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Review Article

The Epidemiology of Human and Animal Brucellosis in Algeria

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Abstract

In this review we summarize the published literatures end research paper on human and animal brucellosis in Algeria, to describe the incidence of human brucellosis and the seroprevalence of animal brucellosis in Algeria with special emphasis on epidemiological assessment of the deployed control measures. Comparatively, the number of new human cases reported from Algeria followed a similar trend in animals, highlighting the impact of the animal reservoir on the public health. Human incidence might reflect the true epidemiological situation of brucellosis in animals. The transmission of *Brucella* infection to humans in Algeria depends largely on the animal reservoir and several factors like food habits, methods of processing milk and milk products, social customs, climatic conditions, socioeconomic status, husbandry practices and environment hygiene. Cattle brucellosis is more prevalent in the north of the country, against the steppes and interior regions were brucellosis is more common among small ruminants. Consumption of milk and raw milk products has been implicated in 85% of human infections. In Algeria, Mass vaccination of all livestock (cattle, sheep and goats) throughout the territory is the most appropriate given the epidemiology of the disease. Therefore the small ruminants Rev 1 vaccination should cover the entire Algerian district and for cattle, the recommended vaccine is the RB51. Collaboration between the department of health and department of veterinary services is important for the control of brucellosis in animals and thereby eliminate transmission to humans. Training of the livestock farmers on the effective implementation of sanitary and hygienic livestock management practice following abortion helps reduce spreading the disease amongst animals as well as to the humans.

Keywords: Algeria; Animal; Brucellosis; Human; Vaccination

Introduction

Brucellosis is one of the most important worldwide zoonoses affecting live stock and humans [1-3]. Described *Brucella* species (*Brucella.spp*) as facultative intracellular parasites; however, this definition does not honor their true nature which is better understood as a facultative extracellular intracellular parasite. This means that *Brucella's* preferred niche is the in tra-cellular environment of the host cells. This environment supports and sustains extensive replication, allowing bacterial expansion and subsequent transmission to new host cells which is frequentlyachieved through the heavily infected aborted foetus [2]. Nine *Brucella* species are currently recognized, seven of which affects terrestrial animals: *B. abortus, B. melitensis, B. suis, B. ovis, B. canis, B. neotomae,* and *B. microti* and two that affect marine mammals: *B. ceti* and *B. pinnipedialis* [4]. The first three species are called classical *Brucella* within which we have seven biovars for *B. abortus*, three for *B. melitensis* and five for *B. suis*. Serovars are yet to be associated with the remaining species. The bacteria are host specie specific and are therefore named after the host specie infected. The strains of *brucella*e were named based on the host animal preferentially infected [5].

Brucella infection is responsible for up to 20 - 25% decrease in milk production, 10 to15% in meat production, 15% loss of calves due to abortions, 30% increase in the rate of animal replacement, and increased calving interval of to 11.5 to 20 months in domestic animals. In addition, every five infected cows abort once or become permanently infertile [6]. Besides the loss of animal productivity, brucellosis is a zoonosis of major health public importance; five out of the nine known *Brucella* species can infect humans and the most pathogenic and invasive species for human is *B. melitensis*, followed in descending order by *B.suis, B. abortus* and *B. canis* [6]. The zoonotic nature of the marine brucellae (*B. ceti*) has been documented by several workers [7-9]. *B. melitensis, B. suis* and *B. abortus* are listed as potential bio-weapons by the Centers for Disease Control and Prevention (CDC) in the USA. This is due to the highly infectious nature of the three species, as they can be readily aerosolized. Moreover, an outbreak of brucellosis would be difficult to detect because the initial symptoms are easily confused with those of influenza [10].

The geographical distribution of brucellosis is constantly changing, with new foci emerging or re-emerging. The epidemiology of human brucellosis has drastically changed over the past few years because of various sanitary, socioeconomic, and political reasons, together with increased international travel. New foci of human brucellosis have emerged, particularly in central Asia, while the situation in certain countries of the Middle East and North Africa is rapidly worsening [11]. Brucellosis is a notifiable disease in most countries; it is reportable to both local and national health authorities

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Table 1: Distribution of human and animal population in Algeria according to region.

