**Annotated Bibliography on the Transmission and Management of Rabies Outbreaks in Kazakhstan**

**References**

**Mukhanbetkalyev et al.: Modeling the Epidemiological Processes of Economically Significant Infections of Animals Mukhanbetkalyev:2019aa**

Ersyn Mukhanbetkalyev, Sarsenbay Abdrakhmanov, Altay Ussenbayev, Dina Satybaldina, Ablaikhan Kadyrov, and Nurlan Tashatov. “Modeling the Epidemiological Processes of Economically Significant Infections of Animals”. In: *Computational Science and Its Applications (2019).*

Annotations: Mukhanbetkalyev et al. describe their cluster zone model of Kazakhstan that was created to predict the likelihood of rabies, anthrax, and foot and mouth disease. The three diseases explored in the article were identified as economically significant diseases by the World Organization for Animal Health. Kazakhstan had eradicated foot and mouth disease by 2013 through the strategy of partial vaccination. The government has tried to replicate the same vaccine approach for rabies; however, the method did not prove to be efficient. The authors believe that the only possible way to control zoonotic diseases is through the analysis of infectious agents throughout the country. Their study found that most rabies cases occurring amongst farm animals are cattle, amongst domestic animals are dogs, and amongst wild animals are foxes. The researchers identify rabies as an epidemic of secondary nature in domestic animals since it was found to mostly be transmitted through contact with wild animals. The World Health Association believes that rabies should be addressed through collaborative efforts of veterinary and medical specialists because of the concern for human health risks. The authors find no discrepancy between the suggested vaccination standards and the actual vaccination percentages amongst farm and wild animals. Therefore, the authors highlight the ineffectiveness of the current vaccination approach and inquire about the possibility of a cross-border transmission of rabies. Unlike rabies, anthrax outbreaks are researched through the lens of various biological factors. A strong dependence on environmental conditions is found for anthrax outbreaks, which gives the government and veterinary officials data needed to better manage outbreaks in various geographical territories in Kazakhstan. Western and Central Kazakhstan are identified to have the lowest risk of anthrax transmission compared to other parts of the country. The examination of foot and mouth disease leads to a discovery about the connection of seasons to outbreaks. The authors find that most disease peaks occur in spring and fall. One possible explanation, given in the article, is the transfer of livestock from winter barns to summer pastures.

The significant harm the article is seeking to address is the medical, veterinary, and economic damage caused by zoonotic diseases in Kazakhstan. The economic situation is not prosperous enough to be able to afford to test most of the proposed solutions because zoonotic diseases are relatively low-damage causing in the grand scheme of issues in Kazakhstan. The government is very poorly organized lacks cohesion amongst the different departments. This makes it difficult to efficiently address a problem: especially one that, as the authors of the article mentioned, requires combined efforts of various institutions. Zoonotic diseases carry a significant threat to both animals and humans, but the uncontrollable and difficult-to-trace transmission of such diseases takes a toll on Kazakhstan’s economy. The dimension of human development that is being addressed by the authors is the transmission rate of zoonotic diseases amongst animals and humans. The authors focus on the sustainable development goals of “Good Health and Well-being”. The human development process the authors are investigating is disease management and response. The scientific question the authors are seeking to answer is how the analysis of historical or current epidemiological behavior can be used to predict and prevent future outbreaks. The datasets used by the authors include epidemiologic information about each occurred outbreak of rabies and anthrax, provided by veterinary research institutions and laboratories. Mukhanbetkalyev et al. use the gathered data to model cluster zoning of outbreaks throughout the country. The authors use the concept of a basic reproductive ratio to simulate the possibility of new rabies outbreaks. The article relates to Amartya Sen’s definition of human development by virtue of expanding human freedoms by trying to eliminate zoonotic disease outbreaks. Foot and Mouth disease, for example, is a resolved problem, the absence of which allows people to live a more free and healthier lifestyle without the constant worry of disease transmission. Furthermore, the funds that were previously used to combat foot and mouth disease can now be used for a better cause, and potentially expand people’s economic freedoms.

**Abdrakhmanov et al.: Zoning the Territory of the Republic of Kazakhstan as to the Risk of Rabies among Various Categories of Animals Abdrakhmanov:2016aa**

Sarsenbay K. Abdrakhmanov, Akhmetzhan A. Sultanov, Kanatzhan K. Beisembayev, Fedor I. Korennoy, Dosym B. Kushubaev, Ablaikhan S. Kadyrov. “Zoning the Territory of the Republic of Kazakhstan as to the Risk of Rabies among Various Categories of Animals”. In: *Geospatial Health* 11.429 (2016).

