Vitamin A deficiency and anemia among children 12–71 months old in Honduras

Penelope Nestel,[1] *Alejandro Melara,*[2] *Jorge Rosado,*[3] *and Jose O. Mora*[4]

ABSTRACT *Vitamin A deficiency (VAD) and iron deficiency anemia (IDA) have been recognized as public health problems in Honduras for over 30 years. This paper, based on the 1996 National Micronutrient Survey on 1 678 children 12–71 months of age, presents the results for vitamin A status and anemia prevalence, as well as the level of vitamin A in sugar at the household level. The results showed that 14% of the children were subclinically vitamin A deficient (plasma retinol < 20 μg/dL) and 32% were at risk of VAD (plasma retinol 20–30 μg/dL). These data indicate that VAD is a moderate public health problem in Honduras. Logistic regression analysis showed that children 12–23 months old living in areas other than the rural south of the country were at greatest risk of subclinical VAD. Infection, indicated by an elevated alpha-1-acid-glycoprotein level, increased the risk of subclinical VAD more than threefold. Children from households that obtained water from a river, stream, or lake were at twice the risk of subclinical VAD compared with other children. That same doubled risk was found for children from a household with an outside toilet.*

VAD can be controlled by fortifying sugar. Retinol levels in sugar at the household level were about 50% of those mandated by Honduran law. There appears to be significant leakage of unfortified sugar into the market. This is particularly true in the rural north, where 33% of samples contained no retinol.

Overall, 30% of children were anemic (Hb < 11 g/dL). Logistic regression analysis showed that children whose fathers lived with them but who had not attended at least grade 4 of primary school were at 33% greater risk of being anemic. Infection and being underweight increased the risk of being anemic by 51% and 21%, respectively. Many of the anemic children had not been given iron supplements, suggesting health care providers may not be aware that anemia is widespread among young children and/or know how to diagnose it.

Vitamin A deficiency (VAD) and iron deficiency anemia (IDA) have been recognized as public health problems in Honduras for over 30 years. The 1966 national nutrition survey (1) showed 40% of the preschool children, 34% of the school-age children, and 22% of the general population had VAD (serum retinol levels < 20 μg/dL). In addition, the majority of families surveyed reported a very low intake of foods rich in vitamin A and iron. Micronutrient interventions were later initiated. Sugar fortification with vitamin A was begun in 1977, but it did not include an effective monitoring system. Thus, fortification of an unknown quality was irregularly implemented until the late 1980s, when efforts were made to improve the monitoring process.

The second national nutrition survey (2), conducted in 1987, showed vitamin A and iron intakes were low and derived mainly from vegetables, where the bioavailability is lower than in other foods rich in vitamin A or iron. Vitamin A intake was estimated to be

1 Johns Hopkins University, School of Hygiene and Public Health, Department of International Health, Baltimore, Maryland, United States of America.
2 Ministry of Health, Tegucigalpa, Honduras.
3 National Institute of Nutrition, Mexico City, Mexico.
4 Emory University, Rollins School of Public Health, Department of International Health, Atlanta, Georgia, United States of America. Address correspondence to: Dr. Jose Mora, MOST Project, ISTI, 1820 North Fort Myer Drive, Suite 600, Arlington, VA 22209, United States of America.

less than 300 μg/day in 75% of households and, on average, met less than 50% of the recommended daily allowance. Iron intake was under 15 mg/person/day in 66% of households, less than 20% of the intake came from meat, and more than 50% of households consumed an amount below 80% of the recommended daily allowance for iron. The iron actually absorbed, however, would have been lower because the bioavailability of the iron was not taken into account in the calculations. No national-level biochemical surveys have been conducted for anemia. In addition, although the 1987 national survey included the collection of blood for vitamin A assays, the results were never fully disclosed.

In the last decade, micronutrient interventions have focused on delivering pharmaceutical supplements and fortified food. These programs have been supported by the donor community, including the Institute of Nutrition of Central America and Panama (INCAP), the Pan American Health Organization, the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the U.S. Agency for International Development. In 1995, the Ministry of Health determined that nationally representative data on both VAD and anemia were needed. This article presents the results for vitamin A status of children, based on plasma retinol level, and the prevalence of anemia in children, based on hemoglobin measurements. The piece also presents data on the level of vitamin A in sugar at the household level.

METHODS

The 1996 National Micronutrient Survey was conducted between July and October. Full details on the survey design and survey population will be published in a future article (3). The survey comprised a nationally representative sample of children 12–71 months old. Equal numbers of boys and girls were included, and there was no age bias across the demographic/geographic areas of Honduras called "dominions."[5] Data were collected by three field teams, each with a supervisor, two phlebotomists, and two interviewers. Before the survey, all field staff received 2 weeks of training, including on standardization of anthropometric measurements.

Data collected included standard household social and economic variables; morbidity (cough, runny nose, or diarrhea with ≥ 3 or more watery stools/day) in the preceding 15 days (2 weeks), including the day of the survey; and supplement use among children 12–71 months old. Children were weighed using a Salter hanging scale (United Nations Children's Fund, Copenhagen, Denmark) to the nearest 100 g. Height was measured to the nearest 0.1 cm using a wooden anthropometer. Nutrition indicators were calculated using the U.S. Centers for Disease Control Anthropometric Software Package (Atlanta, Georgia, United States of America), which is based on the growth curves of the National Center for Health Statistics. Children with z scores below -2 were considered undernourished, in line with WHO standards (4). The exclusion criteria for anthropometric values that are recommended by the WHO (5) were used, i.e., 4 z-score units from the observed mean z score for height/age, weight/age, and weight/height, with a maximum height/age z score of +3.

