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Demographic, socioeconomic and environmental changes affecting circulation of neglected tropical diseases in Egypt

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ABSTRACT

Egypt has been plagued by many neglected tropical diseases since Pharaonic time. These diseases are Schistosomiasis, soil-transmitted helminthiasis, lymphatic filariasis, leishmaniasis and fascioliasis beside the epidermal parasitic skin diseases. Indeed, theses diseases still persist as public health problem in the country by the influence of demographic, socioeconomic and environmental obstacles. This study seeks for understanding the contribution of each factor in each obstacle in neglected tropical diseases perpetuation which in turn could help the governorate in planning integrated control strategies. It was found that poverty, unregulated urbanization and inadequate sanitation are important socioeconomic factors that have great effect on the transmission dynamics of the diseases. The environmental factors which affect the epidemiology of these diseases in the country are scarcity of water, construction of dams, land reclamation for agriculture beside the climate factors. Unfortunately, the panic increase in the population growth rate minimizes the efforts done by the governorate to elevate the public health services. These conditions also affect the transmission of epidermal parasitic skin diseases including scabies, head lice and hookworm-related cutaneous larva migrans. The control programs and the recommendations to combat the diseases were discussed. The present study showed that the ecological factors affecting each neglected tropical disease in Egypt are somewhat similar which makes it worthy to develop an integrated control approaches aiming at improving the leading factors of neglected tropical diseases circulation in the country.

1. Introduction

Neglected tropical diseases (NTDs) are a group of infectious diseases caused by parasites, bacteria and viruses affecting more than one billion people globally. They are called neglected because they persist exclusively in the poorest populations often living in remote, rural areas, urban slums or in conflict zones, inflicting tremendous disability and suffering. Few efforts have been done to control NTDs in comparison to those for malaria, tuberculosis and HIV/AIDS. However, NTDs can still be controlled and are largely eliminated from the more developed parts of the world, hence, they are often forgotten [1].

Egypt has been plagued by many NTDs since Pharaonic time. It is one of the nations that stand out for having suffered the highest rates of NTDs in the Middle East and North Africa region and these diseases constitute persistent public health problems in the country despite the continuing improvement in the economic status, standard of living, sanitation and ecology of the Egyptian society. The infection with more than one parasite (polyparasitism) is prevalent which has a great impact on the morbidity and increase the susceptibility to other infections. This leads to impaired physical and cognitive growth with subsequent decrease in worker productivity [2–4].

The present study will give an overview of Egypt's major obstacles and how each factor in these obstacles interact to influence the endemic state and the circulation of the NTDs transmission to the residences. It will also discuss how changes in these challenges may lead to emergence/re-emergence of these parasites in the country. Searching for the contribution of each obstacle in the disease transmission is essential to any intervention and may help finding alternative approaches for the control alongside the chemotherapy [5].

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2. Challenges affecting NTDs in Egypt

The demographic, the socioeconomic composition of the population and the environmental conditions are the main obstacles facing the development of the country. They lead to perpetuation of poverty, increasing unemployment rates and mismatching between graduates' degree and job market as well as high rates of illiteracy, severe stress on the public education, shortages in housing, food and water resources and environmental degradation. It is increasingly accepted that perpetuation of the parasitic diseases is influenced by these challenges. Any changes affecting these circumstances may have significant effects on the disease acquisition and control. Nevertheless, considering these disciplines in designing and planning control strategies is neglected. Recently, there is a trend to enroll these factors with the epidemiological surveillance [5,6].

2.1. Demographic condition: population growth, nature and composition

The determinant factor of most of the problems in the country are predisposed and related to the growth of the population, their nature and composition. The Egyptian population grows each year by approximately 1.5 million people. This unsustainable rate of growth leads the country to rank sixteenth on the list of the most populous countries worldwide. While the Egyptian government is struggling to provide even basic government services, Egypt's population will reach 91.8 million by 2015. The population shows unbalanced distribution over the land. The accelerating population growth rate causes a stress burden on Egypt Governorate to achieve the economical development and good services including health services [7].

