FROM FOOD BASKET TO FOOD SECURITY. THE FOOD FACTOR IN NUTRITIONAL SURVEILLANCE

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SUMMARY

One important indicator of nutritional surveillance is the one devoted to monitor food security. The experience toward the development of one of such indicators is presented. This includes the development of a food basket, defined as the group of foods that meet the characteristics such as is now consumed by important population segments of the community; it contributes a substantial portion of the calories and proteins purchased, and is responsible for an important proportion of the food budget.

The concept implies a dynamic food basket, the quantities of which are calculated in a way that simulates the behavior of the consumer and the best nutrition knowledge. For this purpose we use linear program techniques. A measure of the risk of being unable to buy the foods needed for a family is presented, and is used as a proxy for food security risk. In the appendix, the mathematical expressions of the model used for a linear program is also presented.

INTRODUCTION

Nutritional well-being is a product of many interacting factors (Figure 1). We have, in other papers, discussed the role and measurement of nutritional status and health parameters (1). Another central factor in nutrition is the adequacy of nutrient intake by the individuals, particularly by those at greatest risk of health or developmental problems.

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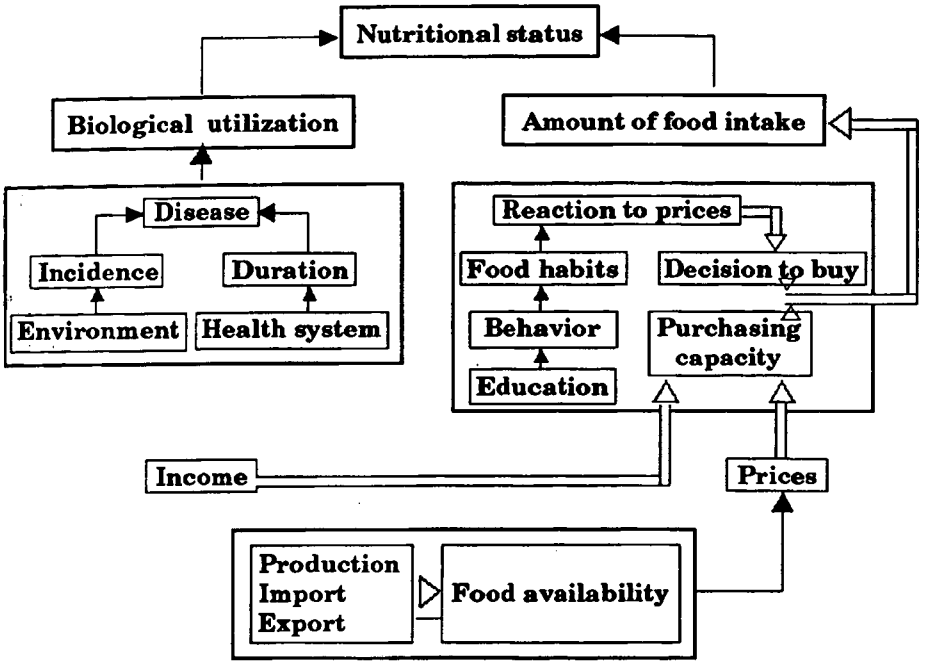

FIGURE 1

Simplified model for the nutritional system

A clearly central factor in nutritional well-being is the adequacy of food intake to provide the nutrients necessary for optimal function health, and maintenance of the body structure (2).

There are 33 vitamins and minerals known to be required by man along with the well-known proteins, fats, carbohydrates, and calories. Malnutrition can be produced by deficiencies of one or many of these, but since the most frequently limiting nutrients in most populations in developing countries are the macronutrients, our further discussions will be focused primarily on calories and protein.

The customary approach to estimating nutrient intake has been to conduct "nutrition surveys", which include either the weighing of the foods that are eaten by the individual, or obtaining a food consumption pattern based on recall. Several problems, both in theory and methodology, make these methods impractical for nutritional surveillance. The weighing methodology is clearly out of place if data are needed on a frequent and continuous basis. Similarly, the 24-hour recall involves one or more visits to the families to be surveyed, in order to obtain complete consumption data for a single day for all family members. Furthermore, daily food intake may vary significantly over time due to a variety of external factors. Therefore, both direct weighing and recall methods require repeated visits to the home to be sure that normal daily variations are taken into

account. Consequently it becomes necessary to develop a new more appropiate methodology that does not require repeated home visits, and yet provides a reasonable estimate of food consumption.

Another point to be considered is that nutritional surveillance is concerned with the monitoring of populations, rather than individuals; therefore, indicators of nutrient intake at the community level should be constructed. Communities, in turn, are composed of family units. Since it is unlikely that there will be a single malnourished individual within an otherwise healthy family, particularly in cultures where families often are defined as those who eat together rather than o a biological or legal basis, then the family unit may be used for estimations of nutrient intake. Furthermore, as may be recalled from the nutrient flow model (3), one of the main determinants of the risk that an individual will not satisfy his or her nutrient needs, is the lack of availability of enough food at the family level.

