Name of the project: «Improvement preventive measures against infectious diseases of animals (on the rabies example), based on using of information and communication technologies».

Aim of project. Improving ongoing preventive anti-epizootic measures against rabies in RK using methods of quantitative epidemiology, geospatial analysis and computer programs.

Relevance. The basis for the research is the complex epizootic situation of rabies in the Republic, the need to switch to modern methods of planning and organizing effective preventive, antiepizootic and veterinary-sanitary measures, using information and communication technologies in accordance with the recommendations of international veterinary organizations (OIE, FAO, WHO). The use of information and communication technology implies working with a certain set of variables and geographical space, as well as time indicators that need to be studied, analyzed and visualized in relation to the studied territory. Therefore, the development of ICT technology in the field of veterinary medicine for Kazakhstan should be a priority, and first of all – in terms of prevention and control of especially dangerous zoonoses registered on the territory of the Republic of Kazakhstan and posing a threat to public health.

Expected results. Within the framework of the project, will be published at least 2 (two) articles and (or) reviews indexed in the Science Citation Index Expanded of the Web of Science database, and (or) in peer-reviewed scientific publications with a CiteScore percentile in the Scopus database of at least 35 (thirty-five). At least 2 articles will be published in a peer-reviewed foreign and (or) domestic publication with a non-zero impact factor (recommended by the Committee for Control in the Field of Education and Science).

An act of implementation of the developed interactive maps will be received as a tool for veterinary specialists, while improving and carrying out measures for veterinary supervision, monitoring, control, monitoring of the epizootic state of animal rabies.

Interim and final results of scientific research will be reported at national and international conferences, including in foreign countries.

As a result of the research, will be prepared and published a monograph «Information and communication technologies in veterinary medicine».

As a result of scientific research, a methodology for mathematical modeling of the risk of occurrence and/or introduction of socially significant zoonotic diseases will be developed. Interactive online maps will be created showing the status of districts regarding the safety of export/import of livestock products;

Table 1 - Members of the research group

№	Surname, first name, education, degree, academic title	Main place of work, position	Position in the project	Hirsch Index, Researcher ID, ORCID, Scopus Author ID
1	Abdrakhmanov Sarsenbay Kadyrovich, Doctor of Veterinary Sciences, Professor	NCJSC «S.Seifullin KATRU»	Scientific supervisor	Hirsch Index 6 http://orcid.org/0000-0003-3707-3767, https://www.scopus.com/authid/detail.uri?authorId=57189578133, ResearcherID: O-5800-2017, Author ID57189578133
2	Andres Perez PhD	Professor of the Department of Veterinary Population	Chief Scientific Officer	Hirsch Index 36 https://www.scopus.com/authid/detail.uri?authorId=7402509981

		Medicine at the University of Minnesota (USA)		
3	Mykhanbetkaliyev Yersyn Yergazyievich Candidate of Veterinary Sciences, Associate Professor	NCJSC «S.Seifullin KATRU», Head of the Department of Veterinary Medicine	Leading Researcher	Hirsch Index 4 https://orcid.org/0000-0003-3320-7182, https://www.scopus.com/authid/detail.uri?authorId=57194544992, ResearcherID: S-8811-2016, https://publons.com/researcher/S-8811-2016
4	Korennoy Fedor I., Candidate of Geographical Sciences	FGBI «Federal Centre for Animal Health», Senior Researcher	Senior Researcher	Hirsch Index 11 http://orcid.org/0000-0002-7378-3531, ResearcherID: I-9428-2016, Scopus Author ID: 46461328200
5	Mykhanbetkaliyeva Aizada A., Candidate of Veterinary Sciences, Associate Professor	NCJSC «S.Seifullin KATRU», Associate Professor of the Department of Veterinary Medicine	Senior Researcher	Hirsch Index 1 https://orcid.org/0000-0003-3232-9831, Researcher ID: O-8690-2017
6	Bakishev Temirlan Gomarovich, Doctor of PhD	NCJSC «S.Seifullin KATRU», Senior lecturer of the Department of Veterinary Sanitation	research associate	Hirsch Index 2 https://orcid.org/0000-0001-7845-975X, Scopus Author ID: 56007665400
7	Yessembekova Gulzhan Nyrlybekovna, PhD	NCJSC «S.Seifullin KATRU», senior lecturer of the Department of Veterinary Sanitation	research associate	Hirsch Index 3 https://orcid.org/0000-0002-6358-0511
8	Kadyrov Ablaikhan S.		research associate	Hirsch Index 5 https://orcid.org/0689-0986
9	Kabzhanova Anar M.	NCJSC «S.Seifullin KATRU», Assistant of the Department of Veterinary Sanitation	Junior scientist	Hirsch Index 1 https://orcid.org/0000-0002-3469-0375

