Vitamin A Status of Children in Five Ecuadorian Provinces[1]

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In mid-1993 Ecuador's Health Research Institute conducted a survey to evaluate the general nutrition and vitamin A status of children in five provinces (three in the mountains and two on the coast) containing pockets of extreme poverty. The survey enrolled 1 555 children 12–59 months old who constituted a multiphased stratified cluster sample obtained by random selection methods. Among its other aims, the survey sought to assess all or part of the study subjects' serum retinol levels, dietary vitamin A intake, and ocular signs of vitamin A deficiency, and to weigh the influence on vitamin A status of age, sex, parental (maternal) education, residence in a rural or urban area, and the ethnic background of the residence area. Questionnaire interviews were conducted to gather information about each survey child's identity, diet, pathologic history, and breast-feeding history; a blood sample was obtained; and the child was weighed, measured, and given a complete physical examination (including an eye examination).

Of the 1 232 survey children whose serum retinol levels were measured, 18% and 2% were found to have levels below 0.7 and 0.35 µmol/L, respectively. Low serum retinol levels were more common among children of mothers who had relatively little education and resided in rural areas. The presence of Bitot's spots was confirmed in two of the study children.

Interviews conducted with 39% of the study children's families to assess the children's diets showed the risk of insufficient vitamin A intake to be greater in the mountain provinces and among Indian populations, children born to mothers with no formal education, children living in rural areas, and underweight and stunted children.

Forty-eight percent of the study population had serum retinol levels between 0.70 and 1.05 µmol/L, indicating marginal vitamin A deficiency. It would therefore appear that dietary supplementation would cause a substantial part of the Ecuadorian population to improve its vitamin A status. Overall, the results of the survey were consistent with a previous national survey and confirmed the existence of a pronounced subclinical vitamin A deficiency that clearly constitutes a public health problem, especially in Ecuador's rural Andean areas.

Ecuador's 1985 National Nutrition and Health Survey found the percentage of preschool children with serum retinol levels below 20 µg/dL to be 13.9% (16.4% in rural areas and 11.9% in urban areas) (*1*), reflecting higher vitamin A consumption rates in urban areas. A larger percentage of boys (17.1%) than of girls (10.7%) had serum retinol levels below 20 µg/dL. Based on WHO criteria in effect at the time, it was felt that the overall picture did not constitute a national public health problem.

However, further analysis of the survey data indicated that 48% of the children had serum retinol levels below 30 µg/dL, suggesting widespread "marginal" deficiency.[3] This analysis concluded that pockets of deficiency probably existed in the poorer areas of the country. In addition, at least 11 cases of xerophthalmia were said to have

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been detected in recent years at pediatric health services in Guayaquil and Quito.

Partly to establish the prevalence of vitamin A deficiency in poor population groups, the Ecuadorian Ministry of Public Health's Health Research Institute (*Instituto de Investigaciones de Salud*—IIDES) conducted a prevalence survey in five provinces (three in the mountains and two along the coast) containing pockets of extreme poverty. This article presents the results of that survey, which was carried out to evaluate both the general nutrition and vitamin A status of children 12 through 59 months old. In 1990, the Ministry of Public Health classified all cantons (provincial subdivisions) by level of poverty according to standard criteria (2); the survey provinces contained the five most impoverished cantons in that classification.

MATERIALS AND METHODS

The survey employed a stratified multistage cluster sample obtained by randomly selecting parishes (canton subdivisions) from among all the cantons in the five study provinces, the selection probability being made proportionate to each parish's population size (PPS sampling). Beginning at a randomly chosen starting point, visits were made to households within each selected parish. Within each family having at least one child 12–59 months old, a child was randomly selected from all the family's children in this age range. A blood sample from the child was obtained, together with appropriate information about the child and family (see below), and in one out of every three cases the family's diet was evaluated. It was estimated beforehand that a sample including 1 500 children would be appropriate, given a sample design effect factor of 1.5 and a low serum retinol prevalence of 15%.

The indicators selected to assess vitamin A deficiency were the child's serum retinol level, dietary vitamin A intake, and ocular signs. Other indicators of health and nutrition status that were studied included each child's height, weight, presence or absence of fever, diarrheal or respiratory disease symptoms during the 15 days preceding the interview, and breast-feeding status of children 12–23 months old.

Regarding socioeconomic factors, maternal education was categorized as none, incomplete primary, complete primary, incomplete secondary, complete secondary, or post-secondary. The residence area of each survey cluster was classified as rural or urban according to how that area was defined by the National Statistics and Census Institute. Using the classification of the National Planning Council, the ethnicity of individual parishes was defined by the predominant ethnic group (*mestizo*, Indian, or black) within that parish (3).

