



REVIEW

Epidemiology of Schistosomiasis in Egypt: Travel through Time: Review

Rashida M.R. Barakat *

Tropical Health Department, High Institute of Public Health, Alexandria University, Alexandria, Egypt

Received 2 April 2012; revised 5 July 2012; accepted 6 July 2012

Available online 5 September 2012

KEYWORDS

Schistosomiasis;
Schistosoma mansoni;
Schistosoma haematobium;
Egypt;
Epidemiology;
Control

Abstract Schistosomiasis is a parasitic disease caused by blood flukes (Trematodes) of the genus *Schistosoma* (*S.*). It is well documented that schistosomiasis haematobium was endemic in Ancient Egypt. Infection was diagnosed in mummies 3000, 4000 and 5000 years old. Scott was the first to describe the pattern of schistosomiasis infection in Egypt. Schistosomiasis haematobium was highly prevalent (60%) both in the Nile Delta and Nile Valley South of Cairo in districts of perennial irrigation while it was low (6%) in districts of basin irrigation. *Schistosoma mansoni* infected 60% of the population in the Northern and Eastern parts of the Nile Delta and only 6% in the Southern part. Neither *S. mansoni* cases nor its snail intermediate host were found in the Nile Valley South of Cairo. The building of the Aswan High Dam -which was completed in 1967 – did not cause any increase in schistosomiasis prevalence. In 1990, a study conducted in nine governorates of Egypt confirmed the change in the pattern of schistosomiasis transmission in the Delta. There was an overall reduction in *S. mansoni* prevalence while *Schistosoma haematobium* had continued to disappear. In Middle and Upper Egypt there was consistent reduction in the prevalence of *S. haematobium* except in Sohag, Qena, and Aswan governorates. However, foci of *S. mansoni* were detected in Giza, Fayoum, Menya and Assiut. All schistosomiasis control projects implemented in Egypt from 1953 to 1985 adopted the strategy of transmission control and were based mainly on snail control supplemented by anti-bilharzial chemotherapy. In 1997, the National Schistosomiasis Control Program (NSCP) was launched in the Nile Delta. It adopted morbidity control strategy with Praziquantel mass treatment as the main component. In 1996, before the NSCP, 168 villages had *S. mansoni* prevalence > 30%, 324 villages 20–30% and 654 villages 10–20%. By the end of 2010, in the whole country only 29 villages had prevalence > 3% and none had more than 10%.

© 2012 Cairo University. Production and hosting by Elsevier B.V. All rights reserved.

* Tel.: +20 3 4298368; fax: +20 3 4288436.

E-mail address: barakat@dataxprs.com.eg.

Peer review under responsibility of Cairo University.



Production and hosting by Elsevier

Introduction

Schistosomiasis is a parasitic disease caused by the digenetic trematodes of the genus *Schistosoma* members which are commonly known as blood flukes. *Schistosoma haematobium* was discovered by Theodore Bilharz in 1851 during autopsy at Kasr El Ainy hospital [1]. In 1915, the life cycle of the

Schistosome parasite was first described by Leiper [2]. Schistosomiasis comes after malaria among parasitic diseases as regards the number of people infected and those at risk of infection [3].

There are two major forms of schistosomiasis – intestinal and urogenital-caused by five species of the parasite. Intestinal schistosomiasis is caused by four species namely: *Schistosoma mansoni* (*S. mansoni*), *S. japonicum*, *S. mekongi* and *S. intercalatum*. *S. mansoni* is the most prevalent species being endemic in 55 countries e.g. Arab peninsula, Egypt, Libya, Sudan, Sub-Saharan Africa, Brazil, some Caribbean islands, Suriname and Venezuela [3]. *S. japonicum* is endemic in China, Indonesia and the Philippines while *S. mekongi* prevails in several districts of Cambodia and the Lao Peoples' Democratic Republic and *S. intercalatum* prevails in rain forest areas of Central Africa. On the other hand, *S. haematobium* – which is the causative agent of urogenital schistosomiasis – is endemic in 53 countries in Africa and the Middle East [4].

In the absence of accurate epidemiological data, estimates must still be used to determine the possible burden of infection due to schistosomiasis. On the basis of extrapolating the national prevalence data obtained from the world atlas of schistosomiasis and applying it to 1995 population estimates, it was calculated that about 625 million people would be at risk and 193 million would be infected. Based on these calculations, 85% of the estimated number of infected people are in the African continent [3].

Although successful control projects have been implemented in the last 50 years, yet neither the number of endemic countries nor the estimated number of people infected or at risk of infection were reduced [5].

