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THE EPIDEMIOLOGY OF SCHISTOSOMIASIS IN EGYPT: PATTERNS OF *SCHISTOSOMA* MANSONI INFECTION AND MORBIDITY IN KAFR EL-SHEIKH

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Abstract. This is a descriptive report of the Epidemiology 1, 2, 3 project in Egypt that made use of large probability sampling methods. These results focus on *Schistosoma mansoni* infection in the northern Nile Delta governorate of Kafr El Sheikh. A probability sample of 18,777 persons, representing the rural population of the entire governorate, was drawn. The sample was designed not to exclude villages based on location or presence of health care facilities and to include representation of the smaller ezbas or hamlets. The objective was to obtain detailed estimates on age- and sex-specific patterns of *S. mansoni* infection, and to provide a baseline for prospective studies. Stool specimens were examined by the Kato method. The estimated mean ± SE prevalence of *S. mansoni* infection in the rural population was 39.3 ± 3.3% in 44 villages and ezbas after weighing for the effects of the sample design. The estimated mean ± SE geometric mean egg count per gram of stool (GMEC) was 72.9 ± 7.3. Prevalence and GMEC varied considerably by village and ezba, with ezbas having a significantly higher prevalence. Villages and ezba-specific prevalence was strongly associated with GMEC ($r^2 = 0.61$, $P < 0.001$). The prevalence of *S. mansoni* infection increased by age to 55.4 ± 3.2% at age 16 without a significant change in the adult ages. There were no gender differences until age 6, after which males were consistently higher until middle age, when the differences converged. The age- and sex-specific pattern of GMEC varied widely; however, when the GMEC data were collapsed into 5-year age groups, the GMEC peaked at 81.5 ± 12.1 eggs/g in the 10–14-year-old age group. These estimates provide the basis for evaluating control measures for reducing prevalence, intensity of infection, and transmission.

Historically, both *Schistosoma mansoni* and *S. haematobium* were highly prevalent in Kafr El Sheikh in Egypt.[1] *Schistosoma mansoni* tended to be higher in the northern areas of the Nile Delta with *S. haematobium* prevalent throughout. Various reports from different areas of the Nile Delta indicated that the patterns of infection in both species did not remain static.[2–7] It has become evident that *S. haematobium* has receded almost completely from the entire Nile Delta.[8,9] The prevalence of *S. mansoni* may also be changing.[9]

The origin of the Epidemiology 1, 2, 3 project in Kafr El Sheikh can be found in the introduction to this supplement.[10] Results on prevalence,[11] impact of selective chemotherapy,[12] and rates of infection have been reported previously.[13] In this report, more detail is given on association of infection with different exposure factors and data on clinical and ultrasonographic data are presented.

METHODS

The methods for this study have been published previously.[11] Additional details on sampling methods, parasitology, and ultrasonographic examinations have been provided in this supplement.[14–16]

RESULTS

The age structure of the sample was nearly identical to the age structure of the overall population.[14] The total sample included 18,777 persons, of which 15,017 provided a stool specimen. Overall, the mean ± SE prevalence of *S. mansoni* was 39.3 ± 3.3% and the geometric mean egg count per gram of stool (GMEC) was 72.9 ± 7.3. Taken together, the estimated total number of persons in the rural endemic areas of Kafr El Sheikh infected with schistosomiasis was 550,047 (based on the most recent available Central Agency for Public Mobilization and Statistics census data in 1986). The age- and sex-specific patterns of infection by 5-year age groups is shown in Figure 1. The overall prevalence was 43.6 ± 3.3% in males and 34.8 ± 3.3% in females. The odds of infection in males was 1.4 (95% confidence interval [CI] = 1.3–1.5) relative to females. Prevalence increased with age and had a peak in adolescence at age 16 (55.4 ± 3.2%). There was no statistically significant change or decrease in the older adult ages. The GMEC in males was also higher (82.1 ± 9.5) compared with females (62.9 ± 5.5), but this difference was not significant ($P > 0.05$). The age- and sex-specific pattern of the GMEC varied widely, especially in the younger ages. However, when the GMEC data were collapsed into 5-year age groups, the GMEC increased with age and peaked at 81.5 ± 12.1 in the 10–14-year-old age group. Like prevalence, there was no significant change in the GMEC in the older 5-year age groups.

