EMERGENCE OF SCHISTOSOMA MANSONI INFECTION IN UPPER EGYPT: THE GIZA GOVERNORATE

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Abstract. We found an unexpectedly high prevalence of Schistosoma mansoni in a village in the Upper Egyptian governorate of Giza. Historically, S. mansoni is endemic in the northern Egyptian Nile Delta rather than in the southern Upper Egypt. This observation was made during an evaluation of a rural health care schistosomiasis surveillance program using a cross sectional survey for S. haematobium and S. mansoni in the village of El-Gezira El-Shakra El-Saf district in the Upper Egypt Giza Governorate. A 10% systematic random sample of households of the village was chosen. All persons in the selected houses were invited to submit urine and stool samples. All students from a primary school were also included in the study. Urine was screened by a polycarbonate filtration method and stool was examined using modified Kato-Katz technique. The prevalence of S. mansoni in the population sample and in the school children was 33.7% and 57.7%, respectively, whereas the prevalence of S. haematobium infection in the population sample and the school children was 7.4% and 10.6%, respectively. The prevalence of infection was highest in the younger age groups, and males were infected more than females. Review of Ministry of Health records showed that both species of vector snails, Bulinus truncatus and Biomphalaria alexandrina, were present from 1991 to 1995, and that B. alexandrina was more abundant than B. truncatus in the canals surrounding this village. The unexpected high prevalence of S. mansoni in this village indicates an urgent need to include training programs for S. mansoni surveillance in the primary health care facilities of Giza and to educate villagers to request examinations for S. mansoni as well as for S. haematobium infection.

Schistosoma haematobium has been the predominate species of schistosome throughout Egypt since Theodor Bilharz first described the infection in 1851. Infections with S. haematobium were common throughout the country in 1937 but S. mansoni, the other schistosome species endemic in Egypt, was confined to the north central Nile Delta. Individuals found infected with S. mansoni who resided in the southern areas of the Nile Delta or in Upper Egypt (south of the Nile Delta) were always found to have acquired S. mansoni during visits to the northern endemic areas. Over the period of several decades, during which substantial changes in irrigation patterns occurred, there have been major changes in this pattern of endemicity. Schistosoma haematobium infections have all but disappeared from the Nile Delta where as S. mansoni prevalence has increased throughout the Nile Delta. In addition, the snail vector for S. mansoni, Biomphalaria alexandrina, has been increasing in number in the Nile Delta and has been recovered in locations throughout Upper Egypt. Concern that S. mansoni transmission may become established in Upper Egypt dates back to 1958 when Malek first reported the presence of B. alexandrina just south of Cairo.

Since that time, a number of communities with usually high prevalences of S. mansoni, or so called village foci, have emerged in Upper Egypt. Foci of S. mansoni have been described in the Fayyum by Abdel Wahab and others, in Minya by Oriby and others, and in Assiut by Medhat and others. The National Schistosomiasis Control Program (NSCP) has formulated objectives to prevent the further spread of S. mansoni in Upper Egypt. The spread of S. mansoni has serious implications on public health and on the schistosomiasis control strategy. Patients with S. mansoni infections may remain asymptomatic or have mild symptoms until the disease is well advanced or hematemesis occurs. Detection, recognition, and surveillance of S. mansoni is more difficult than that of S. haematobium. Subsequently, self-referred cases to rural health care services are infrequent and may be missed because of the lack of trained personnel to correctly prepared and examine stool specimens for S. mansoni ova.

The prevalence of S. mansoni in the rural areas of the Giza governorate, located just south of Cairo and traditionally the dividing point between Upper and Lower Egypt, is not known. During the course of a study on an evaluation of the NSCP surveillance program in a small village in Giza, a very high prevalence of S. mansoni was discovered. This study describes the magnitude of S. mansoni and S. haematobium endemicity in this village and its implications for control.

METHODS

Study population. There were two target populations in the study. The first was a sample from the village of El-Gezira El-Shakra. The second target population comprised all pupils enrolled in the El-Gezira El-Shakra village primary school.

