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UDC 619:616.981.42 (574) **Research article**

Episotological monitoring of brucellosis of large and small cattle in the Pavlodar Region of the Republic of Kazakhstan

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Abstract

Background and Aim. Despite the efforts to eliminate brucellosis in the Pavlodar region, its local epizootics remain a huge concern. The aim of this work was to conduct epizootic surveillance and analyze the epizootiological situation with animal brucellosis in the Pavlodar region in 2019-2023.

Materials and Methods. The materials used in this study include the official reports of the Committee for Veterinary Control and Supervision of the Ministry of Agriculture of the Republic of Kazakhstan (CVCS of MoA of RK), the Republican Anti-epizootic Unit (RSI RAU), the regional branch of the Republican Veterinary Laboratory (RVL), the Republican State Enterprise on the rights of economic management "Scientific and Practical Centre for Sanitary and Epidemiological Expertise and Monitoring" of the Ministry of Public Health of the Republic of Kazakhstan (RSE SPC SEEaM of MoPH of RK), and the results of our own epizootiological research.

The research methods used in the study are in full compliance with the official guidelines for diagnosing brucellosis in animals.

Results. We have established the leading role of cattle and small ruminants in the epizootiology of brucellosis, identified the most significant factors promoting brucellosis persistence in livestock and ascertained the occurrence of the infection in the human population in every district of the region.

Using the epizootic surveillance data acquired over the past 5 years, we have identified areas with high, moderate and low incidence of animal brucellosis, as well as disease-free zones, and constructed an epizootic map that can be used to implement adequate interventions.

Conclusion. Epizootic surveillance, coupled with the analysis of dynamics of brucellosis spread to new sites, its incidence in livestock and the results of screening tests, will facilitate epizootic control and help to elaborate a methodologically sound strategy for implementing adequate interventions.

Keywords: brucellosis; diagnostic tests; epizootic map; epizootic surveillance; morbidity.

Introduction

Brucellosis is a socially and economically significant disease widely spread across the Republic of Kazakhstan [1].

Brucellosis is a zoonotic, predominantly chronic infection of humans and animals caused by the pathogenic microorganisms of the genus Brucella. Insufficient control, diagnostics and prevention and the threat the disease poses for human health dictate a need for effective strategies that could be effectively adopted by livestock farming and address the diversity of business models [2, 3].

Brucellosis of cattle and small ruminants contributes significantly to infectious morbidity, reduces livestock population and negatively affects the economy of Kazakhstan [4].

Despite the efforts to eliminate brucellosis in the Pavlodar region, its local epizootics remain a huge concern.

Epizootic surveillance plays a key role in the prevention and control of brucellosis in animals. It involves collecting, analysing and interpreting data on the spread of the infection among animals in a specific area. Surveillance allows brucellosis outbreaks to be timely detected, facilitating a rapid response to the threat and preventing its spread.

Long-term surveillance provides invaluable information about the epizootiology of brucellosis in the area, helping to estimate the risk of this infection. This information is crucial for developing an effective system of brucellosis prevention and control [5, 6].

Materials and Methods

The materials used in this study include the official reports of the Committee for Veterinary Control and Supervision of the Ministry of Agriculture of the Republic of Kazakhstan (CVCS of the MoA of the RK), the Republican Anti-epizootic Unit (RSI RAU), the regional branch of the Republican Veterinary Laboratory (RVL), the Republican State Enterprise on the rights of economic management "Scientific and Practical Centre for Sanitary and Epidemiological Expertise and Monitoring" of the Ministry of Public Health of the Republic of Kazakhstan (RSE SPC SEEaM of the MoPH of the RK), and the results of our own epizootiological research.

The research methods used in the study are described in the official guidelines for diagnosing brucellosis in animals [7].

The following data has been analyzed to study the epizootic activity of brucellosis:

- results of the epizootic and serological surveillance of animal brucellosis across the region, implemented by the Laboratory of Brucellosis;
- statistical reviews and official reports on animal brucellosis prepared by the veterinary inspectors of the Pavlodar region, RSI RAU and RVL.