History of schistosomiasis in Egypt

It is well documented that schistosomiasis haematobium was endemic in Ancient Egypt. Ruffer in 1910, was the first to diagnose *S. haematobium* infections in mummies. He recovered calcified schistosome eggs from two Egyptian mummies of the 20th Dynasty [6]. Calcified schistosome ova were identified radiologically in several mummies from later periods [7]. The radiological examination also strongly suggested that the calcified bladders in two other mummies were due to *S. haematobium* infection [8].

The use of an immunodiagnostic test, the ELISA, led to the diagnosis of the earliest case of human schistosomiasis (*S. haematobium*) which occurred more than 5000 years ago in an Egyptian adolescent [9]. ELISA also identified *S. haematobium* infection in two mummies aged 3000 and 4000 years [7].

Trend of schistosomiasis in Egypt

Scott, 1937, was the first to describe the pattern of *S. haematobium* and *S. mansoni* infection throughout Egypt [10] Fig. 1. His conclusions were based on two series of data which seemed to harmonize fairly well. The first were data obtained from 2 million samples collected by the Endemic Diseases section of the Public Health departments. The second were the results of examination of samples from 40,000 persons in a house to house survey done under Scott's direct supervision. On the basis of the distribution of the human schistosomes, Scott divided Egypt into four regions (the first region is the Northern and

Eastern parts of the Delta, the second is the Southern part of the Delta while the third and fourth parts are in the Nile Valley South of Cairo. The third part is areas with perennial irrigation system and fourth part is areas with basin irrigation). In the first three regions about 60% of the rural population was infected with *S. haematobium*. In the first region, the Northern and Eastern parts of the Delta, *S. mansoni* also infected 60% of the population, while about 85% had either one or both species. In the second region, the Southern part of the Delta, *S. mansoni* infected not more than 6%, although the intermediate host, the *Biomphalaria alexandrina* snail, seemed to be as abundant as in the first region. No topographic, hydrographic or demographic differences between these regions could be noted, although the line of demarcation was very sharp as far as the prevalence of the parasite was concerned. The third and fourth regions were in the Nile Valley South of Cairo and there, the snail intermediate host of *S. mansoni* had never been found. In the third region – where perennial irrigation was used – *S. haematobium* only was found and its prevalence was 60%. In the fourth region -areas with basin irrigation – *S. haematobium* prevalence was less than 5%. Scott observed that the snails were much more abundant where perennial irrigation furnished canals and ditches containing water throughout the year while with basin irrigation most of the breeding places were alternatively swept by the annual flood and desiccated in the hot summer. This led him to conclude that the change in the system of irrigation in Upper Egypt was responsible for the increase in *S. haematobium* infection rate from 5% to 60% [10]. Furthermore, Azim, 1935 and Khalil and Azim, 1938 demonstrated the impact of converting the basin irrigation system to perennial irrigation in Upper Egypt on the transmission of schistosomiasis *haematobium* [11,12]. Similarly, El Zawahry reported that the construction of the perennial irrigation system in old Nubia led to a remarkable increase in *S. haematobium* infection rate [13].

After Scott's survey, several studies were conducted to estimate the pattern of schistosomiasis transmission in one or more governorates of Egypt [14–19]. Twenty years after Scott's study, Wright reported the distribution of both species of schistosomes based on data which originated from another survey carried out by the Egyptian Ministry of Health using the same methods employed by Scott and in the same villages which he had surveyed, but involving 124,253 persons taken by random sampling [14]. Comparing the data obtained with those of Scott's, changes in the pattern of the two species were observed. Both *S. mansoni* and *S. haematobium* had decreased in the Nile Delta. However, *S. mansoni* had increased in Giza and *S. haematobium* had decreased in Upper Egypt except in Sohag, Qena and Aswan where there was a dramatic increase in these three governorates due to conversion to the perennial irrigation system. Furthermore, in 1977, studies conducted in eight villages in Qalubeia governorate reported obvious changes in the pattern of transmission of schistosomiasis prevalence during the previous two decades. The prevalence of *S. haematobium* showed a marked decrease contrary to *S. mansoni* which showed a relative increase [15]. These findings led to the design of two cross-sectional surveys of the population of the Nile Delta in 1983 and 1990 [17,19]. The two surveys included the study of 71 villages, one village from each of the 71 districts comprising the eight governorates of the Nile Delta. When the data of 1983 survey was compared with Scott's data, a slight increase in the overall *S. mansoni* prevalence from 33%

(57.7%) of the same village [36]. In conclusion, the study of the nine governorates of Egypt confirmed the already documented change in the pattern of transmission of both species of schistosome infection in Upper and Lower Egypt [22]. The detailed data are presented in Tables 1 and 2 and Fig. 1.

