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Determination of Risks of Occurrence and Areas of Brucellosis Infection Spread in the Territory of the Republic of Kazakhstan

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ABSTRACT

This paper aims to highlight the situation of brucellosis infection in the Republic of Kazakhstan. To achieve the goal, methods of analysis, regression analysis, and statistical processing were used. The study of brucellosis prevalence revealed that geographical features play a key role: small ruminants are usually preferred in mountainous and arid areas, while highland areas are chosen for cattle. Cattle infections are particularly high in areas located in western, northern, eastern Kazakhstan, and Turkestan. Notably, the maximum number of brucellosis cases among sheep and goats was recorded in the south-eastern regions. Identified as critical, risk factors include large herds and management practices such as lack of veterinary and sanitary facilities and their poor sanitary condition, which increase the chances of spreading the disease. Meat and mixed herds were also found to be more susceptible to the disease compared to dairy herds, and environmental factors, including the presence of unfavorable areas and the use of rented pastures, further increase the risk of spread of infection.

Key words: Epizootic, Cattle, Zoonotic disease, Seropositivity, Vaccination.

INTRODUCTION

Studying the risks and spread of brucellosis in the Republic of Kazakhstan is critical due to its significant implications for public health, animal welfare and economic stability. Brucellosis, a zoonotic disease, poses a dual threat as it can be transmitted from infected animals to humans, resulting in debilitating health consequences and affecting livestock productivity and trade. The multifaceted nature of brucellosis transmission requires comprehensive research to understand its epidemiology. By addressing this, science-based strategies can be developed to mitigate the impact of the disease and promote sustainable agricultural practices that will ultimately protect human and animal populations in Kazakhstan and beyond.

Kazakhstan is among the twenty-five countries with the highest incidence of brucellosis (Taipova et al. 2023). Despite implementing various brucellosis eradication programs, comprehensive epizootological monitoring studies have been insufficient. This lack of data not only complicates efforts to assess the effectiveness of these measures but also hinders the ability to track changes in brucellosis prevalence in both animals and humans over time. In addition, the lack of accurate and up-to-date information on circulating brucellosis genotypes further complicates the understanding and effective organization of health interventions. Regular grazing on leased pastures and wetlands within pastures increase the likelihood of intra-herd transmission of brucellosis (Charypkhan and Rüegg 2022). Moreover, such practices may facilitate interactions between infected and uninfected livestock, although the movement of cattle from home farms for breeding purposes is not a common practice in Kazakhstan. The presence of wetlands is expected to increase the persistence of *Brucella abortus* in the environment.

Jakipov et al. (2021) and Turgenbayev et al. (2023) found that the dairy sector in Kazakhstan is experiencing expansion. This growth is attributed to the increasing demand for dairy products and changing consumer preferences and behavior. The growing dairy industry is undoubtedly making a positive contribution to improving nutrition and dietary diversity among consumers. Nevertheless, growing demand comes with inherent risks, among which brucellosis is a major concern because of its potentially harmful effects on human and animal health and animal productivity. According to Syrym et al. (2019), the current brucellosis control policy in Kazakhstan is functioning effectively. The Ministry of Agriculture of the

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Republic of Kazakhstan (2024) is the main actor in the control of brucellosis, and the implementation of the program is entrusted to various subordinate agencies. The organizational structure is clearly defined: each team and member has specific roles and responsibilities. Collaboration between the Ministry of Health and the Ministry of Agriculture is considered a reliable means of controlling brucellosis outbreaks.

The work of colleagues lacks more specific statistics on regional animal infections and clarity on what factors contribute to the spread of the disease. That is why the aim of the study is a comprehensive assessment of the epidemiological situation of brucellosis among domestic animal populations in Kazakhstan. It also aims to identify key risk factors and develop proposals to minimize the threat of infection spread

MATERIALS AND METHODS

A number of relevant methods and approaches were used to achieve the objective and to obtain the necessary information on the risk of occurrence and areal extent of brucellosis infection in the territory of the Republic of Kazakhstan. In particular, the analysis method was applied to systematize data on the degree of infection in different regions of Kazakhstan. Additionally, a regression analysis method was used to assess the influence of various factors on the probability of infection. Both existing foreign and domestic research works devoted to modeling the development of the region in order to determine the risks of occurrence, and areas of the spread of brucellosis infection on the territory of the Republic of Kazakhstan were analyzed. As a result, the latest theoretical data on modelling technologies were obtained and methods of their use were described.

