The Demographic Risk Factors for Brucellosis in Asia

Sumi Singh

Nepal Medical College and Teaching Hospital, Kathmandu, Nepal.

Author’s contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJRID/2021/v7i330216

Editor(s):
(1) Dr. Win Myint Oo, SEGi University, Malaysia.

Reviewers:
(1) Sonal Gupta, Jawaharlal Nehru University, India.
(2) Jacques Godfroid, UIT -The Arctic University of Norway.
(3) Paul Selleck, Australian Centre for Disease Preparedness (ACDP), Australia.

Complete Peer review History: https://www.sdiarticle4.com/review-history/69715

Received 10 April 2021
Accepted 13 June 2021
Published 22 July 2021

ABSTRACT

Brucellosis is also known as Undulant fever, Malta fever, rock fever, intermittent fever, Gibraltar fever, contagious abortion, Maltese fever, Crimean fever, or even Mediterranean fever. Clinical manifestations commonly encountered are fever and arthralgia. It has veterinary importance making it the leading cause of abortion and infertility in animals. Countries in which mixed agriculture is still the leading occupation have reported this disease in high number. The disease is common in areas where the mixed type of farming is still practiced, it is a type of farming where owners cohabit with their animals in the shed during the nighttime. The incidence of the disease is reported more in humans who have direct contact with the animal’s abortus fetus and reproductive secretions. A favorable environment is created for transmission when the healthy and infected animals are kept together free and are difficult to segregate. Diagnosis of the disease is done by isolation of the bacteria from the sample using the polymerase chain reaction (PCR) technique. The disease was claimed to be eradicated but now as the global trend of infectious diseases is constantly changing it now appears to be a re-emergent disease. The best way to prevent the spread of the infection is through the One Health approach. Although brucellosis has been widely reported in animals and humans only a few studies have addressed the true prevalence of the disease in the context of Asia which is quite a challenge. It is unable to provide the true context of the disease. The case burden is more prevalent in the developing countries where it is found to be endemic in animals as well as in humans. Thus, this paper highlights the risk factors commonly found in Asian countries that are associated with increased prevalence of infection in humans

*Corresponding author: E-mail: sumi1995@gmail.com;
Brucellosis is also known as Undulant fever, Malta fever, rock fever, intermittent fever, Gibraltar fever, contagious abortion, Maltese fever, Crimean fever, or even Mediterranean fever [1]. Brucellosis has been known to be existing for more than 2500 years [2]. It is one of the most common zoonotic diseases with more than half-million reported cases every year in humans. The infection is acquired through the consumption of unpasteurized milk and its milk products from infected animals. Animals acquire infection through vertical transmission. The Asian region is growing rapidly with an average annual income increasing from 4% to 8%, population from 2% to 3%, urbanization to 6%, and meat consumption from 4% to 8%. To support this growth the region has estimated a rapid increase in population, but it is predicted to have a prevalence rate of 2.9% [3]. It also poses an occupational exposure hazard who work closely with infected animal’s aborted fetuses and genital secretions [4].

Brucellosis is caused by small, non-motile, non-sporing, aerobic, gram-negative intracellular coccobacilli. They are catalase, oxidase, and urea-positive bacteria. Several species are known to cause this infection such as Brucella melitensis, Brucella abortus, Brucella suis, Brucella canis, Brucella microti, Brucella inopinata, Brucella ovis Brucella Ceti and Brucella pin-nipedialis [5,6,7] Brucella melitensis is the most pathogenic of all the species found existing and is also the most common cause of serious infection. It is mainly found in cattle involved in mixed farming methods. It has been reported that in some cases the cattle can be affected by both B. melitensis and B. abortus and identification of the etiological factor can only be done when humans have been infected [8]. The clinical features include fever, sweats, chills, fatigue, headache, malaise, weight loss, nausea/vomiting [9]. Among which the most common clinical manifestations reported according to various publications were fever in 76.8%, joint pain/swelling/arthralgia in 74.7%, sweats in 73.3%, fatigue/asthenia/weakness in 50.3%, and back pain in 36.3%. Among the available obstetric outcome information 31.3% suffered preterm delivery, 37.5% had an abortion and 9.8% had intrauterine fetal death [8]. The gold standard method in diagnosing the disease is only by isolation of the bacteria from the sample by using polymerase chain reaction (PCR) but the cost-effective way of diagnosing commonly practiced in developing countries is by serological diagnosis [10]. Investigation arising from such case scenario where mixed farming is practiced may require more than just serology; isolation and PCR are very helpful in identifying the exact species causing infection in the human population [11,12,13].