Two mLs of blood were collected from the antecubital vein for plasma retinol and alpha-1-acid glycoprotein (AAGP) assays. For quality control, duplicate blood samples were taken from every tenth child. Plasma retinol was determined spectrophotometrically following the method of Dary and Arroyave (6). Subclinical VAD was defined using the cut-off level of the WHO (7), which is < 20 μg/dL. It was not possible to separate the prevalence of severe deficiency from moderate and mild VAD because the spectrophotometric method was used to assay retinol levels. This method is not sufficiently specific for values below 20 μg/dL (Dary, personal communication). Children were defined as being at risk of VAD if their plasma retinol was between 20 and 30 μg/dL. Children with a plasma retinol level of 30 μg/dL or higher were considered as having normal vitamin A status.

The concentration of AAGP, which peaks after 48 hours and remains high for about 120 hours before beginning to fall (8), was used as the marker of infection. It was determined using the Behring TurbiTime System (Behring, Marburg, Germany), an immunoturbidimetric assay in which human AAGP forms a precipitin with a specific antiserum. No guidelines currently exist for defining the presence of infection; based on data in the literature (9), a "high" AAGP level was defined as greater than 1.0 g/L.

Hb measurements were made on a drop of venous blood using a portable photometer (HemoCue, Ängelholm, Sweden). Anemia was defined as Hb below 11 g/dL at sea level (10). Hb levels were adjusted for altitude using the formula proposed by Yip[6]: adjusted Hb = Hb $-$ ($-0.032 \times$ altitude + $0.022 \times$ altitude^2), where altitude = elevation in 1 000-foot units or in units of 1 000 m $\times$ 3.3.

Sugar samples were collected from every fifth household for the retinol assays. Vitamin A in sugar was determined spectrophotometrically following the method described by Dary and Arroyave (6).

Data were entered in the EPI INFO version 6 software program (U.S. Centers for Disease Control, Atlanta, Georgia, United States) and exported to SPSS PC files. Analysis was done us-

[5] "Dominions" (*dominios*) are six demographic/geographic groupings used by some ministries of the Government of Honduras. "Urban" dominions have more than 2 000 inhabitants and are divided into the following three groupings: metropolitan Tegucigalpa; San Pedro Sula and "medium" cities—ones with a population between 20 000 and 50 000—in any of the departments of the country; and "other" urban areas, ones with a population between 2 000 and 20 000 inhabitants, also in any department of the country. The three rural dominions—north, south, and west—match the political boundaries of departments but exclude all "urban" communities in their respective areas.

[6] Yip R. Altitude and hemoglobin elevations: implication for anemia screening and health risk of polycythemia. Paper presented at Eighth International Hypoxia Symposium, Hamilton, Ontario, 1993.

ing SPSS for Windows version 5 (SPSS Inc, Chicago, Illinois, United States). A probability level of less than 0.05 was used to define statistical significance. In the bivariate chi-square and analysis of variance (ANOVA), the sample was weighted by the normalized sample weight, which was the product of the inverse of the sample weight, the household response rate, and the individual interview response rate. Sample sizes are presented as weighted observations. Using the variables that were statistically significant in the bivariate analyses, logistic regression models were developed to predict VAD and low Hb levels. In each model, the category in the bivariate analysis most positively associated with not having VAD or a low Hb level was generally used as the reference category. The ratios of the odds in the logistic regressions have been transformed into the ratios of probabilities or relative risks (RR) for ease of understanding.

A technical committee set up by the Ministry of Health of Honduras reviewed all the documents and survey procedures. Written informed consent was obtained from the mother or caretaker of each of the children. Ethical approval for the survey was obtained from the Human Subjects Committee at Johns Hopkins University.

RESULTS

Of the 2 421 households visited, 96.7% agreed to participate in the survey but only 52.2% of the households were eligible, that is, had children 12–71 months old. Of the eligible households, 94.5% were successfully interviewed. Anthropometric, Hb, plasma retinol, and AAGP data were available for 97.2%, 93.8%, 88.7%, and 91.3% of the children, respectively.

Vitamin A deficiency

Overall, 14% of children 12–71 months old had subclinical VAD and 32% were at risk of being deficient, i.e., had plasma retinol 20–30 μg/dL (Table 1). The overall mean and standard deviation plasma retinol level was 31.6 ± 12.1 μg/dL.

There were significant differences in vitamin A status according to dominion ($P < 0.001$) (Tables 1 and 2). Subclinical deficiency was highest in the rural west (19%), followed by the "other urban" areas (16%) and the rural north (16%). The prevalence of being at risk of subclinical VAD was greatest in the rural south (37%), where deficiency levels were among the lowest. Indeed, the country can be divided into two groups based on plasma retinol levels (9). There is a mild public health problem (prevalence of low plasma retinol levels 2–10%) in Tegucigalpa, San Pedro Sula and medium cities, and the rural south. There is a moderate public health problem (prevalence of low plasma retinol levels 10–20%) in the rural west, rural north, and "other urban" areas.

Significantly fewer children were likely to be vitamin A deficient if their mother/caretaker ($P < 0.001$) or her partner ($P < 0.001$) had attended secondary school (Table 2). Other indicators that reflected higher social and economic status were associated with not being vitamin A deficient. These included access to safer water ($P < 0.001$), having a flush toilet ($P < 0.001$), having a better-quality floor ($P < 0.001$), and ownership of a greater number of such possessions as a functioning radio, television, refrigerator, stereo, electric iron, blender, or telephone ($P < 0.001$).

Among the biological factors, there was a significant age-specific ($P < 0.001$) but not gender-specific pattern in the prevalence of VAD for children 12–71 months old (Table 2). Among children 12–23 months old, about one in five was subclinically deficient, but the prevalence declined by 30–40% between the ages of 24–47 months, to about one in seven children. Beginning with the age of 48 months, there was a further small decline in the prevalence of subclinical VAD; just under one in 10 of those children was subclinically VAD.