The acquired information was summarized using the official statistical reports from 2023 prepared by the CVCS of the Ministry of Agriculture of the Republic of Kazakhstan [8]. The epizootic situation was analyzed by the methods described by *S.A. Dudnikov* [9].

The retrospective data on the spread of brucellosis and its incidence among animals in 2019-2023 was used to identify areas with high, moderate and low incidence of the disease. The epizootic maps were constructed using GIS-based technology and the methods of risk assessment for disease emergence and spread, considering WHOA's recommendations.

Results and Discussion

As part of this study, we have conducted our own field and laboratory research at livestock farms of the Pavlodar region, at the Regional Veterinary Laboratory and the Laboratory of Brucellosis of Kazakh Scientific Research Veterinary Institute.

In 2019 through 2023, we were monitoring and analyzing the epizootic activity of animal brucellosis in the Pavlodar region.

The acquired data is presented in the tables below.

Table 1 – The number of epizootic sites (ES) of infectious animal diseases and animal brucellosis in the Pavlodar region in 2019-2023

Epizootic indicators	2019	2020	2021	2022	2023	Total for 5 years	Average for 5 years
Total number of ES of infectious diseases	8	50	22	18	17	115	23
Number of ES of bovine brucellosis	1	24	22	0	0	47	9.4

Continuation of table 1

Number of ES of small ruminant brucellosis	0	0	0	0	1	1	0.2
ES of animal brucellosis, % of total	12.5	48.0	100.0	0	5.8	41.7	8.3

Table 1 shows that 115 ES of infectious diseases, including 48 (41.7%) brucellosis sites, were reported in the Pavlodar region during the 5 years of surveillance. This suggests that brucellosis is a leading animal infection in the region. Table 2 shows the number of ES of cattle and small ruminant brucellosis for each district of the Pavlodar region.

Table 2 – The number of ES of cattle and small ruminant brucellosis in the districts and cities of the Pavlodar region during 2019-2023

Districts	2019	2020	2021	2022	2023	Total for 5 years	Average for 5 years
	cattle/ small ruminants	cattle/ small ruminants	cattle/ small ruminants	cattle/ small ruminants	cattle/ small ruminants	cattle/ small ruminants	cattle/ small ruminants
Uspensky	0	10\0	3\0	0	0	13\0	2.6\0
Pavlodarsky	0	3\0	3\0	0	0	6\0	1.2\0
Irtyshsky	0	4\0	1\0	0	0	5\0	1\0
City of Aksu	0	2\0	3\0	0	0\1	5\1	1\0.2
Akkuli	0	1\0	3\0	0	0	4\0	0.8\0
Mayskiy	0	1\0	2\0	0	0	3\0	0.6\0
Shcherbaktinsky	1\0	0	2\0	0	0	3\0	0.6\0
City of Ekibastuz	0	2\0	1\0	0	0	3\0	0.6\0
Zhelezinsky	0	0	2\0	0	0	2\0	0.4\0
Bayanaulsky	0	1\0	0	0	0	1\0	0.2\0
Terenkol	0	0	1\0	0	0	1\0	0.2\0
City of Pavlodar	0	0	1\0	0	0	1\0	0.2\0
Aktogaysky	0\0	0\0	0\0	0\0	0\0	0\0	0\0
Entire region	1\0	24\ 0	22\0	0 \0	0\1	47\1	9.4\0.2

Table 2 shows that there was only 1 ES of brucellosis in 2019 and 1 ES of brucellosis in 2023 (in cattle and small ruminants, respectively) reported in the Pavlodar region. In 2019-2022, there were no known ES of small ruminant brucellosis. However, a significant number of bovine brucellosis sites were reported in 2020 and 2021 (24 and 22, respectively), mainly in the Uspensky, Pavlodarsky and Irtyshsky districts and in the city of Aksu. In 2022, no brucellosis sites were detected in the region. The only area free from the infection throughout the analyzed period was the Aktogaysky district.

