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Hydatid disease in Arab Countries: An epidemiological review

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Abstract

Background: Cystic hydatid disease (CE), a disease caused by the larval stage of *Echinococcus granulosus* is a persistent disease imposing a significant cost in terms of health and economic indicators of the Arab world in general.

Aims: The current up-to-date epidemiological review aims to synthesize the present state of CE in Arab countries, emphasis was put on defining a geographic variation in prevalence, and estimating the socioeconomic burden introduced by this parasitic scourge.

Methodology: A Scoping review of peer-reviewed sources was conducted to summarize the current epidemiological patterns, genetic lineages, and geographic determinants influencing cystic echinococcosis transmission in Arab countries.

Results: The review clearly shows that CE is still endemic in Arab countries across the Middle East and North Africa (MENA) Region and that hyperendemic foci in the case of North Africa, the Levant, and Iraq are obvious. The persistence of infection is primarily driven by three factors: (1) conventional slaughtering practices, (2) widespread populations of stray dogs, and (3) transnational livestock trade, all of which maintain the parasite's transmission cycle. The genotypes that became predominant in circulation were the ones of sheep and camel.

Conclusion: The burden of hydatid disease in Arab countries requires a multi-faceted approach through One Health paradigm. This form of integrative approach must also interlock the fields of veterinary, medical and environmental, in order to support the ideas of sustainable control programs, and to reduce the severe economic and human cost, which this disease imposes.

Keywords: Hydatidosis; *Echinococcus granulosus*; Cystic hydatid disease; Arab countries

1. Introduction

Hydatidosis, cystic echinococcosis (CE) is a cosmopolitan (zoonotic) disease that is caused by the larval stage of the tapeworm, *Echinococcus granulosus* (*E. granulosus*), sensu lato [1]. It has a complex life cycle which includes definite hosts mainly *Canidae* like domestic dogs as well as a variety of intermediate hosts including domestic and wild ungulates [2]. Humans are accidental intermediate hosts. Infection occurs when eggs deposited in the feces of infected dogs are ingested, leading to the development of hydatid cysts [3]. Globally, CE is estimated to cause over one million cases at the same time, and this will cost the disease burden of more than 180,000 disability-adjusted life years (DALYs) each year [4]. The economic impacts are substantial, with global livestock productivity and human healthcare expenditure losses estimated at approximately US$3 billion annually [5].

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Hydatid disease has been long endemic in the Arab world which extends along the Atlantic coast of the North African to the Arabian Gulf [6]. Climate factors and regional geography including fertile lowland coastal lowlands and arid deserts and rugged mountains support various enterprises of livestock which are helping to spread the parasites. Cultural and religious traditions such as slaughtering of animals in rural regions and intimate interaction of the rural people with their herds create conditions that are conducive to the further perpetuation of the cycle of the *Echinococcus* [7]. Furthermore, the social-political turmoil in a number of localities has sufficiently brought about breakdown of veterinary surveillance systems and massive migration of both human and animal populations thus further complicating the epidemiology of the same [8].

Nevertheless, hydatid disease, despite being extensively studied, remains a neglected as a population disease that although it is very researched a disease, under the health priorities of many Arab states [9]. Even though some countries have implemented national control programmes, others do not have even basic epidemiological data that they can use to assess the magnitude of the issue. This review, thus, aims to summarize existing information about the epidemiology of hydatid disease in the Arab region, highlighting regional differences in prevalence, host species spectrum, and molecular parasite peculiarities. it aims at providing the groundwork behind enhancing the formulation of more effective, comprehensive intervention strategies to stem this persistent zoonosis in the Arab world by outlining the critical drivers of transmissions and control issues [10].

