

Risk assessment the potential occurrence of anthrax outbreaks in the Republic of Tatarstan

Kh.N. Makaev¹, S.V. Ivanova¹, L.A. Melnikova¹,
G.Kh. Murtazina², A.R. Garaev³, A.P. Rodionov¹

¹Federal center for Toxicological, radiation
and biological safety, Kazan, Russia;

²Kazan State Medical University, Kazan, Russia;

³Republican veterinary laboratory, Kazan, Russia

Abstract

Aim. To assess the risks of potential anthrax outbreaks based on a retrospective analysis of the epizootic situation for this infection and inventory data on the number of stationary anthrax-unfavorable sites in the Russian Federation using the case of the Republic of Tatarstan.

Methods. A retrospective analysis of data on animals with anthrax in the Republic of Tatarstan and the inventory of permanently unfavorable sites for this infection in the Russian Federation was carried out by using veterinary reporting documents for the period between 1914 and 2018. The epizooticity index of anthrax-unfavorable sites was determined by the formula: $EI=(n \times t)/(N \times T)$, and the effectiveness of specific prevention of the infection was determined according to the guidelines. Analyzes were carried out using statistical methods.

Results. The analysis of the results of the conducted studies showed that between 1914 and 2018, 2037 group and single animals infected with anthrax on the territory of the Republic of Tatarstan, 1208 stationary unfavorable sites for this infection were registered. When assessing the risks of the potential occurrence of anthrax among animals of the Republic of Tatarstan, it was found that 69.8% of the territory of the republic (every third settlement) is permanently unfavorable for anthrax and has serious risks of a possible re-infection of animals with this infection, therefore all livestock of animals once a year vaccinated against anthrax. A study of more than 11,000 blood serum samples of animals vaccinated against anthrax according to this scheme revealed that the titer of anti-anthrax antibodies decreases 1:2 and 1:4 below the level that protecting the animal from infection with the causative agent of this infection in 20% of animals after 6 months, and in 60% after 12 months after vaccination. This creates high risks of anthrax in animals and people in disadvantaged areas since the anthrax pathogen is transmitted from an infected animal to a person by mistaken autopsy of dead animals or the processing of carcasses of animals, hidden carriers of the anthrax pathogen. With this in mind, in regions with high risks of anthrax, it was confirmed the need for introducing two vaccinations per year into the prevention scheme of this infection in animals and monitor the post-vaccination immunological status, which will allow them to maintain high immunity throughout the year and promptly eliminate the focus of infection.

Conclusion. It was found that 69.8% of the territory of the Republic of Tatarstan (every third settlement) is permanently unfavorable for anthrax and has high risks of anthrax outbreaks in animals; it was shown the need for complex anti-anthrax measures, including two-time vaccination of animals during the year, to reduce the risks of infection of animals and the population with the causative agent of this infection.

Keywords: anthrax, risk, permanently unfavorable site, Republic of Tatarstan, epizootic-epidemiological monitoring.

For citation: Makaev Kh.N., Ivanova S.V., Melnikova L.A. et al. Risk assessment the potential occurrence of anthrax outbreaks in the Republic of Tatarstan. *Kazan Medical Journal*. 2020; 101 (6): 883–889. DOI: 10.17816/KMJ2020-883.

Anthrax is a particularly dangerous zoonosis caused by the spore-forming microorganism *Bacillus anthracis*. The pathogen's spores can stay in the soil indefinitely and propagate them-

selves under favorable conditions; therefore, with the formation of persistent natural foci of anthrax, the soil represents a reservoir for infection. The pathogen poses a potential threat to agricultural

and wild animals by actively spreading in the abiotic environment; and it is also dangerous for people given that the causative agent of this infection is transmitted from animals to humans [1–5].

The disease continues to be registered in many countries and constituent entities of the Russian Federation despite a significant decrease in the incidence of anthrax disease in animals due to general preventive vaccination and veterinary and sanitary measures in disadvantaged sites. According to the literature, there are more than 35,630 permanently unfavorable site (PUS) for anthrax in the Russian Federation's territory, where more than 8000 anthrax animal burial sites have been registered, and 70,000 group and individual cases of animal disease with anthrax. Together with the uniqueness of the causative agents' ecology of this zoonosis, the above facts determine the danger of new outbreaks of the disease in the country [6–11].

