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Measuring Urban Malnutrition and Poverty: A Case Study of Bogota and Cali, Colombia

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When this paper was first published Rakesh Mohan and M. Wilhelm Wagner were members of the Development Economics Department of the World Bank; and Jorge Garcia was a consultant to the International Food Policy Research Instiute/Universidad de los Andes, Bogota.

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ABSTRACT

The paper attempts to measure the extent of malnutrition and poverty in the cities of Bogota and Cali, Colombia. It determines lower bound estimates of the proportion of people who simply do not have incomes adequate to cover the barest minimum of nutritional requirements. Methods usually used to estimate malnutrition are examined critically and the conceptual and empirical difficulties inherent in such estimations are outlined. An attempt is made to account for some of these difficulties by using household level data which account for differences in age-sex composition and household size. However, other difficulties remain owing to the absence of actual food expenditure data. Two methods of estimating calorie consumption are suggested. Under different assumptions, the malnutrition estimates for Bogota and Cali are large enough to warrant closer examination. Large low income households characterized by high dependency ratios are shown to be particularly affected and their children are especially disadvantaged. The exposure to nutritional deficiencies at an early age can be expected to impair the schooling of these children and, hence, their future earnings potential, locking them in a vicious cycle of malnutrition and poverty. Spatially, the pattern of malnutrition is found to be more distinct than the income pattern: the low income areas suffer from malnutrition more than might be expected.

PREFACE

This paper forms part of a large program research grouped under the rubric of the "City Study" of Bogota, Colombia, being conducted at the World Bank. The goal of the City Study is to increase our understanding of the workings of five major urban sectors--housing, transport, employment location, labor markets and the public sector--in order that the impact of policies and projects can be assessed more accurately.

Support for Jorge Garcia's research was provided by a grant of the Rockefeller Foundation to the Universidad de los Andes, Bogota, Colombia, and by a grant of the Ford Foundation to the International Food Policy Research Institute, Washington, D.C.

We are grateful to Yoon Joo Lee for arduous research assistance. Discussions with Surjit Bhalla served to clarify many issues. We have also benefitted from comments kindly provided by Gregory K. Ingram, Alvaro Pachon, Shlomo Reutlinger, T.N. Srinivasan, Miguel Urrutia and other members of the Colombia City Study Advisory Committee. Comments at an early presentation of this study at the City Study Workshop V held in Washington, D.C., February 14, 1980, were also useful.

This paper is part of the labour market and income distribution portion of the City Study. Other papers in this series are:

1. Rakesh Mohan "The People of Bogota: Who They are; What They Earn; Where They live." Washington, D.C., World Bank Staff Working Paper No. 390, May 1980 (City Study Project Paper No. 6).

2. Gary Fields "How Segmented is the Bogota Labour Market" Washington, D.C., World Bank Staff Working Paper No. 434 (forthcoming) (City Study Project Paper No. 9)

3. Rakesh Mohan and Nancy Hartline "The Poor of Bogota: Who They Are, What They Do, Where They Live." Washington, D.C., World Bank City Study Project Paper No. 11.

4. Rakesh Mohan "The Determinants of Labour Earnings in Developing Metropoli: Estimates from Bogota and Cali, Colombia." Washington, D.C., World Bank City Study Project Paper No. 15.

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I. INTRODUCTION

1.1. Objectives

There is now a considerable body of literature attempting to measure the extent of poverty by using the existence of malnutrition as a criterion. These measurements have been made for various countries as well as for the world as a whole. Appropriately enough, this literature can be said to have begun in India (Ojha, 1970; Dandekar and Rath, 1971) but achieved prominence with the publication of Reutlinger and Selowsky (1976) who estimated the extent of malnutrition in the world. Our own aim was to attempt an estimation of the extent of malnutrition and poverty in Bogota and Cali, Colombia, and, further, to locate it spatially within the two cities.

In carrying out this exercise, however, it has become clear to us that these methods of estimating malnutrition and poverty are fraught with conceptual as well as empirical difficulties which may well be impossible to solve. It is difficult to measure the extent of malnutrition directly and it is difficult to define poverty accurately enough to make estimates with precision. We attempt, in this paper, to clarify these conceptual and measurement problems. Our conclusion is that, despite the difficulties, ranges of estimates of malnutrition and poverty can be found and hence bounds can be placed on their magnitudes. The large ranges which result from our sensitivity tests indicate the uncertainty surrounding these calculations. By using relatively simple procedures, this study demonstrates the difficulties involved in making estimates of poverty and malnutrition from normally available sources of data in even two cities which have above average sources of data. The doubts emerging are strong enough to suggest that world

wide as well as country wide estimates of malnutrition and poverty warrant very close examination as to the validity of their magnitudes. It would, however, be valid to provide ranges and distributions stating clearly the assumptions made. We do conclude that, given current methods, it is best to place lower bounds on estimates of poverty and malnutrition and that this can be done with a relatively high degree of confidence.

We had believed, somewhat naively, that we would be able to estimate with some precision the extent of malnutrition in the two cities, to locate the worst off neighborhoods and to find the appropriate cut-off points for levels of income under which people can be said to be in poverty according to a nutrition definition. An earlier paper (Mohan and Hartline, 1980) had taken the bottom 30 percent, ranked by household income per capita, as the definition of poverty and found its correlates. That had motivated this quest for a more firm idea of who do constitute the poor. As indicated above, we have ended up with much more diffuse estimates than we had hoped for, but the results are still found to be useful in tracking welfare trends in Bogota and Cali, Colombia.

The question then remains: what are we measuring in this study and is it worth doing? First, let us state what we are not measuring. It is indeed difficult to estimate an absolute standard of poverty: to state, for example, that thirty percent of a population is in "absolute poverty." We simply do not know what constitutes absolute poverty. The notion of poverty subsumes a whole set of characteristics of a population, e.g. extent of life expectancy, level of literacy as well as extent of malnutrition or shortfall of incomes. Various indicators have been suggested to take account of these criteria such as Morris' (1979) "Physical Quality of Life Index." But most of

the indexes suffer from the choice of arbitrary weights that have to be used for aggregating each characteristic. Similarly, it is difficult to estimate the actual prevalence of malnutrition in a community: 1/ to make a definitive statement asserting that y percent of population is malnourished. Again, the standards of what constitutes adequate nutrition are just too diffuse. We can, however, make a much weaker statement: that z percent of a population simply does not have adequate income to purchase enough food to achieve w percent of average nutrition requirements for that population. As Sen (1980) argues: "considerations of average nutritional requirements can be used for one perspective of poverty even when nutritional requirements vary from person to person." Recognizing the prevalence of inter-individual variation we have to admit that even such an estimate z has a probability distribution around some mean $\bar{z}$ as does w around $\bar{w}$. 2/

Put in simple terms, what we attempt in this paper is to find a lower bound for an estimate of malnutrition and/or poverty such that we can state with a relatively high degree of confidence that $\bar{z}$ percent of the population must be malnourished since they simply do not receive adequate incomes; but there might well be more who are actually malnourished.

1.2 The Measurement of Malnutrition: Some Issues

Malnutrition is essentially a biological or medical concept whose direct measurement involves clinical types of measurement. But even such

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1/ For an overview of the variables most likely to help in identifying the groups at risk see Austin (1980).

2/ Mark Leiserson's comments at an early presentation of this paper and Amartya Sen (1980) helped in these clarifications.

clinical measurements are really indirect since they actually measure the consequences of malnutrition such as "below normal" heights, weights, "state of health," and level of cognitive ability. The essence of the problem lies in the definition of "normal". If we, as economists, relegate that task to the medical profession and merely accept their judgements we can, at least empirically, conceive of a data set which gives "independent" estimates of the prevalence of malnutrition and we can then go off and estimate its determinants. This procedure would be ideal as an empirical matter though it begs the conceptual question of what is "normal". It is clear, however, that we can scarcely hope to undertake such detailed and representative surveys at the national or international level.

Given the difficulty of doing the above, the general procedure usually adopted has been to reduce the nutrition problem to the measurement of a single index rather than of a vector of attributes. This simplification reduces the concept of nutrition to that of energy intake and expenditure and then allows its measurement in terms of the calorie content of foods. An early objection to this simplification was based on the idea that protein deficiencies were as important or more important than calorie deficiencies. The work of Sukhatme has provided strong evidence that "protein malnutrition... is for the most part the indirect result of inadequate energy in the diet" (Sukhatme, 1978). The sole use of calorie intake as a measure of nutrition is then defensible. This focus has led to further problems as Sukhatme himself has so cogently pointed out (Sukhatme 1977a, 1977b, 1978) and as further clarified by Srinivasan (1980). In reducing the measurement problem to that of calorie intake in foods we are left with having to define the calorie norm against which to compare the intake of individuals.

What Sukhatme and Srinivasan have pointed out is that the positing of a normal level of calorie requirements involves two sources of errors. First, is the inter-individual variation in requirements and second, is the intra-individual variation in requirements. 1/ Thus, if μ is a community wide norm for per capita calorie requirements, then the norm for an individual i will be

$$\bar{\mu}_i = \mu + a_i + b_t \qquad (1)$$

where a_i represents the individual i's deviation from the community norm and b_t the individual's own deviation over time from his own norm. Now, we regard a_i and b_t as independent random variables with mean 0 and variance $\sigma^2_{a_i}$ and $\sigma^2_{b_t}$ and we can write 2/

$$\sigma^2 = \sigma^2_{a_i} + \sigma^2_{b_t} \qquad (2)$$

We do not have good estimates for $\sigma^2_{a_i}$ and $\sigma^2_{b_t}$ but Sukhatme suggests that

$$\frac{\sigma}{\mu} = 0.15$$

in approximate terms.

1/ They emphasize the intra-individual variation. According to Srinivasan (in a personal communication): "A person is likely to be in a nutritional stress, if his energy intakes are beyond the limits imposed by the homeostasis mechanism. And this stress appears to be similar to a threshold effect. Everything is alright if intakes are within these limits: sustained intake below the lower limit or above the upper limit leads the system to fall apart. Sukhatme identifies these limits for a given individual as his long run mean intake plus or minus twice the intra-individual standard deviation of intakes."

2/ Assume that a_i and b_t are uncorrelated i.e. Cov $(a_i, b_t) = 0$

Thus, at any given time the requirements of an individual can be said to be in the range $\mu \pm 2\sigma$ with 95 percent of confidence. If $\frac{\sigma}{\mu}$ is approximately 0.15 then there is very low probability (approximately .025) that an individual's requirements at any given time would be lower than 0.7μ.

The establishment of the level of minimum calorie consumption requirements is then crucial in determining the degree of malnutrition. Since there are a large number of people whose calorie consumption falls in a relatively narrow band around the usual requirement levels, a small percentage change in the requirements can lead to substantial changes in the estimate of malnourished people. Energy requirements of individuals depend on four variables interrelated in a complex way: physical activity, body size and composition, age and climate and other ecological factors (FAO, 1973). Thus requirements are specified by age, sex, body weight and nature of activity. Unfortunately, there is still substantial disagreement between different agencies as to the level of requirements. For example, Table 1 shows the discrepancies between the recommendations given by the U.S. Food and Nutrition Board and the Food and Agriculture Organization.

Table 1

U.S. AND FAO CALORIE REQUIREMENTS FOR DIFFERENT AGES

	AGE	U.S.	F.A.O.
	1 - 3	1300	1360
	4 - 6	1700	1830
	7 - 10	2400	2240
Males	11 - 14	2700	2750
	15 - 18	2800	3060
	19 - 22	2900	3000
	23 - 50	2700	3000
Females			
	11 - 14	2200	2425
	15 - 18	2100	2380
	19 - 22	2100	2200
	23 - 50	2000	2200

Sources: FAO (1973) and Recommended Dietary Allowances, Revised 1980, Food and Nutrition Board, Washington, D.C.

In Colombia, the Instituto Colombiano de Bienestar Familiar 1/ (ICBF) is the agency responsible for monitoring nutrition in the country. They have revised their recommendations for the minimum adequate level of caloric intake from an average of 2150 calories in 1972 to 1970 calories per day in 1977 (assuming an unchanged age and sex distribution of the Colombian population). Such changes have serious implications for estimates of malnutrition. In an earlier study Garcia (1980b) estimated that about 70 percent of the Colombian population would be undernourished if 2150 calories were taken as the requirement level while only about 29 percent would be so classified if 1970 calories were taken as the appropriate level. 2/

Another example is reported by Bhalla (1980) who examined the results of the HANES 3/ nutrition survey for the United States. He found that "according to the FAO requirements, 67% of American males and 80% of American females have a calorie intake which is below the requirement level." "If U.S. recommendations are imposed, the corresponding "malnutrition" figures are 46% for men and 70% for women." He adds "Can these figures be believed, i.e., is it possible that approximately half the American population is malnourished (below 80% of FAO requirements) in terms of calories?" "Casual empiricism suggests that, if anything, obesity is the problem in the U.S."

1/ The Colombian Institute of Family Welfare.

2/ This large change is partly caused by the use of grouped data.

3/ Health and Nutrition Examination Survey.

Thus it is clear that estimates of malnutrition are crucially dependent on the level of caloric intake chosen as the cut-off point.

So far this discussion has been conducted solely in terms of the caloric intake of individuals. We need to recall that malnutrition is a wider concept. The prevalence of chronic stomach diseases such as those caused by amoebic infections make the magnitude of energy ingested somewhat irrelevant. This is where the concept of a human body as a servo-mechanism or a self-regulation control system becomes important. Not only do diseases make the body an inefficient energy converter but the control system itself becomes an ineffective regulatory mechanism. Then the intake of the required magnitude of calories does not ensure adequate nutrition. Malnutrition can occur regardless because of infections arising from bad sanitary conditions, quality of water, tardy garbage removal or even bad and overcrowded housing. We recognize that the quality of public services such as medical services, sanitation and garbage removal can often have a greater effect on actual malnutrition in a population than a lack of income.