El-Gezira El-Shakra village was originally selected to evaluate the NSCP surveillance data collection methods at the rural health unit located in the village. This village was chosen because of the readiness of the rural health unit staff to cooperate with the research team, not because of any prior knowledge of schistosome endemicity. El-Gezira El-Shakra is located in the El-Saf district, Giza governorate about 85 km south of Cairo. Based on a census, the village was found to be comprised of a central large village with six small hamlets or ezbas surrounding it, with a total of 916 houses and 6,412 inhabitants. The primary economy of the area is agriculture. The entire village is surrounded on all sides by large canals with a total length of about 15 km. Access to the village is by a canal bridge. The village is essentially an island as reflected in its name, which means blond island.
The village has one primary school and a single Ministry of Health (MOH) rural health unit.

The house numbers from the census were used as the sampling frame. A systematic sample, using a random start, of every tenth household was drawn. All persons living in a selected household were included in the sample. Although this is a cluster sample of village households, systematic selection tends to stratify the sample, giving standard errors very similar to simple random sampling, which we assume for purposes of calculating standard errors and confidence intervals. A total of 106 houses and 738 persons were selected. This was sufficient for detecting a \( S. \) haematobium prevalence of at least 5% with 90% confidence. All houses selected in the sample were visited and demographic data on age, sex, and occupation were collected from all occupants in the household. All persons selected in the sample were invited to give a stool and urine specimen and to complete an interview with one of the field team interviewers.

At the time of the study, El-Gezira El-Shakra village primary school had an enrollment of 157 pupils. The majority of these school children were from other nearby villages. These other villages were not included in the sample frame. All school children enrolled in the local primary school comprised a second target population and all were invited to give stool and urine specimens.

Participation in the study by the villagers or the school children was entirely voluntary and conformable to requirements for the participation of human subjects by the Theodore Bilharz Research Institute and the Ministry of Health and Population, Egypt.

**Parasitology.** The stool and urine samples were prepared in the village rural health unit by technicians from the central laboratory at Theodor Bilharz Research Institute. Urine specimens were collected between 10:00 AM and 2:00 PM, mixed, and 10 ml was filtered through an 8-μm polycarbonate filter.\(^{13}\) Schistosoma haematobium egg counts are reported per 10 ml of urine specimen. Two slides were prepared for each stool specimen using a modified Kato-Katz technique.\(^{14}\) Schistosoma mansoni eggs were counted and converted to eggs per gram of stool. The geometric mean egg count for urine and stool specimens was calculated by transforming egg counts to the log\(_{10}\) for positive specimens only. The population egg count for \( S. \) haematobium or \( S. \) mansoni was calculated by summing the egg counts from all infected persons, respectively.\(^{15}\) All persons who were found positive for either \( S. \) haematobium or \( S. \) mansoni were offered free treatment with praziquantel (40 mg/kg).

**Review of records.** Data collected on snail distributions were obtained from the MOH vector snail section for the village of El-Gezira El-Shakra. The data available from these records are limited to the absolute numbers of \( B. \) truncatus and \( B. \) alexandrina snails collected from water bodies surrounding El-Gezira El-Shakra village. Snail surveillance data were available from 1991 to 1995. The MOH makes these snail surveys once a year during the summer months in the same 15-km sectors of two canals adjoining the village. Explicit detailed information on standardization of snail collection methods, such as the collection apparatus, number of dips, length of canal surveyed, and related factors were not available. Records were also reviewed for the number of vector snails found infected with schistosomes.

**Urine specimens for \( S. \) haematobium.**

The surveillance records of the local rural health unit were reviewed for the number of persons examined and the number of persons found positive for \( S. \) haematobium and/or \( S. \) mansoni.

**Data analysis.** Data entry and analysis was carried out using Epi-Info software.\(^{16}\) Prevalence estimates from the village sample include 95% confidence intervals (CIs). Odds ratios were used to examine the association between infection with \( S. \) haematobium and infection with \( S. \) mansoni in the village population and infection by either species and sex. Stratification was used to examine for modification of odds ratios by age and sex. To have sufficient frequencies for analysis of interaction by age, age was reclassified into three groups; children \( \leq \) 11 years of age, adolescents 12–20 years of age, and adults > 20 years of age. Mantel-Haenszel stratification methods provided by the Epi-Info software were used to test for interaction and estimate weighted odds ratio. No sample of the village primary school children was made since all attending children were included in this target population; therefore, standard errors were not calculated.