Studies were carried out in the Cauca State of Colombia, which is a largely rural area where home production for family or community consumption would be expected. They showed, however, that although this occurred, a much larger percentage of the food consumed by the families came from outside the community. As may be seen in Table 1, less than 17% of the calories available at the family level were

TABLE 1

PERCENTAGE OF CALORIES AVAILABLE AT THE FAMILY LEVEL DERIVED FROM FAMILY FOOD PRODUCTION, 1977-1980

Cauca communities		Communities in other States	
Morales	19.3	Repelón	3.9
Rosas	23.1	Campo de la Cruz	7.1
Puracé	18.9	Manatí	5.9
Piendamó	11.4	Pinillos	10.7
Padilla	12.4	Magangué	12.7
Villarica	14.0	Carmen de Bolívar	13.9
		Marmita	7.2
		Baraya	9.8
		Salado Blanco	22.8
		San Agustín	19.7
		Cáchira	18.4
		Teorama	16.7
		Quinchia	18.0
		Casablanca	14.1
		Chaparral	4.8
		Zarzal	2.2
		Buenaventura	8.8
		Bolívar	6.6
Mean	16.5	Mean	11.0

Nation-wide mean = 13.8%

grown by Cauca families themselves; the remainder were purchased in the market place. This Table also shows that other communities in Colombia have an even lower percentage of home-grown foods for family consumption. Based on these observations, it was believed to be possible to develop the concept of food purchased at the market level as a proxy for family food consumption patterns.

The early studies in Valle del Cauca, the other Colombian State where studies were carried out, showed it to differ significantly from Cauca in that it had a much larger percentage of urban people who would not be expected to be able to rely on home food production. Studies in the rural areas of the State similarly showed that food was largely purchased rather than grown at home. Nutritional well-being for these populations was not related to food production at home, in the community, nor in the whole State. Instead, it was related to size of land holdings, land ownership, and other factors often cited for other cultures but which in Valle del Cauca were indicators of family wealth. The food basket concept was originally developed using data from families and communities in Cauca; more recently it has been found to be applicable to populations in Valle del Cauca as well.

The food basket concept represents the most commonly purchased and consumed foods which, when taken together, will provide the recommeded nutrient intake for the average family. Those families unable to obtain the food basket, for whatever reason, are described as not meeting food security needs and therefore are considered to be at risk of malnutrition.

A. *Development of the Food Basket Concept*

A survey was conducted in 14 communities in Cauca to obtain information on family food purchases at the market level in both urban and rural populations. Information was obtained on the quantity and frequency of purchase of individual food items, along with the price and place of origin of each. These data were used to calculate the daily availability of the different foods to the family, which in turn were converted into calories and grams of protein. Demographic information was also obtained on each family, such as number of persons in the family, their age, sex, occupation and whether women were pregnant or lactating. This information was used to construct a family nutrient requirement profile, based on the FAO/WHO recomended allowances (3). Finally, the daily nutrient availability at the family level was compared to the family nutrient requirement profile to provide per cent adequacy for proteins and calories. These data were summarized at the community level and are presented in Table 2. Marked differences were apparent between communities, but no differences were seen in adequacy between urban and rural areas within the same community.

Development of a description of the most common food purchase pattern at community level must take into account such factors as weight and price of each food purchased, along with the number of families purchasing each item. In order to develop the average food

purchase pattern, the following calculations were prepared for each community:

1. Percentage that each food represented in terms of total weight of food purchased at the family level.
2. Percentage that each food represented in terms of total family food expenditures.
3. Percentage of the families in the community purchasing each food.
4. Percentage contribution of each food to the total family intake of proteins and calories.

For simplicity, it was assumed that there were no intrafamily biases in food distribution, nor were there any intrafamily food losses. Therefore, family protein and calorie purchases could be equated with nutrient intakes at family and individual levels. (NOTE: Detailed analysis of the intrafamily food distribution in these communities showed that in fact, there was significant bias against the mothers; we know of no way to correct for this). Table 3 illustrates the application of the above calculations to foods purchased in one community in Cauca.

TABLE 2

MEAN PROTEIN AND ENERGY ADEQUACY OF FOODS PURCHASED AND GROWN FOR FAMILY USE IN URBAN vs RURAL POPULATIONS IN THE STATE OF CAUCA

	Urban		Rural	
	Protein adequacy*	Energy adequacy*	Protein adequacy*	Energy adequacy*
A. *Poorest Community Segment:* 1977				
Puracé	95	94	93	95
Morales	74	72	74	72
Piendamó	84	81	84	81
Rosas	70	68	70	68
Padilla	95	96	92	90
B. *Total Community:* 1974-1976				
Arrobleda			103	95
Villarica	99	99	100	99
Morales	96	95	96	98
Rosas	96	93	93	92
Puracé	96	93	96	94
Piendamó	94	95	95	93
Ortigal	97	87	99	89
Balboa	99	72		

* Expressed as % FAO/WHO recommended allowances (4).

