RISK FACTORS FOR ANEMIA IN VIETNAM

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Abstract. Anemia is a significant public health problem in Vietnam, but representative national data and comprehensive risk factors analysis are lacking. The objectives of this study were to: 1) determine the distribution and severity of anemia in Vietnam, and 2) to assess potential risk factors for anemia. Nine thousand five hundred fifty households in 53 provinces were covered using a stratified two-stage cluster survey carried out in 1995. Selected household members were interviewed; intestinal helminthes were tested in non-pregnant women by Kato-Katz technique; hemoglobin concentrations were measured with Hemocue. Data were weighted and analyzed by survey procedures using SAS 9.0. Overall, 60% of children under 2 years old, 53% of pregnant women, 40% of non-pregnant women and 15.6% of men were anemic. Hookworm infection was the strongest factor associated with anemia (OR=1.7; 2.9 and 4.5 for 1-1,999, 2,000-3,999 and ≥ 4,000 hookworm egg counts, respectively) and accounted for 22% of anemia. Hookworm intensity was significantly associated with hemoglobin level; for each 1,000 egg increase, hemoglobin was reduced by 2.4 g/l. Living in different ecological zones, eating <1 serving of meat/ week, and farming were significantly associated with anemia in women and children. Other risk factors in women included having >3 children and having a child <24 months old. In men, no variables were found significantly associated with anemia.

INTRODUCTION

Nutritional anemia is a major public health problem in many developing countries. It is estimated that more than two billion people in the world are anemic (Mason, 2001), 90% of them living in developing countries and 600 million of them living in Southeast Asia, including Vietnam (WHO, 1992). The traditional Vietnamese diet is low in bioavailable iron and high in inhibitors of absorption, significant contributors to iron deficiency. In addition, the tropical climate supports a high prevalence of intestinal parasites that may increase anemia risk. Existing data indicate a high prevalence of iron deficiency anemia in Vietnam (Ha Huy Khoi, 2001), but comprehensive risk factor analyses are lacking. To fill this gap, the National Institute of Nutrition (Vietnam), UNICEF (Vietnam), the Centers for Disease Control and Prevention (USA), and the Institutes of Parasitology and Tropical Diseases (Vietnam) carried out a nationwide anemia survey in 1995. The objectives of this study were to use these national data 1) to document the extent and variation of anemia among children < 5 years, women and men, and 2) to assess major risk factors for anemia in Vietnam. This is the first publication reporting analyses of these data.

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MATERIALS AND METHODS

Sample design

The survey was designed as a two-stage

cluster survey and covered a total of 9,550 households in 141 communes and all 53 provinces of Vietnam (in 1995, the country was divided into 53 administrative provinces but now it is divided into 61 provinces). Initially, Vietnam was divided into 7 zones (Fig 1), defined by a grouping of provinces according to their geographic and ecologic similarities, such as, mountainous areas, river basins or coastal areas. Northern Mountain (zone 1) is a large land area with green hills or barren stony mountains. It is characterized by isolated hamlets with the ordinary constrains of transportation, communication and irrigation systems.

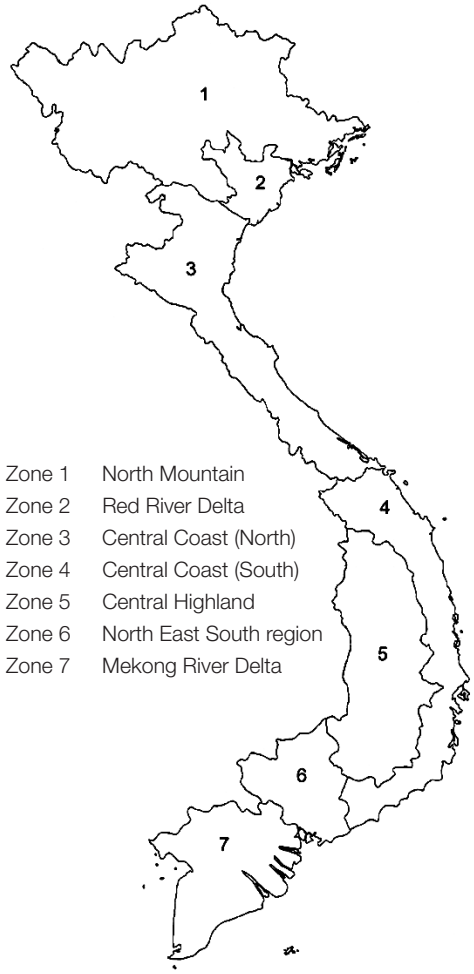

Fig 1–Map of Vietnam with ecological regions.