Children who had had diarrhea, a cough, or a runny nose in the preceding 2 weeks were more likely to have VAD than those who had not: 21% vs. 11% ($P < 0.001$), 17% vs. 10% ($P < 0.001$), and 17% vs. 8% ($P < 0.001$), respectively. The association between a recent history of morbidity and VAD was more clearly seen in the results for the association between AAGP and low plasma retinol levels, where 27% vs. 10% ($P < 0.001$) of the subclinically deficient children had an AAGP above 1.0 g/L (Table 2). Anemia (Hb < 11 g/dL), stunting, and underweight were also associated with having a low plasma retinol level: 17% vs. 12% ($P < 0.02$), 19% vs. 10% ($P < 0.001$), and 22% vs. 11% ($P < 0.005$), respectively.

Having received an antihelminth in the preceding 6 months was protective against a child being subclinically VAD (12% vs. 16% ($P < 0.05$)) (Table 2). It is not known whether this was a direct effect of helminth infection on vitamin A status or an indirect effect of better child health care. In contrast, having received iron supplements in the preceding 6 months was not associated with VAD.

The social, economic, and health variables that were statistically significant in the bivariate analyses were used in a logistic regression model to determine their net effects on subclinical VAD. The model estimates the probability that a child has a plasma retinol level below 20 μg/dL, i.e., the

TABLE 1. Percentage level of serum retinol in children 12–71 months old by dominion, Honduras, 1996

Dominion	Serum retinol (μg/dL) <20 %	20–29.9 %	30+ %	No.
Tegucigalpa	8.1	28.7	63.2	184
SPS[a] & medium cities	7.3	30.2	54.5	207
Other urban	15.6	32.1	52.3	188
Rural north	15.9	32.5	51.5	723
Rural west	18.7	27.3	53.9	192
Rural south	7.9	37.0	55.1	124
Chi-square		$P < 0.001$		
Overall	13.8	32.3	53.9	1 678

[a] SPS = San Pedro Sula.

child has subclinical VAD. The important determinants of subclinical VAD were age group, AAGP level, source of water, type of toilet, and dominion (Table 3). The reference category for child age was 60–71 months old; this was assigned a numerical value of 1.00. Children who were 12–23 months old were more than twice as likely to have subclinical VAD than children 60–71 months old, and this difference was statistically significant. After the age of 23 months, the risk of subclinical VAD declined. The differences were not statistically significant between the children 60–71 months old and those in the three groupings of 24–35, 36–47, and 48–59 months old.

The relative risk of children with an AAGP above 1.0 g/L (presence of infection) having subclinical VAD was over three times higher than that of children with an AAGP below 1.0 g/L, a difference that was significant (Table 3). The type of toilet was also significantly associated with the adjusted relative risk of having subclinical VAD. Children from households with an outside toilet (outhouse) were at sig-

TABLE 2. Percentage of plasma retinol for children 12–71 months of age by nonbiological and biological factors, Honduras, 1996

	Plasma retinol (μg/dL)				Plasma retinol (μg/dL)		
	<20 %	20+ %	No.		<20 %	20+ %	No.
Dominion				*Age group*			
Tegucigalpa	8.1	91.9	184	12–23 months	21.4	78.6	328
SPS[a] & medium cities	7.3	92.7	207	24–35 months	12.7	87.3	371
Other urban	15.6	84.4	188	36–47 months	14.4	85.6	315
Rural north	15.9	84.1	723	48–59 months	9.9	90.1	327
Rural west	18.7	81.3	192	60–71 months	9.0	91.0	270
Rural south	7.9	92.1	124		$P < 0.001$		
	$P < 0.001$[b]			*Diarrhea last 2 weeks*			
Mother's schooling				Yes	20.6	79.4	456
None	20.6	79.4	289	No	10.9	89.1	1 156
Primary 1–3	16.9	83.1	480		$P < 0.001$		
Primary 4–6	10.8	89.2	603	*Cough last 2 weeks*			
Secondary 1+	5.8	94.2	243	Yes	16.7	83.3	913
	$P < 0.001$			No	9.7	90.3	700
Partner's schooling					$P < 0.001$		
None	22.2	77.8	213	*Runny nose last 2 weeks*			
Primary 1–3	18.1	81.9	385	Yes	16.5	83.5	1 084
Primary 4–6	10.4	89.6	496	No	7.9	92.1	526
Secondary 1+	6.5	94.5	175		$P < 0.001$		
	$P < 0.001$			*Alpha-1-acid glycoprotein*			
Source of water				1.0+ g/L	27.0	73.0	393
Tap in house	9.7	90.3	307	< 1.0 g/L	9.9	90.1	1 226
Tap on property	12.0	88.0	811		$P < 0.001$		
Public tap	10.4	89.6	111	*Hemoglobin*			
River/stream/lake	32.5	67.5	170	< 11 g/dL	16.8	83.2	478
Well	13.1	86.9	147	11+ g/dL	12.3	87.7	1 137
Other	9.8	90.2	73		$P < 0.02$		
	$P < 0.001$			*Stunted*			
Type of toilet				Yes	18.8	81.2	609
None	19.3	80.7	438	No	10.1	89.9	989
Pit latrine	12.5	87.5	468		$P < 0.001$		
Outhouse	15.1	84.9	296	*Underweight*			
Flush	7.7	92.3	415	Yes	21.8	78.2	380
	$P < 0.001$			No	10.8	89.2	1 218
Type of floor					$P < 0.005$		
Mud	17.0	83.0	813	*Antihelminth last 6 mo*			
Cement tiles	10.2	89.8	503	Yes	11.5	88.5	718
Mosaic tiles	10.3	89.7	302	No	15.5	84.5	890
	$P < 0.001$				$P < 0.05$		
Possession score[c]							
0	23.0	77.0	449	Overall (12–59 mo)	14.5	85.5	1 341
1–2	11.7	88.3	628	Overall (12–71 mo)	13.8	86.5	1 678
3–4	8.9	91.1	291				
5+	7.0	93.0	250				
	$P < 0.001$						

[a] SPS = San Pedro Sula.
[b] Level of significance based on chi-square test.
[c] One point each was given for owning any of the following possessions: a functioning radio, TV, refrigerator, stereo, electric iron, blender, or telephone.

