INTESTINAL HELMINTH INFECTIONS AMONG REPRODUCTIVE AGE WOMEN IN VIETNAM: PREVALENCE, CO-INFECTION AND RISK FACTORS

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Abstract. Intestinal helminth infections are a significant public health problem for Vietnamese women, but prevalence and risk factor data are scarce. The objectives of this paper were to 1) determine the prevalence of helminth infections among women; 2) investigate interactions among intestinal helminth species in individuals and 3) identify risk factors that contribute to intestinal helminth infections. In a nationwide survey conducted in 1995, 9,550 households in 53 provinces were covered using a stratified two-stage cluster survey. Stool specimens were examined by Kato-Katz technique. Of 5,127 women, 76% were infected with one or more helminth species, 36% with hookworm, 59% with *Ascaris lumbricoides* and 28% with *Trichuris trichiura*. *A. lumbricoides* and *T. trichiura* were more likely to be concurrent than expected by chance. There was significant interaction between prevalence and intensity of infection in all three species. All three helminth species were more common in certain ecologic zones than others. Hookworm infection was associated with farming [Odd ratio (OR)=2.1] and lack of a closed latrine (OR=2.0), *A. lumbricoides* with use of untreated feces as fertilizer (OR=1.2) and co-infection with *T. trichiura* (OR=2.1) and *T. trichiura* with *A. lumbricoides* co-infection (OR=2.1). Our findings suggest that reproductive-age women, especially rural farmers, should be included among the high priority groups for helminth control programs through mass chemotherapy and improving sanitation.

INTRODUCTION

Intestinal helminth infections are a significant public health problem in many developing countries. More than 3.5 billion people worldwide are currently infected with one or more species of intestinal helminths (Crompton, 1999). Southeast Asia is one of the regions most affected (Luong, 2003). The warm, humid climate, agricultural economy and poor sanitation contribute to the high prevalence of intestinal parasites in Vietnam. Published estimates report rates of 50-95% for *Ascaris lumbricoides,* 30-68% for hookworm and <1-89% for *Trichuris trichiura* (Nguyen Duy Toan, 2000).

The importance of helminth infections is due largely to their impact on nutritional status, including protein energy and micronutrient malnutrition (Crompton and Nesheim, 2002), with resultant effects on hemoglobin levels (Stoltzfus *et al,* 1997), cognitive development (Nokes *et al,* 1992a,b; Sakti *et al,* 1999), productivity (Gilgen *et al,* 2001), and pregnancy outcomes (Steketee, 2003; Stephenson *et al,* 2000). Existing data from Vietnam document high rates of helminth in-

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fections in selected areas (Nguyen Duy Toan, 2000) and a disproportionate impact on women (Needham *et al,* 1998). However, detailed information with broad geographic coverage is lacking.

In 1995, the National Institute of Nutrition (Vietnam), National Institute of Malariology, Parasitology and Entomology (Vietnam), UNICEF (Vietnam), and the Centers for Disease Control and Prevention (USA) conducted a nationwide health and nutrition survey. Anemia rates were measured for all demographic groups. Stool specimens were examined for women of reproductive age only. The results of this extensive survey remain unpublished, although a preliminary analysis was carried out. We performed an analysis of these data to 1) determine the prevalence of helminth infections among women across all regions of Vietnam, 2) investigate interactions among different intestinal helminth species in individuals, and 3) identify risk factors that contribute to intestinal helminth infections. Although the survey was carried out a decade ago, environmental conditions have not changed dramatically in Vietnam such that the information from the survey is still valid for program planning, as are the relationships explored in this analysis. The information also provides a baseline against which to measure public health improvements.