TABLE 3

FOODS PURCHASED AT THE FAMILY LEVEL FOR ONE COMMUNITY

Food	Percentage of:			Percent of total:	
	Grams	Expend.	Families	Protein	Calories
Milk	12.1	5.0	76.8	9.0	3.7
Potatoes	12.0	2.9	94.2	5.0	5.6
Plantain	11.6	7.7	97.1	3.0	8.5
Rice	9.1	5.5	98.8	15.6	16.9
Sugar	7.8	4.1	98.0		15.6
Meat	5.8	17.6	94.2	24.0	7.0
Cassava	4.4	0.9	89.9	0.7	3.3
Panela	3.5	2.3	81.2	0.3	5.7
Oranges	2.9	1.8	82.6	0.4	0.5
Corn	2.9	1.6	69.6	5.5	5.0
Guava	2.1	1.6	88.4	0.4	0.3
Mother's milk	2.0	0.15	21.7	0.5	0.7
Carrots	1.8	0.7	95.0	0.2	0.3
Eggs	1.6	5.2	92.8	4.6	1.4
Wheat flour	1.6	1.24	72.5	5.1	2.8
Bread	1.5	2.3	62.3	2.9	2.6
Beans	1.4	2.0	84.1	6.5	2.2
Avocado	1.2	1.7	15.9	0.4	0.8
Arracacha	1.2	0.5	50.0	0.2	0.6
Tomatoes	1.2	0.9	87.0	0.2	0.1
Onion	1.1	0.8	91.3	0.3	0.1
Fat	1.0	1.7	75.4		4.5
Spaghetti	0.9	1.1	78.3	2.1	1.6
Coffee	0.9	1.5	88.4	0.2	0.1
Lentils	0.9	1.4	74.0	4.6	1.4
Oil	0.7	17.6	76.8		3.46
Cabbage	0.5	0.4	58.0	0.2	
Beet root	0.5	0.3	61.0	0.1	0.1
Mango	0.4	0.5	27.5		0.1
French Beans	0.3	0.3	34.8	0.1	
Powder Milk	0.3	1.5	27.5	1.9	0.7
Veget. Mix	0.3	0.3	13.0	1.6	0.5
Ullucos	0.3	0.2	23.2	0.1	
Chocolate	0.2	1.8	31.9	0.2	0.6
Lettuce	0.2	0.2	37.7		
Auyama	0.2				
Banana	0.2	0.1	4.3		
Pineapple	0.2	0.2	10.1		
Corn flour	0.1	0.1	7.2	0.3	0.2
Salt	0.1				
Lulo	0.1	0.3	17.4		
Blackberries	0.1	0.7	44.9		
Tomate de Arb.	0.1	0.1	10.1		
Spinach	0.1	0.1	16.0		
Oats	0.1	0.1	10.0	0.2	0.1
Cucumber	0.1				
Fish		0.4	5.8	0.3	
Butter		0.1	5.8		0.1
Chicken		0.1	1.4	0.1	

TABLE 4

COMPARISONS OF FOODS FOR FOOD BASKET USING ALTERNATIVE APPROACHES
(Based on weekly availability data from one community survey)

Food item	% of weight	Food item	% of families	Food item	% of expend.	Food item	% of protein	Food item	% of calories
Milk	12.1	Sugar	98.6	Oil	17.6	Meat	24.0	Rice	16.9
Potatoes	12.0	Plantain	97.1	Meat	16.6	Rice	15.6	Sugar	15.6
Plantain	11.6	Carrots	95.7	Plantain	7.7	Milk	9.0	Plantain	8.5
Rice	9.1	Meat	94.2	Rice	5.5	Beans	6.5	Meat	7.0
Sugar	7.8	Potatoes	94.2	Eggs	5.1	Corn	5.5	Panela	5.7
Meat	5.8	Rice	92.8	Milk	5.0	Wheat flour	5.1	Potatoes	5.6
Cassava	4.4	Eggs	92.8	Sugar	4.1	Potatoes	5.0	Corn	5.0
Panela	3.5	Onion	91.3	Potatoes	2.9	Eggs	4.6	Fat	4.5
Oranges	2.9	Cassava	89.9	Panela	2.3	Lentils	4.6	Milk	3.7
Corn	2.9	Guava	88.4	Bread	2.2	Plantain	3.0	Oil	3.4
Guava	2.1	Coffee	88.4	Beans	2.0	Bread	2.9	Cassava	3.3
Mother's milk	2.0	Tomatoes	87.9	Oranges	1.8	Spaghetti	2.1	Wheat flour	2.8
Carrots	1.8	Beans	84.1	Chocolate	1.8	Powder milk	1.9	Bread	2.6
Eggs	1.6	Oranges	82.1	Avocado	1.7	Veget. mix	1.6	Beans	2.2
Wheat flour	1.6	Panela	81.2	Fat	1.7	Cassava	0.7	Spaghetti	1.6
Bread	1.5	Spaghetti	78.3	Corn	1.6	Soy beans	0.5	Lentils	1.4
Beans	1.4	Milk	76.8	Guava	1.6	Mother's milk	0.5	Eggs	1.4
Avocado	1.27	Oil	76.8	Coffee	1.5	Oranges	0.4	Avocado	0.8
Arracacha	1.2	Fat	75.4	Powder milk	1.5	Avocado	0.4	Mother's milk	0.7
Tomatoes	1.2	Lentils	73.9	Lentils	1.4	Guava	0.4	Powder milk	0.7
Onions	1.0	Wheat flour	72.5	Wheat flour	1.2	Panela	0.3	Chocolate	0.6
Fat	0.9	Corn	69.6	Spaghetti	1.1	Fish	0.3	Arracacha	0.6
Spaghetti	0.9	Bread	62.3	Cassava	0.9	Corn flour	0.3	Veget. mix	0.5
Coffee	0.9	Beet root	69.0	Tomatoes	0.9	Onion	0.2	Oranges	0.5
Lentils	0.8	Cabbage	58.0	Onion	0.8	Cabbage	0.2	Guava	0.3
Oil	1.7	Arracacha	50.7	Carrots	0.7	Carrots	0.2	Carrots	0.3
Cabbage	0.5	Blackberries	44.9	Blackberries	0.7	Arracacha	0.2	Corn flour	0.2
Beet root	0.5	Lettuce	37.7	Mango	0.5	Oats	0.2	Casabe	0.2
Mango	0.4	French beans	34.8	Arracacha	0.5	Tomato	0.2	Oats	0.1
French beans	0.3	Chocolate	31.9	Cabbage	0.4	Chocolate	0.2	Butter	0.10
Veget. mix	0.3	Powder milk	27.5	Fish	0.4	Coffee	0.1	Onion	0.1
Ullucos	0.3	Mango	24.5	Veget. mix	0.3	French beans	0.1	Coffee	0.1
Chocolate	0.2	Ullucos	23.3	French beans	0.3	Beet root	0.1	Soy beans	0.1
Lettuce	0.2	Mother's milk	21.7	Beet root	0.3	Chicken	0.1	Mango	0.1
Auyama	0.2	Lulo	17.4	Lulo	0.3	Ullucos	0.1	Beet root	0.1
Banana	0.2	Spinach	15.9	Lettuce	0.2			Tomato	0.1
Pineapple	0.2	Veget. mix	13.0	Pineapple	0.2				
Corn flour	0.1	Pineapple	10.1	Ullucos	0.2				
Salt	0.1	Oats	10.1	Oats	0.1				
Lulo	0.1	Tomate de Arb.	10.1	Mother's milk	0.1				
Casabe	0.1	Corn flour	7.2	Corn flour	0.1				
Blackberries	0.1	Fish	5.8	Tomate de Arb.	0.1				
Tomate de Arb.	0.1	Butter	5.5	Butter	0.1				
Spinach	0.1	Banana	4.3	Spinach	0.1				
Oats	0.1	Chicken	1.4	Chicken	0.1				
Cucumber	0.1			Banana	0.1				

