



ORIGINAL STUDY ARTICLES

Original Study Article

<https://doi.org/10.36233/0372-9311-692>



Data update on anthrax stationary hazardous areas and soil foci as a basis for improving epizootological and epidemiological monitoring for anthrax in the Russian Federation

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Abstract

Introduction. Anthrax is registered annually in the Russian Federation. The constant risk of complication of the epizootological and epidemiological situation on anthrax is due to the widespread distribution of soil foci of infection (anthrax burials (AB), «pestilence fields») and associated stationary hazardous areas (SHA).

The aim is to update data on anthrax SHA and soil foci in order to improve epidemiological surveillance of anthrax in the Russian Federation.

Materials and methods. Archival and reference materials on anthrax SHA and soil foci, accounting and reporting data of territorial bodies of Rospotrebnadzor and veterinary service were used.

The selection of criteria for characterizing anthrax SHA, AB and «pestilence fields» was carried out, using which the structure of databases of anthrax SHA and soil foci was developed.

Results. For the first time, electronic databases of anthrax SHA and soil foci on the territory of Russia were developed, containing updated information of the characteristics of 32566 SHA and 3314 soil foci (3185 AB and 129 «pestilence fields»). Analysis of the data revealed a decrease in the number of SHA and AB in the country compared to the reference data, as well as a lack of correlation between the counted number of SHA and AB in most regions, indicating the presence of a large number of unreported AB and the persistence of potential risks of infection situation complications.

Conclusion. The introduction of up-to-date databases of anthrax SHA and soil foci into the practice of Rospotrebnadzor bodies and institutions and veterinary services will improve the level of information support and efficiency of epidemiological surveillance of anthrax in the Russian Federation.

Keywords: anthrax, stationary hazardous area, soil focus, anthrax burial, «pestilence field», epizootological and epidemiological monitoring.

Funding source. This study was not supported by any external sources of funding.

Conflict of interest. The authors declare no apparent or potential conflicts of interest related to the publication of this article.

For citation: Popova A.Yu., Kulichenko A.N., Akimkin V.G., Balakhonov S.V., Logvin F.V., Ryazanova A.G., Gerasimenko D.K., Loktionova M.N., Chekanova T.A., Dugarzhapova Z.F., Nikitina A.V., Oleynikova K.A., Pechkovskii G.A., Mezentshev V.M., Semenova O.V., Aksenova L.Yu., Eremenko E.I., Golovinskaya T.M., Ladnyi V.I., Petremgvdlishvili K., Kravets E.V., Vasiliev V.V., Ivacheva M.A. Data update on anthrax stationary hazardous areas and soil foci as a basis for improving epizootological and epidemiological monitoring for anthrax in the Russian Federation. *Journal of microbiology, epidemiology and immunobiology*. 2025;102(3):271–283.

DOI: <https://doi.org/10.36233/0372-9311-692>

EDN: <https://www.elibrary.ru/QWEPWI>

Оригинальное исследование
<https://doi.org/10.36233/0372-9311-692>

Актуализация данных о сибиреязвенных стационарно неблагополучных пунктах и почвенных очагах как основа совершенствования эпизоотолого-эпидемиологического мониторинга сибирской язвы в Российской Федерации

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Аннотация

Введение. Сибирская язва в Российской Федерации регистрируется ежегодно. Сохранение постоянного риска осложнения эпизоотолого-эпидемиологической ситуации по сибирской язве обусловлено повсеместным распространением почвенных очагов инфекции (сибиреязвенных захоронений (СЯЗ), «морových полей») и связанных с ними стационарно неблагополучных пунктов (СНП).

Цель работы — актуализация данных о сибиреязвенных СНП и почвенных очагах с целью совершенствования эпизоотолого-эпидемиологического надзора за сибирской язвой в России.

Материалы и методы. Использованы архивные, справочные материалы о сибиреязвенных СНП и почвенных очагах, учётные и отчётные данные территориальных органов Роспотребнадзора и ветеринарной службы. Осуществлён подбор критериев характеристики сибиреязвенных СНП, СЯЗ и «морových полей», с использованием которых разработана структура баз данных СНП и почвенных очагов сибирской язвы.

Результаты. Впервые разработаны электронные базы данных сибиреязвенных СНП и почвенных очагов на территории России, содержащие актуализированную информацию о характеристиках 32 566 СНП и 3314 почвенных очагов (3185 СЯЗ и 129 «морových полей»). Анализ данных выявил снижение числа СНП и СЯЗ на территории страны по сравнению со справочными сведениями, а также отсутствие корреляции между учётным количеством СНП и СЯЗ в большинстве регионов, что указывает на наличие большого числа неучтённых СЯЗ и сохранение потенциальных рисков осложнения ситуации по инфекции.

Заключение. Внедрение в практику органов и учреждений Роспотребнадзора, ветеринарной службы актуальных баз данных сибиреязвенных СНП и почвенных очагов позволит повысить уровень информационного обеспечения и эффективности эпизоотолого-эпидемиологического надзора за сибирской язвой в России.