Red River Delta (zone 2) is where Hanoi, the capital of Vietnam, is located. It has a high population density and arable land is scarce, yet it is the second largest rice producer in the country. Northern Central Coastal region (zone 3) is a narrow strip dominated by mountains in the west. It produces industrial crops, such as peanuts, coffee and rubber. Southern Central Coastal region (zone 4) is characterized by a prolonged dry season; it has shortages of both food and labor. Central Highland (zone 5) is famous for industrial crops, such as coffee and rubber. The dry season is prolonged and the lack of water is a major constraint to the region. South region (zone 6), where Hochiminh city is located, is an urban and peri-urban area and it benefits from ready access to markets. Mekong River Delta (zone 7) is the most important rice growing area in the country. Each ecological zone was regarded as a survey universe to avoid the problem of missing large areas with lower population density. Data from the 1990 Vietnamese National survey were used to create a listing of the number of households by zones.

In the first stage, the number of households for each commune was listed within each ecological zone. Twenty clusters (communes) were selected using population proportional to size sampling with a sampling interval equal to 1/20 of the total number of households in the zone. In the second stage, a systematic random sample of 60 households was selected from an existing list of all children under five in each commune. In each household, the youngest child under five, the mother of the child selected and the father of the child selected were included in the survey. In addition, up to 20 households with pregnant women were selected using systematic sampling from the clinic register.

This survey included 9,550 households. Within these households there were 9,550 children under 5 years of age, 9,550 women (2,776 pregnant and 6,774 non-pregnant) and

9,451 men. Only 99 (1%) of the households did not have an adult male living in them.

Data collection

Data collection included two components: 1) an interview with selected household members, including collection of laboratory specimens, and 2) a community level survey with a key informant (commune leader or chief of clinic center). This community level information obviated the need to collect the same information at each household and decreased the survey and data processing time. Standardized questionnaires were used for both components. Hemoglobin (Hb) concentration was determined by finger-prick blood specimens using a portable field hemoglobin photometer (HemoCue system). Anemia was defined as a Hb value <12 g/dl for non-pregnant women, <11 g/dl for pregnant women and children, and <13 g/dl for men (Gillespie, 1998). Three intestinal helminths (hookworm, *A. lumbricoides and T. trichiura*) were sought in stool specimens by trained technicians assigned from the Institute of Parasitology using the Kato-Katz technique (WHO, 1991). Due to limited resources, helminth tests were conducted only on non-pregnant women. Infection intensity was reported as eggs per gram of stool (epg).

Data analysis

Household data were weighted to account for the probability of selection at the level of the zone and the commune. Survey analysis procedures (Korn and Graubard, 1999) from SAS version 9.0 (SAS, 2002-2004) were used to analyze the data, so that the complex data design was taken into consideration. The data set was cleaned using appropriate statistical procedures (Weisstein). All results are presented as weighted proportions or weighted means where appropriate. Linear trends in mean values were tested by linear regression. Multiple logistic regression models were used to explore potential risk factors and control for possible confounding variables. A logistic regression test for trend was used to test for an association between an ordinal categorical exposure and a dichotomous outcome. Data were modeled with the backward elimination process to identify the most parsimonious model from the saturated model. The Hosmer and Lemeshow Goodness of Fit test was used to judge whether a model worked well or not. Odds ratios and significant tests were presented. Population-attributable risks were calculated for each risk factor based on the multivariable models (Bruzzi *et al*, 1985).

RESULTS

Characteristics of the study population

Of the households surveyed, 81.3% lived in rural or remote areas, while only 18.7% lived in urban or suburban areas (Table 1). Zone 6 had the smallest proportion living in rural areas. In both men and women, about 2/3 reported their occupation as farming, with much smaller numbers in business or a salaried job. Not surprisingly, zone 6, the most urbanized, had the lowest proportion of farmers. Nationwide, 10.4% of women reported no formal schooling, 58.5% reported 1-7 years of schooling, and 31.1% ≥ 8 years. A slightly higher proportion of men reported having a formal education. Residents of zones 2, 4 and 6 had more education than those of other zones. Meat consumption was low. Only 17.5% of respondents consumed one serving of meat almost daily, 44% consumed meat 1-3 times a week and 38% had less than one meat serving per week. Fish sauce was consumed widely, with 70.5% of households using it almost daily.