In general, two main factors were responsible for the pattern of schistosomiasis infection in Egypt. The first factor is the irrigation used whether basin or perennial. The change from basin to perennial irrigation was the result of the construction of the Aswan High Dam. The second was the control programs implemented by the Egyptian Ministry of Health. Since both these factors played a vital role regarding the situation of schistosomiasis infection, they will be discussed in details under separate topics later.

Effect of Aswan High Dam on schistosomiasis transmission in Egypt

The Aswan High Dam was constructed on the River Nile, 7 km South of Aswan. The designs of the Dam were completed in 1959 and its construction began in 1960. Temporary closure of the Nile in 1965 was instituted till the building of the Dam was completed in 1967 and by 1970 all 12 turbines were in operation [37,38].

The effect of Aswan High Dam on the prevalence of schistosomiasis has aroused a lot of controversy. Some scientists expected that schistosomiasis prevalence would increase after the closure of the Dam. A tremendous increase in bilharziasis was predicted by Van Der Schalie [39]. He even stated that "there is

Table 1 Prevalence of *S. haematobium* and *S. mansoni* infection in Lower Egypt governorates, 1935–2000.

| Governorate year | Source | <i>S. haematobium</i> (%) | <i>S. mansoni</i> (%) |
|-----------------------------------|-----------------------|---------------------------|-----------------------|
| <i>Beheira</i> | | | |
| 1935 | Scott [10] | 53.1 | 50.7 |
| 1955 | Wright [14] (MoH) | 46 | 31 |
| 1966 | Farouq et al. [50] | 29.7 | 28.5 |
| 1983 | Cline et al. [17] | 8 | 53 |
| 1990 | Mickelson et al. [19] | 1 | 24 |
| <i>Gharbeya</i> | | | |
| 1935 | Scott [10] | 58.3 | 38.0 |
| 1955 | Wright [14] | 51 | 17 |
| 1983 | Cline et al. [17] | 4 | 43 |
| 1990 | Mickelson et al. [19] | 3 | 23 |
| 2000 | El Khoby et al. [22] | 0.26 | 37.7 |
| <i>Kafr El Sheikh^a</i> | | | |
| 1935 | Scott [10] | 44 | 44.7 |
| 1955 | Wright [14] | 43.4 | 25.5 |
| 1981 | Miller et al. [16] | 30 | 20 |
| 1983 | Cline et al. [17] | 4 | 51 |
| 1990 | Mickelson et al. [19] | 2 | 17 |
| 2000 | El Khoby et al. [22] | 0.45 | 39.2 |
| <i>Menoufeya</i> | | | |
| 1935 | Scott [10] | 70 | 10.3 |
| 1955 | Wright [14] | 45 | 1 |
| 1983 | Cline et al. [17] | 5 | 20 |
| 1990 | Mickelson et al. [19] | 3 | 19 |
| 2000 | El Khoby et al. [22] | 0.44 | 28.5 |
| <i>Dakahleya</i> | | | |
| 1935 | Scott [10] | 53.4 | 37.8 |
| 1955 | Wright [14] | 50 | 9 |
| 1983 | Cline et al. [17] | 6 | 45 |
| 1990 | Mickelson et al. [19] | 2 | 31 |
| <i>Sharkeya</i> | | | |
| 1935 | Scott [10] | 65.8 | 27.8 |
| 1955 | Wright [14] | 52 | 5 |
| 1983 | Cline et al. [17] | 5 | 26 |
| 1990 | Mickelson et al. [19] | 6 | 22 |
| <i>Qalubeya</i> | | | |
| 1935 | Scott [10] | 61.5 | 25.9 |
| 1955 | Wright [14] | 31 | 3 |
| 1983 | Cline et al. [17] | 6 | 29.0 |
| 1990 | Mickelson et al. [19] | 7 | 19.0 |
| 2000 | El Khoby et al. [22] | 0.08 | 17.5 |

^a Previously part of Gharbeya governorate.