MATERIALS AND METHODS

Sample design and description of ecologic zones

The survey population was chosen in two stages, designed to cover all ecologic zones of the country, and to represent all 53 provinces of Vietnam as defined in 1995 (subsequent changes resulted in the current administrative structure of 65 provinces). Seven geographic zones were defined, grouping provinces by ecologic similarities, such as mountains, river basins and coastal areas (Fig 1). The Northern Mountain region (zone 1) is a large land area, with green hills and barren stony mountains, populated in isolated hamlets with limited transportation, communication and irrigation systems. The Red River Delta (zone 2), which includes the national capital Hanoi, has a high population density and intensive rice farming, making it the

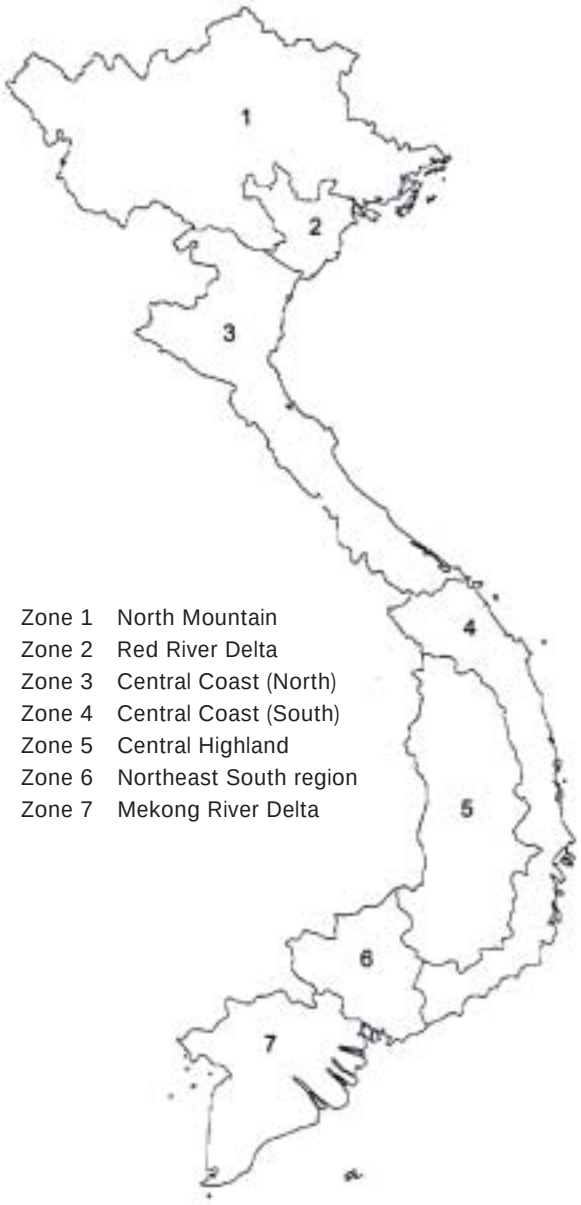

Fig 1–Map of Vietnam with ecological regions.

second largest rice-producing zone. The Northern Central Coastal region (zone 3) is a narrow strip of coastal land bounded by mountains in the west. Industrial crops, such as peanuts, coffee and rubber, are grown here. The Southern Central Coastal region (zone 4) is characterized by a prolonged dry season, and suffers from shortages of both food and labor. The Central Highland (zone 5) is known for the cultivation of coffee, rubber and other industrial crops. The dry season is prolonged and lack of water is a major constraint in this zone. The Northeast of South region (zone 6), including Ho Chi Minh city (formerly Saigon), is a relatively urbanized zone that benefits from ready access to markets. The Mekong River Delta (zone 7) is the most important rice growing area in the country. Each ecological zone was regarded as a survey zone to avoid the problem of missing large areas with low population density and to allow accurate estimates of parameters by zone.

In the first stage of selection, data from the 1990 Vietnamese National survey was used to create zonal lists of communes and the number of households in each commune. For each zone, 20 communes (clusters) were selected using population proportional to size sampling, with a sampling size equal to 1/20 of the total number of households. In the second stage, a systematic random sample of 60 households per commune was selected from an existing list of all children <5 years old. In each household, the youngest child and his or her mother and father were included in the survey.

Data collection

The selected household members were interviewed using a structured questionnaire. Stool specimens were examined by trained technicians from the National Institute of Malariology, Parasitology and Entomology using the Kato-Katz technique (WHO, 1991). Infection intensity was quantified as eggs per gram of stool (epg). Due to limited resources, the helminth tests were conducted only for non-pregnant women.