Helminth data were available only for non-pregnant women. Nationally, 36.4% of women were infected with hookworm, 58.7% with *A. lumbricoides* and 28.2% with *T. trichiura.* Women in zone 3 had a high prevalence of all three worms, while women in zones 4 and 7

Table 1
Characteristics of the study population in different zones.

Characteristics	Zone 1 %	Zone 2 %	Zone 3 %	Zone 4 %	Zone 5 %	Zone 6 %	Zone 7 %	Total % (weighted)
Residence								
Rural	95.2	81.7	95.5	70.3	79.8	42.7	88.7	81.3
Urban	4.8	18.3	4.5	29.7	20.2	57.3	11.3	18.7
Mother's occupation								
Farming	94.6	76.7	80.5	70.7	73.0	21.7	54.6	68.3
Business	0.2	5.9	2.8	13.5	6.3	9.8	18.0	8.3
Salary	4.5	9.1	6.4	9.9	13.6	11.1	5.1	7.6
Others	0.7	8.3	10.3	5.9	7.1	57.4	22.3	15.8
Father's occupation								
Farming	91.6	67.8	77.2	65.8	73.1	26.8	55.4	65.5
Business	0.4	6.2	1.5	12.1	4.6	7.6	13.7	6.8
Salary	6.1	17.4	9.3	18.8	18.4	37.5	12.9	16.1
Others	1.9	8.6	12.0	3.3	3.9	28.1	18.0	11.6
Mother's education								
No formal education	17.6	0.5	5.7	21.4	31.4	8.0	11.9	10.4
1-7 years	61.4	64.0	66.4	35.8	40.2	54.4	61.3	58.5
≥ 8 years	21.0	35.5	27.9	42.8	28.4	37.6	26.8	31.1
Father's education								
No formal education	9.7	0.7	3.6	13.0	23.5	6.7	9.6	7.1
1-7 years	64.5	60.3	59.8	31.3	38.8	47.9	50.8	53.8
≥ 8 years	25.8	39.0	36.6	55.7	37.7	45.4	39.6	39.1
Worm infections in non-pregnant women								
Hookworm	30.3	26.6	67.5	37.4	71.4	42.2	15.6	36.4
A. lumbricoides	76.8	79.4	80.6	26.0	23.9	19.7	34.5	58.7
T. trichiura	27.5	41.3	62.4	4.0	16.6	15.4	1.4	28.2
Consumption of meat								
<1 per week	35.5	27.3	54.4	46.6	49.7	26.8	44.1	38.5
1-3 per week	44.8	54.6	43.0	39.6	35.0	38.0	39.0	44.0
Almost daily	19.7	18.1	2.6	13.8	15.3	35.2	16.9	17.5
Consumption of fish sauce								
<1 per week	38.0	12.9	21.4	20.8	35.1	13.3	5.9	18.3
1-3 per week	12.6	7.9	17.7	1.8	12.0	22.8	7.0	11.2
Almost daily	49.4	79.2	60.9	77.4	52.9	63.9	87.1	70.5

had the lowest prevalence. Hookworm infection was highest in zone 5 and lowest in zone 7.

Prevalence of anemia

Anemia prevalence was highest in women and children, and within these groups, pregnant women and children <2 years old were most affected (Table 2). Anemia was relatively uncommon in men. Zone 3 had the highest prevalence of anemia among women, both non-pregnant and pregnant, whereas zone 5 had the highest prevalence for children and men (Table 3). Zone 2 (where Hanoi is located) had the lowest anemia prevalence for most

Table 2
Prevalence of anemia, mean hemoglobin by population subgroup.