Results. The collection of epizootological data on the spread of rabies in the territory of the Republic of Kazakhstan in the context of administrative regions has begun, with the determination of the exact geographical coordinates and type of sick animals. The total number of cases of rabies registration during the analyzed period (10 years) was 1016, in which 1334

animals became ill. Moreover, the largest number of outbreaks was in 2013 (n-140), 2015 (n-140) and 2020 (n-124). The majority of outbreaks (n-889, 66.6%) were among farm animals, in 395 (29.6%) cases animal companions (dogs, cats) were involved in the infectious process and in the remaining 50 (3.7%) cases, were associated with wild animals. The obtained data is generated in Excel format, indicating epidemiological data, for further work on the use of various modeling and forecasting methods. The socio-economic, geographical and climatic factors influencing the spread of rabies in the administrative regions of the Republic of Kazakhstan were studied. Some features of the course of the epizootic process in various regions of the republic have been established, depending on population density and the number of different animal species (agricultural, domestic, wild), as well as natural and climatic factors from 2013-2022. Using the polynomial scan model resulted in the identification of 5 spatial clusters. In four of the five clusters, O/E values >1 were estimated for one species group (two for domestic animals, two for livestock), while O/E values >1 for two species groups (livestock and wildlife) were estimated at the remaining cluster. The highest population density was noted in clusters No. 1 and No. 2 (35.6 and 64.0 people/km 2, respectively), while it was significantly lower in clusters No. 3, No. 4 and No. 5 (3.1, 4.0 and 3.6 people/km2, respectively). The proportion of cumulative cases in each cluster was highest in the spring and summer months. Moreover, the greatest seasonal difference was observed in clusters in which O/E values > 1 were found for farm animals (clusters No. 3, No. 4 and No. 5), while the difference was not so pronounced for clusters in which O/E values was highest for companion animals (clusters #1 and #2). An analysis of the effectiveness of ongoing diagnostic, preventive and anti-epizootic measures against rabies at the level of administrative regions of the republic was carried out. A mutual autocorrelation (ACF) has been established between the number of rabies cases registered among livestock and wild animals and the epidemiological dynamics of rabies in Kazakhstan. Quantitative data have been identified to support alternative cycles of disease transmission (urban in the south, rural in the east and west) in the country. Clusters in the southern part of the country were associated with companion animals, clusters in Eastern Kazakhstan (No. 3, No. 4), in turn, were predominantly associated with livestock farming, and specifically with cattle (86 and 88% of observed cases for each cluster respectively). Finally, cluster No. 5 in Western Kazakhstan was the only one in which O/E values > 1 were assessed in more than one group of animal species, namely livestock and wild animals. Cases in wildlife were found to typically occur at the same time or 1 month earlier than cases in livestock, suggesting a link in disease transmission between groups of species, consistent with the definition of a sylvatic cycle. In the same cluster, the largest number of cases in wild animals was noted (n = 9), including 7 foxes and 2 wolves. The results support the implementation of graded control and surveillance strategies for rabies in Kazakhstan and provide baseline information that will be useful for assessing the success of prevention programs.

Significant publications of the project manager and members of the research group:

1. Sultanov A.A., Abdrakhmanov S.K., Paul Torgerson et.al. Rabies in Kazakhstan PLOS Neglected tropical diseases Published: August 3, 2016. PLoSNeglTrop Dis 10(8). DOI: 10.1371/journal.pntd.0004889. (Web of science 4,487, Q1, Cite Score 95).

2. Abdrakhmanov S.K., Beisembayev K.K., Korennoy, F.I., Kushubaev D.B., Yessembekova G.N. Revealing spatio-temporal patterns of rabies spread among various categories of animals in the Republic of Kazakhstan, 2010-2013 // Geospatial Health 2016, volume 11:455, 199-205 pp. doi:10.4081/gh.2016.455

3. Abdrakhmanov S.K., Mykhanbetkaliyev Y.Y., Korennoy F.I., Sultanov A.A., Kushubaev D.B., Bakishev T.G. Maximum entropy modeling risk of anthrax in the Republic of Kazakhstan Preventive Veterinary Medicine. //Volume 144, 2017, P. 149-157, DOI: 10.1016/j.prevetmed.2017.06. 003.. (Web of science 2,302, Q1, Cite Score 98).