**RESULTS**

Urine specimens were obtained from 458 persons or from 61.8% of the total sample selected and 445 (60.3%) provided a stool specimen. The estimated prevalence of \( S. \) haematobium in the village sample was 7.4% (95% CI = 5.3–10.3) while 33.7% (95% CI = 29.4–38.3) were estimated to be infected with \( S. \) mansoni (Table 1).

The prevalence of both species was higher in males than females. The odds ratio for males, relative to females, was 2.6 (95% CI = 1.2–6.1) for \( S. \) haematobium and 1.7 (95% CI = 1.1–2.6) for \( S. \) mansoni. The overall geometric mean egg count (GMEC) ± SE was 5.3 ± 1.5 eggs per 10 ml of urine for \( S. \) haematobium and 122.2 ± 1.1 eggs per gram of stool for \( S. \) mansoni among those infected. Twenty-three percent of those infected with \( S. \) mansoni had 400 or more eggs.

**Table 1**

<table>
<thead>
<tr>
<th>Species</th>
<th>Village Prevalence (%)</th>
<th>School Prevalence (%)</th>
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</thead>
<tbody>
<tr>
<td>( S. ) haematobium</td>
<td>7.4 (5.3–10.3)</td>
<td>6.9 (6.9–15.4)</td>
</tr>
<tr>
<td>( S. ) mansoni</td>
<td>33.7 (29.4–38.3)</td>
<td>28.2 (22.5–34.3)</td>
</tr>
</tbody>
</table>

*Values in parentheses are 95% confidence intervals.

GMEC = geometric mean egg count.

\(^{1}\) Odds of \( S. \) mansoni infection given \( S. \) haematobium.
per gram of stool. Proportionally, persons with 400 or more eggs per gram were distributed equally across the broad age groups of childhood, adolescent, and adult ages (childhood = 9.9%, adolescent = 7.1%, and adult = 6.0%; P = 0.37). The total number of S. mansoni eggs excreted by the sample population (population egg count) was 43,164 (95% CI = 43,095–43,232). The age-specific distribution of schistosome infection in the village sample showed a peak prevalence in the younger age groups for both $S. \text{ mansoni}$ and $S. \text{ haematobium}$ (Figure 1).

The prevalence of dual infections, those infected with both $S. \text{ haematobium}$ and $S. \text{ mansoni}$, was 5.5% (18 persons of 328 who gave both urine and stool specimens). Of those with $S. \text{ haematobium}$ infections, 72.0% also had $S. \text{ mansoni}$ infections and of those with $S. \text{ mansoni}$ infections, 15.8% were infected with $S. \text{ haematobium}$. The odds ratio of having an $S. \text{ mansoni}$ infection given an $S. \text{ haematobium}$ infection was 5.5 (95% CI = 2.1–15.3). When this association was stratified by sex, the odds ratio was 3.5 (95% CI = 1.0–12.3) for males and 10.1 (95% CI = 1.8–74.4) for females. However, the difference in these two odds ratio estimates was not statistically significant (Mantel-Haenszel, $P = 0.28$), indicating the lack of interaction. Stratification of the odds ratio by childhood, adolescent, and adult age groups showed the strongest association in children, 18.7 (95% CI = 2.3–413.4), decreasing to 12.8 (95% CI = 1.4–305.4) in adolescents and to 1.0 (95% CI = 0.1–6.1) in adults. These stratified estimates were too imprecise to be significantly different (Mantel-Haenszel, $P > 0.05$).

Of the students enrolled at the local primary school, 151 (99.3%) provided urine samples and 142 (90.5%) provided stool specimens. Students from the primary school had a prevalence of 10.6% for $S. \text{ haematobium}$ and 5.5% for $S. \text{ mansoni}$. These results are shown in Table 1. There was no difference in the prevalence of $S. \text{ haematobium}$ between male and female school children (odds ratio = 0.99), but for $S. \text{ mansoni}$, males had an almost two-fold odds (odds ratio = 1.94) of being infected compared with the females. In fact, the male school children had the highest prevalence (62.9%) of $S. \text{ mansoni}$ of any subgroup in the two target populations. The prevalence of $S. \text{ mansoni}$ in children of the same ages from the village was 40.6% (95% CI = 32.4–49.1). The GMEC for $S. \text{ haematobium}$ was 18.1 eggs/10 ml and the GMEC for $S. \text{ mansoni}$ was 57.7 eggs per gram of stool. The total number of $S. \text{ mansoni}$ eggs excreted by the school children was 6,996. In the school pupils, the odds ratio of an $S. \text{ mansoni}$ infection given an $S. \text{ haematobium}$ infection was 2.9 and there was no modification of the odds ratio by sex.