Population group	N	Hemoglobin (g/dl)[a]		Prevalence of anemia[a, b]		Prevalence of severe anemia[a,c] %
		Mean	95% CI	%	95% CI	
Children (age group)						
0 - 5 months	692	10.6	10.5-10.8	61.3	57.0-65.6	0.4
6 - 23 months	3,201	10.6	10.5-10.7	59.1	55.8-62.3	1.0
24 -60 months	3,045	11.5	11.5-11.6	28.1	25.5-30.6	0.3
All children	6,938	11.0	10.9-11.1	45.1	42.7-47.4	0.7
Non-pregnant women	6,726	12.1	12.0-12.2	39.9	37.2-42.7	0.6
Pregnant women	2,755	10.8	10.7-10.9	52.5	49.7-55.4	0.8
Men	2,415	14.2	14.1-14.3	15.6	13.4-17.9	0.2

[a]Weighted mean or prevalence
[b]Anemia defined as: Children, Hb < 11 g/dl; Non-pregnant women, Hb < 12 g/dl; Pregnant women, Hb < 11 g/dl; Adult men Hb < 13 g/dl
[c]Severe anemia defined as Hb <7g/dl

groups. Zone 6, the most urbanized zone, had the second lowest prevalence of anemia for non-pregnant women, but the prevalence among children was close to the national average.

Risk factors for anemia in non-pregnant women

In univariate analysis, the prevalence of anemia varied significantly depending on several variables (Table 4). Working as a farmer, eating meat less than once per week, having >3 children or a child <24 months old, hookworm infection, and low educational attainment (data not shown) were all associated with a higher risk of anemia. There was a clear dose-response relationship between the intensity of hookworm infection and anemia. Among women with ≥4,000 epg, 72% were anemic, compared to 61% of those with 2,000-3,999 epg, 49% of those with 1-1,999 epg, and 33% of those without hookworm. The relationship between hookworm infection intensity and mean Hb concentration was very strong (Fig 2). For each increase of 1,000 hookworm epg, Hb concentration decreased by an estimated 2.4 g/l (95% CI: 1.8-3.0).

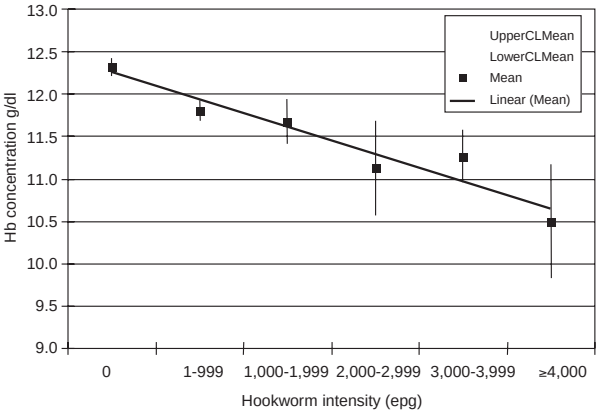

Fig 2–Association between hookworm intensity and hemoglobin concentration.

In multivariate logistic regression models, six potential factors remained significant predictors of anemia. Working as a farmer, consumption of meat less than once per week, having more than 3 children and having given birth in the previous 24 months were all associated with odds ratios ranging from 1.2 to 1.5. Nevertheless, hookworm infection was the strongest predictor of anemia, with the same marked dose-response relation seen in univariate analyses (Table 4). Neither *A.*

Table 3
Prevalence of anemia among different subjects by different zones.

Ecological regions	Non-pregnant women		Pregnant women		Children		Men	
	No. of subjects studied	Prevalence of anemia %	No. of subjects studied	Prevalence of anemia %	No. of subjects studied	Prevalence of anemia %	No. of subjects studied	Prevalence of anemia %
Zone 1	1,028	40.9 (34.7-47.1)[a]	383	52.4 (44.5-60.2)	1,411	44.7 (38.4-50.9)	1,398	17.9 (11.3-24.6)
Zone 2	934	33.7 (26.1-42.3)	387	51.3 (44.6-58.0)	1,321	36.8 (31.7-41.8)	1,318	11.6 (6.3-17.0)
Zone 3	963	49.8 (43.9-55.7)	439	58.6 (52.1-65.1)	1,402	43.1 (36.8-49.3)	1,379	13.8 (8.8-18.8)
Zone 4	945	41.8 (33.2-50.3)	353	54.7 (46.4-63.1)	1,298	48.6 (41.8-55.4)	1,270	17.8 (12.5-23.1)
Zone 5	1,001	45.9 (39.2-52.5)	388	48.2 (39.1-57.3)	1,389	60.8 (54.1-67.5)	1,378	19.9 (13.7-26.2)
Zone 6	935	36.4 (26.9-45.9)	419	50 (41.1-58.9)	1,354	45.3 (36.6-53.9)	1,339	15.4 (8.6-22.1)
Zone 7	968	39.8 (33.9-45.7)	407	50.9 (43.5-58.3)	1,375	51.3 (45.7-57.0)	1,369	18.7 (13.3-24.1)
National estimate	6,774	39.9 (37.2-42.7)	2,776	52.5 (49.7-55.4)	9,550	45.1 (42.7-47.4)	9,451	15.6 (13.4-17.9)