In Kazakhstan, mass serological testing of farm animals is routinely conducted by RVL to ensure timely detection of brucellosis.

The results of serological testing conducted by the Pavlodar branch of RVL in 2019–2023 are provided in Tables 3-8.

Table 3 – Results of serological testing for bovine brucellosis conducted in the Pavlodar region in 2019-2023

Year	Number of tested animals	Number of positive serological tests			Confirmed number of seropositive animals	% of infection
		RBT	CFT	AT		
2019	495.615	3.540	3.395	3.390	3.395	0.68
2020	504.462	2.666	2.243	2.239	2.243	0.44
2021	682.166	3.040	2.664	2.660	2.664	0.40
2022	627.264	1.982	1.874	1.868	1.874	0.30
2023	610.279	3.011	2.863	2.858	2.863	0.47
Total, 5 years	2.919.786	14.239	13.039	13.020	13.039	0.45
Average, 5 years	583.957	2.847	2.608	2.603	2.608	0.45

Note. RBT – Rose Bengal test; CFT – complement fixation test; AT – agglutination test.

As seen from Table 3, there were 2.608 seropositive bovines detected in the Pavlodar region in 2019-2023; the average incidence rate was 0.45%. The Rose Bengal test returned the highest number of seropositive results (2.847), followed by the complement fixation test (2.608) and the agglutination test (2.603). The confirmed number of brucellosis-positive animals was 2,608.

Table 4 – Results of serological testing for bovine brucellosis for each district of the Pavlodar region in 2019-2023

Districts and cities	Number of brucellosis cases and morbidity rate (%)										Total for 5 years		
	2019		2020		2021		2022		2023		Number of infected animals, total	Average values	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%		abs. number	incidence, %
Bayanaulsky	782	0.91	999	1.21	1237	1.33	818	0.87	1.535	1.68	5.371	1.074	1.2
Pavlodar city	97	1.32	68	0.85	71	0.83	31	0.37	94	1.02	361	72	0.9
Ekibastuz city	506	1.17	239	0.66	431	0.72	331	0.59	333	0.61	1.840	368	0.8
Akkuli	764	1.89	73	0.17	79	0.14	26	0.05	22	0.05	964	193	0.5
Pavlodarsky	333	0.64	161	0.31	255	0.44	238	0.43	245	0.38	1.232	246	0.5
Aksu city	149	0.44	122	0.32	129	0.20	205	0.33	363	0.75	968	194	0.4
Mayskiy	161	0.42	89	0.21	81	0.17	77	0.16	108	0.23	516	103	0.3
Terenkol	145	0.37	32	0.09	87	0.21	68	0.16	88	0.21	420	84	0.3
Zhelezinsky	9	0.03	133	0.43	159	0.44	14	0.05	28	0.10	343	69	0.3
Irtyshsky	140	0.46	44	0.12	47	0.10	6	0.01	22	0.05	259	52	0.2
Uspensky	132	0.44	76	0.25	50	0.16	18	0.07	17	0.07	293	59	0.2
Shcherbaktinsky	120	0.33	206	0.57	36	0.06	0	0.00	8	0.01	370	74	0.2
Aktogaysky	57	0.17	1	0.00	2	0.00	42	0.09	0		102	20	0.1
Total	3.395	0.68	2.243	0.44	2664	0.40	1.874	0.30	2.863	0.47	13.039	2.608	0.45

Table 4 shows that the incidence rate of bovine brucellosis was decreasing gradually from 0.68% to 0.30% in 2019–2022, but then rose to 0.47% in 2023. The average incidence rate of the disease calculated for the 5-year surveillance period was 0.45%. Using the data from Table 4, we ranked the

districts of the Pavlodar region by the incidence of the disease (high incidence rate: ≥0.45%; moderate and low incidence: <0.45%). There were no epizootically safe districts in the region (Table 5).