TABLE 3. Adjusted relative risk of subclinical vitamin A deficiency in children 12–71 months old (n = 1 466), Honduras, 1996

	Adjusted relative risk
Age group	
12–23 months	2.19[b]
24–35 months	1.29
36–47 months	1.51
48–59 months	1.03
60–71 months	1.00[a]
Alpha-1-acid glycoprotein	
1.0+ g/L	3.19[b]
< 1.0 g/L	1.00
Source of water	
Tap in house	1.00[a]
Tap on property	0.80
Public tap	0.62
River/stream/lake	2.08[b]
Well	0.83
Other	0.59
Type of toilet	
None	1.39
Pit latrine	1.37
Outhouse	2.17[b]
Flush	1.00[a]
Dominion	
Tegucigalpa	1.00[a]
SPS[c] & medium cities	0.81
Other urban	1.42
Rural north	1.25
Rural west	1.22
Rural south	0.46[b]

[a] Overall $P < 0.05$.
[b] $P < 0.05$ compared with reference category.
[c] SPS = San Pedro Sula.

TABLE 4. Percentage of children 12–71 months old who had ever received a vitamin A capsule by dominion, Honduras, 1996

Dominion	Ever received vitamin A Yes %	No %	No.
Tegucigalpa	94.0	6.0	157
SPS[a] & medium cities	83.1	16.9	167
Other urban	90.8	9.2	159
Rural north	88.9	11.1	618
Rural west	94.7	5.3	189
Rural south	90.4	9.6	106
Chi-square	$P < 0.005$		
Overall	89.9	10.1	1 396

[a] SPS = San Pedro Sula.

nificantly greater risk (RR = 2.17) of subclinical VAD than those from households with a flush toilet. In addition, children from households that obtained water from such open-air sources as a river, stream, or lake were at significantly greater risk (RR = 2.08) of subclinical VAD than those from households that had tap water in the house.

Children living in the rural south were significantly less likely (RR = 0.46) to be subclinically deficient than those in Tegucigalpa (Table 3). In contrast, the risk of subclinical VAD was higher than in Tegucigalpa for three of the dominions—"other urban," the rural north, and the rural west—but the differences were not significant.

Vitamin A supplements

Information on whether a child had received vitamin A capsules was obtained from each child's immunization card. Eighty percent of children had an immunization card that was seen, 14% had a card that was not available at the time of the interview, and 6% of the children did not have a card. More children 60–71 months old had a card that was not seen than in the other age groups. Recording the distribution of vitamin A supplements on immunization cards began in 1994, so these results have to be interpreted with extreme caution. For 99% of the children, the source of the vitamin A capsule they had received most recently was a government health worker.

Overall, about 90% of children had at some time received a vitamin A supplement. The figures were higher in Tegucigalpa and the rural west ($P < 0.005$) than elsewhere (Table 4). There were no gender or age differences in receiving capsules. On average, children had received 2.1 capsules and, again, there were significant dominion differences ($P < 0.001$). As shown in Table 5, children in San Pedro Sula and medium cities had received fewer capsules than children living elsewhere. Table 5 also shows that children who were subclinically VAD or at risk of being subclinically VAD had received significantly fewer vitamin A capsules than those who were not VAD ($P < 0.001$).

Fortified sugar

Overall, the mean retinol level in sugar from the households was 6.2 ± 5.0 μg/g, and the difference between the dominions was highly significant ($P < 0.001$) (Table 6). Nationwide, 22% of the sugar samples contained no retinol (Table 7). No vitamin A was found in 34% of the sugar used in households in the rural north, in 25% of that sugar in Tegucigalpa, and in 21% of that sugar in the "other urban" dominion.

Assuming that the sugar with no retinol was unfortified and the rest was fortified, the average retinol level in the fortified sugar was 7.9 ± 3.9 μg/g, but this too varied by dominion ($P < 0.001$) (Table 6). At the household level, overall fortification was about one-half of the 15 μg/g amount that Honduran law mandates for the mill level.

TABLE 5. Mean and standard deviation (SD) number of vitamin A capsules ever received by children 12–71 months old by dominion and plasma retinol level, Honduras, 1996

Dominion	No. vit A capsules Mean	SD	No.
Tegucigalpa	2.3	1.4	157
SPS[a] & medium cities	1.5	1.1	167
Other urban	2.0	1.3	159
Rural north	2.1	1.4	618
Rural west	2.3	1.2	189
Rural south	2.3	1.3	106
ANOVA	$P < 0.001$		
Overall	2.1	1.3	1 396
Plasma retinol			
< 20 μg/dL	1.9	1.4	184
20–29 μg/dL	2.0	1.4	422
30+ μg/dL	2.3	1.3	683
ANOVA	$P < 0.001$		
Overall	2.1	1.4	1 289

[a] SPS = San Pedro Sula.

TABLE 6. Mean and standard deviation (SD) retinol in sugar by dominion, Honduras, 1996

Dominion	Retinol in all sugar (μg/dL) Mean	SD	No.	Retinol in fortified sugar (μg/dL) Mean	SD	No.
Tegucigalpa	7.0	4.8	51	9.4	2.8	39
SPS[a] & medium cities	7.2	4.8	62	7.6	4.6	58
Other urban	5.3	4.1	53	6.7	3.4	42
Rural north	5.1	5.0	137	7.8	4.1	91
Rural west	9.5	6.0	25	10.7	5.2	22
Rural south	6.0	3.0	22	6.5	2.5	21
ANOVA	$P < 0.001$			$P < 0.001$		
Overall	6.2	5.0	350	7.9	3.9	273

[a] SPS = San Pedro Sula.