This is of great relevance in particular to the conditions that exist today in the middle income level semi-industrialized countries where urban malnutrition might have more to do with neighbourhood environmental factors than with low income levels. In this study our objective is to find a lower bound estimate of the existence of malnutrition based on estimates of income. In these middle income countries (many Latin American and East Asian countries) income levels are now approaching magnitudes at which everyone at least has the <u>potential</u> to enjoy adequate nutrition. As these income levels are approached, and, as our results will show, Colombia is rapidly reaching such levels, estimates of malnutrition will need to be more specific. If it

is found that incomes and environmental conditions of neighbourhoods are highly correlated, only then will the estimation of critical income levels for potentially adequate nutrition begin to be useful. Beyond that the estimation of the effect of sanitation, hygiene, and housing on malnutrition will have to be done directly. With the rapid increases in levels of urbanization these measurements will become more and more important as documented by Samir Basta (1977) for some urban areas. The bright side of the picture is that if low income ceases to be an important determinant of malnutrition these other problems might be more amenable to public policy.

In summary, in keeping with most other studies, our estimates also do not take account of neighborhood effects though we do attempt to focus on the problem areas of the city. We do, however, recognize the existence of inter- and intra-individual variations in the daily requirement of caloric intake for individuals. In our calculations we account for this variation by estimating the proportion of individuals who consume less than 0.7μ or 0.8μ there will then be only a small probability that well-nourished individuals are mis-classified as malnourished. The probability of malnourished individuals being misclassified as well-nourished increases; however, this is in keeping with our objective of finding lower bound estimates.

1.3. The Measurement of Calorie Intake: Some Problems

The measurement of calorie intake by a population has been done in several different ways. At the one end are Reutlinger and Selowsky (1976), Reutlinger and Alderman (1980), Garcia (1980a, b), and various others who attempt to estimate total consumption of energy through nationwide food balance sheets. They estimate the total amount of food consumed in a country and then attempt to distribute it over various income groups in order

to estimate those malnourished. At this nationwide level it is important to take account of the particular age/sex distribution at a given time in order to arrive at a representative per capita or per "reference adult" or per "adult equivalent" measure of the consumption of calories. Thus, the total estimate of calories consumed should be disaggregated by income groups as well as age and sex groups to obtain meaningful results. This is not done in these studies. It is easy to adjust the per capita requirements for a population by its age and sex distribution but more difficult to do the same for the consumption side. Nonetheless, if comparisons are made over time it is important that these adjustments be made, 1/ particularly when the age and sex composition of a population is changing rapidly. Reutlinger and Selowsky adjust for the income distribution as follows:

$$C_o = \sum_i \omega_i c_i \qquad (3)$$

where Co is the nationwide per capita consumption of calories, c_i is the per capita calorie consumption by income group i and ω_i is the weight of the income group. To adjust for age and sex this should be modified to

$$C_o = \sum_i \omega_i \left(\sum_j \sum_k \nu_{jk} c_{ijk} \right) \qquad (4)$$

where c_{ijk} is the per capita consumption of calories of age group j, sex k and income group i and ν_{jk} is the weight of each age and sex group. Such an adjustment is clearly difficult to accomplish empirically.

1/ We thank Nancy Birdsall for this observation in the course of an earlier presentation of this paper.

At the other end, the measurement of calorie intake is done on the basis of data from household surveys on consumption, expenditure and income. Examples of this procedure are the World Bank Human Resources Special Report for Brazil (1979), Visaria (1979) and Gavan and Sri Chandrasekhara (1979) for Sri Lanka and various studies conducted in India. Information on consumption of food items is available for each household and thus the calorie intake for each can be calculated. This procedure has various sources of errors. 1/ First, is the familiar reporting error. Either the household reports on food consumed over a reference period (day, week, month, year), retrospectively; or it keeps a diary of food consumption over a period; or the surveyors themselves make the measurements. We can expect measurement errors to occur in each method due to memory lapses, desire to understate (or overstate) consumption; or, when the observer is making the measurements, because changes from the normal consumption pattern might occur. Second, is the error due to intra-individual variation. Consumption is measured over a reference period and the longer the reference period the smaller this difficulty. But the first type of error might increase when the reference period is increased. Third, is the error due to variation in calorie content of food. Each commodity has different varieties while a norm calorie content is used for each commodity. If there is a systematic correlation between the calorie content of varieties and the varieties bought by the poor (or by the rich), sources of bias in estimates would arise.

1/ This is not meant to imply that these errors are greater than those arising from using national food balance sheets -- indeed the converse since surveys constitute the only source of direct observations on the distribution of intakes among households.

In between the national level and household level estimates are those which use published grouped data from household surveys, as in Knudsen and Scandizzo (1979). Here, average diets have to be imposed on each group to estimate calorie consumption for the group. By necessity, within group variation is lost.

The idea in the majority of these studies is to estimate a relationship between calorie consumption and income in order to derive bases for income cut-offs for the characteristics of absolute poverty. In the estimates from household level data errors arise because of the understatement of income (which is a well known characteristic of most surveys). In the estimates derived from grouped data from household surveys, one problem is that either everyone within an income group is classified as malnourished or no one is, since only averages can be dealt with. 1/ This problem is clearly more serious the smaller the number of groups being considered.

In general, the procedure is to find that income level which corresponds to the minimum daily calorie requirement and then classify everyone below that income as malnourished. If deciles are used, for example, each requirement level will be associated with a decile. A small variation in the requirement level could easily cause the malnutrition estimate to jump one decile. In fact, income data are often grouped such that the bottom half of the population falls in the bottom two or three groups and the top half is divided into many more groups. This type of problem is illustrated in Table 2 which is from earlier studies by Garcia which had to use published data only. As mentioned in the last section a 10% change in the average caloric requirement causes a much larger change in the estimate of malnutrition.

1/ Reutlinger and Alderman (1980) partially solve this problem by assuming a normal distribution of intakes and requirements within income groups.

In summary, just as there are difficulties involved in estimating calorie requirements, there are measurement problems involved in estimating consumption of calories. In this study, we also suffer from some of these problems but attempt to account for them by conducting various simulations in order to indicate the magnitude of possible error.

Table 2: CALORIE CONSUMPTION PER DAY AND DISTRIBUTION OF POPULATION IN COLOMBIA: 1972

Income Bracket	Calorie Consumption	Cumulative Distribution of Population
I	1530	6.49
II	1796	28.52
III	1974	52.00
IV	2116	68.49
V	2292	76.18
VI	2441	83.33
VII	2577	89.29
VIII	2810	94.45
IX	3045	97.58
X	3325	100.00

Source: Jorge Garcia Garcia (1980a, 1980b) for calorie consumption and distribution of population respectively.

II. THE METHOD OF ESTIMATION

2.1 The Data

We have used the 1973 population census sample (about 7 percent of the total population) and the 1978 World Bank/DANE 1/ household survey for Bogota and Cali 2/ to obtain estimates of malnutrition at two points in time. The use of these detailed data sets enables us to avoid some of the pitfalls involved in such an estimation but not all. Specifically, we do not have any estimates of expenditures in these data sets and therefore are confined to using household income for our calculations -- suitably transformed. We have estimated elsewhere 3/ that the 1973 census accounted for only about 50 percent of total personal income in Bogota. Using a similar method we find that the 1978 survey succeeds in capturing over 90 percent of personal income (see Appendix 1). Both the data sources allow us to locate each household spatially within the two cities: we are therefore able to draw a malnutrition/poverty map of Bogota.

2.2 Calculating Calorie Requirements

As mentioned earlier various institutions have published different calorie requirements for adequate nutrition in Colombia. We have utilized three sources (summarized in Table 3.) :

- o World Health Organization and Food and Agricultural Organization Ad hoc Committee of Experts: we have adjusted the mean weight of Colombian males and females downwards to adapt their recommendations to the likely Colombian norm.

1/ Departamento Administrative Nacional de Estadistica - National Colombian Statistical Agency.

2/ The Bogota sample used consists of 2969 households and that for Cali of 960.

3/ See Mohan (1980) Appendix II and III for details of the 1973 census data set used here. In this study a sample of 38,528 households was used.

Table 3. DAILY CALORIC REQUIREMENTS BY AGE AND SEX FOR COLOMBIA

	Source					
	WHO/FAO 1/				ICBF 2/	IIT 3/
Age	Male		Female		Male and Female	
0-1	1090		1090		860	540
1-3	1360		1360		1140	1300
4-6	1830		1830		1710	1870
7-9	2190		2190			
10-12	2600		2350		2270	2470
13-15	2670	(0.97M) 4/	2260	(1.13F) 5/		
16-19	2815	(1.02M)	2100	(1.05F)	2450	2290
20-39	2760	(M)	2000	F	2290	
40-49	2620	(0.95M)	1900	(0.95F)		
50-59	2480	(0.90M)	1800	(0.90F)	1985	
60-69	2210	(0.80M)	1600	(0.80F)		
70 +	1930	(0.70M)	1400	(0.70F)		

Notes.

1/ From WHO/FAO Ad hoc Expert Committee.

2/ Instituto Colombiano de Bienestar Familiar. "Recomendacion de Consumo de Alimentos para la Poblacion Colombiana: Revision", 1977.

3/ Instituto de Investigaciones Tecnologicas, Bogota.

4/ M and F are minimum daily calorie requirements for average weight males and females respectively, where M=BWMx46 and F=BWFx40
we have assumed BWM=60 kg. (average male body weight)
BWF=50 kg. (average female body weight)
WHO/FAO assume BWM=65 kg. and BWF=55 kg. We have taken lower numbers for Colombia to account for lower average weight).

5/ Requirements for lactating mothers are higher in all the sources but have been neglected here.

- o Instituto de Investigaciones Technologicas (IIT). This Institute did a special study 1/ to estimate the level of requirements appropriate for Colombia. Their estimates were, in general, lower than the WHO/FAO recommendations.
- o Instituto Colombiano de Bienestar Familiar (ICBF). As mentioned before this is the governmental agency responsible for nutrition policy in Colombia. They have carried out diet and nutrition surveys, including food expenditures, food prices, etc. in various years. Starting from WHO/FAO recommendations, over time they have gradually brought down the level of calorie requirements appropriate for adequate nutrition in Colombia. We have used their latest recommendations (1977) which average out to 1970 calories per capita per day (age and sex adjusted).

We calculated the total calories required by each household according to each of these three sources. We therefore obtained HCALR1, HCALR2 and HCALR3, 2/ the total calories required by each household according to each of the three different sources WHO/FAO, ICBF and IIT. In so doing we account fully for the age and sex composition of each household on the requirements side of our procedure. 3/ This detail is usually neglected in other studies.

1/ See IIT (1972).

2/ Only the results for HCALRI and HCALR2 are reported later since HCALR3 is quite similar to HCALR2.

3/ For example, (using Table 3) for a household of 3 people consisting of a man aged 41, woman 35 and boy 10 years old, HCALR1 = 2620 + 2000 + 2600 = 7220 calories.

2.3 Calculating Calorie Consumption: Method 1 (M1)

In general, our aim is to calculate the calories consumed by each household and then compare them with the requirements, as computed above, of the household. Thus, we assume that the distribution of food within the household is proportiunal according to each member's requirements. That is, each member within each household is equally well-nourished or mal-nourished. Since we have income data only, a number of steps are required in our calculations.

This study takes Garcia's earlier work as its point of departure and uses some of his results for Colombia to estimate malnutrition in Bogota and Cali. We now provide a brief review of Garcia's method for Colombia (Garcia, 1980 a and b).

Garcia essentially used the Reutlinger-Selowsky method and applied it to Colombian data. Calorie consumption is regarded as an increasing function of income (expenditure):

$$C = f(Y) \qquad \frac{\partial f}{\partial Y} > o, \quad \frac{\partial^2 f}{\partial Y^2} < o \qquad (5)$$

$$\text{or} \quad C = f(Ex) \qquad \frac{\partial f}{\partial Ex} > o, \quad \frac{\partial^2 f}{\partial Ex^2} < o \qquad (6)$$

where C is calorie consumption per capita per day

Y is annual income per capita.

and Ex is annual per capita expenditure on food.

Two functional forms which satisfy the marginal conditions above are:

Semi log $C = a + b(\ln Y)$ (7a) or $C = a + b(\ln Ex)$ (7b)

Inverse $C = a + \frac{b}{Y}$ (8a) or $C = a + \frac{b}{Ex}$ (8b)

The log-log function: In $C = a + b(\ln Y)$

suffers from the problem that the calorie-income (expenditure) elasticity

is constant. For (7) and (8) the elasticities are:

$$\eta_{c/y} = \frac{b}{C} \qquad \text{semi log}$$

$$\eta_{c/y} = -\frac{b}{CY} \qquad \text{inverse}$$

Garcia used data from 1975 to 1975 to estimate the calorie income/expenditure relationship. The whole population was assumed to have the same diet. 1/ Food balance sheets for each of the major categories were used 2/ to estimate total food consumption in the country, making appropriate allowances for animal feed, food bones and effective food content (i.e. elimination of seeds, cortex, etc.). Estimations were made for different time periods (1958-1975), (1960-1975) and (1962-1975). The goodness of fit was best for the 1962-1975 estimation.

The estimated calorie/income/expenditure equations were then applied to grouped data from the 1972 survey to estimate the proportion of malnourished in the country according to income groups. The precision of these estimates obviously depended on the number of income groups available in published data. As alluded to earlier, although ten income groups were provided, more than half of the population fell in the bottom three groups. As a result, depending on different assumptions concerning calorie requirements, either 28 percent of the population was malnourished (the bottom two income groups), 52 percent (the bottom three) or 68 percent (the bottom four). (See Table 2).