2.2. Socioeconomic conditions

2.2.1. Poverty

Based on the World Bank classifications, Egypt is a lower middle income country. There are significant gaps in the income levels and living standards between different parts of the country and across different segments of the society. Egypt faces great challenges in coping with the negative effects of the current economic crisis resulting from the revolution. Currently, 40% of Egyptians live below the $2 a day income poverty line. The 2010 Millennium Development Goal report highlights that poverty is one of the most critical areas of deficit in Egypt [8].

In Egypt, the NTDs are found to be highly relevant to poverty and that infection occurs in low income populations [4,9]. The long term helminths infection in children contributes to anemia and under nutrition which in turn can lead to growth stunting, poor school performance, poor work productivity and continued poverty [3]. Morbidity caused by such infections contributes to a vicious circle of infection, poverty, decreased productivity and inadequate socioeconomic development [4,9].

2.2.2. Population movement and unplanned urbanization

Unemployment and lack of job opportunities in Egypt are significant factors leading to population movement, usually to industrial cities or reclaimed agricultural areas; sometimes with their animals. There is also seasonal migration to the Delta and Nile Valley to work as laborers during planting and harvesting periods. Various population and animal movement influences the disease dynamics and is highly relevant to many NTDs. It leads to exposure of migrating populations to new risks and environment and to the introduction of parasites via infected migrants into the new areas [10]. This leads to overcome the barriers for human infection with parasites which was considered to be geographically limited because of parasites' adaptations to specific definitive and intermediate hosts and particular environmental conditions [11].

The migration to large cities in Egypt together with the high population growth leads to creation of several unplanned urban squatter settlements and formation of unregulated slum areas. These areas constitute a nationwide problem, being unplanned, illegally constructed and under-served. They tend to be the least well served in terms of infrastructure and public services and the settlers suffer from poverty, unemployment, poor housing and sanitation, lack of clean water, poor accessibility and high levels of overcrowding. Settlers at these areas eat at street vendors and mobile carts that become the fast food restaurants for those urban poor. This rapid unplanned urbanization often leads to high prevalence of intestinal parasites especially among children with increase in vector breeding and in human vector contact [2].

2.2.3. Inadequate sanitation

The process of disposal of wastewater in Egyptian villages and unregulated slum areas represents a dangerous challenge to the environment and public health. The majority of people had individual trenches in their houses for sewage disposal with absence of public sewage system in addition to limitation of safe collection and treatment of wastewater [12]. However, sanitation conditions in general are better than other developing countries [13].

2.3. Environmental conditions

Parasites utilize different media to complete their life cycles and may need diverse vectors that have different ecologies. Hence, the changes in environmental and ecological conditions, due to both natural phenomena and human intervention, influence the transmission dynamics of the parasitic diseases. In this context, the major issues in Egypt are related to the hydrological system alongside the climate factors. There is shortage of water with deterioration of its quality and construction of water developmental projects to help in land use for agriculture.

2.3.1. Scarcity of water

Egypt is unique among other countries in its dependence on water from a single source; the Nile River which is the lifeline of the country. The other resources are represented in the scattered rainfall and the groundwater exists in Western Desert and Sinai. Egypt is now facing a water crisis. The country has reached a state where the quantity of water available is imposing limits on its national economic development together with deterioration of water quality. Egypt will need 20% more water in 2020 [14].

Being the most downstream country on the Nile, Egypt is affected by climate change impacts not only within its borders, but also within the whole basin shared with nine other countries. Economic developments in upstream countries and measures they might take to adapt to climate change are likely to put more pressure on water resources in Egypt. On the other hand, Egypt is one of the African countries that could be vulnerable to water stress under climate changes. This situation is alarming as Egypt is an arid country that depends only on the River Nile. The issue lies in Egypt's pressing need to feed its exploding population through the expansion in reclaiming new areas. Besides the population growth, social factors (quality of life, crop pattern, unequal distribution of water and consumer's behavior), economic, physical variables (water resources and land expansion) together with political elements are the main driving forces of water scarcity [14]. Optimum use of water resources is implemented through the reuse of drainage water and recycling the domestic and industrial wastewater. Egypt is one of the pioneer countries in the reuse of water. However, due to inadequate sanitation facilities of the Egyptian rural areas, domestic wastewater is typically discharged directly or indirectly to drainage canals. The drainage water is actually a combination of agricultural drainage water, industrial effluents and sewage water with different ratios. Drainage water returns back to the River Nile leading to its pollution or it is mixed with freshwater and reused for irrigation purposes [15]. Additionally, treated wastewater was found to be contaminated by a broad range of protozoa and helminths eggs [16].