2. Epidemiological situation in North Africa

Researchers recognize the region as hyper-endemic to CE in North Africa particularly in the Maghreb states of Morocco, Algeria, Tunisia, Libya and Egypt [11]. There is a high rate of infection of not only livestock, but also humans within the epidemiological profile of this sub-region which is sustained by a conventional pastoralism and a large number of intermediate hosts. In Tunisia, the hydatid disease is a significant public health priority and rates of surgical incidence are the highest in the world [12]. It has been shown that sheep are the primary intermediate hosts and the rate of infection frequently exceeds 50% in older animals, and the camel-dog cycle also plays a significant role in arid regions [13].

The prevalence of disease is similar in Morocco and Algeria; particularly in rural and semi-rural areas where shepherding dominates local economies, the disease is common [14]. The Moroccan CE prevalence in sheep averages around 10.58%, with higher in regions like Middle Atlas and Loukkos. Infection increases with age, especially over 5 years [15]. In Algeria the disease is endemic in the northern Tellian and the highlands regions where several thousand of human surgical cases reported per annum [16]. This prevalence has been mostly due to the widespread of slaughters at home and especially during religious ceremonies like the Eid al Adha, when the veterinary inspection is ignored and any infected viscera might be left to consume stray dogs [17].

Data from Libya also showed a high burden of hydatid disease with some of the highest rates reported in the area of canine infections [18]. A recent meta-analysis identified that prevalence of *E. granulosus* in Libyan dogs can go to the extent of 25% in dogs thus creating a high risk of human infection [19]. The epidemiological situation in Egypt is different because of the high prevalence of dromedary camels as an intermediate host of the parasite [20]. Despite sheep and cattle being affected, camels have become one of the primary reservoirs of parasites, and in some abattoirs, it was reported that 30 percent of all the dromedaries are infected [21]. The livestock trade across the borders of Egypt, Sudan, and the neighboring countries helps in the movement of the parasites and the importation of new genotypes into the Egyptian environment [22].

3. The epidemiological situation in Iraq

Iraq has been reported as a hyper endemic country of (CE), and the disease is considered as an important public health issue especially in the central and southern provinces [23]. The high prevalence of CE in Iraq is rooted in several intrerelated factors including traditional transmission modes between shepherds and dogs, a large stray dog population, and a general lack of public awareness about the disease's transmission routes [24]. The long term war and socioeconomic deprivation have weakened control efforts and increase in human cases [23].

In Basrah, south Iraq, a very high CE burden in livestock has recorded and along with the lack of adequate awareness about the nature of transmission of the disease among farmers. Incidence of surgically confirmed CE cases was stated at 4.5 per 100 000 population over a period of 2005-2015 with more cases being confirmed in females (61.2%) than males (38.8%). The most recurrent organ was the liver (46.3%) which was followed by the lungs (28.1%) [25]. Economic costs was significantly high as the estimate on the loss per year due to the condemnation of the infected

livestock organs ranges to be US $72,470 annually [25]. A different study in Baghdad on 90 surgically proved cases of CE between 2016 and 2018 showed that females occupied (75.55%) of the cases with housewives as the most affected occupational group (47.77%). The greatest rate of cases was registered in the Al-Rusafah district (62.22%). An extended epidemiological profile of hydatid disease patients in Baghdad Province has also shown that women constituted (70.00%) of all cases compared to males (30.00%), and the highest prevalence was found among aged persons between (31-40) years (30.00%). The upper occupational group (60.00%) affected was housewives with the liver being the only organ with 100 percent infection rate with other organs having minimal interference such as lungs, kidney and spleen having minor involvement [26].

A retrospective study of 62 patients in Kurdistan region during June 2019 and February 2021 found the liver (72.58%) as the most prevalent infection location and the lungs as the second most prevalent (19.35%). Females exhibited more others (66.13%) and the most infected was (21-30) years (27.42%). A great percentage of the victims were the rural inhabitants (54.84) and the housewives (43.55). *E. granulosus* sensu stricto (genotypes G1 and G3) was detected as the etiological agent through molecular analysis and therefore the sheep-dog-human transmission cycle was supported [27].