Table 2 Prevalence *S. haematobium* and of *S. mansoni* infection in Middle and Upper Egypt governorates, 1935–2000.

| Governorate year | Source | <i>S. haematobium</i> (%) | <i>S. mansoni</i> (%) |
|------------------|----------------------|---------------------------|-----------------------|
| <i>Giza</i> | | | |
| 1935 | Scott [10] | 53.7 | 0.6 |
| 1955 | Wright [14] | 34 | 3 |
| 1999 | Talaat et al. [36] | 7.4(10.6) ^a | 33.7(57.7) |
| <i>Fayoum</i> | | | |
| 1935 | Scott [10] | 74.2 | 0.4 |
| 1955 | Wright [14] | 38 | One case |
| 2000 | El Khoby et al. [22] | 13.7 | 4.3 |
| <i>Beni Suef</i> | | | |
| 1935 | Scott [10] | 75.2 | 0.0 |
| 1955 | Wright [14] | 36 | ND |
| 1981 | Miller et al. [16] | 27 | ND |
| <i>Menia</i> | | | |
| 1935 | Scott [10] | 41.6 | Two cases |
| 1955 | Wright [14] | 39 | ND |
| 1987 | Kessler [34] | 5.0 | |
| 2000 | El Khoby et al. [22] | 8.9 | 1.04 |
| <i>Assiut</i> | | | |
| 1935 | Scott [10] | 29.7 | 0.0 |
| 1955 | Wright [14] | 16.0 | ND |
| 2000 | El Khoby et al. [22] | 5.21 | 0.42 |
| <i>Sohag</i> | | | |
| 1935 | Scott [10] | 3.1 | Two cases |
| 1955 | Wright [14] | 42.0 | ND |
| <i>Qena</i> | | | |
| 1935 | Scott [10] | 3.8 | 0.0 |
| 1955 | Wright [14] | 4 | |
| 2000 | El Khoby et al. [22] | 4.78 | 0.44 |
| <i>Aswan</i> | | | |
| 1935 | Scott [10] | 13.2 | 0.0 |
| 1955 | Wright [14] | 23 | ND |
| 1981 | Miller et al. [16] | 4 (25) ^b | 0.0 |

ND: not done.

^a Prevalence in village population (prevalence in primary school children).

^b 4% In desert villages, 25% in agriculture villages.

evidence that the high incidence of the human blood fluke (schistosomiasis or bilharziasis) in the area may well cancel out the benefits the construction of the Dam may yield". This increase in schistosomiasis prevalence was attributed to reclamation of new land and conversion of the basin irrigation system to the perennial. Furthermore, in 1977, Malek stated other reasons for the increase in schistosomiasis transmission [40]. His study indicated that, at least in some sections of the lower Nile, ecological changes as a consequence of the Dam were enhancing the transmission of the disease. In addition to the abundance of the snail intermediate host in the Nile, the absence of silt and decrease in water current velocity in the lower Nile would have given higher chance for the miracidia to come in contact with the snails and for the cercaria to infect humans. The same author reported that human activities in and near the Nile water had increased considerably throughout the year because of the low, clean and slow water [40]. There was more fishing, swimming and washing of domestic utensils and clothes. Such activities used to be done only in irrigation canals. Another significant factor in the ecology of the snail host living in the irrigation canals in the Nile Delta is the

elimination of the winter closure because clearance of the canals -during this period-from the flood silt deposited in their beds was not needed anymore. Such an adverse and disastrous factor which used to affect the snail population will be absent after the High Dam construction, thus leading to flourishing of the breeding of snails in the Nile Delta canals with increase in schistosomiasis transmission [40]. Another study conducted in some villages in Upper Egypt close to the Dam reported an increase in the prevalence rate of schistosomiasis haematobium among some inhabitants of these villages [41].

In contradiction to the previous conclusions, other scientists reported that the construction of the Aswan High Dam did not cause an increase in schistosomiasis prevalence [16,38,42]. In 1978, Miller et al. [42] conducted an environmental and epidemiological survey on 15,329 rural Egyptians who were selected from three major geographical regions of Egypt (Nile Delta, Middle Egypt and Upper Egypt) in addition to the resettled Nubian population. Prevalence of either or both species of schistosomiasis was 42.1% in the North Central Delta region. In Middle Egypt which spreads from Beni Suef and Assiut governorate, *S. haematobium* was the only prevalent

species with a rate of 26.7%. In addition, sporadic cases of *S. mansoni* were noted. Prevalence in the study sites of Upper Egypt varied according to the location of the village. In desert villages, the prevalence of *S. haematobium* was very low (4.1%) compared to the prevalence in agricultural villages (24.8%). The same authors [42] concluded that: “there was sufficient historical and current data to firmly disregard any role of the Aswan High Dam in causing an increase in schistosomiasis in rural Egypt” [42]. They also reported that all available data pointed to an overall decrease of both *S. haematobium* and *S. mansoni* rather than increase and this included the resettled Nubia. However, there was an indication that the distribution of *S. mansoni* is expanding southwards [15,42]. They attributed the reported reduction in the prevalence to the improvement in the domestic water supply to villages, the development and delivery of proper health care in addition to the increase in the general awareness among the population at risk of how to avoid infection and how to get treatment.