This work aims to assess the risk of possible anthrax outbreaks based on a retrospective analysis of the epizootic situation for this infection and cadastral data on the number of PUS for anthrax in the Russian Federation using the example of the Republic of Tatarstan (RT).

Data of the Main Directorate of Veterinary Medicine of the Cabinet of Ministers of the Republic of Tatarstan was used to analyze the retrospective analysis of the epizootic situation in RT for the period 1914–2018.

Territories at risk of possible emergence of anthrax were determined by calculating the epizootic index (EI), which characterizes the intensity of the epizootic situation by taking into account the PUS's proportion and level of activity, according to the equation as follows,

$$EI = (n \times t) / (N \times T),$$

where n is PUS where anthrax infection cases of animals during the monitoring period were registered; t is the number of years during which the disease's cases were registered; N is the number of all settlements in the area under study; and T is the number of years of monitoring [8].

Anthrax's specific prophylaxis efficiency was evaluated by analyzing the immunological status of vaccinated animals using the determination kit of antibodies in the blood serum of animals vaccinated against anthrax by indirect hemagglutination test (IHGT) [12–14].

Analyses were performed using statistical methods.

Retrospective analysis of the epizootic situation and cases of animal infection from 1914 to 2018 showed that more than 2000 cases of animal infection with anthrax were registered in 1208 PUSs in

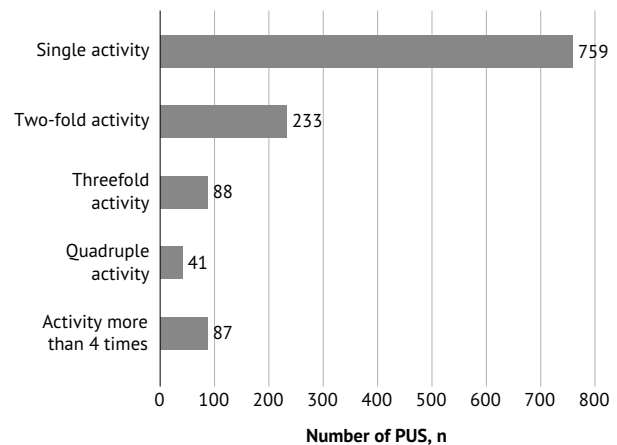


Figure 1. The manifestation frequency activity of permanently unfavorable sites (PUS) for anthrax in the Republic of Tatarstan

the municipal districts of RT. These data indicate that in the RT, every third settlement is unfavorable for this infection, and the presence of a large number of PUSs throughout the republic bear the risk of a possible recurrence. Thus, as illustrated in Figure 1, out of 1208 PUSs for anthrax in the republic, recorded in the cadastre, repeated cases of animal infection with anthrax in the amount of two or more times were recorded in 449 (37.2%) sites.

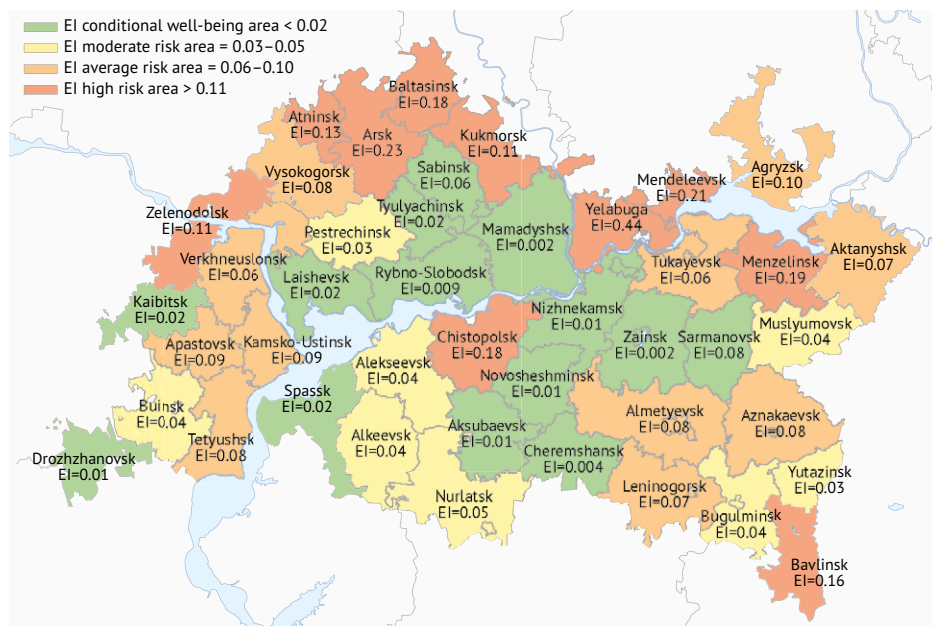
The EI indicator, which characterizes the epizootic situation intensity and takes into account the number of registered cases of animal infection in the PUS, was used to predict the development of the anthrax epizootic process and determine the risk areas in the RT. In this case, this indicator was calculated for a 104-year period (1914–2018) for each district.