The review of the MOH vector snail surveys showed increasing numbers of both $B. \text{ truncatus}$ and $B. \text{ alexandrina}$ species from 1991 to 1995. The number of $B. \text{ truncatus}$ increased from 60 to 112 and $B. \text{ alexandrina}$ increased from 94 to 179 (Table 2). No infected snails of either species were reported.

A review of the village rural health unit parasitology records for the same month and year of the field work showed that 378 persons had requested examinations for $S. \text{ mansoni}$ infections and 2.9% had been found positive. Among 507 children that were screened, 7.8% were found positive for $S. \text{ mansoni}$. The rural health unit records included the results from an examination of a 10% sample of the village in which 150 persons were screened for $S. \text{ haematobium}$ and $S. \text{ mansoni}$. The records showed that 26.3% were infected with $S. \text{ haematobium}$ but none were found infected with $S. \text{ mansoni}$.

**DISCUSSION**

The estimated prevalence of $S. \text{ haematobium}$ (7.4%) in El-Gezira El-Shakra was in good agreement with other areas of Middle and Upper Egypt. $S. \text{ haematobium}$ prevalence was similar in magnitude to the most recently reported cross-sectional estimates from representative samples in 1993 of Minya (8.9%), Assiut (5.2%), and Qena (5.4%). In Middle and Upper Egypt, $S. \text{ haematobium}$ has been steadily decreasing for more than a decade and has all but disappeared from the Nile Delta. Although the elucidation of this decrease remains to be defined, chronologically, the decrease was first noted almost a decade after the closure of the Aswan High Dam.

This is the first report of a foci of $S. \text{ mansoni}$ in rural Giza. The estimated prevalence of $S. \text{ mansoni}$ (33.7%) in El-Gezira El-Shakra was unusually high and in the primary school children, alarmingly high (57.7%). Although the $S. \text{ mansoni}$ GMEC was not especially elevated, this constitutes a more serious problem, since cases may be missed due to decreasing sensitivity among those with lower egg counts. This suggests that the overall prevalence of $S. \text{ mansoni}$ may be underestimated due to the insensitivity of the Kato-Katz technique. By the same measure that the Kato-Katz technique underestimates prevalence, the egg counts (among those infected) may be over estimated. While the reader

**TABLE 2**

<table>
<thead>
<tr>
<th>Year</th>
<th>$B. \text{ truncatus}^*$</th>
<th>$B. \text{ alexandrina}^*$</th>
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<tbody>
<tr>
<td>1991</td>
<td>60</td>
<td>94</td>
</tr>
<tr>
<td>1992</td>
<td>93</td>
<td>125</td>
</tr>
<tr>
<td>1993</td>
<td>80</td>
<td>119</td>
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<tr>
<td>1994</td>
<td>139</td>
<td>179</td>
</tr>
<tr>
<td>1995</td>
<td>112</td>
<td>132</td>
</tr>
</tbody>
</table>

* Absolute numbers recovered.
should bear in mind these issues of detection sensitivity, obtaining more than one stool specimen from Egyptian villagers without impossible increases in resources and unacceptable levels of nonresponse, is unrealistic. A more sensitive non-stool-based diagnostic method for *S. mansoni* detection is needed.

We found that persons infected with one of the schistosome species had an increased probability of being infected by the other as estimated by a significantly elevated odds ratio of 5.5. For example, the estimated overall probability of *S. mansoni* infection in the village sample was 0.337. Among those with *S. haematobium* infection, the probability of *S. mansoni* infection was much higher (0.72). This association indicates that the factors that increase the likelihood of infection, presumably types of water contact, for one species are shared by the other. This was especially true for the village children and females who had a much higher odds ratio for dual infections, although these estimates were not statistically significant due to the limited statistical power of the sample size. Nevertheless, we recommend for Upper Egypt, that all persons found positive for *S. haematobium* also be examined for *S. mansoni* infection, especially women and children.