**ABBREVIATIONS**

**PCR** : Polymerase Chain Reaction

**1. INTRODUCTION**

Brucellosis is also known as Undulant fever, Malta fever, rock fever, intermittent fever, Gibraltar fever, contagious abortion, Maltese fever, Crimean fever, or even Mediterranean fever [1]. Brucellosis has been known to be existing for more than 2500 years [2]. It is one of the most common zoonotic diseases with more than half-million reported cases every year in humans. The disease is common in areas where the mixed type of farming is still practiced, it is a type of farming where owners cohabit with their animals in the shed during the nighttime. The incidence of the disease is reported more in humans who have direct contact with the animal’s abortus fetus and reproductive secretions. A favorable environment is created for transmission when the healthy and infected animals are kept together free and are difficult to segregate. Diagnosis of the disease is done by isolation of the bacteria from the sample using the polymerase chain reaction (PCR) technique. The disease was claimed to be eradicated but now as the global trend of infectious diseases is constantly changing it appears to be a re-emergent disease. The best way to prevent the spread of the infection is through the One Health approach. Although brucellosis has been widely reported in animals and humans only a few studies have addressed the true prevalence of the disease in the context of Asia which is quite a challenge. It is unable to provide the true context of the disease. The case burden is more prevalent in the developing countries where it is found to be endemic in animals as well as in humans. Thus, this paper highlights the risk factors commonly found in Asian countries that are associated with increased prevalence of infection in humans which has now been believed to be involved many generations across the globe.
2. METHODS

2.1 Literature Review

The main purpose of the literature review was to identify studies with brucellosis etiology data. All searches were conducted from the time frame of 1982 to 2021, they were identified using keywords such as brucellosis, etiology, risk factor, global scenarios, in Asia, or epidemiology. Titles and abstracts were screened to identify the potential studies related to risk factors associated with brucellosis in Asia. Eligible studies were abstracted for information with included risk factors associated with brucellosis in the context of Asia. The studies were grouped according to different countries; no statistical testing was undertaken during the formulation of the data.

The criteria for inclusion of the studies were:

- Study of brucellosis and its synonyms in the context of Asia
- Direct association of risk factor with the infection
- Various risk factors depending on the traditional practices in Asia
- Published data from 1982 to 2021 related
- Identification of the risk factor involved in the infection using One Health Approach

The study aimed to identify the risk factors that were associated with the infection. The study was designed with the most comprehensive risk factor association results. We have limited the results to risk factors associated with brucellosis in Asia.

3. RESULTS

Of the forty-three published articles, 16 articles were excluded because they did not meet the eligibility criteria. Forty-three articles were reviewed and studies that showed risk factor associated with brucellosis in the context of Asia. Studies from various countries in Asia like Malaysia, China, Israel, Iraq, India, Iran, Bangladesh, Thailand, Nepal, Jordan, Tajikistan, and many more were identified. Multiple studies were conducted in 12 countries out of 48 countries in continent Asia.

4. DISCUSSION

4.1 Human Brucellosis in Asia

Most of the studies conducted in different countries in Asia showed that the introduction of new animals provided one of the highest risk factors for brucellosis in healthy livestock farms, and this is an important risk factor for farmers to guide against having brucellosis-free herds. Studies conducted in different Asian countries explain that the exposure to the risk factor that is the infected animals is by consumption of raw milk or by humans who directly in contact with these infected reservoir animals. The various publication demonstrates the association of the disease with the risk factor [1,2,5,6,7,8,15,16,17].