Data analysis

Household data was weighted to account for the probability of selection at the level of the zone and the commune, using survey data analysis procedures in SAS version 9.0 (Korn *et al,* 1999; SAS, 2002-2004). The data set was cleaned using biologic criteria and statistical procedures (Weisstein). All results are presented as weighted proportions and weighted means, where appropriate.

A log-linear model was used to investigate the interaction of co-infections between each pair of helminth species (Booth and Bundy, 1992; Howard *et al,* 2001). This model tests the assumption that the probability of being infected by any one species is independent of being infected by any other species. “High intensity” infections were defined as those with egg counts in the top 20% for each species (Forrester *et al,* 1988; Needham *et al,* 1998). A contingency table and chi-square were used to investigate the interactions between high intensity infections with each of the helminth species.

Univariate analyses and chi-square tests were used to examine the association of potential risk factors with infection by each intestinal helminth. Multivariable models were constructed using the backwards elimination process, and the resulting models were tested by the Hosmer and Lemeshow Goodness of Fit test.

RESULTS

A total of 9,550 women were included in the anemia survey. This analysis focuses on a subset of 6,774 women who were not pregnant at the time of survey. Of these, 5,127 (75.7%) had a stool specimen examined for helminth eggs. The weighted estimate for the national prevalence of any helminth infection in non-pregnant women was 76.2% (Table 1). The

Table 1
Prevalence of intestinal helminth infections among non-pregnant women by ecological regions in Vietnam, 1995.

Zone	Descriptions	No. of women examined	Total helminth positive %	Hookworm		*A. lumbricoides*		*T. trichiura*	
				Prevalence (%)	Intensity[b] (Egg/g feces)	Prevalence (%)	Intensity[b] (Egg/g feces)	Prevalence (%)	Intensity[b] (Egg/g feces)
1	Northern mountain	888	88.4 (84.5-92.3)[a]	30.3 (19.8-40.8)	173 (76-271)	76.8 (71.9-81.6)	3,429 (1,539-5,319)	27.5 (18.0-36.9)	53 (24-82)
2	Red River Delta/Hanoi	757	89.6 (86.5-92.7)	26.6 (17.4-35.8)	117 (49-184)	79.6 (75.2-84.0)	3,996 (3,138-4,856)	41.3 (33.5-49.1)	139 (70-208)
3	Central coast/North sea	799	99 (97.9-100)	67.5 (57.5-77.6)	544 (288-801)	80.8 (73.5-88.1)	8,355 (4,167-12,543)	62.4 (48.5-76.2)	582 (272-892)
4	Central coast/South sea	794	52.8 (39.7-65.9)	37.3 (25.3-49.5)	491 (220-761)	26.1 (15.0-36.3)	1,368 (551-2,184)	4 (1.3-6.6)	17 (5-30)
5	Central Highland	800	83.1 (77.5-88.7)	71.4 (63.1-79.7)	723 (499-948)	23.9 (14.8-32.9)	376 (158-595)	16.6 (10.9-22.3)	24 (11-36)
6	Ho Chi Minh City	567	58.2 (45.9-70.5)	42.2 (26.0-58.3)	348 (91-605)	20 (9.4-30.6)	800 (149-1,451)	15.4 (3.4-27.4)	35 (0-70)
7	Mekong River Delta	522	42 (28.5-55.4)	15.6 (6.1-25.0)	30 (10-51)	34.3 (22.4-46.2)	157 (72-241)	1.3 (0-3.1)	0.7 (0-2.2)
Total		5,127	76.2 (73.6-78.8)	36.4 (32.2-40.6)	270 (210-330)	58.7 (55.8-61.3)	3,233 (2,500-3,965)	28.2 (24.8-31.6)	141 (94-188)

[a]95% confidence interval for prevalence

[b]Intensity of worm infection was calculated as arithmetic means

Table 2
Sociodemographic, environmental characteristics and intestinal helminth infections among non-pregnant women in Vietnam, 1995.