Table 5 – Districts of the Pavlodar region ranked by the incidence of bovine brucellosis in 2019-2023

№	Incidence of bovine brucellosis	Number of districts and cities and their contribution to incidence (%)	Average incidence by districts and cities for 5 years, %
1	High, ≥0.45%	5 (38.5%)	Bayanaul district: 1.2 Pavlodar city: 0.9 City of Ekibastuz: 0.8 Akkulinsky district: 0.5 Pavlodarsky district:0.5
2	Moderate, 0.21-0.45%	4 (30.7%)	Aksu city: 0.4 Mayskiy district: 0.3 Zhelezinsk district: 0.3 Terenkol district: 0.3
3	Low, ≤ 0.20%	4 (30.7%)	Uspensky district: 0.2 Shcherbaktinsky district: 0.2 Irtysh district: 0.2 Aktogay district: 0.1
4	Epizootically safe zone, 0.0%	No	

Table 5 shows that the highest incidence of bovine brucellosis in 2019–2023 was observed in 5 districts and cities, which make up 38.5% of the region's territory; moderate incidence was observed in in 4 districts (30.7% of the territory) and low incidence, in 4 districts (30.7% of the territory). There were no epizootically safe districts.

A similar analysis was conducted for small ruminant brucellosis. Its results are provided in Tables 6-8.

Table 6 – Results of serological testing for small ruminant brucellosis conducted in the Pavlodar region in 2019-2023

Year	Number of tested animals	Number of positive serological tests			Confirmed number of seropositive animals	% of infection
		RBT	CFT	AT		
2019	590.747	53	53	51	53	0.01
2020	606.651	64	62	60	62	0.01
2021	774.460	79	53	51	53	0.01
2022	703.121	249	127	122	127	0.02
2023	685.466	313	245	241	245	0.04
Total, 5 years	3.360.445	758	540	525	540	0.02
Average, 5 years	672.089	152	108	105	108	0.01

Note. RBT – Rose Bengal test; CFT – complement fixation test; AT – agglutination test.

According to Table 6, there were 108 head of small ruminants infected with brucellosis in the Pavlodar region in 2019–2023; the average incidence rate was 0.01%. RBT returned the highest number of seropositive results (152), followed by CFT (108) and AT (105). The confirmed number of brucellosis-positive animals was 108.

Table 7 – Results of serological testing for small ruminant brucellosis conducted in the Pavlodar region in 2019-2023

Districts and cities	Number of brucellosis cases and morbidity rate (%)										Total for 5 years		
	2019		2020		2021		2022		2023		Number of infected animals, total	Average values	
	Number	%	Number	%	Number	%	Number	%	Number	%		abs. number (head)	incidence, %
Pavlodarsky	2	0.00	50	0.12	0	0	57	0.13	19	0.03	128	26	0.09
Zhelezinsky	0	0	0	0	43	0.07	62	0.15	56	0.14	161	32	0.07
Pavlodar city	0	0	11	0.08	3	0.01	4	0.03	9	0.05	27	5	0.04
Aksu city	0	0	0	0	0	0	0	0	63	0.08	63	13	0.02
Akkuli	40	0.08	0	0	0	0	0	0	10	0.02	50	10	0.02
Bayanaulsky	1	0.01	0	0	0	0	0	0	52	0.05	53	11	0.01
Mayskiy	8	0.01	1	0.00	2	0.00	4	0.01	15	0.02	30	6	0.01
Irtyshsky	0	0	0	0	0	0	0	0	21	0.04	21	4	0.01
Ekibastuz city	2	0.00	0	0	5	0.01	0	0	0	0	7	1	0.001
Aktogaysky	0	0	0	0	0	0	0	0	0	0	0	0	0
Terenkol	0	0	0	0	0	0	0	0	0	0	0	0	0
Uspensky	0	0	0	0	0	0	0	0	0	0	0	0	0
Shcherbaktinsky	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	53	0.01	62	0.01	53	0.01	127	0.02	245	0.04	540	108	0.02