An interesting comparison between two groups of people living in Israel was demonstrated. It explained that the risk factor attributing to the prevalence of the infection was of the same nature. In southern Israel, the Bedouin tribes who live near their herds and consume lots of unpasteurized milk and dairy products reported a high number of endemic brucellosis, and some inhabitants of Israel, such as the Ethiopian Jews, do not raise animals or consume dairy products and yet are increasingly becoming infected with brucellosis. The cause was often overlooked. From the study, it was postulated that Brucellosis can also be transmitted by the traditional slaughtering of animals. Ethiopian Jews in Israel in which the animal is slaughtered, skinned, eviscerated and the meat is minced. Direct exposure to the pathogen can also cause the infection. Those who traditionally slaughter the animals are equally at risk with those who consume unpasteurized milk and milk products from the infected animals. Thereby exposing both the groups to the pathogen [18].

Table 1. Brucellosis species specific case reported in Asia [14]

| Country       | Man B. ab | B. mel. | Country       | Man B. ab | B. mel. | Country       | Man B. ab | B. mel. |
|---------------|-----------|---------|---------------|-----------|---------|---------------|-----------|---------|
| Syrian A.R.   | +         | +       | Pakistan      | ?          | ++      | Bangladesh    | ++        | +       |
| Lebanon       | +         | +       | Saudi Arabia  | ?          | ...     | Burma         | +         | ...     |
| Israel        | ++        | ++      | Yemen         | ?          | ...     | Thailand      | ++        | +       |
| Jordon        | ?         | ?       | Kuwait        | ++        | ...     | Laos          | ++++      | +       |
| Iraq          | +         | ?       | Sri Lanka     | +         | ...     | Qatar         | ...       | ...     |
| Iran          | ++++      | ++++    | India         | +         | ++++    | Bahrain       | ?         | ...     |
| Afghanistan   | +++       | ++      | Nepal         | ++        | +       | UAE           | ?         | ...     |
A study recently conducted in Iran demonstrated that the most common source of infection with brucellosis was the consumption of unpasteurized fresh cheese. Occupational exposure was recorded in about 52.1% of patients [17].

In Malaysia, the risk factors demonstrated include mean age, occupation, and consumption of unpasteurized milk with farmers having 7.19 times the odds of developing brucellosis when compared to non-farmers with 90% confidence interval [CI]: 1.16-44.71; it also demonstrated that those who were 40 years and below had 7.16 times the odds of developing brucellosis than those above 40 years with 90% Confidence Interval: 1.16-44.41. Among those who consumed unpasteurized milk have 4.5 times the odds of having brucellosis than those who do not consume (90% CI: 1.03-19.15) [19]. The risk factors of brucellosis in Malaysian goats were found to be the introduction of new animals (OR: 5.25; 90% CI: 1.46-18.88), the younger age category of farms (OR: 5.53; 90% CI: 1.09-21.66), and farms with a single breed of goats (OR: 8.50; 90% CI: 1.27-41.97) [20, 21].

In India, it has also been reported that there is a loss of 0.5 USD per goat due to brucellosis infection. [22]. A recently conducted study in rural India concluded that among 1,733 infected individuals, 998 had direct contact with animals, whereas 735 had no evidence of direct contact. Clinical symptoms resembling brucellosis were seen in 8.71% of the subjects. Animal contact especially during milking, parturition/abortion was the major risk factor, followed by raw milk ingestion. None of the participants knew about the disease brucellosis [23].

In Bangladesh, Brucellosis prevalence showed variation based on occupations of people and species of animals (3.7% in cattle, 4.0% in buffalo, 3.6% in goats, and 7.3% in sheep). The prevalence of brucellosis also varied in livestock farmers (2.6-21.6%), milkers (18.6%), butchers (2.5%), and veterinarians (5.3-11.1%) who have had direct contact with the animal and its products or who consume raw milk directly [24]. In Bangladesh the apparent prevalence of brucellosis in high-risk occupationally exposed and in pyrexic patients is also low [25].