Calculation results presented in Figure 2 shows that conditional group 1 include 10 (23.3%) districts of the RT, in which EI was higher than 0.11 and characterized them as zones of intense epizootic situation and a potentially high risk of possible repeated anthrax outbreaks. Group 2 include 12 (27.9%) districts with $EI = 0.06–0.10$, which is also characterized by a large number of PUSs with active dynamics of the occurrence of repeated cases of animal infection with anthrax. Group 3 with $EI = 0.03–0.05$ included eight (18.6%) regions with moderate risk, and Group 4 ($EI < 0.02$) included 13 (30.2%) conditionally safe regions with low risk of possible anthrax outbreaks.

From the calculations, 30 (69.8%) out of 43 districts of RT have a moderate to high risk of possible anthrax outbreak. Conditional well-being was noted in 13 (30.2%) districts, but they need to be given no less attention than high-risk districts. To confirm this thesis, it should be noted that since the end of the 20th century, outbreaks of anthrax

Table 1. The number of cases of anthrax disease in farm animals in the Republic of Tatarstan in 2000–2018

Animal species	2000	2001	2002	2003	2004–2007	2008	2009–2013	2014	2015–2018
Cattle	2	2	1	1	—	1	—	1	—
Small ruminants	—	—	—	—	—	—	—	—	—
Pigs	—	1	—	—	—	—	—	—	—
Total	2	3	1	2	—	1	—	1	—

**Figure 2.** Ranking of the Republic of Tatarstan districts according to the degree of risk of possible anthrax outbreaks

have occurred in 4 (30.8%) out of 13 conventionally well-being districts.

In addition, it should be taken into account that over the past 30 years in the RT, from 1990 to 2018 in particular, there has been an expansion tendency in the number of soil foci of infection; registered in the republic were 14 new PUSs, in which seven (50%) were in the territories characterized by conditional well-being. The presence of 1065 anthrax cattle burial grounds in the republic, 257 of which have unidentified burial coordinates, indicates that other soil foci of anthrax is possible, which can be located both in safe and unsuccessful territories for anthrax. Considering that the spore form of this pathogen remains viable in the soil for a long time and that it is able to propagate itself actively and can accumulate in the upper layers of the soil under favorable environmental conditions, this infection is the most dangerous zooanthroponosis recorded in the RT.

Summarized in Table 1 is the study's data of the episodic situation in the RT.

The last case of an anthrax outbreak in the RT was registered in 2014 when a resident of a rural area was infected with a skin form while cut-

ting the carcass of a cattle carrying the pathogenic pathogen of anthrax. Anthrax vaccinations are known only to prevent the infection of animals, but does not exclude the constant threat of the disease onset. Tolerance, missed vaccinations, violations of the rules for administering vaccines, and non-compliance with the conditions for their storage can be the possible causes of morbidity.

The possibility of the introduction of the pathogen from adjacent maximum and minimum risk territories and unaccounted burial places of animals that died from anthrax is also not excluded. The quintessential examples of underestimation in the anthrax situation are the latest cases of animal and human infection in Zelenodolsk (2003), Cheremshansk (2008), and Kukmorsk (2014) districts of the RT, as well as the largest infection outbreak in modern Russia in the Yamalo-Nenets autonomous district (2016), when vaccination on animals against this infection was stopped and the region was classified as safe because of the long absence of anthrax cases registered. As a result, more than 2.5 thousand animals died and several dozen people were infected, including with a lethal outcome [2].

Consequently, the current anthrax epizootic situation in the Russian Federation, including the RT, remains unstable. Considering that anthrax's causative agent, a particularly dangerous zoonosis, is transmitted from animals to humans by mistaken autopsy of dead animals with anthrax or the processing of animal carcasses that are latent carriers of the causative agent. Moreover, the study results necessitate the comprehensive preventive measures aimed at reducing the risk infection of animals and the population.