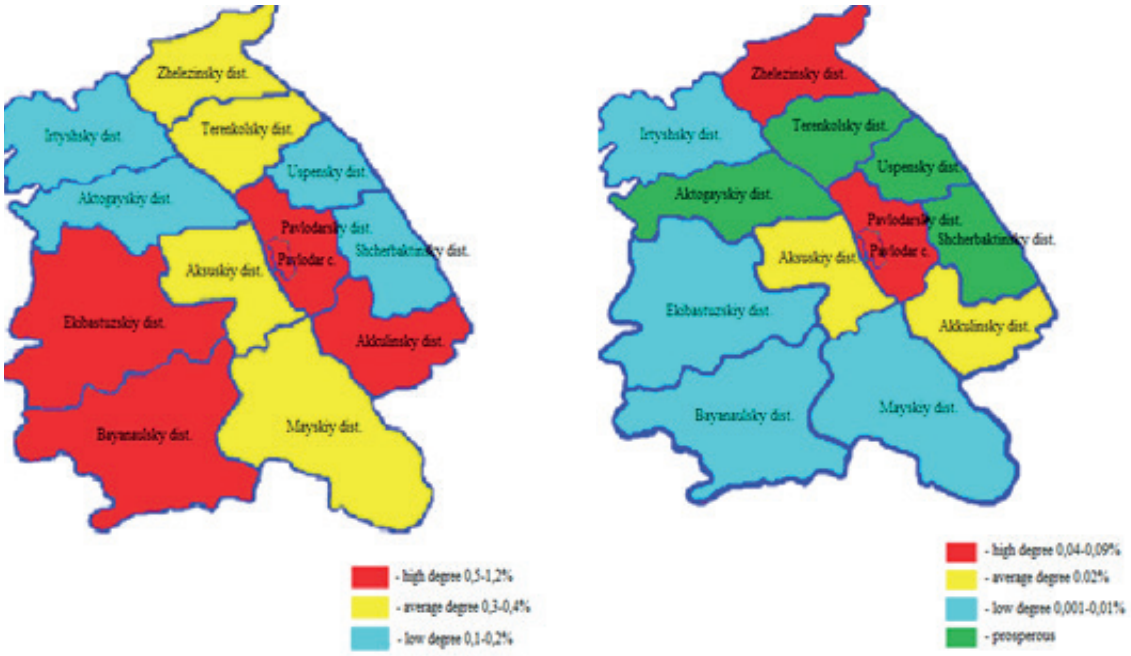
Table 7 demonstrates no dynamics in the incidence rate of small ruminant brucellosis in 2019–2021 (0.01%). However, in 2022, it grew to 0.02% and increased almost twofold to 0.04% in 2023. The relative incidence rate of small ruminant brucellosis calculated for the 5-year surveillance period was 0.02% on average. Using the data from Table 7, we ranked the districts of the Pavlodar region by the incidence of the disease (high incidence: ≥0.02%; moderate and low incidence: <0.02%). Districts with no detected cases of small ruminant brucellosis were considered epizootically safe (Table 8).

Table 5 – Districts of the Pavlodar region ranked by the incidence of bovine brucellosis in 2019-2023

№	Incidence of small ruminant brucellosis	Number of districts and cities and their contribution to incidence (%)	Five-year average incidence rates by districts and cities, %
1	High, >0.02%	3 (23.1%)	Pavlodarsky district: 0.09 Zhelezinsky district: 0.07 City of Pavlodar: 0.04
2	Moderate, 0.02-0.01%	2 (15.4%)	Akkuli district: 0.02 City of Aksu: 0.02%
3	Low, < 0.01%	4 (30.7%)	Bayanaulsky district: 0.01 Irtyshsky district: 0.01 Mayskiy district: 0.01 City of Ekibastuz: 0.001
4	Epizootically safe zone, 0.0%	4 (30.7%)	Aktogaysky district: 0 Terenkol district: 0 Uspensky district: 0 Shcherbaktinsky district: 0

High incidence of the disease was observed in 3 districts, which make up 23.1% of the region's territory, moderate, in 2 districts (15.4% of the territory), and low, in 4 districts (30.7% of the territory). Four districts (30.7% of the territory) were classified as epizootically safe.