			Hookworm		*Ascaris*		*Trichuris*	
Charateristics	n	Percentage	%	95% CI	%	95% CI	%	95% CI
Geographical areas								
Rural	1,390	81.4	39.1[a]	34.4-43.7	61.3[a]	57.4-65.2	29.5	25.2-33.8
Urban	5,384	18.6	22.2	14.5-30	42.7	30.4-54.9	21.3	12.1-30.6
Occupation								
Farming	2,170	68.5	40.8[a]	35.9-45.7	64.5[a]	60.8-68.3	30.1	25.6-34.6
Others	4,604	31.5	24.9	19.2-30.6	42.1	35.4-48.8	23.1	16.3-30.0
Schooling year								
No formal education	965	10.7	41.6	29.7-53.6	48.6[a]	36.5-60.7	19.7	10.3-29.0
1-7 years	3,722	59.2	37.7	33.1-42.3	62.4	58.9-65.9	30	25.4-34.6
≥ 8 years	2,028	30.2	32.4	27.4-37.5	54	49.7-58.4	27.7	23.1-32.4
Using manures								
Yes	1,992	25.4	43.1[a]	34.8-51.4	79.5[a]	76.2-82.8	40.8[a]	33.6-47.9
No	7,526	74.6	33.8	29.4-38.2	49.8	45.7-53.8	23.1	19.5-26.7
Place of defecation								
Closed latrines	1,167	11.7	18.5[a]	12.1-24.9	42.6[a]	30.7-54.6	21.9[a]	14.2-29.7
Open latrines	5,158	54.9	42.8	37.7-48.2	68.7	65.1-72.4	36.5	31.7-41.4
River/pond	1,338	18.4	17.7	10.5-24.7	33.5	24.0-43.0	2.8	1.0-4.6
Bush/open field	1,511	12.5	38.1	27.7-48.1	47.5	36.0-59.0	20.1	11.3-28.9
Elsewhere	376	2.6	42.3	30.9-53.7	61	45.4-76.6	31.9	12.8-51.0

[a]Significant difference in bivariate comparisons

prevalence was lowest in the southernmost zone 7 (42%) and highest in the northern zones 1, 2, and 3 (88 to 99%) (Table 1). Geographic differences were seen for the prevalence of specific helminth species. Hookworm infections were most frequent in the central highlands (zone 5, 71.4%) and central coastal zone (zone 3, 67.5%), and lowest in the far south (zone 7, 15.6%). *Ascaris lumbricoides* and *Trichuris trichiuras* were the most prevalent in the northern zones and the central coastal zone 3 (80.8% and 62.4%, respectively). For all 3 species of worms, the zones with the highest prevalence also demonstrated the greatest intensity of infection (correlation coefficients: hookworm, p = 0.0027, R-square = 0.86; *A. lumbricoides*: p = 0.02, R-square = 0.7; for *T.trichiura* p = 0.008, R-square = 0.79).

Helminth co-infections

Of the women tested, 8.3% were infected with all 3 worm species, 12.5% with hookworm and *A. lumbricoides,* 11.1% with *A. lumbricoides* and *T. trichiura,* and 3.5% with hookworm and *T. trichiura.* The log-linear model demonstrated a strong positive interaction between *A. lumbricoides* and *T. trichiura*. The relationship between hookworm and the other 2 helminth species was more complex, with a higher prevalence of hookworm infection in the population co-infected with both *A. lumbricoides* and *T. trichiura*, but a negative correlation between hookworm and *A. lumbricoides* in the absence of *T. trichiura*. Women with high intensity *A. lumbricoides* infection were more likely to have high intensity *T. trichiura* infections, and high intensity infec-

Table 3
Significant risk factors in multivariate logistic regression analysis of the studied factors and intestinal helminth infections, Vietnam, 1995.