Thailand is still considered endemic for brucellosis and in recent years there have been concerted efforts beginning from 2009 to eradicate brucellosis in animals, but the high volume of goat movements hampers the test and slaughter and compensation policy from achieving the needed objectives [26]. An outbreak of brucellosis in a goat farm in Thailand led to a fatal infection of a 79-year-old goat farmer with unprotected exposure to goat carcasses identified as the main risk factor. [27] Farmers and veterinary personnel must be careful while handling animals in endemic areas.

As recorded by various studies [28, 29, 30, 31, 32] the prevalence of brucellosis in the Nepalese gender specifically explains males 5.60% to 9.42%, and 2.90% to 60% in females. This higher incidence of brucellosis among slaughterhouse workers may have been due to occupational exposure and poor hygiene in slaughterhouses.

In Ningxiang, China, goats are referred to as the major source of Brucellosis for human infection. Most of the farmers and slaughter workers were involved with goats. The disease has caused a significant economic loss to local farmers. The consequences of infection were reported as abortion, stillbirths, and increased mortality in goats [33, 34]. Another major cause identified was that improper disposal of the sick or dead goats adopted by local farmers in China is also a major cause of brucellosis in the human population. The most practical way of dealing with the dead goats identified was burying. However, local farmers often feed the contaminated carcasses of goats to the dogs or abandon them carelessly hence causing the bacteria to survive for months in the environment [35]. Thus, it was concluded that the indirect transmission may have occurred through the contacts between dogs and contaminated soil and water or vectors [35, 36]. There was another risk factor also identified in this same study, it was the poor hygiene in lambing pen where it had a higher chance of contamination by abortions of goats. Introduction and poor hygiene in local goat farms were key risk factors for local farms having goats that were seropositive to Brucellosis [37]. The finding was similar to studies conducted in other countries [38, 39, 40] A goat farm having an introduction in the preceding year would have a dramatically increased risk of infection than a farm. This finding indicates that there might be risky trade practices adopted by local farms [37].

The study was conducted among 667 female sheep and goats >6 months of age from 21 villages surrounding the capital city, Dushanbe.
Fourteen villages had at least one seropositive sheep or goat, resulting in the apparent prevalence of 67% at the village level. This indicates a high prevalence of Brucella infection among sheep and goats in the peri-urban area of the capital city in Tajikistan. Given the dense human population in such areas, this could constitute a threat to public health, besides causing significant production losses [39].

High herd prevalence of Brucellosis has also been reported in other Asia countries. A cross-sectional survey in Jordan reported 45.4% (95% CI: 30.3–61.6) in goat herds and 70.4% (95% CI: 55.5–84.9) in mixed sheep-goat flocks. [40].

Brucellosis in sheep and goats contributes to local human infection. The distribution of human cases was significantly more spatially correlated with the number of sheep and goats than with swine and cattle [41]. Control of Brucellosis in humans requires good control of Brucellosis in livestock. Unfortunately, there has been no reliable strategy of brucellosis control in many developing countries [42]. Understanding the epidemiology of brucellosis is the key to the development of an efficient control strategy for brucellosis control and risk factors identified.

4.2 One Health Approach of Identifying the Risk Factor and Controlling the Spread of Infection

A very fundamental way to control brucellosis was recently developed. It is gaining wide recognition around the developing countries where brucellosis remains an infection of concern. It is popularly known as the One Health approach. In the One Health framework healthcare professionals including from every field working to solve the infection spread that include veterinary, medical, environmental professionals, policymakers and experts involved all collaborate together with the one and only aim of identifying possible risk factors responsible for this infection and formulate a suitable approach in controlling and eradicating the infection [43]. To mitigate effective control and eradication of brucellosis, both the human and animal population, it is vital to understand that which species of Brucellae affect which animals and in return which of these animals can be a vital source of reservoirs, especially in developing countries where mixed farming is commonly practiced. [43]. Reservoir in these infected animals is responsible for the spread of infection and transmitting it to the human population [20,43,44,45]. Unfortunately, in many underdeveloped and developing countries, this kind of collaboration is non-existent or weak which gives room for brucellosis to thrive unchecked especially in rural populations [43].