Region	Human		Cattle		Small ruminants		Camels	
	Number (million)	%	Number (million)	%	Number (million)	%	Number (million)	%
North-Central	12	30	0.6	30	3.72	13	0	0
North-Eastern	11.2	28	0.65	32.5	4.87	15	0	0
North-Western	9.2	23	0.4	20	3.55	11	0	0
Steppe	5.6	14	0.34	17	17	55	0	0
Sahara	2	5	0.01	0.5	1.86	6	0.35	100
Overall	40	100	2	100	31	100	0.35	100

by health workers. However, it is under reported and official numbers constitute only a fraction of true incidence of the disease. Thus the true incidence of human brucellosis is unknown and the estimated burden of the disease varies widely, from <0.03 to >160 per 100,000 population [11,12]. Although estimates of the costs associated with brucellosis infections remain limited to specific countries, all data suggest that worldwide economic losses due to brucellosis are extensive not only in animal production (reduced milk, abortion and delayed conception), but also in public health (cost of treatment and productivity loss) [6].

Human brucellosis remains the most common zoonotic disease worldwide, with more than 500,000 new cases reported annually [11]. Globally this disease is highly under-reported because of its vague (pathognomonic) clinical flu like symptoms, difficulty to diagnose in the laboratory and lack of familiarity by medical professionals [13]. Therefore, the true incidence of human brucellosis is unknown for most developing countries of the world including Algeria. Data documenting human and animal brucellosis are very meager in Algeria. However, brucellosis has been reported in humans and ruminants in Algeria causing huge economic losses [14,15].

Diagnosis of brucellosis in humans and animals is mainly based on detection of Brucella LPS specific antibodies in milk and serum samples using serological tests. These tests do not differentiate between an acute and a chronic infection [16]. Cross reaction can occur with other Gram negative bacteria such as: *Yersinia enterocolitica* O:9, *Escherichia coli* and *some Salmonella spp*. That have antigenic similarities with Brucella LPS and can lead to false positive reactions [17]; isolation of *Brucella* is required for confirmatory diagnosis of brucellosis. Published bacteriological investigations in Algeria did characterize *Brucella* at the species and biovar levels [14,15,18]. Recently a real-time PCR based assay was used to identify the *Brucella* at the molecular level inhuman sera [19].

In this review we summarize the published literatures end research paper on human and animal brucellosis in Algeria. Data reviewed were also obtained from the Algerian Ministry of Agriculture and Rural Development (MADR) and the Algerian Ministry of Public Health (MPH). The objectives of this review are to describe the incidence of human brucellosis and the seroprevalence of animal brucellosis in Algeria with special emphasis on epidemiological assessment of the deployed control measures.

Geographical Area

Algeria is the largest country in Africa. It is located between latitudes 19° and 37°N and longitudes 9°W and 12°E. It is bounded by the Mediterranean Sea to the north, Tunisia to the east, Morocco to the west, Mali and Niger to the south. It has a long coastline at the Mediterranean Sea (1600km); Most of the coastal area (northern region) is hilly, sometimes even mountainous. South of the northern region is a steppe; farther south, there is the Sahara desert. For reasons of animal health, transportation of animals is forbidden between Sahara and northern Algeria. Administratively, Algeria is divided into 48 districts but for the present study and according to geographical and farming management specificity, five regions were delimited and each region contained 7 to 12 districts; north-central (35.3°-36.8°N and 1°E-4.7°E), north-western (35°-36.3°N and 2°W-1°E), north-eastern (35.3°-37°N and 4.7°E-8.5°E), steppe region (33°-35.3°N and 2°W-8.5°E). And the Sahara (19°-33°N and 8.8°W-12°E). Algeria has 2,147,570 km^2 area of land with about 40 million people (Table 1). More than 80% of the people live in coastal areas [20].

In Algeria, livestock farming represents a significant financial income of an important part of the Algerian population (Table 1) with ≈ 2 million cattle, 31 millions small ruminants and 0.35 millions camels all reared under traditional extensive husbandry system, although intensive husbandry systems have recently been introduced in the country [21]. In spite of the considerable livestock potential of Algeria, the country still faces a huge deficit in dairy and meat production; this problem imposes each year a huge spending evident from the import invoice which amount to 2.045 billion dollars for milk and 0.307 billion dollars for meat in 2014. Diseases and poor flock-health management practices pose a significant challenge to optimal and efficient management and profitable production in Algeria [21].

Human Brucellosis

Brucellosis is endemic in the Mediterranean basin, especially in the Northern African countries [11]. Until the 1980s, the epidemiological situation was not well known in Algeria and cases of human brucellosis were rarely reported or misdiagnosed despite an important animal reservoir. However since the middle of 1980s, several outbreaks due to *B. melitensis*, were reported in Ghardaia (Southern Algeria) Tlemcen (Western Algeria) and Setif (Eastern Algeria), resulting in more of human cases, this led the public health services to implement control and eradication measures, regarding animal as well as human brucellosis in Algeria [22,23].