Ключевые слова: сибирская язва, стационарно неблагополучный по сибирской язве пункт, почвенный очаг, сибиреязвенное захоронение, «моровое поле», эпизоотолого-эпидемиологический мониторинг

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Для цитирования: Попова А.Ю., Куличенко А.Н., Акимкин В.Г., Балахонов С.В., Логвин Ф.В., Рязанова А.Г., Герасименко Д.К., Локтионова М.Н., Чеканова Т.А., Дугаржапова З.Ф., Никитина А.В., Олейникова К.А., Печковский Г.А., Мезенцев В.М., Семенова О.В., Аксенова Л.Ю., Еременко Е.И., Головинская Т.М., Ладный В.И., Петремгвлишвили К., Кравец Е.В., Васильев В.В., Ивачева М.А. Актуализация данных о сибиреязвенных стационарно неблагополучных пунктах и почвенных очагах как основа совершенствования эпизоотолого-эпидемиологического мониторинга сибирской язвы в Российской Федерации. *Журнал микробиологии, эпидемиологии и иммунобиологии*. 2025;102(3):271–283

DOI: <https://doi.org/10.36233/0372-9311-692>

EDN: <https://www.elibrary.ru/QWEPWI>

Introduction

Anthrax is a highly dangerous zoonotic infectious disease characterized by its practically ubiquitous distribution in the Russian Federation [1, 2]. The persistence of epizootiological and epidemiological instability regarding anthrax is due to the existence of *Bacillus anthracis* in the form of spores resistant to environmental factors, capable of long-term survival in the soil and the formation of numerous soil foci—anthrax burials (AB), “pestilence fields” (extensive areas without clear boundaries where mass animal deaths associated with anthrax epizootics were observed in the past), the indicators of which are stationary hazardous areas (SHA) [2–4].

In Russia, over 37,000 SHA active from 1900 to 2003 (several SHA since the late 19th century) have been registered more than 70,000 times [5], and at least 4,000 AB [6–10]. A significant number of hazardous areas and soil foci, along with incomplete surveillance and coverage of vaccination for livestock, as well as individuals at high risk of infection, maintain a potential threat of worsening the situation with zoonotic diseases in the country [11, 12].

The stabilization of the situation regarding anthrax infection can be facilitated by an approach to the comprehensive solution of tasks in epizootiological and epidemiological monitoring, the most important component of which is the updating (revision and clarification of data) and systematization of information about anthrax and soil foci in each subject of the Russian Federation. The generalization and analysis of updated information on SHA and soil foci will ensure the improvement of surveillance over anthrax, increasing the effectiveness of managerial decisions during disease outbreak investigations, including the use of modern geographic information systems in conducting a combined correlational analysis of the characteristics of anthrax activity depending on the influence of environmental factors (natural-geographical, social, etc.), preventing the emergence of new infection cases [1, 3, 13–16].

The aim of the study is to update data on SHA and anthrax soil foci (anthrax, “pestilence fields”) to improve epidemiological surveillance of anthrax in Russia.

Materials and methods

Archival and reference information on anthrax in SHA (Cadastre of stationary hazardous areas of anthrax in the Russian Federation, edited by B.L. Cherkassky, 2005, hereinafter referred to as the Cadastre) [5] and soil foci (List of animal burial sites (including anthrax sites) located in the territory of the Russian Federation, 2011–2013, in 5 parts, hereinafter referred to as the List) [6–10], as well as accounting and reporting data from the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing (Rospotrebnadzor)

by subjects of the Russian Federation and territorial veterinary service bodies, were used as research materials.

The necessity to update the Cadastre [5] is due to changes in the administrative status of a large number of settlements: renaming and re-subordination of municipal formations, the transfer of several settlements to other municipal formations (consolidation, etc.), the liquidation of many settlements under the status of “former settlement”, etc., as well as the inclusion of data on the settlement activity in the 21st century. The importance of updating the List [6–10] in the regions of Russia is related to the elimination of a large number of AB, the identification of previously unreported burials, the clarification of AB characteristics: AB sizes, compliance of AB facilities with veterinary and sanitary regulations for maintenance, the presence of administrative and economic affiliation of AB, the sanitary protection zone (SPZ) of AB, geographical coordinates of location, etc.

With the aim of updating data on SHA and anthrax soil foci in the subjects of the Russian Federation, an expanded selection of criteria for the characteristics of SHA, AB and “pestilence fields” has been carried out, based on which the structure of regional databases for SHA and soil foci of infection has been developed.

Specialists from the Stavropol Anti-Plague Institute of Rospotrebnadzor, the Central Research Institute of Epidemiology of Rospotrebnadzor, the Irkutsk Anti-Plague Institute of Rospotrebnadzor and the Rostov State Medical University have conducted the systematization and analysis of the established regional databases of anthrax and soil foci for each subject, and created two generalized electronic databases (EDB): “Stationary Hazardous Areas of Anthrax on the Territory of the Russian Federation” and “Soil Foci of Anthrax on the Territory of the Russian Federation.”