4. The epidemiological situation in the Levant

A remarkable endemic area of CE in the Arab world is the Levant region, which was composed of Jordan, Lebanon, Syria and Palestine [23]. Jordan can be considered as the country with a significantly high incidence of endemicity according to serological surveys that were conducted on, the prevalence rate in the general population was approximately (5.2%), Collection of data indicated that the endemicity levels in the country are notably high [28]. Jordanian surgical registries always indicate that there are constant occurrences of CE, mostly hepatic infection [29]. In Lebanon there are no recent and comprehensive data; however, Lebanon due to the historical and localized research is confirms as endemic area. The highest rates of endemicity are observed in rural localities where the concentration of livestock is high [30]. The arrival of the Syrian refugees has also determined the epidemiology of the communicable diseases in Lebanon and outbreaks have been recorded of measles, mumps and hepatitis A [31]. The current civil war in Syria has worsened the epidemiology such displacement of millions, disruption of veterinary care, and surveillance efforts have likely increased the rates of hydatid disease presentation [32]. In Palestine, a study conducted in the period between 2010-2015 aiming to know and document the number of patients with CE and the results were average 353 patients of CE with a surgical incidence of 2.1 per 100,000 inhabitants in the West Bank. The regions of Al-Khalil and Bethlehem became some of the main target areas, with average incidences of 4.2-3.7 per 100, in each case. It was established by molecular interests that the most common etiologic agent of CE in humans is represented by molecular analysis of *E. granulosus* sensu stricto (G1 and G3 genotypes) [33].

5. Epidemiological situation in the Arabian Peninsula

The Arabian Peninsula, Saudi Arabia, the United Arab Emirates (UAE), Oman, Qatar, Kuwait, Bahrain and Yemen offer a unique epidemiological setting of hydatid disease [34]. Even though the region has been commonly thought of as being highly urbanised and industrialized, the disease continues to pose a great challenge particularly in those areas that still engage in the traditional pastoral activities as well as the areas that import live animals. Hydatid disease is an endemic disease in Saudi Arabia, and high prevalence rates have been recorded amongst slaughtered livestock in several provinces including Taif, Jeddah, and Al -Qassim [35]. Studies of Saudi slaughter facilities indicate a high number of sheep, goats, and camel infections with the most common molecular genotype being G1 in sheep [36].

In UAE the genetic epidemiologic studies of hydatid disease during the period of 1990 to 2019 have shown persistent enzootic growth [37]. The disease in Oman, is believed to be rather uncommon, but clinicians are being increasing reminded about the form of increased diagnostic surveillance to identify any sporadic human cases [38]. Without recent systematic data due to the humanitarian crisis, Yemen is obviable overloaded with high CE prevalence in livestock, which is a key element of its rural economy [39].

Combined prevalence data of CE in livestock on the Arabian Peninsula are close to 13.4%, which highlights the high animal health and economic cost in the area [40]. One of the main reasons that have contributed to the continued existence of the CE in the Gulf Cooperation Council (GCC) countries is the large-scale importation of live animals in endemic regions of East Africa, the Middle East, and Central Asia to meet the demands of meat [41]. International trade, in addition to the introduction of infected animals, has the potential to spread a variety of genotypes of the disease, which could gain local transcriptional cycles in case of contact with domestic dog stocks [42].

6. Sudan and Mauritania epidemiological situation

Sudan and Mauritania, located to the east and west of the center of the Arab world, respectively, are other important endemic foci whose epidemiological forms are significantly different [43]. Hydatid disease is a significant disease in Sudan, and it is found in the central, western and southern provinces with a high prevalence [44]. The role of the dromedary camel in the transmission cycle is central, and it is a major reservoir of the parasite [45]. Hepatic involvement predominates in the range of infection and human seroprevalence of the selected states of Sudan including south Darfur has been reported as 1.22% [46]. In Sudan, molecular epidemiology is highly heterogeneous as the G1, G3, and G6 genotypes have been identified, hence indicating the complex movement of livestock and human population in the area [47].