2.3.2. Water developmental projects and land reclamation

Approximately 4% of Egypt's total area is an agricultural land represented mainly in the Delta, the Fayoum oasis and the Nile Valley that is a narrow strip along the Nile. This agricultural area has one of the highest population densities in the world. The remaining 96% of the land is arid desert. Since the 1980s, land reclamation by converting desert areas to agricultural land lies on top of the Egyptian government priorities. In the 1990s the government launched three mega-projects to increase irrigation on “new lands”. The Toshka project is designed to create a new delta south of the Western Desert parallel to the Nile. Al-Salam Canal to cultivate lands at the west of the Suez Canal and Sinai and East Uwaynat at southwest of Western Desert. The High Dam has the merit to supply these projects by all required substantial amounts of water. The reused drainage water participates in irrigating theses areas [17]. Other small older water projects were also constructed along the Nile.

Through dam building and agricultural development the breeding sites for the vectors are increased and the parasites are introduced to populations with no previous exposure [18].

2.3.3. Climate factors

Egypt lies in the equatorial region except its northern areas which are located in the warm region within a climate similar to that of the Mediterranean region. Rainfall in Egypt is very scarce except in a narrow band along the northern coastal areas in winter. Flash floods occur due to short-period heavy storms mainly in Sinai [19]. Rainfall variability within Egypt is almost insignificant, given that the country receives very little rainfall. Nevertheless, because of the large proportional contributions to the Nile from the Blue Nile and Lake Victoria their variability is strongly reflected in the Nile flow record (El Raey 2010). Local parts of the coastal plain of the Red Sea are threatened by the risk of heavy rains which become occasionally active as a result of sudden seasonal rainfall. The heavy rains lead to increase the habitat of vector's larva and vector population [20].

Egypt's vulnerability to climate change impacts is high although its contribution to the global greenhouse gas emissions is 0.57%. Vulnerability to climate change is considered to be high in developing countries due to social, economic and environmental conditions that amplify susceptibility to negative impacts and contribute to weak adaptive capacity to cope with and adapt to climate hazards [21]. In terms of future climate changes there is high confidence that temperatures will