	Hookworm[a]		*Ascaris*		*Trichuris*[b]	
Characteristics	OR	95% CI	OR	95% CI	OR	95% CI
Occupation						
Farming	2.2	1.6-2.8				
Others	ref					
Using untreated feces for farming						
Yes			1.3	1.0-1.6		
No			ref			
Place of defecation						
Others	2.1	1.4-3.1				
Closed latrines	ref					
Co-infection						
Yes			2.0[c]	1.6-2.7	2.0[d]	1.6-2.7
No			ref		ref	
Ecological regions						
Zone 1	1.8	0.8-4.2	11.7	6.4-21.6	1.7	0.6-4.5
Zone 2	1.8	0.8-3.9	12.3	6.4-23.5	3.0	1.2-7.5
Zone 3	10.5	4.7-23.7	11.4	5.5-23.9	7.1	2.6-19.9
Zone 4	3.1	1.4-7.1	1.6	0.7-3.3	0.2	0.1-0.7
Zone 5	12.1	5.7-25.9	1.2	0.6-2.6	1.2	0.5-3.0
Zone 6	5.9	2.5-14.2	ref		ref	
Zone 7	ref		2.4	1.1-4.9	0.1	0.02-0.3

[a]Model adjusted for infection with *A. lumbricoides, T. trichiura* and interaction between them
[b]Model adjusted for women's occupation; [c]Co-infection with *T. trichiura*; [d]Co-infection with *A. lumbricoides*

tions with all 3 worms were also more common than expected by chance.

Risk factors for helminth infections

Infection prevalence for all three species tended to increase between 15 and 20 years of age and then to plateau, with a second upward slope after age 40 for hookworm. However, no statistically significant association was found between age and the prevalence or intensity of any of the intestinal helminths. For hookworm and *A.lumbricoides*, infection prevalence was significantly higher in rural areas than in urban/suburban areas, and in women who worked as farmers (Table 2). In univariate analyses, there was an inverse relationship between education level and helminth infection, but this reached statistical significance only for *A. lumbricoides*. Use of untreated feces as fertilizer and open latrines showed a significant association with all three helminth infections. Those using closed latrines or river/pond for defecation were least likely to be infected. However, nearly all users of river/pond reside in zone 7, raising the possibility of other ecologic differences that might confound this relationship.

In multivariate logistic regression models, three potential factors remained as significant predictors of hookworm infection: farming, lack of a closed latrine, and zone of residence (Table 3). For *A. lumbricoides*, significant predictors were use of untreated feces as fertilizer, co-

infection with *T. trichiura* and zone of residence. For *T. trichiura,* only co-infection with *A. lumbricoides* and zone remained significant.

DISCUSSION

Our findings, based on the first nationwide helminth survey in Vietnam, demonstrate strikingly high rates of infection in reproductive-age women. In the country as a whole, 76% of women were infected with one or more helminth species, 59% with *A. lumbricoides*, 36% with hookworm and 28% with *T. trichiura*. Although Vietnam has seen rapid economic growth in the last ten years, socioeconomic improvements have occurred predominantly in cities. The situation in rural areas with respect to sanitation and other factors related to helminth infection has not changed substantially. A recent survey in one province in northern Vietnam still showed a very high prevalence of helminth infections: hookworm (52%), *T. trichiura* (50%) and *A. lumbricoides* (45%) (Verle *et al,* 2003). These high helminth infection rates carry a significant impact for both the health and development of the Vietnamese population. Hookworm is an important contributor to anemia (Stoltzfus *et al,* 1997) a major public health issue for women of reproductive age. Other negative effects of helminth infections and anemia include hindering growth (Stephenson *et al,* 1989, 1993a,b), impeding physical fitness (Stephenson *et al,* 1990, 1993a), decreasing physical activity (Stephenson *et al,* 1990), damaging school performance (Nokes *et al,* 1992a,b; Sakti *et al,* 1999) and reducing work productivity (Gilgen *et al,* 2001). Based on our data, helminth control should be a high priority for Vietnamese public health policy.