[a]95% confidence interval

lumbricoides nor *T. trichiura* was associated with anemia risk. Women living in zones 3, 4, and 7 were more likely to be anemic than those living in zone 2.

We used the multivariable model and population-based survey results to estimate the population-attributable fraction for each preventable risk factor. Place of residence was not considered, because it is not likely to be altered through public health measures. Twenty-two percent of anemia was attributable to all hookworm infection, but only 6% to moderate and heavy hookworm infection (≥ 2,000 epg), 25% to working as farmers, 9% to having more than three children, 11% to low meat consumption and 7% to childbirth in the previous 24 months.

Risk factors for anemia in pregnant women

In univariate models, the risk factors for anemia that could be assessed in pregnant women were similar to those for non-pregnant women. Stool specimens were not examined for pregnant women, so the contribution of hookworm infection could not be estimated. Three significant risk factors were identical: working as a farmer, low meat consumption (Table 5), and having more than 3 children (data not shown). In addition, the further along the women were in pregnancy, the more likely they were to be anemic. In multivariate logistic regression models adjusted for ecological zones, three potential factors remained as significant predictors of anemia: farming, low meat consumption and trimester of pregnancy (Table 5). Nearly 11% of anemia was attributable to low meat consumption and 16% to working as farmers.

Risk factors for anemia in children

Similarly, stool specimens were not examined for children. In univariate analyses,

Table 4
Risk factors associated with anemia among non-pregnant women in Vietnam.

Factors	Percentage anemic %	Multiple logistic regression		Population attributable risk %
		OR	95% CI	
Occupation				
Farming	43.6	1.5	1.1-1.8	25
Others	32.1	ref		
Meat consumption				
< 1/wk	45.9	1.3	1.0-1.8	11
1-3 times/wk	37.9	1.1	0.9-1.3	
Almost daily	31.9	ref		
Parity				
≥ 3 children	46.3	1.3	1.2-1.5	9
0-2 children	36.2	ref		
Age of youngest child				
< 24 mos old	41.0	1.2	1.0-1.3	7
≥ 24 mos old	38.7	ref		
Hookworm egg counts				
≥ 4,000	72.0	4.6	2.2-9.3	22
2,000-3,999	61.0	2.8	1.7-4.6	
1-1,999	48.6	1.7	1.4-2.0	
0	33.6	ref		
Ecological regions				
Zone 1	40.9	1.2	0.8-1.7	
Zone 2	33.7	ref		
Zone 3	49.8	1.4	1.0-2.1	
Zone 4	41.8	1.4	1.0-1.9	
Zone 5	45.9	1.1	0.8-1.5	
Zone 6	36.4	1.4	0.8-2.3	
Zone 7	39.8	1.5	1.0-2.3	

Table 5
Risk factors associated with anemia among pregnant women in Vietnam.

Factors	Percentage anemic[a] %	Multiple logistic regression[b]		Population attributable risk %
		OR	95% CI	
Occupation				
Farming	55.4	1.4	1.1-1.7	16
Others	46.5	reference		
Meat consumption				
< 1/week	56.5	1.5	1.1-1.9	11
1-3 times/week	52.6	1.3	1.0-1.7	
Almost daily	43.7	reference		
Gestational age				
1-14 weeks	30.2	reference		
15-28 weeks	52.0	2.6	2.1-3.2	
> 28 weeks	60.4	3.6	2.8-4.7	

[a]Weighted percentage; [b]Model adjusted for ecological zones

Table 6
Risk factors associated with anemia among children in Vietnam.