The database “Stationary Hazardous Areas of Anthrax on the Territory of the Russian Federation” is an MS Excel workbook with the following structure: summary data on SHA in the territory of Russia and information on the presence and characteristics of SHA in the subjects of the Russian Federation.

The SHA EDB for each subject has the following structure:

- 1) data on SHA in accordance with the Cadastre [5]: subject of the Russian Federation, administrative district, municipal formation, populated area;
- 2) updated data on SHA with an indication of the current status of SHA (existing, former/liquidated settlement, incorporated into another settlement, renamed, etc.): subject of the Russian Federation, administrative district, municipal formation, settlement;
- 3) information on SHA activity: years of SHA activity manifestations;
- 4) information on the morbidity of animals and humans;

5) geographical coordinates of the SHA location.

The EDB "Soil Foci of Anthrax in the Territory of the Russian Federation" is a MS Excel workbook that includes summarized information about anthrax soil foci (AB, "pestilence fields") and data on the presence and characteristics of anthrax soil foci in the subjects of Russia.

The EDB of soil foci for each subject has the following structure:

1) updated data on the AB ("pestilence fields"): subject of the Russian Federation, administrative district, municipal formation, populated area;

2) availability of a veterinary sanitary card for the breeding farm;

3) years of animal burial (for AB), animal mortality (for the "pestilence fields");

4) type of soil focus: AB (earth pit, equipped animal burial ground, Bekari biothermal pit, wooden log cabin), "pestilence field";

5) method of animal disposal: not disposed of (burial of animal carcasses), incineration (burial of ash residue);

6) the number of buried/deceased animals by species;

7) AB Square ("pestilence field");

8) Veterinary and sanitary condition of the AB: fence, signboards, hill, moat;

9) presence of the AB in the flood zone: yes/no;

10) use of the AB: conserved/used;

11) administrative and economic affiliation of the AB: presence of a land user (custodian);

12) characteristics of the AB SPZ: information on the presence and size of the SPZ, economic use of the regulated SPZ (within a radius of 1000 m): presence of residential development, parks, recreational areas, livestock farms, cattle transit routes, planned construction sites, exploration and extraction of mineral resources, flood zones, etc.;

13) geographical coordinates of the location of the AB ("pestilence field").

Certificates of state registration have been obtained for the developed databases of SHA and soil foci in the subjects of the Russian Federation^{1, 2}.

Results

Results of the data update on anthrax in the subjects of the Russian Federation

The EDB "Stationary Hazardous Areas of Anthrax on the Territory of the Russian Federation" as of April 2025 contains updated information on the characteris-

tics and locations of 32,566 SHA (Table 1).

In the subjects of the Russian Federation as a whole, 4795 fewer SHA have been updated compared to the Cadastre data [5]. The number of accounted SHA in most subjects of Russia in the Central, Northwestern, Volga and Ural federal districts is less than the number of SHA indicated in the Cadastre [5]. An increase in the number of SHA has been identified in several subjects of the Southern, North Caucasian, Siberian and Far Eastern federal districts.

In 18 subjects of the **Central Federal District**, 7969 SHA have been updated. Compared to the Cadastre [5], the number of SHA decreased by 2458 points. The highest number of SHA (over 700 points) were recorded in the Oryol (759 SHA), Voronezh (781) and Ryazan (840) regions. From 2000 to 2024, 35 SHA were active in 7 subjects of the Central Federal District: in Voronezh (12 SHA), Kursk (10), Tambov (5), Belgorod (4), Tula (2), Oryol (1) and Ryazan (1) regions. Geographical coordinates of the locations have been established for 7810 (98%) SHA.

In the **Northwestern Federal District**, out of 2148 SHA [5], information on 1500 SHA has been updated in 10 out of 11 subjects, and there are no registered SHA in the federal city of St. Petersburg. The majority of SHA are recorded in the Novgorod (772 SHA) and Vologda (435) regions, while the fewest are in the Nenets Autonomous District (16), Kaliningrad (3) and Murmansk (2) regions. Since 2000, anthrax infection has not been observed in the Northwestern Federal District. Geographical coordinates are known for 98.6% of SHA in the Northwestern Federal District.

In the **Southern Federal District**, information has been updated on 2,589 SHA located in all subjects, except for the city of federal significance Sevastopol. The number of SHA exceeded the Cadastre data [5] by 136 points, which is primarily due to the inclusion of the Republic of Crimea in the Southern Federal District, where 211 SHA are accounted for, as well as the increase in the number of SHA in the Volgograd region (from 719 to 727), the Republic of Kalmykia (from 79 to 99), and the Republic of Adygea (from 74 to 75). The maximum number of SHA was recorded in the Rostov region — 797 points. In the Southern Federal District, manifestations of the infection were registered in 35 SHA from 2000 to 2016, with a relatively larger number in the Rostov region (11 SHA active in 2000, 2002, 2003, 2005–2007, 2010, 2014). Geographical coordinates have been determined for the majority of SHA (96.6%), and in the republics of Kalmykia (99 SHA) and Crimea (211), for all points.