5. CONCLUSION

Brucellosis is a zoonotic infection most acquired to the human population from the infected animal reservoir. Consumption of raw milk and milk products poses the same amount of threat to those who handle the infected animals with close contact. Different studies available from Asian countries explain that mixed farming is commonly practiced in this region. Due to this, contact between the pathogen and host is inevitable. The pathogen survives in the host if a suitable environment is available to strive in it. Brucellosis is likely to continue to be a global threat for years to come in Asian countries due to mixed farming, but concerted efforts and political willpower of various government agencies can facilitate the process of reducing the disease spread among animals and ultimately among the human population [45]. There is lack of data explaining the accurate incidence and prevalence of human brucellosis from many countries this causes underestimation of the actual burden of the disease. A very important key to controlling brucellosis in humans is controlling it in animals [46].

CONSENT

It's not applicable.

ETHICAL APPROVAL

It's not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Available:https://rarediseases.info.nih.gov/diseases/5966/brucellosis
2. Percin D. Microbiology of Brucella. Recent Pat Antiinfect Drug Discov. 2013;8(1):13-7. PMID: 22812617.
3. Bamaiyi Pwaveno, Hassan, Lolena, Bejo, Siti Zainal MA. update on Brucellosis in Malaysia and Southeast Asia. Malaysian Journal of Veterinary Research. 2014;5:71-82.
4. Bamaiyi PH. Prevalence and risk factors of brucellosis in man and domestic animals: A review. Int J One Health. 2016;2:29-34.
5. Roushan MR, Kazemi S, Rostami FF, Ebrahimpour S. A study of Brucella infection in humans. Crescent J Med Biol Sci. 2014;1:69-75.
6. Godfroid J, De Bolle X, Roop RM, O’Callaghan D, Tsolis RM, Baldwin C, et al. The quest for a true one health perspective of brucellosis. Rev Sci Tech. 2014;33:521-38.
7. Ficht T. Brucella taxonomy and evolution. Future Microbiol 2010;5:859-66.
8. Liu, Zhe, et al. Different Clinical Manifestations of Human Brucellosis in Pregnant Women: A Systematic Scoping Review of 521 Cases from 10 Countries. Infection and Drug Resistance. 2020;13:1067-1079. DOI: 10.2147/IDR.S248779
9. Dean, Anna S, et al. Clinical manifestations of human brucellosis: A systematic review and meta-analysis. PLoS Neglected Tropical Diseases. 2012;6(12):e1929. DOI: 10.1371/journal.pntd.0001929
10. Minejajd R, Vahdati AR, Ahmad A, Mortazavi SM, Piranfar V. Comparison of culture and multiplex PCR technique for detection of Brucella abortus and Brucella melitensis from human blood samples. Zahedan J Res Med Sci. 2013;15:29-32.
11. Godfroid J, Al Dahouk S, Pappas G, Roth F, Matope G, Muma J, et al. “one health” surveillance and control of brucellosis in developing countries: Moving away from improvisation. Comp Immunol Microbiol Infect Dis. 2013;36:241-8.
12. Godfroid J, DeBolle X, Roop RM, O’Callaghan D, Tsolis RM, Baldwin C, et al. The quest for a true one health perspective of brucellosis. Rev Sci Tech. 2014;33:521-38.
13. Bamaiyi PH, Hassan L, Khairani-Bejo S, ZainalAbidin M, Ramlan M, Adzhar A, et al. The prevalence and distribution of Brucella melitensis in goats in Malaysia from 2000 to 2009. Prev Vet Med. 2015;119:232-6.