Factors	Percentage anemic %	Multiple logistic regression		Population attributable risk %
		OR	95% CI	
Mother's occupation				
Farmers	47.2	1.3	1.1-1.6	17
Others	40.5	ref.		
Mother's education				
No formal schooling	60.8	1.8	1.2- 2.6	11
< 8 years schooling	44.8	1.2	1.0- 1.4	
≥ 8 years schooling	39.7	ref.		
Meat consumption				
< 1/wk	50.7	1.3	1.1- 1.6	8
1-3 times/ wk	42.2	1.1	0.9-1.3	
Almost daily	39.6	ref.		
Children's age				
< 24 months	59.5	3.7	3.2-4.3	
≥ 24 months	28.1	ref		
Fever in last 2 weeks				
Yes	50.2	1.2	1.1-1.4	3
No	44.1	ref.		
Diarrhea in last 2 weeks				
Yes	54.1	1.2	1.0-1.5	2
No	43.8	ref.		
Ecological zones				
Zone 1	44.7	1.2	0.8-1.8	
Zone 2	36.8	ref.	0.9-1.8	
Zone 3	43.1	1.3	1.0-2.0	
Zone 4	48.6	1.4	1.4-2.7	
Zone 5	60.8	2.0	1.1-2.4	
Zone 6	45.3	1.6	1.2-2.4	
Zone 7	51.3	1.7		

children of mothers working as farmers, and of those with no formal education, had higher prevalence of anemia than children of women with other occupations and more education (Table 6). Younger children and those with fever or diarrhea in the previous 2 weeks were also more likely to be anemic. In multivariate logistic regression models, seven factors remained as significant predictors of anemia: having mothers who were farmers, having no formal education, consumption of meat <1 serving per week, age <24 months, fever or diarrhea in previous 2 weeks, and ecologic zone (Table 6). Nearly 17% of anemia was attributable to maternal occupation as a farmer, 11% to low meat consumption, 8% to low maternal education, 3% to fever and 2% to diarrhea in the last two weeks.

Risk factors of anemia for men

No significant associations of any variables with anemia were found for men.

DISCUSSION

Anemia is a major public health challenge in Vietnam according to the analyses pre-

sented. The 1995 anemia survey was nationally representative and careful attention was paid to design and methods of data collection. This is the first publication of the results of this survey. Although the survey was collected over a decade ago, the findings remain important. First, they serve as a baseline for future surveys. Second, the relationships explored, such as the risk factors associated with anemia, are likely to remain valid over time. On the other hand, the extent of anemia and helminth infection may have declined since the 1995 survey, but the degree of change is unknown since no national data are available for comparison to the 1995 data. In recent years, Vietnam's economy has changed appreciably. Annual gross domestic product growth averaged around 8% from 1990 to 1997 and 6.5% from 1998-2004. However, anemia and helminth infections remain a significant public health problem. For example, a study in Phan Tien Village in southern Vietnam found that the prevalence of anemia was 43% among the mountainous ethnic minority community (Le Hung *et al*, 2005). In addition, various studies have shown very high prevalence of hookworm infections. For example, a review of various surveys that were done in several localities between 1991-2001 showed that the hookworm prevalence was 28% (van der Hoek *et al*, 2003). Another local study in 2003 in Hoabinh Province in northwest Vietnam showed that 52% were infected with hookworm (Verle *et al*, 2003), a figure not unlike that of 30.3% found for this region in 1995. The tropical climate and the largely unchanged nature of the agricultural economy may help explain the persistence of helminth infections. The1995 findings are also relevant for other countries in the region, such as Lao PDR and Cambodia, which share common agricultural practices and a similar climate.

Our data describe a continuing cycle that perpetuates the high prevalence of nutritional anemia in the Vietnamese population. A very large proportion of reproductive-age women have low iron reserves from high rates of hookworm infection, frequent child-bearing, inadequate birth spacing, and diets low in bioavailable iron. Maternal low iron reserves during gestation lead to iron deficiency in their infants, who are often unable to replenish their reserves in childhood because of low dietary iron intake. To break this cycle will require an effective program to control anemia in women and children. The very high prevalence underscores the need for a population-based approach.