In all 7 subjects of the **North Caucasian Federal District**, 1256 SHA have been recorded, which is 31 points more than in the Cadastre [5]. Since 2000, the infection has been detected in 49 SHA across 5 regions, during this period, anthrax was only absent in the Kabardino-Balkar and Karachay-Cherkess republics.

¹ Database "Permanently affected by anthrax sites in the territory of the Russian Federation", certificate of state registration dated 08/01/2024 No. 2024623389.

² Database "Soil foci of anthrax on the territory of the Russian Federation", certificate of state registration dated 05.11.2024 No. 2024624926.

Table 1. Summary data on updated SHA in the Russian Federation

Federal District	Number of SHA according to the Cadastre [5]	Number of SHA according to the updated data	Number of SHA with manifestations of activity since 2000	Number of SHA with information about cases of disease in animals	Number of SHA with information about cases of disease in humans	Number of SHA with known geographical coordinates of the locations
Central Federal District	10,427	7969	35	1549	111	7810
Northwestern Federal District	2148	1500	—	63	9	1479
Southern Federal District	2453	2589	35	953	172	2500
North Caucasian Federal District	1225	1256	49	919	547	1234
Volga Federal District	13 113	10,947	32	4001	804	10,511
Ural Federal District	2096	1945	4	187	2	1896
Siberian Federal District	4766	4990	24	2942	168	3643
Far Eastern Federal District	1133	1370	5	466	118	1093
Total	37,361	32,566	184	11,080	1931	30,166

In the Republic of Dagestan, the predominant number of SHA in the North Caucasian Federal District was recorded — 516 (41%), of which 25 outbreaks of the disease were active in 23 SHA from 2000 to 2022. In the Stavropol Krai, out of 361 SHA from 2001 to 2022, 10 outbreaks were registered at 10 points. Overall, the geographical coordinates of the locations have been determined for more than 98% of SHA in the North Caucasian Federal District (in the Republic of Ingushetia and the Kabardino-Balkar Republic — for 100% of SHA).

In the **Volga Federal District** (a total of 14 subjects), the number of hazardous production facilities decreased by 2,166 — 10,947 SHA were updated. The reduction in the number of recorded SHA is most pronounced in the Kirov region (from 1275 to 534 SHA), the Republic of Bashkortostan (from 1587 to 1292), the Orenburg region (from 1064 to 822), and the Ulyanovsk region (from 608 to 372). More than 60% of all SHA in the Volga Federal District are localized in 5 subjects: Nizhny Novgorod Region (1893), the Republic of Tatarstan (1320), the Republic of Bashkortostan (1292), the Chuvash Republic — Chuvashia (1231), and Saratov Region (1040). At the same time, in the Republic of Tatarstan, the number of SHA exceeds the Cadastre data [5] by 111 points. Since 2000, anthrax has been observed in 32 SHA, with the highest activity recorded in 2000–2014 in the Republic of Tatarstan

(12 outbreaks in 10 SHA); 1–6 SHA were active in 7 subjects of the Volga Federal District. The coordinates of the locations have been established for 96% of the SHA in the Volga Federal District.

In the **Ural Federal District**, 1945 SHA have been updated in 6 subjects, which is 151 SHA fewer than in the Cadastre [5]. The overwhelming majority of SHA are noted in the Tyumen region (952 SHA; 49%), followed by Sverdlovsk (372), Kurgan (317), and Chelyabinsk (255) regions. In the Yamalo-Nenets Autonomous District, the number of SHA increased from 8 to 29. The smallest number of SHA was recorded in the Khanty-Mansi Autonomous District — Ugra — 20 (1%) SHA. The latest instances of anthrax were recorded in Chelyabinsk Region (in 2009 — 1 SHA) and Yamalo-Nenets Autonomous District (in 2016 — 3 points). Geographical coordinates have been determined for 97.5% of the district areas.

In the **Siberian Federal District**, 4,990 SHA have been accounted for—the current number of SHA exceeds the Cadastre data [5] by a total of 253 in 8 out of 10 subjects; a decrease in the number of SHA has been recorded in the Republic of Tyva (from 175 to 156 SHA) and Kemerovo Region (from 161 to 151). The highest number of SHA was recorded in Altai Krai (1363) and Omsk Region (1175), while the lowest was in the Altai Republic (61). Outbreaks of anthrax after 2000 occurred in the Republic of Tuva (10 active an-

thrax foci; 11 outbreaks), Altai Krai (9; 9), Omsk Region (3; 3), and Krasnoyarsk Krai (2; 3). The geographical coordinates of 73% of the SHA in the Siberian Federal District have been established.

