(E)	R=0.7 (F=0922)	R=NS F=NS				
P(T(E))	R=0.96 (F=5878)	-	-			
CB(E)	R=0.62 (F=593)	R=0.47 (F=195)	R=0.4 (F=131)	R=0.68 (F=816)		
CC(E)	R=0.45 (F=198)	R=0.22 (F=143)	R=0.42 (F=161)	R=0.47 (F=215)	R=0.37 (F=127)	
CO(E)**					R=0.97 (F=8515)	

R = Correlation coefficient
F = Of the regression line
** = Elbow circumference for age

From Column 1 Table III, we can observe that variable P(E) correlates significantly with both P(T) and T(E). In other words, variable P(E) tends to detect both acute and chronic malnutrition. Again, since variable P(E) has a high correlation with variable P(T(E)), it may be concluded that variable P(E) is also a measure of Global Malnutrition. The question is: What is the sensitivity and specificity of the weight for age (Gomez classification) measure?

On the basis of the strength of association between P(E) and P(T(E)) it can be said that:

1. For a child with both acute and chronic malnutrition, the probability of the Gomez Method, i.e., (P(E)) to detect such a child as malnourished, is 100%. If $P(T) < 0.9$ and $T(E) < 0.95$, then the product $P(T) \times T(E) < 0.9$ lies below the limit for detection of malnutrition by the Gomez Method.
2. For a child with either acute or chronic malnutrition, the probability for the Gomez Method (P(E)) to detect him as malnourished, depends on the values of both variables P(T) and T(E) and not only on the value of variable which classified the child as malnourished. Fig. 1 shows this relationship.

For example, if T(E) = 1.1 the probability for the Gomez Method to detect malnutrition is 1 only if the variable P(T) is 0.65. That is conceivable in a very severe case of Acute Malnutrition. On the other hand, if a child has mild Acute Malnutrition, $0.82 \leqslant P(T) \leqslant 0.9$, and his height with respect to age T(E) is $\geqslant 1.1$, then the product $P(T) \times T(E)$ will tend to be high. In this case, the probability for this child to be detected as malnourished by the Gomez Method (i.e., P(E)) is very low.

In conclusion, the sensitivity of the Gomez Method is low when gigantism is associated with acute malnutrition. For the sample analyzed it was found that the Gomez Method does not detect 15% of the cases of Acute Malnutrition and 14% of the cases of Chronic Malnutrition.

For a child classified as well nourished by his weight and height and height for age, with values of P(T) and T(E) near the lower limit of 0.9 and 0.95, there is high probability for such a child to be classified as malnourished according to the Gomez Method. The P(T) and T(E) value tends to be low. For the sample of this study, 10% of the well nourished children were classified as malnourished by the Gomez Method. Nevertheless, as a method that detects at-risk children, this low specificity may be considered as an advantage rather than a defect.

From the observation of columns 1 to 5 and rows 5 and 6, we can say that:

1. mid-arm circumference CB(E) is a better indicator of Global Malnutrition than head circumference (CC(E))
2. head circumference CC(E) is closely related to Chronic Malnutrition, while mid-arm circumference correlates better with Acute Malnutrition. But because CB(E) correlates with both T(E) and P(T), it is a poor indicator of either Acute or Chronic Malnutrition.

The surprising low correlation between T(E) and P(T) can be explained with a chronological perspective of the occurrence of malnutrition in the studied population. Figure 1 shows the mean value of variables P(T) and T(E) for the different age groups.

It can be seen that Acute Malnutrition tends to rise during the first two years and then decline, while Chronic Malnutrition takes a longer time to appear: it may be said to follow a monotonic curve. Under these conditions, a close association between Chronic and Acute Malnutrition can not be expected.

CONCLUSION

From an analysis of the instruments and methods used for anthropometric evaluation of the state of nutrition of individuals we concluded that mid-arm circumference and head circumference have the smallest instrumental error and the best characteristics of field performance with regard to the weight for age methods. These have instrumental errors comparable in magnitude to the standard deviation of their distribution for normal populations.

From a regression and correlation analysis for the different anthropometric methods it was concluded that:

1. The Gomez Method P(E) of comparing weight for age tends to detect cases of Acute and Chronic malnutrition, but loses sensitivity in the cases of Acute Malnutrition associated with taller-for-age children.

2. Mid-arm circumference and elbow (CO(E)) circumference are measures of Global Malnutrition, while head circumference is a measure of Chronic Malnutrition.

THE COMMUNITY GAP

A. Definition of Community and Its Limits

Community is a broad concept which can be applied in a variety of situations. It can include few families as well as many thousands of persons. According to Tonnies, we can distinguish basically two kinds of communities: "Gemeinschaft" and "Gesellscaft". The first one is a kind of traditional folk-society held together by common values, mutual dependence, strong kinship relations among all the members of the society; the second definition refers to a kind of community where relations are more formal and regulated through official agencies. Our definition is quite general and can include both of them: any cluster of urban and/or rural population interacting on the basis of socio-economic or cultural relations is eligible as our target community.

Once a community has been selected for the nutritional study, the first step, before any field work, is to define the limits of the community from which one statistical sample shall be drawn. The definition of the community limits is necessary because the total food produced within the community area, and the total nutrients required for adequate nutrition by its inhabitants are both non-linear functions of the size of the community, and can have a determinant weight in the design of interventions. Although many criteria have been investigated which could help in the definition of community limits, we have chosen for our field work to respect the community boundaries according to the administrative or fiscal limits of the political unit (generally the "municipio") which the area belongs to. There are several reasons for this decision:

- In case of nutrition intervention, it can be uneasy (or unfair) to discriminate among population clusters belonging to the same territorial jurisdiction;
- Institutional involvement in terms of resources, collaboration, etc., is almost always allocated in a

prefixed "amount" to areas with well defined political boundaries;

Already existing information generally refers to areas or regions with political boundaries; similarly, the nutritional data collected by our field team can be more useful to other agencies if it is congruent with their jurisdictions.

Once the political boundaries have been established for a community, we can exclude from it any subarea or cluster which presents one or both of the following characteristics:

1. Land tenure patterns in the subarea are quite different from the prevailing ones and its agricultural output is completely directed to outside markets. This is, for example, the case of rich land owners who, within the area of poor farmers, grow cattle for exportation.
2. Specific economic or industrial settlements which bear little or no economic or socio-cultural relations with the area, with the possible exception of some job opportunities for low skilled workers of the area. This can be the case of a mine managed by a foreign corporation which absorbs some 10% of the labor force of the community.

Therefore a cluster or subarea, though located within the physical boundaries of the community, can be kept outside of the definition of the target community; yet the design of a nutrition intervention which aims at improving the nutritional status of the target community can take all of them into account as active components of an interacting socio-economic system.

B. <u>The Community Gap Definition</u>

Within the general framework of the Nutrient Flow Theory, many definitions of Community Gap could have been proposed. However, we needed one which:

- Was easy to measure;
- Its gap closure represented the condition "sine qua non" for the closure of the Family and Individual Gap; and
- It could give an aggregate picture of the nutrient balance of the community.

In the definition finally chosen, the Community Gap is calculated as the difference between the community requirements and the actual availability of nutrients (proteins and calories).

We have definied the Community Gap as:

$$CG = CR - P - I + E$$

where CG is the Community Gap, CR is the community requirement for nutrients calculated by summing up the daily requirements of each of its members, P is the total food produced within the area, I is the total food imported, and E is the amount of food produced within the area but exported outside. All of them are expressed as quantities per day.

In our analysis we distinguish between the Community Gap of food and the Community Gap of nutrients. The first one refers to commodities which belong to the dietary habits of the community; the second one refers to commodities which, though suitable for human consumption, are not consumed by the community under study. This disaggregation is necessary because:

1. It allows a clearer etiology of malnutrition. For example, in the case of a positive Community Gap it is useful to know if the community produces a very little amount of food and nutrients or if it produces a little quantity of food but a lot of nutrients which are exported.
2. It allows a more comprehensive and realistic analysis of the possible alternative interventions and their combinations. As a matter of fact, a nutrient based intervention can present implementation costs, response time, nutritional impact, etc. quite different from an inter-

vention based on food, or can involve a quite different strategy of resource allocation.

C. Interfamily Food Distribution

By interfamily distribution of food we mean here the patterns of food purchasing among families of a community according, not only to the nutritional needs of each family, but also to its income, tastes, marginal utility of food with respect to other goods, etc. The degree of homogeneity of food consumption among families is quite important in the case of malnourished communities because it can affect the strategy and resources of the planned intervention. If all the families have the same gap, we say that the distribution of food is optimal; if not, the distribution is biased. In order to measure this bias relative to a community, we propose here some ways which can be useful in designing nutritional interventions. Of course, this list is not exhaustive:

1. To calculate the Lorentz curve and Gini coefficient;
2. To calculate the expected increase of the Nutritional Gap at a community level with respect to the same gap calculated under conditions of optimal intrafamily distribution;
3. To calculate the mean value of the distribution curve and its standard deviation
4. To calculate the difference between the mean value of the gap for families with positive gap.

We have chosen the second method because it looks more useful for nutrition planning applications.

If all the families of a community have the same relative gap

$$GR = \frac{Ri - Ci}{Ri}$$

where Ci is the average daily amount of nutrients available to the family and Ri is its requirements.

When the Family Gap is closed for all the families of the community,

we have

GR = for all the families, and

$$\sum_{i=1}^{NF} Ri = X$$

represents the total nutrients available at the community level with perfect interfamily distribution. If there are no losses due to storage, transportation, etc. within the community, X is the amount needed to close the Community Gap. We assume here that these kinds of losses are negligible. We can calculate now how much X is increased where there is a biased interfamily distribution. This can be done bearing in mind two assumptions:

1. The Community Gap is closed without changing the distribution patterns of food among families, i.e., by increasing the family consumption of all the families by the same quantity Q until at least 80% of the families have met their requirements (we cannot say 100% because in this case Q would be constant for each community irrespective of the interfamily distribution of food). This corresponds to shifting the gap distribution curve horizontally, without changing the shape of it.
2. To close the community and family gap by giving to each family with a positive gap just the exact amount of food which is needed in order to close the family gap. Obviously, this procedure does not affect families with negative gap.

Thus, if X is the total consumption of the community, in the case of optimal intrafamily distribution, we need to increase X by a quantity KX, in the case of a biased distribution so that we have

$$X' = X + Kx = X(1+K),$$

where K is expressed as % of X and is an indirect index of the bias in the food distribution patterns among the families of a community. In the case of assumption 1, in order to define K, we need to:

1. Calculate the actual average consumption C_1 of the community;
2. Calculate the minimum additional consumption C_2 which is needed to fulfill the nutritional requirements of 80% of the community families, with the given patterns of interfamily food distribution;
3. We have $K = \frac{C_1 + C_2}{X} - 1 = K(1)$

In the case of assumption 2, K is given by the following procedure:

1. Evaluate the excess consumption C for families with negative gap.
2. We have $K = \frac{C}{X} = K(2)$

Generally if $K(1) \geqslant K(2)$, as the first assumption implies, the possible intervention operates in a free market context, and the second in a controlled market situation. In the real case, K is probably between K(1) and K(2):

$K(2) \leqslant K \leqslant K(1)$

For Villa Rica and 4 other communities of Northern Cauca, we give here the values of K(1) and K(2)

COMMUNITY	K(1)	K(2)
Villa Rica	1.45	1.10
Rosas	1.31	1.04
Morales	1.34	1.04
Piendamo	1.50	1.02
Coconuco	1.41	1.05

According to these data, it seems that Villa Rica has the most biased distribution. Nevertheless, we should take two conditions into account:

1. Villa Rica presents the worst environmental sanitation conditions which are strongly related to the incidence of infectious diseases among families and young population

groups of the community. This fact tends to bias the food distribution patterns among families when some families try to meet their requirements.

2. As Villa Rica was the first "pueblo" to be surveyed by our team, the incidence or random and systematic errors due to interviewers ability to carry out a survey is probably high in this case. Therefore, these errors tend to increase the bias of the intrafamily distribution curve more than they do for the other pueblos. For these important reasons, we can not say that Villa Rica's intrafamily food distribution is quite bad. This fact needs to be taken into account in the design of interventions.

D. The Community Gap Analysis

The Community Gap (CG) is calculated as the difference between the community requirements (see previous report) and the actual availability of nutrients (proteins and calories):

$$CG = CR - P - I + E$$

where P is the agriculture production of the rural area, CR is the community requirement calculated by summing up the DR (daily requirements) of each of its members, I is the total food imported and E is the amount of food produced within the area but exported outside. All of them are expressed as quantities per day.

The available data for the community of Villa Rica, Colombia, shows a deficit (gap) of approximately 125,000 grams of proteins and 5,000,000 calories per day. This represents respectively 33% of protein and 30% of calorie requirements. The area which encloses the target community measures approximately 4000 hectars and includes 1300 families, of which 44% belong to the urban area. Almost 75% of the total area belongs to big farms with capital-intensive technology and export-oriented production of cattle and cash crops like sugar cane and soybeans. The other 25% belong to small farmers who represent about 95% of the rural population with an average income less than 1.5 (one and half) dollars per

day. The traditional crops of this subsistence sector were cocoa, coffee, and plantain. Today, all of the above three crops are in the process of being replaced by beans, soybeans, and corn. As this poor sector, together with the urban sector of Villa Rica represents our target community, all the quantities listed (P, I, E) refer to it and do not include the agriculture production of the modern sector which is entirely destined for export. The agricultural production of the subsistence sector is mainly exported (only 5% is used for local consumption) toward national urban markets. If the process could be reversed and the export of the agricultural production relative to the subsistence sector stopped and only commodities produced in the area would be used for community consumption, there would still be a Community Gap (as defined before) of 35% of calories while one third of the total protein production would be enough to close the relative gap at the community level.

How do we close the community gap under these conditions? Referring to our definition of community gap, we can say that there are in general three ways of doing this:

- by increasing the agricultural production;
- by increasing food imports;
- by decreasing agricultural exports in order to use locally produced food for local consumption.

1. Increasing the Agricultural Production

   This could be accomplished by increasing the average size of the farms or by increasing productivity. Farm size cannot under the present situation, be increased for the community of Villa Rica. The subsistence sector cannot compete for land on the free market with the modern agriculture sector which is gradually displacing the traditional or subsistence one, in the absence of an adequate government intervention.

   How much increase in the agriculture productivity of the

traditional sector do we expect in order to close the Community Gap for Villa Rica? In order to answer this question, we need to distinguish between commodities which belong to the dietary habits of the community and those which do not. We refer to the first as food and to the latter as nutrients. If we decide to increase the production of food instead of nutrients, it should satisfy the relation:

Total Average amount of food produced per day

$$CR\ (1+K) \quad (1)$$

Average production per day of farmer i

$$CR_i\ \ (1+d) \quad (2)$$

K is a coefficient which takes into account the unequal interfamily distribution of food as explained before, CR is the total community requirement per day, CR_i is the requirement for farmer i and d is a coefficient which takes into account the fact that a family need not only produce enough food to overcome its nutritional needs, but also leave a surplus for exchange in the market for other goods and services such as education, health, clothes, etc.

One important assumption underlying relation (1) is that the rural area should produce enough food in order to feed the urban sector of the community, i.e., we assume that the criterion of self-sufficiency is valid for a community regardless of its degree of "closeness" with respect to exterior economic markets. It is generally more convenient (from the economic point of view) for the urban sector of a community to buy a large share of its own food from its own rural area rather than from outside, because of the transportation and commercialization costs which, for developing countries like Colombia, are generally high. As for Villa Rica, the total production can be increased only by increasing productivity. We can analyze which change in this parameter is able to satisfy

relations (1) and (2). The basic crops of the area are beans, corn and soybeans. As beans and corn can be adapted to community diet, we consider them as food and soybeans as a cash crop and nutrient.

Beans and corn are consumed in the area in the proportion of 1:2.2. The total land available to small farmers for food production is approximately 900 hectars, which should be shared between corn and beans in a fixed proportion. With the present level of technology this amount of land could produce an average of 14.5×10^6 calories* per day, so that the current productivity should be increased no more than 5% in order to match current production with requirements.

In the area under study, there are about 750 small farmers. This means an average daily production ** of 5.8 kilos (aggregate of beans and corn in the proportion of 1:2.2) of which approximately 70% are to be used for family consumption in order to meet requirements and the remaining production to be exchanged on the market for other foods. With the current technology, the estimated average income per farm is approximately $40.00 pesos (U.S. 1.17 dollars) per day. Therefore $28 pesos (corresponding to 70% of income) would be used for adequate consumption and $12 pesos for other needs.

If the second alternative of buying food from outside and selling cash crops (nutrients) is selected, which produces

* We have made the calculation just for calories and not for proteins because if calorie requirements are met, protein requirements are met too in the case of corn and beans.

** We assumed here that there are no losses in the nutrient flow between production and consumption.

with the current technology approximately the same income of 40 pesos per 1.2 hectars, how much should the average income be increased, in order for a family to be well nourished with its current diet and have about 12 pesos left over for other needs as in the previous case? We know that the average expenditure on food is 32 pesos per day in the rural area, which supplies 70% of family requirements. Therefore, we calculate:

32/07 + 12 = 58 pesos

This average income can be reached only* by increasing productivity 50% relative to cash crops instead of 5% in the previous case. Therefore the actual loss in the process of selling cash crops and buying food can be on the order of 40-50%. In this case relation (1) is realizable if the possibility of converting nutrients to food by introducing a processing stage and getting people to consume it through a massive educational campaign is considered a feasible alternative intervention.

Until now we have analyzed the increase in productivity in order to satisfy the nutrient requirements of a community with perfect interfamily distribution. If agricultural production is used for community consumption and not for the market, the productivity of corn and beans should be increased, not by 5%, but by about 50% if we accept assumption (1) of the previous paragraph, or by 15% if assumption (2) is selected. According to agriculture experts, the productivity of corn, beans, and soybeans can be increased (using better technology) by 3, 2, 1.5 respectively in the area so that those changes seem quite possible. As we made the calculations for the "average" farmer, the problem arises when we take

* We assume here that the price of the agriculture output is fixed; if this is not the case, price improvement can offer another alternative to increase income.

into account the patterns of land distribution among farmers of the area. The following figure gives the Lorentz Curve for land tenure within the total community area of 4,000 hectars.

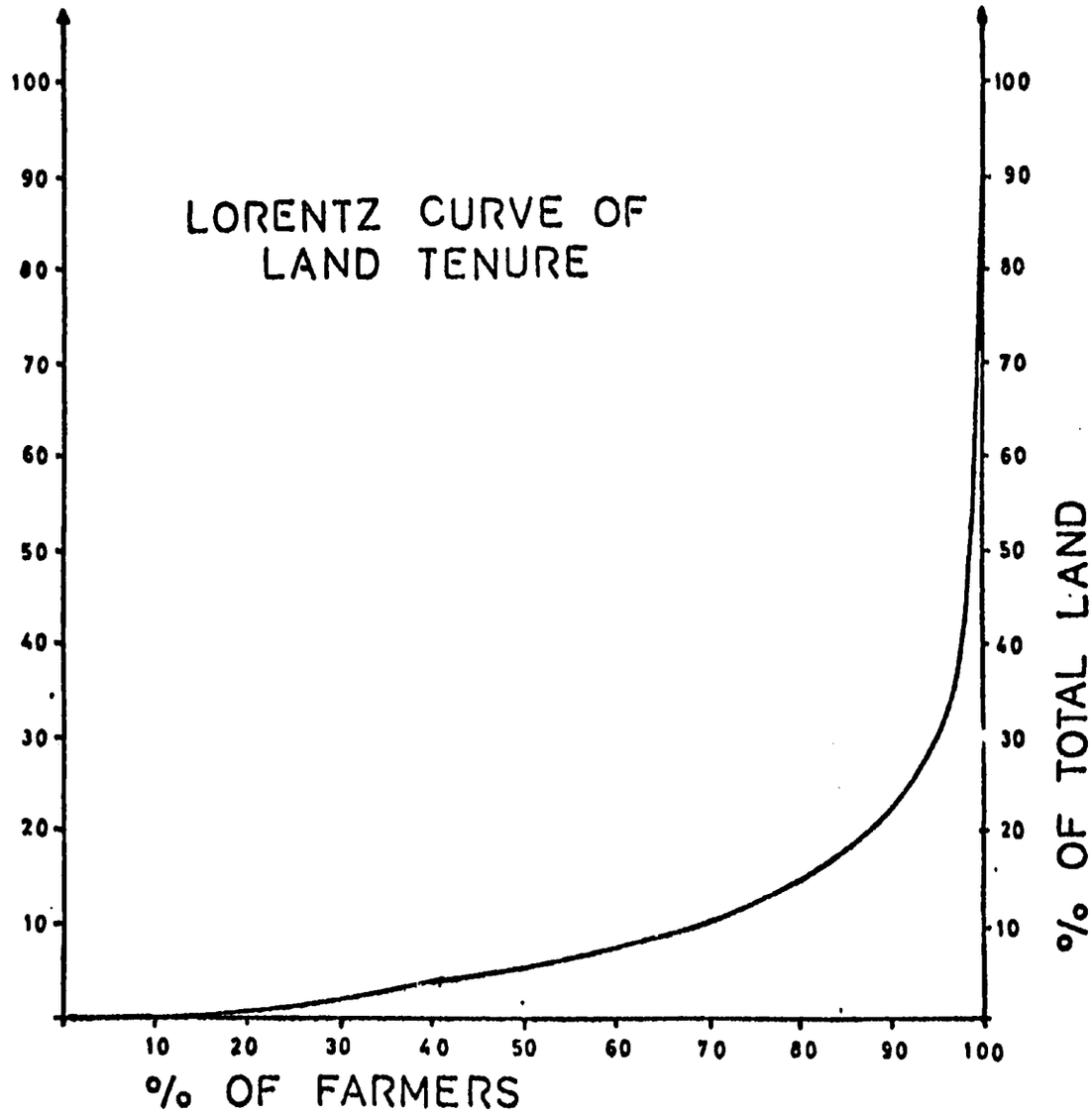


FIG 1

We can see from Figure 1 that 50% of the farmers own only 7% of the total land with an average farm size of 0.7 hectars, and 33% of the farmers own less than 3% of the land: for them, there is no increase in technology which can help, and therefore their requirements should be met by increasing their purchasing power, which calls for increasing food imports.

2. Increasing Food Imports

The second strategy of food importation comes in when it is difficult or impossible to close the Community Gap with the local production, or when the commodities produced need a sophisticated industrial process before being converted to food. When the urban sector produces little or no food it needs to import it from the rural sector of the community or from outside. As we said before, it is generally more convenient for the urban sector to buy its own food from its own rural area, at least for developing countries like Colombia. It is when the purchasing power of the urban sector is too low to retain the agricultural production of the area, that food and nutrients are exported.

In order to get people to import and consume more food, it is necessary to raise income and/or to reduce the cost of food. The first solution calls for higher wages for the community in question, and the second one implies* food purchase through stamps.

Though far from our professional field of research and involvement, income improvement is a kind of alternative intervention which can not be excluded from the analysis,

* If the cost of food in the community is too high with respect to average national levels, market improvements such as transportation, distribution, etc., can reduce that cost.

especially in the case of some manufacturing settlements (transformation industry, food processing, etc.) which present clear comparative advantages for the target community. For example, a food processing industry which can process the soybeans and sorghum produced in the area, present the advantages of proximity to inputs and outputs, markets, cheap labor force, etc. Furthermore it can increase the availability of nutrients at the community level and decrease the cost of nutrients. The possibility of this kind of intervention is being investigated in terms of cost-benefits within the community and the official institutions working in the area.

3. Decreasing Agricultural Export

The last of the three major alternatives aims at reducing the export of nutrients from the area. It can open an interesting field of interventions in nutrition when cheap nutrients are produced in the area which are suitable for human consumption, as in the case of soybeans in the community of Villa Rica. It is generally more time consuming than other kinds of interventions, but it can be less expensive and fairly stable in time if carefully planned and if community participation is progressively utilized. The socio-cultural and technical aspects of this kind of intervention, which almost always implies not only changes in the alimentary habits of the community but also an indirect change in many economic and cultural components of the social system structurally related to food habits, is presented in a specific section of this report.