TABLE 7. Percent distribution of retinol in sugar, Honduras, 1996

Dominion	Retinol (μg/g) 0 %	1–4.9 %	5–9.9 %	10–14.9 %	15+ %	No.
Tegucigalpa	25.0	5.3	36.8	30.3	2.6	51
SPS[a] & medium cities	6.1	25.8	50.0	9.1	9.1	62
Other urban	21.0	29.0	43.5	3.2	3.2	53
Rural north	33.9	12.5	39.3	8.9	5.4	137
Rural west	11.4	8.6	37.1	31.4	11.4	25
Rural south	7.3	27.3	60.0	5.5	0.0	22
Chi-square			$P < 0.001$			
Overall	22.4	17.0	42.6	12.6	6.4	350

[a] SPS = San Pedro Sula.

Anemia

Overall, 30.4% of children 12–71 months old were anemic, and of these 0.5% were severely so (Hb level below 7 g/dL). The distribution of Hb was normally shaped, and the mean and standard deviation Hb values were 11.5 ± 1.3 g/dL. Anemia did not vary by dominion, indicating the problem was widespread throughout the country.

As shown in Table 8, children were significantly less likely to be anemic if their mother/caretaker ($P < 0.01$) or her partner ($P < 0.001$) had attended at least grade 1 of secondary school. Also less likely to be anemic were children whose mother/caretaker was either married or not in a union ($P < 0.05$). Other indicators associated with a child not being anemic were ones that reflected a higher social and economic status, including source of water ($P < 0.05$), type of floor in the house ($P < 0.005$), or ownership of possessions ($P < 0.02$).

There was a significant age-specific pattern in the prevalence of anemia for children 12–71 months old ($P < 0.001$) (Table 8), but this was not true for gender. Between 12 and 23 months of age, more than 50% of the children were anemic, but the prevalence fell to about 40% by the age of 24–36 months, to 23% by 36–47 months, and to 14% for the two older groups of children, 48–59 months and 60–71 months.

Children who had had diarrhea in the preceding 2 weeks were more likely to be anemic than other children, 40% vs. 26% ($P < 0.001$) (Table 8). Similarly, children who had had a cough in the preceding 2 weeks were more likely to be anemic than children who had not, 33% vs. 27% ($P < 0.02$) (Table 8). Also associated with anemia were having an AAGP level above 1.0 g/L, 42% vs. 26% ($P < 0.001$), and being underweight, 38% vs. 28% ($P < 0.001$).

There was no association between being anemic and having received an antihelminth or iron supplements in the preceding 6 months.

The social, economic, and health variables identified as important in the bivariate analyses were used in a logistic regression model to determine their net effects on anemia. The model developed estimated the probability of a child having a hemoglobin level below 11 g/dL, i.e., the child was anemic. The important determinants of anemia among Honduran children 12–71 months old were diarrhea, AAGP level, underweight, and the amount of schooling completed by the partner of the mother/caretaker (Table 9). For diarrhea, not having had diarrhea in the preceding 15 days was the reference category, with a numerical value of 1.00. The risk of a child with a recent history of diarrhea being anemic was 36% greater than for a child without a recent history of diarrhea.

Children with an AAGP above 1.0 g/L, which indicated the presence of infection, were 51% more likely to be anemic than those with an AAGP below 1.0 g/L (Table 9). Children who were underweight were 21% more likely to be anemic than those who were not underweight. The differences were significant for both of those categories. Where the mother's partner had completed no further than grade 3 of primary school, the children were one-third more likely to be anemic than those children whose mothers did not have a partner. This was the case even after controlling for infection and age group. Although not statistically significant, children of mothers with partners who had attended at least grade 1 of secondary school were at less risk of being anemic than those children whose mothers did not have a partner.

Iron supplements

Mothers/caretakers were asked whether their child had received an iron-containing supplement in the preceding 6 months. Overall, 30% of children had received iron supplements, and there were no gender differences in who received supplements. There were, however, significant dominion differences ($P < 0.001$) in whether a child received iron supplements (Table 10). Fewer children in the rural west (19%) had received iron supplements in the preceding 6 months than elsewhere (25–38%). Table 10 also shows there were more children in the 12–23 month age group (41%) who had received iron supplements in the previous 6 months than in the other age groups (25%–30%), and this difference was significant ($P < 0.001$). Thus, while targeting to young children was ongoing, not enough children were receiving supplements. There was no association between a child having received iron supplements in the preceding 6 months and the schooling level of the mother/caretaker.

Just under 50% of the children who had received iron supplements got them from a government health worker, 28% got them from a private health care provider, and about 23% got them from some other source, such as a family member or other individual. Table 10 shows that there were

TABLE 8. Percentage hemoglobin level for children 12–71 months of age by nonbiological and biological factors, Honduras, 1996