The results of the analysis are presented as maps showing the incidence of brucellosis among cattle and small ruminants across the Pavlodar region in 2019-2023 (Figure 1).



А Б

Figure 1 – The burden of bovine (A) and small ruminant (B) brucellosis in the Pavlodar region in 2019-2023

It is clearly visible that bovine brucellosis and small ruminant brucellosis occur in almost the same parts of the region. In 2019-2023, the disease was widespread in the Akkulinsky, Zhelezinsky and Pavlodarsky districts and in the cities of Ekibastuz, Pavlodar and Aksu. The Aktogai, Terenkol, Uspensky and Shcherbaktinsky districts were epizootically safe in terms of small ruminant brucellosis, but bovine brucellosis was found everywhere across the region.

The epizootic maps illustrate the geographical distribution of bovine and small ruminant brucellosis across the region and the potential risks of its expansion. They can provide support in implementing veterinary surveillance in different areas with different epizootiological status and can be used to develop a methodologically sound plan of interventions aimed at preventing and controlling the disease.

The spread of brucellosis among livestock animals directly affects the epidemiological status of the human population. As part of this study, we collected and analyzed data on the morbidity of brucellosis in the human population of the Pavlodar region in 2019-2023 (Table 9).

Table 9 – The incidence rates of human brucellosis in the Pavlodar region in 2019-2023

Districts and cities	2019		2020		2021		2022		2023		Overall, 5 years	
	absolute number	per 100,000 population	absolute number	per 100,000 population	absolute number	per 100,000 population	absolute number	per 100,000 population	absolute number	per 100,000 population	absolute number	per 100,000 population
Uspensky	0	0	1	7.5	4	30.18	5	37.7	0	0	10	
Mayskiy	3	23.8	1	7.9	3	23.81	2	15.9	0	0	9	
Bayanaulsky	1	3.5	7	24.7	6	21.20	3	10.6	1	3.5	18	
Akkulinsky	2	13.7	1	6.9	0	0	5	34.3	1	6.9	9	
Zhelezinsky	0	0	0	0	3	16.81	4	22.4	1	5.6	8	
Terenkolsky	1	4.5	1	4.5	2	9.01	3	13.5	3	13.5	10	
Shcherbaktinsky	4	18.3	0	0	0	0	0	0.0	5	22.9	9	
Irtyshsky	0	0	3	14.4	1	4.80	1	4.8	2	9.6	7	
Pavlodarsky	2	6.9	0	0	1	3.47	1	3.5	2	6.9	6	
City of Aksu	1	1.5	1	1.5	3	4.43	3	4.4	6	8.9	14	
Aktogayskiy	0	0	0	0	0	0	2	13.2	0	0	2	
City of Ekibastuz	1	0.7	0	0	5	3.51	5	3.5	2	1.4	13	
City of Pavlodar	3	0.9	0	0	4	1.19	3	0.9	8	2.4	18	
Total	18	2.4	15	2.0	32	4.31	37	5.0	31	4.2	133	

Table 9 shows that the incidence rate of human brucellosis per 100,000 population was almost twice as high in 2021-2023 (4.2-5.0) than in 2019 and 2020 (2.4 and 2.0, respectively). Notably, there was an increase in the incidence rate of bovine (0.40%; 0.30%; 0.47%) and small ruminant (0.01%; 0.02%; 0.04%) brucellosis on livestock farms across Pavlodar region in 2021-2023. From 2019 to 2023, 133 persons contracted the infection; the average incidence rate per 100,000 population was 3.6. High morbidity rates were reported in the Uspensky, Mayskiy, Bayanaulsky and Akkulinsky districts. The absolute number of the infected individuals was the greatest in the Bayanaulsky district (18) and the city of Pavlodar (18), followed by the cities of Aksu (14) and Ekibastuz (13). The results of the comparative analysis demonstrate that human brucellosis occurred in every district and every big city of the Pavlodar region where bovine or small ruminant brucellosis were reported. This confirms the role of animals as the source of brucellosis in humans.