In order to get an idea of the relative costs of strategies aimed at closing the community gap in Villa Rica, we give here the approximate market value of the food needed daily in order to close the community gap in Villa Rica (rural

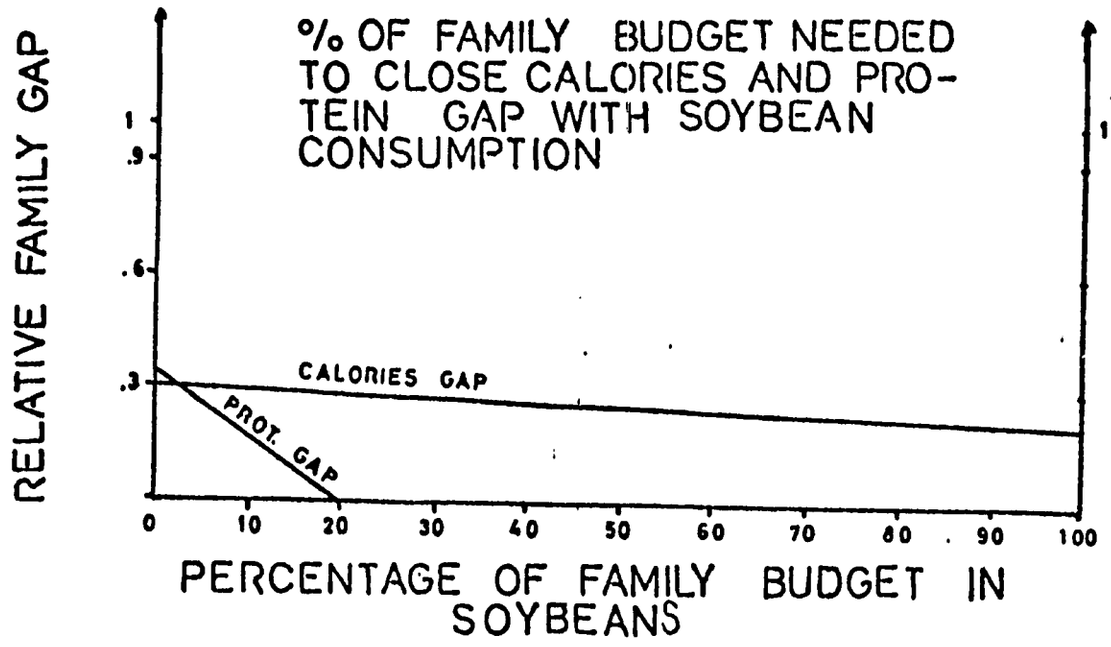
and urban sector). We do it under assumption 2 of the previous paragraph (i.e., that each family gets a quantity of food which is proportional to its gap) and for various combinations of food. As the proportion of one commodity to another can vary in the case of a diet which employs more than one kind of food, the costs presented here correspond to the minimum cost, under the constraints that no commodity can enter the diet with a proportion less than a fixed amount. The limiting gap is the "lagging gap" between the proteins and calories; when it is closed, the second one is automatically closed too.

DIET	MARKET VALUE OF THE DIET (PESOS)	LIMITING GAP
Current Community Diet	29,000	Protein-Calories
Soybeans	18,500	Calories
Corn-Beans	29,000	Calories
Soybeans-Sorghum	17,500	Calories
Soybeans-Plantain	20,500	Calories
Soybeans-Rice	19,300	Calories
Corn-Rice	20,000	Calories
Soybeans-Sorghum Plantain	18,800	Calories
Soybeans-Rice Plantain	20,000	Calories

We have observed that:

a. Except for the community diet, calories determine the limiting gap. If we exclude proteins of high biological value like meat, fish, milk, etc., we can say that in general it is cheaper to close the protein gap rather than the calories gap. That is, on a per unit requirement scale, proteins of vegetable origin are cheaper than calories, at least in Colombia. This may not be true for children who require a diet with higher protein concentration.

b. The costs of the various diets do not differ greatly. As calories define the limiting gap, and the cost of one unit of calories is more or less the same (except for beans which make the third diet a little more expensive) for the various commodities considered, the differences in costs are minimal. The soybeans and sorghum diet represents the cheapest combination because sorghum calories are cheaper than soybean calories*.



* Incidentally, these are the main ingredients of "albondigas" or vegetable meat which is the most popular food prepared at the "Fuente de Soda Tombolita".

If 20% of the current average expenditure on food of the community could be diverted from the actual diet to soybean consumption, it would be possible to close the community gap of proteins but it would leave almost unchanged the calories gap (Figure 2).

This means that when the calories gap is lagging behind (is greater than) the protein gap, or both are of the same order, soybean-based diets can partially lose their comparative advantages. Again, this may not be true in the case of small children because higher protein concentration and higher density of nutrients per volume of food ingested should be taken into account. As we include only market prices in the second column of the previous table, for a more realistic analysis educational costs should be added in order to change the dietary habits of a community when necessary.

c. The current community diet seems to be more expensive than other proposed diets. This is not only due to the fact that we did not include the costs of fruits and vegetables which are necessary components of a diet. If we group the various commodities (excluding fruits and vegetables) in three big groups:

1. commodities which are sources of "noble" protein (meat, fish, milk, eggs, etc.)
2. commodities which are mainly sources of calories (cassava, plantain, oil, sugar, potatoes, etc.)
3. commodities which are mainly sources of vegetable protein (brown rice, corn, soybeans, sorghum, beans, etc.)

> We can say that, at least in Colombia, diets made up with commodities belonging to the first group are generally the most expensive and diets made up from group (3) the cheapest ones. Almost 2/3 of the Villa Rica diet belongs to group (2) and 1/3 to group (3) so that it tends to be more expensive than diets belonging to group (3) which are the proposed ones.

In conclusion, each one of the three major alternatives to closing the Community Gap seems feasible for the community of Villa Rica. The "best" combination of them should be decided with the community itself and with all the technical, economic, and political institutions working in the area.

THE FAMILY GAP AND ENVIRONMENTAL SANITATION

The Family Gap is defined as the difference between the daily requirements R of a generic family and its daily consumption of nutrients C. The two variables R and C can be defined respectively as:

$$a. \quad R = \sum_{i=1}^{NF} Rj\ (Ei, Si)$$

where Rj are the daily requirements of the individual i (in the family) with age Ei and sex Si. NF is the total number of persons in the family considered.

$$b. \quad C = \sum_{J=1}^{NA} Nj\ \ Qj;$$

where Nj is the nutrient content (proteins and calories) per unit of commodity J which belongs to the family's diet and Qj is the mean value of the total amount of commodity J which is available for family consumption every day. Because of random and systematic errors which can affect the measurement of C in our calculations, we actually used an estimation C of C. If we express C in units of R, we get what is called nutrients adequacy A:

$$A = \frac{C}{R}$$

If the absolute gap G is expressed as:

$$G = R - C$$

and the relative gap GR as:

$$GR = \frac{R - C}{R}$$

thus,

$$GR = 1 - \frac{C}{R} \text{ or } 1 - A$$

In the analysis, each of these concepts of Family Gap is used.

As we want to relate the Family Gap with preschool age malnutrition, we need to define the quantity

$$D = \frac{1}{N} \sum_{i=1}^{N} Di$$

where Di is the nutritional status, detected through anthropometric measurements of the preschool child i belong to a family whose gap is

known, and N is the total number of preschool children in the family. The anthropometric methods used are:

1. $P(E) = \dfrac{\text{Actual weight of a child}}{\text{Expected weight of the child according to its age and sex}}$

2. $P(T) = \dfrac{\text{Actual weight of a child}}{\text{Expected weight of the child according to its height and s}}$

these correspond respectively to the Weight-Age (Gomez) and Weight-Height methods.

Here, too, we are using an estimation D of D, under the assumption that the systematic error which affects D is negligible with respect to random errors.

We can observe at this point that, while the gap refers to a family as a whole, the quantity D refers only to a group or a category of this family. Before comparing them it is necessary to "homogenize" them, by taking into account those factors which, within the family itself car account for the different Nutritional Status of its members. One of these factors can be related to the patterns of food distribution within the family. Age, sex, physical or health status, economic contribution to family income, physical activity, etc., can all affect the process of intrafamily food distribution (according to criteria that may be different from those related to the nutritional requirements of each member of the family.) For this reason we introduce the coefficient I

$$I = \frac{\frac{1}{N} \sum_{i=1}^{N} \frac{Ci}{Ri}}{\frac{1}{N} \sum_{i=1}^{NF} \frac{Ci}{Ri}}$$

where the sum $\frac{1}{NF} \sum_{i=1}^{NF} \frac{Ci}{Ri}$ includes all the members of the family

considered, and the sum $\frac{1}{N} \sum_{i=1}^{N} \frac{Ci}{Ri}$ only those preschool children whose aggregated nutritional status D is known. Ci and Ri represent the nutrient consumption and requirements of the individual i in the family. The closer I is to one, the higher the probability that the preschool children group is getting its "right" share of food in proportion to its requirements. This proportion is relative to the Family Gap.

The quantity:

$$A' = 1 \times A$$

is the "adjusted" family adequacy measured through the nutrient adequacy of preschool children in the family. Of course A' = A only when there is an optimal intrafamily distribution. Here, too, we use an estimation 1 of 1 which is assumed to be subject to random and systematic errors.

At this point we can begin to correlate some of the variables already defined, in order:

- To identify the possible factors which can affect malnutrition;
- To determine the strength of association among variables; and
- To study the conditions under which each of the variables behaves with respect to the others.

For this purpose, we introduce a 2 x 2 contingency table of D and A. D is the column variable which splits up families into two categories: those with and those without malnourished preschool children*, A is the row variable which divides families in two categories: those with positive and those with negative gap. Each of the four boxes contains the mean value of adequacy and, in the brackets, the number of families of the community belonging to that box.

* For the method Weight-Age, as well as for Weight-Height, the limit between the two categories is D = 0.9.

The bottom of each column presents the mean value of nutrient adequacy for families with (left column) and without (right column) malnourished children, together with the number of families for each case. An empty box means that no families of the community fit in either category.

Table I presents the contingency tables for Villa Rica. Table II presents the same tables with the adjusted adequacy A' instead of A. We have observed that:

1. There is no significant difference in nutrient consumption between families with and without malnourished children; i.e., preschool age malnutrition is independent of family adequacy of nutrients.
2. In the community of Villa Rica preschool children are not affected by mal-intrafamily distribution. This can be inferred by comparing values and numbers in the corresponding boxes in Fig. 1 and 2. By averaging the coefficient 1 over all the families of a community and for each group or category of persons, we get the mean value $\bar{1}$ of the intrafamily distribution coefficient calculated at the community level, which is presented in Fig. 10. We can observe that, while infants and preschool children received an "appropriate" amount of food according to their theoretical requirements and to the family gap, school children between 7 and 13 years old and lactating or pregnant mothers received less, while adult male parents receive slightly more. In order to understand the previous results and to broaden the frame of the analysis, we present in Figs. 3 to 7 the contingency tables for other rural communities of the Northern Cauca region.

Here D refers to weight-age malnutrition and the family adequacy is not multiplied by the distribution coefficient 1. We can observe that, at least for some "pueblos", there is a significant correlation between family adequacy of nutrients and child malnutrition.

If we assume that the random and systematic errors which affect each one of the variables previously defined, and have the same sign and size for all of the 6 communities listed, which other factor(s) could explain the different correlation between D and A for the various communities?

As far as we know, malnutrition can be produced by inadequate intake of nutrients, by inadequate biological utilization of them, or both. The most common condition which reduces nutrient utilization is associated with infectious diseases, which in turn are strongly related to hygienic habits and sanitary conditions (quantity and quality of water consumed, types of sewage systems available, etc.). This indirect association between sanitary conditions of the environment and biological food utilization has been suggested and proven at least qualitatively in many studies. We have attempted a quantitative solution to the above problem. We approached the problem by defining an ordinal scale of 5 points: 1 (very poor); 2 (poor); 3 (fair); 4 (good); 5 (quite good) by which to assess "grosso modo" the sanitary conditions of a community, a suburb, a group of families, etc., just by looking at the most common sources of water for drinking or domestic usage, the types of excreta disposals, sewage systems, etc. This can be done very quickly without time-consuming surveys. We did it for Villa Rica and for the other 5 communities whose names are listed below.

SANITATION LEVEL	COMMUNITIES
1	Villa Rica, Balboa
2	Piendamo
3	Rosas, Morales
4	Coconuco

Comparing Figures 1 to 7, we can observe that the average nutrient adequacy of families with and without malnourished children begins to differentiate as the sanitary conditions of the community improve. In other words, child malnourishment is sensitive to changes in the Family Gap only when the Health Status is at a relatively high level

(indicating the absence of infectious diseases and diarrhea).*

Of course, this is only an initial analysis. We need to improve the methodology for defining a more precise scale for the sanitation variable and to investigate the relations between this variable and each one of the possible infectious diseases, but the above preliminary results look promising. The findings can assist in the formulation of a tentative theory or a general model, which can include all the aforementioned factors. Among other things, such a model should:

1. Explain the qualitative and quantitative relations between the various factors which are not completely clear at the moment
2. Give the probability of malnutrition for a given Family Gap and for a given level of sanitary conditions;
3. Give the terms of the trade-off between food consumption and environmental sanitation.

As the Villa Rica and Balboa data show, this trade-off is almost impossible when the sanitary conditions are very poor. For example, in the case of a child with severe diarrhea, an adequate diet scarcely exists which can compensate for nutrient losses in view of the digestive capacity of his stomach.

For communities with a sanitation level greater than 1, it seems meaningful to speak of a minimum level of adequacy above which the probability of malnourishment is quite low. For example, we can see that in the case of Rosas and Coconuco there are no families in the

* Specifically, in Villa Rica, the stomachs of children 0-6 can not hold a sufficient quantity of the type of food in the diets to bring the nutrient intake to a level which would (theoretically) overcome the effects of the health state due to poor environment.

box 2-1 (second row, first column) which means that the minimum level of adequacy (we call it protecting level) is probably lower than the 100% level of adequacy based on F.A.O. daily requirements. For a community like Riendamo, the protecting level seems to be around 120% of adequacy (relative family gap = -20). In the upper box of the right column we can observe that for almost every community there are cases of well nourished children but with quite a low level of family adequacy (Family Gap almost 45%). Even if this is statistically possible according to the normal curve of distribution of requirements for different individuals, the observed probability (of being in that range) looks higher than the theoretical one. Although this may be due to bias in our data, it may as well be due to the recommended M.D.R. (minimum daily requirements) proposed F.A.O.

As we showed for Villa Rica, the contingency table has been calculated for the anthropometric methods of Weight-Age and Weight-Height. It is clear that the number of children with acute malnutrition increases (with respect to the number of children classified as malnourished according to the Gomez Method) as we move from communities with good sanitation to communities with very poor sanitation conditions. One is tempted to conclude that Acute Malnutrition is more correlated to infectious diseases rather than to food consumption. While this may not be true for Chronic Malnutrition, we prefer to state our findings as hypotheses, to be tested at a later time.

Our conclusions at this point are:

1. If the sanitary level of the environment is very poor, interventions aimed at increasing community nutrient consumption can end in failure;
2. There is a trade-off between consumption and infections determined by the minimum protecting level;
3. The association between Weight-Age malnutrition and nutrient adequacy tends to be highly significant as the sanitary level of the environment improves from fair to very good;
4. It is possible to make a rough prediction of the sanitary conditions of a community only by looking at the aggregate

results of a contingency table relative to malnutrition in children and Family Gap;

5. It is possible to develop a simple but effective methodology in order to analyze malnutrition in children at the community level.

VILLA-RICA
WEIGHT - HEIGHT

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	55 % (24)	62 % (32)
	GAP (-)	125 % (14)	129 % (9)
	TOTAL	80 % (38)	76 % (41)
PROTEINS	GAP (+)	51 % (25)	54 % (34)
	GAP (-)	125 % (13)	131 % (7)
	TOTAL	76 % (38)	67 % (41)

SANITATION LEVEL : 1

FIG. 1

VILLA RICA
WEIGHT - AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	58 % (39)	62 (17)
	GAP (-)	128 (18)	114 (5)
	TOTAL	80 (57)	74 (22)
PROTEINS	GAP (+)	54 (39)	54 (20)
	GAP (-)	128 (18)	125 (2)
	TOTAL	76 (57)	61 (22)

SANITATION LEVEL : 1

FIG. 2

VILLA-RICA
WEIGHT - HEIGHT

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	59 % (29)	57 % (31)
	GAP (-)	128 % (9)	134 % (10)
	TOTAL	75 % (38)	75 % (41)
PROTEINS	GAP (+)	53 % (26)	53 % (33)
	GAP (-)	124 % (12)	136 % (8)
	TOTAL	76 % (38)	69 % (41)

SANITATION LEVEL : 1

FIG. 3

VILLA-RICA
WEIGHT - AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	58 % (42)	59 % (18)
	GAP (-)	131 % (15)	132 % (4)
	TOTAL	77 % (57)	72 % (22)
PROTEINS	GAP (+)	53 % (40)	54 % (19)
	GAP (-)	130 % (17)	123 % (3)
	TOTAL	76 % (57)	63 % (22)

SANITATION LEVEL : 1

FIG. 4

BALBOA
WEIGHT AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	55 % (11)	54 % (5)
	GAP (-)	NO FAMILIES	NO FAMILIES
	TOTAL	55 % (11)	54 % (5)
PROTEINS	GAP (+)	47 % (10)	56 % (5)
	GAP (-)	120 % (1)	NO FAMILIES
	TOTAL	54 % (11)	56 % (5)

SANITATION LEVEL : 1

FIG. 5

PIENDAMO
WEIGHT AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	52 % (32)	57 % (12)
	GAP (-)	110 % (3)	105 % (2)
	TOTAL	56 % (35)	65 % (14)
PROTEINS	GAP (+)	50 % (33)	56 % (13)
	GAP (-)	100 % (2)	130 % (1)
	TOTAL	53 % (35)	61 % (14)

SANITATION LEVEL : 2

FIG. 6

MORALES
WEIGHT AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	54 % (17)	63 % (10)
	GAP (-)	105 % (2)	122 % (5)
	TOTAL	59 % (19)	83 % (15)
PROTEINS	GAP (+)	54 % (18)	53 % (10)
	GAP (-)	100 % (1)	126 % (5)
	TOTAL	56 % (19)	77 % (15)

SANITATION LEVEL : 3

FIG. 7

ROSAS
WEIGHT AGE

	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	48 % (11)	48 % (6)
	GAP (-)	NO FAMILIES	120 % (3)
	TOTAL	48 % (11)	81 % (9)
PROTEINS	GAP (+)	46 % (11)	48 % (6)
	GAP (-)	NO FAMILIES	140 % (3)
	TOTAL	46 % (11)	80 % (9)

SANITATION LEVEL : 3

FIG. 8

COCONUCOS WEIGHT AGE			
	ADEQUACY	MALNOURISHED	WELLNOURISHED
CALORIES	GAP (+)	58 % (13)	56 % (7)
	GAP (-)	NO FAMILIES	130 % (6)
	TOTAL	58 % (13)	90 % (13)
PROTEINS	GAP (+)	52 % (12)	54 % (8)
	GAP (-)	10 % (1)	146 % (5)
	TOTAL	55 % (13)	89 % (13)
SANITATION LEVEL : 4			

FIG. 9

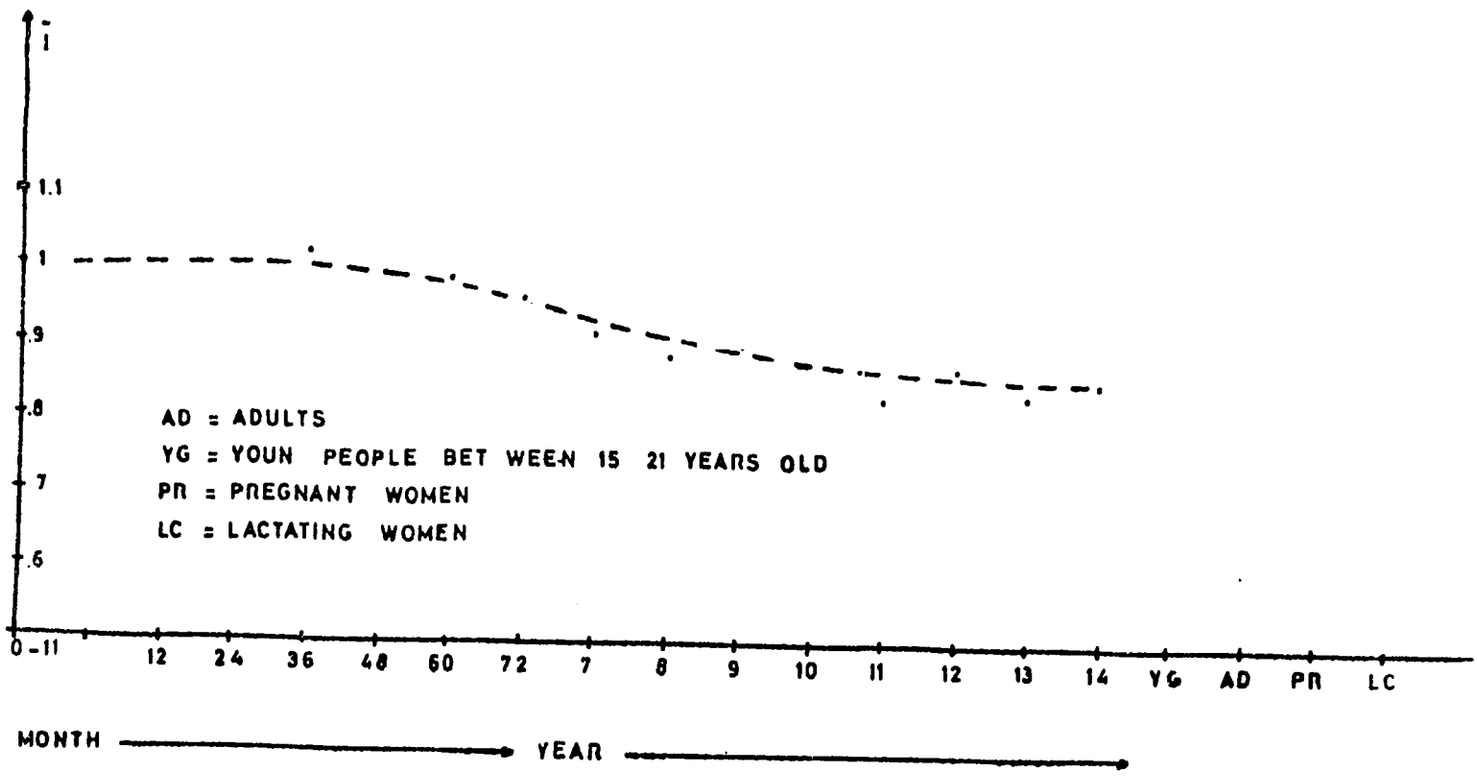


FIG. 10

V. THE VILLA RICA RESULTS

In the previous sections we have introduced the diagnostic procedure and its underlying theory and the sequence of steps in the analysis. In this section we present the results of applications of the diagnostic procedure to the specific community of Villa Rica.

The anthropometric survey showed that the percentage of preschool children malnourished is approximately 60% when calculated as a deficiency of weight for a given age (Gomez Method), and approximately 55% when calculated as a deficiency of weight for a given height. This high rate of malnutrition is related to:

a. A deficient intake of nutrients; i.e., a positive Nutrient Gap; and,

b. A deficient Health Status which reduces the biological utilization of food at the individual level, which in turn, increases individual requirements.

In the diagnostic procedure, we analyze how both deficiencies are generated in their respective magnitude. The relative average* Individual Gap is approximately 30% for proteins and calories. Since this is the same as the average Family Gap, we can safely conclude that the loss of food within the family, if we exclude the intrafamily food distribution, is negligible.

The analysis of intrafamily food distribution shows that the preschool children in Villa Rica get an adequate share of nutrients in proportion to their requirements.

The coefficient already explained is therefore almost 1 for this group. The same coefficient is significantly less than 1 for pregnant and lactating women and for school children: they seem to be the most disadvantaged group. The remaining categories get an adequate

* The average is with respect to all the 34 categories of individuals.

share of food or more. Furthermore, from the pattern of food distribution within the family, we can infer that the inadequate intake of food at an individual level is a direct consequence of an inadequate amount of food available at a family level. In fact the analysis shows that an average amount of 96 grams of protein and 4000 calories are needed per family in order to close the respective gap.

Of course, not all the families have the same gap. The curve for interfamily distribution of food in Villa Rica is presented in section III, page 29. We can see that approximately 22% of the families consume more than their requirements (i.e., they have a negative gap), while 78% of the families have a positive gap with an average value of approximately 50%. Therefore, if we could divert the excess amount of food eaten by the most advantaged 22% of the families to the 78% of the families with positive gap, the relative average gap of this last group could be reduced 20% (from 50 to 30%). This is a measure of the bias in the patterns of intrafamily food distribution. To measure this bias we estimate the excess amount of nutrients which are needed to ensure that each family can have at least its requirements fulfilled. This is done under two opposite assumptions. The results show that in the case of unchanged intrafamily distribution patterns (see section IV), the community requirements are increased by 45% with respect to a case of optimal interfamily distribution, and by 11% in the case of controlled food distribution. These are quite important figures because in the case of feasible interventions, the real value should be between these two extremes.

By summing up all the food available at the family level, and comparing it with the food available at the community level (which is given as the sum of community production of food, plus imports, minus exports), we do not observe a big difference. We can conclude, therefore, that community losses in the nutrient flow due principally to transportation, storage, distribution, etc., are not greater than 10-12%. We are still looking for a more direct procedure to measure these kinds of losses.

VI. INSTRUMENTS FOR INTERVENTIONS

In addition to the development of the diagnostic procedure, some research on the instruments for interventions has also been conducted. Thus far, we have focused our attention on the most likely interventions to be implemented in the rural areas:

A. Screening for Malnutrition

B. Food Habits

C. Production

D. Health

E. Sanitation

The following discussions refer to our progress in these areas. In the case of Screening for Malnutrition and Health, the chapters represent the final report. On the other items our findings are only preliminary.

A. Screening for Malnutrition

1. Introduction

Anthropometric measurements are the more widely used methodology for the assessment of the Nutritional Status of Individuals.

Some of them are sensitive, accurate and specific, but their implementation under rough field conditions is impracticable and prohibitively costly, particularly when used for mass screening.

It is for these reasons that we have placed priority in our research on the search for an anthropometric measure for the assessment of Nutritional Status that takes into account the characteristics of sensitivity and specificity with good field performance and low cost.