Despite these adopted control measures, the disease is still present with underestimated and/or underreported incidences. Table 2 shows the *Brucella* incidence reported in humans in Algeria. The incidence of human brucellosis in Algeria shows an upward trend since 2006, with values ranging from 23.6 in 2006 reaching 28 per

Table 2: Brucellosis in humans (MPH, 2014).

Year	Number of new cases	Incidence (cases /100 000 inhabitants)
2006	15437	23.6
2007	15218	23.9
2008	5271	14.8
2009	6530	18.9
2010	18669	28,1
2011	4449	16.6
2012	5298	15.3
2013	5170	15.1
2014	5234	15.2

Table 3: Distribution of humans Brucellosis in Algeria according to region 2006-2014 (MPH, 2014).

Region	Mean Incidence (cases /100 000 inhabitants)
North-Central	7.37
North-Eastern	9.89
North-Western	4.67
Steppe	65.87
Sahara	18.26

100,000 inhabitants in 2010. However, since 2011the incidence of human brucellosis in Algeria started to decrease significantly ($p< 0.05$) with values ranging from 16.6 in 2011 reaching 15 per 100,000 inhabitants in 2014.

The distribution of human brucellosis (Table 3) was observed to be predominant in the steppe region compared to other region. The high density of small ruminant population in these areas has been associated with the high number of cases.

Higher number of cases has been attributed to food contamination through ingestion of milk vintage and dairy products. Ten percent (10%) of the cases were exclusively of professional origin while 20 % were as a result of mixed sources [24]. *B. melitensis biovar 3* is the most incriminated in human cases [14,19,24].

Assessment of the genetic diversity of Algerian *B. melitensis biovar 3* strains by [19] for possible epidemiological relationship with European strains was recently carried out. The obtained results showed that the Algerian and European strains cluster together. These results confirmed the existence of a circulating lineage resulting from socio-historical connections between Algeria and Europe.

Sex-wise analysis showed a male predominance possibly because professionally, men are more within the health sector compared to women. Contrarily, women are more exposed than men when it has to do with contamination through food origin. Traditionally, this can be attributed to the fact that women handle the food items domestically than men. Generally all ages are infected, but adults are the most affected by the disease [24].

Comparatively, the number of new human cases reported from Algeria followed a similar trend in animals, highlighting the impact of the animal reservoir on the Public Health. Human incidence might reflect the true epidemiological situation of brucellosis in animals. In fact flock prevalence was reported in cattle to be 15.7% [14] and 15.84% in small ruminants [15].

Animal Brucellosis

The first studies made in Algeria on animal brucellosis go up to 1907, when it was reported in goats [25]. A few years later after the Algeria independence in 1962, the first brucellosis study in cattle in Algeria showed high individual prevalence (23%) compared to neighboring Tunisia (1.94%) and Morocco (1.4%) [26]. There was a general regression in sero-prevalence in 1976 to 12% and by 1990 the individual prevalence in cattle also regressed with 5% [27] possibly as a result of health and sanitary measures. [18] isolated *B. abortus biovar 1* from cattle and *B. melitensis biovar 3* from goats in 1990 which further confirms the circulation of the bacteria in Algeria.

In 1995, a multiannual national program to control ruminants' brucellosis (cattle, sheep and goats) was launched by the Algerian Veterinary Services. It is based on sanitary prevention with the screening-sloughing operations. The program had the following guidelines [21].

- The proclamation of Animal brucellosis as a national notified disease.
- Identification of all ruminants (cattle, sheep and goats) and their exploitation in Algeria.
- All identified animal's, of more than one year, must undergo the screening tests; Rose Bengal as screening test and the compliment fixation as confirmatory test.
- Positive animals were slaughtered.
- Owners of slaughtered animals were to be compensated at 50% of only the females while the male were not compensated.

Cattle brucellosis

The epidemiologic and statistical evaluation of the screening-sloughing program of cattle brucellosis revealed improvement of the sanitary statute regarding animal brucellosis with prevalences ranging from 5% in mid 90 to 0.76 in 2014. However the identification and screening rate involved only 6 % of the Algerian cattle population [21]. This weakness of the identification and screening program was due to: - The large superficies of Algeria. - Low rate of compensation which does not exceed the 50%. - The lack of transportation means for the veterinary service teams for adequate ambulatory and control services towards the livestock in the rural zones.

