INTRODUCTION

Lymphatic filariasis is a mosquito-transmitted parasitic disease that affects an estimated 120 million persons.\(^1\) It is considered a leading cause of permanent disability worldwide,\(^2\) and more than 44 million persons with this disease have chronic effects of hydrocele or lymphedema of the limbs.

In the Americas, it is thought that transmission of the filarial parasite *Wuchereria bancrofti* became established after its importation with the African slave trade. The disease has been recognized in Haiti at least since the mid 1700s, when it was referred to as pied-botte.\(^3\) Léon reported six cases of elephantiasis of the leg in 1786.\(^4\) In 1894, Audain noted a large number of cases of filariasis in Haiti,\(^5\) and Jeanty reported a case of crural lymphadenopathy caused by *W. bancrofti* in 1896.\(^6\)

During the 20th century, detection of *W. bancrofti* microfilariae in blood smears was used to define the epidemiology of lymphatic filariasis in Haiti. In 1928, Wilson reported the results of a survey of 11,000 Haitian laborers headed to work in the Cuban sugarcane fields; 187 (1.7%) were microfilaria-positive. Of 2,007 children also examined, 12 (0.6%) were microfilaria-positive. The infected children lived in Cap-Haitien, Port de Paix, Port au Prince, and Jeremie.\(^7\)

In 1964, Gentilini and others suggested that the distribution of *W. bancrofti* infection was nationwide, with two major foci: Les Cayes in the south and a triangular-shaped region in the north, with the apices being Cap-Haitien, Port de Paix, and Gonaives.\(^8\) Since the mid 1970s, Racourt and others have conducted epidemiologic investigations of lymphatic filariasis throughout the major endemic foci in Haiti that further defined the geographic distribution and highlighted the public health importance of this parasitic disease.\(^8\)–\(^11\) In spite of these scientific investigations and clinical observations, which spanned almost 250 years, no nationally representative survey of Haiti has previously been conducted.

The Republic of Haiti has a population of approximately eight million inhabitants. The country was divided at the time of this study into nine administrative departments and 133 communes, or districts. When the National Lymphatic Filariasis Elimination Program was announced in January 2001, a national survey was the first priority. This survey was made feasible by the recent development of a sensitive, specific, and field-ready assay that detects circulating filarial antigen in whole blood during the daytime,\(^12\) as well as sampling strategies recommended by the World Health Organization (WHO).\(^13\)

MATERIALS AND METHODS

Between January and April 2001, the Ministère de la Santé Publique et de la Population, with the assistance of the field staff of Hôpital Sainte Croix in Leogane, surveyed 6–11-year-old schoolchildren in all 133 communes for infection with *W. bancrofti*. The sampling method was an adaptation of the lot quality assurance sampling (LQAS). The objective of the sampling was not to precisely determine the prevalence of filarial infection in each commune, but rather to determine if the prevalence in each commune was high enough to warrant mass treatment with antifilarial drugs. To interrupt transmission of *W. bancrofti*, the WHO recommends mass treatment in any area where a threshold infection prevalence of 1% is detected.\(^13\) Negative test results in 250 children yield an estimate of *W. bancrofti* infection prevalence such that the upper 95% confidence interval is < 1%. Thus, it is necessary to test at least 250 persons before one can say that this threshold is not reached.

Within each commune, a list of known schools was assembled. Five schools were selected in each commune based on size (i.e., minimum of 50 children 6–11 years old was required) and accessibility to a road. Included in each sample was at least one public school, where tuition tends to be lower than for private schools. These factors being equal, there was a preference for schools in areas where there was clinical evidence of lymphatic filariasis.

Fifty children were tested in each school and a minimum of 100 children (i.e., two schools) was tested in each commune. If one or more antigen-positive children were detected in these first two schools, no further testing was done. Otherwise, testing continued until the first antigen-positive child was detected or until a total of 250 children (all five schools) were tested and found to be antigen negative. In areas where transmission was not known to have occurred previously, or where there was any doubt that one or two positive test results represented autochthonous cases, testing continued until
more antigen-positive children were detected or until 250 children were tested.

Before testing, the Minister of Education sent a letter to the headmaster of each school selected explaining the mapping activity for lymphatic filariasis and the nature of the blood test, and inviting his or her school to participate. If the headmaster agreed, he or she contacted the parents of students 6–11 years old, explained the purpose of the survey, and sought parental permission. After verbal informed consent and assent were obtained, 100 μL of finger stick blood were collected in a capillary tube and placed on the pad of an immunochromatographic test (ICT) card (AMRAD, Melbourne, Victoria, Australia). The results were read 15 minutes later, recorded as either positive or negative, and the cards were saved for confirmatory reading after each commune was completed. Few discrepancies in test results were noted when test cards were checked later. All children found to have circulating filarial antigen were treated with a single dose (6 mg/kg) of diethylcarbamazine and a single dose (400 mg) of albendazole.

Commune-level test results were entered into a database and analyzed using the statistical program Epi-Info version 6.1 (Centers for Disease Control and Prevention, Atlanta, GA). Differences in proportions were compared using the chi-square test. To obtain a crude population-based estimate of antigen prevalence among school children throughout Haiti, we weighted the results of antigen prevalence in each commune using population data from the national census in 1997.