Mauritania, which has reported fewer cases in the past, has, however, also seen the emergence of hydatid disease as an eminent public-health issue [48]. The studies conducted in the district of Nouakchott in recent times have revealed a remarkable percentage of active cases within a single year therefore disputing the previous image of the scarcity of the disease in the country [49]. The pastoral daily living of a large group of the Mauritanian people, the close interactions between humans, dogs, and animals provide the necessary ecological settings to support the *Echinococcus* life cycle [50]. Similar to Sudan, the camel-dog spectrum is an element of choice of transmission in the arid environment of Mauritania [51].

7. Risk factors and dynamics of transmission

Due to the complex interaction of biological, environmental and socio-economic factors, the endemic nature of hydatid disease in Arab countries persists [52]. The most important risk determinants include large populations of stray and semi-domesticated dogs that serve as an ultimate reservoir to the parasite [53]. In most Arabic societies, dogs are used as stock guard or house guard but are rarely taken to a clinic or even dewormed [54]. These dogs systematically contract the infection through raw offal of slaughtered animals, which are the main sources of the parasite [55].

Conservative livestock farming and ritual slaughter are also decisive factors in pathogen spread [56]. Domestic slaughtering, during religious festivals and communal occasions is also common in all parts of the Arab world [57]. Without formal veterinary inspection, infected viscera, especially hepatic and pulmonary organs loaded with hydatid cysts are discarded or offered to dogs thus maintaining the complete life cycle of the parasite [58]. Meanwhile, a lack of modern, controlled abattoirs in most of the rural and peri-urban areas allows even commercial slaughter to contribute environmental pollution with *Echinococcus* eggs [59].

Dynamics of the diseases are also regulated by environmental factors, the eggs of *E. granulosus* having extreme levels of resistance which allows them to survive long periods in soil and water provided the conditions are favorable [60]. Eating of uncooked vegetables and fruits that could contaminate with dog feces are the key vehicles by which the enters human bodies [61]. Awareness of the folk concerning the spread and control of hydatid disease is very low in various parts of the Arab world especially in the rural areas and cattle owners [62]. Such lack of knowledge commonly triggers behavioral trends that foster the spread of diseases, including allowing dogs to roam, or touching them without appropriate sanitation [63].

8. Economic and public health impact

Regarding the viewpoint of a public-health, the disease causes a lot of morbidity very often, which requires expensive and invasive surgical or radiological interventions [64]. Hydatid disease has a substantial impact on Egyptian states, whether on a human or a state level [65]. There are many affected people who experienced long-term sequelae and the chronic nature of the disease may cause loss of productivity [66]. The incidence of CE in the Eastern Mediterranean area is high thus making contributions to the total Disability-Adjusted Life Years in the region linked to neglected tropical illnesses [5].

On the economic side: it first associated with human health, and the second is associated with the livestock sector [67]. Human cases are associated with a massive pressure on the healthcare budgets of most Arab countries, due to the financial cost required in the management of human cases such as the hospitalization, surgery, and postoperative care [68]. In Iran, which shares similar epidemiological trends, the financial cost of CE has been estimated along the millions of dollars per year, and such values will be expected in Arab countries that are hyper-endemic i.e. Tunisia and Iraq [69]. In the livestock sector, the economic consequences are experienced by the possibility of exclusion of infected organs in the slaughterhouses and reduced meat and milk production, lower fertility and growth rates in contaminated animals

[70]. Small-scale farmers and pastoral communities, whose livelihoods depend on livestock, are particularly vulnerable to the economic burden of hydatid disease [71].