14. Thimm BM. The Incidence of Brucellosis in Asia, Australia and Oceania. In: Brucellosis. Veröffentlichungen aus der Geomediizinischen Forschungsstelle der Heidelberger Akademie der Wissenschaften (Sitzungsberichten der Mathematisch-naturwissenschaftlichen Klasse Jahrgang 1982). Springer, Berlin, Heidelberg. 1982:1. Available:https://doi.org/10.1007/978-3-642-81760-1_4
15. Ghanbari MK, Gorji HA, Behzadifar M, Sanee N, Mehed N, Bragazzi NL. One health approach to tackle brucellosis: a systematic review. Trop Med Health. 2020;48:86. Published 2020 Oct 20. DOI: 10.1186/s41182-020-00272-1
16. Dean AS, Crump L, Greter H, Schelling E, Zinsstag J. Global burden of human brucellosis: A systematic review.
17. Nassaji M, Govhary A, Ghorbani R. Epidemiological, clinical and laboratory findings in adult patients with acute brucellosis: A case-control study. Acta Medica Mediterr. 2015;31:1319-25.
18. Fuchs I, Osyntsov L, Refaely Y, Ciobotaro P, Zimhony O. Ritual slaughter as overlooked risk factor for brucellosis. Emerg Infect Dis. 2016;22:746-8.
19. Bamaiyi PH, Hassan L, Khairani-Bejo S, Krishnan N, Adzhar A, Ramlan M, et al. Risk factor for Brucellosis in urban and rural areas of Malaysia. In: UPM, editor. 2nd Malaysia-Thailand Graduate Forum 2013 in Life Science, Food Science and Agriculture (MTGF) 2013. Serdang, Selangor, Malaysia: University Putra Malaysia. 2013;139-40.
20. Bamaiyi PH, Hassan L, Khairani-Bejo S, ZainalAbidin M, Ramlan M, Adzhar A, et al. The prevalence and distribution of Brucella melitensis in goats in Malaysia from 2000 to 2009. Prev Vet Med. 2015;119:232-6.
21. Bamaiyi PH, Hassan L, Khairani-Bejo S, ZainalAbidin M, Ramlan M, Krishnan N, et al. Case-control study on risk factors associated with Brucella melitensis in goat farms in Peninsular Malaysia. Trop Anim Health Prod. 2014;46:739-45.
22. Singh BB, Dhand NK, Gill JPS. Economic losses occurring due to Brucellosis in Indian livestock populations. Prev Vet Med. 2015;119(3-4):211–5.
23. Mangalgi SS, Sajian AG, Mohite ST, Kakade SV. Serological, Clinical, and Epidemiological Profile of Human Brucellosis in Rural India. Indian J Community Med. 2015;40(3):163-167.
24. Islam MA, Khatun MM, Werre SR, Srijananthan N, Boyle SM. A review of Brucella seroprevalence among humans and animals in Bangladesh with special emphasis on epidemiology, risk factors and control opportunities. Vet Microbio. 2013;166:317-26.
25. Rahman AKM Anisur. Epidemiology of brucellosis in humans and domestic ruminants in Bangladesh;2015. DOI: 10.13140/2.1.3923.2800.
26. Inchaissi C, Prasomsri P, Boonserm T, Hogeveen H, Ajaranyakorn K. A stochastic simulation model for brucellosis eradication in goat flocks in an area with high flock prevalence but low animal prevalence. Small Rumin Res. 2016;136:227-37.
27. Wongphraksasoon V, Santayakorn S, Sitthi W, Chuxnum T, Pipatjaturong N, Kunthu A, et al. An outbreak of Brucella melitensis among goat farmers in Thailand, December 2009. Outbreak Surrveill Investig Rep. 2012;5:14-21.
28. Joshi DD, Upadhyaya M, Mishra PN. Brucellosis in animal and human of Chitwan NZFHR Tahachal. 2005;37-48.
29. Singh HL. Principal records of Nepal: a collection of important facts and events of Nepal in the chronological order. 2nd ed. Lalitpur: Satish Singh. 1985;45–62. [Google Scholar]