Epidemic-environmental factors and basic statistical information related to the spread of brucellosis on the territory of the country were analyzed. In the course of the study, functional dependencies between socio-ecological factors and their impact on the dynamics of infection spread were developed. These dependencies were presented in the form of specialized tables and graphs, which made it possible to visualize their influence on the dynamics of brucellosis spread. Regularities determining the nature of functioning and dynamics of socio-ecological processes in the context of brucellosis spread in the territory of Kazakhstan were revealed.

Official statistical reports of the Ministry of Agriculture of the Republic of Kazakhstan and the Committee for Veterinary Control and Supervision of the Ministry of Agriculture of the Republic of Kazakhstan were used to summarize the information obtained. In addition, data from the World Health Organization, and Food and Agriculture Organization were used in the study. Data from government sources were provided by the Bureau of National Statistics. These organizations provide researchers with up-to-date information to analyse and predict the epidemiological situation.

RESULTS AND DISCUSSION

Kazakhstan's approach to brucellosis control was fragmented, with no unified national strategy. This approach has had limited success in reducing the prevalence of brucellosis. The need for a more structured and comprehensive approach led to the development of the Order of the Minister of Agriculture of the Republic of Kazakhstan No. 7-1/587 (2015). This legal document outlined a national strategy for brucellosis control and prevention. It ordered a comprehensive vaccination campaign for livestock, especially cattle, sheep, and goats. The aim was to reduce the prevalence of the disease and thus minimize the risk of transmission to humans. Enhanced surveillance measures were also introduced. This included regular testing of livestock and recording of brucellosis cases in both animals and humans. The Order included provisions for educational programs aimed at farmers, livestock owners and the public. These programs focused on brucellosis transmission routes, preventive measures, and the importance of vaccination. The Order imposed strict controls on the movement of animals from affected areas.

Yespembetov et al. (2019) indicated that the implementation of the Order had a profound impact on the control of brucellosis in Kazakhstan. The vaccination program led to a decrease in the incidence of the disease among livestock, significantly reducing the risk of human infection. Enhanced surveillance and monitoring have allowed early detection of outbreaks. Despite these achievements, challenges remain in eliminating brucellosis in Kazakhstan. These include logistical issues related to vaccination of nomadic herds and the need for continuous public education and government support (World Health Organization 2022).

Mangistau oblast stands out against the background of other regions as the least developed in cattle reproduction (Fig. 1). Comparing with other regions, such as Atyrau and Kyzylorda oblasts, it can be noted that they are 8 times ahead of Mangistau oblast ($P \leq 0.04$). Increase in the number of cattle is observed in Aktobe, Karaganda, West Kazakhstan, and Akmola oblasts. The most favorable conditions for agriculture are noted in Turkestan, Almaty, and East-Kazakhstan regions, where the number of cattle is three times higher ($P<0.04$) (Bureau of National Statistics 2024).

The Pearson correlation coefficients obtained indicate significant relationships within the dataset. Particularly notable is the strong positive correlation of 0.67 ($P \leq 0.004$) between total herd size and number of cases. This suggests that as the total number of heads in the herd increases, the number of reported cases also increases. There was also a moderate positive correlation of 0.47 ($P<0.02$) between the total population size and the proportion of infected animals. This indicates a tendency for a higher proportion of infected animals in areas with larger populations (Committee for Veterinary… 2024). This allow conclusions to be drawn about relationships between different aspects of agricultural activities. A relationship was found between the total number of goats and sheep and the number of infected animals, indicating the influence of the total number of small ruminants on the number of infected animals and vice versa. It is important to note that the number of regions suitable for cattle breeding exceeds the number of regions suitable for small ruminants by a