As regards transmission of schistosomiasis in Lake Nasser, infection with *S. haematobium* was prevalent among the fishermen working there. The prevalence of detected *S. haematobium* infection at entry to the lake declined from 67% in both 1974 and 1975 to 18% in 1980 and 20% in 1981. This was attributed to the widespread use of metrifonate in Upper Egypt beginning in 1975. As regards *S. mansoni* infection, no cases were reported among fishermen examined [32].

The snail intermediate host of *S. haematobium* (*Bulinus truncatus*) was present in abundance; some of them were infected with *S. haematobium*. On the other hand, *Biomphalaria alexandrina*, (the intermediate host of *S. mansoni*) was detected in only one site at the Northern tip of the lake, but none of them was infected [32].

Schistosomiasis control in Egypt

The first attempt to control schistosomiasis in Egypt started in 1920 [43]. The Egyptian Ministry of Health installed mobile units to examine and treat all pupils at a large number of elementary, primary and secondary schools thus stopping the disease in early childhood. The number of these units increased from 6 in 1924 to 56 in 1933 with the number of annual treatments increasing from nearly 47000 to 311000 [44].

In 1926, the first planned control scheme was started at Dakhla oasis. It comprised treatment of about a third of the population with tartar emetic in addition to application of copper sulfate for 96 h to all irrigation canals. All *Bulinus* snails were killed and none was found 6 months later [45]. Regular surveys in the early 1930s failed to detect snails and none of the 70 children born after the last mollusciciding in 1929 was infected at 1936 survey [46].

Until mid eighties of the last century, the strategy for schistosomiasis control -recommended by the WHO - aimed at reducing transmission by diminishing the snail population. As this method became effective, morbidity in the human population was slowly reduced and in the long term, the complete eradication of the parasite might have been achieved [47].

In 1984, a major change in the strategy became possible with: (a) Recognition that morbidity of schistosomiasis was directly related to the prevalence and intensity of infection, both being high in the 10–14 years age group. (b) The development of simple quantitative diagnostic techniques suitable for field

studies. (c) The development of new antischistosomal drug (praziquantel) which is safe and effective against the three important human schistosome species. At present, the main objective of control is to reduce or eliminate morbidity or at least serious disease [47].

All schistosomiasis control projects carried out in Egypt followed the same strategy recommended by the WHO. All programs conducted before 1984 aimed at transmission control and the main activity was based on snail control which might be supplemented by antibilharzial treatment. The following control projects were implemented during the period from 1953 to 1985 [35].

- Qaliub project (1953–1954): Snail control using copper sulfate.
- Qalubeya project (1953–1959): Mass treatment using tartar emetic.
- Warrak El Arab project (1953–1959): Snail control using sodium pentachlorophenate.
- Egypt 049 project (1961–1969): Snail control using niclosamide.
- Iflaka project (1962–1966): Mass treatment using Astiban.
- Giza project (Shimbari 1970): mass treatment using hycanthone.
- Fayoum project (1969): Chemotherapy and snail control using niclosamide [48].
- Middle Egypt control program: started in 1977, implemented in Beni Suif, Menia and Assiut North of Dairut.
- Upper Egypt control program: started in 1980, implemented in Assiut South of Dairut, Sohag, Qena and Aswan.

Middle and Upper Egypt control projects [24,36] were the largest of those conducted in Egypt. They covered about two million irrigated Feddans and a total population of more than 12 million people. Extensive land reclamation with installation of the drainage has been carried out in different parts of the area. The project was divided into three phases: (1) Intensive phase; 3 years. (2) Consolidation phase; 3 years. (3) Maintenance phase. The intensive phase involved: (a) Area wide application of niclosamide for three times/year. (b) Chemotherapy for infected individuals, metrifonate (bilarcil), three doses with 14 days apart. In 1988 praziquantel was used for treatment.

Impact of the projects: an international evaluation team, in 1985, showed that since the initiation of control intervention, the overall prevalence of schistosomiasis haematobium [35] of about 30% in the Middle Egypt project area, determined in 1977, had been reduced to approximately 8.5% [34]. Furthermore, the detailed data reported by the Ministry of Health showed a continuous downward trend in prevalence rates. But significant re-infections were reported among school children particularly in young age groups during the summer season indicating that appreciable transmission was continuing in the project area [35].