Mid-arm circumference for age appears to fulfill the requirements of low cost and good field performance. The objective of the present study, then, is to analyze the measurement of

mid-arm circumference for age for its sensitivity and specificity compared with the traditional methods of assessing malnutrition, i.e., weight for age, weight for height and height for age.

2. Materials and Methods

   The surveys are described on pp. 51 of this report.

3. Results and Discussion

   In our previous discussion, we have shown that since mid-arm circumference provides a statistically positive correlation with P(T) and T(E), it can be considered as a useful measure of Global Malnutrition. The high correlation between mid-arm circumference and elbow circumference also allows us to extend the results of mid-arm circumference to elbow circumference.

Under these conditions we can assume that the Gomez classification is the standard methodology with which to compare the arm circumference measurement. The correlation we found between the two methods was approximately 0.6. Since this value is not too high, we can expect the tape to present some nutritional diagnostic errors with respect to the Gomez Method. We will examine this assumption within the context of the null hypothesis: If a child is well nourished, according to the Gomez Method, the possible lack of agreement between the Gomez and arm circumference can be the result of two different conditions:

a. The Gomez Method classifies as malnourished a child who, by the tape, is classified as well nourished. If we assume that the Gomez Method is the correct one, the tape in this case can present a Type 2 Error as we are accepting the null hypothesis. The probability of an error of this type is inversely related to the sensitivity of the instrument.

b. The Gomez Method classifies a child as well nourished while the tape classifies him as malnourished. As we are rejecting the null hypothesis, which is correct, we can call it a Type 1 Error. The probability of an error of this type is inversely related to the specificity of the instrument. The probability of these two errors for a

given tape depends, of course, on where, along the tape range, the limiting values are set for identifying the different status of nutrition. Suppose, for example, we define as malnourished all the children less than 6 years old with arm circumference less than 6 centimeters. The percent of malnutrition according to the tape will be quite low. Thus, the probability of Type 2 Error will be high and that of Type 1 Error will be low. The contrary occurs when the limit is too high.

Without limiting the generality of this analysis* we assume here that we are designing a tape with only one limit X in order to separate the cases of malnutrition from the others.

If for a generic tape we define the following quantitites:

E1 = probability of Type 1 Error

E2 = probability of Type 2 Error

ET = probability of an error, irrespective if 1 or 2

T = malnutrition rate of a population, defined as the percent of preschool children malnourished, defined as grade I, II, or III according to Gomez

C = confidence level of the tape, defined as the percent of cases of a children population for which the Gomez and tape diagnosis coincide.

It is shown in Appendix A, paragraph A1 that:

i) if we change the limit of a generic tape in order to reduce Type 2 Error, Type 1 Error increases and vice versa

ii) the confidence level C of a tape is maximum for that value of X which makes the total error ET minimum;

* Once the limit X has been defined, limit X' which separates cases of mild malnutrition from the severe ones can be determined by the following relation X'=0.9X.

iii) as limit X varies within its allowed range, error E1, E2, ET describe 3 curves E1(K), E2(X), ET(X) which intersect one another at the same point Xo.

The probability value that the three curves assume at the point of intersection Xo is a rough measurement of the lack of correlation between the variable P(E) relative to the Gomez Method and the variable

$$CB(E) = \frac{\text{Actual arm circumference of a child}}{\text{Normal arm circumference according to the age and sex of the child}}$$

The lower the intersection point, the higher is the correlation between the two variables (see Appendix A, paragraph 2). As the actual value of the arm circumference is determined not only by Nutritional Status of a child but also by his level of physiological growth relative to his age, the possible errors of a tape can be reduced by narrowing the range of ages for which the tape is valid. In this way, we limit the effect of the growth on the observed variations of the arm circumference. The question is: For a fixed range of ages, which is the limiting value X which makes the total error ET minimum and the confidence level of a tape maximum? Figure 1 shows the maximum confidence level which can be attained by varying X, when the malnutrition rate T is passing from 0% to 100%. This implies that it is not possible to design a tape for which the confidence level is maximum, until we know the percent of malnourished children of a community. Figures 4 and 5 show how, for a malnutrition rate of T = 30% and T = 60%, the total error varies for the same range of ages. What we want to point out here is that if we want to design a tape to be used in different communities, we cannot use the maximum level of a confidence interval as a performance criterion.

On the other hand, it can be shown that the probability of a Type 1 or Type 2 Error is independent of the malnutrition rate T because of the ways in which they are defined.

Therefore, under practical circumstances, it seems advisable to design the performance characteristics of a tape not as a function of the maximum confidence level desired, but as a function of the maximum value of probability for Type 1 and Type 2 Errors which can be accepted.

These are two possibilities for reducing Type 1 and Type 2 Errors:

i) Change the limit X which separates the cases of malnutrition from the others. In this case it is necessary to look for an acceptable trade-off between the two types of error. Recall that Type 1 Error tends to increase exponentially as Type 2 decreases asymptotically. Of course, this trade-off can significantly effect the total costs and benefits of a social project.

ii) Reduce the age limits for which a tape is valid. Here too, it is necessary to make a compromise between the feasibility of using a lot of tapes and the permissible size of Type 2 Error. Furthermore, reducing the range of ages for which the tape is valid can hardly make the Type 2 Error negligible.

We have shown that the tape is affected by two kinds of error, and that it is almost impossible to design a tape for which both errors are negligible at the same time. It is important, therefore, to know which categories of malnourishment are most affected by tape errors. Figure 10 shows the probability of Type 1 and 2 Errors as a function of the Gomez variable P(E), for a tape designed to give the same weight to both errors. We can observe from this figure that the probability of a Type 2 Error is high for children with grade I malnourishment ($0.75 < P(E) < 0.9$) and quite low for cases of grade III malnourished $P(E) < 0.6$. That is, the sensitivity of the tape increases with the severity of malnutrition. We can observe also that the two curves relative to the probability of Type 1 and 2 Errors are quite symmetric with respect to $P(E) = 0.9$

Since we defined two different kinds of malnutrition (Chronic and Acute Malnutrition) and assumed that the Gomez Method can detect Global Malnutrition, one could put forward the hypothesis that the tape is able to detect only one kind of malnutrition -- Acute. Therefore, the tape and the Gomez Method show better agreement only when a child shows evidence of Acute Malnutrition. Figure 8 and 9 clarify this point. Figure 9 shows the graph of Type 1 and 2 Errors of a tape with respect to Weight-Height P(T) method. Figure 8 presents the same kind of graph with respect to Height-Age T(E) method. We can observe that the point of the intersection of P_e in Figure 8 is shifted to the right (and upward) of the point P_g of Figure 6, which is the same figure but relative to the Gomez Method. This displacement is not observed for the point P_i of Figure 9. This means that if we design a tape to detect Global Malnutrition, the Type 2 Error that the instrument can make tends to be more closely associated with Chronic rather than Acute Malnutrition. The contrary happens for Type 1 Error. This conclusion is evident if we consider that a Type 2 Error is prevalent to the left and a Type 1 Error to the right of the point of intersection in Figures 2 to 9. Yet there is a more than negligible probability of Type 2 Error for cases of Acute Malnutrition and Type 1 Error for cases of Chronic Malnutrition. According to recent studies (see Health section of this report) Acute Malnutrition seems to be more prevalent in the first years of life while Chronic Malnutrition becomes more important in later years. Type 2 Error can therefore be more serious for the range 0-2 years. Yet the relative importance of the two kinds of errors, i.e., the trade-off between specificity and sensitivity, should be consistent with the objectives of the anthropometric measurements. For example, if the objective of the nutritional study is to detect malnutrition at the community level, (i.e., to detect malnourished communities), both kinds of errors can have the same weight. But if it is necessary to detect malnourished families or individuals, Type 2 Error can become more serious and more care should be taken in reducing Type 2 rather than Type 1 Error. If the objective is to evaluate the

effects of a nutritional intervention, or to detect a change in Nutritional Status, both errors tend to have the same weight, be it community, family or individual level.

4. Conclusions

From the comparative analysis of arm circumference and other anthropometric measurements, we can draw the following conclusions:

a. the tape can be classified as a valid method for detecting Global Malnutrition;

b. the tape is more sensitive in cases of Acute rather than Chronic malnutrition or in cases of severe rather than mild malnutrition;

c. the tape is of limited validity when used to detect individual cases of malnutrition (i.e., to detect malnourished children) because of the lack of a high level of specificity and sensitivity;

d. the tape can show better performance in cases of an aggregate diagnosis of a population. Since its sensitivity to detect children with Grade II and III, malnutrition is acceptable in many cases, it is possible to make an inference about the aggregate Nutritional Status of the children's population in a given community, given the percent of Grade II and Grade III Malnutrition cases;

e. the tape can also be useful in making an approximate and rapid evaluation of nutritional programs at a community level, since these kinds of programs, if effective, tend to reduce the prevalence of the most severe cases of malnutrition which are easily detected by the tape.

f. The criteria which should direct the design of a tape should be related to the degree of specificity and sensitivity allowed rather than to the confidence level desired.

APPENDIX A

For N equal to total number of children 0 to 6 years old.

N_1 number of children classified as normal by the weight for age method (Gomez Method)

N_2 number of children classified as malnourished by the weight for age method (Gomez Method)

$n_1(x)$ number of normal children by Gomez and malnourished by the arm tape (with a prefixed limit X of the tape)

$n_2(x)$ number of malnourished children by Gomez Method classified as normal by the arm tape (with prefixed limit X of the tape)

For a large N

$E_1(x) = \frac{n_1(x)}{N_1}$ = probability for Type 1 Error; it is assumed that E_1 is a monotonic function of X

$E_2(x) = \frac{n_2(x)}{N_2}$ = probability for Type 2 Error; it is assumed that E_2 is a monotonic function of X

$ET(x) = \frac{n_1(x) + n_2(x)}{N_1 + N_2} = \frac{n_1(x) + n_2(x)}{N}$ = probability of total error

$C(x) = 1 - ET(x)$ = confidence interval of the tape

$\frac{N_2}{N}$ = T malnutrition rate.

If it assumed that the coefficient of correlation between P(E) and CB(E) is 1, then, given a unique relation between the two variables, there will be a point x_o on the tape corresponding to the limit value of P(E) = 0.9, in which case $E1(x_o) = E2(x_o) = 0$.

On the other hand, if it is assumed the coefficient of correlation is zero, then, for any point on the tape that is chosen as limit x, the probability of a correct dignosis is equal to the probability of a wrong one.

In this case, $E1(x) = E2(x) = 0.5$

For cases where the correlation coefficient lies between 0 and 1, the intersect point of the three curves will be between 0 and 0.5.

Thus, the Family Gap is a direct consequence of a positive Community Gap, and it is influenced by a biased intrafamily distribution. This gap corresponds to approximately 125,000 grams of proteins and 5,500,000 calories per day. In the urban sector, the Family Gap can be explained by low purchasing power of families, while for the rural sector the proximal causes can be traced to two principal factors:

a. The existing inadequate land tenure system in the area, (e.g., the poorest 95% of the farmers in the rural sector holding less than 30% of the total land);
b. The low level of technology, inadequate technical assistance, lack of credit and infrastructure, etc.

The nutritional conditions in the area are further worsened by the tendency of the families to export nutrients produced in the area and then import food from outside. This process increases the cost of nutrients available for consumption quite considerably.

The second cause of malnutrition in Villa Rica is to be found in the high incidence of morbidity among young children. The health and sanitation survey showed that 65% of the children less than 6 years old had experienced one or more episodes of diarrhea within two weeks before the date of the interview. For 20% of them the diarrhea was accompanied by fever and vomiting. The incidence of infectious diseases, like upper respiratory infections, and measles, seems quite low in the area, however. The same survey also showed that environmental sanitation conditions are responsible for gastrointestinal infections. Nearly 50% of the families in the urban sector have latrines, but the other 50% (mainly in the rural sector) use the back yard or the open field. No sewage system is available in either the urban or rural areas. With respect to water supply the picture is even worse. The main source of water for domestic use and for drinking is the "aljibe". This is a well with little or no protection at all. In the rainy season the wells collect the surface running water, and become highly contaminated with human or animal excretions. Other sources of water include:

1. A local aqueduct in the urban area.
   Because of inadequate protection, water from this source also presents a dangerous level of fecal contamination and a very high content of mineral salts. Its use is therefore very limited.
2. The rivers in the rural areas.
   These are used as waste water by sugar can processing factories; thus, the level of contamination is also very high. Their waters are used only by those families which do not have "aljibe" (less than 20%).

From the above analysis, a pertinent question to pose is:

Which is the most serious problem responsible for malnutrition that sets the first priority for intervention in Villa Rica?

The results of our methodological analysis show that when the prevalence of infectious diseases is high, the level of nutrient intake has little or no effect on the Nutritional Status of children. Only if the morbidity rate is low can increased food consumption improve Nutritional Status. Therefore, in Villa Rica the improvement of sanitary conditions becomes the priority intervention followed, necessarily, by an increase in nutrient consumption.

B. Food Habits

Soya in Villa Rica

Villa Rica offers an exceptional opportunity to learn about the relationship between eating habits and malnutrition.

The existence of economical, highly nutritional foods in this community does not imply that its inhabitants consume them daily. The reason can probably be found in the description of their eating habits and the importance the inhabitants give to each one of the foods which make up their daily diet. It is only by understanding this information that we can reach the community and thereby propose feasible ways to improve their Nutritional Status.

Villa Rica exports proteins

This community, like other population groups, demonstrates that nutrition does not depend on the proximity or availability of food per se. Nutrition cannot be reduced simply to a physiological need or buying power.

Villa Rica produces four times more protein than it requires to satisfy its nutritional needs. The total protein production is exported while its population suffers a protein and/or energy deficiency. What we do not know is what percentage of each person's production of proteins and calories belongs to him, since as a salaried worker the major portion of the production does not belong to him. The worker exchanges his production for wages. These products are sold in order to purchase basic foods: rice, beans and meat which cost three or more times more than what is received from the sale of these products.

Technical Solution

It is evident that in order to reduce the nutrition gap, all the entire community has to do is to reserve for itself a small portion of the products exported, thus increasing by 30% its consumption of proteins and calories.

For each family, an additional 100 grams of protein and 5,000 calories daily are needed to close this gap.

There is also a gap between this ideal technical solution (which should reduce malnutrition to 0) and the reality of attempting to implement it.

The Nutrient Gap can be expressed on two levels:

1. The existence of social standards. The present day farmer is a salaried worker. He produces for others. (He lives in a much wider world of economic relations.) We do not know, nor have we estimated, the average amount of food that a family can reserve for consumption.
2. Eating habits exist which lead persons to consume a traditional-type diet, which does not include the high protein food currently produced and exported.

If we expect to carry out a controlled intervention and attain a certain margin of success, it is not enough to simply say, "We should make the people eat 30% more by withholding exports for themselves". We should realize that this is not the solution, but rather, the problem. How then can we make them retain 30% of their produce? If we reject the possibility of achieving changes at the macro-economic level since we can not modify the social standards, we could consider the possibility of improving eating and nutrition at level 2.

Before the local population was fully integrated into the modern production system their buying power was very high due to the

existence of two economic systems, subsistance and cash. Very few were integrated into the latter mode of production. With the advent of the modern system of production several people sold their land and their labor. Today, they are very poor because the over worked soil does not produce as much as before; the lands cannot lie fallow as before, and fertilizer is not used because farmers cannot purchase it.

But the food habits have not changed. Only the balance has begun to vary slightly during the last few years. This is in keeping with the new economic changes. We became aware of an eating pattern when we discovered the most expensive foods are purchased in smaller quantities and that the more economical foods, which were formally served with the main meal, have now become main dishes. This is where malnutrition begins: the transition of a traditional society to a "modern" way of life ("modern" understood in this sense in a different context from that of development).

The eating habits are reinforced by their own symbolic logic. The current scientific eating model indicates those foods which contain the nutritional properties desired, which are precisely the tastiest, most expensive and therefore the most tempting foods. This symbolic logic is embedded in a system of beliefs which are transmitted from generation to generation.

Soybeans, for example, were originally not consumed by the inhabitants of Villa Rica. They were first planted for exportation. Many people have probably tasted them but they do not have the characteristics of other legumes, e.g., beans. They are too tough to cook and are not tasty. But they contain high protein (34%). Unfortunately, man does not eat only protein or vitamins but rather foods or diets which, according to certain rigid concepts, are or are not acceptable.

Millet is also produced in the area and is related in the same manner as soybeans to the exportation sector, or else utilized as poultry

food. It is occasionally used as baby cereal or puddings.

A Proposal

We propose that both of these foods be integrated into the local diet so that they look like foods which are already accepted by the population, such as synthetic meat, flour, soybean milk, and cheese mixed with local dishes.

We know that cereals are low in certain amino acids but also contain high quantities of other important amino acids. For this reason, those cereals must be associated with other foods, such as soybeans, in order to establish a complete protein ration.

We have chosen soybeans and millet because they are the cheapest local foods. We believe that when they are consumed by the population, the Nutrient Gap can be closed for proteins as well as calories. We are aware that it is impracticable to attempt to change eating habits overnight since these have evolved over generations. Naturally, people have a tendency to appreciate and desire those foods which closely resemble those of their childhood.

As a first step in the study of the food habits through community participation, it was proposed:

1. to establish a soda fountain. It is preferable to set up a local store which would "naturally" attract the consumer, and thereby establish a whole informal educational program in which people learn to eat foods which, in the past were considered animal food. These foods should be given status by preparing them and serving in an attractive environment. In addition to promoting the nutritional aspect, other social rites of the community are being reinforced. These products can be sold at a very low price and thus motivate consumers to come up with different ways of preparing them.

2. to promote informal meetings with parents during which information on nutrition would be given in order to facilitate the acceptance of the proposed diet. We intend to tap the resources of personnel available in the area: health promoters, teachers participating in adult education in the surrounding villages, etc.

Methodology

What to sell? Excerpts from the sociologist's account of her experience:

"From my third day in Villa Rica we started to prepare soy meat, soy milk, soy cheese, kumis, and additional preparations for 'sancocho' with soy and millet. We started at Frankelina's house and my own house. The preparations were offered to different persons, all of them housewives. From then on we visited several houses to discuss the preparations and to take notes on the observations of the housewives:

1. Soya milk is better, if when cooking, a piece of charcoal and wood ashes are added, because the soya flour is lost.
2. For meat and cakes people prefer to use millet, contrary to our initial thinking to use corn or barley.
3. Ladies tested for themselves the soy milk against their own standards for real milk in local preparations such as mazamorra, milk sweet, natilla, etc. They approved of the soy milk.
4. Preparations were adopted by the housewives to local eating patterns; what was initially designed to serve as a beefsteak for lunchtime was found to be appropriate for breakfast when it goes with coffee! They do not know of beefsteak at their dinner table.

In this way a collection of recipes was elaborated."

How to sell?

The Tombolita

The soda fountain was named the "Tombolita". It started to function in February 1976. Community involvement in planning and operation of the fountain was considered essential. Project staff involvement took the form of a close identification with the local people to gain insight into their perceptions of problems and solutions.

The site, furniture, decoration, equipment, operating hours and personnel chosen for "Tombolita" do not differ from those of the other local stores. The price of the meals served reflects their actual cost, and the presentation of dishes was adjusted according to customer preferences. A distinguishing feature of the soda fountain is the willingness of all personnel to teach others how to prepare the recipes on display, and the manner of diffusing information to families.

Some women from the community were selected to serve at the soda fountain. They had a brief training of 8 days for their respective assignments in the "Tombolita".

Information to Families

Our approach was to use the existing regular channels of communication in the Villa Rica community.

First, it was essential that the "Tombolita" attract attention toward soya products. Second, we were aware that the persons the families believe in are not necessarily the traditional authority figures or leaders, such as the priest, policeman, etc., but other persons in the community. Then the strategy was to identify the strategic individuals and use them as "change agents".

Third, three ladies of the community received training in preparing the soy during 8 days at the soda fountain. The ladies then visited all the families in one block (nucleated part of Villa

Rica). They explained to the housewives that there was going to be a meeting in one of the houses of the block to discuss the recipes that are prepared and sold in the soda fountain. A housewife was invited to suggest the house where she thought the meeting could take place. The purpose of this procedure was twofold. First it allowed us to identify the strategic individuals; and second, to assure real involvement of the community in the "Tombolita" activities.

The above procedure was repeated several times. Gradually, the strategic individuals for each block were identified. They then became the teachers, helped by the other housewives of the community and the three members of the staff.

It is interesting to note here that the materials needed in the teaching were paid for with part of the cash proceeds of the "Tombolita".

The Results

As mentioned before, the results reported here are only the initial findings of six months of operations. The results so far are encouraging: Over 60 percent of the families have received instructions on soy preparation.

At this time, the same courses have begun in rural sectors of Villa Rica. It is equally significant to note that the invitation to "teach" the courses came from the inhabitants of the rural communities themselves. Our recent "tienda" survey shows that of 37 stores in Villa Rica, 7 have now substantial sales of soy, amounting to 120 pounds of soy per week and 118 pounds of millet per week. These figures are big enough to close the average protein community gap by 10%.

The cumulative cost of the operation so far amounts to $315 pesos (U.S. $10.00) per family. If the actual research personnel is

excluded from the budget calculations, the cumulative cost of the whole program, per family, during 4 months amounts to $85.6 pesos (U.S. $2.44). The cost of reducing the protein gap by 10% is $0.70/day/family (U.S. $0.20/family/day).

C. Food Production - Buenos Aires

The work being carried out in Buenos Aires, Cauca, continues to emphasize community participation in carrying out the diagnostic methodology. We believe that this approach may eventually enable members of a community to develop their own nutrition plan. There exists the potential for a tremendous impact on the national planning process if communities could analyze their own problems and propose solutions to state and national agencies. In addition to improving the planning process, an effective community participation approach will also greatly improve the implementation process.

While the long range effect of the Buenos Aires work is community planning, the immediate implementation instrument is "extension". The students of the Buenos Aires Hogar are becoming "extension agents" in nutrition. This nutrition extension has two distinct aspects. First, the students are receiving instruction in the Hogar in a variety of areas which are related to potential nutrition solutions. Second, students are also carrying out the diagnostic methodology in several "veredas" (rural communities). Towards the completion of the diagnoses, the students will be able to select and evaluate solutions from the instruction which they received.

During the past year the Hogar students received a wide range of instruction as part of their regular program. They experimented with growing different varieties of beans, corn, peanuts and soy using different kinds and different concentrations of fertilizer. They received instruction from the project group in Villa Rica on preparing the various soy recipes. They learned how to increase coffee production using new varieties. During the summer vacation a series of short courses were offered on topics including first aid, health and sanitation, and family planning. Most of the instruction was not directly related to the nutrition project. Instructors were provided by various Colombian agencies and groups

and formed part of the regular Hogar Juvenil Campesino program in Buenos Aires.

The principal activity of the nutrition project has been to work with the students on learning and executing the diagnostic procedure. This work has progressed slowly, primarily due to the limited time which the students have. The situation is expected to improve in the coming year as more time has now been allotted to nutrition work. Furthermore, the students are now grasping much more quickly the concepts which are being introduced.

The diagnostic procedure is now half completed in three veredas; Asnazu, San Francisco and Honduras. For each of these communities a map was constructed and a census was completed for the number of houses. From this, a representative sample was drawn of approximately 20 percent of the houses. Included in the sample were the families of the Hogar students (five to ten additional families for each of the communities). Family composition forms were completed for each family in the sample and anthropometric measurements were taken for all of the preschool children. This was followed by the family consumption surveys of "24 hour recall" and "weekly market purchases".

All these activities were carried out by the students with little field supervision. The results indicate that the data have approximately the same degree of reliability as data gathered by project staff in other sites such as Villa Rica. Given the manpower and training of the Hogar students, it should now be possible to perform the same measurements in various dispersed communities in a relatively shorter period of time.

In accordance with the philosophy detailed in the first annual report, the concepts behind each of the activities have been given primary emphasis. For example, when the first study was begun in Asnazu, discussions were held with the students in defining the community and setting, and ascertaining to what group

the conclusions could be applied. To demonstrate the concepts of representative sampling, an analogy was made with the process by which their coffee is purchased. The purchaser does not just examine the beans at the top of their bag, but rather extracts a few beans randomly selected from different parts of the bag in order to determine the quality of the whole bag. It can be said that some of the students now have a rather sophisticated understanding of experimental design and the scientific method which could now be applied to solving other related problems in their communities.

There are four different types of activities which are planned for the coming year. The first will be to complete the diagnostic measurements in Asnazu, San Francisco and Honduras. This will consist primarily of evaluating environmental sanitation, Health Status and also food production.

A second type of activity which is already in progress is the analysis of the data from the three veredas. Like other activities, this process is being carried out by the Hogar students. The students themselves are classifying and reviewing the data, and looking for relationships between families with malnourished children and the effect of health-related factors to malnutrition. They are also seeking to discover the relationships between family production and family consumption.

The third type of activity is closely related to the second. Based on the results of their analyses they will design, implement and evaluate a series of mini-interventions. These interventions will entail the extension of certain knowledge or techniques to small groups of families. The interventions will take the form of small pilot experiments designed to yield information for possible larger scale intervention later. It is this intervention design stage which is expected to bring together:

1. The causal theory of nutrition learned in the diagnostic methodology;
2. The scientific method of learning through experimentation; and
3. The specific nutrition-related knowledge (such as how to grow and prepare more nutritious foods) acquired as part of the regular Hogar Juvenil Campesino program. These three factors should make for very effective extension agents.