4. Abdrakhmanov S.K., Beisembayev K.K., Korennoy F.I., Spatiotemporal analysis of foot-and-mouth disease outbreaks in the Republic of Kazakhstan, 1955 – 2013. Transboundary and Emerging Diseases, 2018. DOI: 10.1111/tbed.12864, (Web of science 3,554, Q1, Cite Score 99).

5. Kanankege K., Abdrakhmanov S.K., Korennoy F.I., Comparison of spatiotemporal patterns of historic natural Anthrax outbreaks in Minnesota and Kazakhstan, PlosONE, 2019. DOI: 10.1371/journal.pone.0217144. (Web of Sience 2,776, Q1, Cite Score 89).

6. Abdrakhmanov S.K., Mykhanbetkaliyev Y.Y. Modeling the Epidemiological Processes of Economically Significant Infections of Animals. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2019. DOI: 10.1007/978-3-030-24302-9_39, (Cite Score 51).

7. Abdrakhmanov S.K., Mukhanbetkaliyev Y.Y., Korennoy F.I., Beisembayev K.K., Kadyrov A.S., Kabzhanova A.M., Adamchick J., Yessembekova G.N. Zoning of the republic of Kazakhstan as to the risk of natural focal diseases in animals: the case of rabies and anthrax. Geography, Environment, Sustainability. 2020;13(1):134-144. https://doi.org/10.24057/2071-9388-2020-10

8. Schettino, D.N., Abdrakhmanov, S.K., Beisembayev, K.K., ...Kadyrov, A.S., Perez, A.M. Risk for African Swine Fever Introduction into Kazakhstan. Frontiers in Veterinary Science, 2021, 8, 605910. (Web of Sience Q1, Cite Score 82).

9. Abdrakhmanov, S.K., Beisembayev, K.K., Sultanov, A.A., ...Zhakenova, A.Y., Torgerson, P.R. Modelling bluetongue risk in Kazakhstan. Parasites and Vectors, 2021, 14(1), 49. (Web of Sience Q1, Cite Score 78).

10. Abdrakhmanov, S.K., Mukhanbetkaliyev, Y.Y., Sultanov, A.A., Yessembekova G.N., Perez, A.M., Korennoy, F.I. Mapping the risks of the spread of peste des petits ruminants in the Republic of Kazakhstan, Transboundary and Emerging Diseases, 2022, 69(4), pp. 2296–2305. (Web of Sience Q1, Cite Score 98).

11. Uakhit, R., Smagulova, A., Syzdykova, A., Abdrakhmanov, S., Kiyan, V. Genetic diversity of Echinococcus spp. in wild carnivorous animals in Kazakhstan. Veterinary World, 2022, 15(6), pp. 1489–1496. (Web of Sience Q2, Cite Score 79).

12. Tyulegenov, S.B., Zhakupbayev, A., Berdikulov, M., Perez, A.M., Abdrakhmanov, S.K. Foot-and-mouth disease in Kazakhstan. Transboundary and Emerging Diseases, 2022, 69(4), pp. 1712–1714. (Web of Sience Q1, Cite Score 98).

13. Nkamwesiga, J., Korennoy, F., Lumu, P., ...Kiara, H., Muhanguzi, D. Spatio-temporal cluster analysis and transmission drivers for Peste des Petits Ruminants in Uganda. Transboundary and Emerging Diseases, 2022

14. Kanankege, K.S.T., Errecaborde, K.M., Wiratsudakul, A., ...Alvarez, J., Perez, A. Identifying high-risk areas for dog-mediated rabies using Bayesian spatial regression. One Health, 2022, 15, 100411.

Information about existing patents and other security documents.