Although it was apparent that a large measure of control had been achieved since intervention began, the results showed some upward trends in prevalence of infection during the maintenance phase [35].

National Schistosomiasis Control Program (NSCP) in the Nile Delta: This project started in 1997 and was based on the morbidity control strategy adopted by the WHO in 1984 [47]. The main activity of the project was praziquantel

chemotherapy. Mass treatment was offered without prior diagnosis to all school children 6–18 years old and to all inhabitants of villages where *S. mansoni* prevalence among outpatients of rural health units was $\geq 20\%$. Otherwise, treatment was given to infected persons only. Furthermore, focal mollusciciding using niclosamide was applied on water courses with high snail density or harboring infected snails. In addition, health education campaigns and capacity building through training of personnel working in rural health units or involved in snail control activities were applied [49].

As the program progressed, and *S. mansoni* prevalence decreased, the threshold for mass chemotherapy was changed to $\geq 10\%$ in 1999, $\geq 5\%$ in 2000 and $\geq 3.5\%$ in 2002 to 3% in 2003. The records of Ministry of Health reported that in 1996 before the application of mass chemotherapy campaign; 168 villages had prevalence $> 30\%$, 324 villages had prevalence 20–30% and 654 villages had prevalence 10–20%. By the end of 2010, in the whole country only 20 villages had prevalence more than 3.5% and none had prevalence more than 10% [49].

At present, a multi-sectoral approach is adopted. This aims at interrupting transmission and achieving elimination through wider integration of the present strategy with other interventions such as mass chemotherapy campaigns for school-age children and populations in hot spot areas together with improvement of health awareness, social mobilization, snail control within the activities of the primary healthcare system, and environmental sanitation. The strategy adopted for control differs according to the epidemiological setting. In newly developed areas with no transmission and no autochthonous cases, surveillance and routine screening is done. In villages where schistosomiasis prevalence is $< 3\%$, active population screening, monitoring after treatment, snail control and water and sanitation are done. On the other hand, in villages with active transmission and a prevalence $> 3\%$, mass treatment, snail control and clean water and sanitation are stressed [49].

Conclusion

Although it is well documented that schistosomiasis haematobium was endemic in Ancient Egypt, yet the first detailed study describing its pattern of prevalence was carried out in 1937 by Scott. He reported that schistosomiasis was highly prevalent in both the Nile Delta and the Nile Valley South of Cairo in districts where the perennial irrigation system was used. The highest prevalence was recorded in the Northern and Eastern parts of the Delta where 85% of the population was infected with either one or both species of the parasite. On the other hand, *S. mansoni* infection was very low in the Southern part of the Delta and completely absent from the Nile Valley South of Cairo whether basin or perennial irrigation system were used.

After Scott's study, several large scale surveys were conducted to estimate the pattern of schistosomiasis infection. In general, in the Nile Delta governorates there was a gradual reduction in the overall prevalence of *S. mansoni* infection while *S. haematobium* prevalence continued to decrease till it disappeared completely. In Middle and Upper Egypt governorates, there was a consistent reduction in the prevalence of *S. haematobium* infection except in Sohag, Qena and Aswan following the construction of the High Dam where basin irrigation was converted to perennial irrigation system.

At present, the Ministry of Health and Population records indicate that by the end of 2010 only 20 villages in the whole country showed prevalence more than 3.5% and none had more than 10%. The great success in controlling schistosomiasis in Egypt is achieved through the implementation of several control programs which adopted the same strategy recommended by the WHO.