1/ Average diet for Colombia according to ICBF (1972). Bogota falls in the Cundinamarca/Boyaca region, hence, the average diet for this region was used in this paper and is shown in Appendix 3.

2/ These have been prepared by FAO and ICBF since the earlier sixties. They are not mutually consistent. Garcia prepared his own balance sheets.

In estimating the calorie-income (expenditure) relation from national average time series data the implicit assumption is that there is an egalitarian distribution of income and that everybody has the same nutrition level nutrition level in the country. This is clearly not true. The problem is further compounded by the fact that the distribution of calorie consumption in a population is obviously much more egalitarian than the distribution of income (the ratio between highest and lowest incomes can be 1000 to 1 while that between highest and lowest calorie consumption is unlikely to be greater than 4 to 1). The estimated function should therefore be highly non-linear and is likely to be most accurate around the requirements range.

We also need to choose between expenditure and income as the more appropriate determining variable. As mentioned earlier, household surveys characteristically underestimate income. In Colombia, the last income-consumption survey that was undertaken was in 1972. 1/ Garcia estimated that it accounted for about 77 percent and 91 percent of per capita personal income and private consumption expenditures respectively as compared with the national income accounts. The permanent income hypothesis also implies that permanent income is a better explanator of food consumption than current income and that expenditure from household surveys would then be a more reliable proxy for permanent income than measured current income. Expenditures also capture the life cycle effect. A third reason for using expenditure per capita rather than income per capita from national income accounts as an explanator of calorie consumption is connected with income

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1/ DANE Encuesta de Hogares 6. (EH6) Ingresos y Gastos.

distribution aspects. Income is highly concentrated in Colombia with the share of labour in national income being only about 40 percent. This proportion is lower than the share of total personal expenditure. But capital income goes to only a small proportion of the population, hence the use of GNP per capita, would, on the other hand, vastly overstate average consumption. Therefore, it is more appropriate to use total expenditure per capita. Furthermore, it is a common characteristic of household surveys on consumption that the total expenditure reported by low income households is greater than their incomes. Aggregated expenditures from such surveys are then more consistent with total personal expenditure in national share accounts. Transferring the calorie expenditure relation derived from national time series data to cross section data then becomes somewhat more defensible. In this paper we therefore utilize Garcia's calorie expenditure estimates rather than the calorie-income ones.

Finally, there is another problem inherent in using published grouped data from household surveys. The information from such households is usually given as the number of households within each income class. Usually, these household groups are not broken down by either size or age-sex composition. Within such income classes per capita consumption or income then has to be assumed according to some average size and composition. Moreover, the distribution within the income class has to be regarded as uniform. These problems are avoided in our calculations since we use household level information.

We utilize Garcia's estimates for equation (7b)

$$C = a + b \ln Ex$$

for Colombia where C is the calories consumed per capita and Ex is the annual expenditure per capita (in 1970 pesos). His estimate was

$$(M1) \quad C = -3088 + 609 \ln Ex \qquad (9)$$

for 1960-1975 data.

Garcia obtained better goodness of fit characteristics for his 1962-1975 1/ equation but regarded the parameters of equation (9) as more robust.

If we regarded 1800-2000 calories per day as the approximate requirement level the calorie expenditure elasticity for equation 9 (at the requirements level) is

$$\eta_{C/Ex} \approx \frac{600}{1800} \text{ to } \frac{600}{2000} \quad (\frac{b}{C})$$

$$= 0.33 \text{ to } 0.3$$

Since our data sets do not have expenditure data we estimate a relation between "expenditure share" and household income from the 1972 DANE consumption survey (Appendix 2 gives the data on which this estimation was based). The estimated equation is

$$\frac{EXH}{YH} = \underset{(-10.8)}{2.2666 \quad -0.1546 \ln YH} \qquad (10)$$

$$R^2 = 0.936$$

(t statistic in parenthesis)

where EXH and YH are monthly household expenditure and income respectively

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1/ The estimated equation for 1962-1975 was C =-4622 + 790 ln Ex which implies an $\eta_{C/Ex}$ at 2000 calories of about .4.

(in 1973 pesos). Equation (10) is used to derive the expenditure for each household in our 1973 1/ and 1978 1/ data sets and thence household expenditure per capita (Ex) 2/. The derived Ex is then used to derive the M1 (Method 1, equation 9) estimate of calorie consumption per capita per day in each household. Finally, the total household calorie intake per day (CALM1) is obtained which can then be compared with household calorie requirements (HCALR1, 2 and 3).

This method suffers from a few shortcomings. First, a time series country-wide relationship is applied to cross section household data from urban households only. Second, expenditure per capita is used to derive calories consumed per capita in the household without accounting for the within household age-sex distribution. Third, the estimation of total expenditure from income does not allow for variation in expenditures between households with the same income. We attempt to improve on this in our second method of estimation.

1/ Incomes are adjusted to account for inflation so that equations (9) and (10) could be applied to our 1973 and 1978 data. Incomes quoted in 1973 pesos were used to estimate equation (10) while incomes in 1970 pesos were used to estimate the calorie consumption measure of equation (9). Note that Garcia's estimates are in constant 1970 pesos. In summary, all calculations have accounted for price changes.

2/ Appendix 2 also shows the expenditure/income relation graphically. The 1973 and 1978 deciles are also marked off. Note that households up to the 7th decile spend more than their income.

2.4. Calculating Calorie Consumption: Method 2 (M2)

This method also has to use a few steps to get at the calories consumed by each household. The 1972 household survey results were used again to derive the food share of total expenditure as a fraction of total household income. The equation estimated 1/ was

$$FSHARE = \underset{(16.5)}{1.6998} \; \underset{}{-0.1486} \ln YH \qquad (11)$$

$$R^2 = 0.971$$

(t statistic in parenthesis)

where $FSHARE = \frac{\text{Food Expenditure}}{YH}$

and YH is total monthly household income as before (1973 pesos).

This procedure for calculating food share in total expenditure (or income) would be improved if household size were also taken into account. Since no 3-way tabulations were provided between income groups, household size and food share, we could not accomplish this. The data, however, indicate that, surprisingly, household size does not appear to make much difference. Table 4 shows the proportion of food expenditure to total expenditure from two sources which turn out to be remarkably consistent. The picture is not likely to be as smooth if the same table were available by income groups. It does, however, give us confidence that our estimations do not suffer from a major error. Economies of scale in food consumption, perhaps, account for this as well as the correlation between household size and total household income. 2/

1/ See Appendix 2 again for details of data used as well as a graphical representation of the equation.

2/ Mohan (1980) does show that household income rises with household size--though not proportionately. (Household income per capita decreases).

Having obtained the food share we now calculate total calories consumed by the household

$$(M2) \qquad CALM2 = \frac{FSHARE \times YH}{P_c} \qquad (12)$$

where CALM2 is the total calories consumed by the household per day by Method 2 (M2);

FSHARE and YH are as before and

P_c = "monthly cost of consuming 1 calorie per day"

P_c clearly needs an explanation. ICBF conducted a National Survey of diets (Encuesta Nacional de Dietas) 1/ in 1972 and published an average daily diet disaggregated for each region. We have used their data for the Cundimarca-Boyaca region. The information provided includes the quantity of each of 25 main food items, their caloric content and price. 2/ It is therefore possible to compute the cost of this average fixed bundle of foods, hence the cost of calories implied by this diet and consequently "monthly cost of consuming 1 calorie per day.

1/ The results are reported in DNP (1974).

2/ See Appendix 3 for details of the reported diet, as well as the procedure for calculating P_c.

Table 4. FOOD EXPENDITURE AND HOUSEHOLD SIZE

Household Size	Food Expenditure/Total Expenditure	
	DANE 1972 1/	MUSGROVE 2/
1-2	.42	.44
3	.38	.46
4	.43	
5	.37	.48
6	.40	
7-8	.39	.47
9 +	.41	

Sources: 1. DANE Household Consumption Survey 1972 (EH4).

2. Musgrove (1977). Calculated from ECIEL 1967 Household Consumption Survey.

A couple of observations are in order here. Using the average diet for all households is clearly incorrect. There is good evidence from other countries that poor families generally obtain more calories per unit of expenditure, i.e. P_c is lower for poor families than for richer families. This is indicated in the Brazil report (World Bank, 1979); for Pakistan by Hammer (1978) and for Sri Lanka by Visaria (1979). Hammer reports income elasticities for the demand for commodities such as wheat, rice and sugar on the one hand and more preferred (or more expensive) foods such as meat and milk on the other. Bhalla (1980) estimates for Sri Lanka from data in Visaria (1979) that the price per calorie paid by the poor can be about 30 percent less than the mean. We are not able to obtain comparable information for Colombia, but included in Appendix 4 is a suggestive table which reports proportions of food expenditure by commodity for 10 broad income groups. These proportions are consistent with the evidence cited above for other countries. The proportions spent on cereals and tubers

decrease while those on meat and eggs increase with increasing income. Nevertheless, the diet difference between the rich and poor is not dramatic. While we cannot make an accurate estimate, this evidence suggests that P_c for low income groups is likely to be about 20-30 percent less, as in Sri Lanka, as compared with the mean. We attempt to account for this problem by conducting sensitivity tests by varying P_c. 1/

From equations (11) and (12) we can derive the calorie income elasticity $\eta_{C/Y}$ for M2. Writing

$$FSHARE = g + h \ln YH \text{ for equation} \qquad (11)$$

we have 2/

$$\eta_{C/Y} = 1 + \frac{h}{FSHARE}$$

where h = -0.1486.

1/ We do not need to do it differentially for the poor and rich since we are mainly concerned with the bottom end of the scale.

2/ $FSHARE = g + h\ln YH$ (11) and $CALM2 = \frac{FSHARE \times YH}{P_c}$ (12)

i.e. $CALM2 = \frac{1}{P_c}(g + h\ln YH) \cdot YH$

$$\frac{\partial CALM2}{\partial YH} = \frac{1}{P_c}(g + h\ln YH + h) = \frac{1}{P_c}(FSHARE + h)$$

$$\eta_{C/Y} = \frac{\partial CALM2}{\partial YH} \cdot \frac{YH}{CALM2} = \frac{1}{P_c}(FSHARE + h) \cdot YH \cdot \frac{P_c}{FSHARE \times YH}$$

$$= 1 + \frac{h}{FSHARE}$$

Here it is difficult to calculate FSHARE at the requirements level because it is dependent on household size and composition. From Appendix 2 we find that it will be in the range of .6 to .7. Thus

$$\eta_{C/Y} = 0.75 \text{ to } 0.8 \text{ in the relevant range.}$$ 1/

Note that since FSHARE declines with increasing income, and h is negative, so does $\eta_{C/Y}$ as it should.

i.e.

$$\frac{\partial \eta_{C/Y}}{\partial Y} \text{ is negative.}$$

Around the requirements level, therefore, the calories consumed by a household according to M2 are much more income elastic than by M1.

M2 corrects for two of the shortcomings in M1. First, all calculations for calorie consumption are done at the household level--the commensal unit. Thus, the age-sex composition is accounted for implicitly. We continue to assume an even intra-family distribution commensurate with each individual's requirements. Second, we utilize information on actual diets consumed to calculate calories consumed from the food share in expenditures. Thus, there is no jump from time-series or per capita calculations to household cross-section data. We do, however, continue to suffer from the problem that all households

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1/ This is somewhat higher than most estimates of calorie-income elasticity.

at the same income level devote the same proportion of their income to food and therefore do not allow for inter-household variation in food expenditures for households at the same income level.

2.5. Estimating Malnutrition

Having accomplished all the above we have 6 estimates of malnutrition for each set of data and city. We calculate for each household 3 sets of calorie requirements: those according to WHO/FAO, IIT and ICBF. Similarly we have 2 sets of estimates for calories consumed: those according to M1 and M2. Thus, we obtain the nutrition level for each household:

$$NLH = \frac{CALMi}{HCALCRj} \qquad (14)$$

where

NLH is the nutrition level,

CALMi is calories consumed by method i (i = 1,2) and

HCALRj is calories requires as recommended by source j (j = 1,2,3) by the household.

The household is malnourished or well-nourished according as

$$NLH < 1$$

or

$$NLH > 1$$

respectively.

Each person in the household is assigned the household NLH so that the age and sex distributions of nutrition can be obtained. In order to account for inter-individual as well as intra-individual variations, we also report the proportions of households who have

$$NLH < 0.7$$

or

$$NLH < 0.8$$

Thus, the reader can choose the level of requirement that he considers "reasonable."

The next section reports the results for both the cities of Cali and Bogota. While they do give us some idea of the lower bound of malnutrition in the two cities, the spread of results demonstrates well the strength of arguments in the introduction which emphasized the difficulties inherent in such an estimation.

III. THE RESULTS: A RANGE OF ESTIMATES

3.1. Malnutrition in Colombia

The malnutrition problem in Colombia has preoccupied policy-makers, government institutions and private researchers for a long time. At the policymaking level, the Instituto Colombiano de Bienestar Familiar 1/ (ICBF) had been in charge of the main nutrition programs until 1974; after this, a special Food and Nutrition Program was implemented under the coordination of the Colombian National Planning Office but carried on by several government agencies. Though ICBF has done research on different aspects of malnutrition in Colombia, most of it has been directed to the medical aspects of it with scant reference to economic factors. 2/ A survey on consumption habits of the Colombian population was carried on by ICBF in 1972 whose results have not been published in a comprehensive manner but in somewhat scattered working documents of the ICBF and of other government agencies. 3/

This survey has been outdated by one performed under the auspices of the managing office of the Food and Nutrition Program (PAN is its spanish acronym) but its results are not available yet.

1/ Colombian Institute for Family Welfare.

2/ See Eberth Betancourth (1977) and the references cited therein.

3/ See Departamento Nacional de Planeacion (1974), Betancourt (1977) and the references cited therein.