Brucellosis is common in many countries, especially in the areas with developed livestock production and insufficiently strict sanitary control. Its highest incidence is reported in the countries of the Mediterranean, Middle East, Central Asia, Africa and Latin America [10-14]. The World Health Organization (WHO) has included brucellosis in the list of zoonotic diseases that have serious implications for public health. According to WHO, this infection has been found in more than 170 countries in the past decade, with up to 500.000 confirmed cases of human brucellosis per year [15].

Today, the outbreaks of human brucellosis are most often reported in Central Asia, including the Republic of Kazakhstan [16-19]. New sites of brucellosis are emerging continuously, and more animals and humans are contracting the disease. Therefore, research of its sources and transmission routes should be a priority for human and veterinary medicine in Kazakhstan.

Kazakhstan is among the twenty-five countries with the highest incidence of brucellosis in the human population [20]. The high incidence of this infection is also reported by Kazakhstan's neighbors, including Iraq, Tajikistan, Saudi Arabia, Iran, and Kyrgyzstan [21].

Brucellosis transmission to humans largely occurs through the alimentary and airborne routes. In most countries, human brucellosis is contracted through the consumption of undercooked meat and unpasteurized dairy products. Extensive development of pastoral farming, inadequate approaches to sanitation and hygiene and poor food safety practices at smallholder livestock farms and markets promote the disease.

The problem of animal brucellosis in Kazakhstan has been vastly addressed by Kazakhstani scientists [22-27].

The incidence of bovine brucellosis is growing in West Kazakhstan, the Karaganda and Pavlodar regions [28]. There is an increase in the incidence of small ruminant brucellosis in the Kostanay, Zhambyl and Almaty regions. The lowest incidence rate is observed in the Mangistau region. The causative agent of bovine brucellosis B. abortus has been isolated in more than 90% of the samples collected in the northern regions of Kazakhstan, whereas the causative agent of small ruminant brucellosis B. melitensis has been found in the southeast of the country [29].

Despite the efforts to eliminate brucellosis in the past 80 years, there is a lack of comprehensive epizootic surveillance studies. The scarcity of data hinders the understanding of the dynamics of brucellosis incidence among both animals and humans.

The aim of this paper was to conduct the epizootiological surveillance of animal brucellosis, analyze the results of mass serological testing and the risks of spread of the disease, thereby contributing to the elaboration of scientifically sound anti-epizootic measures that ensure a rapid response to the threat and prevent its spread.

We have identified 5 districts and cities, which make up 38.5% of the region's territory, with high incidence of bovine brucellosis in 2019–2023, 4 districts with moderate incidence (30.7% of the territory) and 4 districts with low incidence (30.7% of the territory). Not a single district of the Pavlodar region was free from bovine brucellosis during the entire five-year surveillance period.

Three districts that comprise 23.1% of the region's territory have been identified as having high incidence of small ruminant brucellosis, 2 districts (15.4% of the territory) as having moderate incidence and 4 districts (30.7% of the territory) as having low incidence of the disease. Four districts (30.7% of the territory) represented an epizootically safe zone.

The analysis of associations between the incidence of brucellosis among humans and its incidence in livestock in 2019–2023 reveals that there were no reports of epizootic sites of bovine or small ruminant brucellosis in the region in 2022. However, serological testing conducted at the region's veterinary laboratories detected 1.874 seropositive head of cattle and 127 seropositive head of small ruminants. In 2022, 37 persons contracted the infection; its incidence per 100. 000 human population was as high as 5.0.