We have shown in the Nile Delta that the prevalence of *S. mansoni* is associated with incidence. Based on the relationship of prevalence and incidence in those studies, the incidence of *S. mansoni* in El-Gezira El-Shakra is 15.8 cases per 100 noninfected villagers per year.

The data recorded in the rural health unit in El-Gezira El-Shakra over-reported the endemicity of *S. haematobium* and missed *S. mansoni* infections. Over-reporting of *S. haematobium* may have been due to self-referral bias of those with gross hematuria. A false sense of the absence of *S. mansoni* infections in the village and in Giza by the rural health unit workers may have also contributed to under-reporting *S. mansoni* infections. Data from rural health units throughout the country comprise the NSCP surveillance system. In light of *S. mansoni* endemicity in this village, a modification of the surveillance system to address this changing pattern of schistosome infection is indicated.

The pattern of age-specific prevalence was typical of established schistosome endemicity and does not suggest that the prevalence of *S. mansoni* has recently increased. When *S. mansoni* was first introduced into the village, how *S. mansoni* was introduced, and when autochthonous transmission began, is not known. The high prevalence in the school children, many of whom reside in other near by villages, suggest that this foci may not be limited to El-Gezira El-Shakra but to other villages as well. A follow-up survey for *S. mansoni* throughout rural Giza is needed.

The high prevalence of *S. mansoni* detected in El-Gezira El-Shakra village could be associated with the increasing abundance of *B. alexandrina* snails seen in the canals of the village. Since the data on snail population were collected by MOH surveys, we cannot assess its accuracy in regard to the absolute numbers of snails or make any measure of an association between snail numbers and prevalence. Regardless of possible systematic error, *B. alexandrina* snails are clearly present in the village canals and their numbers may be increasing. That no infected snails were reported, which is an important measure of local transmission, may have been due to the low sampling rate, noting that snail infection rates can be less than 1% in endemic areas of Egypt. We do not know if the transmission of the level seen in this village is being acquired from other near by canals that were not sampled.

The emergence of *S. mansoni* in Upper Egypt has not followed any recognized pattern. More than three decades ago, Malek reported the recovery of *B. alexandrina* snails as far south as Beni Suef (located just east of the Fayoum and immediately south of Giza) in the late 1950s. By 1979, *B. alexandrina* had been recovered from canals in Aswan and in Lake Nassar, indicating that the entire Egyptian Nile Valley had become infected with *B. alexandrina* snails. Medhat and others demonstrated that *B. alexandrina* snails from Upper Egypt were suitable vectors for *S. mansoni*. Miller and others documented *S. mansoni* infections in villagers living in Aswan, Kom Ombo, and in the Qena governorate, all in Upper Egypt, and suggested that the reservoir of infection was present as well as the snail vector and indicated concern for the potential establishment of *S. mansoni* transmission throughout Upper Egypt. In 1993, a high prevalence of *S. mansoni* (22.3%) was reported in the Fayoum in one village (Sheikh Fadl). Since then, a representative sample of the entire governorate has shown that *S. mansoni* prevalence was generally low, i.e., less than 5%. Further south, in the village of Attnia in the Minya governorate, the prevalence of *S. mansoni* was 16%. Attnia was the only village with this level of *S. mansoni* infection among 33 villages or ezbas surveyed that had an overall prevalence of 2% or less. In similar representative studies, further south in the governorates of Assuit and Qena, *S. mansoni* was found only sporadically with only a few number of individuals infected in a given village or hamlet. No single village or hamlet had sufficiently high prevalence to be designed as a foci. There are no current data on village foci of *S. mansoni* in the Upper Egyptian governorates of Beni Suef, Sohag, Aswan, or the fishing communities located on Lake Nasser.

Expanded surveillance, use of sentinel surveillance groups, improved detection of *S. mansoni*, and community awareness are important components of an integrated control program specifically aimed at village foci of *S. mansoni* in Upper Egypt. Such measures should complement the NSCP.

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