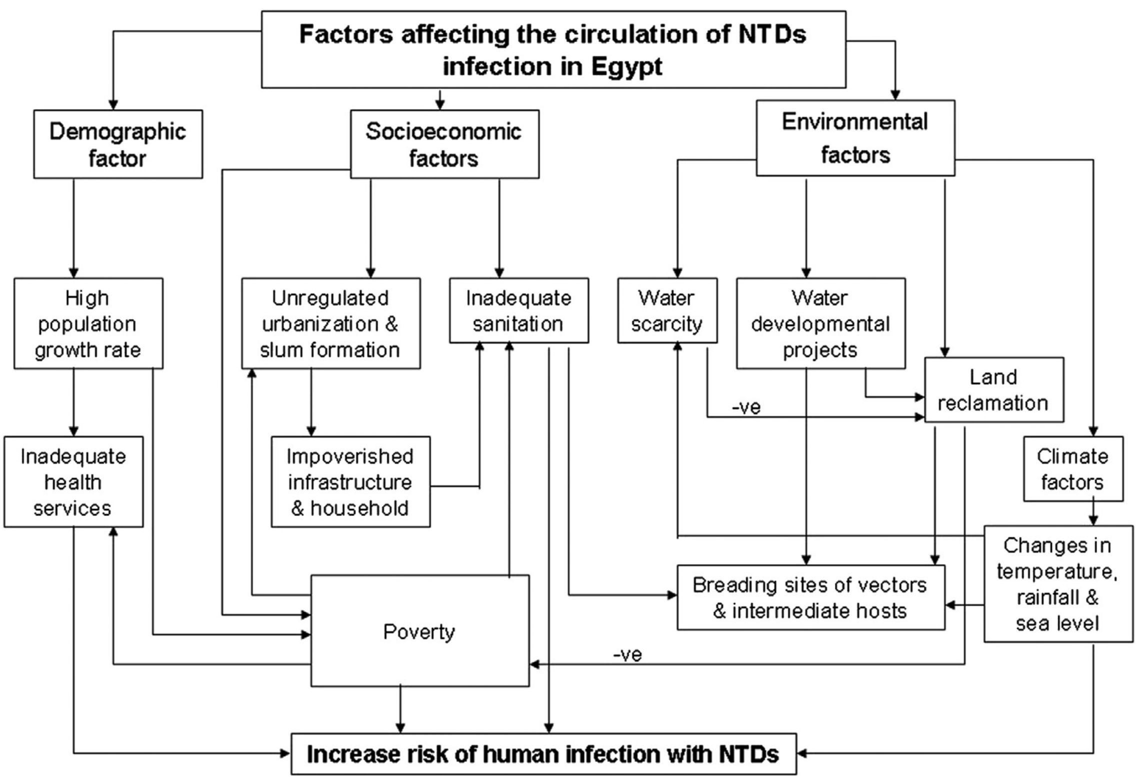

Figure 1. Effect of the demographic, socioeconomic and environmental conditions on the circulation of NTDs infection in Egypt.

continue to raise, probably more rapidly than before (Saber 2009). Climatic conditions especially global warming strongly influences the development and reproduction of parasites in their vectors [22]. It is also expected to enhance the northern spread of parasites within their vectors to northern countries [23]. The rise in temperature increases vectors growth and their feeding rate. Therefore expands seasonality distribution increases vector-human contact and enhances the susceptibility to some pathogens. However, the rise in temperature may lead to decrease in the survival of some vectors [20].

The sensitivity to sea level rise is particularly high in the country. Shoreline erosion and saltwater intrusion in groundwater can occur in the northern part of the Nile Delta. Changes in salinity of Lake Manzala may change its ecology. The coastal zone of the Red Sea on the Egyptian side is generally narrow as there is a mountain chain runs relatively close to the shoreline limiting the extensive erosion. However, artificial lakes could be formed [7]. Coastal flooding affects the abundance of vectors breeding in brackish water [20].

The effect of the demographic, socioeconomic and environmental conditions on the circulation of NTDs infection in Egypt is illustrated in Figure 1.

3. Dynamics of NTDs in Egypt

Parasites are the causative organisms to 11 out of the 17 NTDs prioritized by the WHO [24]. Five of these diseases are present in Egypt namely schistosomiasis, soil-transmitted helminthiases (STHs), lymphatic filariasis, leishmaniasis and fascioliasis.

3.1. Schistosomiasis

Schistosomiasis is a parasitic disease caused by the digenetic trematode of the genus *Schistosoma*. Schistosomiasis is considered the second most important parasitic disease in the world next to malaria [25]. Schistosomiasis is the most important endemic parasitic disease in Egypt causing 70% of the adult chronic liver diseases and 35% of child liver diseases [26].

International trading played an important role in transmission of schistosomiasis to Egypt and national trading helped the dissemination of the parasite in the country since ancient times. Infected individuals and baboons were taken from the Land of Punt to Thebes through journeys that occurred at Pharaonic time and wee dispersed in Upper and Lower Egypt. According to the environment suitability of the snail host, *Schistosoma haematobium* became established in Upper and Lower Egypt and *Schistosoma mansoni* (*S. mansoni*) became established only in the Delta region of the Nile (Lower Egypt). It was suggested that both *Schistosoma* species were present during the same Pharaonic period [27].