ICBF has carried out surveys for particular groups of the population and then made estimates of malnutrition for different regions as well as for the country as a whole. Other estimates have been made by Lemoine and Becerra (1978), Garcia (1980a, b), Betancourt (1977) and Pinstrup-Andersen and Caicedo (1978). These estimates are not all comparable but we provide a summary of their main results below.

ICBF conducted its most recent survey in 1972 when it sampled 1400 families in different regions of the country. From food balance sheets it was found that the overall supply of food was adequate to cover 104 percent of total calorie requirements for the country as a whole (using 2150 calories per day per capita as the age-sex adjusted average requirement). From their household survey, however, the overall calorie adequacy was only 94 percent, with variations by region ranging from a low of 77 percent to 106 percent (Betancourt, 1977). 1/ About 60 percent of the population was found to have some calorie deficit while about 5 percent consume less than 40 percent of requirements.

Lemoine and Becerra (1978) used the 1972 information of ICBF 2/ and attempted to apply their results to household income surveys done by the Compañia Colombiana de Datos (COLDATOS) during 1974-76. Using the 1972 results they associated specific magnitudes of calorie deficiency with particular

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1/ The low adequacy Departamentos (states) were Huila and Tolima and the high adequacy ones were Valle, Cauca, Choco and Meta; this is surprising since Choco and Cauca are among the lowest income regions in the country.

2/ Published as Analisis de Brechas Nutricionales in 1975.

income ranges. They then used the same income ranges for every region and city in the country to estimate the percent of people malnourished by income group. Thus everyone under a certain income was assigned the same calorie deficiency irrespective of interregional price differences etc. Because they used the ICBF national averages and because ICBF had found overall adequacy of food to be only 94 percent of requirements, Lemoine and Becerra found that for the households in the COLDATOS survey "all groups and not only those in the low income population suffer from calorie (and other nutrient) deficiencies."

As mentioned earlier, Garcia (1980a) estimated a calorie consumption function at the country level and used information on a household income and expenditure survey done by DANE (1977) in 1972 to estimate the degree of malnutrition by income bracket. He found that in 1972 around 40 percent of the Colombian population suffered from malnutrition, and that the incidence is of between 20 and 39 percent for the urban sector and 72 percent for the rural sector. Thus for the country as a whole estimates vary from 40 percent malnourished to 100 percent.

At the city level both Bogota and Cali have been studied but the focus has been on poor children. Betancourth (1977) found that the average level of calorie consumption for children of age 6 belonging to low income families in Bogota was 87 percent of requirements and distinguished as follows by age:

Age (years)	1	2	3	4	5
Adequacy (%)	97	100	84	65	86

Neither the calorie requirement level nor the criteria for defining low income families were reported. Per Pinstrup-Andersen and Elizabeth Caicedo (1978) report the results of a survey conducted in Cali between 1969 and 1970 which classified 18 - 30 percent of the population as malnourished depending on the requirements level assumed. They estimated the income Gini coefficient to be 0.42 1/ and that for calorie intake at 0.12. They also simulated a model to demonstrate that small changes in the distribution of income would be enough to ensure everyone an adequate diet without any changes in aggregate food supply.

In summary, it is clear that estimates of malnutrition for Colombia vary over a wide range - from 18 to 100 percent of the population - depending on the reference population, the level of requirements and the methodology utilized. We now present our results as ranges of estimates depending on different assumptions.

3.2. The Cities as a Whole

The aim of this section is to present the estimate of malnutrition in Bogota and Cali in order to demonstrate both that it is possible to obtain some idea of the magnitude of the problem as well as to show the range of uncertainty involved. It is well to recall from Section I what it is we are actually estimating. We are neither estimating the actual proportion of people malnourished in Bogota or Cali nor those actually in absolute poverty. We are essentially estimating the proportion of people who do not have incomes adequate to cover their food and nutrition needs given existing food and consumption habits and prices. We are thus approximating the number of people who do not even have the current potential for being well nourished.

1/ This is much lower than most estimates for urban Colombia.

We present results for both the years 1973 and 1978. The two sets of estimates are not strictly comparable. Almost 10 percent of the respondents in the 1973 sample did not report their incomes. They have been excluded from this calculation 1/ as have any households holds who have even one working individual whose income is not reported. Live-in maids are excluded from both samples because it is difficult to assign them to any household except as themselves being single member households.

For the 1978 survey, income was reported by almost all the households: only about 3 percent of the sample suffered from no information. These households were imputed income according to the procedure outlined in Mohan (1980) Appendix 1. As was mentioned earlier, the income coverage for the 1973 census was estimated to be only 50 percent but about 90 percent for the 1978 sample. Thus, estimates of malnutrition are somewhat high for 1973 but we attempt to account for this underreporting by various sensitivity tests.

Tables 5a and 5b report the range of estimates of malnutrition in Bogota and Cali. We do not report the estimates using the requirements according to IIT since they fall between the WHO, ICBF range and are quite similar to the ICBF estimates.

As we would expect, the extent of malnutrition in the two cities is higher for the WHO requirements than for the ICBF requirements at all requirement levels. The percent malnourished (PCM hereafter) at 0.7R

1/ See Technical Appendices in Rakesh Mohan (1980) for details on the 1973 census sample.

(70 percent of requirements) and 0.8R are higher according to M2. At 1.0R the PCM is higher according to M1. For Bogota the total range of estimates is from 17.2 percent malnourished (at 0.7R) to 75.0 PCM (at 1.0R) for 1973 and from 5.5 to 58.1 for 1978. This is the range in the sense that there is no general agreement in the level of requirements. Note that 1.0R itself is lower than the actual WHO/FAO recommendations. It is clear therefore that the estimate is very sensitive to the level of requirements used as well as to method of calculating consumption. The sensitivity is much greater to the former than to the latter. The picture is muddied further when we attempt to account for the under-statement of income referred to earlier. Table 7 reports the results of the "income experiments." These estimates serve two purposes. They provide an idea of PCM accounting for income under coverage as well as some estimate of the possibility of eliminating malnutrition with mere income growth. How long will it take to eliminate malnutrition with current income trends with optimistic assumptions: real income per capita growing at 3 -4 percent a year, and income distribution remaining unchanged, i.e., everyone's income increasing by the same proportion?

Table 5.a: EXTENT OF MALNUTRITION IN BOGOTA

(Proportion of Population below Requirement Levels)

	Categories of Requirements					
1973	0.7R 1/		0.8R 1/		1.0R 1/	
Method 2/	WHO	ICBF	WHO	ICBF	WHO	ICBF
M1	24.6	17.2	42.8	31.9	75.0	66.4
M2	38.2	34.0	46.3	41.6	59.0	55.2
1978						
M1	9.5	5.5	21.3	14.7	58.1	47.0
M2	18.3	16.0	25.1	21.1	36.6	33.1

Range of Estimates

	1973	1978
Total Range	17.2 to 75.0	5.5 to 58.1
0.8R	31.9 to 46.3	14.7 to 25.1

Notes:

1. R is requirements according to WHO/FAO and ICBF as detailed in Table 6. 0.7R, 08R, 1.0R refer to percent receiving less than 70 percent, 80 percent and 100 percent of requirement levels.

2. Method refers to the calculation of calories consumed. See Section II.

Table 5.b: EXTENT OF MALNUTRITION IN CALI

(Percentage of Population below Requirement Levels)

	Categories of Requirements					
	0.7R 1/		0.8R 1/		1.0R 1/	
1973						
M1	26.9	19.1	45.1	34.8	77.3	68.6
M2	41.1	36.9	48.5	44.6	61.1	57.2
1978						
M1	11.0	7.3	22.9	15.9	60.7	50.6
M2	19.7	16.7	25.7	22.1	40.3	36.4

Range of Estimates	1973	1978
Total Range	19.1 to 77.3	7.3 to 60.7
0.8R	34.8 to 48.5	15.9 to 25.7

Notes:

1. R is requirements according to WHO/FAO and ICBF as detailed in Table 6. 0.7R, 0.8R, 1.0R refer to percent receiving less than 70 percent, 80 percent and 100 percent of requirement levels.

2. Method refers to the calculation of calories consumed. See Section II.

What can we conclude from these tables? If we compromise between Type I (misclassifying well-nourished as malnourished) and Type II errors (misclassifying malnourished as well-nourished), we can regard 0.8R as the "correct" requirement level taking account of inter-individual variation. Intra-individual variation is implicitly accounted for in our methods since we are either using annual expenditures or monthly expenditures to calculate calorie consumption. The maximum Type 1 error at 0.8R (assuming a normal distribution of individuals around R with standard deviation about 15 percent) is about 10 percent. It is probably not unreasonable to assume that there might be about 5 percent Type II error. 1/ We can therefore subtract 5 percent from our PCM at 0.8R. From Tables 5a and 5b we can then conclude that the proportion of population malnourished was between 25 and 35 percent in Bogota (30 to 40 percent in Cali) in 1973 and 10 to 16 percent in both Bogota and Cali in 1978. These results would hold if incomes at the low end were fully reported in both the samples.

In order to examine the extent of under-reporting of income at the low income levels we compared the reported wages of some selected low wage occupations from both the samples. Table 6 shows that the real income of people in these occupations rose by about 8 percent per year. Surprisingly, the minimum wage also increased in real terms at a similar rate: 8.8 percent per year.

1/ We have no rigorous basis for this assumption.

Table 6: REAL WAGE TRENDS [1/] IN LOW INCOME OCCUPATIONS 1973-1978 (MALES)

ILO Code	Occupation	Wages as Proportion [2/] of Minimum Wage		Monthly wages in constant 1970 pesos		Rate of Growth (% per Year) 1973 - 1978
		1973	1978	1973	1978	
37	Mail Distribution Clerk	1.9	1.9	543	835	8.9
53	Cook, Waiters and Bartenders	2.7	2.5	745	1094	8.0
58	Protective Service Workers	2.8	2.7	787	1170	7.9
77	Food and Beverage Processors	2.6	2.5	724	1106	8.5
93	Painters	2.5	2.7	709	1170	10.0
95	Construction	2.5	2.2	692	966	6.7
97	Transport Equipment Operators	2.1	2.0	580	879	8.3
Monthly Minimum Wage		1.0	1.0	279	434	8.8

Note:

1. Consumer Price Index (1970 = 100)

   1973 150
   1978 400

2. Source: 1973 Population Census Sample
   1978 World Bank - DANE Household Survey.

It is remarkable that the relative structure of wages has remained very stable and that a constant relationship has been maintained between the minimum wage and low income occupation wages. We can reach two conclusions from this evidence. First, assuming that under-reporting of low wages in the 1978 survey was minimal, it would appear that at least at the low end there was good coverage of incomes in the 1973 census. Second, low income groups in the population have registered considerable increases in real incomes during the 1973 to 1978 period. The fact that average real wages reported in these occupations were more than twice the minimum wage gives further confidence in these conclusions. The overall under-coverage of income in the 1973 census must then be attributed to the higher income groups. 1/

Our estimates of malnutrition given above then do not suffer seriously from the under-estimation of incomes. Nonetheless, we have conducted income experiments as reported in Table 7. We augmented the income of every household by fixed percentage levels and recomputed the malnutrition estimates. If we assume that that the low end incomes in 1973 were really 30 percent higher (i.e. under-reported by about 20 percent) we have an estimate of malnutrition of about 30 percent according to M2 at the 0.8R level. If we assume under-reporting of income by 10 percent in 1978 the comparable figure is 18 percent by M2 and 12 percent by M1. Our new estimates of malnutrition

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1/ Further evidence on this point is provided in Mohan (1980).

Table 7. INCOME EXPERIMENTS FOR BOGOTA

(Percentage of Population below ICBF Requirement Levels)

Percentage Increase in Income 1/	Categories of Requirements					
	0.8R			1.0R		
	1973	1978		1973	1978	
	M2	M2	M1	M2	M2	M1
0	41.6	21.1	14.7	55.2	33.1	47.0
10	37.5	17.7	12.4	51.4	29.6	43.0
20	33.9	16.0	10.3	47.2	26.4	39.0
30	30.4	13.7	7.8	43.8	22.9	35.1
50	24.6	9.3	5.7	37.3	18.1	29.0
70	20.2	6.7	3.6	32.3	15.2	23.8
100	15.3	4.0	2.7	25.3	10.1	17.8

1/ The income of each household was augmented by these percentages and the calories consumed were then calculated at these incomes.

are therefore 25 to 30 percent for 1973 and 12 to 18 percent in 1978 for Bogota and the estimates for Cali are quite similar.

There is one other adjustment that should be made. As mentioned earlier the poor are more efficient in their consumption of calories than the rich. They probably buy low quality varieties of foods but with similar calorie content. In other words, price per calorie for them is likely to be lower than for higher income groups. Table 8 reports the results of our price experiments. We find that if prices paid by the poor are 20 percent less than the average our estimate of malnutrition is reduced by about 10 percent for each year.

It is difficult to be too precise about the extent of adjustments that should be made to our estimates on account of under-reporting of income and price variations between the rich and the poor. Combining the two experiments according to M2 at 0.8R of ICBF requirements and taking account of Type I and Type II errors we can say with a high degree of confidence that the proportion of malnourished in Bogota in 1973 could not have been much less than about 25 percent. Doing the same for 1978 we obtain an estimate of about 12 percent. Thus it is probably fair to assert that malnutrition and absolute poverty in Bogota decreased from about 25 percent in 1973 to 12 percent in 1978 - give or take 5 percent on either side. The estimates for Cali are similar.