9. Environmental permanence and climate change

E. granulosus egg survival and transmision in the environment are some of the key determinants in epidemiology of hydatid disease in Arab world. Those eggs can withstand extreme temperatures and desiccation which are normal conditions in arid and semi-arid climates of the MENA region [60]. Several empirical research studies have shown that eggs may last up to several months in soil, especially in shaded areas or wet places, like around water bodies or water irrigation fields [61]. This environmental endurance sustained the risk of infection for both the livestock and the human beings even in areas where definitive hosts presence can be temporary.

Climate change is also estimated to have a greater impact on the distribution and transmission dynamics of hydatid disease throughout the Arab world. Changes in temperature and precipitation patterns can alter the survival rates of eggs of the parasite and change the interaction pattern of definitive and intermediate hosts. As an example, increased aridity can cause the gathering of both livestock and dogs around limited water resources, which increases the level of transmission. On the other hand, high temperatures could decrease the viability of eggs in some regions and could also promote the spreading to other areas that have never been colonized by the parasite. Understanding the effects of climatic change on the ecology of *Echinococcus* is important in formulating long-term, dynamic control measures [72].

10. Socio-Cultural dimensions and social enlightenment

The socio-cultural consequences of the Arab societies have a dramatic impact on the epidemiology of hydatid disease [73]. Livestock farming, identity and livelihood of rural and nomadic people, create a unique set of problems affecting the management of disease [74]. Interaction between humans and animals is close with saliency in the cultures, and in many cases, the close interaction leads to the spread of the zoonotic pathogens. Most pastoral communities tend to ignore the fact that dogs are not companion animals but a utilitarian one, therefore they are not well taken care of in relation to health and cleanliness, yet they are around the human settlements closely [75].

Hydatid disease is one of the most neglected issues in the Arab world accompanied by public awareness [76]. A lot of people living in endemic areas are not aware of how the parasite is transmitted or the danger of interacting and consuming infected produces. Where they are available, educational programs are often unable to reach the most vulnerable population, either faced with literacy barriers or geographic dislocation or cultural limits. There is an overriding need of a culturally sensitive health communication approach that involves community leaders and makes use of local knowledge systems [77]. The effectiveness of technical interventions, e.g. canine deworming, abattoir improvements, can be significantly increased by enabling the communities with relevant information about the need to protect themselves and their livestock.

11. One health: A way forward to the Arab world

The complexity of hydatidosis cycle and transmission, requiring the involvement of several hosts and environmental elements, means that a One Health approach is required to be able to live outside of the usual disciplinary boundaries [78]. This requires, in the Arab world, a strong coordination established among ministries of health, agriculture and environment. In the past, most areas have been in silos creating more disjointed and sometimes conflicting policies. Creating a single, regional surveillance and management system of hydatid disease may offer an avenue of data, resources, and expertise sharing [79].

One Health implementation in the Arab region also requires the involvement of the international organizations and regional institutions like the Arab league and the WHO Eastern Mediterranean Regional Office (EMRO) [80]. These organizations can be instrumental in the reconciliation of control standards, technical support and the provision of research networks in the region. In addition, the sustainability of interventions can be ensured by incorporating hydatid disease control into broader programs of the general population health and rural development. As a case in point, greater improvements in water and sanitation infrastructures that are imperative in averting human infection also have overriding health advantages to the population [81]. A holistic and collaborative approach would help Arab states to write substantive steps towards reducing the burden of this chronic and overlooked zoonosis.

12. Molecular epidemiology and genotypic diversity

The rise of molecular technologies has provided better information on the genetic model of the *E. granulosus*, and *sensu lato* in the Arab world [82]. The area exhibits a great variety of genotypic diversity, and the implications of it are severe to the transmission processes, host specificity, and future control means [83]. The leanest type of genotype (the sheep strain, G1) is the most prevalent in the Arab countries revealing the supremacy of the sheep-dog cycle in the region epidemiology [84]. It is a very zoonotic genotype, which causes most human cases in North Africa, the Levant and in the Arabian Peninsula [85].