	Hemoglobin level <11 g/dL	Hemoglobin level 11+ g/dL	
	%	%	No.
Mother's schooling			
None	33.0	67.0	309
Primary 1–3	30.0	70.0	507
Primary 4–6	37.6	67.3	648
Secondary 1+	21.8	78.2	260
	$P < 0.01$[a]		
Partner's schooling			
None	37.0	63.0	223
Primary 1–3	33.1	66.9	405
Primary 4–6	31.5	68.5	526
Secondary 1+	17.3	82.7	190
Not applicable	28.5	71.5	382
	$P < 0.001$		
Marital status			
Married	27.3	72.7	535
Free union	33.1	66.8	820
Not in union	28.4	71.6	368
	$P < 0.05$		
Mother works			
Yes	33.8	66.2	711
No	27.9	72.1	1 010
	$P < 0.01$		
Source of water			
Tap in house	26.2	73.8	320
Tap on property	30.1	69.9	875
Public tap	38.9	61.1	122
River/stream/lake	36.3	63.7	185
Well	25.2	74.8	150
Other	33.3	66.7	74
	$P < 0.05$		
Type of floor			
Mud	32.8	67.2	877
Cement tiles	30.9	69.1	526
Mosaic tiles	23.0	77.0	324
	$P < 0.005$		
Possession score[b]			
0	33.2	66.8	478
1–2	32.4	67.6	677
3–4	27.5	72.5	310
5+	23.3	76.7	262
	$P < 0.02$		
Age group			
12–23 months	52.5	47.5	374
24–35 months	40.4	59.6	392
36–47 months	23.4	76.6	331
48–59 months	14.4	85.6	341
60–71 months	14.4	85.6	282
	$P < 0.001$		
Diarrhea last 2 weeks			
Yes	40.3	59.7	513
No	26.3	73.7	1 208
	$P < 0.001$		
Cough last 2 weeks			
Yes	33.0	67.0	967
No	27.2	72.8	755
	$P < 0.02$		
Alpha-1-acid glycoprotein			
1.0+ g/L	41.6	58.3	380
< 1.0 g/L	26.1	73.9	1 183
	$P < 0.001$		
Underweight			
Yes	37.6	62.4	420
No	28.2	71.8	1 285
	$P < 0.001$		
Plasma retinol			
< 20 g/dL	36.6	63.4	220
20–29 g/dL	31.0	69.0	524
30+ g/dL	27.0	73.0	871
	$P < 0.02$		
Overall (12–59 mo)	33.5	66.5	1 438
Overall (12–71 mo)	30.4	69.6	1 726

[a] Level of significance based on chi-square test.
[b] One point each was given for owning any of the following possessions: a functioning radio, TV, refrigerator, stereo, electric iron, blender, or telephone.

TABLE 9. Adjusted relative risk of anemia in children 12–71 months old (n = 1 462), Honduras, 1996

	Adjusted relative risk
Diarrhea last 2 weeks	
Yes	1.36[a]
No	1.00
Alpha-1-acid glycoprotein	
1.0+ g/L	1.51[a]
< 1.0 g/L	1.00
Underweight	
Yes	1.21[a]
No	1.00
Partner's schooling	
None	1.35[a]
Primary 1–3	1.33[a]
Primary 4–6	1.22
Secondary 1+	0.83
Not applicable	1.00[b]

[a] $P < 0.05$ compared with reference category.
[b] Overall $P < 0.05$.

also significant ($P < 0.001$) dominion differences in the source of the iron supplements. More children in the rural west (78%) and rural south (64%) received supplements from government health workers than did children elsewhere. Private health care providers supplied more children in San Pedro Sula and medium cities (45%) than elsewhere. More children received supplements from a family member or friend in the "other urban" areas (31%).

The source of the iron supplement was significantly associated with the schooling of the mother/caretaker ($P < 0.001$). Not unexpectedly, children whose mother/caretaker had attended secondary school obtained the supplements most often from a private health care provider (54%), while those whose mother/caretaker had never been to school were more dependent on the government health system (67%).

Among the children receiving iron supplements, 53% were given syrup, 39% were given drops, and the remainder tablets or injectable iron (data not shown).

Antihelminths

Overall, 45% of children had received an antihelminth in the preceding 6 months. There was no difference in whether children had been dewormed or not based on gender, dominion, age group, and mother/caretaker schooling (data not shown). The standard protocol for deworming children that is being developed in Central America is known as PEPIN (the Spanish acronym for Standardized Protocol for the Control of Intestinal Parasitic Diseases), and it has identified children over 2 years old as the target group.

DISCUSSION

VAD is a moderate public health problem in Honduras. Just over one in

TABLE 10. Percentage of children 12–71 months old who received iron in the preceding 6 months and, among children receiving iron, the percent distribution source of the iron by background characteristics, Honduras, 1996

	Received iron last 6 months		Source of iron		
			GHW[a]	PHW[b]	Other
	%	No.	%	%	%
Dominion					
Tegucigalpa	25.4	48	45.1	35.2	19.7
SPS[c] & medium cities	38.3	86	30.8	45.1	24.2
Other urban	33.9	66	39.0	29.9	31.2
Rural north	31.2	240	53.1	21.4	25.5
Rural west	18.7	37	78.4	15.7	5.9
Rural south	29.0	36	64.4	27.6	8.0
Chi-square *P* value	$P < 0.001$			$P < 0.001$	
Age group					
12–23 months	41.3	157	55.9	26.5	17.6
24–35 months	26.9	103	51.9	33.4	14.7
36–47 months	29.8	93	47.7	22.8	29.5
48–59 months	25.8	88	42.3	31.5	26.2
60–72 months	25.4	70	40.3	25.3	34.4
Chi-square *P* value	$P < 0.001$			$P < 0.05$	
Mother's schooling					
None	28.8	86	67.3	14.5	18.2
Primary 1–3	26.3	133	49.1	21.6	29.3
Primary 4–6	32.5	204	52.3	26.2	21.6
Secondary 1+	33.8	89	25.5	53.8	20.7
Chi-square *P* value	$P > 0.05$			$P < 0.001$	
Overall	30.2	512	49.4	27.8	22.9

[a] GHW = government health worker.
[b] PHW = private health worker.
[c] SPS = San Pedro Sula.

seven children in the survey had subclinical VAD. A further one in three were at risk of being subclinically VAD. Children 12–23 months old and those who did not live in the rural south were at greatest risk of subclinical VAD. Because living in a particular dominion does not by itself cause VAD, the dominion must have been acting as a proxy for other factors associated with vitamin A status, such as access to and use of vitamin A-rich foods, that were not measured in the survey. This suggests that there may be age-specific dietary patterns or other factors (e.g., parasites) that affect vitamin A status in young children that were not collected in this survey. VAD is known to increase the risk of severe diarrhea and also child mortality; thus, its prevention is important for child survival.