The fourth type of activity is the replication of the complete diagnostic methodology in a number of new veredas. Two veredas (Bella Vista and El Ceral) are being considered. They are each represented by several Hogar students and are six to eight hours from Buenos Aires. It is felt that these two sites will serve as a test of the students mastery of the diagnostic procedure. The students will be expected to plan their work in advance and then execute it quickly and effectively. Because of the distances involved, the work will take place over several weekends or during Christmas or Spring vacation.

In addition to being a final test of the methodology, this exercise will also provide the project with data from a remote mountainous region. This is a cultural and geographical area not well covered in our present studies.

D. Health - The Effect of the Promotora Program in Candelaria on the Occurrence of Malnutrition and Disease.

This document is a report of the results obtained in a health care program carried out by health promoters and conducted in Candelaria, Colombia during 1968-1974. Our evaluation is that the program in general was successful and that to institute the same program in other places would achieve the same reduction in infantile malnutrition.

Description of the Promotoras Program

The program is based on the concept that modification of the synergistic factors of malnutrition improves the nutritional condition of children less than six (6) years old.

Youths between 16 and 21 years of age were localized in the community to serve as voluntary health promoters. Following a 6-month training period, they began their principal task of making visits every two months to all families having children of preschool age.

During the visit, the worker provided education on child nourishment and hygiene and the utilization of health services, and gathered information on the nutritional state of the children, presence or absence of disease and socio-economic and demographic variables.

Sick children discovered during the visits were referred to level II of the health care programs. Level II consisted of four auxiliary Public Health nurses, one registered Public Health nurse and a general practitioner (a student in the last year of medical school). At his level, pregnant and lactating mothers received instructions on the pre and post-natal care of their children.

The most important objectives of the program were to prevent disease and to identify sick children early, before the illness progressed to the point of requiring expensive treatment.

The Effects of the Promotora Program

1. Coverage

Ten workers, four auxiliary nurses, one Public Health nurse and one general practitioner took charge of the Program (1968-1974). The Promotora Program serviced an average of 921 families per year (except the first year, when 737 families were involved), including 1392 children (first year - 694) less than 6 years old.

In order to evaluate the coverage of the program, we should examine the following facts:

a. A census conducted in 1963 reported the existence of 506 families, including 1094 children less than 6 years old, with 2.16 children less than 6 years old per family.

b. The 1973 census indicated 1260 dwellings with 1952 families, for a total of 8773 inhabitants. Presently, no data concerning the number of children less than 6 years old exist for Candelaria, but it is reasonable to believe that between 20 and 25% of the population belong in this age group. Based on these criteria, we can conclude that close to 80% of the children in the population participated in the program. (Previous information gives a range of 90 ± 4%).

c. During the 7 years of the program's operation, 1840 different families participated, including 9051 children less than 6 years old. The operation of the program was fairly stable. The first year, 40% of the attending families registered, of which 240 families

(13%) permanently enrolled in the program for the 6 years of its duration. Abandonment by the enrolled families for whatever reason during their first year in the program was on the average of 17% (Figure 2).

2. Malnutrition rate for the population of Candelaria.

First of all, let's consider if an actual reduction in the malnutrition rate in Candelaria would occur during the 6 year duration of the program.

A child was considered undernourished if he had lost 15% of the expected weight for that age. The Mexican standard was used, which measures slightly below the 25th percentile of the Boston standard for children. It should be noted that the actual standard for the population of Colombia runs slightly above the 25th percentile of the Boston standard for children and undernourishment is defined as a weight loss of 10% with regard to the standard.

The former suggests that some children considered normal in Candelaria would be considered undernourished if defined by the standard of undernourishment actually accepted in Colombia.

Given that during the entire period of the program the same standards and definitions were used, it is possible to draw conclusions from the variations in the malnutrition rate.

It is necessary to note the different interpretations of the variations in the malnutrition rate and their implications. The most current opinion is to express the measurement of undernourishment as a function of its variations by calendar years (malnutrition vs. calendar year). One of the factors that can seriously affect this type of analysis is internal and external migration. In Candelaria, the phenomenon of migration is important. It has been calculated that each

year a migration of 15-25% occurs. Variations in the income of the population services are also important.

Another means of expressing the variations in the malnutrition rate consists of examining its relationship to the amount of time spent in the program by the participants (% malnutrition vs. year in the program); the greatest inconvenience with an analysis of this type lies in the impossibility of deducing the effect of the program with the accompanying effect of an increase in the age of the population served.

Finally, it is possible to express the % of child malnutrition per years of age in groups of children that remained in the program for different periods of time. This obviates the problems described previously, but recognizing the fact that the number of children in the older ages is generally low, the data seem less conclusive.

First of all, let's consider the evolution of the program from a chronological point of view (Figure and Table 3). In 1968, at the beginning of the program, the malnutrition rate was 28.6%; in 1971 it was 19%. Between 1972 and 1974, this rate remained stable at around 21%. Reduction of the severe degrees of undernourishment (Grade III) occurred in the first and second calendar years of the program and remained stable; the decrease in children having a Grade II level of malnutrition was constant among the children involved in the program; and the decrease in children at a Grade I undernourishment level was slow and of little intensity in the first three years of the program's operation, later stabilizing itself with a tendency to increase (Graph 4).

It is important to consider if, for the population of Candelaria, we should expect a major reduction in the malnutrition rate independently of whether or not such a

reduction is due to the intervention of the program; or if the stabilization of the malnutrition rate is due to the point at which the normal distribution of weight/age does not permit a major reduction. If it is fair to compare what is considered the normal weight distribution for the population of Bogota with the population of Candelaria, we can observe how the lower weight limit for each age considered normal in Candelaria coincides with the 20th percentile of the weight distribution for Bogota children. Then, the actual definition of undernourishment would classify 20% of the normal children of both populations as undernourished. In other words, it is important to stress that the maximum sensitivity of the instruments to the measurement of undernourishment is 20%.

3. Once it had been established that between 1968 and 1974 a reduction in the malnutrition rate occurred in Candelaria for children less than 6 years old, we faced the difficult problem of identifying and explaining the factors that contributed to it, evaluating the role of the promotora and presenting the results in a useful format.

   To accomplish such a task, the methodology will be to enumerate the hypothesis seemingly obvious to the explanation of the phenomenon and try to compare the theory (hypothesis) with the observed reality. Although expensive, such methodology permits us to place ourselves inside a frame of reference that functions in time and space, making it possible to evaluate the situation in Candelaria with respect to itself through time and with respect to Colombia.

   Hypothesis No. 1. The malnutrition rate in Candelaria during the years 1968-1974 is comparable to that obtained in the rest of the country and is not a situation specific to Candelaria.

After examining Table 3, we can see that, in Candelaria in 1968, the malnutrition rate in children less than 6 years old (29%) was much less than that reported for the rest of the country before, during, or after the year 1968. The country reported an average of 51.30% (Table 5).

Recent studies (1975) concerning the malnutrition rate in rural communities similar to Candelaria show a malnutrition rate greater than 50% in children less than 6 years old. We can conclude that the rates found in Candelaria during the years 1968-1974 are significantly lower than those reported for the country.

This conclusion permits us to study the situation in Candelar in more detail.

Hypothesis No. 2. Programs begun in Candelaria by the Univer sity before 1968 may have influenced the present results.

A detailed description of these programs may be found in Appendix B. Here we will simply study the effect of the previous programs on the malnutrition rate and their possible long-term prospects.

In 1958 the Department of Preventative Medicine and Public Health of the Universidad del Valle established a rural healt center. Services in preventative and curative medicine were rendered by residents and medical students exposed by their work to community problems. The point was utilization of available resources rather than development of a "University Hospital" in rural surroundings. Students and residents learned to resolve problems they might face in other communities with no university assistance.

The Nutritional Recuperation Center, started in August, 1962, provided care for children with Second and Third Degree

Malnourishment after release from the hospital. Children remained at the Center during the week and were sent home on weekends. Besides furnishing children with adequate food, the Center was to educate the mother about the importance of balanced diets. It became evident, however, that the educational efforts were not reaching the rest of the community; often the siblings of the children under treatment were malnourished. Even some of the "recuperated" children became malnourished upon return home. The costs of the program per recuperated child were high and the scarce facilities limited the number who could be treated. The emphasis was on curative rather than preventative medicine.

In January, 1964, the Nutritional Recuperation Center was disbanded and all children showing any sign of malnourishment were treated as outpatients. Weekly food supplements were distributed for each person of vulnerable age (preschool children, pregnant or nursing mothers). Mothers in groups of 25-30 took part in seven educational presentations. The educational efforts of this project appeared to have reached the rest of the community. The Weight-for-Age malnourishment rate decreased from 40.8% to 31.8% in the first six months of the program and was proportionately greater in the severely malnourished groups. While the project was considered successful, the costs were high in relation to the economic resources of the health center.

Water and Sewer Systems

As a result of various intensive programs, by 1964, 67.7% of the houses were connected to the sewer system and had sanitary hygiene facilities, and 90.9% had potable water in the home. The impact of these sanitary facilities on the malnutrition rate cannot be precisely determined, but a survey taken in 1963 showed a malnutrition rate of 40.8%, in contrast with the national median of 55.6%.

Thus, with the initiation of the Promotora Program, the children of Candelaria were in comparatively better condition.

Other Programs

Official estimates of the malnutrition rate for 1968 in communities similar to Candelaria were 66.6%. When the Promotora Program was initiated in 1968, the malnutrition rate in Candelaria was approximately 30%. It is clear that such a situation does not currently occur in other semi-rural communities in Colombia.

Although many of the families studied in Candelaria resided there only temporarily, the community itself became accustomed to the presence of the University and the projects it conducted within the town. This was undoubtedly a major factor in the acceptance of the Promotora Program. The availability of potable water and a sewer system make the job of reducing the rate of infection via education much easier.

Thus, it is difficult to predict exactly what impact a similar program would have had in a community with minimum sanitary facilities and a malnutrition rate of 50-60%.

In spite of these problems, the day-to-day Program in Candelaria is the only one that can be evaluated; and, while recognizing the limitations imposed by some of the data, we have still found it possible to draw conclusions.

Hypothesis No. 3. The Promotora Program in Candelaria produced a reduction in the malnutrition rate of the population exposed to the Program. To evaluate this hypothesis, it is necessary to analyze the results in three different contexts:

a. The Program itself produced an effect.
b. Other factors external to the Program, but that occurred simultaneously, do not explain the observed effects.

c. Elaboration of a theory that explains how the Program could produce the observed effects.

a. The Program itself produced an effect.

When we speak about programs which reduce the malnutrition rate, we must clarify: (1) the nature of what we call undernourished and (2) the focus we use in achieving its reduction and the instruments we employ to measure the changes produced by the programs.

If we review the natural history of disease, we see that the children born in an acceptable nutritional state suffer a period of Acute Malnutrition characterized essentially by a weight loss in relation to height, although at the same time height may or may not be normal for that particular age.

Acute Malnutrition produces a permanent deficit of variable intensity on the actual Height-for-Age. This deficit is what we call Chronic Malnutrition. To the extent that it is the height that determines weight proportional to individuals Chronic Malnutrition produces a permanent loss in Weight-for-Age.

Recovering from malnutrition includes a weight gain proportional to height and a variable increment in height proportional to age. With respect to the instruments that measure malnutrition, we know that the weight deficits per age represent the sum of the damages produced by Acute and Chronic Malnutrition; the weight loss per actual height represents Acute Malnutrition.

The data described in this report concerning rates of malnutrition refer to weight deficits per age. For the most part, the possible changes produced in the program

to improve Acute Malnutrition cannot be evaluated with certainty. In the same manner, at an individual level we cannot expect the program to eliminate malnutrition completely since by definition Chronic Malnutrition is a permanent deficit.

Figure 7 illustrates how the percentage of malnutrition varies with the age of the children, independently of the existence of any program. Hence, for the purposes of this evaluation, it is necessary to extract the effect of ageing of the children during their participation in the Program.

In Figure 8 we see that the malnutrition rate for children less than four years old decreases with each year of participation in the Program. As the population control (children that did not benefit from the Program) we consider for each age group those children who were in their first six months of the Program.

We can conclude then that the infant population (0-4 years) that participated in the Promotora Program in Candelaria had a lower malnutrition rate than the infant population not associated with the Program (control), and that the longer the participation time in the Program, the greater the reduction in the malnutrition rate.

In Figure 9, we see that for all ages the malnutrition rate is less for those children who enter the Program during the second year of life. This is evidence of the urgency to enroll children into the Program during their first months of life.

b. Analysis of additional factors external to the Program.

For an analysis of other factors extraneous to the Program that could have influenced the observed results, we should

examine the process that induces a determined nutritional state (Figure 10).

Age of the Infant population. As it can be observed in Figure 3, the malnutrition rate also diminishes through calendar years. In 1968 the malnutrition rate was 28.6%, and 21.4% in 1974. Once again, we must consider the effect of the increase in age of the population served by calendar year (Figure 11), but this is not significant since the slight increase in the malnutrition rate. The diminution observed is due primarily to factors other than age.

Income - Inflation. The majority of the families of Candelaria subsist on their monetary income. It should be expected that these families were very susceptible to inflation due to their low incomes. Graph 12 from the Index of Consumer Prices reflects the increase in the cost of living in Colombia for the seven-year period during which the Promotora Program occurred. Graph 13 of the percentage of change in the Index of Consumer Prices is more easily understood since it represents the annual rate of inflation,

If the incomes and the per capita expenditures do not increase in a form corresponding to inflation, it is possible that families would choose to buy less food or less expensive food (lower biological quality?), and for the most part malnutrition would increase.

Applying the Consumer Price Index to the monthly income in pesos, it can be noted that the true income of the families participating in the Promotora Program decreased from 1968-1974 by 7.1% (Figure 14), in as much as weekly per capita food expenses also saw a reduction of 8.7% more than the reduction of the monthly income.

Food expenses are more inelastic at low income levels. For the most part, the percent of reduction in per capita food expense was less than the decrease in income, since the people would increase proportionately the amount of income they would spend on food. Similarly the percentage of income not spent on food is at least as inelastic as food expenditures. The explanation for this relative inelasticity probably lies in the high percentage of income expended on food (between 80 and 90%). The remaining income is so small that only the most essential expenses are permitted, and for the most part are less expendable than if a percentage lower than the expenses was allotted for food.

More arguments concerning the effects of inflation on malnutrition are brought forth to examine the manner in which children's malnutrition rate corresponds to food expenses in constant pesos (15). At almost exactly the same point in time in which real family expenses for food begin to diminish (1971), the malnutrition rate ceased to diminish and began to increase slightly.

Thus, we can conclude that not only is the Promotora Program effective in improving the nutritional state of children, but it is effective as well in alleviating and arresting the detrimental effects of inflation.

Food Consumption

Figures 16, 17 and 18 illustrate how, during the years of the Promotoras Program, the caloric and protein gap became greater (22.7% in 1968 vs. 33% in 1975 for proteins, 19.7% in 1968 vs. 29.7% in 1974 for calories), reflecting our previous conclusions on food expenditure.

In terms of the quality of food consumed, the prediction that inflation would lead people to buy food of lower quality is also fulfilled, as evidenced by the fact that the percentage of animal proteins therein diminishes from 47% in 1968 to 37% in 1974 (16).

Here again we can expect the effect of the Promotora Program to diminish the malnutrition rate in spite of not having provoked an increase in the consumption and quality of food. However, if we examine the intrafamilial distribution of nutrients for 1974, we see that there exists a tendency to improve children's rations, except for the school children (Figure 19). Unfortunately, we have no positive evidence that this tendency in intrafamilial nutrient distribution as observed in Candelaria is due exclusively to the education provided by the Program.

Education

Chart 20 depicts once again the effect of education on malnutrition, though it does not really augment what is already known about the causes of malnutrition. Yet to attempt an analysis of the manner in which education influences the success of the Promotora Program in the reduction of malnutrition poses a problem for which we do not have an answer. In other words, we do not have previous information that permits us to present a hypothesis and to learn from its evaluation, and the information obtained from the Promotora Program as we see it is not conclusive. The response that we had wanted to obtain should reply to whether or not the Program is more effective in the reduction of malnutrition with regard to the degree of literacy of the parents of the children who were the object of the program. Figure 21 and 22 show that the % of reduction in the malnutrition rate was essen-

tially equal for all children whether or not their parents were literate.

With respect to malnutrition, let's analyze now age groups that have remained in the program for 1, 2, or 3 years, noting that children whose father or mother are illiterate number about 10%; for the most part it is impossible to draw valid conclusions, especially for age groups older than 4 years.

Figure 23, 24, 25, and 26 illustrate the tendency for baby sons of a literate father or mother, who remain in the Program longer than other children, to lower the malnutrition rate. For the baby sons of an illiterate father or mother this tendency is not as evident, although for all ages the malnutrition rate is less following a year of participation in the Program than the malnutrition rate for children unexposed to the Program.

Finally, in Figure 27, as was to be expected, food expenses are greater in families whose fathers are literate than they are in families whose fathers are illiterate.

In conclusion, we can state that the Promotora Program is effective in the reduction of the malnutrition rate among literate families as it is among illiterate families, but in the latter it is not possible to predict the magnitude of the effect.

c. Elaboration of a theory on how the Program functions

In a previous chapter recounting the natural history of malnutrition, we saw how an event that unleashes a state of severe undernourishment usually occurs, as well as how the processes of severe malnutrition engender a sequel, Chronic Malnutrition.

To compare the graphs of incidence of malnutrition and diarrhea by age for the population of Candelaria, we see that the greatest incidence of diarrhea occurs at 12 months of age, while the highest incidence of malnutrition occurs at 24 months of age. Such a fact makes us believe that the greatest causal relationship is that of diarrhea producing malnutrition, although we do not disregard the fact that malnutrition augments the incidence of diarrhea.

From the analysis of Graph 28 which links the % of children in the population having a normal nutrition to food expenditures, we can see how, for all levels of food expenditures, the occurrence of diarrhea produces a lower % of children with normal nutrition. More dramatic is the fact that the occurrence of diarrhea in the infant population creates a need for at least a 50% increase in nutrients.

Graph 29 tentatively establishes a relationship between food expenses (nutrient ingestion) and weight loss (nutritional state). As was to be expected, in the population having greater food expenditures, the weight loss produced by the diarrhea is less; but for the population with lesser food expenses, diarrhea induces a difference in weight loss of more than 15%. (According to the Gomez classification of undernourishment, this weight loss is sufficient to advance the child by more than one degree of severity).

Thus, it is to be expected that an intervention program conducted to diminish the frequency, severity and intensity of diarrhea in children less than 6 years old, would achieve a diminution in the incidence of Acute Malnutrition and for the most part would diminish Chronic Malnutrition.

Figure 30 illustrates the effect on diarrhea and malnutrition rates of child participation in the Promotora Program. At first glance, it would seem as if the Program was successful in reducing the diarrhea rate and consequently the malnutrition rate. But we must clarify our data slightly since they may lead to equivocal interpretations. Figure 31 shows the increase in the average age of children for each year of participation in the program. As we know from the natural history of diarrhea, its incidence decreases with an increase in age. Consequently, the possible effects of the program cannot be disassociated from the effects of age.

For the Promotora Program, diarrhea was defined as the number of diarrhetic episodes that the mother remembers her child suffering in the month prior to the survey.

We attempted to correlate the duration of each episode and its severity with the nutritional state of the children, but we found no consistent effect. As we can see in Figure 32, the % of children in Candelaria suffering diarrhetic episodes (rate of diarrhea) decreased by about 20% in 1968 to 11% in 1974, in a form similar to the decrease in the malnutrition rate.

Finally, if we compare the diarrhea rate for each age group for each year of participation in the Program (Figure 33), we can observe that for all the ages the diarrhea rate of children in the Program diminishes as their participation time increases, reaffirming the positive effect that the Promotora Program has on the decrease in diarrhea rate.

In conclusion, we have outlined a theory describing the dynamics of the Promotora Program in the following form:

"By means of the attention provided by the Promotora Program to families having children less than 6 years old, a reduction in the rate of diarrhea can be achieved, accompanied by a corresponding decrease in the occurrence of severe undernourishment, which in its turn reflects the gradual disappearance of Chronic Malnutrition as observed in the different groups of children in Candelaria."

FIGURE 1

CHILD MALNOURISHMENT AND DIARRHEA RATE

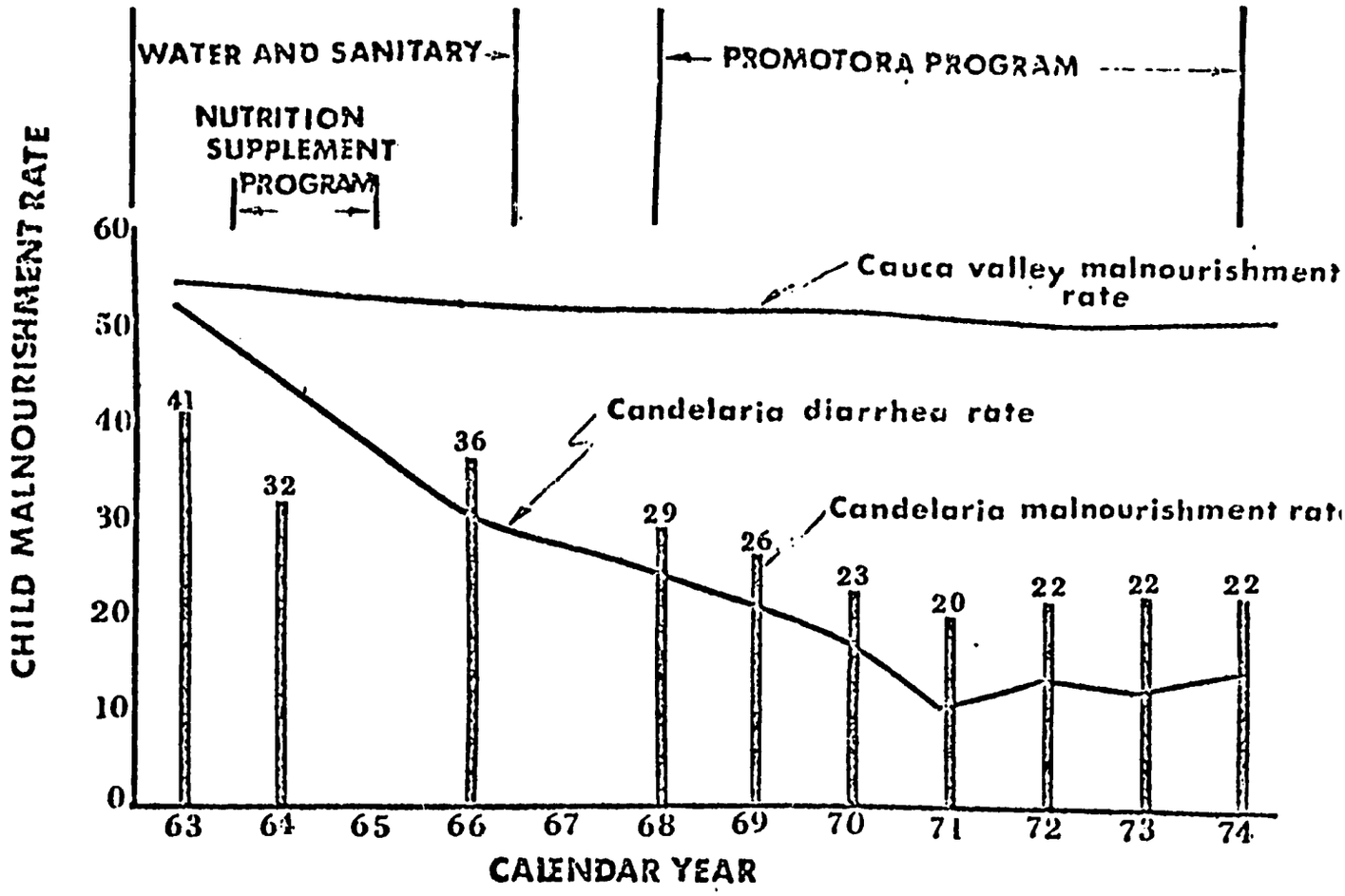


TABLE 1

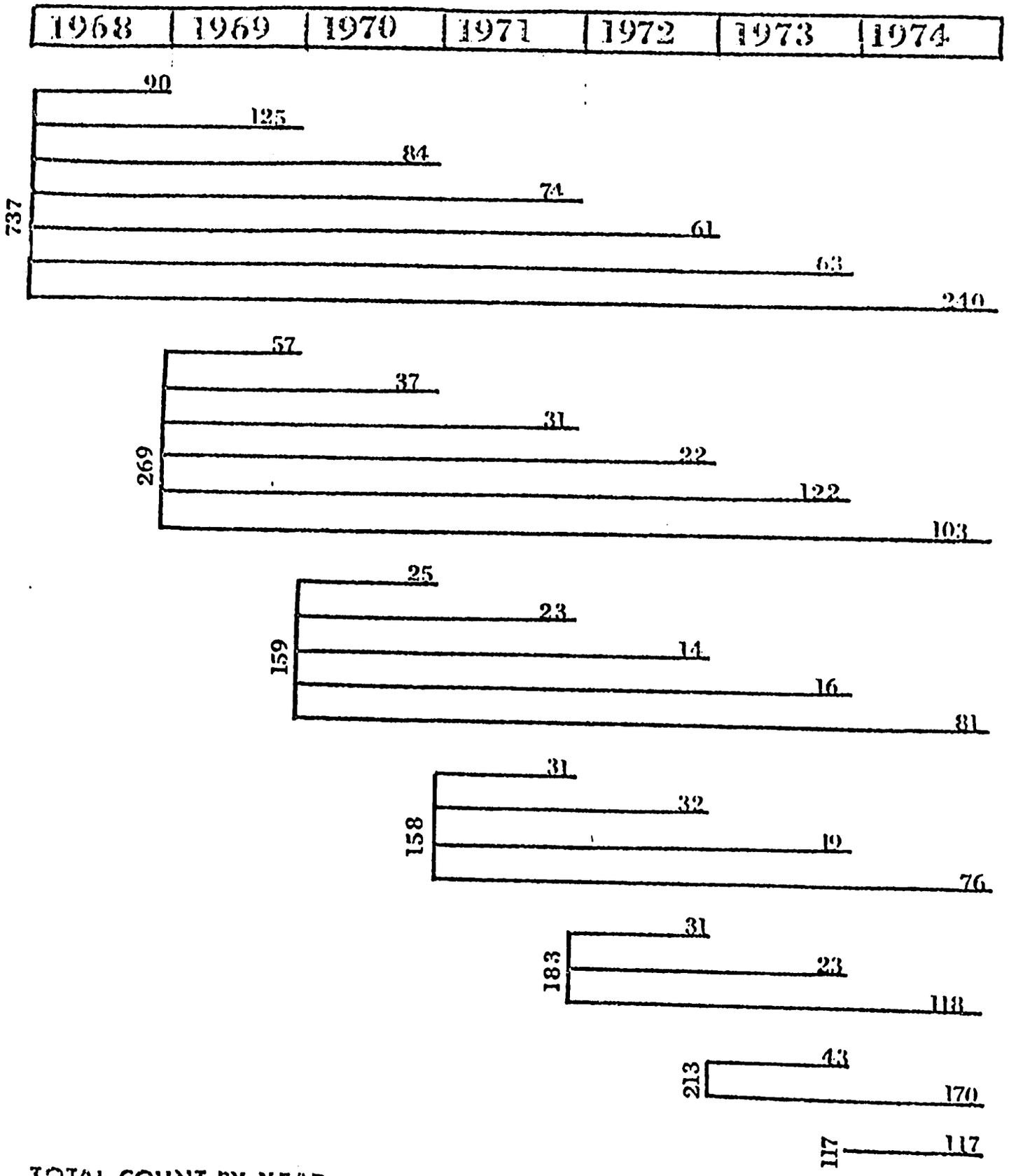
CHARACTERISTICS OF THE PROMOTORA PROGRAM IN CANDELARIA 1968 - 1974

Year:	1968	1969	1970	1971	1972	1973	1974
Participating Families	737	916	893	905	929	982	905
Participating Children	694	1,309	1,350	1,438	1,430	1,638	1,192
Children per family (< 6 years)	0.94	1.43	1.53	1.53	1.54	1.62	[illegible]
Average Age of Attenting Children (months)	26.9	27.9	28.2	28.1	28.9	31.6	31.4