Annotations: Abdrakhmanov et al. describe rabies as a disease that becomes a more prominent threat to animals and humans in Kazakhstan from year to year. The disease is fatal for all bearers who do not receive immediate treatment. The authors touch upon the significant effect of rabies on Kazakhstan's economy since livestock farming is one of its primary sectors. The current measures imposed by the Kazakhstani government against rabies are oral vaccinations of animals in areas with an active outbreak as well as adjacent territories, forced preventative vaccination of animal species prone to rabies, control of stray animals, and various awareness raising campaigns. The study identifies climatic factors such as land cover type, air temperature, precipitation, altitude, and green vegetation fraction to be correlated to the prevalence of rabies in various geographical regions. The conducted research identifies areas alongside the borders of Kazakhstan to be prone to more rabies outbreaks. The authors therefore identify disease importation as a potential cause of the epidemiological situation in Kazakhstan. However, the land alongside borders has a higher rate of inhabitation of both animal and human species, possibly explaining the increased transmission rate of rabies.

The article identifies rabies as a significant development problem in the Kazakhstan region. The disease is identified as infectious and highly dangerous to both animals and humans. Not only is the disease affecting the health of Kazakhstan’s inhabitants, considering the 100% mortality rate in the absence of immediate treatment; however, rabies also presents a serious threat to the economy, valued at 4 billion euros annually worldwide. The scientific question the authors are seeking to answer through their research was the identification of a geographical area’s susceptibility to rabies and the application of results to a better controlled system of rabies prevention and outbreak management. To conduct their research, the authors use 2003-2014 rabies outbreak data provided by the Kazakhstani veterinary services, which includes 762 cases of rabies outbreaks in domestic, wild, and farm livestock animals. The authors use temperature, precipitation and altitude datasets from WorldClim, as well as green vegetation fraction and land coverage data provided by the United States Geological Survey. The authors use a maximum entropy modelling method for the gathered data to develop a geospatial regression model between rabies outbreaks and a set of climactic, geographical, and ecological factors as explanatory variables to identify the risk of rabies outbreaks through Kazakhstan. The authors investigate the development process of precision epidemiology and disease transmission. The dimension of human development that is being addressed by the authors’ research is the transmission rate of rabies as well as the mortality index percentage. The two sustainable goals, identified by the United Nations, tangent to the article are “Good Health and Well-being” as well as “Life on Land”. The article connects to Amartya Sen’s definition of human development, which he defines as the process of expanding human freedom, by virtue of attempting to understand the patterns and causes of rabies outbreaks, which, like all other diseases, limit human freedoms. Economic, physical and time resources are required to address a rabies outbreak; therefore, in the absence of the disease, people could choose where to supply those resources.

**Grigoryan et al.: Global Financial Crisis as a Challenge for Prevention of Human Rabies in the Former Soviet Republics Grigoryan:2016aa**

Grigor V. Grigoryan and Artem Y. Metlin. “Global Financial Crisis as a Challenge for Prevention of Human Rabies in the Former Soviet Republics”. In: *Austin Virol and Retrovirology* 3.1 (2016).

Annotations: Grigoryan et al. identify poor economies as a primary factor behind rabies outbreaks in former Soviet Union countries. The authors explain that a shortage of funds leads to a lack of preventative measures, routine surveillance, early detection, and appropriate treatment for people. There is a plethora of various diagnostic tests that have been designed to accurately detect the presence of rabies in a human body. Authors mention a new intra-vitam test that is able to be administered post-mortem. The use of necropsy is banned by some religions, making the new test a possible solution to detecting rabies in a deceased person. The tests allow for accurate detection and management of rabies but can also provide transparent data about the epidemiological situation Kazakhstan. However, the authors clarify that such reagents and kits are not readily available at medical centers throughout many rabies-affected countries due to the associated costs. A lot of former Soviet Union countries don’t have the means of producing treatment shots on their own and, therefore, must turn to importation of pharmaceuticals. All people who have been bitten by an animal are subject to post-exposure prophylaxis in the form of a series of treatment shots. This use of the treatment medication is highly wasteful as not all animal bites automatically equate to a transmission of rabies. Moreover, unnecessary administrations of the shots can lead to a shortage in a critical scenario. On the other hand, the authors explain that many people, typically those from poor villages who are naturally at high risk of rabies transmission, do not live in close proximity to medical centers, and therefore are unable to receive treatment. One proposed solution is providing the rabies shots free of charge to those who financially cannot afford it. Another presented solution is the development of preventative vaccines; however, the option is highly time and labor consuming. The authors also introduce the idea of oral vaccinations through a process similar to “catch-sterilization-release”, yet they recognize the difficulty of allocating the proper resources for the method. Another introduced solution is the government’s ability to prohibit people from feeding stray dogs in attempts to decrease reproduction. However, such practice may be viewed as too radical in the public view and may require prior awareness campaigns. The authors conclude their argument by stating that the current approach is inadequately allocating the country’s funds and is preventing further research from being conducted because of the lack of data available on rabies.