Because our study was based on a nation-wide survey with a large sample size and was representative of all ecological zones, our data provide the first comprehensive overview of anemia in Vietnam. While it is clear from our data that some areas of the country are at higher risk than others, anemia is a substantial problem throughout Vietnam. The cross-sectional nature of the analysis precludes the rigorous determination of causal relationships, and we only assessed hookworm infection in non-pregnant women. We were unable to determine status with respect to malaria and this may be an important contributor in some parts of the country. In addition, our dietary iron determination was very rough, based only on semi-quantitation of reported meat intake and we were unable to assess intake of inhibitors of iron absorption, such as vegetable phytates and tannins in tea. Another potential unmeasured contributor to anemia may be hemoglobinopathies, some of which occur in parts of Vietnam (Svasti *et al*, 2002). Nevertheless, the risk factors we describe are consistent with decades of previous research, and none are surprising. The only surprising findings are the very high frequencies of anemia and the major risk factors, such as hookworm infection.

In children, anemia has profound adverse effects, including growth stunting, cognitive delays and reduced physical activity (Stephenson *et al*, 2000). In addition to improving the

child's dietary iron intake, prevention of iron deficiency in childhood will require better maternal iron nutrition during pregnancy. The high prevalence of anemia among very young children is explained in part by the fact that more than half of pregnant women were anemic. This reflects an even higher prevalence of low iron stores in the mothers, since anemia appears only late in the course of iron depletion. Iron-deficient mothers themselves are at higher risk for hemorrhage and maternal mortality (WHO, 1996), and their infants begin their development at a disadvantage from low birth weight, and higher rates of prematurity and infant mortality (Steketee, 2003). Our data indicate that population-based, rather than targeted interventions to improve iron nutrition in reproductive age women, before as well during pregnancy, will be essential to anemia prevention in both women and children.

Our data highlight the multifactorial nature of iron deficiency in reproductive-age women. In Vietnam, women who farm and those who live in the zones most hospitable to hookworm were at highest risk, but women from nearly all parts of the country had high rates of anemia due to widely shared factors. These factors include inadequate dietary iron and the nutritional demands of menstruation, repeated pregnancies and lactation. The combined iron losses make it nearly impossible for women's iron intake to keep up. Farming was strongly associated with high anemia risk, an association likely mediated through several factors that contribute to anemia, including higher rates of poverty, lower access to high quality dietary iron sources, and perhaps most importantly, higher exposure to fecal contamination in fields fertilized with human excreta, leading in turn to higher hookworm risk.

In individual analyses of reproductive age women, hookworm was the strongest risk factor for anemia. We were only able to collect intestinal helminth infection data for non-pregnant women, but these data are likely to mirror rates in other demographic groups as well. For example, the ecological zone with the highest prevalence of hookworm (zone 5) also had a high anemia prevalence in men and children. The strength of the association is underscored by a linear corelation between hookworm infection intensity and mean hemoglobin, consistent with previous studies (Stoltzfus *et al*, 1997, 1998). Clearly, the highest intensity hookworm infections confer the highest risk. Nevertheless, our data demonstrate that among Vietnamese women, the anemia burden due to light hookworm infections is far greater than that due to heavy infections. We estimate that targeting moderate to heavy infections would decrease the anemia burden by only 6% compared to 22% for the complete elimination of hookworm.

Despite the use of only a rough proxy measure, our data confirm that iron consumption is seriously inadequate. Nearly 40% of households reported consuming less than one meat serving per week and 44% only 1-3 servings per week. These findings are similar to the results of the 2000 General Nutrition Survey which reported per capita iron intake of 11.2 mg per day, with absorption rates of 5-10% of iron content (Anonymous, 2003). This amount is too small to satisfy the iron requirements of reproductive age women. A recent study confirms that 80% of anemia in Vietnam is associated with iron deficienry anemia (Le Hung *et al*, 2005). In our data, low meat consumption was a significant risk factor for anemia in both women and children. These findings suggest the need for iron supplementation, food fortification and/or dietary intervention. Fish sauce was reported to be consumed almost daily by 70.5% of households, indicating a potentially useful food for iron fortification. Indeed, a recent study demonstrated that iron-fortified fish sauce significantly reduced the prevalence of iron deficiency anemia in Vietnamese women during a 6-month intervention (Thuy *et al*, 2003).

In summary, our data highlight the widespread problem of iron deficiency anemia in Vietnam and support the idea that population-based interventions to improve bioavailable iron consumption, birth spacing, prenatal iron supplementation, and to decrease hookworm risk should be instituted. Targeting may be possible at the level of zones or regions, and should ensure high coverage of the highest risk groups, including female farmers, reproductive age women and young children.

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