NUMBER OF FAMILIES PARTICIPA[illegible] TABLE

IN PROMOTORA PROGRAM BY YEAR

(BASED ON 1840 FAMILY RECORDS)



TOTAL COUNT BY YEAR

737	916	893	905	929	982	905

FIGURE 3

PERCENT MALNOURISHMENT FOR CHILDREN OF ALL AGES

IN CANDELARIA, COLOMBIA 1968 TO 1974

(BASED ON 9800 INDIVIDUAL CHILD RECORDS)

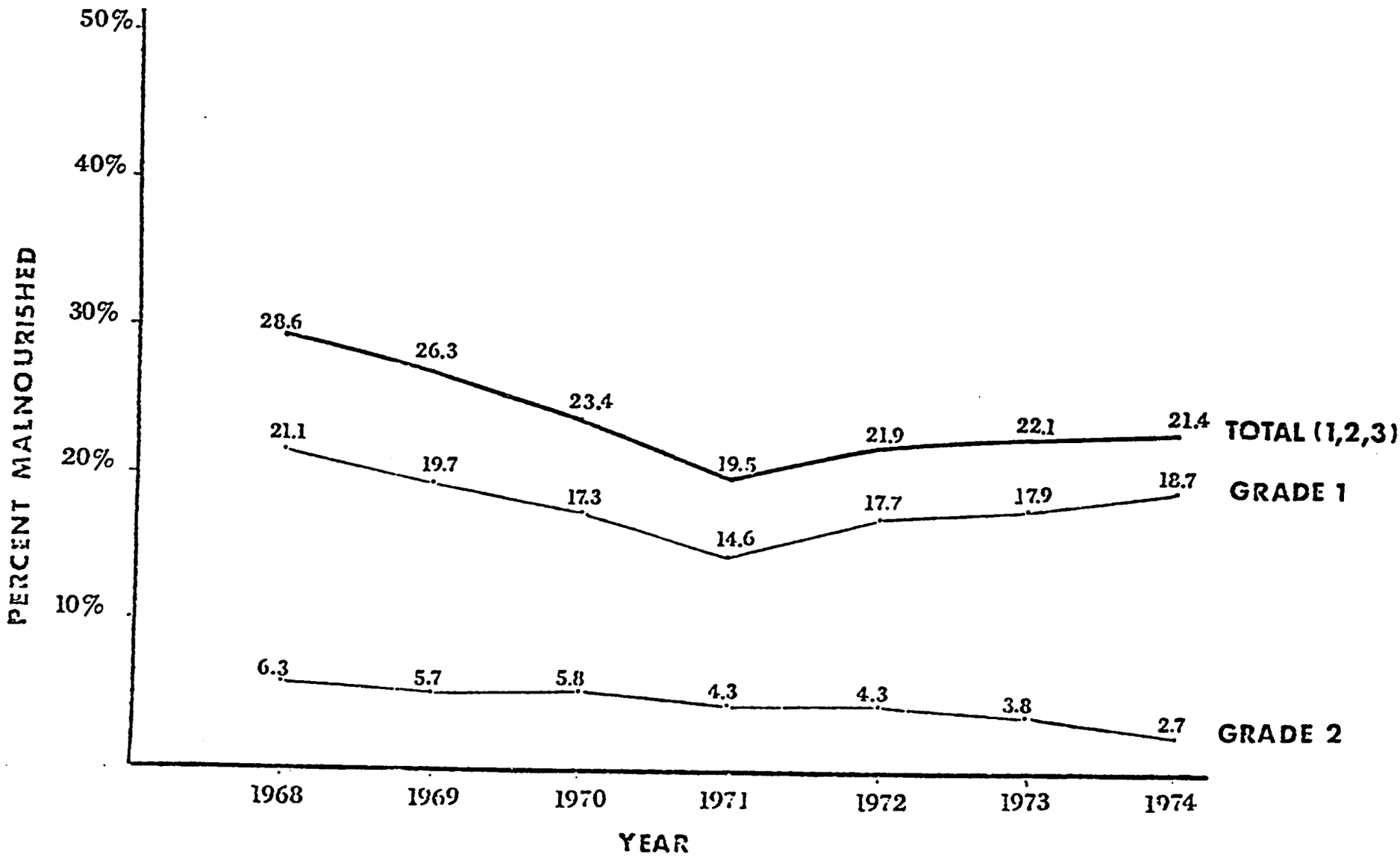


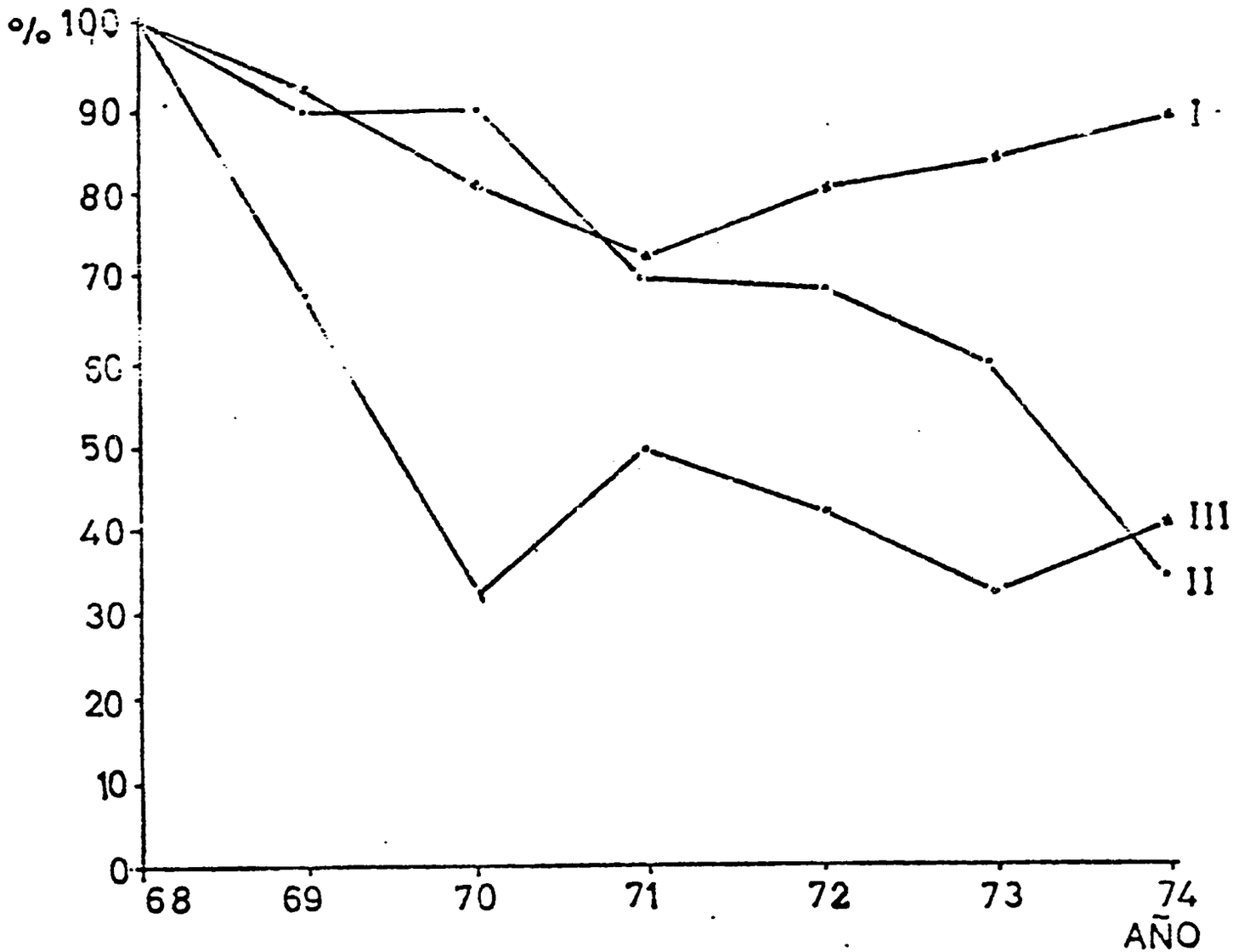
TABLE 4

PERCENT MALNOURISHMENT FOR ALL CHILDREN 0-72 MONTHS
CANDELARIA COLOMBIA 1968-74
(Based on Individual Child Data)

NUTRITIONAL STATUS	PERCENT MALNOURISHMENT						
	1968	1969	1970	1971	1972	1973	1974
Grade I	21.1	19.7	17.3	14.6	17.0	17.9	18.7
Grade II	6.3	5.7	5.8	4.3	4.3	3.8	2.2
Grade III	1.2	.8	.4	.6	.5	.4	.5
Total	28.6	26.3	25.4	19.5	21.9	22.1	21.4
Normal	71.4	73.7	76.6	80.5	78.1	77.9	78.6
Count	694	1309	1350	1438	1430	1638	1192
Nursing	18.5	21.6	19.6	20.0	17.6	13.1	13.4
Count	694	1309	1350	1438	1430	1638	1192

N° 4

% DE REDUCCION EN LA TASA DE DESNUTRICION EN GRADOS POR AÑO. AMBOS SEXOS Y TODAS LAS EDADES



Drake, Fajardo

TABLE 5

NUTRITIONAL STATUS OF COLOMBIAN CHILDREN 1960 - 1974

CHILDREN	AREA	AGE (Months)	YEAR OF SURVEY	% N	I	II	III
477	Huila (Tolima) Templado (U)	0-15 (a)	1960	47.8	27	28	6
314	Nariño. Alti-Plano (U)	0-12	1960	52.5	23	11	9
1094	Valle (S.R.)	0-6	1963	59.2	26	13	1.3
640	Colombia (S.R.)	0-3	1963	58.4	25.8	13.8	2
970	Rural. Haliconia (Ant.)	0-13	1968	+	+	+	+
964	S.R. San Jacinto (Bolivar)	3-72	1968	33	49.2	15.8	1.1
452	San Andrés	0-6 (a)	1974	62	27.6	9.5	0.7
3378	Colombia (9 localidades)	0-6 (a)	1953--68	33.4	45.6	19.3	1.7
2000	Colombia	0-18	1964	44	40	14	2
400	Bogatá. Medio hospitalario	0-6	1962--63	29	47	20	4
9725	AVERAGES			48%	33%	14%	2.9%

FIGURE 6

PERCENT MALNOURISHMENT AND DIARRHEA VS. AGE OF CHILD
(CANDELARIA, COLOMBIA)

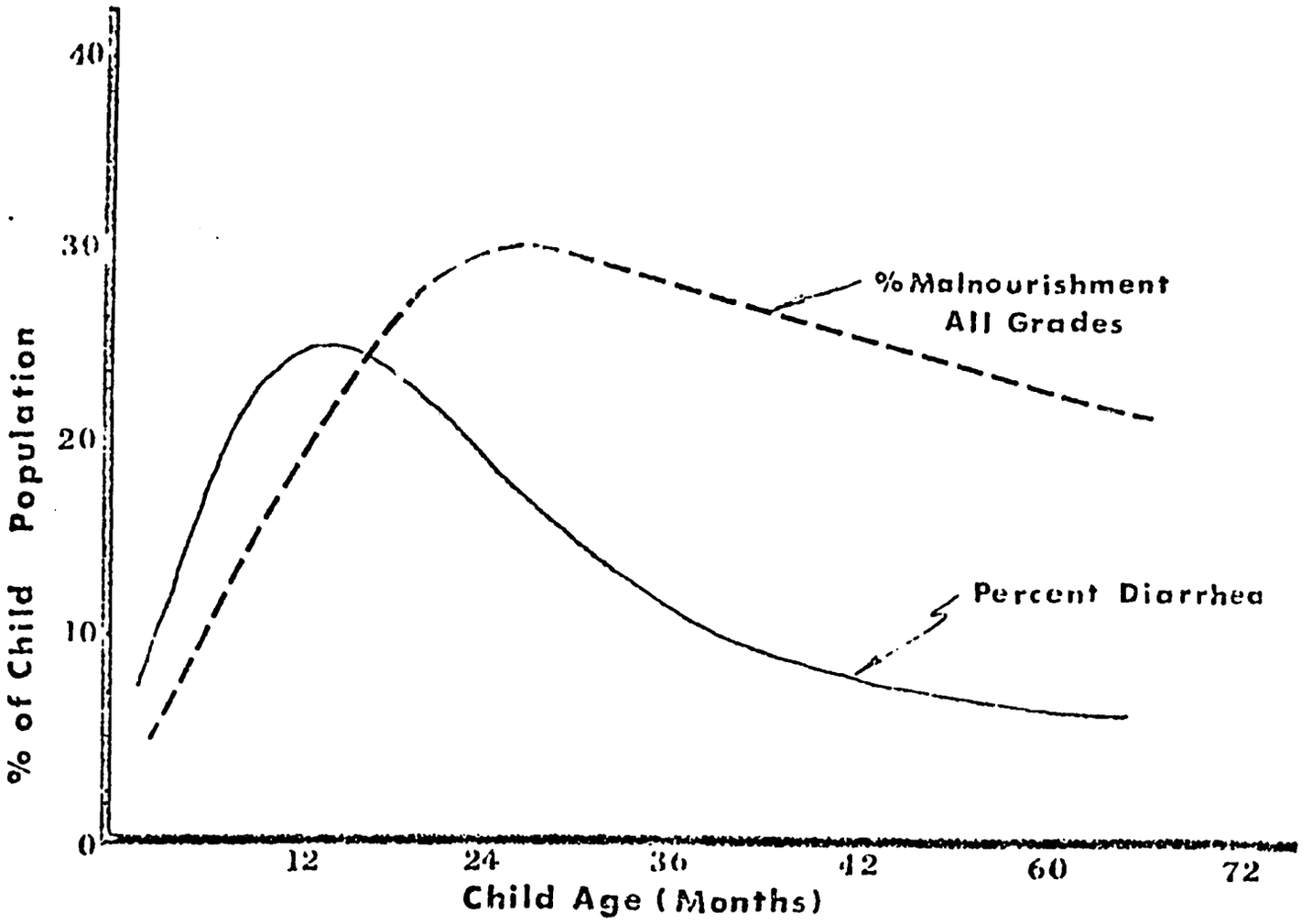


FIGURE 7

MALNOURISHMENT RATE VS. AGE AND NUMBER OF YEARS IN PROGRAM

(CANDELARIA, COLOMBIA)

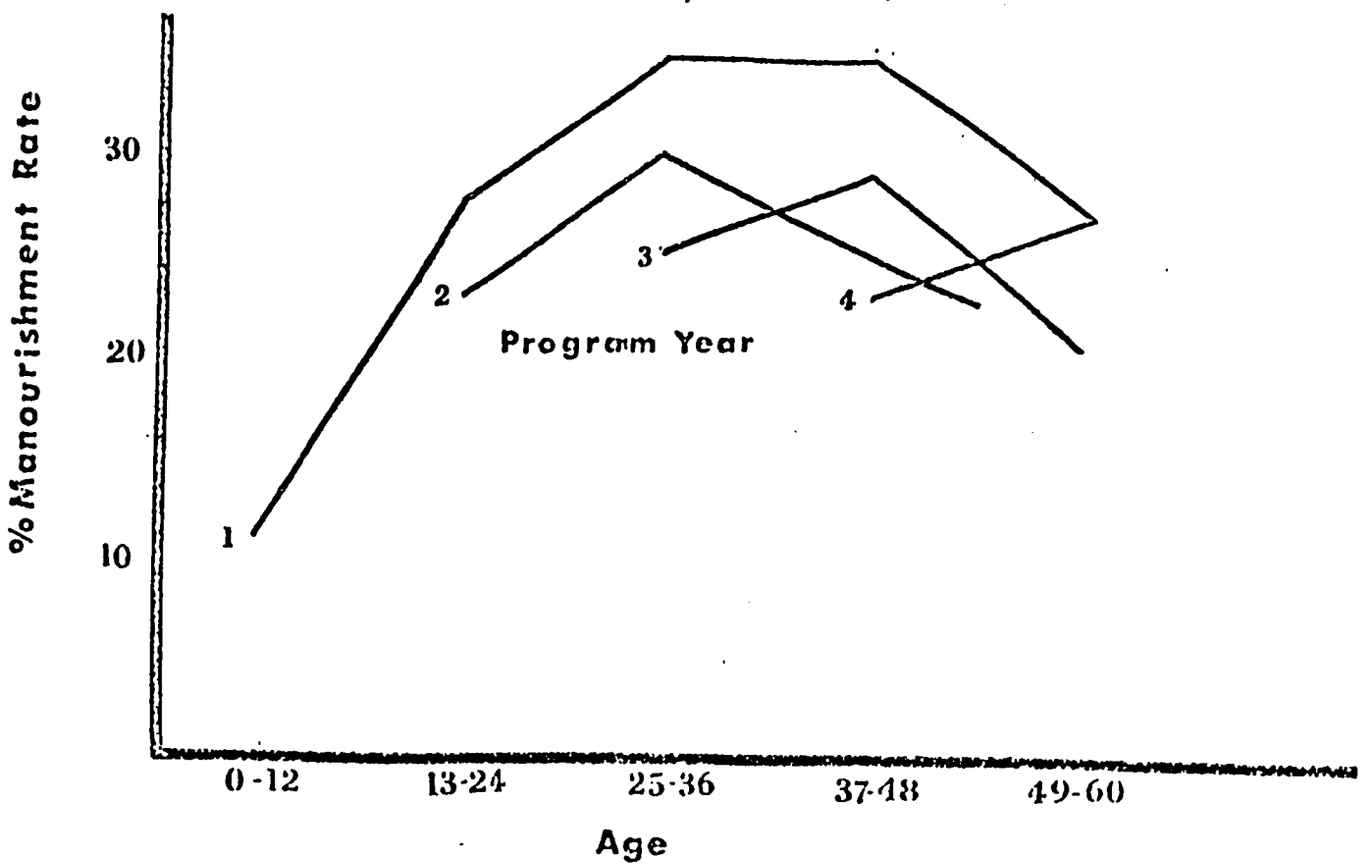


FIGURE : 8

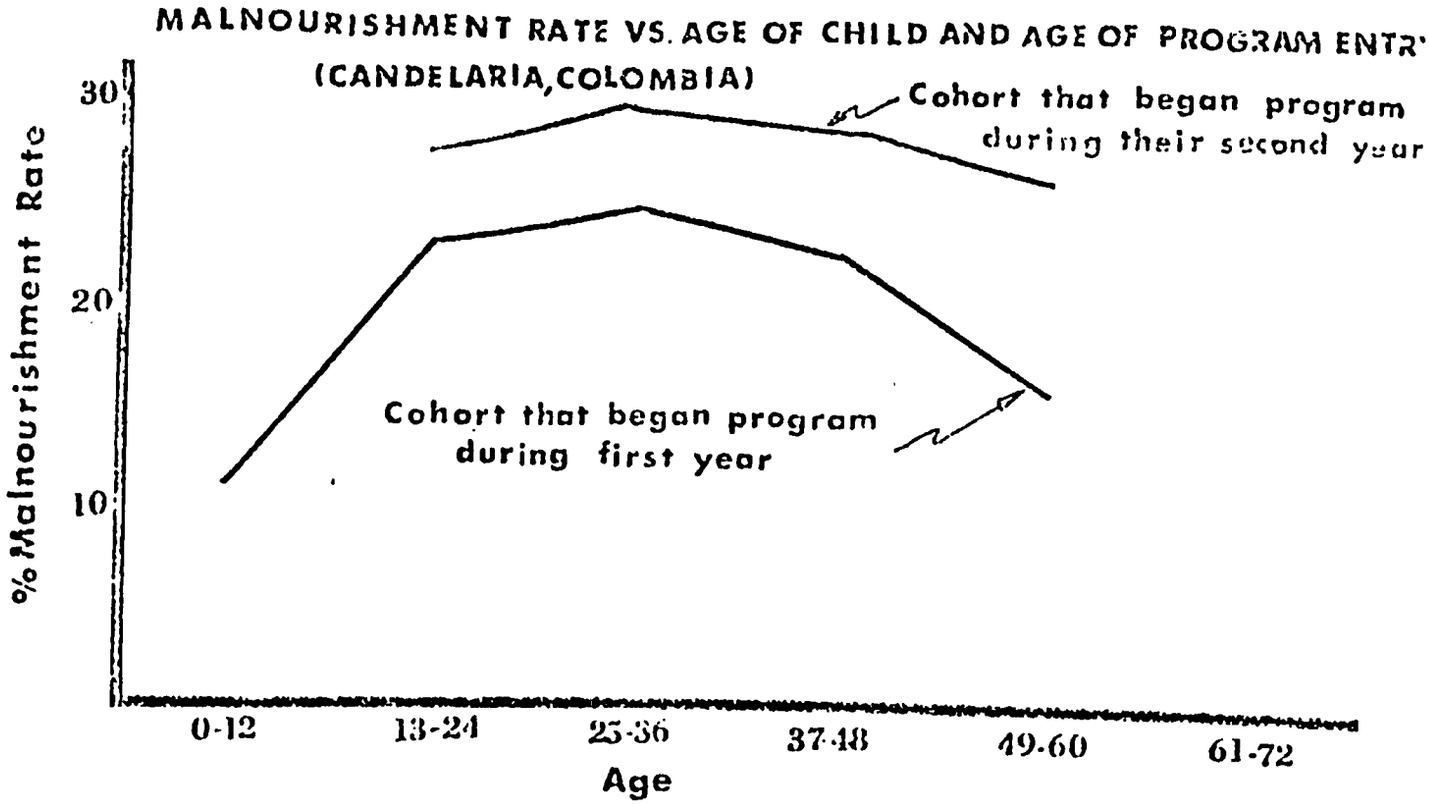
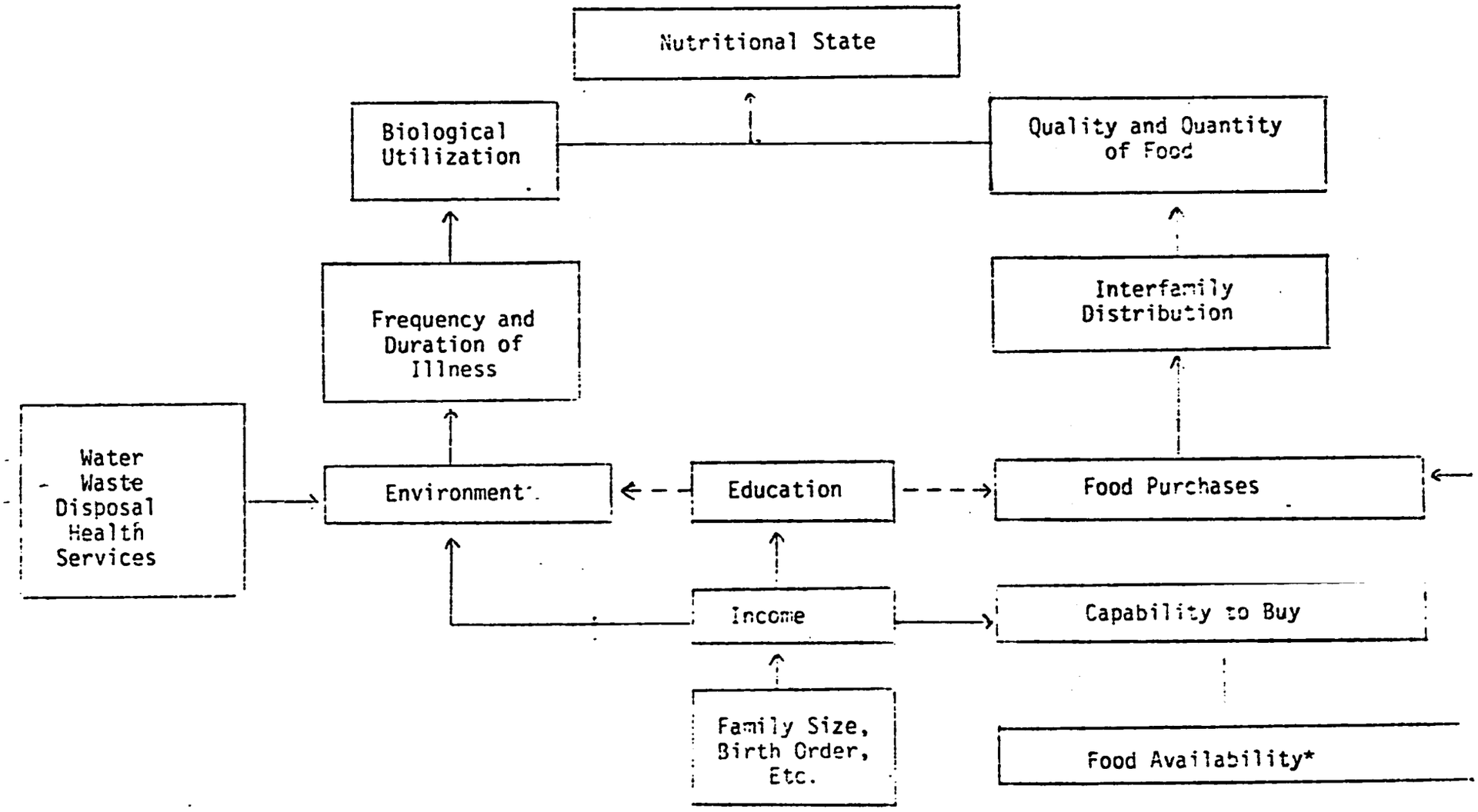