The prevalence of *S. mansoni* infection ranged from a low of 24.5% (ezba 28) to a high of 68.9% (village 41) as shown in Figure 2. There was a nearly 3-fold difference in prevalence between the highest and lowest village (24.4% versus 69.8%; $P < 0.001$). An even larger difference was seen in GMEC values (37.8 versus 129.7; $P < 0.001$). There was a significant relationship between prevalence and GMEC at the village and ezba level of analysis. The correlation coefficient between prevalence and GMEC was $r^2 = 0.61$, $P < 0.001$, i.e., 61% of the variation in village GMEC was explained by the level of prevalence. The fitted trend line increased steeply and can be estimated from the relationship $g = 9.46 + p(1.55)$, where g is the GMEC and p is the village prevalence. Since the age structure of the different villages and ezbas throughout Kafr El Sheikh are very similar, age did not significantly modify this relationship.

Table 1 shows the pattern of infection in relationship to age, sex, water contact, clinical examination, and ultrasonographic findings. Most associations measured by odds ratios (ORs) were small, i.e., less than 3.0. However, associations with exposure to canal water and infection were in

TABLE 1

Odds ratio and 95% confidence limits for risk factors for infection with *Schistosoma mansoni* in Kafr El-Sheikh Governorate*

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence limits
Demographics				
Age groups (years)				
0–10	4,635	939 (20.3)		
11–20	3,727	1,982 (53.2)	4.47	4.06–4.92
21–35	3,437	1,666 (48.5)	3.70	3.36–4.08
36–55	2,281	1,056 (46.3)	3.39	3.04–3.78
>55	949	408 (43.0)	2.97	2.56–3.44
Gender				
Female	7,741	2,790 (36.0)		
Male	7,288	3,261 (55.3)	1.44	1.35–1.53
Domicile				
Village (≥500 houses)	1,890	649 (34.3)		
Ezba (<500 houses)	13,139	5,402 (41.1)	1.34	1.21–1.48
Exposure to canal water				
Bathing (males)				
No	1,914	463 (24.2)		
Yes	4,921	2,579 (52.4)	3.45	3.06–3.89
Washing (females)				
No	2,666	545 (20.4)		
Yes	4,924	2,181 (44.3)	3.09	2.77–3.45
Playing (children <15 years old)				
No	2,282	316 (13.8)		
Yes	3,942	1,479 (37.5)	3.74	3.26–4.28
Clinical findings				
History of schistosomiasis				
No	5,131	2,027 (39.5)		
Yes	6,141	2,524 (41.1)	1.09	0.99–1.15
Prior treatment of schistosomiasis				
No	8,294	3,381 (39.6)		
Yes	6,067	2,456 (40.5)	1.04	0.97–1.11
History of blood in stools				
No	914	341 (37.3)		
Yes (total)	195	107 (54.9)	2.04	1.50–2.79
<15 years	60	26 (43.3)	2.06	1.18–3.59
≥15 years	135	81 (60.0)	1.76	1.20–2.60
History of abdominal pain				
No	574	214 (37.3)		
Yes	537	235 (43.8)	1.31	1.03–1.66
<15 years	193	70 (36.3)	1.79	1.20–2.67
≥15 years	344	165 (48.0)	0.91	0.66–1.24
Hepatomegaly in MCL (by PE)				
No	1,044	428 (41.0)		
Yes	33	14 (42.4)	1.06	0.53–2.14
<15 years	3	0 (0.0)		
≥15 years	30	14 (46.7)	0.89	0.43–1.85
Splenomegaly (by PE)				
No	1,037	414 (39.9)		
Yes	75	38 (50.7)	1.55	0.97–2.47
<15 years	9	5 (55.6)	3.08	0.82–11.66
≥15 years	66	33 (50.0)	1.04	0.62–1.73
Ultrasonography				
Hepatomegaly in MCL				
No	732	310 (42.3)		
Yes	133	63 (47.4)	1.23	0.85–1.77
<15 years	39	13 (33.3)	1.02	0.50–2.06
≥15 years	94	50 (53.2)	1.14	0.73–1.79

TABLE 1
Continued

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence limits
Hepatomegaly in MSL				
No	808	343 (42.5)		
Yes	57	30 (52.6)	1.51	0.88–2.58
<15 years	16	10 (62.5)	3.61	1.28–10.17
≥15 years	41	20 (48.8)	0.93	0.49–1.76
Splenomegaly				
No	505	163 (32.3)		
Yes	414	230 (55.6)	2.62	2.00–3.43
<15 years	104	54 (51.9)	3.01	1.89–4.80
≥15 years	310	176 (56.8)	1.99	1.40–2.82
Periportal fibrosis				
No	269	86 (32.0)		
Yes (>3 mm)	651	307 (47.2)	1.90	1.41–2.56
<15 years	211	88 (41.7)	2.39	1.53–3.72
≥15 years	440	219 (49.8)	1.01	0.64–1.59
Grade I (3–<5 mm)	376	177 (47.1)	1.89	1.37–2.62
Grade II (5–<7 mm)	213	100 (46.9)	1.88	1.30–2.73
Grade III (≥7 mm)	62	30 (48.4)	1.99	1.14–3.49