In 2019-2022, no epizootic sites of small ruminant brucellosis were reported in the Pavlodar region (Table 1), and yet routine serological testing conducted by RVL detected 10,176 seropositive head of cattle (Table 4) and 295 seropositive head of small ruminants (Table 7). The average incidence rate of brucellosis among humans during that period ranged from 2.0 to 5.0 per 100.000 population; there were 102 new cases of human brucellosis, which accounts for 76.7% of all cases (133) in the human population during the five-year surveillance period.

This suggests that sites where seropositive animals are detected are not always reported officially, so farms with infected animals are falsely considered safe. Confusion and inconsistency with the results of epizootic surveillance obscure the real situation in the region.

The analysis of data acquired through the epizootic surveillance of bovine and small ruminant brucellosis in rural areas suggests that the most significant factors contributing to the persistence of brucellosis are:

- incomplete screening coverage of livestock population;
- non-compliance with the guidelines on the isolation of seropositive animals: delayed separation from the herd and delayed transportation to a slaughter facility;
- promotion of interspecies contact through co-housing;
- poor control over animal movement and migration within farms and districts;
- restrictions are not always imposed on the affected farms in spite of the substantial number of seropositive animals;
- unwillingness to report abortions and stillbirths in the herd and contact veterinary laboratories for further diagnostics to determine the underlying cause;
- lack of administrative control of immunization programs and poor record keeping of vaccinations
- inadequate implementation of administrative, sanitary and veterinary containment measures at the sites of brucellosis outbreaks, etc.

These and other factors provide a conducive environment to brucellosis persistence on many livestock farms and obstruct the effective elimination of the disease.

Thus, considering the current situation with brucellosis in Kazakhstan, epizootic surveillance should be continued to estimate the spread of brucellosis and the intensity of the infectious process and assess the risks and factors promoting its spread. Future research should focus on the analysis of brucellosis control and prevention measures and their effectiveness.

Conclusion

Brucellosis is a zoonotic infection that frequently occurs across the Pavlodar region. In 2019–2023, 115 ES were reported there, including 48 sites (47%) of brucellosis, which suggests that brucellosis is a leading zoonotic infection in the region.

In 2019–2023, 13.039 infected head of cattle and 540 infected head of small ruminants were detected in the region. High cattle morbidity was observed in the Bayanaulsky, Akkulinsky, Pavlodarsky and Zhelezinsky districts, in the cities of Pavlodar and Ekibastuz.

The comparative analysis demonstrates that human brucellosis occurs in every district and big city of the region where bovine or small ruminant brucellosis is registered. This suggests the role of farm animals as a source of brucellosis infection in the human population.

The most significant factors contributing to the persistence of brucellosis among animals in the Pavlodar region are: inadequate implementation of administrative, sanitary and veterinary containment measures at the sites of brucellosis outbreaks; deliberate unreporting of abortions and stillbirths in the herd that, therefore, cannot be further investigated by veterinary laboratories to determine their underlying cause; restrictions are not always imposed on the affected farms in spite of the substantial number of seropositive animals; non-compliance with the guidelines on the isolation of seropositive animals, delayed separation of sick animals from the herd and delayed transportation to a slaughter facility, etc. These and other factors provide a conducive environment to brucellosis persistence on many livestock farms and obstruct the effective elimination of the disease.

The epizootic surveillance carried out in the past 5 years allowed us to identify epizootically safe zones in the Pavlodar region, as well as areas with high, moderate and low brucellosis incidence where appropriate anti-epizootic measures will be implemented in the future.

The study shows that timely epizootic surveillance of animal brucellosis and the analysis of the acquired data, including the results of diagnostic tests and the spread of the disease, facilitate effective control of the infection in areas with different epizootic status and can be used to elaborate a methodologically sound strategy for implementing adequate interventions.

Authors' Contributions

AA, GB and AB: Conceptualized and designed the study, conducted a comprehensive literature search, analyzed the gathered data and drafted the manuscript. YSh, AA, GK and BO: Conducted the final revision and proofreading of the manuscript. All authors have read, reviewed, and approved the final manuscript".

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