MALNOURISHMENT RATE VS. AGE OF CHILD AND AGE OF PROGRAM ENTR
(CANDELARIA, COLOMBIA)
Cohort that began program during their second year
Cohort that began program during first year
% Malnourishment Rate
30
20
10
0-12
13-24
25-36
37-48
49-60
61-72
Age

FIGURE 9

INTERRELATIONSHIP BETWEEN NUTRITIONAL STATUS & SOCIOECONOMIC FACTORS



*Risk Factors

FIGURE 10

AVERAGE CHILD AGE BY CALENDAR YEAR

(CANDELARIA, COLOMBIA)

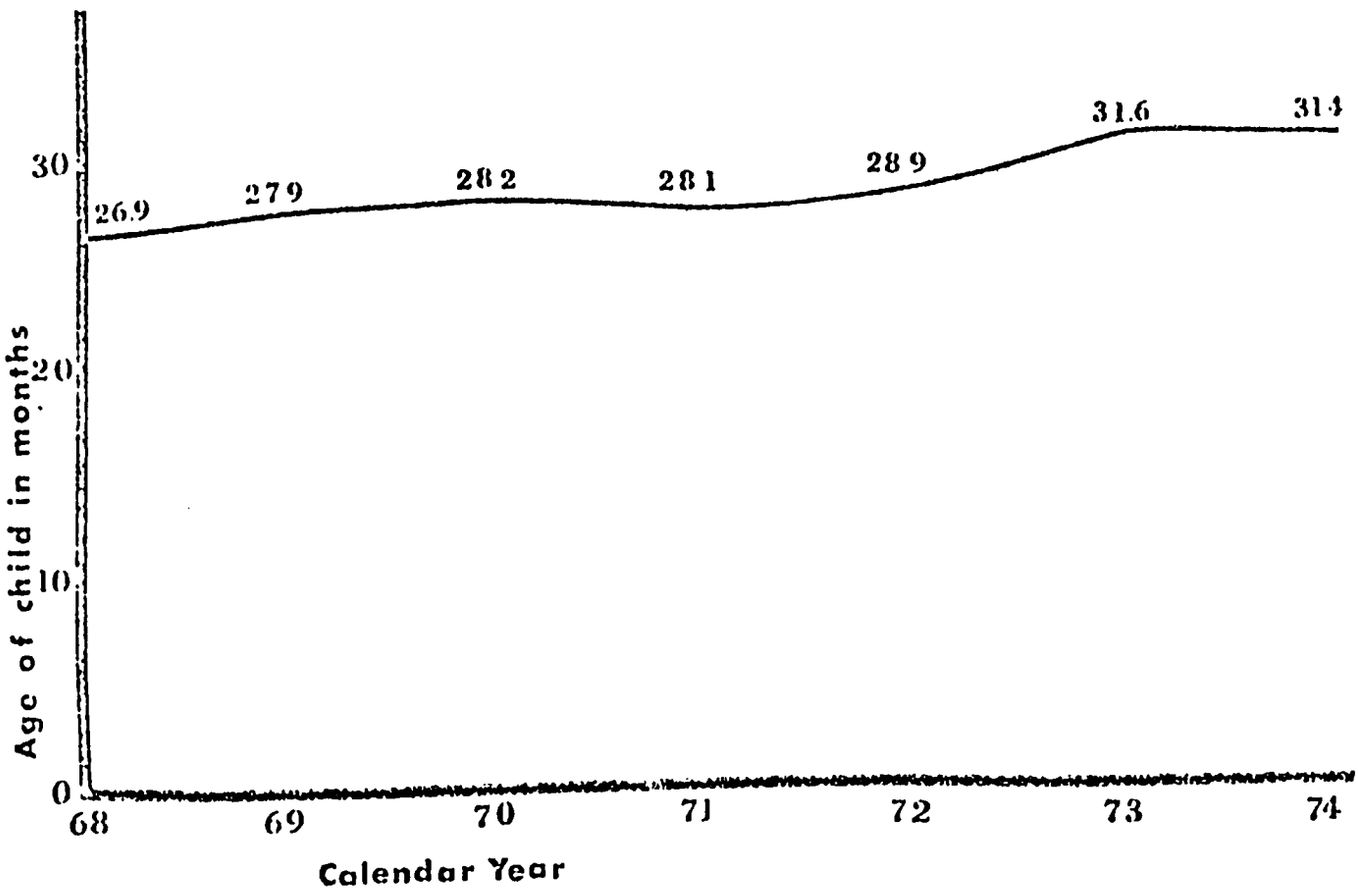


FIGURE 11

CONSUMER PRICE INDEX IN COLOMBIA 1968 TO 1974

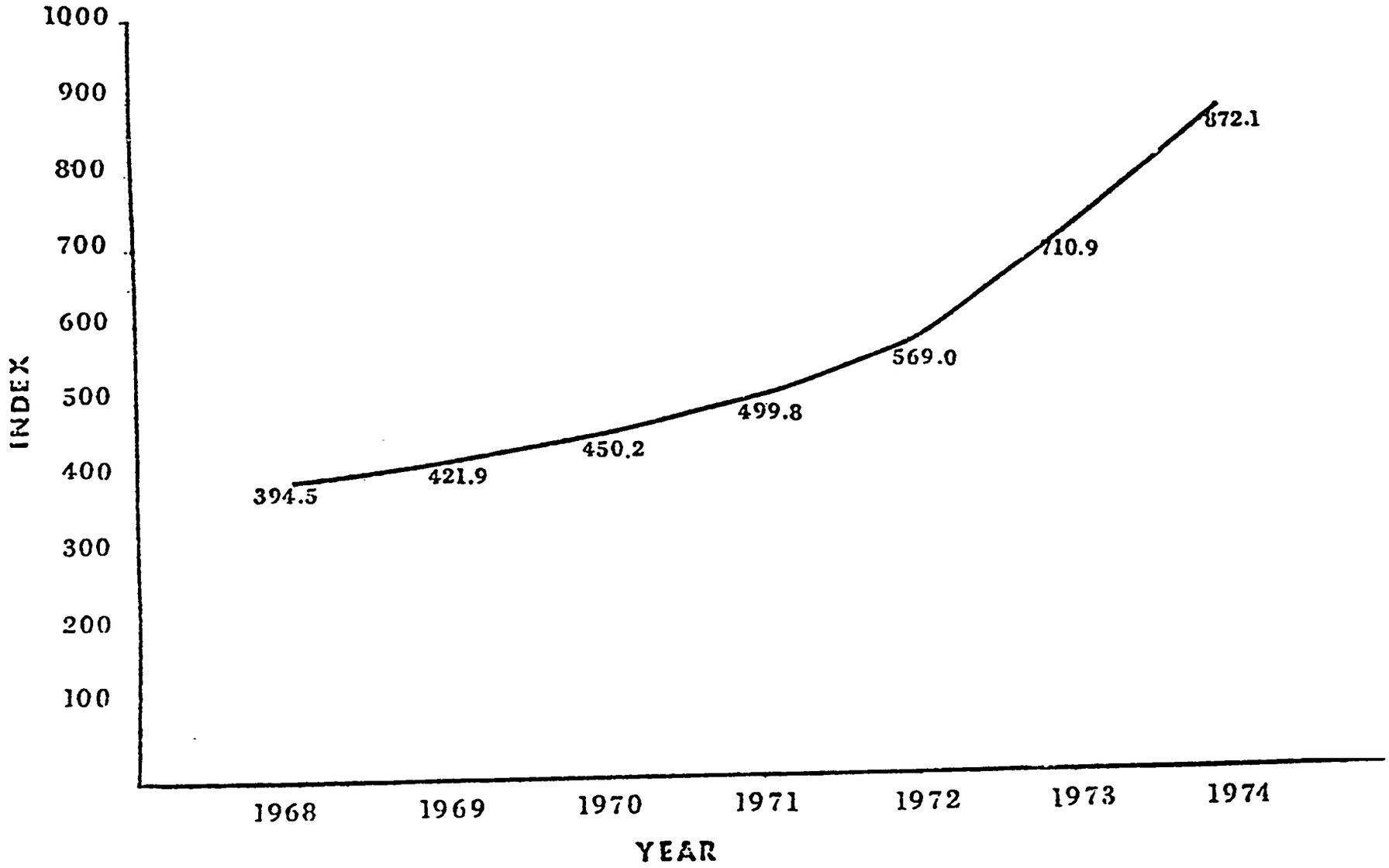


FIGURE 12

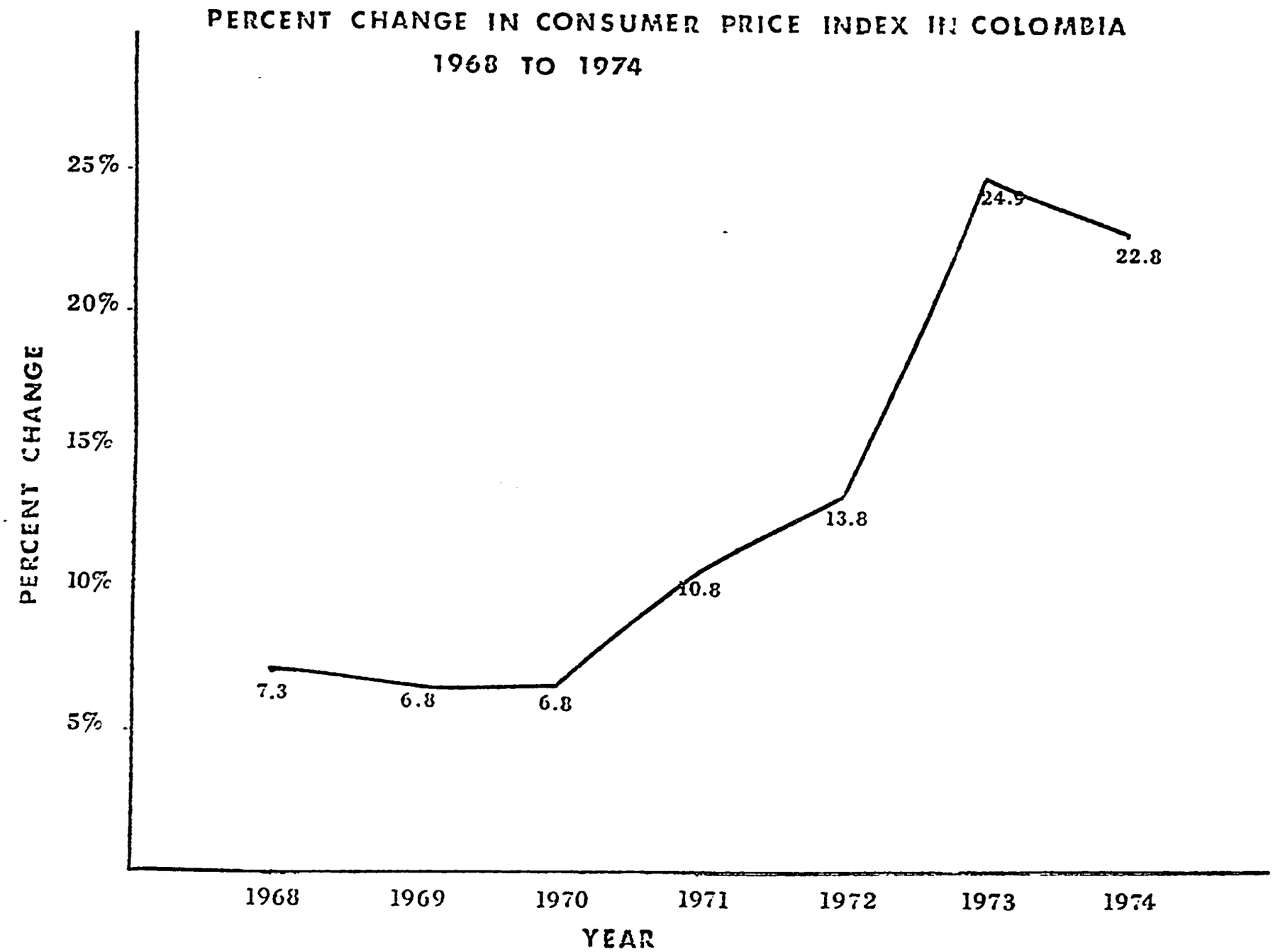

PERCENT CHANGE IN CONSUMER PRICE INDEX IN COLOMBIA
1968 TO 1974
25%
20%
15%
10%
5%
PERCENT CHANGE
7.3
6.8
6.8
10.8
13.8
24.9
22.8
1968
1969
1970
1971
1972
1973
1974
YEAR

FIGURE 13

MONTHLY INCOME IN PESOS

IN CANDELARIA, COLOMBIA BETWEEN 1968 AND 1974
(BASED ON 1840 FAMILY RECORDS)

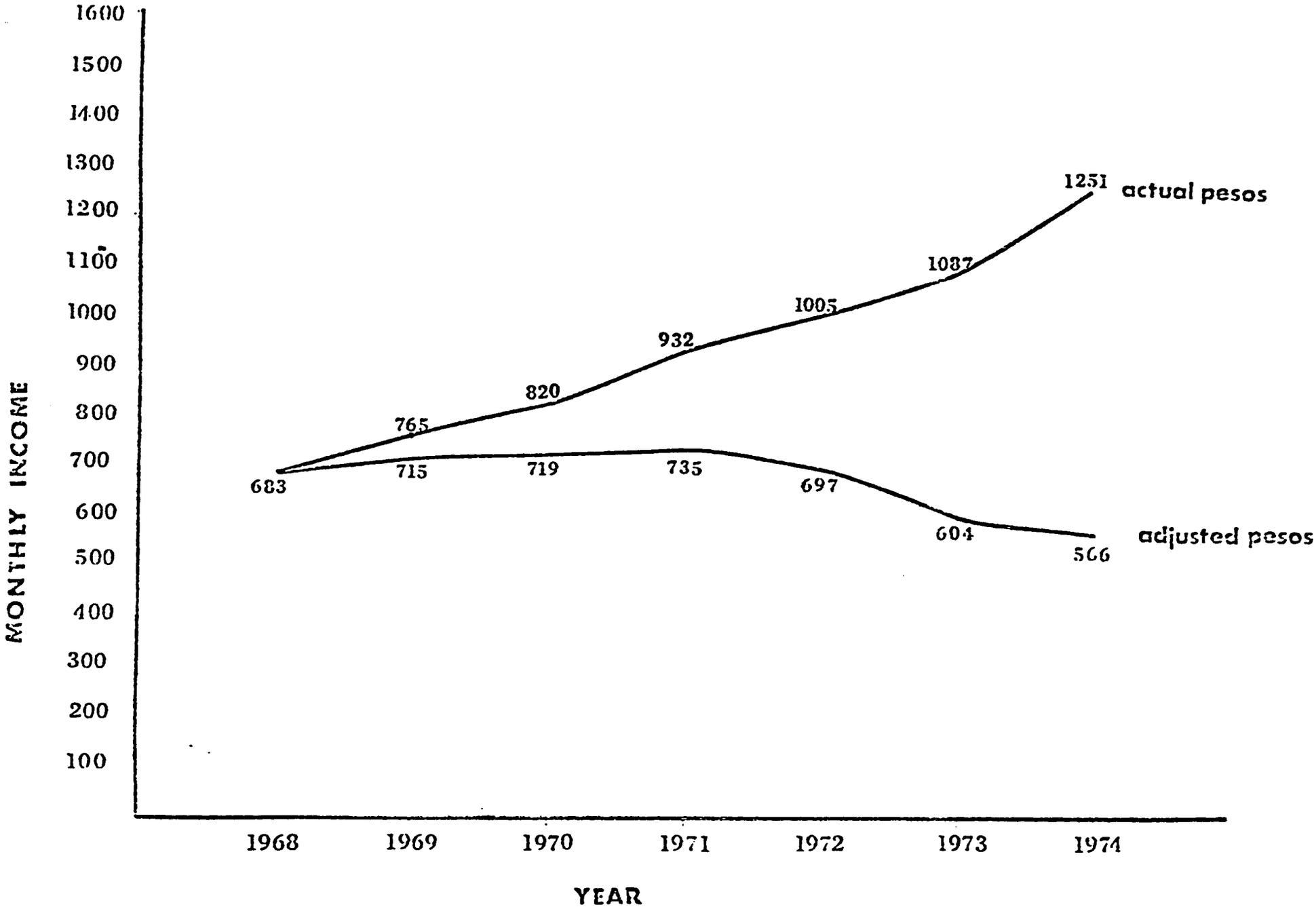


FIGURE 14

EXPENDITURES ON FOOD IN PESOS
IN CANDELARIA, COLOMBIA 1968 TO 1974
(BASED ON 1840 FAMILY RECORDS)

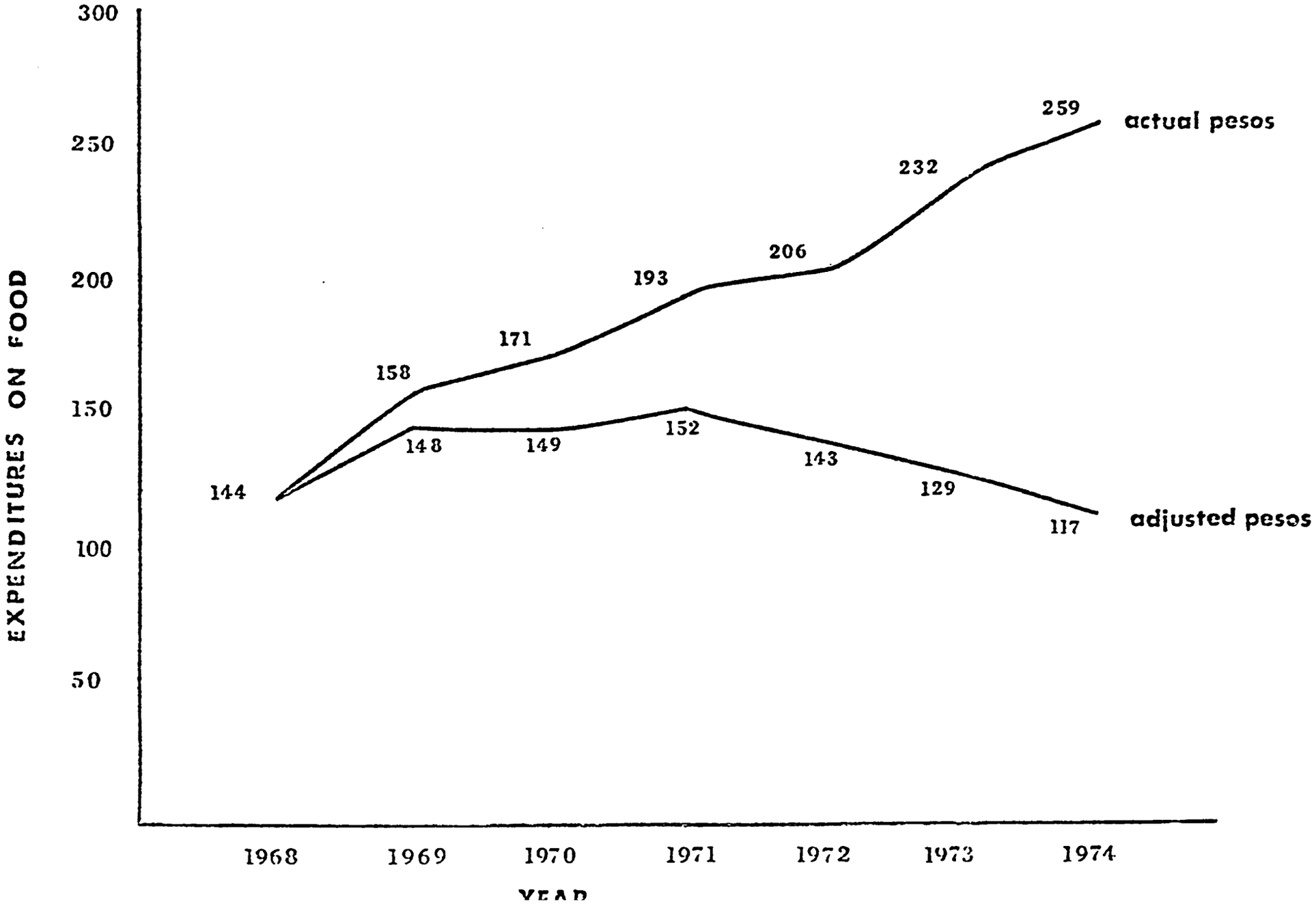


TABLE 15

CONSUMPTION OF NUTRIENTS IN CANDELARIA

1968 - 1974

	1968	1969	1972	1973	1974
Calorie Deficit	19.17	33.50	39.6	3[illegible].7	29.7
Protein Deficit	22.7	29.33	42.6	34.5	33
Calcium Deficit	61.83	58.83	79.6	75.6	74.8
Iron Deficit	25.0	27.4	54.2	30.2	30.2
Animal Protein Consumed (%)	47.0		43.0	36.0	37.0
Vegetable Protein Consumed (%)	53.0		57.0	64.0	63.0

TABLE 16

PERCENTAGE OF REQUIRED PROTEINS CONSUMED IN CANDELARIA 1964 - 1974

Calendar Year \ Age Groups	Breast Fed Children	Preschool	School Age	Adolescent Boys	Adolescent Girls	Male Adults	Female Adults
1964	58	89	65	90	90	81	81
1969	51	79	58	84	84	76	76
1972	41	64	47	68	68	62	62
1973	47	73	53	78	78	71	71
1974	48	74	54	80	80	72	72

TABLE 17

PERCENTAGE OF REQUIRED CALORIES CONSUMED IN CANDELARIA 1964 - 1968

Calendar Year \ Age Groups	Breast Fed Children	Preschool	School Age	Adolescent Boys	Adolescent Girls	Male Adults	Female Adults
1964	64	77	51	72	92	89	132
1969	53	62	42	60	76	73	109
1972	48	57	38	54	66	66	99
1973	54	65	43	61	78	75	112
1974	56	67	44	63	80	77	115