Total Wt. = 492,920 No. Families = 69 Tot. Exp. Col. $ = 11,384 Tot. Prot. = 22,443 g Tot. Cal. = 954,467

Examination of the food purchase patterns in each community showed that there was no difference in purchase patterns between the urban and rural parts of each, thereby permitting the construction of a "typical" food basket for each community. These surveys also showed that market purchases of foods were quite similar for most of the communities in Cauca. Consequently, a single food basket was constructed using food purchase patterns for Cauca as a whole.

Although the most direct approach for selecting the foods to be included in a family food basket would be to use all 50 foods on the list in Table 3. This was not considered to be practical in an on-going project such as nutritional surveillance. It was preferably to identify the most important foods purchased, and to restrict the food basket estimations to these. Each of the above four approaches have been explored for this purpose.

Rankings of foods purchased in one community using the different methods outlined above, are compared in Table 4. When we limited the food basket to 15 food items, it was clear that each approach would yield a very different group of foods, none of which were nutritionally acceptable. Furthermore, none of the combinations represented purchase patterns that were representative of family food preferences. For example, using the ranking based on family food expenditures (one of the most common approaches), nearly all fruits and vegetables, all condiments, and coffee and milk were excluded from the basket. Even expanding this list to 20 items did not make a significant nutritional difference. Using the ranking by weight purchased, all of the oil and legumes and most condiments were excluded; again, expansion to 20 items did not make a major difference. Look now at the ranking based on calories. The first 15 items came close to nutritional adequacy; expansion to 20 items included additional fats, milk and eggs. This combination came closer to both adequacy and food preferences. Nevertheless, we concluded that the most common market and econometric models did not fully meet the needs of nutritional surveillance.

Based on the above considerations, we have developed a modified approach which, we believe, encompasses some of the advantages of each ranking system, while at the same time coming closer to real family preferences and purchase patterns. For this purpose we have adopted six criteria for including foods in the food basket:

1. The food item must be purchased by at least 30% of the families.
2. The food item provides at least 1% of the total protein purchased.
3. The food item represents at least 1% of the total calories purchased.
4. The expenditure on the food is at least 1% of total family food purchased.
5. The food item constitutes more than 0.5% of the total quantity of food purchased.
6. Finally, 5-10% of total food expenditures should be set aside for the inclusion of foods providing taste or other important characteristics, e.g. salt, onions, vegetables, coffee, etc. These foods

TABLE 5

DEVELOPMENT OF CAUCA FOOD BASKET FROM MARKET PURCHASE DATA

Foods	> 1% of energy	> 1% of protein	> 1% of money	> 0.5% of weight	> 30% of families	Food basket
Meat	*	*	*	*	*	*
Rice	*	*	*	*	*	*
Milk	*	*	*	*	*	*
Red beans	*	*	*	*	*	*
Potato	*	*	*	*	*	*
Corn	*	*	*	*	*	*
Bread	*	*	*	*	*	*
Spaghetti	*	*	*	*	*	*
Eggs	*	*	*	*	*	*
Wheat flour	*	*	*	*	*	*
Lentils	*	*	*	*	*	*
Powder milk		*	*		*	
Plantain	*	*	*	*	*	*
Panela	*		*	*	*	*E
Cheese						
Dry peas	*	*	*	*	*	*
Cassava	*		*	*	*	*E
Corn flour						
Cabbage				*	*	*M
Onion			*	*	*	*M
Tomato			*	*	*	*M
Coffee			*	*	*	*M
Carrots			*	*	*	*M
Chocolate			*			
Banana				*		
Oranges				*	*	*M
Acelga						
Bone			*			
Salt			*	*	*	*M
Mango						
Butter						
Apples						
Guava						
Avocado						
Oil	*		*	*	*	*E
Fat	*		*	*	*	*E
Sugar	*		*	*	*	*E

must be used by at least 20% of the families and must not contribute more than 1% of the major nutrients.