The above statements are somewhat more definitive than intended. We are really giving lower bounds: there must be at least as many who simply do not have incomes which would allow adequate nutrition. There might well be more who have adequate incomes but suffer from malnutrition due to other

Table 8. PRICE EXPERIMENTS FOR BOGOTA

(Percentage of Population below ICBF Requirement Levels) (M2)

Percentage Change in Calorie Price	Categories of Requirements			
	0.8R		1.0R	
	1973	1978	1973	1978
-50	9.9	2.1	17.0	4.7
-40	15.6	4.1	25.4	9.4
-30	22.1	7.4	34.6	10.6
-20	28.8	11.2	41.6	21.1
-10	35.6	16.7	49.2	27.9
0	41.6	21.1	55.2	33.1
10	48.6	26.2	60.7	38.4
20	52.9	30.9	65.0	45.1
30	57.6	35.1	69.2	49.9

reasons. Note from the income experiments in Table 7 that even if there is a 5 percent rate of growth in average household income annually for the next 10 years there would still be at least 5 percent of the population malnourished. The high average income level reached after such a growth rate in income should make it possible to eliminate malnutrition completely. However, it seems that mere income growth is not going to be adequate in the medium term so that malnutrition and poverty will have to be attacked directly to relieve the most affected individuals. The bottom 5 to 10 percent are possibly the old and infirm and to malnourished to be able to work: general expansion of employment and income growth then does them no good.

3.3. The Age Distribution of Malnutrition

Mohan and Hartline (1980) examined the correlates of poverty by looking at the bottom 30 percent of the population ranked by household income per capita. One of their interesting findings was a distinctly higher incidence of poverty among children, despite the fact that income was distributed evenly within the households. This is implicit in ranking persons by household income per capita. Though it is not surprising since we are basically using a transform of income we find the same phenomenon in our estimates of malnutrition. If anything, malnutrition among children is even more pronounced. Note once again that NLH is the same for all members of the same household, so we are not making any comment on the intra-family distribution of nutrition.

Tables 9a and 9b present the age distribution of malnutrition in Bogota and Cali calculated at 0.8R and 1.0R of ICBF requirements

by both M1 and M2. Children in the age group 5 to 14 have a PCM(M2) 14 to 16 points higher than the city wide PCM in 1973 and 7 to 13 points higher in 1978 at the 0.8R level. The levels for the 0-4 age group are near the mean. This is somewhat reassuring since the maximum irreparable damage done by malnutrition is in the 0-4 age group. 1/ Nevertheless, the higher estimate for the 5-14 age group is very disturbing. One can expect that the schooling of these children is adversely affected, hence their future chances in the labor market and hence their lifetime earnings. We can extend the chain to the next generation to continue the vicious cycle.

A word of interpretation is in order here. Who are these children and why are they badly off when nutrition is evenly distributed within the household? As is well known and is documented in particular for Bogota in Mohan (1980), the age-earnings profile is relatively flat for less educated low income workers. Thus, for households headed by these workers, income per capita declines as household formation progresses and more children appear. As the children grow up and leave home, the income per capita increases again. What we are observing therefore may be termed as a life cycle phenomenon. Visaria (1980) also observes this in general when looking at poverty across detailed household data sets for 6 countries in Asia. These children are therefore based in the larger households headed by less educated low income workers. If these children are indeed malnourished as our calculations indicate, their handicap in the labor market which exists regardless because of their low socio-economic background, is magnified through its effects in their schooling.

1/ As reported, among other, by McKay and others (1978).

Table 9a: EXTENT OF MALNUTRITION IN BOGOTA BY AGE GROUP

(ICBF Requirements)

Age (Years)	1973			
	0.8R		1.0R	
	M1	M2	M1	M2
	(percent malnourished)			
0-4	25.5	44.3	59.7	58.9
5-9	41.5	55.8	75.0	69.5
10-14	49.9	57.7	81.1	70.5
15-54	28.0	35.3	63.8	48.8
55-99	23.0	27.8	53.5	39.4
Total	31.9	41.6	66.4	55.2
	1978			
0-4	8.6	19.7	35.0	32.1
5-9	18.0	28.4	51.7	43.7
10-14	26.9	34.1	69.7	49.9
15-54	12.9	17.7	44.6	28.8
55-99	12.0	15.4	36.5	21.9
Total	14.7	21.1	47.0	33.1

Table 9b: EXTENT OF MALNUTRITION IN CALI BY AGE GROUPS

(ICBF Requirements)

Age (Years)	1973			
	0.8R		1.0R	
	M1	M2	M1	M2
	(percent malnourished)			
0-4	31.2	48.7	63.5	62.9
5-9	45.3	59.9	78.8	73.1
10-14	47.3	55.6	76.4	66.7
15-54	31.1	38.6	67.0	51.5
55-99	26.4	33.3	57.4	44.1
Total	34.8	44.6	68.6	57.2
	1978			
0-4	12.0	22.1	36.6	37.1
5-9	21.7	31.7	56.5	47.9
10-14	26.5	33.4	70.0	51.3
15-54	13.6	18.3	48.8	31.7
55-99	11.9	15.3	41.4	27.2
Total	15.9	22.1	50.6	36.4

To lend further credence to these ideas we have disaggregated malnutrition in Bogota by family size for 1978 in Table 10. It is clear that the incidence of malnutrition increases monotonically with family size and we find that as many as 50 percent of those in the largest families are likely to be malnourished. It is probably the case that we are not accounting fully for economies of scale in food consumption - although M2 does so in principle. The differences between family sizes are, however, so marked that the results are unlikely to change substantially when such economies of scale are accounted for. As also shown in Mohan (1980) larger households have fewer workers per dependent than do smaller households and therefore proportionately lower incomes. Larger families have proportionately more children and hence those results show up in the age distribution.

We can now state our composite picture again. The malnourished are in low income households which are large and characterized by high dependency ratios. The income earners in these households have flat age-earnings profiles. As a result children in these households suffer disproportionately and could be said to be trapped in the low end poverty trap. Trickle-down or normal income growth has helped considerably in the last decade in reducing the number of people who have no potential of achieving minimally adequate nutrition. However, given the long term consequences of malnutrition in growing children, it would be desirable to make direct interventions in reducing the incidence of malnutrition among these children in order to make a dent in the vicious cycle sketched above. Normal income growth would simply be too slow to affect the nutritional status of these children.

Table 10. EXTENT OF MALNUTRITION IN BOGOTA BY FAMILY SIZE 1978

(Percentage of Population below ICBF Requirement Levels) (M2)

Household Size	Categories of Requirements					
	Bogota			Cali		
	0.8R	1.0R	% Population in Category	0.8R	1.0R	% Population in Category
1	1.8	3.2	1.1	5.4	5.4	1.3
2	3.7	5.7	4.7	4.3	10.3	4.8
3, 4	6.9	13.8	28.2	6.3	14.3	25.3
5, 6	18.2	30.1	31.2	20.0	31.7	31.9
7-9	33.0	49.0	24.8	36.1	58.9	27.2
10+	50.9	73.4	10.0	41.6	63.0	9.6
Total	21.1	33.1	100	22.1	36.4	100.0

3.4. The Spatial Distribution of Malnutrition

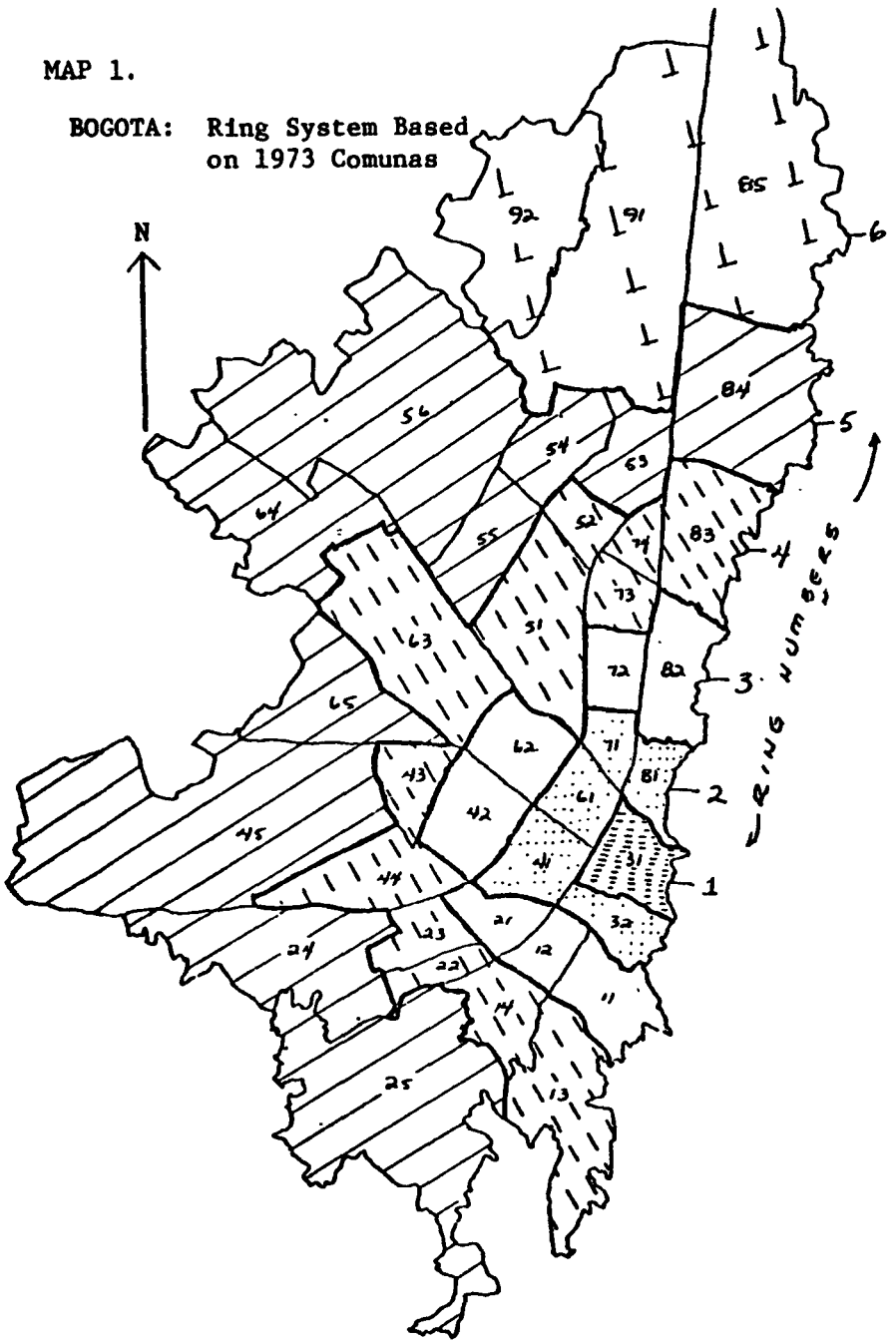
We are particularly concerned with spatial distribution of socio-economic characteristics in the City Study. Map 1 shows our standard division in Bogota into circumferential rings and radial sectors and Map 2 that for Cali.

In Mohan (1980) and Mohan and Hartline (1980), it was observed that in Bogota incomes rose mildly with distance from the city center up to ring 3 and then declined. The pattern-- both according to mean household income per capita and by proportion of bottom 30 percent--was not very distinct. Table 11a shows a much stronger pattern. In 1973, the PCM in the two outer rings was about 7-13 points higher than in ring 1 (the central business district) while in ring 3 it was about 6 points lower. This difference gets even more magnified in 1978 (proportionately). There is one large change in 1978 as compared with 1973. Ring 6, which lies entirely in the extreme North, has apparently changed character from a particularly poor area to being relatively rich. As the rich have moved toward the North, the average income of these areas has naturally increased but some of the poor may have moved to the South.

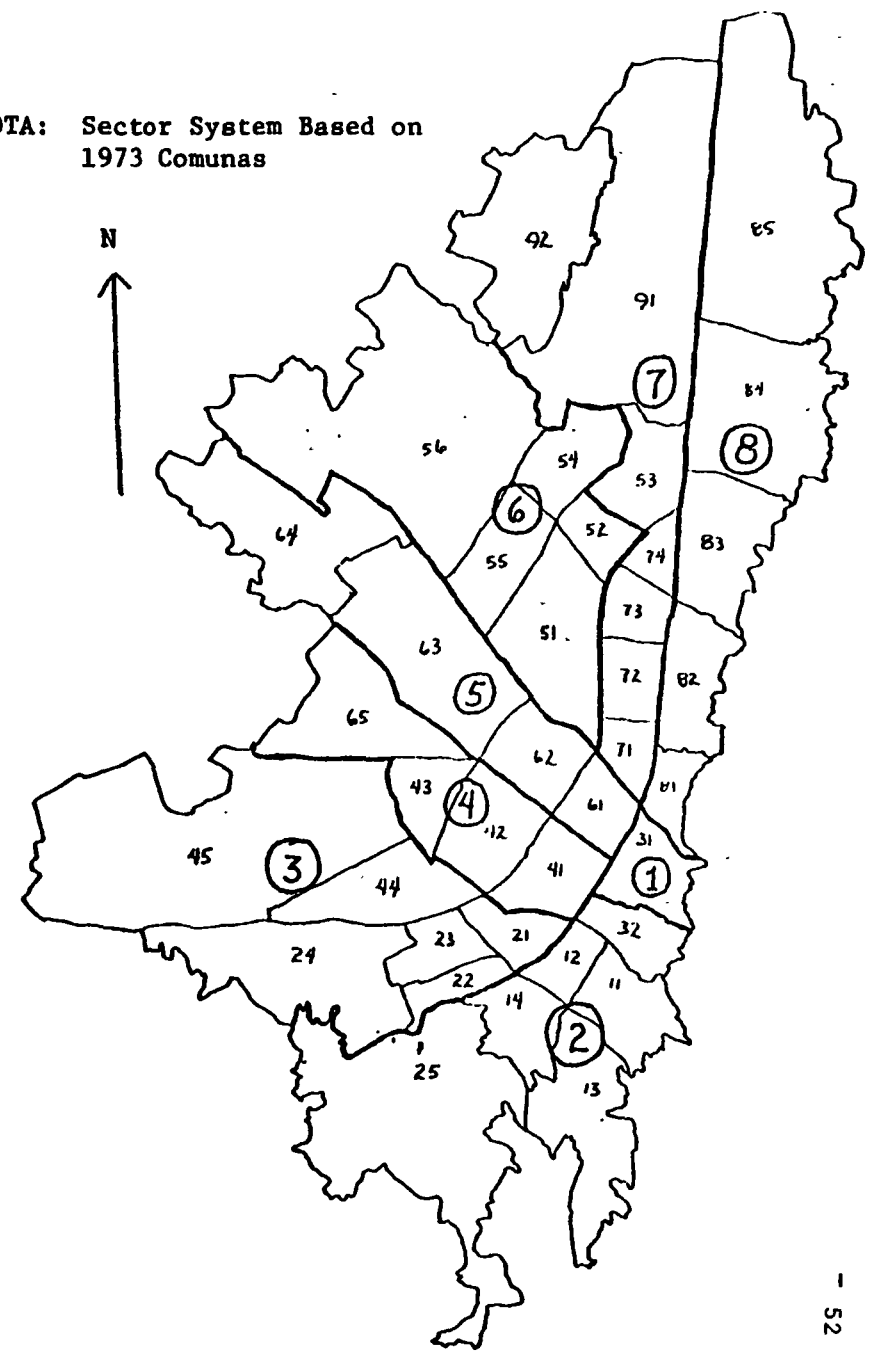
In Cali, apart from the central business district (c.b.d.), the PCM increases consistently with distance from the c.b.d. It is much more correct to say that in Cali the poor live on the periphery while the relatively rich nearer the center.