1. Abdrakhmanov S K., Mykhanbetkaliyev Y.Y., Kushubaev D.B., Kadyrov, A.S., Balji Y.A. A method for visualizing an epizootic focus, using GIS technology. Innovative patent №03090, from 16.01.2016

2. 0KZ18781-A Cultivating classical swine fever virus strain Pestis suum KT, used to make vaccine involves infecting rabbits with the virus strain, and collecting virus-containing material after infection of the rabbits. Patent holder: UNIV Kaza state Agrotechnical. Inventors: Abdrakhmanov S K; Mamadaliev S M; Ufimtsev K P. Derwent Primary Identification Number: 2019-51249H;

3. 0KZ22918-A4 New strain of hybrid cultured animal cells Mus musculus, used to e.g. produce monoclonal antibodies to classical swine fever (CSF) virus, in development of diagnostic tests to differentiate CSF virus from other types of animal viruses. Patent holder:

UNIV KAZA Agrotech. Inventors: Eseneeva S S; Kuybagarov M A; Abdrakhmanov S K; with co-authors. Derwent Primary Identification Number: 2019-36789W;

4. 0KZ23497-A4 New strain of hybrid cultured cells obtained by fusion of immune lymphocytes of BALB mouse/with cells of myelogenic line, useful for producing monoclonal antibodies to Alzheimer's disease. Patent holder: Univ Kaza agrotechnical. Inventors: Assauova Z S; Kuibagarov M A; Abdrakhmanov S K; with co-authors. Derwent Primary Identification Number: 2019-361089;

5. KZ16261-B Preparing vaccine useful for prophylactic immunization against Aujeszky's disease, culturing virus in primary trypsin broth of avian embryo fibroblasts, combining with solution of bicomponent protective medium and freeze-drying mixture. Patent holder: KAZA NAT CENT Biotechnologies ISSUES BIO. Inventors: Mamadaliyev S M; Mambetaliyev M; Abdrakhmanov S K; Abduraimov Y O; with co-authors. Derwent Primary Identification Number: 2019-36710D;

6. KZ10332-B New strain of virus of classical hog cholera Pestis suum KT, useful as vaccine strain against classical hog cholera Pestis suum. Inventors: Ufimtsev K P, Mamadaliev S M, Mambetaliev M, Abdrahmanov S.K. Names and codes of patent holders: UNIV Kazakh nat Al-farabi physical & CHE(UYKA-C). Derwent Primary Identification Number: 2019-51054C.

Information for potential users. The scientific results obtained will serve as the basis for the veterinary service of the republic, in the improvement of veterinary measures to control the epizootic situation. The results obtained will provide new knowledge about the epizootology of rabies and will have a positive impact on improving the epidemiological situation of rabies among humans and animals. The application and implementation in veterinary practice of modern methods of quantitative epidemiology, geospatial analysis and computer programs, as well as the training of scientific personnel in the process of project implementation, will have a positive effect on the scientific and technical development of the Republic of Kazakhstan in the field of epidemiology.

The target consumers of the results obtained will be the state veterinary service and economic entities involved in animal husbandry, as well as animal owners. The results of the work will be disseminated among the veterinary community by publishing research results, holding seminars (lectures) for practical veterinary workers and introduced into the educational process in the training of veterinary personnel.

Based on the research results, an article was published: Rabies in the Republic of Kazakhstan: spatial and temporal characteristics of disease spread over one decade (2013–2022), authors Kabzhanova, Anar M., Kadyrov, Ablaikhan S., Mukhanbetkaliyeva, Aizada A., Yessembekova, Gulzhan N., Mukhanbetkaliyev, Yersin Y., Korennoy, Fedor I., Perez, Andres M., Abdrakhmanov, Sarsenbay K. (DOI 10.3389/fvets.2023.1252265 Frontiers in Veterinary Science General Veterinary, percentile 84, Q1, Volume 10, 2023, article number 1252265

Participation in the international conference in the 16th International symposium on Geospatial Health, University of Twente, the Netherlands 13-16 November 2023. Topic of the report: «Rabies in the Republic of Kazakhstan: spatial and temporal characteristics of disease spread over one decade (2013–2022)». Following the results of the conference, the speaker was awarded the 2nd place and a free publication in the journal Geospatial Health https://cloud.mail.ru/attaches/17004963731734774324%3B0%3B1 ?folder-id=0&x-email=s_abdrakhmanov%40mail.ru&cvg=f. The impact factor of the journal is 1.7, Q2, percentile 61.

This is also translated and inserted at the end: Participation in the international conference «FOOD QUALITY FOOD SAFETY 2023» (Quality and Safety of Food), Astana, September 20-22, 2023. The topic of the report: «Primeneniye informatsionno-kommunikatsionnykh tekhnologii v otsenke riska rasprostraneniya infektsionnykh bolezney zhivotnykh» ("Application of information and communication technologies in assessing the risk of the spread of infectious animal diseases").