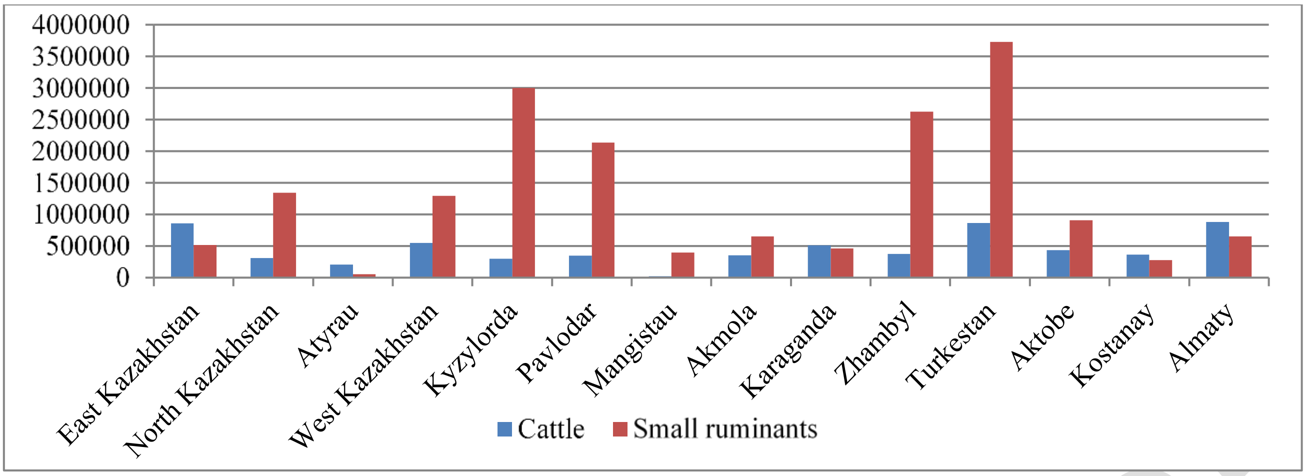

Fig. 1: Quantitative indicators of the number of large and small ruminants in the regions of the Republic of Kazakhstan; Source: compiled by the authors based on Turgenbayev et al. (2023).

factor of almost two. To visualize these dynamics, it is useful to calculate the percentage of infected animals to the total number of animals in a herd within a given administrative unit. This ratio allows a better understanding of disease patterns. It is important to note that the results obtained show a strong correlation with maps of agricultural land, especially areas allocated to pastures. This correlation is important in the context of the Republic of Kazakhstan, where pastures play a dominant role in the sustainable development of livestock production.

The increased prevalence of sheep and goat diseases in the south-eastern regions is primarily due to their proximity to the border with Kyrgyzstan, where high levels of animal infestation are also observed. Inadequate control at border checkpoints, together with the common use of pastures and evacuation routes, leads to increased spread of diseases. However, when analyzing data from the Ministry of Agriculture of the Republic of Kazakhstan (2024), it is evident that with a constant pasture size, the probability of disease infection decreases. This indicates that effective management and optimization of pasture allocation can play a key role in mitigating the spread of disease. The highest prevalence of bovine brucellosis disease is observed in the regions of West Kazakhstan, North Kazakhstan, East Kazakhstan, and Turkestan oblasts (Raushan et al. 2023) (Table 1). The lowest number of brucellosis cases was recorded in Pavlodar and Zhambyl oblasts.

After a regional analysis, it was revealed that some regions of the country can be classified by the degree of infection. Thus, Karaganda, Pavlodar, Almaty and Zhambyl oblasts showed a low degree of infection, they are classified as class “A”. Atyrau, Akmola, Kostanay and Kyzylorda regions are classified as class “B”, indicating a medium degree of infection. The remaining regions have the status of “C”, which represents a high degree of infection (Food and Agriculture Organization 2021). A detailed analysis of the data compared with the physical map of the Republic of Kazakhstan (United Nations 2020) by the Bureau of National Statistics (2024) revealed that cattle breeding is mainly concentrated in hilly and flat areas of the country. Nevertheless, a closer look at the prevalence of brucellosis in cattle and small ruminants reveals interesting features. Small ruminants are more likely to be raised in mountainous and arid areas, while cattle are preferably raised in highland areas. Thus, these observations highlight the importance of considering geographical features when analyzing the prevalence of diseases in livestock.

Taipova et al. (2023) emphasize the importance of several aspects affecting the probability of brucellosis infection, such as herd size, management conditions and environmental factors. It is observed that herds exceeding a certain threshold in animal numbers show a higher risk of infection, indicating a direct correlation between herd size and the level of disease risk. Multivariate analysis confirmed this, showing that herds consisting of more than 50 cows had a significantly higher risk of infection. It is also noted that the lack of vaccination and specialized calving pens significantly increased the likelihood of brucellosis outbreaks. In addition, herd type influenced the spread of infection. The use of rented pastures and the purchase of breeding animals were also found to increase the risk of infection (Table 2). In light of this, the results of the study emphasize the importance of controlling herd size, strict adherence to vaccination protocols, and optimizing management and environmental conditions.

Since the twentieth century, quite a few countries have taken stringent measures to control brucellosis in animal populations (Di Bari et al. 2022). Although some developed countries have successfully controlled bovine brucellosis, it remains a serious problem in other regions, especially in the Middle East. This study indicates that Kazakhstan is indeed at risk. As noted by Liu et al. (2020), in animals, the disease is manifested by infertility, late abortion, decreased milk production, secondary endometritis and placental retention. In Iran, it is not uncommon to observe dairy animals grazing on or near state-owned lands due to land scarcity. Cattle grazing on communal land are associated with a higher prevalence of brucellosis compared to animals reared under semi or intensive production conditions (Vygovska et al. 2023). It has been documented that the serological prevalence of bovine brucellosis in Iran varies widely, from 0.4 to 59.6%. The noted symptoms are the same for any country whose animals are sick with brucellosis, including Kazakhstan, also the results of comparison of different dairy management systems are quite similar.