MAP 1.

BOGOTA: Ring System Based on 1973 Comunas

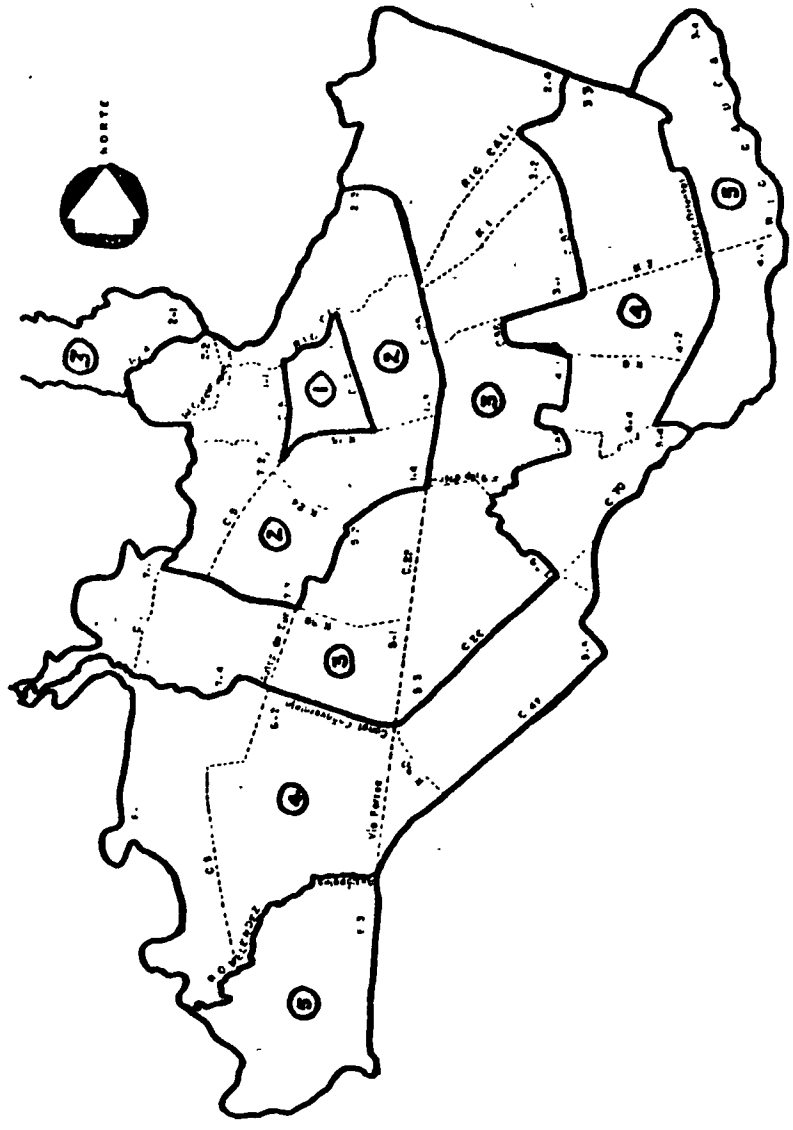


BOGOTA: Sector System Based on 1973 Comunas



Map A.2a

CALI: Ring System



Map A.2b

CALI: Sector System

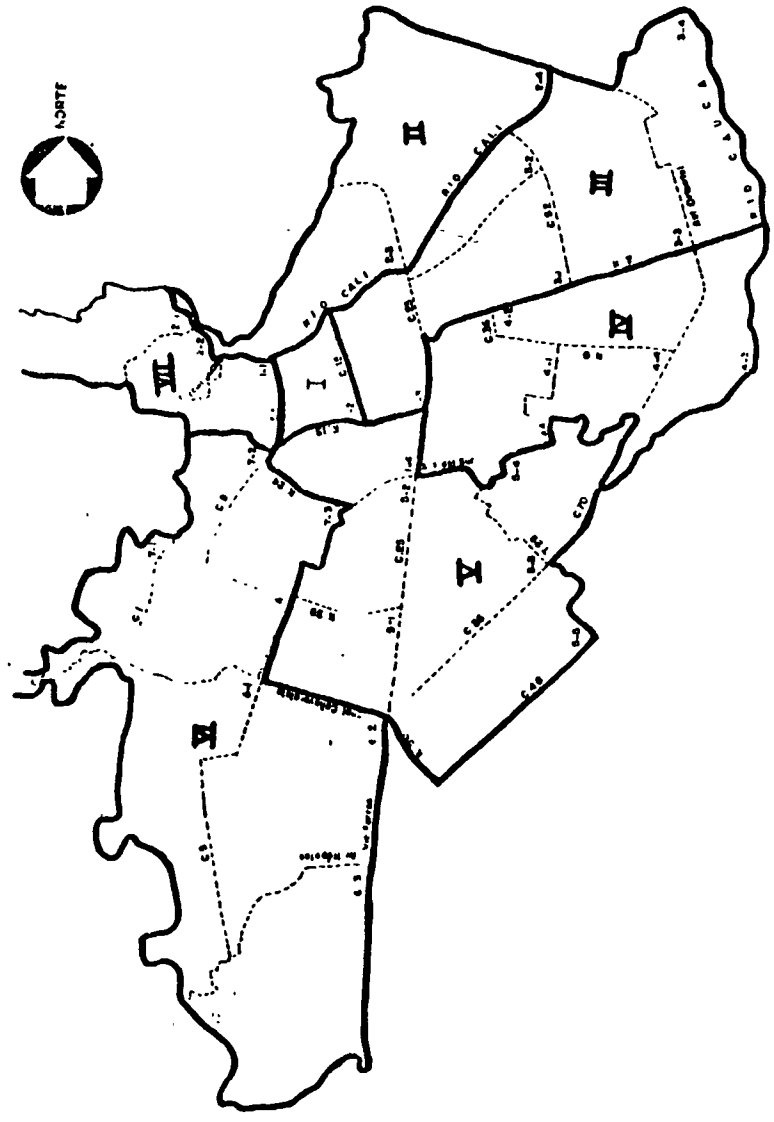


Table 11a: THE SPATIAL DISTRIBUTION OF MALNUTRITION IN BOGOTA BY RINGS

(Percent Malnourished at 0.8R of ICBF)

	1973		1978	
	M1	M2	M1	M2
Ring 1	30.1	36.2	18.1	21.4
Ring 2	27.4	33.7	10.9	15.3
Ring 3	23.9	30.8	9.8	11.6
Ring 4	28.7	38.0	12.2	17.2
Ring 5	37.1	48.6	17.6	26.8
Ring 6	37.2	49.5	17.2	20.7
Total	31.9	41.6	14.7	21.1

Table 11b: THE SPATIAL DISTRIBUTION OF MALNUTRITION IN CALI BY RINGS

(Percent Malnourished at 0.8R of ICBF)

	1973		1978	
	M1	M2	M1	M2
Ring 1	32.6	39.3	0.0	22.9
Ring 2	20.8	26.4	9.8	11.4
Ring 3	35.0	45.3	12.9	18.1
Ring 4	47.0	59.6	21.5	30.8
Ring 5	48.4	63.4	26.8	34.3
Total	34.8	44.6	15.9	22.1

Table 12a shows that the distribution of malnutrition by radial sectors is even more distinct than that by rings. Malnutrition in Bogota is much higher in the southern sectors 2 and 3 and in sector 6 as we would expect from income patterns mapped earlier in Mohan (1980) and Mohan and Hartline (1980). Once again, the differences are somewhat magnified. Cali has a less distinct sectoral pattern. Broadly, the western part of the city is better-off than the North. Sector 2 stands out as being particularly well-off.

Maps 3 and 4 provide a more disaggregated and better representation of the distribution of malnutrition and povery in Bogota. The darker shades represent higher PCMs. The concentration of high PCMs in the periphery and in the South of Bogota is brought out more forcefully. Mohan (1980) also showed that larger households were more likely to be located at the periphery. Thus the observed malnutrition map is a confirmation of the effects of low incomes and larger household size in the darkly shaded areas of the city. A further interpretive word is in order here. We have remarked before that the existence of malnutrition is accentuated by bad sanitation, hygiene, disease and crowding. Thus, our estimates of malnutrition due to lack of income are more likely to be understated in the poor neighborhoods. There even the people with somewhat higher incomes who can afford more food probably suffer from malnutrition because of chronic stomach disorders and other neighborhood effects 1/. This likelihood gives cause for further concern about the excessive PCMs found in children. We inferred the existence of these children in large poor families. Given the spatial pattern, these families

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1/ This was found to be the case in a recent detailed clinical nutrition study of Cali (personal communication from Mr. Luis Fajardo of the Universidad del Valle).

Table 12a: THE SPATIAL DISTRIBUTION OF MALNUTRITION IN BOGOTA BY SECTORS
(Percent Malnourished at 0.8R of ICBF Requirements)

	1973		1978	
	M1	M2	M1	M2
Sector 1	30.1	36.3	18.1	21.4
Sector 2	43.0	55.4	22.6	32.7
Sector 3	34.5	45.9	13.6	20.6
Sector 4	26.0	33.1	13.2	16.9
Sector 5	30.6	39.1	10.2	15.1
Sector 6	33.3	44.3	15.1	23.5
Sector 7	19.9	25.3	11.2	12.8
Sector 8	20.0	26.4	7.1	8.1
Total	31.9	41.6	14.7	21.1

Table 12b: THE SPATIAL DISTRIBUTION OF MALNUTRITION IN CALI BY SECTORS
(Percent Malnourished at 0.8R of ICBF Requirements)

	1973		1978	
	M1	M2	M1	M2
Sector 1	32.6	39.3	0.0	22.9
Sector 2	4.6	8.5	6.7	6.7
Sector 3	30.5	39.3	11.0	14.5
Sector 4	37.0	48.8	21.3	28.5
Sector 5	42.0	53.2	19.3	26.0
Sector 6	33.4	41.5	10.5	18.3
Sector 7	32.3	42.2	9.8	13.4
Total	34.8	44.6	15.9	22.1

Map 3.

1973 Calorie Consumption in Bogota

N

Map 4

1978 Calorie Consumption in Bogota

would tend to be concentrated in the southern and peripheral locations. These children, being malnourished because of lack of income for food expenditures, are then even more likely to be affected by infectious diseases because of bad sanitation and crowding. We thus begin to see the combination of life cycle effects and spatial or neighborhood effects on the nutrition of children and their perpetration in the future.

To further investigate the spatial pattern of malnutrition in Bogota we provide an Index of the Incidence of Malnutrition by age group for each ring and sector in Table 13. Our index gives a sense of the relative incidence of malnutrition in a particular age group in a particular sector/ring as compared with the overall incidence for the age group. Thus indices of over a 100 mean that the incidence of malnutrition is particularly high in that sector/ring in that age group. Several points of interest are evident. Rings 1 and 5, and to a lesser extent ring 6, that is the centre and the periphery are particularly hard hit. However, the children are not disproportionately affected. The adults in these areas are relatively worse-off as compared with the overall city average. If we look at the sectoral distribution we find much the same story. The poor southern sector 2 has much higher incidence in all age groups but proportionately higher among adults and particularly so among old people.

We can therefore restate our earlier summary of the pattern of malnutrition and poverty in Bogota. The Southern and peripheral areas of Bogota have much higher incidence of malnutrition as compared with the rest of Bogota. Interestingly, the adults are more disproportionately affected than the children in these areas. This tends to confirm the idea that there is

Table 13: THE SPATIAL DISTRIBUTION OF MALNUTRITION BY AGE GROUP IN BOGOTA 1978

(Malnutrition at 0.8R of ICBF Requirements by M2)

Age Group	Rings						Total % of Malnourished in Age Group
	1	2	3	4	5	6	
	(Index of Malnutrition) 1/						
0-4	160	92	54	77	117	101	19.7
5-9	28	76	77	81	120	112	28.4
10-14	126	83	76	86	112	98	34.1
15-54	77	65	45	84	133	92	17.7
55+	131	97	51	68	140	88	15.4
Total	101	73	55	82	127	98	21.1

	Sectors								Total % Malnourished in Age Group
	1	2	3	4	5	6	7	8	
	(Index of Malnutrition) 1/								
0-4	160	147	94	54	81	103	75	40	19.7
5-9	28	144	98	73	55	96	70	77	28.4
10-14	126	147	95	88	67	94	70	58	34.1
15-54	77	156	97	85	71	120	57	29	17.7
55+	131	188	108	83	141	84	51	23	15.4
Total	101	155	98	80	72	111	61	38	21.1

1/ The Index of Malnutrition

$$A_{ij} = \frac{\text{\% Malnourished in Age Group } i \text{ in Sector } j}{\text{\% Malnourished in Age Group } i}$$

higher malnutrition in these areas because of larger household sizes and higher dependency ratios which tend to accentuate the degree of malnutrition of families where income earners have relatively flat age-income profiles.