FIGURE 18

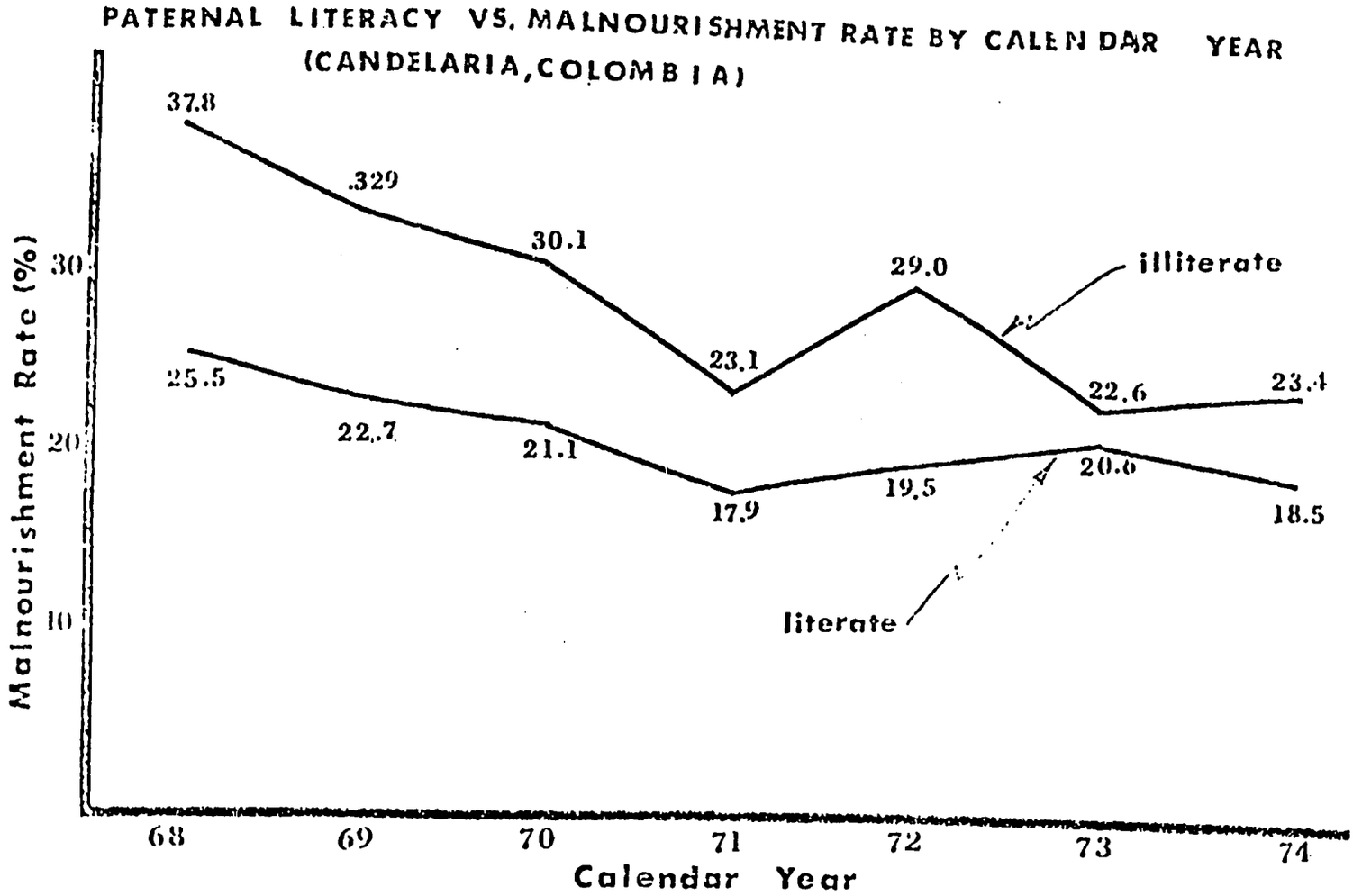
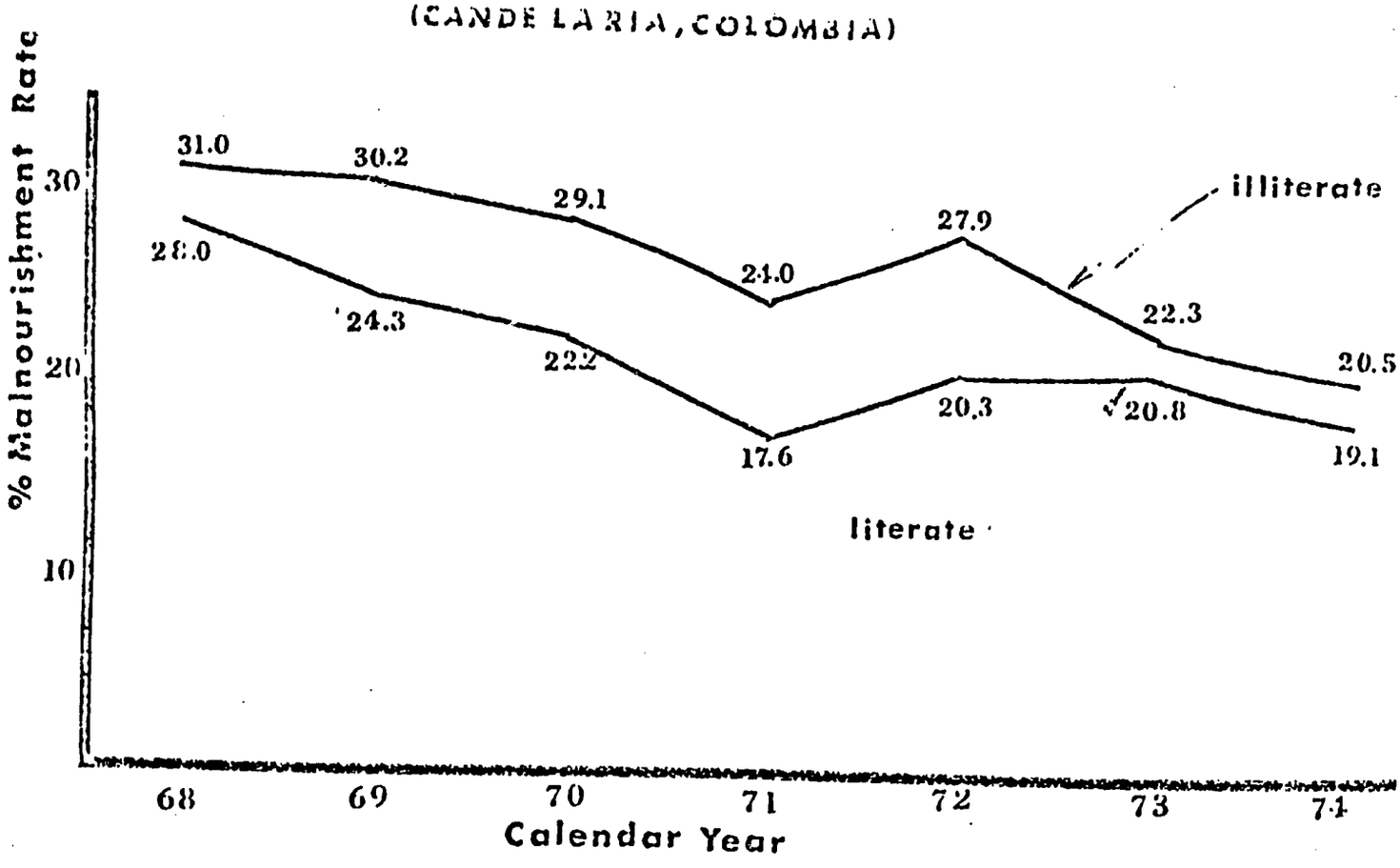
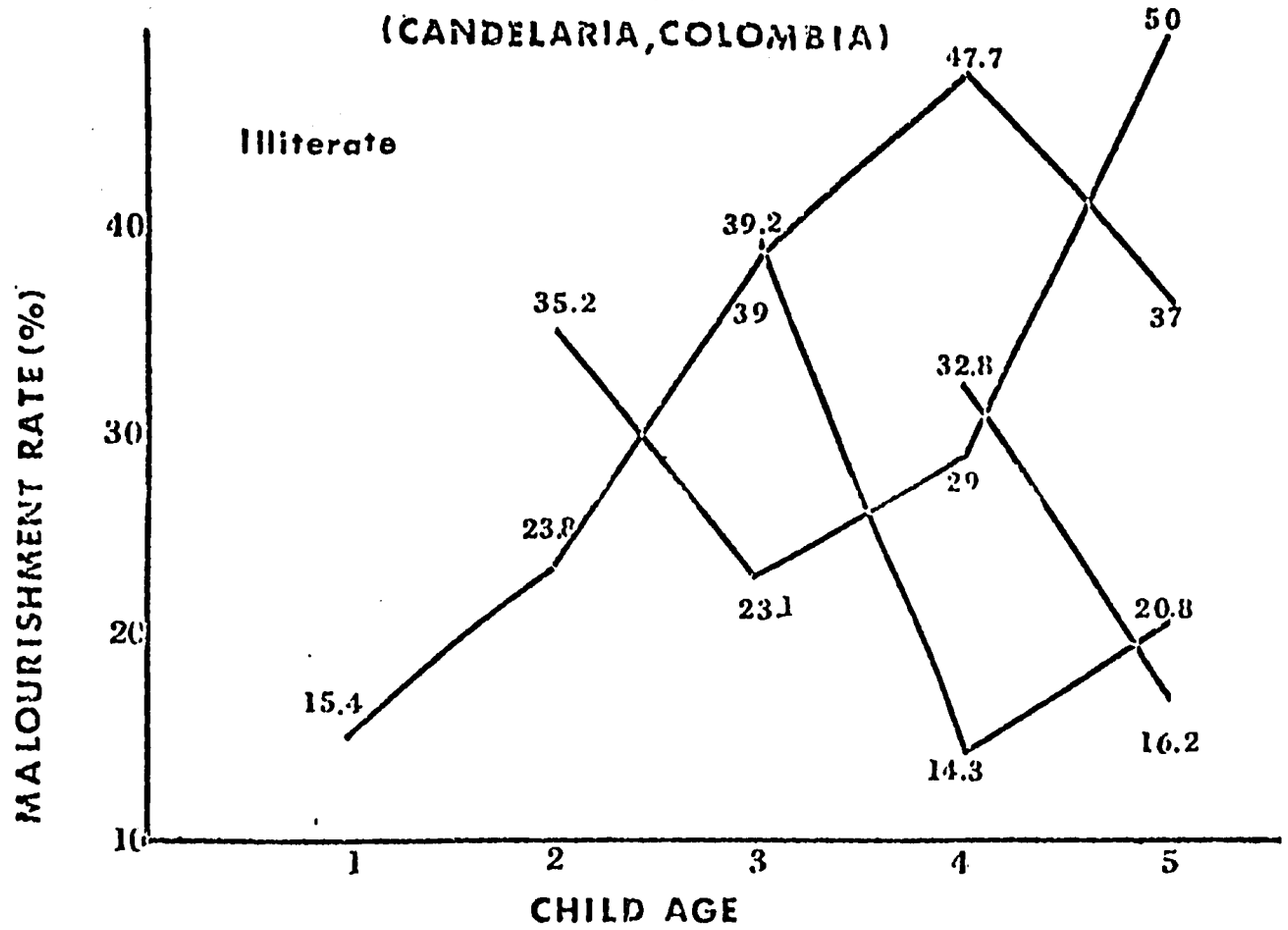

PATERNAL LITERACY VS. MALNOURISHMENT RATE BY CALENDAR YEAR
(CANDELARIA, COLOMBIA)
Malnourishment Rate (%)
30
20
10
37.8
.329
30.1
23.1
29.0
22.6
23.4
illiterate
25.5
22.7
21.1
17.9
19.5
20.6
18.5
literate
68
69
70
71
72
73
74
Calendar Year

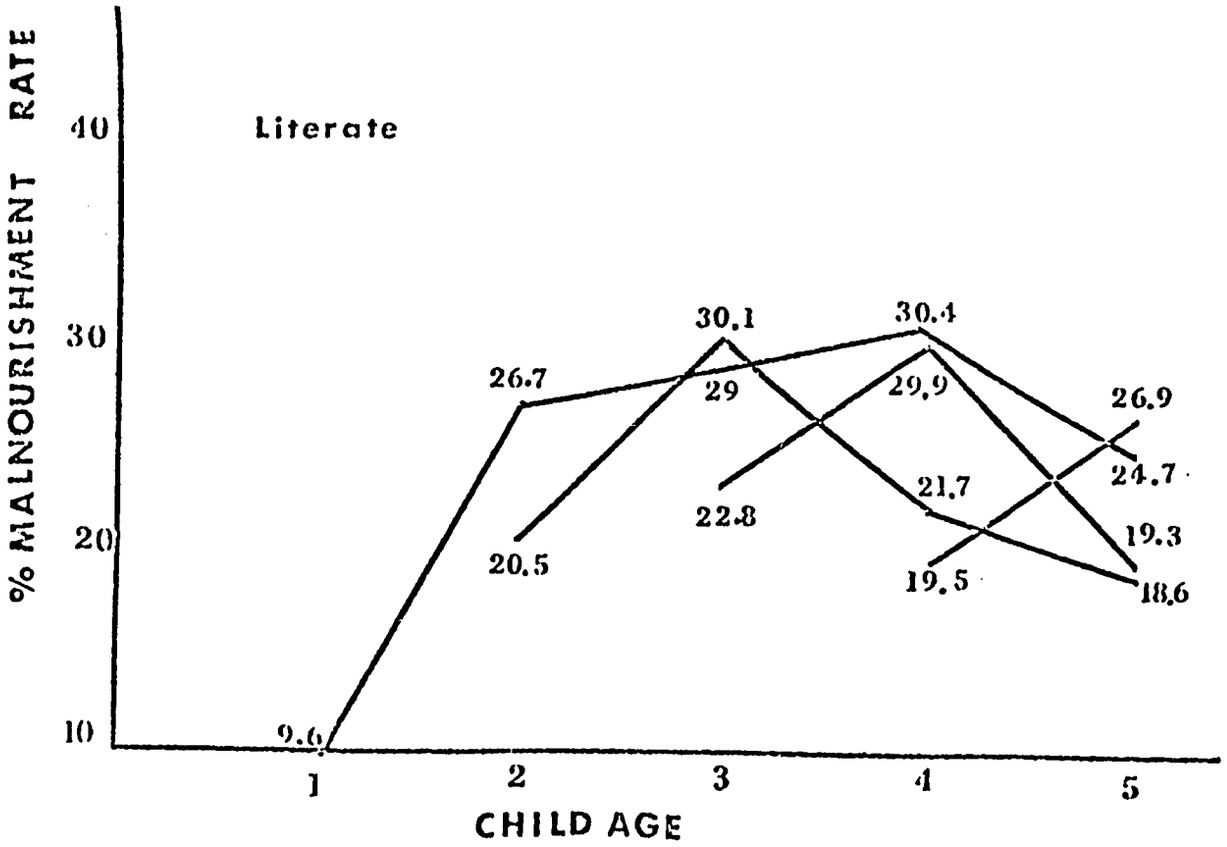
FIGURE 19

MATERNAL LITERACY VS. MALNOURISHMENT RATE BY CALENDAR YEAR
(CANDELARIA, COLOMBIA)

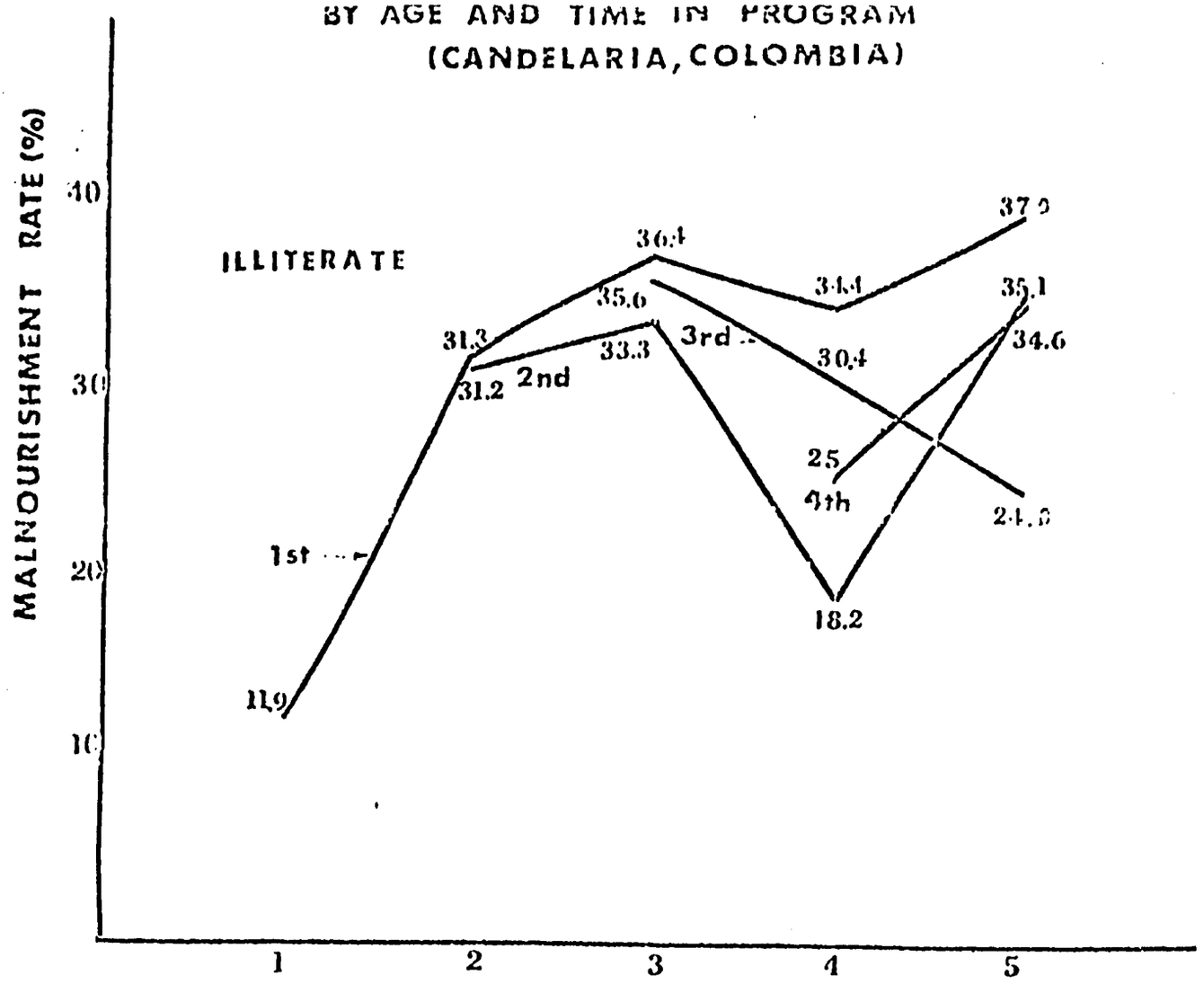


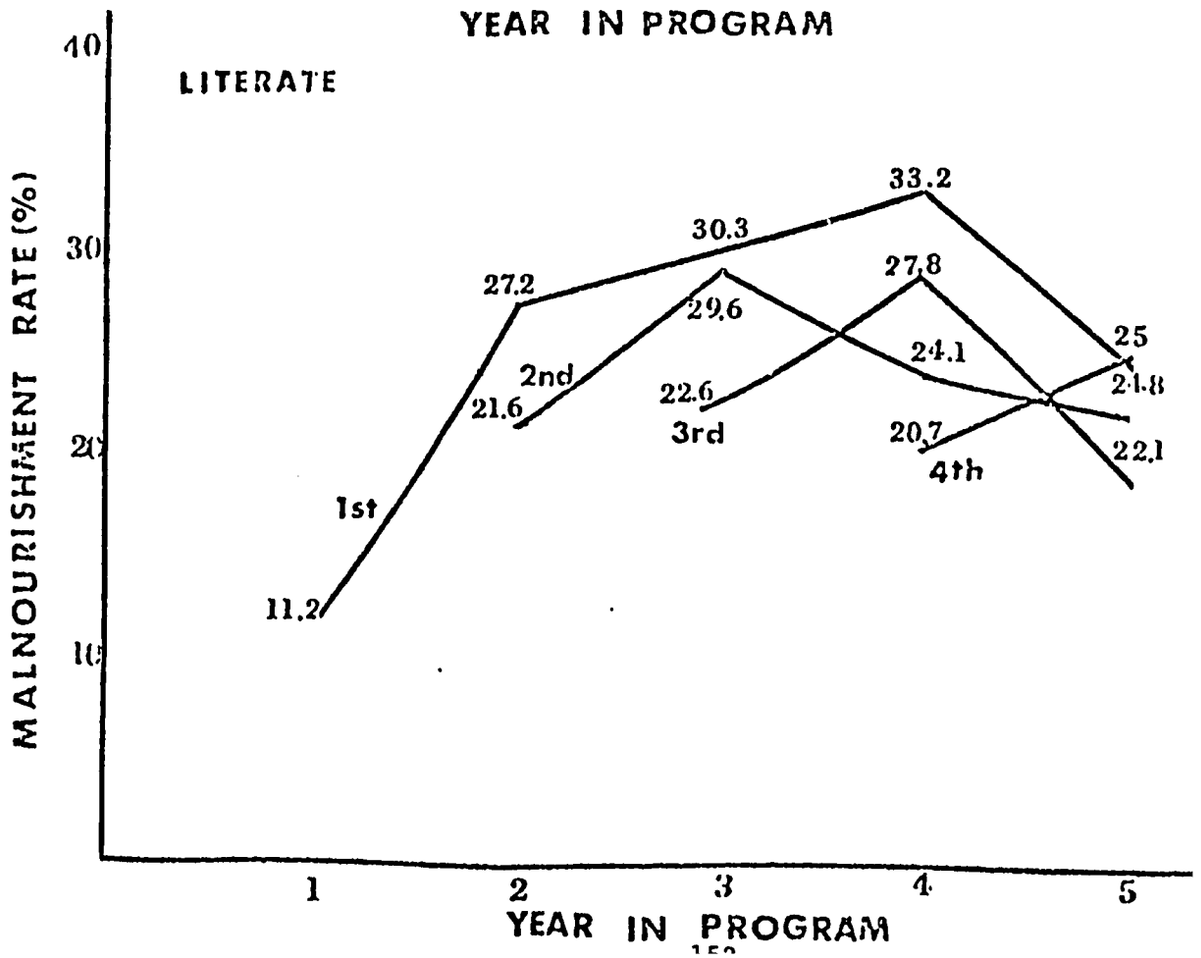
PATERNAL LITERACY VS PERCENT MALNOURISHMENT
BY CHILD AGE AND TIME IN PROGRAM
(CANDELARIA, COLOMBIA)



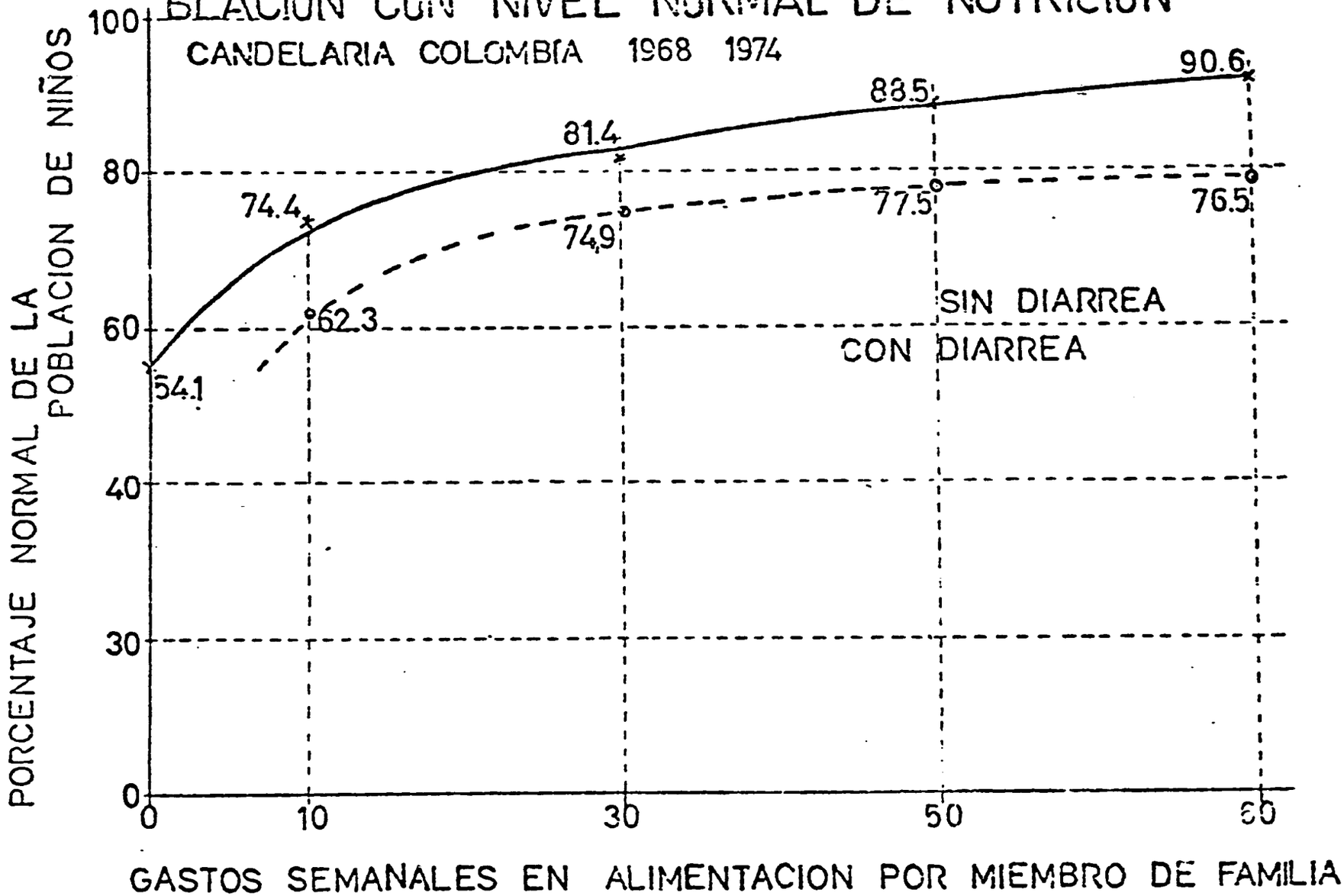


BY AGE AND TIME IN PROGRAM
(CANDELARIA, COLOMBIA)