References

- [1] Bilharz T. Further observations concerning *Distomum haematobium* in the portal vein of man and its relationship to certain pathological formations with brief notes by Seibald. *Z Wiss Zool* 1853;4:72.
- [2] Leiper R. Report on the results of the Bilharzia mission in Egypt: Part I. Transmission. *J R Army Med Corps* 1915;25:1–55.
- [3] Chitsulo L, Engles D, Montresor A, Savioli L. The global status of schistosomiasis and its control. *Acta Tropica* 2000;77:41–51.
- [4] WHO. Schistosomiasis. Fact sheet. No*115;2012.
- [5] Savioli L, Renganathan E, Montresor A, Davis A, Behbehani K. Control of schistosomiasis – a global picture. *Parasitology Today* 1997;13:444–8.
- [6] Ruffer M. Note on the presence of “*Bilharzia haematobia*” in Egyptian mummies of the twentieth dynasty. *Br Med J* 1910;1:16.
- [7] Contis G, David A. The epidemiology of Bilharzia in ancient Egypt: 5000 years of schistosomiasis. *Parasitol Today* 1996;12:253–5.
- [8] David A. Disease in Egyptian mummies: the contribution of new technologies. *Lancet* 1997;349:1760–3.
- [9] Deelder A, Miller N, De Longe M, Krijker F. Detection of schistosome antigen in mummies. *Lancet* 1990;335:724–5.
- [10] Scott J. The incidence and distribution of the human schistosomiasis in Egypt. *Am J Hyg* 1937;25:566–614.
- [11] Azim M. The epidemiology of schistosomiasis in Egypt. *J Egypt Med Assoc* 1935;18:215–30.
- [12] Khalil M, Azim M. Further observations on the introduction of infection with *Schistosoma haematobium* infection. *J Egypt Med Assoc* 1938;21:95–101.
- [13] El Zawahry M. A health survey in Egyptian Nubia, Part 1: objectives and design of survey, and epidemiological features of parasitosis. *J Egypt Public Health Assoc* 1964(39):313–40.
- [14] Wright W. Geographical distribution of schistosomes and their intermediate host. In: Ansari N editor. *Epidemiology and control of schistosomiasis (Bilharziasis)* Baltimore: University Park Press; 1973. p. 42–8.
- [15] El Alamy M, Cline B. Prevalence and intensity of *Schistosoma haematobium* and *S. mansoni* infection in Qalyub, Egypt. *Am J Trop Med Hyg* 1977;26:470–2.
- [16] Miller F, Hussein M, Mancy K, Hilbert M, Monto A, Barakat R. An epidemiological study of *Schistosoma haematobium* and *S. mansoni* in thirty-five Egyptian villages. *Trop Geograph Med* 1981;33:355–65.
- [17] Cline B, Richards F, El Alamy M, El Hak S, Ruiz-Tiben E, Hughes J, et al. Nile Delta schistosomiasis survey: 48 years after Scott. *Am J Trop Med Hyg* 1989;41(1):56–62.
- [18] Abdel-Wahab M, Yosery A, Narooz S, Esmat G, El Hak S, Nasif S, et al. Is *Schistosoma mansoni* replacing *Schistosoma haematobium* in the Fayoum? *Am J Trop Med Hyg* 1993;49(6):697–700.
- [19] Mickelson M, Azziz F, Gamil F, Wahid A, Richards F, Juraneck D, et al. Recent trends in the prevalence and distribution of schistosomiasis in the Nile Delta region. *Am J Trop Med Hyg* 1993;49(1):76–87.