The incidence of anthrax in animals primarily depends on the effectiveness of anti-anthrax measures, in particular, animal vaccination. However, it is not always possible to achieve maximum proportion of immunized animals in both large livestock enterprises and private farmsteads. This may be because of the tolerance of the vaccinated animal's organism, an accidental omission during vaccination, or a decrease in the vaccine immunogenicity because of noncompliance with its storage condition or transportation.

Taking these facts into account, the Federal Center for Toxicological, Radiation, and Biological Safety developed a determination kit to determine the intensity of postvaccination immunity in animals by titer of antitoxic antibodies in the blood serum of animals vaccinated against anthrax by the IHGT and to assess anthrax's specific prophylaxis efficiency [12]. The study was performed from 2015 to 2018 on more than 11,000 blood serum samples of cattle in order to assess the postvaccination immune status in the RT. It was found that the titer of antitoxic antibodies in the blood serum in 20% of animals by the age of 6 mo and 60% by the age of 12 months decreased from 1:4 to 1:8 after vaccination, which is 3–4 times lower than the titer that protects the animal from infection with the anthrax pathogen [13].

Based on the results obtained during the assessment of the animal's postvaccination immune status, and taking into account the PUS of the RT with anthrax, studies were conducted to improve the vaccination of anthrax, aimed at analyzing the possibility of using two-time animal vaccination during a year. Experiment results on laboratory animals and cattle revealed that two-time cattle vaccination per year (in spring and autumn) allows maintaining high titers of anti-anthrax antibodies in the animal's blood serum throughout the year [13].

In this regard, the experience of improving the scheme of specific prevention for this infection in the USSR in the 1980s can be considered indicative, as that time, in the republics of the North Caucasus, due to the frequent registration of anthrax outbreaks, two-time vaccination of animals against anthrax during the year was introduced, which

resulted in a significant decrease in the number of cases of anthrax in animals and humans [8].

Therefore, the introduction of specific anti-anthrax prophylaxis of animals with two-time vaccination scheme, as well as the mandatory assessment of the effectiveness of vaccine prophylaxis and the identification of nonimmune animals, will reduce the incidence of anthrax in animals in the RT. Such prevention will lead to a decrease in the number of PUSs for this zoonosis, given that the disease's causative agent is transmitted from sick animals to humans.

CONCLUSIONS

1. It has been established that 69.8% of the RT territory is permanently unfavorable for anthrax and has a serious risk of possible repeated disease outbreaks in animals. This fact is associated with the presence of a large number of PUS (38.8%) with high frequency of case manifestations of animal infection (more than 3–4 times).

2. To prevent an increase in the number of anthrax cases in animals and the spread of the pathogen, a two-time prophylactic vaccination per year is recommended (in spring and autumn), as well as constant monitoring of the effectiveness of the animals' post-vaccination immune status. Given that people become infected with anthrax because of mistaken autopsy on dead animals or the processing of carcasses of hidden carriers of the disease's causative agent, these measures will help maintain intense immunity in animals. Moreover, taking timely anti-anthrax and anti-epidemic measures is necessary in order to prevent the animal and human infection with this disease.

Author contributions. Kh.N.M. was the work supervisor, and wrote the text; A.G.Kh. and A.R.G. collected and prepared archival data; S.V.I., L.A.M., G.Kh.M., and A.P.R. performed the research; Kh.N.M., A.G.Kh., S.V.I., and L.A.M. performed analysis of the results and prepared the manuscript.

Funding. The study had no external funding.

Conflict of interest. The authors declare no conflict of interest.

REFERENCES

1. Dugarzhapova Z.F., Chesnokova M.V., Kosilko S.A., Balakhanov S.V. *Tekushchaya situatsiya po sibirskoy yazve v nekotoryh sub"ektah Sibiri i Dal'nego Vostoka.* (The current situation with anthrax in some regions of Siberia and the Far East.) In: *Materialy XI s"ezda nauchno-prakticheskogo obshchestva epidemiologov, mikrobiologov i parazitologov.* (Materials of the XI Congress of the Scientific and Practical Society of Epidemiologists, Microbiologists and Parasitologists.) Moscow. 2017; 203. (In Russ.)