The camel strain (G6), which is widely found especially in those nations where the numbers of dromedaries are significant (Sudan, Egypt, and Mauritania) [86]. Recent molecular scans have highlighted G6 as a significant agent of human infection in these sites, thus, amplifying the public-health significance of the camel-dog of contact route [87]. Other studies have also documented the genotypes G3 (the so-called buffalo strain) in the area, particularly in Egypt, where buffaloes are the common intermediate hosts [88]. The presence of diverse genotypes in a geographical location promises a complicated pattern of transmissions and cross-species infection ones [89].

Molecular characterization of the parasite is essential to understand how the disease started and spread [90]. An example, genetic similarity between *E. granulosus* strains in Egypt and Sudan, which indicates that the extensive inter-border movement of the parasite is likely to take place, which may be attributed to the large-scale trade of camels and sheep [91]. On the same note, establishing different genotypes in the Arabian Peninsula can in most cases be linked to the origin of imported livestock [92]. These findings highlight the importance of regional cooperation and introduction of molecular surveillance to track the movement of the parasites and to identify the emergent strains [93].

13. Control and prevention strategies: problems and possibilities

The effort to contain hydatid disease in the Arab world requires a multi-sectoral and inter-sectoral strategy that is both concerted and consistent [94]. Although some Arab countries have already started on national control programs, they have faced limitations of limited funding, political instabilities, and complexity of the life cycle of the parasite [95]. The most effective methods of control are based on the One Health paradigm which has a systematic approach based on the interventions in the animal domain, human domain and environmental domain [78].

The main elements of an effective control programme include regular deworming of dogs using praziquantel, control of stray dog numbers, and improvement of slaughterhouse hygiene as well as strict veterinary check-up [96]. The educational activities that aim at increasing the education consciousness of the people about the spread of diseases are equally irreplaceable especially in rural society and in the livestock owners [97]. Moreover, there has also been some speculation in some settings where EG95 vaccine has shown potential to be used as an adjunctive control step like inoculating the intermediate hosts like sheep [98].

However, there are still several problems in the Arab region. Domestic slaughter which is practiced in a very common way and mostly during religious gatherings, is a major drawback to canine infection prevention [57]. Livestock transboundary flow and influx of the refugees to the conflict-infected regions also complicate surveillance and control efforts [8]. Additionally, the lack of a consistent regional approach and scarcity of coordination between the medical and the veterinary fields frequently result in the disjointed and ineffective interventions [99]. Nevertheless, there are still hopes of improvement, among which the use of modern diagnostic tools, the creation of local surveillance systems, the increasing status of hydatid disease as a neglected tropical disease of priority by such international organizations as the World Health Organization, etc. [100].

14. Conclusion

Strongly connected to long-standing cultural practices, livestock systems, and socioeconomic conditions.

Cystic echinococcosis (CE) remains a significant threat to the public health with social and economic consequences in the Arab world, being deeply rooted in the traditional culture and socioeconomic environment of the region, high pervasiveness of the disease among the human and animal communities and not only in the hyper-endemic regions of North Africa and the Levant but also the new issues in the Arabian Peninsula and some neighboring countries of Sudan and Mauritania. Despite the decline in prevalence of the so-called sheep-dog and camel-dog cycles, both fuelled by uncontrolled slaughter methods and poor management of the stray dog population, the spread of the *E. granulosus* remains enabled. The molecular epidemiology has also helped to shed light on the genetic complexity of the parasite in

the region hence highlighting the need to localized and genotyping strains specific control programs. Managing the problem of hydatid disease in Arab nations requires shifting to an integrated approach to One Health that fosters trans-sectoral partnership and local collaboration. The burden of this zoonosis can only be reduced through long-term investment in surveillance and popular educational efforts combined with specific control measures, which eventually will lead to the improvement of human and animal health and economic impacts in the Arab world.

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