The **Far Eastern Federal District** consists of 11 subjects, among which manifestations of anthrax have historically not been registered only in the Magadan region and the Chukotka Autonomous District. In total, as a result of the update, 1370 SHA have been accounted for in the Far Eastern Federal District (1133 according to Cadastre data [5]). An increase in the number of SHA was noted in 5 subjects, a match in 3, and a decrease in 1 (Khabarovsk Krai — from 46 to 41 SHA). The highest proportion of SHA (more than 60% of points) was identified in the Sakha Republic (Yakutia) (400 SHA) and the Zabaykalsky Krai (454). In 2002, 2007 and 2008, *Yersinia pestis* manifested in the Zabaykalsky Krai (2 active foci; 2 outbreaks) and the Republic of Buryatia (3; 4). Geographic coordinates are known for 80% of SHA.

Results of the data update regarding anthrax soil foci in the subjects of the Russian Federation

The EDB "Soil Foci of Anthrax in the Territory of the Russian Federation" as of April 2025 includes updated information on 3314 anthrax soil foci: 3185 AB and 129 "pestilence fields" (**Table 2**).

Data analysis showed that the number of registered AB in the subjects of the Russian Federation is 930

lower compared to the information in the List [6–10] due to a decrease in the number of recorded infectious diseases in most subjects of the Central Federal District, Southern Federal District, North Caucasian Federal District, Volga Federal District, Ural Federal District and Far Eastern Federal District. In certain subjects of the Northwestern Federal District and the Siberian Federal District, an increase in the number of registered AB has been noted. There is information about 129 "pestilence fields" in the Russian Federation.

In 13 subjects of the **Central Federal District**, 534 AB have been updated, which is 126 fewer than the data in the List [7]. The decrease in the number of AB in the Central Federal District is due to the removal of AB from the registry. Thus, in the Voronezh region, all 81 AB were removed from the registry, 50 of which had custodians, after receiving negative laboratory test results for the presence of anthrax in individual soil samples taken from the AB. They were also removed from the regional registers of AB in the Belgorod (14), Kostroma (13), Kursk (13) and Tver (10) regions. AB are not listed in the Ryazan, Smolensk, Tambov and Tula regions.

The highest number of registered AB is in the Kursk (146), Tver (143), and Belgorod (71) regions. Fewer than 10 AB are registered in the Yaroslavl (4), Kaluga (3), Bryansk (1) regions, and in the city of Moscow (1). The number of registered AB in the Central Federal District increased compared to the data from

Table 2. Basic data on updated anthrax soil foci in the Russian Federation

Federal District	Number of AB according to the Lists [6–10]	Number of AB according to the updated data	Number of «pestilence fields»	Method of animal disposal		Number of AB appropriate/partially appropriate to the content of VSRC	Number of AB inappropriate to the content of VSRC	Number of AB having a custodian/ownerless AB	Number of AB with the presence of usable territories within a radius of 1000 m	Number of soil foci with known geographical coordinates of the locations
				number of AB with burial of animal carcasses	number of AB with burial of ash residues					
Central Federal District	660	534	–	156	286	427/42	64	140/394	325	533
Northwestern Federal District	112	115	50	27	87	109/1	3	95/20	93	163
Southern Federal District	210	112	–	1	111	50/0	62	91/21	55	112
North Caucasian Federal District	278	238	–	26	212	84/20	134	4/234	343	112
Volga Federal District	2197	1742	–	426	1170	1519/0	223	1468/274	470	1738
Ural Federal District	185	123	39	8	102	70/0	53	49/74	49	162
Siberian Federal District	162	180	40	12	152	143/36	1	144/36	89	219
Far Eastern Federal District	311	141	–	10	102	28/30	83	21/120	86	128
Total	4115	3185	129	666	2222	2430/129	623	2012/1173	1510	3167

the List [7] in the Moscow (from 37 to 41) and Bryansk (from 0 to 1) regions.

According to the available data, 286 (53.6%) AB contain ash residues after the incineration of livestock that died from anthrax, in 156 (29.2%) AB the carcasses of animals are buried, and for 92 AB, information on the burial method is absent. Data analysis showed that compliance of the AB with the veterinary and sanitary regulations content was noted for 427 (80%) AB, partial compliance for 8% of the burials, and non-compliance for 12%. However, the majority of AB in the district (394 AB; 73.8%) do not have economic affiliation, including all 143 AB in Tver, all 17 AB in Lipetsk, 138 out of 146 in Kursk, 49 out of 51 in Ivanovo, 39 out of 41 in Moscow, 6 out of 71 in Belgorod, and 2 out of 24 in Vladimir regions. The risk of being in a potential flooding zone has been identified for 5 burials: 3 in the Kursk region and 2 in the Ivanovo region. The geographical coordinates of the locations are known for all the burial sites, except for one AB in the Kursk region.