The number of cattle screened within the national program remains insufficient and far from detecting all the positives animals and very far for controlling this major zoonosis. The status of almost 94% of the Algerian ruminant population remains unknown and represents a significant source of contamination to humans and other ruminants. In fact, [14] reported 15.7% flock prevalence in cattle within this population.

Small ruminants brucellosis

Brucellosis in sheep and goats due to *Brucella* melitensis is the most important zoonosis that constitutes a serious hazard to public health. Successful campaigns have been carried out against small-ruminant brucellosis based on screen-and-slaughter policy, and eradication has been achieved in many countries [28]. However,

similar policy in Algeria since 1995 has failed to control brucellosis in small ruminants because of so many factors chiefly, the type of animal husbandry practiced that determined the effectiveness of the campaign.

In Algeria, sheep-and-goat farming is the largest sector of food-animal production, with a total of 31.483.680 sheep and goats. The flocks are kept for producing meat and milk mainly for feta cheese. The husbandry is semi-intensive; in many parts of the mainland, the summer climate leads farmers practice transhumance for > 6 months per year. In 2002 the Algerian agriculture ministry conducted a survey to estimate the prevalence of sheep and goats brucellosis seven years after the lunched of the screening-sloughing program, the results showed that the endemic character of the diseases in Algeria with a national small-ruminants herd prevalence of 5.68% and herd prevalence of more than 10% in the steppe region. Consequently, and within the strategy of control and prevention of this zoonosis, the Algerian state adopted in 2006 a new prophylactic approach, by vaccinating sheep and goats in steppe region with the Rev-1 vaccine and the screening-sloughing program was continued in other regions [21].

From the beginning of the campaign in 2006 till the end of 2013, the vaccination covered 32 of the 48 district in Algeria and a total of 21,036,314 small ruminants have been vaccinated. As a result, the herd prevalence of brucellosis in small ruminants in 2014 was slightly decreased to 3.33% [29]. In addition [30] reported a significant improvement of small ruminant brucellosis sanitary status in the steppe region eight (08) years after the Algerian state adopted the Rev-1 vaccination in 2006 as a prophylactic approach. However in the non-vaccinated region [15] reported a herd prevalence of 15.84% which underscore the relevance of vaccination and adequate control and eradication program to avoid complicating the control program.

Large number of Algerian unpublished studies had suggested an association between *Brucella* seropositivity and abortion in Algerian small ruminant's flocks. However, [29] revealed no significant association between abortion history and brucellosis infection in Algerian small ruminant's flocks.

Camel brucellosis

Besides cattle, sheep and goats, brucellosis was reported in camels as early as 1931; since then, the disease has been reported from all camel-keeping countries. The infection is caused by different biotypes of *Brucella abortus* and *Brucella melitensis*. The seroprevalence of brucellosis in camels appears to follow two distinct patterns: low (2–5%) prevalence in nomadic or extensively kept camels and high (8–15%) prevalence in camels kept intensively or semi-intensively [31]. In Algeria camels were reared under nomadic mode and the seroprevalences were estimated between 2 and 3% [29].

Dog brucellosis

The number of dogs in Algeria is unknown. Very few people in the rural areas have pet dogs while in major towns and cities there are pet dogs. There are large numbers of stray dogs roaming freely on the street, human dwelling places and animal sheds. Stray dogs eat garbage, discarded food, dead animal carcasses including placenta and aborted fetuses *(Kardjadj M. personnel communication)*. They can scavenge or hunt small rodents and birds. Dogs have been identified as a link in the brucellosis transmission chain for *B. abortus* and *B. melitensis*; the aborted material and infected vaginal discharges of cattle were believed to spread *Brucella* from cattle to dogs and vice versa [2]. Seroprevalence study of brucellosis in Algerian dogs performed on 280 sera of stray dogs by Rose Bengal test revealed a prevalence of 12.5% (35/280). The dogs were thought to be infected with *Brucella* as a result of eating aborted materials originating from cattle and goats. Data from this study suggested that stray dogs may play a role in the transmission of *Brucella* to the domesticated animals and humans [29].