Regarding blood samples, these were taken with 10 mL syringes and immediately placed in vacutainers. The samples were then kept on ice in the dark for a maximum of six hours until it was possible to separate and freeze the sera. After that the frozen sera were transported on dry ice to the Research Institute of the Faculty of Chemistry at the Central University of Ecuador in Quito for analysis. Serum retinol levels were measured by high-pressure liquid chromatography according to the method of Bieri *et al.*, using retinol acetate as an internal standard to control for retinol recovery (4).

Regarding diet, the subjects' risk of insufficient vitamin A intake was estimated in a systematic 33% subsample using a computerized version of the Simplified Dietary Assessment (SDA) Methodology (5), as proposed by the International Vitamin A Consultative Group (6). The SDA was adapted to the Ecuadorian context by identifying foods containing vitamin A that were available in both the coastal and mountain provinces, and by estimating the sizes of the portions customarily fed to children in those regions. These tasks were performed by professional nutritionists during visits to markets and homes prior to the survey.

Thereafter, the surveyors estimated the amounts of foods containing vitamin A that were given to the children during the 24 hours preceding the visit, as well as the frequency with which they were given such foods during the seven days preceding the survey. On this basis, each child's vitamin A consumption on the survey day ("index of consumption") and during the week preceding the survey ("usual pattern of food consumption") were estimated.

Ocular signs of vitamin A deficiency were evaluated by physicians trained by an ophthalmologist. The WHO xerophthalmia scale was used to classify the signs in accordance with their degree of severity: X1—conjunctival xerosis, Bitot's spots; X2—corneal xerosis; X3—corneal ulceration, keratomalacia; and XS—corneal scarring (*7*). Suspected xerophthalmia cases were referred to an expert ophthalmologist for verification.

The field work began in June 1993 and ended in August. Advance teams visited the survey sites one to three days before the interviewers. They advised community leaders about the survey's purpose and benefits for participants. They also updated census maps and identified dwellings in a clockwise order, starting from a predetermined landmark and listing those with children 12–59 months old. These homes were visited, and children were recruited to visit an examination/interview center at an appointed time.

At the center, physician interviewers employed a questionnaire to gather information about each survey child's identity, diet, medical history, and breast-feeding history. In addition, a blood sample was obtained from each subject, and each was measured, weighed, and given a complete physical examination (including an eye examination). Ill children were treated or referred to nearby health facilities.

Data entry and management were performed using the EPI-INFO software package (*8*). Chi-square analyses were performed, and results with $P < 0.05$ and $P < 0.01$ were considered statistically significant and highly significant, respectively. The degree of association between the scores obtained for the "index of consumption" and "usual pattern of food consumption" was estimated using Pearson's correlation coefficient.

The participants' nutritional status was evaluated on the basis of their weight-for-age and height-for-age *z* scores with respect to the standard employed by WHO and the US National Center for Health Statistics. These calculations were made using the EPI-INFO anthropometric software (*8*). Children whose weight-for-age or height-for-age was more than two standard deviations below *z* were considered respectively underweight or stunted for their age.

RESULTS

In all, 1 555 children 12–59 months old (104% of the anticipated sample size) participated in the survey. The children were distributed homogeneously by age and sex (Table 1), and the number from each province corresponded to that province's population size. Table 1 also shows the sample's distribution in terms of maternal education, area of residence (urban or rural), and predominant ethnic group in the parish.

Serum retinol levels were measured in 1 232 children (only 79% of the sample, because some specimens were hemolyzed or of insufficient quantity for analysis). The median value for this variable plus or minus one standard deviation (SD) was 0.96 ± 0.32 μmol/L (27.6 ± 9.1 μg/dL). Sixty percent of the children had serum retinol levels below 1.05 μmol/L (30 μg/dL), 18% had levels below 0.7 μmol/L (20 μg/dL), and 2% had concentrations below 0.35 μmol/L (10 μg/dL). Figure 1 shows the distribution of serum retinol levels for the entire sample, while Table 2 shows the prevalence of serum retinol levels below 0.7 μmol/L (20 μg/dL) by province, maternal education, ethnic

Table 1. Distribution of the children in the sample (N = 1 555) by various sociodemographic variables.

Variable	Study children No.	Study children %
Province:		
Cotopaxi	178	12
Chimborazo	254	16
Esmeraldas	219	14
Azuay	345	22
Manabí	559	36
Maternal education:		
None	157	10
Incomplete primary	351	23
Complete primary	460	30
Incomplete secondary	281	18
Complete secondary	176	11
Post-secondary	130	8
Ethnic group:		
Mestizo	1 200	77
Indian	285	18
Black	70	5
Area of residence:		
Urban	896	58
Rural	659	42
Age (in months):		
12–23	362	23
24–35	398	26
36–47	423	27
48–59	372	24
Sex:		
Male	777	50
Female	778	50

group, area of residence (urban or rural), and age.