The prevalence of infection varied widely by zone, reflecting differences in climate, environment, sanitary practices and the use of human waste as fertilizer. *A. lumbricoides* and *T. trichiura* infections were most common in the northern zones, where both composted and untreated human feces are often used as fertilizer. These two helminth species were less common in the south, perhaps due to the prolonged dry season that may decrease survival of eggs in soil (Toan, 1992). Hookworm distribution was somewhat different, with two diverse ecologic zones (central coast and central highlands) most affected, a finding consistent with published data (van der Hoek *et al,* 2003). Our methods did not distinguish between *Necator americanus* and *Ancylostoma duodenale*, but a previous study in Vietnam identified 98% of hookworm infections as *N. americanus* (De, 1995).

The interaction between *A. lumbricoides* and *T. trichiura* infection and intensity was not surprising, given the common mode of transmission of these two worm species; our findings confirm those of previous studies (Booth and Bundy, 1992; Needham *et al,* 1998). However, our analysis also showed that hookworm infection was more common than expected in individuals infected with the other two worm species. This finding varies from that of a study in Hanam Province, where hookworm infection was independent from the other two species (Needham *et al,* 1998). This contrast may relate to differences in sample size and study population; the 1998 study included just one commune in a rural area with 543 individuals of all ages, whereas our data were nationally representative but included only women of reproductive age. Our findings suggest that simultaneous control of all three worm species would be highly beneficial for affected communities.

Our analysis demonstrated a plateau in helminth prevalence over the age group studied. By contrast, data from China showed a continuous increase in hookworm prevalence with age, with a plateau only after age 40 (Gandhi *et al,* 2001; Bethony *et al,* 2002). Not surprisingly, important determinants of helminth infection risk included use of open latrines,

use of human feces for fertilizer and working as a farmer. The use of untreated human feces in agricultural fields concentrates hookworm eggs in a location where women may be exposed on a daily basis. Farmers often work with bare feet in the field, making them vulnerable to penetration by infective hookworm larvae.

The classic design of helminth control programs relies on 6-monthly mass drug administration to schoolchildren with a single dose of mebendazole or albendazole. In most surveys, preschool- and school-age children have the highest overall prevalence of helminth infection; treatment in schools facilitates access. However, it is clear from our data that adults may also have a very high prevalence of infection. Indeed, unlike ascariasis and trichuriasis, hookworm prevalence tends to peak in adulthood (Cowden and Hortez, 2000). Mebendazole and albendazole are safe for use in the second and third trimesters of pregnancy (Horton, 2000). Efforts should be made to include women of reproductive age in mass chemotherapy campaigns, and to offer anti-helminthic therapy during routine prenatal care after the first trimester (WHO, 1996). Our data demonstrate that the greatest need exists among women in rural and remote areas, especially those working as farmers.

Improved sanitation practices form another foundation of effective helminth control. In our data, the high risk category "open latrine" included unimproved pit latrines, as well as double- and single-vaulted composting latrines. Composting latrines effectively eliminate bacterial and viral pathogens, but may be much less efficient against helminth eggs. Most composting latrines fail to reach the required temperatures (50-60ºC); *Ascaris* eggs, in particular, have been demonstrated to survive in composted feces up to 10 months (Feachem, 1983). Unimproved pit latrines may carry an additional risk of direct fecal contact during use. Our data did not allow us to assess risk by type of open latrine. The combination of repeated mass chemotherapy and improved feces disposal had the best long-term effects (Bradley and Horton, 2001), and over a period of years, can decrease the prevalence of infection in the population. Research is ongoing on the development of dry fecal disposal systems, which may be more effective in eliminating helminth eggs. Further study will be necessary to determine the most practical way to handle composted fecal material to prevent transmission of helminths. Wearing shoes will decrease hookworm exposure, but may not be an economically practical recommendation.

In conclusion, this nationwide survey showed that intestinal helminth infections pose a very significant public health challenge in Vietnam. Intestinal nematode prevalence varies by region and socioeconomic factors, such as occupation, sanitary conditions and agricultural methods. The very high prevalence of helminth infections among women calls for redoubled efforts to establish an effective helminth control program that incorporates both anti-helminthic therapy and sanitary improvement. Priority should be given to coverage of women in rural and remote areas, especially those working as farmers.

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