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

excess of 3.0 reaching 4.5 (95% CI = 3.8–5.3) in those less than 15 years old with a history of play in the canals. Associations, odds ratios, of infection with clinical and ultrasonographic findings were also consistently less than 3.0 with ultrasonographically determined splenomegaly more strongly associated with infection than either hepatomegaly or periportal fibrosis (PPF).

Table 2 shows the relationship between PPF and similar factors listed in Table 1. The strongest association with PPF was historical exposure by males bathing in canal water (OR = 5.1, 95% CI = 3.3–7.9). Splenomegaly determined by PPF and ultrasonography were similarly associated (OR = 5.6, 95% CI = 3.8–8.1).

Figure 3 shows the age pattern of hepatomegaly and splenomegaly as determined by physical examination. The prevalence of both increase irregularly with age. Figure 4 shows the age pattern of ultrasonographically determined hepatomegaly, splenomegaly, and PPF. All measures show a consistent increase in prevalence in the 5-year age groups.

Schistosoma haematobium infection was found in 41 specimens. These infections were scattered throughout the different villages and ezbas, except for village 32 where 14 persons were positive (2.1%). This was significantly different from the overall prevalence ($P < 0.05$, by chi-square test) of *S. haematobium*. The highest egg count per 10 ml of urine was 37.

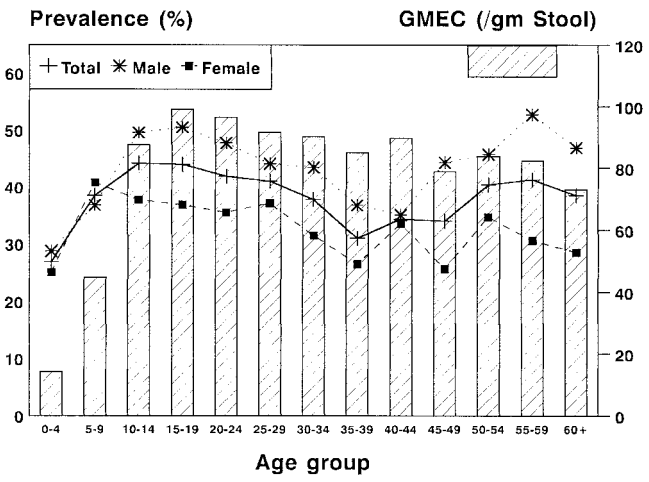

FIGURE 1. Age (years) and sex prevalence and intensity of infection with *Schistosoma mansoni* in Kafr El-Sheikh. GMEC = geometric mean egg count.

DISCUSSION

This is the largest sample drawn to date in Kafr El Sheikh for estimating schistosomiasis prevalence and intensity of

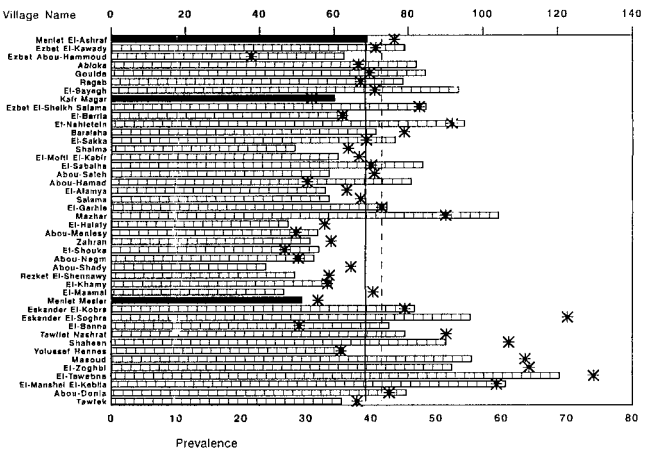

FIGURE 2. Prevalence (%) (**bars**) and intensity (**asterisks**) of *Schistosoma mansoni* infection in Kafr El-Sheikh governorate. Solid horizontal bars show prevalences in villages, open horizontal bars show prevalences in *ezbas*, the solid vertical line is the mean prevalence for all communities, the broken vertical line is the mean intensity of infection, and the asterisks are the geometric mean egg counts/gram of stool for each community.