Challenges

The transmission of *Brucella* infection to humans in Algeria depends largely on the animal reservoir and several factors like food habits, methods of processing milk and milk products, social customs, climatic conditions, socioeconomic status, husbandry practices and environment hygiene. In this context, environmental sanitation is particularly important. Despite the ongoing demonstrations and disclosures about risk of consuming raw/inadequately heat treated milk and milk products, contact with animals without observing bio-safety precautions, handling and manipulations of viscera and by products of excretions from animals without the use of personal protective equipments. Brucellosis remains an important public health problem worldwide. Information relating to the activities of livestock management is fundamental to the generation of high quality animal products. However, often not enough information to small producers and others working in rural areas and this lack of information is still an obstacle on the health of livestock.

Cattle brucellosis is more prevalent in the north of the country, against the steppes and interior regions were brucellosis is more common among small ruminants [21]. Consumption of milk and raw milk products has been implicated in 85% of human infections [20]. There is single serological test that is suitable for all epidemiological situations. All diagnostic tests' have limitations, particularly for individual diagnosis. In Algeria, the two methods used for the detection of animal brucellosis are buffered antigen test and the complement fixation method as a confirmatory method. However, in humans, there is need for training and retraining of health professionals for appropriate diagnosis of the disease.

Control and eradication of brucellosis is a measure desired by many countries where the disease is endemic. However, this result is difficult and expensive, taking into account the specific climatic, geographical, socio-economic, technical resources and personnel, prevalence of disease, as well as the strict commitment of farmers to vaccinations programs. In this sense, developing countries have major difficulties both in setting and in achieving success in their programs of control and eradication of animal brucellosis [28]. Certainly, some significant flaws can be identified, such as voluntary vaccination and lack of adequate compensation frame-works leading to loss of positive animals due to non-disclosure [32].

Prevention of human brucellosis depends mainly on the control or eradication of the disease in animals. However, few countries were successful in eradicating it from their herds. However, control of infected animals in developing countries requires considerable effort to build solid infrastructure that educates people about the risks of

contracting brucellosis [2]. Although rural populations, as well as professionals who deal directly with livestock industry are at higher risk situations, it is important to note that urban populations in developing regions are also at risk of acquiring the disease through consumption of products of animal origin. In the general context, without interest and mutual effort of all aspects of society, couple with good measure of health education and, above all, political support, success in the eradication brucellosis is almost nonexistent [12].

For preventing human brucellosis, the most efficient approach is the control and elimination of the infected animal. In Algeria control and eradication programs against brucellosis in small ruminants are applied, based on various strategies: screening-sloughing program against cattle brucellosis, Rev1 vaccination in 32 of the 48 district in Algeria and screening-sloughing program against small ruminant's brucellosis in the other 16 district. However, the animal infection is not yet controlled, the heat treatment (pasteurization) of dairy products is not systematic and certain food habits and faiths (consumption of raw milk/cheese) and/or inadequate hygienic practices related to poverty increases transmission to humans.

Conclusion and Recommendation

In Algeria, mass vaccination of all livestock (cattle, sheep and goats) throughout the territory is the most appropriate given the epidemiology of the disease. Therefore the small ruminants Rev 1 vaccination should cover the entire Algerian district. For cattle, there commended vaccine is the RB51, this vaccine strain, rough *B. abortus*, free O chain is generally desired by the diagnostic tests and therefore, the possibility of detection is not completely eliminated. The indicated dose is about 1 to 3.4 x 10^{10} CFU [2].

Collaboration between the department of health (MPH) and department of Veterinary Services (MADR) is important for the control of brucellosis in animals and thereby eliminate transmission to humans. Periodical joint meetings will be of mutual benefit for both services and the general public. Veterinary medicine must implement methods to control/eradicate brucellosis in animals while human medicine must develop complementary methods to prevent transmission and develop effective treatment of human patients. Open communication and integration of surveillance and monitoring both humans and animals will be mutually beneficial, so it is critical that physicians and veterinarians cooperate in these efforts. A detailed epidemiological investigation focusing on host, agent and environmental factors needs to be performed throughout the country in order to identify the risk factors associated with transmission and maintenance of brucellosis in animals. Biomedical research focusing on epidemiology, isolation and characterization of field isolates, development of the best diagnostic method and more effective vaccines against brucellosis should be undertaken.

Training of the livestock farmers on the effective implementation of sanitary and hygienic livestock management practice following abortion helps reduce spreading the disease amongst animals as well as to the humans. Education of farmers and animal care workers on the basic hygiene and sanitary procedures and techniques as well as practical demonstration on the use of disinfection and personal protection methods are important.

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