- [20] Stoll N, Hausheer W. Concerning two options in dilution egg counting: small drop and displacement. *Am J Hyg.* 1926;6(March supp.):134–45.
- [21] Katz N, Chaves A, Pellegrino J. A simple device for quantitative stool thick-smear technique in schistosomiasis mansoni. *Rev Inst Med Trop Sao Paulo* 1972;14:397–400.
- [22] El Khoby T, Galal N, Fenwick A, Barakat R, El Hawy A, Nooman Z, et al. The epidemiology of schistosomiasis in Egypt: Summary findings in nine governorates. *Am J Trop Med Hyg* 2000;62(2 S):88–99.
- [23] El-Enien M, Oriebay A, Shawky E, Saad A, Shokrani N, El Fattah M, et al., editors. Schistosomiasis in Egypt: Prevalence, intensity and morbidity in El Minya governorate. International conference on schistosomiasis; 1993; Cairo.
- [24] Medhat A, Abdel-Aty M, Nafeh M, Hammam H, Abdel-Samir A, Strickland G. Foci of *Schistosoma mansoni* in Assiut Province in Middle Egypt. *Trans Roy Soc Trop Med Hyg* 1993;87:404–5.
- [25] El Khoby T, Zemaity O, Fenwick A. Countries where both *S. haematobium* and *S. mansoni* are endemic: Progress in control of schistosomiasis since 1984 in Egypt. Geneva: World Health Organization; 1991 [contract no.: SCH/EC/91/WP.42].
- [26] El Khoby T, Hussein M, Galal N, Miller F. Epidemiology 1, 2, 3: Origins, objectives, organization, and implementation. *Am J Trop Med Hyg* 2000;62(2 S):2–7.
- [27] Barakat R, Farghaly A, El Masry A, El Sayed M, Hussein M, Miller F. *Schistosoma mansoni* in the Nile Delta, Egypt: a large scale epidemiological study in Kafr El Sheikh governorate. *Trop Geograph Med* 1995;47:259–65.
- [28] El Hawy A, Amer M, Abdel-Rahman A, Elibiary S, Agina M, Abdel-Hafez M, et al. The epidemiology of schistosomiasis in Egypt: Gharbia governorate. *Am J Trop Med Hyg* 2000;62(2 S):42–8.
- [29] Abdel-Wahab F, Medhat E, Esmat G, Narooz S, Ramzy I, El Boraey Y, et al. The Epidemiology of schistosomiasis in Egypt: Menofia Governorate. *Am J Trop Med Hyg* 2000;62(2S):25–34.
- [30] Habib M, Abdel-Aziz I, Gamil F, Cline B. The Epidemiology of schistosomiasis in Egypt: Qalubeia Governorate. *Am J Trop Med Hyg* 2000;62(2 S):49–54.
- [31] Nooman Z, Hassan A, Waheeb Y, Mishriky A, Ragheb M, Abou Saif A, et al. The Epidemiology of schistosomiasis in Egypt: Ismailia Governorate. *Am J Trop Med Hyg* 2000;62(2 S):35–41.
- [32] Hammam H, Allam F, Moftah F, Abdel-Aty M, Hany A, Abdel-Motagaly K, et al. The Epidemiology of schistosomiasis in Egypt: assiut governorate. *Am J Trop Med Hyg* 2000;62(2 S):73–9.
- [33] Hammam M, Zarzour A, Moftah F, Abdel-Aty M, Hany A, El Kady A. The Epidemiology of schistosomiasis in Egypt: Qena Governorate. *Am J Trop Med Hyg* 2000;62(2S):80–7.
- [34] Kessler P, Southgate B, Klumpp R, Mahmoud M, Restrand L, Saleh L. Report of an independent evaluation mission on the national bilharzia control program, Egypt, 1985 (abridged version). *Trans Roy Soc Trop Med Hyg* 1987;81:1–57.
- [35] Webbe G, El Hak S. Progress in the control of schistosomiasis in Egypt 1985–1988. *Trans Roy Soc Trop Med Hyg* 1990;84:394–400.
- [36] Talaat M, El-Ayyat A, Sayed H, Miller F. Emergence of *Schistosoma mansoni* infection in Upper Egypt: the Giza governorate. *Am J Trop Med Hyg* 1999;60(5):822–6.
- [37] White G editor. Alternative uses of limited water supplies. The problems of the arid zones. Paris Symposium; 1960; Paris: UNESCO.
- [38] White G. The environmental effect of the High Dam at Aswan. *Environment* 1988;30(7):5–39.
- [39] Van Der Schalie H. New High Dam, asset or liability. *The Biologist* 1960;42:63–70.
- [40] Malek E. Effect of the Aswan High Dam on prevalence of schistosomiasis in Egypt. *Trop Geograph Med* 1975;27:359–64.
- [41] Dazo B, Biles J. The present status of schistosomiasis in the Nile Valley north of the Aswan High Dam: World Health Organization; 1972 [contract no.: PD/72.14].
- [42] Miller F, Hussein M, Mancy K, Hilbert M. Aspects of environmental health impacts of the Aswan High Dam on rural population in Egypt. *Prog Water Tech Ltd* 1978;11(1/2):173–80.
- [43] Jordan P. From Katayama to the Dakhla Oasis: the beginning of the epidemiology and control of bilharzia. *Acta Tropica* 2000;77:9–40.
- [44] Khalil M. Individual variation in the excretion of drugs as an important factor in their therapeutic results. A practical method for detecting the schistosomiasis cases with so called idiosyncrasy to anatomy to avoid fatalities and complications. *J Egypt Med Assoc* 1936;19:285–305.
- [45] Khalil M. The eradication of bilharziasis: a successful attempt in an endemic area. *Lancet* 1927;ii:1235.
- [46] Khalil Bey M, Abdel Azim M. On the history of anti-bilharzial campaign in the Dakhla Oasis. *J Egypt Med Assoc* 1938;21:102–6.
- [47] WHO. The control of schistosomiasis. Geneva; 1985 [contract no.: 728].
- [48] El Hak S. Schistosomiasis control in Egypt. In: Miller M, Love E, editors. Parasitic diseases: treatment and control. Florida: CRC Press, Inc.; 1989. p. 108–13.
- [49] WHO. Informal consultation on schistosomiasis control. Geneva: WHO; 2011.
- [50] Farooq M, Nielson J, Samaan M, Mallah M. AA A. The epidemiology of *Schistosoma haematobium* and *S. mansoni* infections in the Egypt-49 project area. 2. Prevalence of bilharziasis in relation to personal attributes and habits. *Bull World Health Org* 1966;35:293–318.