TABLE 2

Odds ratio and 95% confidence limits for risk factors for morbidity (periportal fibrosis) with *Schistosoma mansoni* in Kafr El-Sheikh Governorate*

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence limits
Demographics				
Age groups (years)				
0–10	320	135 (42.2)		
11–20	222	175 (78.8)	5.10	3.45–7.54
21–35	238	206 (86.6)	8.82	5.72–13.61
36–55	143	122 (85.3)	7.96	4.76–13.30
>55	58	46 (79.3)	5.25	2.68–10.30
Gender				
Female	502	338 (67.3)		
Male	479	346 (72.2)	1.26	0.96–1.66
Domicile				
Village (≥500 houses)	142	122 (85.9)		
Ezba (<500 houses)	839	562 (67.0)	0.33	0.20–0.55
Exposure to canal water				
Bathing (males)				
No	158	78 (49.4)		
Yes	298	248 (83.2)	5.09	3.29–7.86
Washing (females)				
No	194	92 (47.4)		
Yes	298	238 (79.9)	4.40	2.95–6.56
Playing (children <15 years old)				
No	206	76 (36.9)		
Yes	214	140 (65.4)	3.24	2.17–4.82
Parasitologic findings				
S. mansoni infection				
No	527	344 (65.3)		
Yes	393	307 (78.1)	1.90	1.41–2.56
<100 ova/gram of stool	224	172 (76.8)	1.76	1.23–2.52
≥100 ova/gram of stool	169	135 (79.9)	2.11	1.39–3.20
Clinical findings				
History of schistosomiasis				
No	358	232 (64.8)		
Yes	381	313 (82.2)	2.50	1.78–3.51
Prior treatment of schistosomiasis				
No	559	336 (60.1)		
Yes	379	312 (82.3)	3.09	2.26–4.23
History of blood in stools				
No	785	548 (69.8)		
Yes	165	113 (68.5)	0.94	0.65–1.35
<15 years	54	25 (46.3)	0.78	0.44–1.39
≥15 years	111	88 (79.3)	0.69	0.41–1.18
History of abdominal pain				
No	483	314 (65.0)		
Yes	466	347 (74.5)	1.57	1.19–2.08
<15 years	173	104 (60.1)	1.78	1.20–2.64
≥15 years	293	243 (82.9)	0.91	0.57–1.44
Hepatomegaly in MCL (by PE)				
No	890	628 (70.6)		
Yes	29	19 (65.5)	0.79	0.36–1.73
<15 years	3	0 (0.0)		
≥15 years	26	19 (73.1)	0.53	0.21–1.30
Splenomegaly (by PE)				
No	882	605 (68.6)		
Yes	70	57 (81.4)	2.01	1.08–3.73
<15 years	8	2 (25.0)	0.30	0.06–1.52
≥15 years	62	55 (88.7)	1.66	0.73–3.78

TABLE 2
Continued

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence limits
Ultrasonography				
Hepatomegaly in MCL				
No	781	556 (71.2)		
Yes	139	90 (64.7)	0.74	0.51–1.09
<15 years	44	19 (43.2)	0.64	0.34–1.20
≥15 years	95	71 (74.7)	0.52	0.31–0.89
Hepatomegaly in MSL				
No	859	601 (70.0)		
Yes	61	45 (73.8)	1.21	0.67–2.18
<15 years	17	10 (58.8)	1.27	0.47–3.41
≥15 years	44	35 (79.2)	0.77	0.36–1.66
Splenomegaly				
No	540	313 (58.0)		
Yes	439	370 (84.3)	3.89	2.86–5.30
<15 years	110	79 (71.8)	3.17	1.98–5.07
≥15 years	329	291 (88.4)	2.35	1.49–3.71

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

infection. The calculation and reporting of standard errors, from which confidence intervals can be drawn, make it possible to interpret the precision of the results. By calculating the 95% CI, the precision of overall *S. mansoni* prevalence estimates was adequate for fulfilling the study objectives, i.e., to provide a representative sample sufficient for stable village and age specific estimates of prevalence and intensity of infection. The pattern of infection that emerged and elaborated on below provides insight for control. The sample design using first stage villages as the primary sampling unit allowed logistical flexibility to the field team and was feasible within typical constraints of time for data collection, analysis, and cost. A strength of the sample design was the representation of the smaller ezbas, which has been a typical problem in previous Nile Delta studies.[1,2,4,8,9] Also, prevalence was normally distributed in the primary sampling units (villages), strengthening the external validity of the results.