As the WHO-recommended first step in developing a national program to address lymphatic filariasis,13 the approach reported here is being used in many of the 80 countries that are endemic for this disease. The Administrative and Ethics Committee of the Hôpital Ste. Croix (which assisted in the execution of this study) reviewed and approved the protocol of this study as ethical public health practice.

RESULTS

A total of 22,365 children were tested in 440 schools. Of these, 10,378 (46.4%) were boys and 11,987 (53.6%) were girls. The median age was 8 years. Overall, 901 (4.0%) children were antigen positive. A total of 517 (5.0%) boys tested positive, compared with 384 (3.2%) girls (P < 0.00001).

Of 133 communes in Haiti, 117 (87.9%) had one or more children who were antigen positive by the ICT. These communes, where the upper 95% confidence interval for antigen prevalence was > 1%, met the criteria for mass treatment recommended by WHO (Figure 1). All 16 (12.1%) communes in which none of 250 children tested positive are located in the eastern and southern part of the country (Figure 1).

Because a modified LQAS scheme was used, the confidence intervals around the prevalence estimates for each commune were quite wide. Nonetheless, considerable variation was observed, with prevalence ranging as high as 45%. Twenty communes had an estimated antigen prevalence ≥ 10% and 13 had a prevalence of 5–9.9%. An antigen prevalence > 10% was limited to the northern plains and to the coastal plains north, west, and east of Port au Prince (Figure 2). The overall prevalence of filarial antigenemia, when weighted for the total population in each commune, was 7.3%.

DISCUSSION

The results of this national mapping exercise confirm the high prevalence of infection in the major filariasis-endemic areas identified years ago by Gentilini and others3 and Rac-curt and others.14 Indeed, the highest prevalence of filarial antigen was observed in these areas, most notably along the northern coast. Thus, foci of intense W. bancrofti transmission in Haiti appear to have been remarkably stable since 1928.7 Antigen-positive children were found in 53 of the 57 communes in four northern departments (North, Northwest, North East, and Artibonite). In addition, of 33 communes with prevalence estimates ≥ 5%, 23 (69.7%) were found in these same four northern departments.

The reasons for the higher levels of W. bancrofti transmission in the coastal areas of the north are unclear, but probably involve historic, ecologic, socioeconomic, and environmental factors.13,14,15 An additional finding, which has significant implications for the national Lymphatic Filariasis Elimination
Program in Haiti, was the broad distribution of *W. bancrofti* infection throughout the country. All nine departments are affected, and in only 16 communes did none of 250 children test positive for filarial antigen. The degree to which the absence of transmission within an entire commune is indicated by negative antigen test results among children attending a few schools is unknown. Transmission elsewhere within these 16 communes cannot be excluded as a possibility. Thus, the Lymphatic Filariasis Elimination Program must be national in scope.

Despite its national distribution, at a more local level *W. bancrofti* infection in Haiti appears to be quite focal. This has been shown both in Léogâne\(^{14}\) and in Port de Paix.\(^{11}\) Based on data collected in Léogâne, risk factors for these more microlevel foci of *W. bancrofti* transmission in Haiti include agricultural vegetation and an altitude < 70 meters, although other factors certainly play a role.\(^{14}\) Raccurt and others have suggested that areas of sugar cane cultivation and processing provide good habitat for *Culex*, the major mosquito vector of *W. bancrofti* in Haiti, and therefore may be geographically associated with transmission of the parasite.\(^{10}\)

The survey also identified some unexpected findings, including those in three different communities in the plateau of the Central Department. Despite having many channels of polluted water where mosquito larvae are plentiful, the prevalence of filarial antigenemia in the community of Hinche was quite low (1%). In contrast, the rural community of Saut d’Eau in the hills at an altitude of 614 meters had extraordinarily high levels of antigenemia (44%) and microfilaremia (13%). Finally, lymphedema of the leg and hydrocele are commonly observed in the community of Lascabosas, but only one of 250 children in this area tested positive for filarial antigen.

We noted a higher prevalence of *W. bancrofti* antigenemia among boys than among girls in our survey. Sex-related differences in *W. bancrofti* microfilaremia are commonly observed in adults, particularly in those of child-bearing age.\(^{16}\) However, little information is available on sex-specific antigenemia prevalence in children. Previous studies,\(^{17,18}\) including one in Léogâne, Haiti,\(^{14}\) have tended to show a similar prevalence of filarial antigenemia in boys and girls.

When weighted for total population in each commune, the national prevalence of filarial antigenemia for 6–11-year-old children was 7.3%. This figure would be a conservative estimate of the percentage of the entire population infected since the prevalence of antigenemia continues to increase with age.\(^{19}\) Therefore, with an estimated population of eight million, at least 600,000 persons in Haiti are likely infected with *W. bancrofti*, by far the largest number of any country in the Americas. National estimates of filarial disease are not yet available. However, the prevalence of hydrocele in Léogâne is approximately 25% (Michel MC, unpublished data) and the prevalence of lymphedema is approximately 2%.\(^{20}\)

In summary, *W. bancrofti*, which has been endemic in Haiti for at least 250 years, is widespread throughout the country and poses an important public health problem. Even though there are foci of very intense transmission as well as a few areas where *W. bancrofti* transmission apparently does not occur, for programmatic purposes, the entire population of the country, an estimated eight million persons, must be considered at risk of infection. Thus, national-level interventions are required. Currently, the areas of highest endemicity are targeted for, or are already undergoing, mass distribution of antifilarial drugs. Expansion of mass distribution is planned to include the entire country.

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