If nutrition programs are to be organized they can be targeted at these areas and particularly at the children so that the vicious cycle alluded to earlier can be broken. The obvious intervention point is the school system. In addition better education and the provision of day care centers in these areas would enable the women to participate in the labour force and therefore reduce dependency ratios. Given the sanitation conditions and crowding in these areas, actual malnutrition must be still higher than our calculations. Thus environmental improvement programs in terms of improved public services can certainly be focused on these areas.

3.5 Malnutrition by Income Classes

As has been remarked earlier a common method used to estimate the extent of malnutrition is to find an income level under which everyone is characterized as malnourished. This last section demonstrates the kind of errors that arise as a result of such a simple mapping.

Table 14 gives a number of characteristics of the population of Bogota by income deciles. The ranking criterion used is household income per capita for all individuals. Row 1 gives the breakdown of people with PCM less than 0.8R by decile for Bogota in 1978. It is clear that virtually all malnourished so defined fall in the bottom three deciles. If, however, we define the third decile as the malnutrition cut-off point we would misclassify many individuals in the second and third deciles as shown by Rows 2, 3 and 4. Thus as many as 32 percent in the second decile and 58 percent in the third

Table 14. MAPPING MALNUTRITION INTO INCOME DECILES IN BOGOTA 1978

(By M2 according to ICBF Requirements)

Deciles	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eigth	Ninth	Tenth	Total
1. % 0.8R in Decile	46	32	20	1	1	0	0	0	0	0	100.0
2. 0.8R	100	68	42	1.7	2.5	0	0	0	0	0	21
3. 0.8R to 1.0R	0	28	35	40	16	3	0	0	0	0	12
4. 1.0R +	0	4	23	58	82	97	100	100	100	100	67
				Percent of Decile							
5. Total	100	100	100	100	100	100	100	100	100	100	100
6. Percent in Decile	9.8	10.0	9.8	9.7	10.0	10.4	9.8	10.1	10.3	10.3	100 (3.5 million people)
7. Average Household Size	6.1	5.5	5.4	5.3	5.2	4.8	4.6	4.3	4.1	3.5	4.8
8. Average Household 2/ Income per Capita	440	720	925	1200	1470	1810	2300	3110	4780	12640	2980
9. Average Household Income 3/	2580	3980	5050	6340	7680	8710	10675	13400	19670	51790	18140

1/ The population is ranked according to Household Income Per Capita.

2/ Monthly Income in 1978 Pesos.

3/ Minimum Monthly Wage in 1978: 1738 pesos.

decile would be misclassified as malnourished. In all we would misclassify 9 percent of the total population as malnourished. Conversely, we may note that it is only in the top five deciles that we can be sure that there is no malnutrition due to income deprivation. Row 7 shows how household size declines monotonically with income deciles 1/ confirming our earlier conjectures about the malnourished falling predominantly in large families with high dependency ratios.

Rows 8 and 9 give the average household income per capita and household income by decile. We can profitably compare the level of minimum wage with these average incomes. The 1978 monthly minimum wage was 1738 pesos. Since the majority of the second decile and part of the third decile are malnourished we utilize an intermediate household income level as necessary for minimum adequate nutrition. This would be in the range of 4000 to 5000 pesos. It is clear then that for adequate nutrition those households need roughly 2.5 workers per household at minimum wages. In fact these households have characteristically higher dependency ratios i.e., they have fewer than 2.5 workers per household. 2/ In this sense we can assert that the minimum wage is not unreasonable: indeed, it should be higher if the objective of a minimum wage is to assure everyone of at least having the potential to consume a minimally adequate diet. 3/

1/ Note that the deciles are ranked by household income per capita. As mentioned earlier, household size increases if households are ranked by household income.

2/ Mohan and Hartline (1980).

3/ Abstracting from other labor market effects of imposing a higher minimum wage, Table 6 showed that mean wages in even the lowest paid occupations were substantially higher than the minimum wage. In current conditions, it would be difficult to argue that the minimum wage in Bogota is the cause of unemployment as is often suggested.

In conclusion we must be wary of malnutrition estimates reached by simple income cut-off levels. Our results are different from other studies essentially because we have accounted for household size and intra-household age and sex compositions. We need to recall that our own calculations are also based on income but which has been adjusted to estimate food expenditures.

IV. CONCLUSIONS

This paper has attempted to provide estimates of the extent of malnutrition in Bogota and Cali, Colombia, in order to get a better idea of who do constitute the poor. In so doing we have demonstrated the difficulties inherent in attempting such an estimation. These difficulties are both conceptual as well as empirical in nature. We have argued that the kind of methods used in the literature can, at best, provide some bounds on the magnitude of the problem of malnutrition and poverty. Specifically, what such methods really do is to provide lower bound estimates of the number of people who simply do not receive adequate income for even the barest minimum of nutritional requirements.

Previous estimates of malnutrition in Colombia lie in a large range: from about 18 to 100 percent of the population. The total range of our own estimates for Bogota is 17 to 75 percent in 1973 and 6 to 58 percent in 1978 depending on the level of requirements assumed and the method used for calculating calories consumed. The ranges for Cali are not very different. Despite our misgivings about making point estimates from such ranges, we have concluded that the proportion of malnourished owing to lack of income could not have been much less tban 25 percent in 1973 and about 12 percent in 1978 in both cities.

We have attempted to rectify some of the shortcomings of earlier studies but some remain. By using household level data we have been able to adjust for the age and sex distribution as well as the size of household on the requirements side though not as well on the consumption side. Method 2 (M2)

implicitly adjusts for this problem since all calculations for consumption are done at the household level - the commensal unit. This adjustment would have been done better had we had data on actual consumption for each household.

Since there is little agreement between different authorities on the appropriate level of requirements we have presented results of the incidence of malnutrition at 70 percent, 80 percent and 100 percent (0.7R, 0.8R and 1.0R) of calorie requirements levels. Thus the basis of the range of estimates is clear and we can get a better appreciation for the extent of the problem. Such a procedure also corrects for inter-individual variation in requirements if certain assumptions are made about the distribution of these requirements levels. Since we have used monthly or annual income estimates we have implicitly taken account of intra-individual variations in the level of requirements. Furthermore, although we have only income information we have attempted to estimate total consumption or food expenditures which can then be assumed to be better proxies for permanent income than the observed current income. Our estimates should therefore, not suffer seriously from this bias. By doing income experiments we have attempted to account for the understatement of income that is characteristic of most household surveys. Our evidence suggests that at the low income end the problem of understatement of income is probably not very serious.

By calculating the price of an average diet or average calorie consumed we have assumed a balanced diet as observed in Colombia. In not cost minimizing for calorie intake we have attempted to preserve the preference structure of Colombians in terms of the food they consume. This procedure does not, however, correct for changes in relative prices unless more frequent diet and cost of food surveys become available. By doing price experiments we

have attempted to account for the allegedly more energy efficient consumption of food by the poor. If the poor do spend less per calorie consumed, our price experiments give the resulting possible ranges of malnutrition.

We have had to assume an even distribution of food within the family without any information to the contrary. Similarly, we cannot account for any neighborhood effects like lack of sanitation, prevalence of disease, etc. More direct estimates of malnutrition would be better in accounting for these effects. It is likely that in the middle income countries these causes will become more important as determinants of malnutrition quite soon if current income trends continue. Income inadequacy will then cease to be a problem for nutrition.

We have tried to delineate the areas of the two cities which have greater malnutrition and poverty difficulties. These neighbourhoods are characterized by large low income families with high dependency ratios because of the presence of many children. Given the importance adequate nutrition plays in the development of cognitive ability, one can expect that malnutrition seriously impairs the schooling of these children which can then be expected to affect their future earnings potential and chances in the labour market adversely. Thus a vicious cycle of poverty is likely to be the result if direct nutrition and health measures are not taken in the most seriously affected parts of the city.

Spatially, malnutrition follows closely the income patterns of Bogota and Cali although the differences are somewhat magnified. In Bogota, malnutrition is observed to have high incidence in the periphery of the city as well as in the center. Malnutrition clearly increases with distance from the center in Cali.

We also show that defining an income level under which everyone is classified as malnourished can lead to quite serious errors. For example, if the third decile by income is defined as the cut-off point for Bogota as much as 9 percent of the population would be misclassified as malnourished.

In summary, most estimates of malnutrition, being based on the calorie-income relationships (or its variants), should be viewed with some suspicion. Better estimates need more careful work as well as a delineation of ranges of estimates rather than the assertion of point estimates. We have shown that income growth in Bogota and Cali has been substantial for people at even low levels of income during the period 1973 to 1978. Malnutrition solely due to income inadequacy has certainly decreased. It does appear, however, that in Bogota and Cali, even now there must be at least 10-12 percent of the people in these cities who must be malnourished because they simply do not earn enough to buy an adequate diet: in round numbers, as many as half a million people in these two cities alone.

APPENDIX 1: THE COVERAGE OF INCOME IN BOGOTA IN HOUSEHOLD SURVEYS

There is considerable skepticism concerning the coverage of income in household surveys. Detailed estimates of the coverage of Bogota have been made by comparing the total personal income from regional accounts, national income accounts and incomes as revealed in surveys. 1/ The results are as follows:

Survey	Income Covered
1973 Census	49.3 percent
1977 Household Survey	61.3 percent
1978 Household Survey	92.0 percent

Outline of Method	Millions of 1978 Colombian Pesos		
1978 Colombia GDP	(1)	870,000	
Bogota GRP	(2)	200,100	(.22 of 1)
Personal Income	(3)	130,065	(.65 of 2)
From Survey	(4)	119,634	
Survey Coverage		92.0%	(4/3)

1/ Details in Rakesh Mohan (1980), Appendix 2.

APPENDIX 2: FOOD EXPENDITURE AND TOTAL EXPENDITURE BY INCOME GROUP

Ideally one would like to have the total expenditure and budget composition for each household to estimate accurately the two calorie consumption measures proposed in the text. However, given that there was no expenditure data available at the household level, we estimate "expenditure share" (equation 10) and "food share" (equation 11) relationships from the 1972 DANE Consumption Survey to help derive our calorie consumption measures. Table A.1. gives the data on which the estimation of equations 9 and 10 are based. The fitted curves and actual data points are plotted in Graphs A.1a,b. Also indicated in the graphs are the decile cut-offs by household monthly income of the 1973 census and the 1978 Household Survey in Bogota. 1/ The decile ranges for monthly household income and monthly household income per capita are presented in Table A.2.

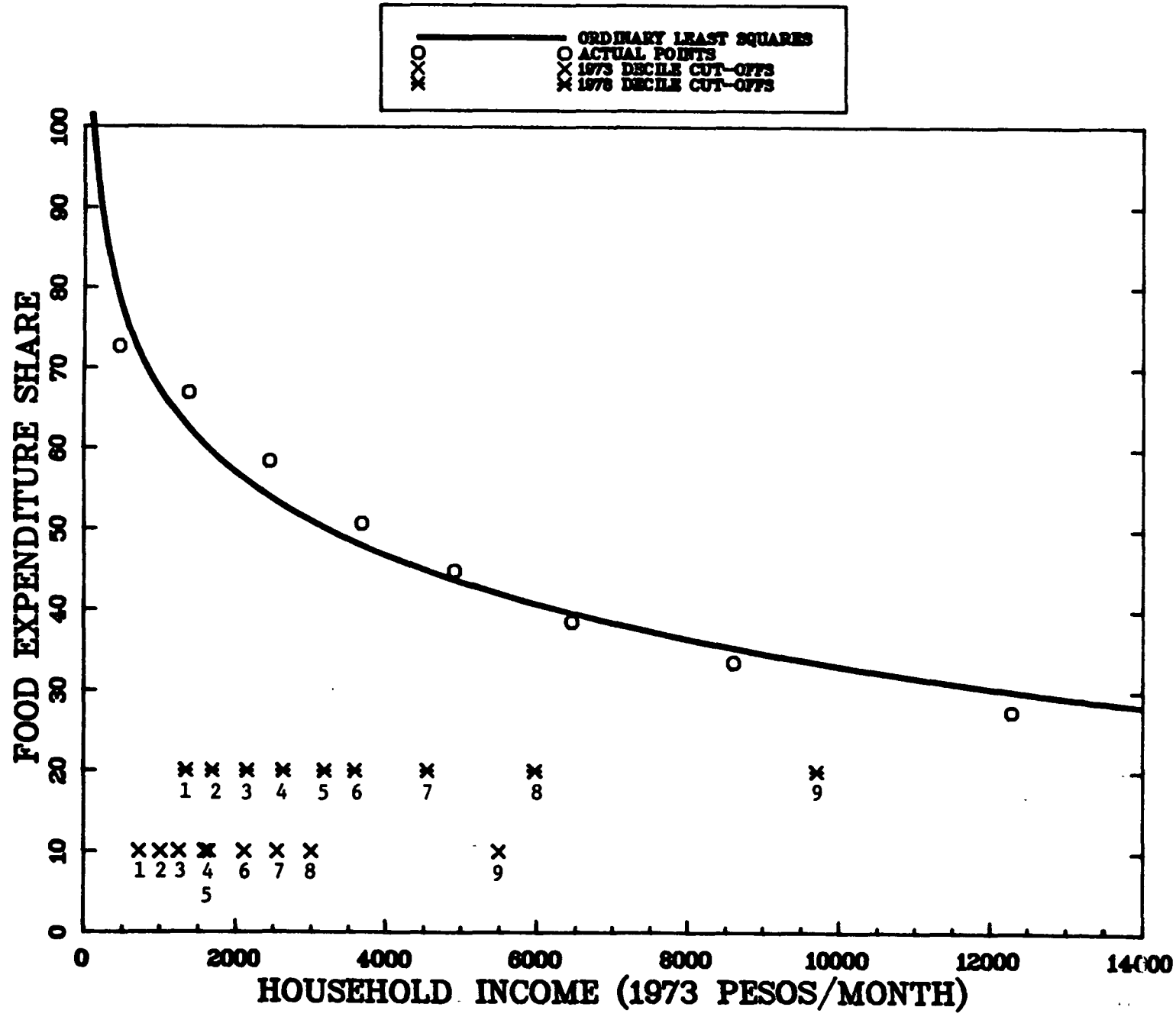
1/ The data points for the two highest income groups fall outside the ranges shown in the graphs. This was done purposefully to indicate the decile cut-offs.