Table 5 indicates which foods would be included in the basket under each of the six criteria. The last column indicates those foods selected for the food basket, including those which satisfied all five basic criteria. A few foods were included which only satisfied four criteria but represented good sources of calories; these are indicated by (E). Seven foods (indicated by M) were included to meet criterion 6; the price elasticity for these items is high so that combinations purchased will vary markedly from season to season without greatly affecting nutritional well-being or the purchase of the other, more basic food items.

Having identified the foods to be included, it was necessary to establish the relative quantity of each food to use. The first, most direct, approach would be to determine the mean percentage that each food represented of the total food purchased. While not incorrect, this very simple approach resulted in a fixed market basket that did not allow for individual variation in food selection in response to prices or seasonal variation in food availability. Alternatively, using the survey data it was possible to determine the relative range of purchase of each food throughout the year. Within these ranges, individual families would seek to maximize their purchases according to variations in food prices. Well-established mathematical techniques exist to simulate this behavior (e.g. linear programming, which is widely used in agriculture to minimize the cost of animal feeding but which we have adapted to maximize nutrient intake at a given family food budget). The output from linear programming analysis will be a list of the same foods, but the quantities will vary according to changes in market prices. (See Appendix).

Another advantage of using the linear programming model is that it allows one also to impose certain empirically based limits on the composition of the basket derived from experience gained in the surveys. In the case of Cauca, these restrictions included such concepts as the amount of corn purchased may not exceed the amount of rice, or the amount of protein coming from eggs (which are very inexpensive, but are not eaten in large quantities) may not exceed that from meat. Furthermore, no single food may provide more than 20% nor less than 1% of the calories.

Surveys have shown that the limiting nutrient in the Cauca population were calories. Therefore, the food basket content was adjusted to meet the recommended calorie needs for the average family, calculated on the basis of available demographic information and the FAO/WHO recommeded dietary allowances. Our survey data indicated that the composition of the average family in Cauca included two pre-school children less than six years of age, two school-age children (e.g. 7-14 years), two parents, and one other adult. About 22% of the families included a lactating mother, with lactation continuing for a median of 7.5 months. These data and the occupation were used for calculating family nutrient requirements.

An example of the composition of the Cauca food basket based on

the above limitations and assumptions is presented in Table 6, along with its contributions to protein and calorie intake. It should be clearly recognized here that this combination of foods was not meant to be a dietary guideline in any sense of the word; rather, it has been employed solely for monitoring risk due to fluctuating market conditions.

TABLE 6

COMPOSITION OF THE FOOD BASKET FOR THE STATE OF CAUCA, INCLUDING ENERGY AND PROTEIN CONTRIBUTIONS

Food	Weight (g)	Energy (Cal)	Protein (g)
Oil	168	1,481	0
Dry peas	480	1,481	110
Rice	7,677	25,175	598
Sugar	3,906	15,000	0
Meat	1,004	2,330	192
Beans	490	1,481	111
Wheat flour	460	1,481	62
Eggs	1,007	1,481	127
Milk	10,618	6,371	379
Lentils	470	1,481	116
Corn	6,007	24,182	544
Fat	2,593	22,561	0
Bread	439	1,481	40
Panela	475	1,481	2
Potatoes	2,028	1,481	41
Spaghetti	423	1,481	46
Plantain	2,056	1,481	29
Cassava	7,841	9,175	64
Miscellaneous	126	194	8
Total	48,268	121,279	2,469

Family protein requirements per week: 2,472 g.
Family energy requirements per week: 121,360.

The food basket must not be viewed as permanently fixed for all times. Family food purchases may be expected to change with introduction of new foods or changes in available income. Therefore we found it essential to do periodic surveys to reconfirm both the content of the food basket and the limits to be expected on the purchase of each item. These surveys were less expensive than earlier research studies since the questions to be asked were more

focused and they could be carried out as part of other ongoing household surveys.

In our surveillance system we have expanded the concept of community to the regional level (i.e. Cauca). This has been done on the basis of demonstrated similarity of food purchase patterns among the communities studied. Further expansion to nearby states or to a national level cannot be done in the absence of market purchase information justifying a more widely applicable food basket. In larger cities, such as Cali or Bogotá, one might anticipate differences in food purchasing patterns based on socioeconomic level. Data developed by us clearly show that there was a surprising similarity of basic foods purchased across the six different socioeconomic strata we have studied in Cali (5). Nevertheless, purchases of certain food items such as meat, bread, and milk, were markedly different in different strata, being progressively more frequently purchased as economic strata improved; the use of cassava was restricted almost entirely to the lower strata. Other major ecologic areas within the country may be expected to differ as well.

B. *Development of Food Security Indicators*

The concept of food security rests on the ability for a family to purchase or produce the food basket to meet its nutrient needs. This is a somewhat more limited use of the term than is frequently encountered in the international literature, where food security applies to national food supplies and to international reserves and trends (6).

Our surveys showed that Cauca and Valle del Cauca were essentially market economies and, therefore, our analysis could be based on market conditions. The major factor affecting ability to obtain a food basket is income, assuming that market supplies are adequate. Adequate food has been and is available in Colombia; most major food items are available in all markets within Cauca and Valle del Cauca. If a family's income is inadequate to purchase the food basket, their food security is at risk. Therefore, our indicator of risk must combine both income and food basket components.