In the past few decades, with the increase in human demand for freshwater, dams had been constructed. This led to changes in the water habitats and in the water velocity that influence the snail distribution with consequence alterations in the epidemiology of schistosomiasis. The conversion of the basin irrigation system to perennial irrigation increased the prevalence of schistosomiasis. The decrease in water velocity allows *Biomphalaria alexandrina* (*B. alexandrina*) snails that prefer slower flowing water to replace *Bulinus truncates* (*B. truncates*) snails all over the country. The former snails are also more tolerant to the pollution than *B. truncates*. These changes were followed by continuous increase in the prevalence of *S. mansoni* throughout Egypt with a subsequent decline in *Schistosoma haematobium*, which had nearly disappeared from the Nile delta. By 1979, *B. alexandrina* was recovered from canals in Aswan and Lake Nasser. Another example of population movement in influencing the epidemiology of the disease is the movement of the refugees from the Suez Canal zone to the Delta during the war. They became heavily infected with *S. mansoni*, and they transmit the disease after return home [27].

The expansion in land reclamation projects that are irrigated by new water resources from the Nile have further exacerbated the problem. Schistosome parasites and their snail hosts were introduced and schistosomiasis had been spread to the new reclaimed areas. It was found that there is no evidence of local adaptation between *S. mansoni* and *B. alexandrina*, however, the parasite is adapted to its intermediate host throughout the water bodies located in Egypt [28].

Egyptian farmers used to swim, defecate and wash domestic utensils and clothes in irrigation canals. This water is also used for religious purposes and ablution. These human activities allow feces to contaminate freshwater containing intermediate host snails and pose a high risk of exposure to cercariae [29]. The deficiency of piped safe water supplies and inadequate sanitation increase the chance of the parasite to complete its life cycle [30].

Climate change along with other forms of global environmental changes alters the parasite transmission. As rising temperatures affect the geographical distributions and the interactions between the host and parasite, it may result in an increase or decrease in the severity of the disease [31]. With the increase in polluted snail water habitats in Egypt, colonization of physids snails that have high levels of tolerance for pollution may occur [32]. These snails transmit avian schistosomes leading to cercarial dermatitis. So, cercarial dermatitis may become an important public health problem [33].

3.2. Soil-transmitted helminthiases

Soil serves as an intermediate host for STHs where it provides conditions under which immature stages that are passed with feces develop to maturity and provides protection for the infective stages for a period during which it may be ingested [*Ascaris lumbricoides* (*A. lumbricoides*) and *Trichuris trichiura* (*T. trichiura*)] or may penetrate the skin (Hookworms). STHs collectively cause a high global burden of parasitic diseases [34]. Demographic, socioeconomic and environmental conditions in Egypt are suitable for transmission of STHs infections. The demographic and socioeconomic conditions are closely related with the behavior of people resulting in close contact with infective stages of these worms in the environment. Poverty, lake of personal hygiene habits, sewage disposal, safe water and playing out baer foot are strongly associated with STHs infections [9]. Environmental conditions including soil type, moisture and temperature favor the propagation of STHs that spend part of their cycles in these physical environments [35]. There are complex interactions between these environment conditions and the human behavior involved in the maintenance of the endemic status of STHs. The interaction of these factors leads to infection of about 8.3 million Egyptian with *A. lumbricoides* and about 1.7 million with *T. trichiura* [36]. In Egypt the indigenous infections by the hookworm are caused by *Ancylostoma duodenale*. This is more prevalent in rural areas and still constitutes a significant risk for laborers in agriculture [12]. *A. lumbricoides* and *T. trichiura* infection showed high prevalence and intensity of infection in urban districts than rural areas. School-age children are considered the highest risk group for STHs that lead to anemia and disturbed physical and intellectual growth. These consequences may continue into adulthood with effects on the economic productivity resulting in trapping the communities at risk of infections in a cycle of poverty and underdevelopment [4,9].