The estimated prevalence of *S. mansoni* in the rural villages of Kafr El Sheikh was high. This is likely an underestimate of prevalence. Given the large size of the sample, it was impractical to examine more than 1 stool specimen. In a much smaller scale study, the number of persons found positive increased when the number of Kato slides were increased, reflecting the sensitivity for this technique as observed by de Vlas and others.[17] Using the model developed by de Vlas and others[17] for estimating prevalence, given the sensitivity of the Kato method and our estimates of prevalence and GMEC, the actual prevalence could be greater than 50%.

There were significant differences between sexes in *S. mansoni* prevalence, although small and, from the public health point of view, not important. The GMEC was low relative to prevalence and this was true across all age groups with little difference between sexes. This suggests that the community was at a high risk for contracting infection but adequate exposure, necessary for a high intensity of infec-

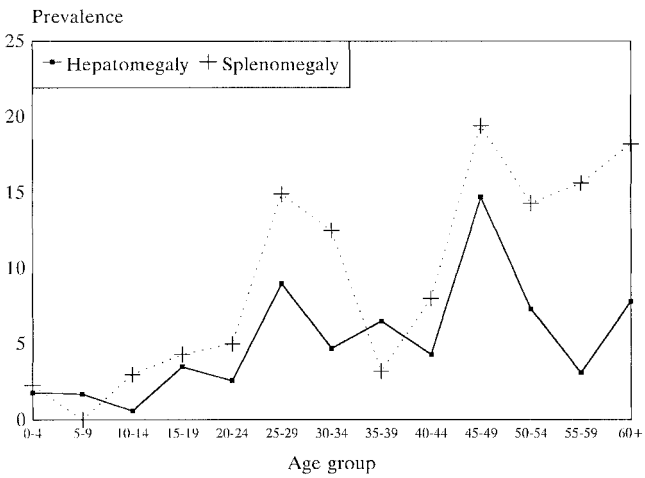

FIGURE 3. Prevalence (%) of hepatomegaly and splenomegaly (as determined by physical examination) in relation to age (years) in Kafr El-Sheikh governorate.

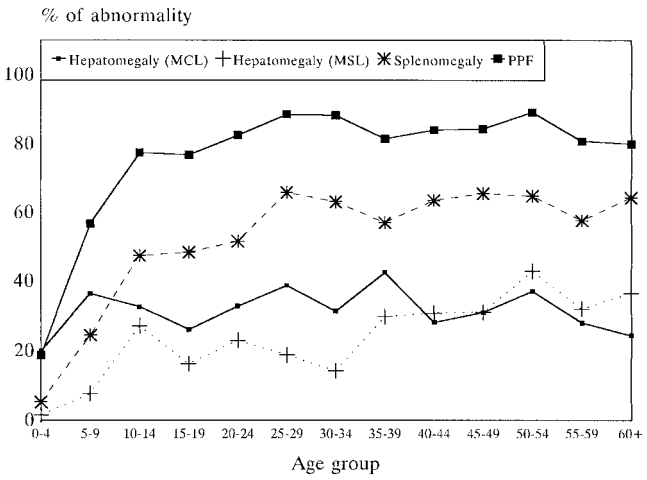

FIGURE 4. Hepatomegaly, splenomegaly, and periportal fibrosis (PPF) in relation to age (years) in Kafr El-Sheikh governorate. MCL = midclavicular line; MSL = midsternal line.

tion, was limited to a small proportion of the population. This is consistent with a nonrandom dispersion of egg intensities seen in other endemic areas;[18] however, among those infected, GMEC was not associated with age or sex but varied from high to low in very young children. The GMEC was highest in 1-year-old children (115 eggs/g). Some of these 1-year-old children had egg counts >1,000. It was unexpected to find children 1-year of age or less, with high egg counts. To better understand this and the large variation of GMEC in young children, we are currently investigating routes of exposures in these children.

One explanation of the low GMEC could be due to the availability of passive chemotherapy. Rural health units and local physicians are present throughout the governorate. Based on summary reports from Ministry of Health Endemic Disease Control offices, self-referral for examination and treatment is common. Praziquantel has been available at local rural health units since 1989. Because detailed information was obtained during the interview on a history of treatment and infection, it will be possible to investigate the impact of passive chemotherapy. This is currently being completed in a separate analysis of the data.