Having an infection predisposed children to being subclinically VAD. This finding not only reflects the importance of having a marker for infection, but it also highlights the question on the validity of using 20 μg/dL to define subclinical VAD, given that retinol levels fall with infection. Whether that decrease is due to increased excretion of vitamin A during infection or reduced mobilization from body stores remains unknown (Yip, 1993 symposium paper mentioned previously). The risk of subclinical VAD was also determined by source of water and type of toilet, two proxies for environmental sanitation that could reflect chronic risk of morbidity. These results suggest that subclinical VAD is unlikely to be eliminated until infection levels are better controlled and environmental hygiene is improved. In the meantime, the distribution of vitamin A supplements among high-risk children should be promoted. Vitamin A supplements should be targeted to communities of extreme poverty, which can be identified using a method the Ministry of Health has developed.

Domestic sugar is fortified with vitamin A as a preventative measure. At the household level, however, the retinol level in sugar was about one-half of the level that Honduran law stipulates for production sites. Recent work on the quality control of sugar fortification has shown that retinol levels at the mills were 15 μg/g (11), which suggests that there is considerable loss of retinol once sugar leaves the mills. This is most likely due to unfavorable storage conditions and inadequate packaging. There also appears to be significant leakage of unfortified sugar into the market, particularly in the rural north, where one-third of the sugar samples collected contained no retinol. One possibility is that unfortified sugar destined for the Honduran food industry, which is not mandated to use fortified sugar, was leaking into the retail market. Another possibility is that unfortified sugar was coming in from neighboring countries. Further work is needed to identify where these retinol losses and market leakages are occurring.

There is a growing awareness that iron deficiency anemia (IDA) in young children is very common. The primary reasons for this IDA include the low content of bioavailable iron in a typical infant's diet, the high iron requirements of rapid growth, and possibly high hookworm infestation. This situation has serious implications for child development and child survival beyond just anemia. Iron deficiency in infants and young children is associated with impaired cognitive and psychomotor development (12, 13, 14), reduced growth (15, 16), and decreased resistance to infection (17, 18). Although there are no specific criteria for defining anemia as being a public health problem, the UNICEF/WHO Joint Committee on Health Policy (19) states that where IDA in preschool age children is in excess of 20% of the population, the country should have a national plan of action that includes specific programs to prevent and control IDA and iron deficiency.

In Honduras, three out of 10 children were anemic, with an age-specific pattern. Compared with the 1994 sentinel site data from three health districts (11), the anemia levels found in the 1996 National Micronutrient Survey were lower for children 12–23 months old (67% vs. 52%) and 24–35 months old (60% vs. 40%). This result could have been a sampling issue or it could be a real difference. Despite the differences in the results, both data sets indicate that the critical age for developing anemia was up to 24 months of age. This suggests that infant and young-child feeding practices need to be improved in terms of quality and quantity and/or pediatric supplements need to be issued to children under 3 years of age.

Children with a recent history of infection, including diarrhea, were at greater risk of being anemic than other children, possibly reflecting the effect of diarrhea on nutrient absorption. Unfortunately, the survey did not include infants under 12 months of age, who are at high risk of being anemic. The survey results indicate that controlling infection is likely to have a significant impact on the hemoglobin levels of young children. Indeed, including AAGP in the logistic regression model overrode the effect of age, thus highlighting the importance of infection in determining hemoglobin levels among children over 12 months of age. Chronic undernutrition also predisposed children to anemia, while coming from a household in which the father was present and had attended at least grade 4 of primary school protected them. This education difference probably reflects the income effect associated with more schooling, as well as the effect of a better parental education per se on child welfare.

There was no association between anemia and having received iron supplements in the preceding 6 months. This finding was not unexpected because receiving iron supplements does not reflect how many supplements were taken. Even if a question about that were asked, the data would not be valid since the recall period would be too long, thus producing significant misreporting. Nevertheless, many of the children who were anemic were not given iron supplements. This suggests that health care providers may not have been aware that anemia is widespread among young children and/or may not have known how to diagnose it.

One-third of the households participating in this survey did not have a radio (3). This was especially evident in the rural areas, where face-to-face communication thus remains an important way of reaching parents.

The micronutrient indicators studied were in one way or another directly associated with environmental health. This suggests that unless there is concurrent progress in environmental sanitation, it is unlikely that micronutrient status will improve dramatically.

The results of this survey raise some important child survival program issues. One of these is the need to develop and implement an effective program to control iron deficiency anemia in preschool children, especially those under 2 years old. The essential components of this program are fortification of widely consumed foods, such as processed wheat and maize flour, and the routine administration of iron/folate supplements to the high-risk group under 2 years old. If it is found that the prevalence of intestinal parasites is high, especially hookworm, consideration should also be given to periodic deworming of groups at high risk of helminth infestation.

In summary, it is particularly important that the design and execution of effective strategies to reach the most vulnerable children include the provision of iron/folate supplements and twice-yearly vitamin A supplements to children under 2 years old, as well as the fortification of foods. It is equally important that the levels of vitamin A in sugar be maintained throughout the country by institutionalizing a more effective quality assurance system.

Acknowledgments. The survey was implemented in collaboration with the International Eye Foundation. Technical and financial assistance was provided through the Opportunities for Micronutrient Interventions (OMNI) Project of the U.S. Agency for International Development, under contract HRN-C-00-93-00025-08. Dr. Omar Dary's laboratory at INCAP conducted the retinol and AAGP assays. Thanks are due to the field teams and households who made the survey possible and to Dr. Frances Davidson of the U.S. Agency for International Development, Washington, D.C., for his support and helpful comments.