Table A.1: HOUSEHOLD FOOD EXPENDITURE AND TOTAL EXPENDITURE BY INCOME GROUPS IN URBAN COLOMBIA - 1972

Monthly Household Income (1973 pesos)	(midpoint)	Food Expenditure as a % of Income (used for equation 11)	Total Expenditure as a % of Income (used for equation 10)
0-921	460.5	.727	1.2395
922-1842	1382.0	.669	1.1527
1843-3070	2456.5	.584	1.1007
3071-4298	3684.5	.507	1.0521
4299-5526	4912.5	.448	.9862
5527-7368	6447.5	.386	.9454
7369-9824	8596.5	.336	.8297
9825-14736	12280.5	.275	.8071
14737-24560	19648.0	.220	.7813
24561-50000	37280.5	.135	.5492

Source: Adapted from DANE Ingresos y Gastos de los Hogares, Colombia 1972.

GRAPH A.1a: FOOD EXPENDITURE RELATIONSHIP



GRAPH A.1b: TOTAL EXPENDITURE RELATIONSHIP

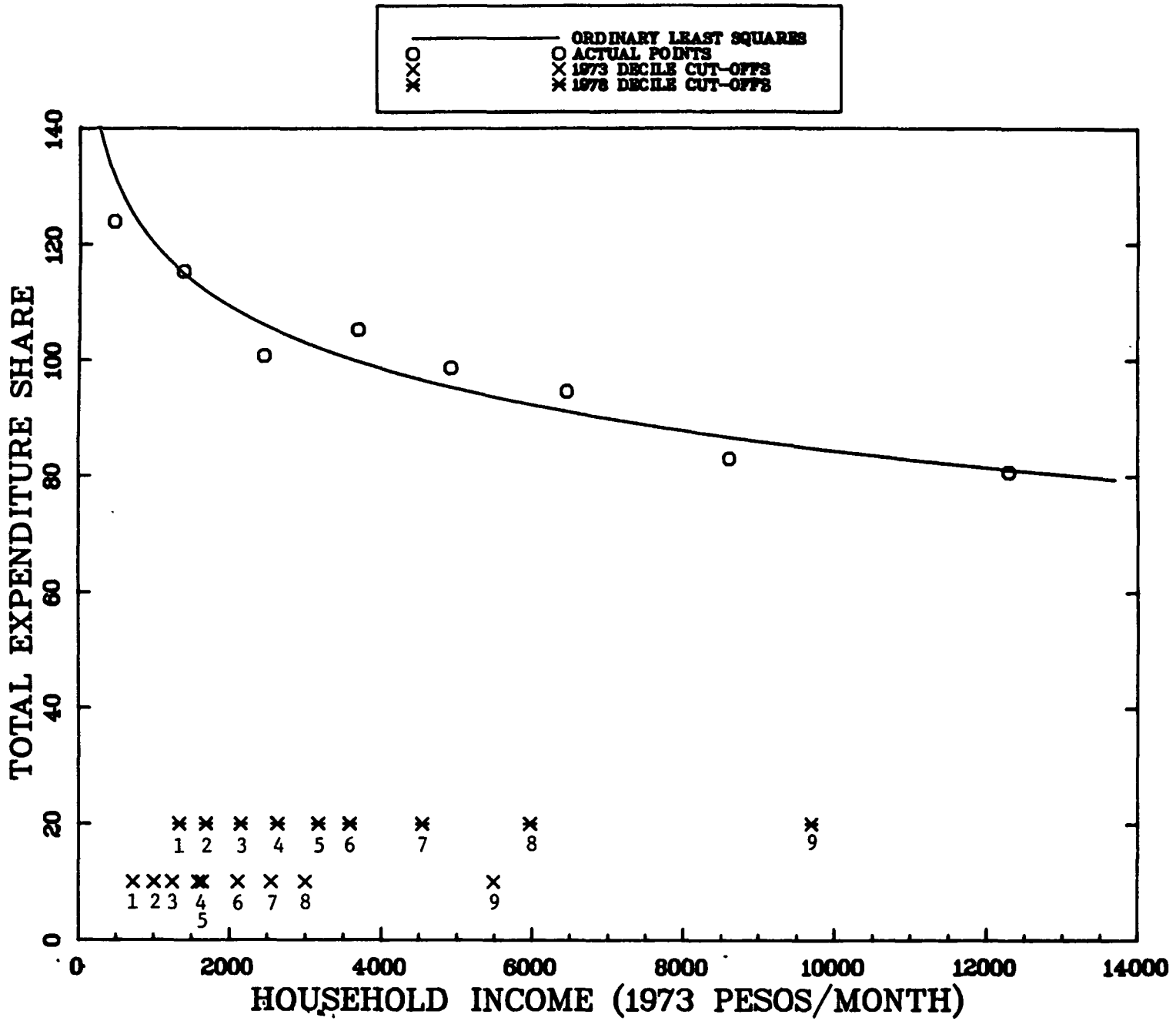


Table A.2: DECILE RANGES FOR MONTHLY HOUSEHOLD INCOME AND MONTHLY HOUSEHOLD INCOME PER CAPITA IN BOGOTA

(1973 Census and 1978 Household Survey)

Decile 1/	Monthly Household Income			Monthly Household Income Per Capita		
	1973 (1973 Pesos)	1978 (1978 Pesos)	1978 (1973 Pesos)	1973 (1973 Pesos)	1978 (1978 Pesos)	1978 (1873 Pesos)
First	0 - 732	0 - 3584	0 - 1344	0 - 124	0 - 592	0 - 222
Second	773 - 1009	3585 - 4529	1345 - 1698	125 - 179	593 - 816	223 - 306
Third	1010 - 1249	4530 - 5741	1699 - 2153	180 - 233	817 - 1057	307 - 396
Fourth	1250 - 1594	5742 - 7041	2154 - 2640	234 - 299	1058 - 1338	397 - 502
Fifth	1595 - 1649	7042 - 8471	2641 - 3177	300 - 359	1339 - 1624	503 - 609
Sixth	1650 - 2113	8472 - 9578	3178 - 3592	360 - 450	1625 - 2000	610 - 750
Seventh	2114 - 2556	9579 - 12133	3593 - 4550	451 - 598	2001 - 2625	751 - 984
Eighth	2557 - 3002	12134 - 15940	4551 - 5977	599 - 831	2626 - 3704	985 - 1389
Ninth	3003 - 5493	15941 - 25872	5978 - 9702	832 - 1498	3705 - 6340	1390 - 2378
Tenth	5494+	25873+	9703+	1499+	6341+	2379+

Notes: 1/ Ranking of decile is by household income per capita.

APPENDIX 3: CALCULATING CALORIE PRICE

Three pieces of information are required to calculate the price of consuming one calorie per day: the composition of the diet, the calorie content and price of each food item. Fortunately, this information was available to us and is reported in Table A.3. The steps leading to the estimated "monthly cost of consuming one calorie per day" are discussed below.

First, we calculate the calorie content and cost of each food item in terms of the same numeraire taking account of the importance of each foodstuff in the representative diet. By multiplying columns A and B we obtain the calorie content of each food item weighted by its share in 100 grams of the average diet. Similarly, by multiplying columns A and C we obtain the cost of each food item weighted by its relative importance in 100 grams of the average diet.

Second, adding overall food items and dividing the total cost by total calorie intake in 100 grams of average diet, an approximate measure of the cost per day of one calorie of diet a day is obtained.

Finally, to make our estimate comparable to monthly income, the daily cost of one calorie of diet per day is multiplied by the average number of days in one month (30.5) to obtain the "monthly cost of one calorie per day."

Calorie content of 100 grams of average diet (in 1973 pesos)	=	169.12 calories	(1)
Cost (in 1973 pesos) of 100 grams of average diet	+	0.6148 pesos	(2)

Monthly cost (in 1973 pesos) of one calorie per day (i.e., $\frac{(2)}{(1)} \times 30.5$) = 0.1108763 pesos/month

Table A.3: CALCULATING CALORIE PRICE

Food Item	A Share of food item in the diet by weight 1/ (%)	B Calorie content per 100 grams of food item 1/ (calories)	C Cost per 100 grams of food item in Bogota 2/ (1973 pesos)	D Calorie content of food item in 100 grams of average diet (calories)	E Cost of food item in 100 grams of average diet (1973 pesos)	F Per Capita calories per day 1/ (calories)
Potatoe	33.46	91	0.392	30.44	.1312	325
Milk	19.12	61	0.478	11.66	.0914	124
Wheat	7.50	314	0.600	23.55	.0450	251
Panela (unrefined brown sugar)	7.40	312	0.418	23.09	.0309	246
Meat	5.72	227	2.400	12.98	.1373	138
Rice	5.72	359	0.588	20.53	.0336	219
Plantain	3.00	142	0.358	4.26	.0107	45
Banana	2.62	94	0.330	2.46	.0086	26
Maize	2.44	328	0.600	8.00	.0146	85
Yuca (cassava)	2.16	146	0.372	3.15	.0080	34
Sugar	1.41	384	0.576	5.41	.0081	58
Lard	1.22	870	1.510	10.61	.0184	113
Orange	1.03	35	0.292	0.36	.0030	4
Green pea	.94	308	1.240	2.90	.0117	31
Tomatoe	.94	17	0.918	0.16	.0086	2
Arracacho	.84	100	0.560	0.84	.0047	9
Carrot	.84	36	0.236	0.30	.0020	3
Egg	.66	163	1.170	1.08	.0077	11
Onion	.66	54	0.264	0.36	.0017	4
Fish	.56	111	3.000	0.62	.0168	7
Cooking oil	.47	900	2.52	4.23	.0118	45
Cabbage	.47	24	0.238	0.11	.0011	1
Sweet pea	.37	297	0.560	1.10	.0021	12
Beans	.28	304	1.924	0.85	.0054	9
Guayaba (guava)	.19	36	0.216	0.07	.0004	1
	100.00			169.12	.6148	1803

Sources:

1/ ICBF, Encuesta Nacional de Dietas, 1972. Column F is the ICBF finding of the average calorie consumption per day for the Cundi-Boyacense region of the country. The diet for this region was assumed to be representative of Bogota on account of food availability and social custom. Comparable data for Cali was unavailable. Thus, the diet and commodity prices for Bogota were used as proxies for those of Cali.

2/ DANE, Consumer Price Index Tabulations, 1971-1974.

APPENDIX 4: THE DIET IN URBAN COLOMBIA BY INCOME GROUP - 1972

In developing countries the staples of the general population and particularly the poor are cereals and tubers. In urban Colombia the situation is not that different. Table A.4. presents the share in food expenditure of various commodities for 10 income groups in 1972. Although, the differences are not dramatic, low income households spent proportionately more on cereals and tubers than their richer counterparts. Conversely, the proportions spent on meat and dairy products increase with increasing income. Note also the high expenditure share of meat in the food budget across all income groups and the rising expenditure share with increasing income of more preferred (or more expensive) fruit.

Table A.4:

PROPORTION OF FOOD EXPENDITURE BY COMMODITY FOR 10 INCOME GROUPS - URBAN COLOMBIA, 1972

Foodstuff	MONTHLY HOUSEHOLD INCOME (1973) (0-941)	(922-1842)	(1843-3070)	(3071-4298)	(4299-5526)	(5527-7368)	(7369-9824)	(9825-14736)	(14737-24560)	(24561+)	Total
Cereals	16.1	16.3	15.8	15.1	14.4	14.3	13.4	12.0	11.7	10.4	13.9
Tubers, roots, plantain, dry legumes	13.4	16.3	14.8	14.5	13.7	12.6	12.5	10.1	8.6	7.4	12.4
Vegetables, fresh legumes, fresh seasoning	5.4	5.2	6.4	6.8	6.1	7.1	6.6	6.7	7.1	6.5	6.5
Fruit	2.2	3.2	3.4	3.7	4.5	5.3	5.2	8.1	7.5	7.1	5.1
Meat	17.3	20.3	22.6	25.3	23.2	24.0	26.3	25.2	24.5	24.0	24.0
Milk, dairy products, eggs, fat	11.4	13.3	13.9	15.0	15.3	16.5	16.7	16.7	17.7	14.8	15.4
Other foodstuffs	15.1	13.4	12.5	12.6	11.3	11.1	10.9	10.4	9.4	8.9	11.4
Food and drinks consumed out of the house or prepared out of the house to be consumed in the household	6.6	6.5	3.1	2.2	3.9	5.5	3.3	5.0	5.7	4.7	4.2
Food and drink received in kind	12.5	7.5	7.5	4.8	7.6	3.6	5.1	5.8	7.8	16.2	7.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: DANE, Ingresos y Gastos de los Hogares en Colombia, 1972.

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