

ANNOTATION
of the dissertation by Anar Magzhanovna Kabzhanova
on the topic: “The influence of climatic and socio-economic factors on the
epizootic process of rabies”,
submitted for the degree of Doctor of Philosophy (PhD) in the specialty
6D120200 – Veterinary Sanitation

Relevance. Rabies is among the most dangerous infectious diseases of animals, characterized by a natural focal pattern of pathogen circulation, absolute lethality, and a pronounced interspecies transmission potential. A wide range of reservoir hosts, including both domestic and wild mammals, determines the stability of the epizootic process and the formation of long-functioning nosoareas. The zoonotic nature of the infection adds further social significance, as even isolated epizootic events may transform into epidemiological risks for the population. In this regard, rabies occupies a special place in the system of biological safety and requires continuous scientific support from veterinary epizootology and related disciplines.

The relevance of the study is обусловлена the persistent threat of rabies to humans and animals in Kazakhstan, the need to identify species-specific foci and clusters, and the implementation of modern spatial analysis methods and GIS technologies to optimize preventive measures and targeted vaccination under conditions of climate change affecting habitat ranges, migration of wild animals, and the seasonal dynamics of the epizootic process.

Aim and objectives of the study. The aim is to identify patterns of the epizootic process of rabies in animals under the influence of natural-climatic and socio-economic factors using information and communication technologies (ICT).

Research objectives:

1. To develop a structured database on animal rabies, including epizootological, territorial, and species-specific characteristics (localization of foci, coordinates, species composition, and number of animals).
2. To conduct spatial and spatio-temporal analysis of the rabies epizootic process using modern GIS technologies.
3. To assess the influence of natural-climatic, socio-economic, and abiotic factors on the dynamics and features of rabies spread in animals.
4. To perform zoning of the territory of the Republic of Kazakhstan according to the level of epizootic risk of rabies and to carry out spatial forecasting of its spread.
5. To analyze the effectiveness of veterinary measures against rabies in animals and to develop practical recommendations for their improvement, taking into account the identified spatial patterns.

Materials and methods. The study was based on official reporting data on cases of animal rabies in the Republic of Kazakhstan for the period 2013–2024 obtained from departmental veterinary reporting. For each focus, spatial (administrative affiliation, coordinates), temporal (year, season), and species-specific characteristics of animals were recorded.

Additional data included natural-climatic and geographical characteristics of the territory, such as air temperature indicators, climatic anomalies, terrain (altitude above sea level, slope), land cover and vegetation types, as well as socio-economic and demographic parameters (population density and density of agricultural animals).

Spatial and spatio-temporal analysis of rabies distribution patterns was performed in a geoinformation environment using ArcGIS Pro software and Geoprocessing tools.

To identify and assess spatial clusters of morbidity considering population density, the specialized software SaTScan based on Poisson cluster analysis methods was used.

The influence of natural-climatic factors on the development of the rabies epizootic process was assessed using correlation and regression analysis methods, taking into account time lags corresponding to the minimum (seasonal) and maximum (annual) duration of the incubation period.

Zoning of territories according to rabies spread risk was carried out using the mathematical-geographical method of Ecological Niche Modeling (ENM) optimized by the Maximum Entropy principle (MaxEnt).

The effectiveness of veterinary preventive measures was analyzed by comparing the spatial distribution of rabies outbreaks with the volumes of preventive measures implemented using ArcGIS Pro tools, on the basis of which scientifically grounded practical recommendations were developed.

Main provisions submitted for defense.

1. A detailed geospatial database on animal rabies in the Republic of Kazakhstan for 2013–2024 has been developed, including epizootological characteristics of infection foci, species structure and number of affected animals, outbreak coordinates, as well as accompanying natural-climatic and socio-economic indicators, providing an information basis for a comprehensive analysis of the epizootic process.

2. Based on modern GIS technologies (ArcGIS Pro, SaTScan), spatial and spatio-temporal analysis of the rabies epizootic process was carried out, which made it possible to identify stable territorial and species-specific clusters, assess the dynamics of spatial density of foci, and determine features of the spread of epizootic waves.

3. Epizootological patterns of the formation and development of rabies in animals under the influence of natural-climatic and socio-economic factors were established; stochastic zones of localization of natural foci were identified, and comprehensive zoning of the territory of the Republic of Kazakhstan according to the level of epizootic risk was performed.

4. Scientifically substantiated recommendations were developed to improve veterinary preventive measures against rabies in animals, based on spatial analysis results and предусматривающие a differentiated approach to vaccination considering spatio-temporal patterns, species specificity, and environmental factors,

which enhances the effectiveness and targeting of prevention in epizootically unfavorable regions.

Description of the main research results.

1. A database on animal rabies in Kazakhstan for 2013–2024 was developed and verified, including 998 foci with 1,299 infected animals. The database contains territorial data (region, district, settlement), coordinates of foci, species affiliation (more than 10 species, from rodents to deer), registration dates, epizootological status, and information on veterinary measures. The most unfavorable administrative units identified were: rural settlement – Kokzhyra village (Abai region); urban – Semey city (35 foci); district – Urzhar district (East Kazakhstan region); region – East Kazakhstan region (181 foci).

2. Spatial analysis using ArcGIS Pro and geostatistical methods (Anselin Local Moran's I, Kernel Density, Space-Time Cube, Hot Spot Analysis) identified three main cluster types:

Eastern Kazakhstan – a cluster among agricultural animals (141 foci (263 animals) out of 181);

Southern Kazakhstan – a cluster among domestic animals (186 of 297 foci), mainly near densely populated cities (Shymkent, Taraz);

Western Kazakhstan – a mixed cluster involving wild and agricultural animals.