REFERENCES

1. Interdepartmental Committee for National Defense/Instituto de Nutrición de Centro América y Panamá. Nutritional evaluation of the population of Central America and Panama. Washington, D.C.: U.S. Department of Health, Education, and Welfare; 1972. (DHEW Publication No HSM72-8120).
2. Barahona F, Soto RJ, Mendosa I, O'Connor G, Madariaga A, Corrales G. Informe de la encuesta nacional de consumo de alimentos: Honduras 1987. Tegucigalpa: Ministerio de Salud Pública; 1988. (Publicación Científica 0021-08-88).
3. Nestel P, Mellara A, Rosado J, Mora JO. Undernutrition among Honduran children 12 through 71 months of age. Rev Panam Salud Publica. Forthcoming 1999.
4. World Health Organization. Measuring change in nutritional status. Geneva: WHO; 1989.
5. World Health Organization. Physical status: the use and interpretation of anthropometry, report of a WHO expert committee. Geneva: WHO; 1995. (WHO Technical Report Series 854).
6. Dary O, Arroyave G. Sugar fortification with vitamin A: analytical methods for the control and evaluation of sugar fortification of vitamin A. Washington, D.C.: U.S. Agency for International Development/Opportunities for Micronutrient Interventions; 1996.
7. World Health Organization. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating inter-

vention programs. Geneva: World Health Organization; 1994.
8. Fleck A. Acute phase response: implications for nutrition and recovery. Nutrition 1988;2: 109–117.
9. Filteau SM, Morris SS, Abbott RA, Tomkins AM, et al. Influence of morbidity on serum retinol of children in a community-based study in northern Ghana. Am J Clin Nutr 1993;58 (2):192–197.
10. World Health Organization. Nutritional anemia. Geneva: WHO; 1972. (WHO Technical Report Series No. 3).
11. Mora JO, Estrada W, Swindale A. USAID/IMPACT micronutrient field support to the government of Honduras, 1994–97: achievements, results, and lessons learned. Washington, D.C.: U.S. Agency for International Development/IMPACT; 1997.
12. Oski FA. Effect of iron therapy on behavior performance in nonanemic, iron-deficient infants. Pediatrics 1983;71(6):877–880.
13. Walter T. Infancy: mental and motor development. Am J Clin Nutr 1989;50:675–686.
14. Lozoff B. Iron deficiency anemia and iron therapy effects on infant developmental test performance. Pediatrics 1987;79(6):981–995.
15. Chwang LC, Soemantri AG, Pollitt E. Iron supplementation and physical growth of rural Indonesian children. Am J Clin Nutr 1988;47 (3):496–501.
16. Latham M, Stephenson LS, Kinoti SN, Zaman MS, Kurz KM. Improvements in growth following iron supplementation in young Kenyan school children. Nutrition 1990;6(2): 159–165.
17. Ramdath DD, Golden MHN. Non-haematological aspects of iron nutrition. Nutr Rev 1989;2:29–49.
18. Cook JD, Lynch SR. The liabilities of iron deficiency. Blood 1986;68(4):803–809.
19. UNICEF/WHO Joint Committee on Health Policy. Strategic approach to operationalizing selected end-decade goals: reduction of iron deficiency anaemia. Geneva: World Health Organization; 1995.

Manuscript received on 14 March 1998. Revised version accepted for publication on 5 February 1999.

RESUMEN

Deficiencia de vitamina A y anemia en niños de 12 a 71 meses de edad en Honduras

En Honduras, la deficiencia de vitamina A (DVA) y la anemia ferropénica (AF) han sido problemas de salud pública reconocidos desde hace más de 30 años. Este trabajo, que se basa en la Encuesta Nacional de Micronutrientes de 1996 aplicada a 1 678 niños de 12 a 71 meses de edad, presenta los resultados relacionados con la situación de la vitamina A y la prevalencia de anemia, así como con las concentraciones de vitamina A en el azúcar de consumo domiciliario. Según los resultados, 14% de los niños tenían deficiencia subclínica de vitamina A (retinol plasmático < 20 μg/dL) y 32% estaban en riesgo de DVA (retinol en plasma 20–30 μg/dL). Estos datos indican que en Honduras la DVA es un problema de salud pública de importancia moderada. Un análisis de regresión logística demostró que los niños de 12–23 meses de edad que no vivían en la zona rural del sur del país corrían el mayor riesgo de DVA subclínica. El tener una infección, reflejada en una elevación de las concentraciones de alfa-1-glucoproteína ácida, aumentó más de tres veces el riesgo de DVA subclínica. Los niños de hogares con agua extraída de ríos, arroyos o lagos mostraron un riesgo doble de DVA subclínica, en comparación con otros niños. Ese mismo riesgo doble se encontró en niños de hogares con el baño situado en el exterior.

La VDA puede controlarse mediante la fortificación del azúcar. Las concentraciones de retinol en el azúcar de consumo domiciliario fueron de alrededor de 50% de las dictadas por la ley en Honduras. Hay una filtración importante de azúcar sin fortificar en el mercado, particularmente en la zona rural del norte, donde 33% de las muestras no tenían retinol.

En general, 30% de los niños mostraron anemia (Hb < 11 g/dL). Un análisis de regresión logística reveló que los niños cuyos padres vivían con ellos pero no habían cursado por lo menos el cuarto año de primaria corrían un riesgo 33% mayor de tener anemia. La presencia de una infección y el tener insuficiencia de peso aumentaron el riesgo de anemia en 51 y 21%, respectivamente, lo cual indica que los proveedores de atención de salud no siempre saben que la anemia es un problema muy diseminado en niños pequeños ni tampoco saben diagnosticarla.