GASTOS SEMANALES EN ALIMENTACION POR MIEMBRO DE LA FAMILIA VS. PORCENTAJE DE POBLACION CON NIVEL NORMAL DE NUTRICION



Drake Fajardo

FIGURE : 29

WEEKLY EXPENDITURES ON FOOD PER CHILD VS. NOURISHMENT LEVEL
(CANDELARIA, COLOMBIA)

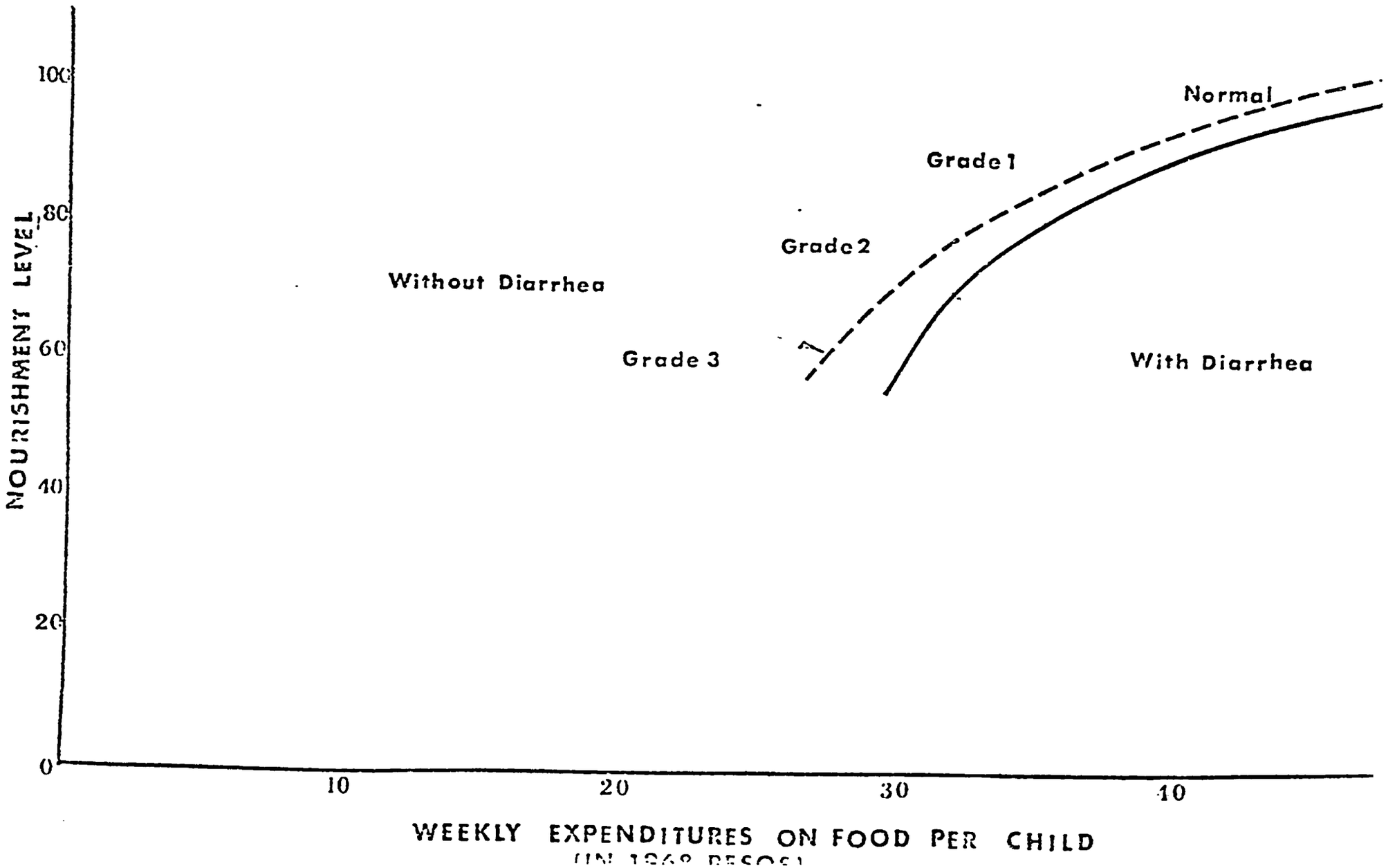


FIGURE 30

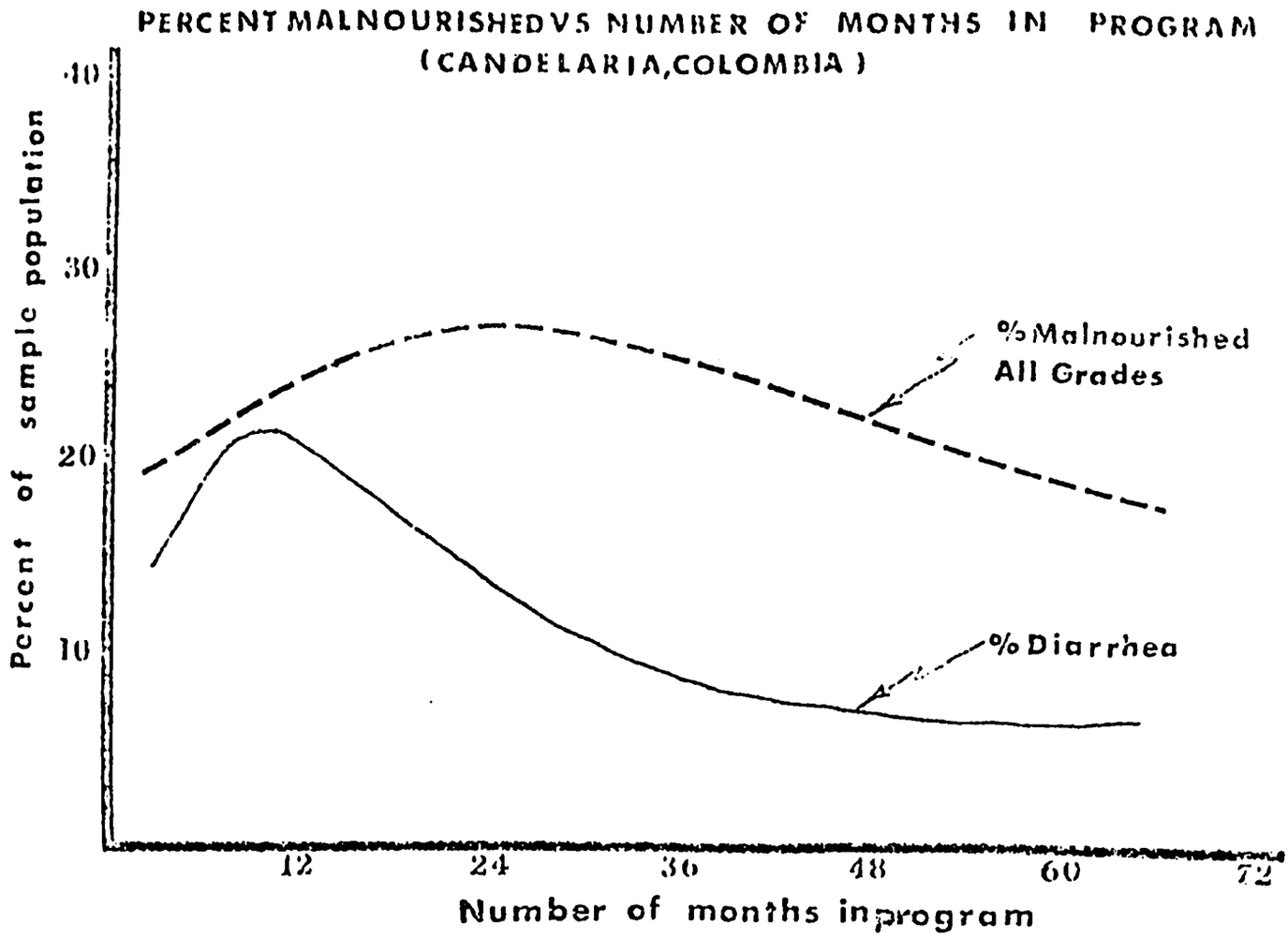

PERCENT MALNOURISHED VS NUMBER OF MONTHS IN PROGRAM
(CANDELARIA, COLOMBIA)
Percent of sample population
40
30
20
10
% Malnourished
All Grades
% Diarrhea
12
24
36
48
60
72
Number of months in program

FIGURE 31

AVERAGE AGE OF CHILD IN MONTHS BY YEAR IN PROGRAM

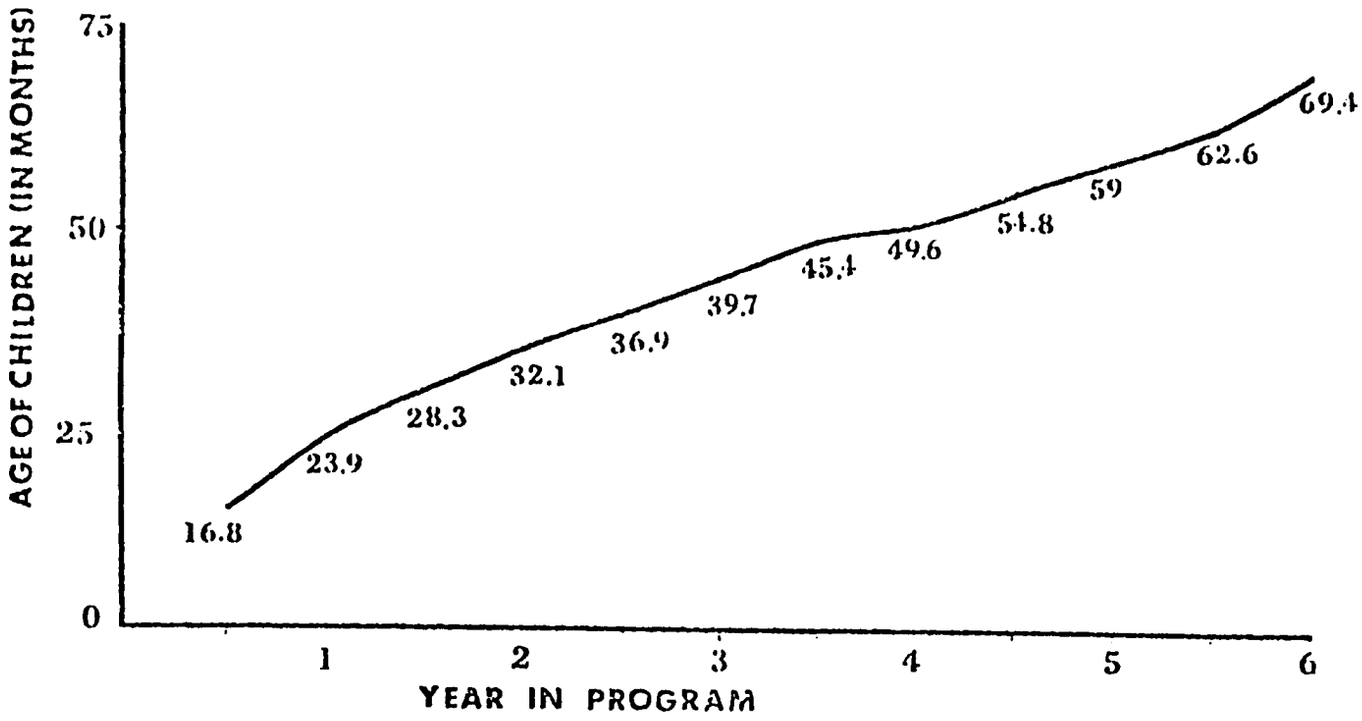


FIGURE .31

CHILD DIARRHEA RATE BY YEARS IN PROGRAM

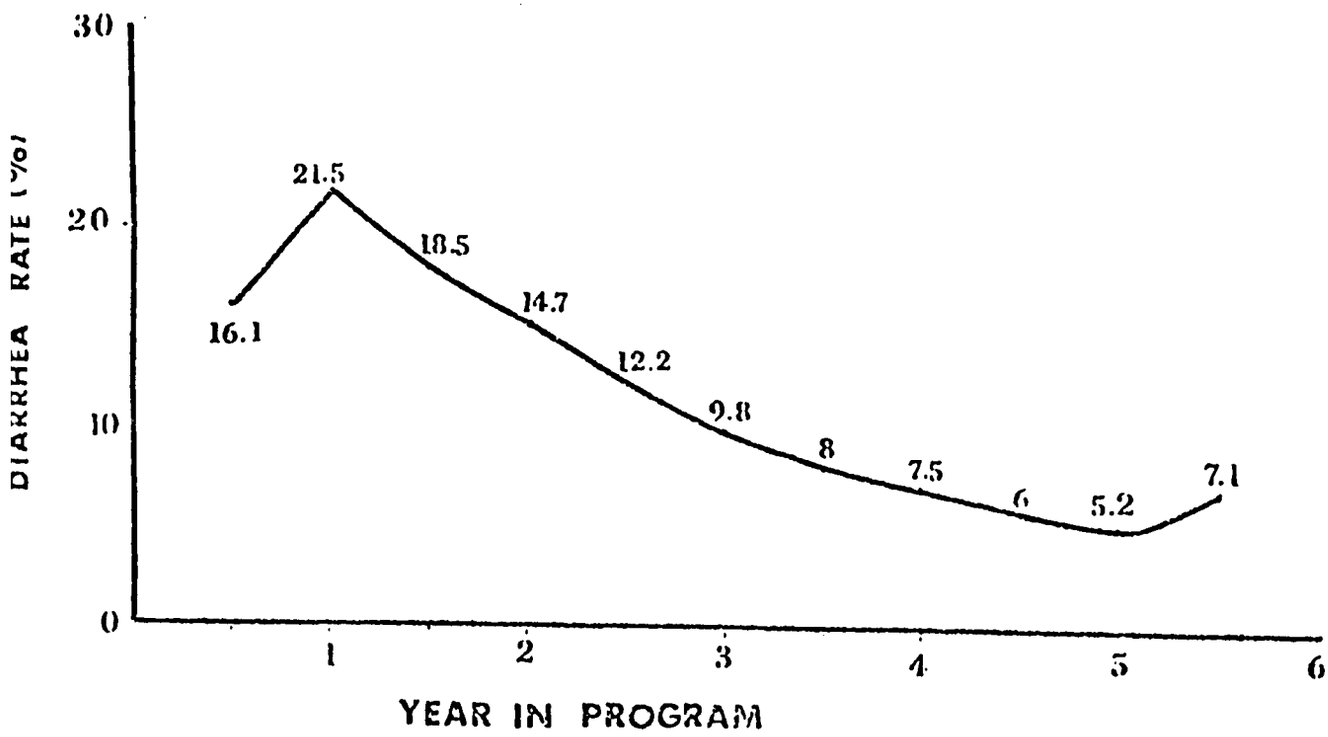
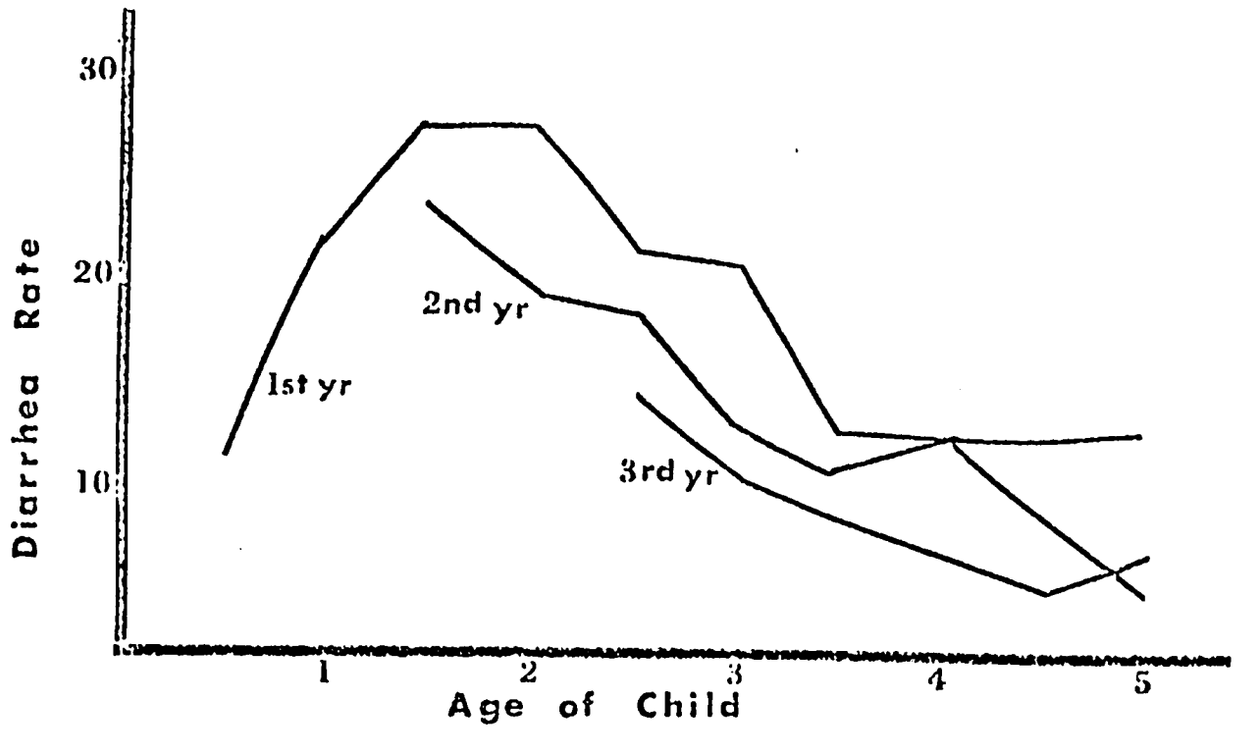


FIGURE 32

DIARRHEA RATE BY YEAR IN PROGRAM AND CHILD AGE
(CANDELARIA, COLOMBIA)



E. Sanitation - Ortigal and El Turco

The purpose of the work being carried out in Ortigal and El Turco is to further develop and test methodologies for determining the nutritional effect of environmental sanitation programs. The objective is to begin to provide information which will contribute directly to the planning process. For example, in the Plan de Alimentacion y Nutricion for Cauca, the decision was made to support rural water supply systems but not sewer systems. The assumption was that water supply is a cost effective intervention in terms of nutrition benefits whereas sewer systems are not. In fact, quantitative information is not available which allows cost effectiveness statements on either type of intervention.

The methodologies to be developed and tested should be based on a theory of the relationships, to the extent they are understood. The Nutritional Status of a person is dependent on the quantity and quality of nutrients consumed, and on the efficiency with which the nutrients are assimilated and utilized. The efficiency of assimilation and utilization is to a large degree dependent on the frequence and severity of infectious disease, particularly in the gastro-intestinal system. Gastro-intestinal diseases are in turn effected by the quality of water ingested and the quantity of water used for diluting or washing infecting agents from the environment. Finally, the quality and quantity of water are partially a result of the type of water system in use.

The above is an extremely brief description of the theory relating environmental sanitation (specifically water supply) to malnutrition. The relationships which are described in the theory are essentially qualitative ones. There has been no really systematic work which satisfactorily quantifies these relationships. Without quantification it is not possible to compare water supply to other interventions for the purpose of cost-effective decision-making.

Much of the work which has been done in this area is fairly narrow in scope and sophisticated in its theory and technique. What is sought in this study is a simplified theory which is complete enough to be of value to decision makers. Furthermore, the theory must be verifiable by a methodology which is capable of being incorporated into existing activities.

The basic approach of this study is to measure certain factors before and after a specific intervention. In El Turco, the intervention is the installation of an aqueduct which delivers piped water to the patios or yards of the individual houses. This will represent a change in both quality and quantity of water. The source of water will be uncontaminated and it will be protected in tubes up to the point of delivery in the patio. The quantity can be expected to increase because it will be more convenient. That is, there will be pressurized water within several meters of the house. In Ortigal, the intervention is the installation of a sewer system. Although this sewer became operational a couple of weeks prior to initiating measurements, it can be expected that each family's environmental sanitation situation will change gradually over time. It is felt that most families may begin with just one connection (e.g., sink in the kitchen) and add others (such as toilet and shower) as money becomes available. The quality of water should remain unchanged, but the quantity or convenience should increase as the number of in-house connections increase.

The first step is to define the population of each of the two sites and select representative samples. The populations are defined to consist of the families for which the systems are designed. Some families may never, in fact, be connected to the system but are included in the study population if the system is designed to reach them. In El Turco, the project is to include connections to individual houses and, as a result, it can be expected that most families will be affected when the system is installed. On the other hand, in Ortigal, connection will

probably be made gradually over a year or two. In either case, the conclusions will be based on those families which experience a change in sanitation conditions.

The number of families in El Turco and Ortigal is approximately 160 and 240 respectively. Random sample tentatively were selected at 80 and 100 families respectively. The first contact with these families was to explain the project and carry out the family composition survey.

In another visit to each family, the data was gathered. This will include malnourishment data (Survey 5) plus family level consumption data (Surveys 2 and 3). The reason for collecting consumption data is to help determine when factors not related to environmental sanitation have effected malnourishment rates. Environmental sanitation and diarrhea information was collected as per Survey 7 with a few modifications or additions. The diarrhea portion of Survey 7 was carried out for two separate weeks. Data is being collected only for those families with preschool children. This is because both the malnourishment and diarrhea data would only be available on the preschool age group.

The information gathering process will be repeated at some later date when the interventions have been operational for a period of time sufficient to expect some change. This second data gathering stage will begin by updating the family composition forms for the original sample. As such, the subsample, on which data is collected, will be modified to include families with newborns and exclude families whose children have passed the six year mark. Hopefully, this will keep the age distribution for preschoolers constant.

The analysis of the data cannot be defined in its entirety at this point. The results from preliminary analyses will lead to more detailed questions to be answered later. Since the prin-

cipal dependent variables (i.e., malnourishment and diarrhea) tend to be age dependent for preschoolers, any preliminary analysis should recognize this fact. This can be done by presenting the results by age group in a matrix form such as in Figure A.

FIGURE A

SAMPLE DATA SHEET

Age Groups in Months

0-6, 6-12, 12-18, 18-24 ----- 60-60, 66-72

Number of Children

Time 1
Time 2
T1/T2

Malnourishment

Time 1
Time 2
T1/T2

Diarrhea Rate

Time 1
Time 2
T1/T2

Family Gap

Time 1
Time 2
T1/T2

No. Faucets Patio

Time 1
Time 2
T1/T2

No. Toilets

Time 1
Time 2
T1/T2

VII. PLANS FOR THE FUTURE

Verification of the Model

Once the model is described and its instruments and field operation designed, the next stage must be to verify the validity of the theoretical assumptions.

There are several alternative ways to validate the model:

1. To make a diagnosis in several communities, select some with different needs, design the intervention and implement it.
2. To make a diagnosis in a large number of communities where different governmental interventions are programmed, follow them up and validate the prediction in negative and positive ways.
3. To make a diagnosis of several communities and propose to the government to apply the more efficient program as predicted by the model.
4. To select groups of families within a community with different needs as detected by the diagnostic procedure, and to implement the more efficient solution (sanitation, increase productivity, etc.) on a small scale.

Each one of the alternatives has some advantages and disadvantages, but in general the following ideas are being discussed:

1. If the model and the diagnostic procedures are to be used by national agencies, the real test must come from government interventions.
2. Pilot interventions designed and applied by a research group to interfere with the normal and real life of the community include economic and social structures foreign to it and which are difficult to reproduce. This situation is aggravated if the pilot study is undertaken in very small population groups.
3. Only in a limited number of communities will the government undertake to perform a single intervention as suggested by the model. Most of the time, the Food and Nutrition Plan

(PAN) will include production, sanitation, health and education. The verification and quantification of one isolated variable will be almost impossible.

4. Besides PAN, different public stores are inaugurating specific programs in different municipalities.

The decision has been made to proceed with the diagnosis in several municipalities of Department of Cauca and Huila where sectorial programs will be initiated within the next two years.

In some cases, it will be possible to influence the specific sector to establish the most efficient program.

A prediction of the results will then be made, and a close follow-up of the community will permit the validation of the theoretical model.

OTHER PROJECTS

Several basic questions have emerged in the process of validating the model. For instance there are questions that relate to:

- the validity of minimal requirements as a single variable;
- the morbidity as related with nutritional status and minimal requirement; and,
- the methodology for planned changes, etc.

All these questions must be analyzed within specific projects.

Once the diagnosis is made for different municipalities it will provide an opportunity to validate some of the data collected by different official sectors as a means to establish a low cost surveillance system for nutrition.