Economic use of the territory at a distance of 1000 m from the AB has been determined for half of the burial sites (50.9%) — near 149 AB there are residential buildings and recreational areas, 123 AB have livestock farms, pastures, etc., and 53 are flood-prone areas. The SPZ has been established for 81 AB in the Belgorod (70), Tver (8), Yaroslavl (2), and Bryansk (1) regions.

In the territory of 9 out of 11 subjects of the **North-western Federal District**, 115 AB have been registered, which is 3 more than in the List [6]: the number of AB increased from 25 to 30 in the Pskov region, while there was one less burial site in the Republic of Karelia and the Leningrad region. The overwhelming majority of AB in the district are located in Vologda (42), Pskov (30), and Arkhangelsk (24) regions, with isolated sites recorded in the Republic of Karelia (7), Novgorod (4), and Murmansk (3) regions, the Republic of Komi (2), Kaliningrad (2), and Leningrad (1) regions. The AB is absent in the federal city of St. Petersburg and the Nenets Autonomous District. Information has also been obtained about 50 “pestilence fields” in the territory of the Nenets Autonomous District, which formed between 1880 and 1934 during the course of epizootics of the disease.

According to the provided information, ash residues are buried in 87 (75.7%) AB, unutilized carcasses in 27 (23.5%) AB; data on the burial method is unknown for 1 AB in the Republic of Karelia. According to the available data, 96% of the AB in the Northwestern Federal District fully or partially comply with the content of the veterinary and sanitary regulations, while 3 burial sites in the Pskov (2) and Vologda (1) regions do not comply. The presence of a custodian has been established for the majority (82.6%) of the facilities (95 AB), while its absence has been noted for 20 (Arkhangelsk region — 13, Republic of Karelia — 6, Vologda region — 1). On the territory at risk of flooding, there

is 1 burial site in the Vologda region. Geographical coordinates are known for 98.3% of the AB and 100% of the “pestilence fields”.

Within a radius of 1000 meters from 67 AB, the presence of residential development and recreational areas has been identified, from 23 AB — livestock farms, and from 1 AB — a flood-prone area. SPZ are defined only for 2 AB in the Arkhangelsk and Vologda regions.

In the **Southern Federal District**, 112 AB have been updated in 5 out of 8 subjects, with the highest number in the Rostov Region (78), as well as in the Astrakhan Region (15), the Republic of Crimea (13), the Republic of Kalmykia (5), and Krasnodar Krai (1). The removal from the registry of all 114 burial sites in the Republic of Adygea, as well as 1 burial site in the Republic of Kalmykia, resulted in a nearly twofold decrease in the number of burials in the Southern Federal District compared to the information in the List [6], according to which 210 burial sites were registered in the Southern Federal District (excluding burials in the Republic of Crimea due to the release of List [6] in 2011). The absence of registered AB is also indicated for the Volgograd region and the federal city of Sevastopol.

According to the provided information, almost all (99%) AB in the Southern Federal District contain the burial of ash residues after the incineration of fallen livestock, except for one AB in the Krasnodar Krai with the burial of an unprocessed animal carcass. Fifty (44.6%) AB comply with veterinary and sanitary standards; among the 62 AB that do not comply with veterinary and sanitary regulations, 55 (88.7%) AB are located in the Rostov region. Administrative and economic affiliation has been determined for 91 (81.3%) AB: 75 (96%) burials in the Rostov region, 13 (100%) AB in the Republic of Crimea, 2 AB in the Astrakhan region, and 1 AB in the Krasnodar region. Geographical coordinates are known for 100% of the burial sites.

The presence of residential buildings and parks has been identified within the one-kilometer zone of 39 AB, livestock farms within 15 AB, and flood-prone areas within 1 AB. Buffer zones have been established for 3 AB in Astrakhan Region and 1 AB in Rostov Region.

In the **North Caucasian Federal District**, 238 hazardous AB have been identified in 5 out of 7 subjects. Overall, the number of AB in the North Caucasian Federal District has decreased by 40 burial sites compared to the List [6], which is related to the removal of 45 AB from the registry in the Stavropol Krai (a decrease from 75 to 30) and the inclusion of 5 previously unaccounted AB in the regional registers of supervised facilities: 2 in the Karachay-Cherkess Republic (0/2), and 3 in the Republic of North Ossetia-Alania (139 out of 142). The number of AB remained unchanged in the Kabardino-Balkar Republic (62) and the Republic of Dagestan (2). In the Chechen Republic and the Republic of Ingushetia, the anthrax is not accounted for.

Ash residues are contained in 212 (89%) of the 4 subjects. The unutilized carcasses of livestock that died from the infection are buried in 24 AB of the Stavropol Krai and 2 AB of the Republic of Dagestan.