3.3. Lymphatic filariasis

Lymphatic filariasis is a debilitating disease that has plagued Egypt since the time of the pharaohs. The causative organism is *Wucheraria bancrofti*. The main vector in Egypt is *Culex pipiens* followed by *Culex perexiguus*. By 1936, filariasis was recognized as one of the most important vector-borne diseases in Egypt, posing a major public health problem in six governorates in the Nile Delta. Between 1950 and 1965, a large-scale filariasis control program was carried out. Although the infection was considered to be almost eliminated in the 1960s, reappearance of the disease in the Nile Delta occurred in the 1980s with an estimated 250 000 people infected and 3.65 million people at risk. This was attributed to the increase of irrigation for agricultural production after construction of the High Dam. The groundwater table has rose resulting in poor and delayed drainage of ditches and formation of heavily polluted stagnant pools where the vector mosquitoes breed [37].

In 1990, *Culex pipiens* and *Culex perexiguus* were detected in the unplanned urban areas of Greater Cairo due to the lacking of piped sewage systems leading to creation of favorable conditions for mosquito proliferation. This situation could carry the risk of filariasis transmission with the movement of parasite-carrying migrants from rural areas where filariasis is endemic [38].

3.4. Leishmaniasis

Leishmaniasis is a vector-borne disease caused by obligate intracellular protozoan parasites of the genus *Leishmania*. Transmission of the parasite occurs mainly by the bite of infected female sand flies of the genus *Phlebotomus* in the Old World and *Lutzomyia* in the New World. In a domestic environment, dogs and rodents are the most important reservoirs maintaining the parasite endemic foci [39]. The disease is manifested clinically as cutaneous, mucocutaneous and visceral forms. In Egypt, only the cutaneous and visceral forms are present. The causative organism of cutaneous leishmaniasis (CL) is *Leishmania major*, a zoonotic cutaneous leishmaniasis and *Phlebotomus papatasi* is the vector. *Leishmania tropica*, an anthroponotic cutaneous leishmaniasis, that was recently detected in the country also causes CL and is transmitted by *Phlebotomus sergenti* [40,41].

CL is mainly present in Sinai. The geographic and demographic situations of this area make it a crossroads with neighboring countries where several *Leishmania* parasites are endemic. Extreme weather events have occurred in recent years in Sinai, such as heavy rains and floods, leading to change in potential risks of the disease transmission by changing habitat structure for rodent reservoirs and vector populations. *Phlebotomus sergenti* which was limited to the South Sinai subsequently spread to the North Sinai district as well [42]. The prevalence of the disease is underestimated due to the Bedouin traditions of preventing females from visiting clinics and their dependence on routine heat therapy for the treatment. In Sinai, different habitats are present in which human populations are either scattered across the desert or live in villages where people from different parts of Egypt work or live. These human activities along with potential changes in climate may create new risk factors for CL distribution in Egypt [43].

The DNA of *Leishmania donovani*, the causative parasite of visceral leishmaniasis (VL) was already found in bone marrow samples taken from ancient Egyptian and Nubian mummies that originate from around 4000 BC [44]. Since 1904, rare cases of VL have been reported in Egypt. In 1982, a focus of infantile VL was detected in the northern costal margins at El-Agamy near Alexandria [45].

Urbanization has a great impact on VL in Egypt as it was associated with the outbreak of infantile VL in El-Agamy due to abundance of *Phlebotomus langeroni* (*P. langeroni*); the proven vector in the area. El-Agamy is a coastal resort area 14 km west of Alexandria City with the limestone fences of the Bedouin settlements surrounded this resort. However, socioeconomic and demographic factors have led to increase population movement rendering this resort a densely populated suburb area. The outbreak of the disease was coincided with the expansion of construction work. The density of the vector continues to increase dramatically with significant increase in the urbanization levels. After completion of the construction and subsequent ground stabilization, sand flies were completely absent from El-Agamy. Urbanization dramatically changed the ecology of *P. langeroni*. Fig trees that serve as sugar meal source for sand flies are no longer there. Soil where sand flies breed has changed and modern buildings are now made from concrete while Bedouins' houses used to be made from local limestone that were serving as suitable niches for sand fly resting. Furthermore stray dogs that act as animal reservoir were eliminated [46]. *P. langeroni* that was no longer present in El-Agamy has been detected recently in cities more to the west of Alexandria. This can give a possibility of re-appearance of infantile VL in these areas with the return of the Egyptian employees and their families from Libya [45]. Recently, stray dogs are found infected with visceralizing *Leishmania* species [47].