There was a large range in prevalence and GMEC between the 44 villages and ezbas, justifying a closer look at the characteristics that make these villages unique. The higher prevalence seen in many of the ezbas may be because they have fewer village services, less access to medical care, i.e., examination and treatment, and have more exposure to contaminated surface waters.

At the community level, prevalence and GMEC were strongly associated, suggesting that an estimate of village or ezba prevalence is a good predictor of intensity of infection in the community in this area of the Nile Delta.

The age-sex curve of *S. mansoni* began to flatten by age 10 and did not decrease in the adult ages in the classical manner seen in *S. haematobium* infections in Upper Egypt.[19] The lack of a decrease in the adult years has implications in regards to methods for evaluation of control. Evaluation of control programs frequently limits the collection of data to samples of school children. The use of school children to monitor control has been rationalized because this age group has so frequently been associated with the highest age-specific prevalence and GMECs.[20] In Kafr El Sheikh, the results show a large proportion of the infection and intensity of infection present in the adult ages.

In addition to the classic study by Scott[1] and surveillance data collected by the Ministry of Health,[2] there are 4 other reports on schistosomiasis in Kafr El Sheikh.[2,7–9] Although summary estimates cannot be made with the data from Scott,[1] others, using Scott's data, indicated that 41% were infected with *S. mansoni* and 54% with *S. haematobium* in 1938.[9] Data from 1955 collected by the Ministry of Health for the same area indicated 17% and 51% infected, respectively.[2] Both reports were based on spot surveys. The number of persons examined by Scott[1] was 3,095 and the number examined in the 1955 study was 6,131.[2] In 1976, data on *S. mansoni* were collected from 7 villages and ezbas (n = 4,838) located in Kafr El Sheikh.[7] In that period, 20% were found positive for *S. mansoni*, 30% for *S. haematobium*, and 42% were infected with either or both species. More recently, the Ministry of Health Center for Field and Applied Research (CFAR) completed 2 Nile Delta surveys.[8,9] In 1983, CFAR reported the prevalence of *S. mansoni* for Kafr El Sheikh as 51%[8] and in 1990 as 17%.[9] *Schistosoma haematobium* was much lower, less than 5%.[8,9]

Although there are serious limitations in making comparisons between these studies, *S. haematobium* has shown a consistent decrease in this area of the Nile Delta, with a substantial decrease occurring sometime in the late 1970s or early 1980s. The epidemiologic determinants of this decrease have yet to be identified. *Schistosoma haematobium* infection, although present in the sample, was rare (0.2%). One village had a prevalence of 2.1%, which was significantly higher than the background level. Whether local transmission is occurring or that these cases were acquired elsewhere cannot be confirmed. Methods to detect low levels of *S. haematobium* need to be assessed to adequately monitor this species.

Secular trends for *S. mansoni* have been less clear. *Schistosoma mansoni* may have decreased from Scott's time to 1955[2] and later in 1976.[7] The CFAR reported another decrease between 1983[8] and 1990.[9] There is a substantial difference between the most recent report of 17%[9] and our finding of 39.3%. There may have been an increase since 1990, but there are several limitations to making any firm conclusions. The foremost of these is that the overall prevalence for the entire sample in both the 1983 and 1990 CFAR reports were summed directly across villages for the entire governorate without consideration of the varying district populations from which each village was selected. It is not possible to determine how much error this introduces into the total reported figures. However, this type of analysis bias can cause substantial error in either direction.[21] Standard errors were not provided; therefore, the precision of the reported prevalence estimates could not be evaluated and inferences to the target population cannot be made, for example, an estimate of the total number of persons infected in rural Kafr El Sheikh. Village definitions differ and ezbas were not included in the sample design of the CFAR studies. In both CFAR reports, non-response was reported to be low. However, CFAR sampling protocols sample with replacement for non-response. That is, if the persons in a selected household do not participate, then the house next to it is selected. This form of replacement can introduce self-referral bias.[21] The replacement rates from more recent studies by CFAR in the southern Nile Delta varied substantially.[22]

Obviously, there may be differences in the sensitivities between the techniques used and the amount of stool specimen examined, in addition to study design issues, that limit the comparisons between these studies. Nevertheless, the lowest prevalence of *S. mansoni* in our sampled villages was 24.5%, which is greater than the mean value of 17% reported for Kafr El Sheikh by CFAR.[9] Due to these differences in study design, it is not possible to conclude that there are real differences in the reported prevalence of *S. mansoni* between this study and the studies by CFAR. The need for standardized sampling methods, parasitology, and analyses for future studies in the Nile Delta is apparent.

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