2. Dyagilev G.T., Chernyavsky V.F., Ignatyeva M.E. et al. Epizootic-epidemiological monitoring of anthrax in the central and southern zones of Yakutia. *Yakutskiy meditsinskiy zhurnal*. 2018; (2): 96–100. (In Russ.) DOI: 10.25789/YMJ.2018.62.29.
3. Galiullin A.K., Sadykov N.S., Gosmanov R.G. *Sibirskaya yazva sel'skokhozyaystvennykh zivotnykh*. (Anthrax of farm animals.) SPb.: Lan'. 2019; 224 p. (In Russ.)
4. Onishchenko G.G., Vasil'ev N.T., Litusov N.V. et al. *Sibirskaya yazva: aktual'nye aspekty mikrobiologii, epidemiologii, kliniki, diagnostiki, lecheniya i profilaktiki*. (Anthrax: current aspects of microbiology, epidemiology, clinical picture, diagnosis, treatment and prevention.) Moscow: VUN MC MZ RF. 1999; 448 p. (In Russ.)
5. Simonova E.G., Raichich S.R., Kartavaya S.A. et al. Manifestation of activity of potentially hazardous as regards anthrax areas across the Russian Federation under current conditions. *Problemy osobo opasnykh infektsiy*. 2018; (2): 90–94. (In Russ.) DOI: 10.21055/0370-1069-2018-2-90-94.
6. Eremenko E.I., Ryazanova A.G., Buravtseva N.P. The current situation on anthrax in Russia and in the world. main trends and features. *Problemy osobo opasnykh infektsiy*. 2017; (1): 65–71. (In Russ.) DOI: 10.21055/0370-1069-2017-1-65-71.
7. Makayev Kh.N., Ivanova S.V., Melnikova L.A., Chernov A.N. Epizootological analysis of anthrax situation in Republic of Tatarstan. *Trudy Federal'nogo tsentra okhrany zdorov'ya zivotnykh*. 2018; 16: 54–63. (In Russ.)
8. Kulichenko A.H., Buravtseva N.P., Ryazanova A.G., Eremenko E.I. *Sibirskaya yazva na Severnom Kavkaze*. (Anthrax in the North Caucasus.) Maykop: Kachestvo. 2016; 198 p. (In Russ.)
9. Cherkasskiy B.L. *Kadastr statsionarno neblagopoluchnykh po sibirskoy yazve punktov v Rossiyskoy Federatsii*. (Inventory of permanently unsatisfactory anthrax sites in the Russian Federation.) Moscow: InterSEN. 2005; 829 p. (In Russ.)
10. Ivanova S.V., Melnikova L.A., Rodionov A.P. et al. Analysis of the epizootic situation and improvement of the scheme for the specific prevention of anthrax. *Intern. J. Res. Pharmaceutical Sci.* 2020; 11 (1): 949–952.
11. Sean Shadomy, Ahmed El Idrissi, Eran Raizman et al. *Anthrax outbreaks: a warning for improved prevention, control and heightened awareness*. Food and agriculture organization of the United Nations. 2016. <http://www.fao.org/3/a-i6124e.pdf> (access date: 15.04.2020).
12. *Declaration of Conformity "Kit for the determination of antibodies in the blood serum of animals vaccinated against anthrax in the reaction of indirect hemagglutination"* No. ROSS RU.CC07.D00022, issued at 07.06.2017. (In Russ.)
13. Ivanova S.V., Khisamutdinov A.G., Makaev Kh.N. et al. *Metodicheskie rekomendatsii po otsenke effektivnosti immunoprofilaktiki sibirskoy yazvy u krupnogo rogatogo skota reaktsiy nepryamoy gemagglutinatsii*. (Methodical recommendations for evaluating the effectiveness of anthrax immunization in cattle by indirect hemagglutination reaction.) Kazan: Al'yans. 2019; 17 p. (In Russ.)
14. Ivanov A.V., Makaev Kh.N., Mel'nikova L.A. et al. *A method for obtaining erythrocyte anthrax antigen, a method for obtaining a control positive serum for a kit for the determination of antibodies in the blood serum of animals vaccinated against anthrax in the reaction of indirect hemagglutination and a kit for the determination of antibodies*. Patent for invention RU 2599035 C1, issued at 10.10.2016 (In Russ.)