High-Low outliers were also identified in Mangystau, Atyrau, and West Kazakhstan regions, indicating possible sporadic introductions of infection by wild animals.

3. Comprehensive analysis showed that rabies epizootic activity is closely associated with positive air temperature anomalies (increased incidence in warm winters of 2013, 2015, and 2020), population density (up to 64 persons/km² in southern clusters with 186 foci among domestic animals), natural conditions (mountains and rivers acting as limiting factors, while border areas with the Russian Federation promote biodiversity and interspecies contact), and anomalously cold weather (outbreaks among wild animals in 2014 and 2018 with temperature decreases of –1 and –0.5°C in western regions). The cluster identified in Western Kazakhstan by multinomial scanning is characterized by a stable concentration of rabies foci among both wild and agricultural animals and is the only cluster where the observed-to-expected (O/E) ratio exceeds 1 for both categories, indicating a high level of epizootic activity.

4. Zoning and forecasting showed that eastern and southern regions of Kazakhstan are the most susceptible to animal rabies. In most districts, no more than one case is expected. Livestock and domestic animal populations demonstrate a decreasing trend since 2013, while rabies among wild animals remains relatively stable. Expected cases by category: agricultural animals – 21 (14–29), domestic animals – 5 (2–9), wild animals – 4 (1–6).

5. Analysis of veterinary plans showed that vaccination distribution corresponds to species-specific patterns of rabies: in southern Kazakhstan, rabies predominates among domestic (companion) animals; in western and northeastern regions – among agricultural animals; however, despite high incidence among wild

animals in western regions, oral vaccination is absent. Scientifically substantiated methodological recommendations for improving preventive measures against rabies in animals have been developed.

Scientific novelty and significance of the results.

The scientific novelty lies in the integrated combination of spatial, seasonal, temperature, and species-specific analysis of rabies foci in Kazakhstan for 2013–2023 using modern GIS technologies (ArcGIS Pro, SaTScan, Kernel Density, Moran's I, Getis-Ord Gi*), which for the first time made it possible to identify stable geoepidemiological clusters considering climatic anomalies, seasonality, and population density, and to propose a scientifically grounded prevention strategy accounting for territorial specificity and interspecies transmission cycles.

The practical significance is determined by the development and implementation of methodological recommendations aimed at improving the effectiveness of preventive measures and targeted vaccination considering spatial and species-specific clusters.

The results are of applied importance and can be used to improve the system of rabies prevention and control in the Republic of Kazakhstan. The use of geoinformation technologies and spatio-temporal analysis provides an objective assessment of epizootic risk, allows optimization of veterinary planning, and increases the effectiveness of preventive vaccination considering territorial, species-specific, and natural-climatic features of the epizootic process.

Modern spatial analysis methods and the developed methodological recommendations have been implemented in the educational process and in the practical activities of veterinary services (National Reference Center for Veterinary Medicine, Ministry of Agriculture of the Republic of Kazakhstan).

Compliance with state programs.

The research was carried out within the framework of the following projects:

- BR06249242 “Scientific support of veterinary welfare and food safety” (2018–2020), Kazakh Scientific Research Veterinary Institute LLP;
- BR10765016 “Study of the epizootological characteristics of the country's territory for especially dangerous diseases and development of veterinary-sanitary measures to improve their effectiveness” (2021–2023);
- AP19679670 “Improvement of preventive measures against infectious animal diseases (on the example of rabies) based on the use of information and communication technologies” (2023–2025).

Author's contribution.

Literature review, experimental studies, data analysis, preparation of scientific publications, and writing of the dissertation manuscript were carried out with the direct participation of the author.

A total of 14 scientific works have been published, including:

3 articles in journals indexed in Scopus (percentiles 57, 59, 92) and presented in Web of Science;

7 articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education;

4 articles in proceedings of international scientific conferences;
1 scientific-methodological publication (guidelines).

The results were presented at international scientific conferences, including:

1. International Scientific and Practical Conference “*120 Years of Kazakh Veterinary Science: Achievements and New Challenges in Ensuring Biological Safety*” – Almaty: KazNIVI LLP, 2025. – pp. 279–284.

2. International Scientific and Practical Conference “*Seifullin Readings – 18(2): Science of the 21st Century – Era of Transformation*” – 2022. – Vol. I, Part II. – pp. 284–286.

3. International Scientific and Practical Conference dedicated to the 130th Anniversary of S. Seifullin – 2024. – Part I. – pp. 57–60.

4. Jubilee International Scientific and Practical Conference “*Scientific Foundations for Improving Productivity and Health of Farm Animals*” – FGBNU KNCZV, Krasnodar, 2019. – Vol. 8, No. 2–2016, No. 10. – pp. 3–7.5.

5. 16th International Symposium On Geospatial Health University Of Twente, The Netherlands 13 - 16 November 2023

5. 17th International Symposium on Veterinary Epidemiology and Economics, 2024 | ICC Sydney, Australia

6. First Kazakhstan-China Academic Forum on Veterinary Science, 2022, NAO “S. Seifullin Kazakh Agrotechnical Research University”.

Structure and scope of the dissertation.

The dissertation comprises 125 pages of text and includes an introduction, literature review, materials and methods, results, discussion, and conclusions. It contains 114 references, 15 tables, and 48 figures.