Our surveys also have shown that, in those population segments with the lowest income and considered to be at risk for food security, 80% of the family income was spent on food; the other 20% necessarily were spent on other essentials. As may be seen in Table 2, the foods available (both purchased and home grown) to the poorest families in these communities was inadequate to meet calorie and protein needs, e.g. for Piendamó the mean adequacy was 81-84%, or for Rosas it was 68-70%.

Based on these figures we have assumed that a community will be at risk for food security if the families are unable to buy the food basket at current market prices with 80% of their income. Ideally, we should have data on individual family incomes in order to provide a basis for setting cut-off points for risk as part of nutritional surveillance. Such data were not available in detail for Cauca, although

some data have been obtained. As an alternative, it seemed appropriate to assume that the legal minimum salary for Colombia represented a "social estimate of the minimum needed for necessities". This, then, was used as the monetary value against which the market cost of the food basket was compared. If the food basket cost more thant 80% of this figure, then the families in the community were considered to be at risk for food security.

The above approach provided a "yes-no" indication of risk. It would be more informative if the indicator reflected the degree of risk. The food basket represents an adequate caloric intake for the family. Therefore, the percentage of these calories that can be purchased with 80% of the minimum salary was adopted as our measure of risk, taking into account current market prices and the constraints previously discussed.

Trends in monitoring food security depend on availability of market food prices. In Colombia these are assessed regularly by the National bureau of statistics, from where fairly disaggregated data may be obtained. Similarly, agricultural extension agents frequently are concerned with local market food prices and are able to provide data at the community level. We have usted both sources.

C. *Application of the Indicators of Food Security Risk*

The food security indicator has been used with actual market prices from individual communities in Cauca (Table 7). It may be readily seen that 80% of the official minimum salary would not buy sufficient calories for an average family in 1983. By comparing data for given communities in this Table with those for the poorest population segments in Table 2, it may be seen that the risk indicator in 1983 was similar to the caloric adequacy figure in 1977, recognizing that there was some increase in the purchasing power of the minimum salary during that period. This suggested that the indicator was more applicable to those populations at greatest food security risk. Further examination of the data in Table 7 revealed that the food security risk was more or less stable, when January to January data were compared. On the other hand, there was a decrease in the adequacy (i.e. increased risk) between January and August reflecting the continuing impact of inflation on market prices and purchasing power during the year. In making these comparisons it was important to keep in mind that the official minimum salary is adjusted annually at the beginning of the year.

One more point also can be derived from the data in Table 7. The adequacy of the food basket (e.g. risk) may also be calculated for the entire State of Cauca using the mean prices for the State for each food item in the basket; this has been done. The resultant risk was very similar to that obtained with the individual community market data, and the trends over the 1983-84 period also were similar. The comparability of these indicators probably reflects the homogeneity of the Cauca population and the well established State-wide food marketing system. One must caution against the temptation to reduce data

TABLE 7

FOOD SECURITY INDICATOR FOR SELECTED COMMUNITIES IN CAUCA (Indicator = per cent of caloric adequacy that could be purchased by 80% of minimum salary)

Community	Jan-March '83	Jan-March '84	July-Sept '84
Miranda	82.7		
Padilla	81.0		
Puracé	83.2		
Bolívar	82.1	69.1	72.2
Timbío	81.0		
Morales	80.6		
Cajibío	83.1		
Rosas	82.1		
El Tambo	81.1	95.7	64.4
Silvia	82.5	84.3	68.8
Sotará	82.1		
Mercaderes	80.6	88.2	78.2
Inzá	83.1	91.2	81.1
Buenos Aires	81.1	73.5	
Popayán		80.3	71.9
La Sierra		88.4	75.6
La Vega		72.8	71.4
Santander		63.8	65.1
Caldono		92.8	78.1
Caloto		68.7	67.5
Toribio		80.0	72.9
Argelia		89.6	63.1
Patía		71.0	73.5
Paez		91.2	85.6
Timbiquí		76.8	69.2

acquisition to the State level, however, in that our data have been obtained for too short a period of time, and also because nutritional surveillance is designed to identify the hidden departures of communities that are not apparent in aggregated data.

As with the health and anthropometric indicators used in nutritional surveillance, time series analysis will provide the most valuable information in terms of changes over time. To do this we calculated risk indicators for both Cauca and Valle del Cauca between 1973 and 1983 using the food basket for each State, plus the average market food prices for each State. These data are plotted in Figures 2 and 3, where the mean monthly caloric adequacy is entered as a single point for each year. The plot for each State shows a marked reduction in food security risk over this decade. Further interpretation suggests that the low point seen for 1977 for Valle del Cauca

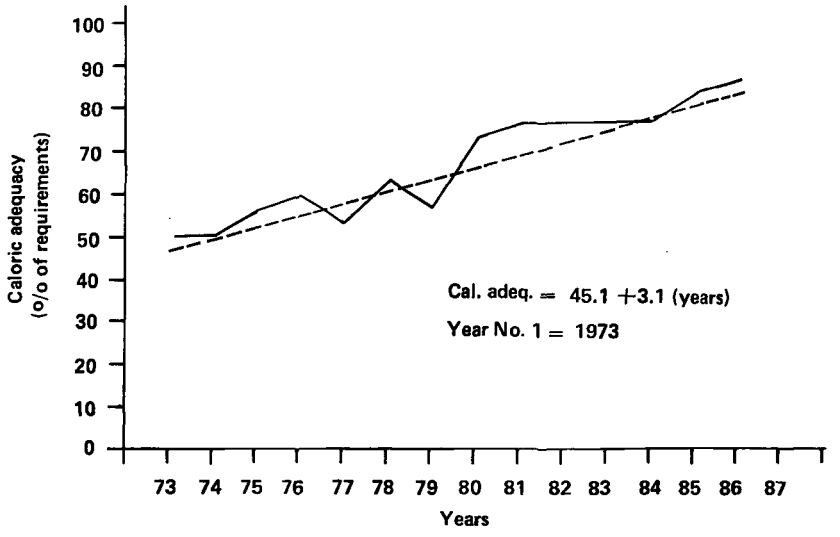

FIGURE 2

Maximum caloric adequacy (as % of requirements) obtained with 80% of the minimum wages in the State of Valle del Cauca 1973-1983