Compliance of the AB with the standards of the veterinary and sanitary regulations was determined for 84 (35.3%) AB — all AB located in the Republic of Dagestan, Kabardino-Balkar, and Karachay-Cherkess republics, and for 18 (60%) AB in the Stavropol Krai. Partial compliance was established for 20 (8.4%) AB: 17 (12%) in the Republic of North Ossetia-Alania, and 3 (10%) in the Stavropol Krai. 134 (56.3%) of the AB do not comply with the veterinary and sanitary regulations: the overwhelming majority of the burials are in the Republic of North Ossetia-Alania (125 out of 142; 88%) and 9 (30%) in the Stavropol Krai. In the North Caucasian Federal District, there are 4 AB sites with custodians (2 each in the Republic of Dagestan and the Karachay-Cherkess Republic). In the area of potential flooding, there are 2 burial sites located in the Kabardino-Balkar Republic. The exact geographical coordinates have been determined for 112 (47.1%) of the AB in the district.

Within a radius of 1000 meters from 176 AB, residential development has been identified, from 162 — livestock enterprises, pastures, from 3 — flood zones. SPZ are established only for 11 (4.6%) AB in the Stavropol Krai (8), the Republic of Dagestan (2), and the Karachay-Cherkess Republic (1).

In the *Volga Federal District*, 1742 AB are currently accounted for, located in 12 out of 14 subjects. The number of burials has decreased by 455 compared to the data in the List [10], which contains information about 2197 AB. The decrease in the number is due to the removal of 483 AB from the records: 345 in the Chuvash Republic, 102 in the Mari El Republic, 33 in the Kirov region, 2 in the Penza region, and 1 in the Orenburg region. The number of registered AB increased in the Republics of Mordovia (by 23) and Tatarstan (by 4), and in the Udmurt Republic (by 1).

The territorial distribution of AB is as follows: the majority of AB are accounted for in the Republics of Tatarstan (808) and Mordovia (250), Nizhny Novgorod Region (231), Udmurt Republic (101), Penza Region (84), Perm Krai (79), Chuvash Republic — Chuvashia (52); followed by Ulyanovsk Region (39), Republic of Mari El (37), Kirov Region (34), Orenburg Region (24), and Samara Region (3). In the Republic of Bashkortostan and Saratov Region, no AB have been registered.

The majority (67.1%) of AB are characterized by the burial of ash residues, 24.5% by the burial of corpses of domestic animals, and for 8.4% of AB, information about the nature of the burial is absent. Non-compliance with the veterinary and sanitary regulations has been established for 223 (12.8%) AB in the district, while 1519 (87.2%) AB comply with the maintenance regulations. A significant portion of the AB (84.3%) has

administrative and economic affiliation. All 250 AB in the Republic of Mordovia, 11 in the Orenburg region, 10 in the Kirov region, and 3 in the Samara region (a total of 274 AB) are unowned. Five burials in the Nizhny Novgorod region and three in the Republic of Mari El are at risk of flooding. Geographic coordinates have been determined for 99% of the AB in the Volga Federal District, and are unknown for 4 burials (2 each in the Republic of Tatarstan and Penza Region).

Economic use of the territories adjacent to the burial sites within a radius of 1 km has been determined for 406 AB, and flood-prone areas for 43. SPZ have been established for 69 AB, 45 of which are located in the Republic of Tatarstan.

The information on the presence of 123 burials across all 6 subjects of the *Ural Federal District* has been updated, which is 62 fewer than in the List [8]. The decrease in the number of AB was recorded only in the Tyumen region, where 72 out of 74 burials were removed from the registry. An increase in the number of registered cases of anthrax was noted, primarily due to the formation of 9 cases in Yamal-Nenets Autonomous District during the largest anthrax epizootic among reindeer in 2016 (an increase from 0 to 9), as well as the registration of 1 case in Kurgan Region (an increase from 20 to 21). The number of registered AB in the other subjects of the Ural Federal District remained the same: Sverdlovsk Region — 72, Chelyabinsk Region — 17, Khanty-Mansi Autonomous District — Ugra — 2. In addition to the anthrax outbreaks, the location of 39 “pestilence fields” formed since 1908 during anthrax epizootics among reindeer, which cover more than 8 million hectares of the Yamalo-Nenets Autonomous District.

According to the available information, 83% of AB contain ash residues, 8 AB in the Sverdlovsk region have unprocessed carcasses, and data is missing for 13 burials. Compliance with the veterinary and sanitary regulations has been established for 57%, while 53 (43%) AB in the Sverdlovsk (49), Chelyabinsk (3), and Kurgan (1) regions do not comply with the veterinary and sanitary regulations. A significant number (74 out of 123 AB; 60%) are abandoned, including 49 AB in Sverdlovsk Region, 16 in Kurgan Region, and 9 in the Yamalo-Nenets Autonomous District. In the area of potential flooding, 1 contaminated site is located in the Sverdlovsk region. Geographical coordinates are known for 100% of the soil sites in the Ural Federal District.

Within a radius of 1000 meters from 43 AB, economic use of the territories has been noted, and a flooding zone is present near 5 burials. SPZ have been established for 14 (11.4%) AB in the Kurgan (6), Sverdlovsk (6), and Chelyabinsk (2) regions.