30. Shrestha B. Sero-prevalence of Brucellosis in different species of meat animals of Nepal. B.V.Sc & AH internship report. IAAS. TU; Nepal; 2008.
31. Joshi DD. Incidence of human brucellosis in Kathmandu. JNMA J Nepal Med Assoc. 1984;22:1–7.
32. Joshi DD, Shrestha IL, Aryal A. Veterinary and human public health importance of brucellosis in Nepal. Nepal Vet J. 2007;29:77–81.
33. Montiel DO, Bruce M, Franken K, Udo H, van der Zijpp A, Rushton J. Financial analysis of brucellosis control for small-scale goat farming in the Bajo region, Mexico. Prev Vet Med. 2015;118(4):247–59.
34. China State Council. Law of the People’s Republic of China on Animal Disease Prevention. In. Edited by Congress SCotNPs, 2015 edn. Beijing: China State Council; 2015.
35. Aune K, Rhyan JC, Russell R, Roffe TJ, Corso B. Environmental persistence of Brucella abortus in the Greater Yellowstone Area. J Wildl Manage. 2012;76(2):253–61.
36. Neglia G, Veneziano V, De Carlo E, Galiero G, Borriello G, Francillo M, Campanile G, Zicarelli L, Manna L. Detection of Brucella abortus DNA and RNA in different stages of development of the sucking louse Haematopinus tuberculatus. BMC Vet Res. 2013;9:236.
37. Li Y, Tan D, Xue S, et al. Prevalence, distribution and risk factors for brucellosis infection in goat farms in Ningxiang, China. BMC Vet Res. 2021;17:39. Available: https://doi.org/10.1186/s12917-021-02743-x
38. Mai HM, Irons PC, Kabir J, Thompson PN. Herd-level risk factors for Campylobacter fetus infection, Brucella seropositivity and within-herd seroprevalence of Brucellosis in cattle in northern Nigeria. Prev Vet Med. 2013;111(3-4):256–67.
39. Rajala EL, Grahn C, Ljung I, Sattorov N, Boqvist S, Magnusson U. Prevalence and risk factors for Brucella seropositivity among sheep and goats in a peri-urban region of Tajikistan. Trop Anim Health Prod. 2016;48(3):553–8.
40. Musallam II, Abo-Shehada M, Omar M, Guillian J. Cross-sectional study of Brucellosis in Jordan: Prevalence, risk factors and spatial distribution in small ruminants and cattle. Prev Vet Med. 2015;118(4):387–96.
41. Li YJ, Li XL, Liang S, Fang LQ, Cao WC. Epidemiological features and risk factors associated with the spatial and temporal distribution of human Brucellosis in China. BMC Infect Dis. 2013;13:547.
42. Rubach MP, Halliday JE, Cleaveland S, Crump JA. Brucellosis in low-income and middle-income countries. Curr Opin Infect Dis. 2013;26(5):404–12.
43. Bamauiy PH. Prevalence and risk factors of brucellosis in man and domestic animals: A review. Int J One Health 2016;2:29-34.
44. Godfroid J, DeBolle X, Roop RM, O’Callaghan D, Tsolis RM, Baldwin C, et al. The quest for a true one health perspective of brucellosis. Rev Sci Tech 2014;33:521-38.
45. Bamaiyi PH, Hassan L, Khairani-Bejo S, Zainal MA, Ramlan M, Krishnan N, et al. Isolation and molecular characterization of *Brucella melitensis* from seropositive goats in Peninsular Malaysia. Trop Biomed. 2012;29:1-6.

46. Bamaiyi Pwaveno, Hassan Lolena, Bejo Siti, Zainal MA. Update on Brucellosis in Malaysia and Southeast Asia. Malaysian Journal of Veterinary Research. 2014;5:71-82.

© 2021 Singh; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/69715