As already predicted, global warming will affect the distribution of leishmaniasis directly by its effect on parasite development and vector competence and indirectly by changing the range and abundance of the sandfly vectors [48]. Accordingly, the expansion of visceral leishmaniasis from Sudan, an endemic area of the disease to the southern areas in Egypt is expected [49].

3.5. Fascioliasis

Fascioliasis is present in Egypt since Pharaonic times and *Fasciola gigantica* was the endogenous and the only species present in Egypt [50]. Recently *Fasciola hepatica* was considered the source of emerged human fasciolosis after the increase in the international trading and importation of animals infected with this species [51]. A hybrid form between *Fasciola hepatica* and *Fasciola gigantic* was confirmed in Egypt [52]. However, in 2014 a study by El-Bahy e*t al.* [53] proved that human fascioliasis in the Nile Delta was due to *Fasciola gigantic* and not *Fasciola hepatica*. Until the 1970s, only sporadic cases of human fascioliasis were detected, and the first endemic focus was a village in the Abis, area near Alexandria, identified in 1978. Since 1990, fascioliasis is considered as an emerging health problem in both rural and urban areas in the Nile Delta with some rural areas being endemic with a prevalence of 7%–17% while few cases are reported from Upper Egypt [13]. According to Hussein and Khalifa [54] this situation may be due to the different *lymnaeid* snail vectors between the two regions. *Radix natalensis* is the only described intermediate snail host in Upper Egypt. On the contrary, many other *lymnaeid* species potentially intermediate host of *Fasciola hepatica*, are additionally known in Lower Egypt. The parasite and its intermediate snail host have adapted to the irrigation systems of the Nile Delta after the water projects activities leading to increasing incidence of human fascioliasis [51].

The disease has serious veterinary, medical and economic impacts and is found to be responsible for 30% of the annual loss in milk and meat [55].

The poor sanitary habits and low health awareness of the population in Egypt about the disease are the main reasons for its persistence [50]. Many green leaves and weeds which are eaten raw including *Eruca sativa*, *Lactuca sativa* and *Allium kurrat* are cultivated along the banks of the water channels which are frequently visited by domestic animals. Farmers usually pick vegetables and leave them immersed in the canals to keep them fresh before marketing. This habit leads to encystment of the cercariae and in a few hours become infective [36].

The incidence of fascioliasis in humans and animals has been related to climatic factors as other snail transmitted parasites which may influence the future prevalence of the disease in Egypt [49,56].

4. Epidermal parasitic skin diseases

These diseases have the criteria of neglected diseases of neglected populations however, they are not listed on national or international agendas for their control [57]. In Egypt the epidermal parasitic skin diseases (EPSD) of particular importance are scabies, pediculosis (head lice infestation) and hookworm-related cutaneous larva migrans (HrCLM).

Scabies is a highly contagious disease caused by *Sarcoptes scabiei* mite. It is more prevalent among the lower socioeconomic classes. Poverty and poor hygiene are factors in the spread of scabies, as they are nearly always associated with overcrowding, sharing of beds, poor hygiene, lack of access to health care, inadequate treatment and malnutrition. Some authors prefer to link this disease to low socioeconomic status rather than to deficient hygiene [58].

The human louse, *Pediculus humanus*, is probably one of the oldest ectoparasites. Lice are mentioned in the Bible as the third plague visited on the Egyptians when the Pharaoh denied the request of Moses to let the Israelites go-“when all the dust throughout the land of Egypt became lice”. Poverty, infrequent hair washing and sharing hairbrushes play a role in the transmission dynamics of head lice [59]. *Sarcoptes scabiei* and lice accomplish their life-cycle within or on top of the epidermis. They propagate continuously and cause persisting symptoms if the infestation remains untreated.