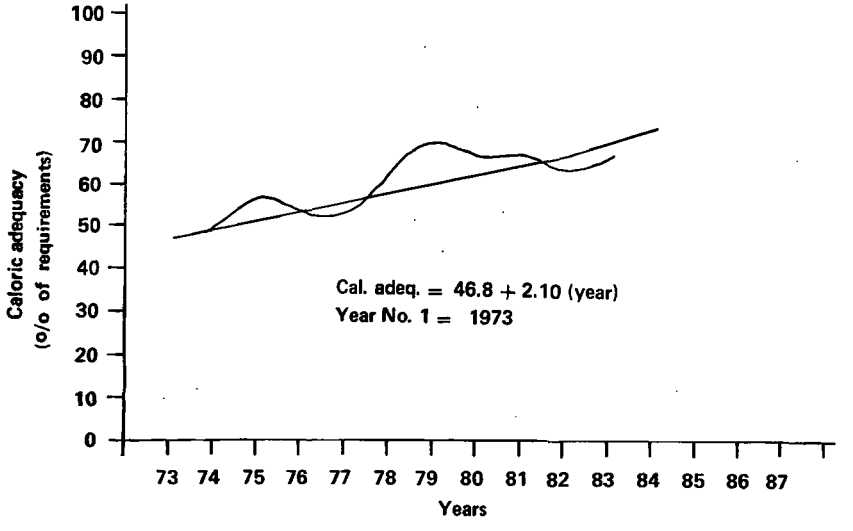

FIGURE 3

Maximum caloric adequacy (as % of requirements) obtained 80% of the minimum wage in the State of Cauca 1973-1986

reflected the increase in market prices that occurred during that year. Since 1981 there has been a steady decline or plateau in food basket adequacy (increase in food security risk) for Valle del Cauca, reflecting economic stagnation and a general decline in purchasing power. A similar plateau has been apparent in the State of Cauca since 1982.

Also of interest is the fact that the regression line for Cauca is higher than for Valle. Although this suggests that risk may be less in Cauca than in Valle del Cauca, it is important to keep in mind that the concept of the food basket assumes that a family has only one wage earner. This may be true in many parts of Cauca but probably is less true for many families in Valle del Cauca where employment opportunities are greater. Nevertheless, the poorest families in Valle del Cauca are poorly prepared to take advantage of the increased job opportunities and incomes, and thus are more likely to live on the minimum salary. Furthermore, they may be presumed to be at even greater risk than those in Cauca due to the generally higher cost of living (i.e. higher food prices) in Valle del Cauca.

D. *The Indicators of Food Security Risk*

For determining risk for food security, measures have been obtained for food prices at the community market level, current minimal wage as an estimate of minimum necessities, and demographic characteritics of the families in the communities under surveillance. The latter have in turn been employed to estimate caloric requirements at the family level. Using linear programming techniques, this information has been used to calculate the maximum amount of calories that can be purchased in each community with 80% of the minimum salary, and to compare this to family and community caloric needs. From this it was possible to:

1. Identify communities unable to meet 80% of family calorie needs.
2. List communities according to amount of calories that may be purchased with 80% of the minimum salary.
3. Identify communities with decreasing caloric adequacy (i.e. increasing food security risk).

RESUMEN

DE LA CANASTA DE ALIMENTOS A LA SEGURIDAD ALIMENTARIA. EL FACTOR ALIMENTO EN LA VIGILANCIA NUTRICIONAL

Un indicador de importancia en la vigilancia nutricional es el dedicado al seguimiento de la seguridad alimentaria. Se expone la experiencia conducente hacia el desarrollo de uno de tales indicadores. Este incluye el desarrollo de una canasta de alimentos definida como el grupo de alimentos que satisface las características, tal como ésta es consumida realmente por segmentos poblacionales importantes de la comunidad; aporta una porción

substancial de las calorías y proteínas compradas, y es responsable de una proporción importante del presupuesto alimentario.

El concepto implica una canasta de alimentos dinámica, cuyas cantidades se calculan en tal forma que simulan el comportamiento del consumidor y el mejor conocimiento nutricional. Para este propósito utilizamos técnicas de programación lineal. Se presenta una medida de riesgo del no poder comprar los alimentos que necesita una familia, y se usa mandatoriamente para determinar el riesgo de la seguridad alimentaria. Asimismo, en el Apéndice se dan a conocer las expresiones matemáticas del modelo de un programa lineal.

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APPENDIX

CALCULATIONS FOR THE FOOD SECURITY INDICATOR

This Appendix presents the optimization model used to calculate the security indicator.

As explained in the text, this indicator has been developed to monitor the amount of nutrients that an average family of the region could buy with money available for food purchases, given the market prices of foods, family food habits and preferences, especially in those families considered at risk.