The development problem the article is seeking to address is human health and transmission of rabies. Limiting the spread of rabies and providing proper treatment is directly linked to the economy. Funds for such causes are very scarce since rabies is not deemed as the most important threat to humanity. While that is true, the disease has a 100% mortality rate amongst humans, if left untreated, and therefore deserves attention and funding too. The lower-cost solutions are not easily implemented because of their potential to be viewed as controversial. The authors are seeking an answer to the question of an effective solution to human rabies prevention in the developing countries of Eurasia. The authors are investigating the process of animal-to-human disease prevention, transmission, and management with a focus on the “Good Health and Wellbeing” and “Decent Work and Economic Growth” sustainable development goals. The authors use data sets containing the number of animal bite instances, number of executed post-exposure prophylaxis treatments, and the mortality rate for various Former Soviet Union countries. The gathered data is to perform a descriptive epidemiological analysis based on the review of retrospective and operative information about the occurrence of human rabies in the Former Soviet Union republics. The article connects to Amartya Sen’s definition of human development, which he defines as the process of expanding human freedom by virtue of proposing solutions to the prevention of rabies outbreaks in order to limit human mortality, which is an immediate limitation on human freedom.

**Sultanov et al.: Rabies in Kazakhstan Sultanov:2016aa**

Akmetzhan A. Sultanov, Sarsenbay K. Abdrakhmanov, Aida M. Abdybekova, Bolat S. Karatayev, Paul R. Torgerson. “Rabies in Kazakhstan”. In: *PLOS Neglected Tropical Diseases* (2016).

Annotations: Sultanov et al. expand on the idea of the economic and health burden that rabies cause in Kazakhstan. The researchers conclude that the number of bite incidents has been rising over the years, alongside the increased administration of the post exposure prophylaxis treatment. Children between ages of 6-14 years old are identified as the age group that is most likely to get bitten by animals. The authors also conclude that bites in different parts of the body carry different probabilities of rabies transmission. Similarly, they are able to identify a pattern showing that lower extremities are the body part most susceptible to bites. In terms of rabies’ effect on the economy, Sultanov et al. evaluate the loss at $20.9 million annually. Categories that contribute to the annual total cost, from most to least financially impactful, are as follows: post exposure prophylaxis treatment, death and its associated costs, animal control, vaccination of domestic animals, vaccination of wild animals, and livestock loss. Though the post exposure prophylaxis is a major cost, it has proven to be one of the most effective tactics when combating rabies. The authors note an interesting pattern that the number of individuals who received rabies from a bite is lower than the number of reported rabies cases, indicating that rabid animals tend to bite multiple times. The study shows that almost all cases of human rabies were seen in individuals who did not receive the shot treatment. One solution the authors propose is a modification of the current vaccination program since they have not been able to prove its effectiveness. The current program imposes mandatory vaccination policies for all susceptible livestock in high risk areas and monitoring practices in all other areas. Though most vaccinations occur orally, some animals get vaccinated through consuming baits placed throughout the woods. The authors find that one of the two currently administered vaccines, the Indian Raksharab, is ineffective in antibody production against rabies. Sultanov et al. discuss the benefits of stopping livestock vaccination in order to use the funds for vaccinations of dogs and foxes. The researchers suggest that this would indirectly protect the livestock and create new funding can be used towards control of stray animals. Stray dogs happen to be a massive problem in Kazakhstan that pose a significant rabies risk because of their difficult-to-track nature.

The significant harm the article is seeking to address is the ineffective use of funds dedicated to vaccination against rabies. Combating rabies is a complex task, specifically in Kazakhstan, because of the large number of stray animals that are left unaccounted for in statistics. Animal disease control centers are not focused on catching and fostering the animals which causes more complications. First, the stray animals are able to go wherever they choose, which increases their points of interaction with other animals, which in turn translates into increased risks of rabies transmission. Secondly, most stray animals have no shelter or food, which can cause them to behave aggressively and bite people. Each bite can potentially transmit rabies, but it also depletes the economy of the post exposure prophylaxis resources, which are valued at $147 per treatment. The scientific question the authors are seeking to answer is how to prevent transmission of rabies and better allocate funds. The scientists use the public health and veterinary surveillance data from 2003 to 2015, diagnostic results provided by the regional branches of the Republican Veterinary Laboratory, as well as statistical data from the Ministry of Agriculture, Veterinary Control, and Monitoring Committee. For human rabies data, the number of individuals with animal bites and those who received the post exposure prophylaxis was provided by the Kazakhstani government’s monitoring committee. Sultanov et al. analyze the gathered data through GIS technology to illustrate the density estimation for animal rabies on the map of Kazakhstan, as well as the density estimation for outbreaks of rabies. The authors are investigating the transmission process of rabies and the associated impact on the economy through the lens of “Economic Growth” and “Good Health and Wellbeing” sustainable development goals. The dimension of human development that the authors are addressing in this paragraph is the mortality index in animal and human species caused by rabies. The article also explores the economic state of Kazakhstan and the significant costs associated with rabies. Eradication of rabies could increase people’s personal freedoms; which Amartya Sen identifies as the process of human development. Disease is a debilitating factor present in human lives, so elimination of rabies, in both animals and people, would create a better living space for humanity as a whole. Getting bitten by an animal and fearing the transmission of rabies is a palpable fear of Kazakhstani people because of the massive numbers of stray animals roaming the streets.