HrCLM is a parasitic skin infection caused by hookworm larvae that usually infest cats, dogs and other animals. Animal hookworm larvae that have penetrated into the epidermis of man find themselves at different biological circumstances and cannot develop further. HrCLM is a self-limiting disease but the parasites may persist for months and occasionally grow to immature adults in the small intestine of humans. Atypical transmission in poor communities is an epidemiological characteristic of EPSD. A high risk of contamination by hookworm larvae from dog and cat feces is met when laundry is dried on the ground, instead of using clothes lines [60].

With the continuing unplanned urbanization in the country; EPSD will remain prevailing parasitic diseases for people living in these remote conditions indicating neglecting by the authorities.

5. Programs for NTDs control in Egypt

5.1. Programs for schistosomiasis control

The decrease prevalence of schistosomiasis in Egypt is achieved through the adoption of several control programs applying the same strategy recommended by the WHO. The control projects implemented in Egypt from 1953 to 1985 depends on using molluscicides supplemented by chemotherapy. In 1990, the National Schistosomiasis Control Program adopted the strategy of morbidity control based on the use of Praziquantel as a safe drug that is given in a single oral dose and effective for all human schistosome species. The improvement in the domestic water supply to villages and the proper health care and education enhance the reduction in the prevalence. By the end of 2010, only 29 villages among the whole country had prevalence >3% and none more than 10% [29].

5.2. Programs for soil-transmitted helminthiases control

A School Health Program was implemented in 1996 in Behera Governorate by annual administration of Albendazole and weekly iron supplementation to primary school-age children together with health education [13]. Although there was a decrease the STHs in the endemic areas reinfection occurred.

5.3. Programs for filariasis control

Egypt was one of the first countries to apply annual treatment to eliminate and break lymphatic filariasis transmission. In 1970, the Ministry of Health and Population applied a focalized treatment with a 12-day regimen of diethylcarbamazine (DEC) with a dose of 6 mg/kg/day. In 1996, only a single-dose of DEC (6 mg/kg) was used as it was shown to be equally effective. In 1997, the WHO developed a global program for elimination of lymphatic filariasis as a public health problem by the year 2020. Egypt was among the first countries to join the WHO global efforts and a national program of elimination was initiated in year 2000 where 75% of the costs were provided by the Egyptian government and international agencies contributed the rest [61]. In this program mass drug administration of an annual dose of DEC (6 mg/kg) in combination with albendazole (400 mg) were used. This led the prevalence of microfilaria to be less than 1% [62].

5.4. Programs for leishmaniasis control

No effective national leishmaniasis control program is present. WHO is supporting ministries of health in Eastern

Mediterranean Region through a plan focusing on training personnel on diagnosis and case management, establishing a harmonized regional surveillance system, creating a regional network of experts and promoting political commitment of national governments [63].

5.5. Programs for fascioliasis control

In 1998, a public health school-based intervention to control human fascioliasis using triclabendazole was launched by the Egyptian Ministry of Health and Population which resulted in decrease the prevalence in the endemic area from 5.6% to 1.2% in 2002 [64].

6. Recommendations for combating NTDs

There is an urgent need to decrease the population growth rate which in turn will be reflected on the socioeconomic standers of life, health, education and other services provided by the governorate. The problem of unplanned urban areas should be solved by moving the inhabitants to new public apartments with reachable coast and provided with clean water supply and well constructed sanitary system. The Ministry of Health should increase the control programs for NTDs. The rural health units as a part of public health service should be supplied by anti-helminthic drugs preferably free of charge and have well trained personnel with availability of diagnostic equipments. Health education and improvement of the hygienic behavior should be encouraged. This could be achieved in schools to communicate with the children or via informal media as television and radio channels to reach the illiterate individuals specially mothers. It should be taken in consideration that the collaboration between the Ministry of Health and the sectors responsible for improving water supply, sanitation and hygiene will help in long term control of the diseases.

This review helped in addressing the contribution of each factor belonging to the major challenges facing the country in NTDs perpetuation. The similarities found in the ecological factors affecting each disease make it worthy to development integrated control approaches aiming at improving the leading factors of NTDs circulation in the country.

Conflict of interest statement

We declare that we have no conflict of interest.

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