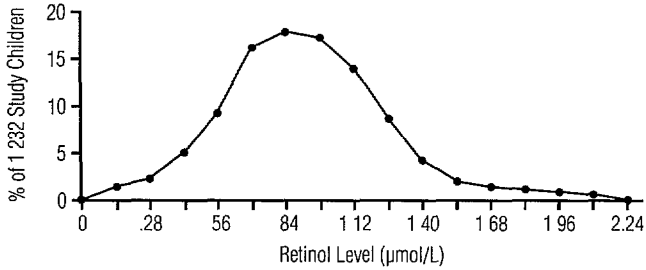
With regard to provincial and ethnic categories, it should be noted that all of the children classified as black (coming from predominantly black parishes) resided in the province of Esmeraldas, while all of the children classified as coming from predominantly Indian parishes were living in the provinces of Cotopaxi and Chimborazo.

Marked variation was observed in the prevalence of low retinol levels (<7 µmol/L) in different provinces, these prevalences ranging from a low of 10% in Cotopaxi to a high of 26% in Azuay. However, no obvious difference emerged between the coastal and mountain provinces, the prevalences in the coastal provinces (Esmeraldas and Manabí) being in the middle (15–18%) while prevalences in the three mountain provinces ranged from lowest to highest (10–26%).

Low serum retinol levels were more common among children of mothers who had relatively little education and resided in rural areas (see Table 2). These statistically significant trends were observed among both boys and girls as well as in all three ethnic groups. A trend was also found toward higher prevalences of low serum retinol levels in younger children, but this was not statistically significant. No significant relationship was found between serum retinol levels and nutritional status, although stunted children tended to have lower retinol levels.

Interviews were conducted in 601 families (39% of the sample, an oversampling due to expected absence or rejection of interviews) one or two days after blood specimen collection to assess the study children's diets. Children estimated to consume less than 70% of the recommended amount of vitamin A—400 retinol equivalents (RE) per day over the period of a day or week—were deemed at high risk of having insufficient vitamin A intake (9). Prevalences of this high nutritional risk by province, maternal education, ethnic group, area of residence, and age are shown in Table 2. The degree of association between the daily (index of consumption) scores and weekly (usual pattern of food consumption) scores was moderately high (Pearson's correlation coefficient = 0.83, $P < 0.0001$). It is important to note that both sets of scores followed the same prevalence patterns with respect to degrees of maternal education, ethnic group, and urban or rural area of residence.

Figure 1. Distribution of the study children in terms of serum retinol levels (N = 1 232).



The dietary evaluation showed the risk of insufficient vitamin A intake to be greater in the mountain provinces than in the coastal provinces. It was also highest in parishes with predominantly Indian populations, lowest in those with predominantly black populations, highest among children whose mothers had no formal education, and highest among those residing in rural areas. In addition, underweight and stunted children were more likely to have high dietary risk than those with normal scores for these variables (*RR* = 1.5 and 2.0, respectively).

The presence of Bitot's spots was confirmed in two children (0.13% of those studied), one in the mountain province of Azuay and the other in the coastal province of Manabí. Obviously, the small number afflicted with these ocular signs made it impossible to draw statistical inferences from the data.

DISCUSSION AND CONCLUSIONS

The prevalence of low serum retinol levels (18%) found by this survey was greater than the 12% reported by the 1985 National Health and Nutrition Survey. This result was not surprising, because the survey was designed to assess vitamin A deficiency in impoverished areas. Since the study provinces contain about 1 million inhabitants, i.e., 20% of the national population, including some 240 000 children between the ages of 12 and 59 months, the results indicate that at least 43 000 children in those provinces are vitamin A deficient.

The Ministry of Public Health classifies as "critically poor" those cantons with the highest infant mortality, lowest health service coverage, and most deficient basic sanitation and other services. All such cantons so classified are rural, a high percentage being located in the Andes mountains, and many have large Indian populations with low levels of literacy.

The group of provinces with the largest numbers of "critically poor" cantons are also classified as being critically poor, even though their urban populations are usually unaffected by rural poverty. The sample for this study was drawn from all of the cantons included in those provinces, regardless of whether or not they were critically poor. Accordingly, it is probable that the prevalence of vitamin A deficiency estimated for the rural areas (23%) represents an underestimate of the situation to be found in the critically poor poverty pockets. These latter areas, in turn, are undoubtedly similar to the country's other poor rural cantons, especially those with Andean Indian populations.

WHO recently suggested that a prevalence of low serum retinol (<20 µg/dL) exceeding 10% constitutes a problem of pub-

Table 2. Prevalences of vitamin A deficiency (as determined by measurement of serum retinol levels and assessed risk of dietary deficiency) in the study children, by various sociodemographic variables.