The underlying hypothesis may be stated as follows: "a family will seek maximize the amount of food (i.e. nutrients) purchased for the available money, taking advantage of the variations of food prices, and within limits of their food preferences and eating habits."

As explained in the text, we have found that families at the lowest income level generally will not spend more than 80% of their income for food and still meet other expenses. Operationally we have adopted the official minimum salary as the reference point. Therefore, the food security indicator could be defined as the *maximum* amount of calories, that 80% of the minimum salary can buy at market prices at a given point in time.

The *optimization model* used for this calculation is a linear program model, using the Simplex. The model simulates the family food behavior such that, within certain limits as stated in the hypothesis, the person buying food will try to maximize the amount of calories for the money available.

The optimization model quantifies the amounts of food, from a given list called the food basket, that will yield the maximum amounts of calories. This can be mathematically expressed as finding:

$$\text{Max.} \sum_{i=1}^{n} q_i n_i \qquad (1)$$

where n_i is the quantity of each food, *i*, expressed in grams, and q_i is the calorie content per gram.

For the above model there is a set of limits or restrictions that must be satisfied simultaneously with finding the quantities of food

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Symbols Used

qi = Caloric content of food *i* in kcal per g.

ni = Quantity of food *i* in grams.

ci = Cost of food *i* in Colombian pesos per gram.

Pi = Protein content of food *i* in grams per gram.

that will yield the maximum calories. The first of these restrictions is that the total cost of the quantities of foods selected cannot exceed 80% of the minimum salary. This can be expressed as:

$$\sum_{i=1}^{n} c_i n_i \; <= 0.80 \text{ X Min. Salary} \qquad (2)$$

where c_i is the cost per gram of each food.

This restriction differs from the more frequently encountered optimization programs used in animal feeding which seek to minimize cost to meet fixed nutrient needs. Our model seeks to maximize the nutrient content given a fixed amount of money.

Two other limits or restrictions are imposed on the model. In our nutrition surveys no food item was found to contribute more than 25% of the calories purchased; therefore, no one food item should contribute more than 25% of the calories. Conversely, practical considerations restrict the number of foods that may be considered in the food basket, leading to the second limit that no food may provide less than 1% of the calories.

These restrictions can be expressed in the following way:

$$\sum_{i=1}^{n} q_i n_i \; >= \; 0.01 \sum_{i=1}^{n} q_i n_i \qquad (3)$$

and

$$\sum_{i=1}^{n} q_i n_i \; <= \; 0.25 \sum_{i=1}^{n} q_i n_i \qquad (4)$$

Still another restriction recognizes that the combination of foods must also fulfill nutritional criteria for a balanced diet. Thus the total foods selected not only must meet caloric adequacy for the family but also must provide adequate protein. From a practical point of view based on survey data, caloric adequacy of the food basket may not vary more than 10% from protein adequacy. This can be mathematically expressed as:

$$\left[\left(\sum_{i=1}^{n} q_i n_i\right) / \text{Cal. req.}\right] - \left[\left(\sum_{i=1}^{n} P_i n_i\right) / \text{Prot. req.}\right] <= 0.1 \qquad (5)$$

The next set of restrictions are based on well-known nutritional practices which, even though they are not in fact practiced by the population under surveillance, they are considered to be important for nutritional well being.

For example, the calories coming from sucrose are limited to 20% of the total calories coming from carbohydrates. This is expressed mathematically as follows:

$$\sum_{s=1}^{n} qsns \quad <= \quad 0.20 \ X \sum_{j=1}^{j} q_j n_j \qquad (6)$$

where *s* represents food sources of sucrose and *j* represents food sources of total metabolizable carbohydrates. Thus this restriction states that the sum of the calories coming from sucrose (foods *s*) should be less than 20% of the sum of the calories coming from the carbohydrates in all the foods in the food basket (foods *j*).

The next restriction is imposed on the amount of calories that may be contributed by added oils and fats. This is set at 20% of total calorie supply, and may be expressed as:

$$\sum_{k=1} q_k n_k \quad <= \quad 0.20 \sum_{i=1} q_i n_i \qquad (7)$$

where *k* corresponds to foods such as oils, lard, margarine, and shortening.

Another restriction of the nutritional type has to do with the amount of proteins that must come from animal sources. This restriction is necessary in order to assure a protein mixture of adequate biological value. Under this restriction, 20% of the proteins must come from animal sources. It can be expressed as follows:

$$\sum_{j=1}^{n} P_j n_j \quad >= \quad 0.20 \sum_{i=1}^{n} P_i n_i \qquad (8)$$

where *j* refers to foods of animal origin.

The last set of restrictions apply to observed food behavior. For instance, in our communities the amount of rice consumed consistently was found to be greater than that of corn. Therefore, though there is no clear nutritional reason to eat the more expensive rice when corn is cheaper, a limitation is imposed on the amount of corn. Similar behaviors were observed in the case of eggs and meats. The

following mathematical expressions are used:

$$^{n}\text{rice} - {}^{n}\text{corn} > 0 \qquad (9)$$

$$^{n}\text{meat} > {}^{n}\text{eggs} \qquad (10)$$

where n is expressed in grams.

Finally, as noted in the text, an amount equivalent to 10% of the money must be spent on such foods as species, salt, fruits, and some vegetables (tomatoes, lettuce, etc.) These have been designated as "miscellaneous":

$$^{c}\text{misc}\,{}^{n}\text{misc} < 0.1 \sum_{i=1}^{n} c_i n_i \qquad (11)$$