Table 1: The ratio of the number of infected and the total number of large and small livestock on the territory of the Republic of Kazakhstan in 2023

Regions	Cattle			Small ruminants		
	Total number of animals	Infected animals	%	Total number of animals	Infected animals	%
East Kazakhstan	856,979	5,069	0.59	512,930	803	0.16
North Kazakhstan	310,113	5,335	1.72	1,340,049	3,231	0.24
Atyrau	202,786	1,529	0.75	51,246	539	1.05
West Kazakhstan	550,136	10,256	1.86	1,291,334	5,339	0.41
Kyzylorda	297,397	1,465	0.49	2,997,634	3,192	0.11
Pavlodar	347,032	483	0.14	2,135,507	2,572	0.12
Mangistau	21,204	624	2.94	394,879	478	0.12
Akmola	354,356	1,679	0.47	649,287	2,333	0.36
Karaganda	507,341	938	0.18	460,810	240	0.05
Zhambyl	373,354	457	0.12	2,624,014	2,224	0.08
Turkestan	864,887	12,100	1.4	3,726,588	1,262	0.03
Aktobe	433,906	3,621	0.83	906,722	1,560	0.17
Kostanay	362,530	1,980	0.55	273,685	126	0.05
Almaty	880,209	1,115	0.13	652,738	231	0.04

Source: compiled by the authors based on Raushan et al. (2023)

Table 2: Analysis of the influence of individual risk factors on the spread of brucellosis among cattle at the herd level in Kazakhstan

No.	Variable	Seropositive	Seronegative	Total number (Seropositive)	Total number (Seronegative)	P-value
1	Livestock size over 50 cows over two years old	70	85	492	1,153	0.9
2	Availability of land in joint ownership	74	89	225	1,215	0.6
3	Availability of horses	77	80	819	1,205	0.6
4	Presence of cats	101	80	980	1,197	0.7
5	Abortion cases in the last year	64	85	492	1,153	0.7
6	Purchase of reproductive animals	74	85	500	1,153	0.5
7	Mixed herd	58	85	259	1,158	0.8
8	Bird presence	85	85	608	1,158	>0.95
9	Livestock size over 140 heads of agricultural animals	101	82	1,016	1,128	0.5
10	Place of slaughter of reproductive animals	14	85	228	1,215	0.8
eleven	Handling post-abortion products	86	82	458	1,200	0.9
12	Application of artificial insemination	7	82	32	1,200	0.7
13	Lack of veterinary support	111	85	874	1,215	0.6
14	Presence of lakes and swamps on the territory	26	85	308	1,200	0.8
15	Use of leased pastures	77	107	792	1,043	0.6
16	Using an intensive breeding system	19	85	130	1,207	0.7
17	Dairy herd	15	85	110	1,215	0.5
18	Failure to vaccinate against brucellosis	41	85	321	1,204	0.9
19	Availability of sheep and goats	109	85	935	1,215	0.9
20	Presence of dogs	50	85	482	1,215	>0.95
21	Presence of wild animals	34	85	225	1,215	0.9
22	Meat herd	97	85	875	1,215	>0.95
23	Lack of a special place for childbirth	74	85	607	1,215	0.7
24	Availability of pigs	26	74	230	1,118	0.5

Source: compiled by the authors based on Taipova et al. (2023)

The correlation between herd size, presence of brucellosis, and herd density in cattle was confirmed by Vakamalla et al. (2023). These results can be explained by a positive correlation between purchasing repair cattle from external sources and herd size. Other studies have supported the hypothesis that brucellosis transmission is directly influenced by the movement of cattle, emphasizing the disease risk associated with the introduction of infected animals from external sources (Busol et al. 2023). These observations are confirmed in the above study, where the difference in the number of heads of the same herd significantly influenced the spread of brucellosis.

Efforts to control zoonotic diseases are most reliable and successful when the focus is on reservoir hosts (Colman et al. 2022; Zhou et al. 2022). Strategies such as vaccination, on-farm biosecurity measures, diagnostic testing, and culling are critical to control brucellosis in domestic animals. However, implementing these measures may conflict with the traditions of affected groups and create problems due to the significant costs associated with monitoring, slaughter of sick livestock and comprehensive compensation in less developed countries. Thus, it is possible to establish some rules of control that take into account the unexamined side of the analyzed data from the brucellosis scoping study.