Variable	Retinol (% <0.7 µmol/L) (N = 1 231)	Dietary risk (%) 24 hour recall (N = 601)	Dietary risk (%) 7 day recall (N = 601)
Province:			
Significance*	†	†	†
Cotopaxi	10	23	30
Chimborazo	18	28	24
Esmeraldas	18	6	5
Azuay	26	34	29
Manabí	15	12	12
Maternal education:			
Significance*	‡	†	†
None	28	48	56
Incomplete primary	20	29	27
Complete primary	18	19	20
Incomplete secondary	15	16	9
Complete secondary	16	10	5
Post-secondary	9	5	0
Ethnic group:			
Significance*	NS	†	†
Mestizo	18	18	15
Indian	17	37	41
Black	22	8	4
Area of residence:			
Significance*	†	†	†
Urban	14	10	10
Rural	23	32	30
Age (in months):			
Significance*	NS	NS	NS
12–23	21	20	22
24–35	21	26	23
36–47	15	25	20
48–59	15	15	13

*Statistical significance.
† = $P < 0.001$.
‡ = $P < 0.01$.
NS = Not significant ($P \geq 0.05$).

lic health significance (*10*). Thus, the prevalence of this deficiency in all of the provinces and sociodemographic classes studied clearly indicates a public health problem that needs to be addressed.

The prevalence of inadequate vitamin A intake, as indicated by the dietary data, closely paralleled the distribution of low serum retinol levels by area of residence (urban or rural) and maternal education, although not by province (nutritional deficiency appeared less prevalent than low retinol levels in the coastal provinces) or ethnic group (nutritional deficiency appeared more prevalent than low retinol levels in the predominantly Indian groups).

Regarding the differences observed between the coast and mountain provinces, it is known that diarrheal and viral infections reduce the concentration of retinol in the blood and cause retinol to be lost through urination (*11–13*). Diarrheal and respiratory infections were detected more frequently on the coast. In addition, malaria is known to be endemic in the coastal province of Esmeraldas, which was one of those surveyed. Thus, prevailing disease rates could help to explain the lack of association between serum retinol levels and nutritional deficiency in the coastal areas.

In addition, the time of year during which the survey was conducted in the coastal region (July and August) coincided with the beginning of the harvest season. For this reason, the high prevalence of low serum retinol levels observed on the coast relative to dietary risk could be indicative of vitamin A status during the "hungry" period just prior to the harvest.

Like the serum retinol level, the indicator of vitamin A precursor consumption in the diet makes it possible to identify high-risk population groups within similar provinces or geographic regions; thus, it could be used to detect high-risk groups living in the same areas and, possibly, to monitor dietary changes occurring over time in the same groups. However, as used in this study, it would not be useful for making inter-regional comparisons.

The IVACG recommends using a 24-hour recall period to study populations with a monotonous diet and a 7-day recall period for populations with greater dietary diversity. Because of considerable variation within the study population, this survey examined both periods. As the Panama vitamin A survey demonstrated (*14*), studies using relatively long recall periods tend to detect less frequently consumed vitamin A sources and thereby tend to reduce the observed prevalence of high dietary risk. The close relationship found between data for the two recall periods used in this study suggests low dietary diversity. Therefore, future dietary studies using this methodology in similar Ecuadorian settings could probably dispense with the 7-day recall period.

Ocular signs of vitamin A deficiency are so rarely reported in Latin America that ophthalmologists have often concluded the deficiency does not exist there. This study identified and confirmed two cases of Bitot's spots (cheesy accumulations on the conjunctiva characteristic of vitamin A deficiency), which may indicate that poor children suffering from this deficiency are not normally seen by ophthalmologists. However, the subjects' serum retinol levels were not deficient, suggesting that the Bitot's spots could have represented residual evidence of prior deficiency.

Forty-two percent of the Ecuadorian study population had serum retinol levels between 0.70 and 1.05 μmol/L (between 20 and 30 μg/dL), indicating marginal vitamin A deficiency. Several studies have confirmed reductions in child mortality following administration of vitamin A supplements to members of population groups having such subclinical deficiency (*15, 16*). Flores *et al.* showed that children who had received vitamin A supplements did not have serum concentrations of retinol below 1.05 μmol/L (30 μg/dL) (*17*). Accordingly, it would appear that appropriate dietary supplementation would cause 60% of the Ecuadorian population studied to improve their vitamin A status and would reduce childhood mortality.

Overall, the results of this survey, which showed substantial consistency with those of the previous national survey, confirmed the existence of significant subclinical vitamin A deficiency that clearly constitutes a public health problem, especially in the rural Andes.

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