Dadar et al. (2021) indicated that high-intensity farming practices in large-scale farming operations are associated with the persistence and spread of *Brucella* infection, especially after abortions, whereas more extensive and less concentrated livestock husbandry approaches are thought to limit the spread of such infections. The level of interaction with infected herds and the presence of contaminated environmental sources are recognized as important factors in the transmission of brucellosis, but the influence of these variables on disease patterns among small ruminants remain unclear.

Risk factors for *Brucella* infection identified in one particular agricultural and ecological zone may not be directly applicable to another zone. This is very important for the Republic of Kazakhstan, because control measures need to be considered in a much more regionalized manner. An additional problem that Mosiara (2022) attributes to the persistence and spread of bovine brucellosis is related to livestock trade. This item was not addressed in the reports of Kazakhstani authors and government services, as it is rather unstable and requires additional control methods.

The implementation of the land reform initiative in India has led to increased movement of livestock between the commercial sector and smallholder farming (Jamil et al. 2021). This reform has created a clear livestock management structure. The impact of different climatic conditions in livestock producing regions of India on brucellosis infections remains unexplored. There is a recognized need to identify factors associated with transmission and persistence of *Brucella* infection to improve the effectiveness of any brucellosis control measures. The studies cited above shed light on such factors for Kazakhstan, thus providing an opportunity to organize more effective control. Mousa et al. (2022) and Munyua et al. (2021) accurately identify the main factors contributing to the spread of brucellosis – inadequate farm management practices and deficiencies in the epizootic monitoring system. Obviously, the earliest solution involves reforming the land use system. This approach would reduce contact between herds and reduce the risk of re-infection.

The spread of brucellosis is mainly related to economic and geographical variables (Kustiningsih et al. 2023). Some argue that physiographic factors such as climate and weather have minimal influence on the incidence of brucellosis due to careful animal care practices. However, this view does not take into account the potential influence of physiographic factors on the nature of agricultural activities that ultimately determine the economic viability of stabling and grazing. This discrepancy highlights the complex interplay between environmental conditions and human behaviour. The prevalence of brucellosis in Egypt is associated with the effects of global climate change, especially the trends of general warming (Li et al. 2023). This situation is exacerbated by intensive agricultural development and violation of veterinary and sanitary regulations. Factors such as unregulated movement of infected animals, poor hygiene of premises and the use of semen from untested animals contribute to the spread of brucellosis. Despite Kazakhstan's somewhat northern location, the effects of global warming are nevertheless affecting farms in this region.

The study by Mellado et al. (2023) primarily revolves around medical aspects such as disease clinics, diagnostic methods, and veterinary and sanitary interventions. However, there is a significant research trend worldwide embracing interdisciplinary approaches, especially using geospatial research methods. Geographic information systems are effectively used to identify spatial clusters important for studying disease etiology and understanding spatial and temporal distribution patterns. This principle is very important and can significantly advance brucellosis research in Kazakhstan.

Conclusion

A study of brucellosis prevalence shows that bovine infection rates are markedly higher in West Kazakhstan and East Kazakhstan and Turkestan oblasts, while Pavlodar and Zhambyl oblasts have lower infection rates. It is important to note that the south-eastern regions have the highest number of brucellosis cases in sheep and goats. Topographical conditions have a decisive influence: small livestock are usually raised in mountainous and arid areas, while cattle are more likely to be raised at higher altitudes above the sea.

Key risk factors identified include larger herds and management practices such as lack of specialized calving pens and vaccination, which contribute to the spread of the disease. In addition, beef and mixed herds were found to be more susceptible compared to dairy herds, and environmental conditions such as wetlands and leased pasture practices also contribute to increased risk. In addressing this problem, the study recommends an integrated risk management strategy that includes controlling herd size, strict adherence to vaccination schedules, and optimizing management and environmental conditions. The importance of adapting brucellosis control measures to regional specificities is emphasized, especially in south-eastern areas. The study emphasizes the serious challenge that brucellosis poses to livestock production in Kazakhstan and calls for an integrated approach that considers regional differences in control efforts.

Prospects for further research are to develop the study of geographical factors influencing the spread of brucellosis and to develop more effective diagnostic and preventive methods, as well as to increase public awareness of brucellosis.

Author Contributions

Concept and design: Yerzhan Ospanov and Altynay Arysbekova. Gathering of the data: Akerke Kaiyrbek. Analysis and systematisation of the data: Vladimir Kirpichenko and Aiken Karabassova. Writing the draft of the manuscript: Yerzhan Ospanov. Editing: Altynay Arysbekova. All authors read and approved the final version of the manuscript.

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