In 7 out of 10 subjects of the *Siberian Federal District*, 180 burials have been accounted for, which is 18 more than the number of AB indicated in the List [9], due to the registration of 10 AB in the Republic of

Tuva, 6 in the Altai Krai, and 2 in the Irkutsk Region. The overwhelming majority (103) of the AB facilities are located in Kemerovo Region, 26 in Altai Krai, 15 each in Krasnoyarsk Krai and Irkutsk Region, 11 in the Republic of Tuva, and 9 in Novosibirsk Region. Burials have not been registered in the Altai Republic, Omsk, and Tomsk regions. In the Krasnoyarsk Territory, in addition to burials, 40 “pestilence fields” with a total area of over 4500 hectares, formed during epizootics among reindeer in the Taymyr region from 1904 to 1967, are also accounted for.

A significant portion of the AB (152 AB; 84.4%) is characterized by the burial of ash residues, in 12 AB of the Krasnoyarsk Krai, the carcasses of fallen livestock are buried, and burial conditions for 16 AB are not established. For 99% of the AB in the district, full (143) and partial (36) compliance with the veterinary and sanitary regulation is indicated, and geographical coordinates are known; 1 AB in the Kemerovo region does not comply with the maintenance regulations. Most of the AB in the Siberian Federal District (144 AB; 80%) have custodians; 36 AB have been identified without economic affiliation. In the flood zone, there is 1 AB in the Altai Territory.

The presence of residential development in the adjacent one-kilometer zone has been identified for 65 AB, livestock farms for 20 AB, and flooded areas for 4 AB. SPZ have been established for 114 (63.3%) AB in the territories of Kemerovo (103), Novosibirsk (8) regions, and Krasnoyarsk Krai (3).

There are 141 AB located in 6 out of 11 subjects of the **Far Eastern Federal District**, which is 170 fewer than the information in the List [7], which contains data on 311 AB. Changes in the number of burials affected 7 subjects of the district. As a result of the review and analysis of data, due to the lack of information on the exact location of the AB, the number decreased by 268: in the Republic of Sakha (Yakutia) — by 239 (from 275 to 36), in the Jewish Autonomous Region — by 19 (from 22 to 3), in Primorsky Krai — by 9 (from 12 to 3), in Sakhalin Region — by 1 (from 1 to 0). The number of registered cases of anthrax increased in the Zabaykalsky Krai by 81 (from 0 to 81), in the Republic of Buryatia by 16 (from 1 to 17), and in the Kamchatka Krai by 1 (from 0 to 1). AB are absent in the Khabarovsk Krai, Amur, Magadan, Sakhalin regions, and the Chukotka Autonomous District.

Burials of ash remains were noted in 102 (72.3%) AB, corpses of livestock in 10, and information regarding 29 AB is absent. For the majority of AB (83; 59%), a discrepancy in the content of veterinary and sanitary regulations was identified—predominantly in the Trans-Baikal Territory (43) and the Sakha Republic (Yakutia) (33), as well as in the Republic of Buryatia (4) and the Primorsky Territory (3). Most of the Far East District burials (120; 85%) are unclaimed. The presence of a custodian has been established only for

21 AB in 4 regions (Republic of Buryatia — 12, Zabaykalsky Krai, Primorsky Krai, and the Jewish Autonomous Region — 3 each). Two burial sites in the Republic of Buryatia and the Jewish Autonomous Region are located in areas prone to possible flooding. Geographical coordinates are known for 128 (91%) burial sites, while the exact location is unknown for 13 burials in the Sakha Republic (Yakutia).

Within a radius of 1000 meters from 71 AB, the presence of livestock enterprises has been identified, from 11 — residential development, from 3 — flood zones. In the Far Eastern Federal District, there are no AB with established SPZ.

Discussion

The update of data on anthrax in Russia allowed for the characterization of over 85% of SHA from the number of sites presented in the Cadastre [5], with information on the geographical coordinates of 92.6% of updated SHA located in 81 out of 85 subjects.

The decrease in the number of SHA was noted in 51 subjects, in 13 of which by more than 100 points, among which the most significant difference was determined in 3 regions (Smolensk region — a decrease of 941 SHA, Kirov region — 741, Oryol region — 523). The decrease in the number of SHA is due both to the liquidation of several settlements and their merger with others, as well as to the fact that SHA are not only settlements but also livestock farms, pastures, etc., where outbreaks of anthrax were registered at least once, and the impossibility of restoring information about the location of these previously hazardous and abolished enterprises of various forms of ownership.

The excess number of SHA compared to the Cadastre [5] has been established in 22 subjects, with the maximum difference in the Republics of Sakha (Yakutia) (by 129) and Tatarstan (by 111). The database also includes information about unfavorable points in the Republic of Crimea, which are not present in the Cadastre [5]. According to archival materials, anthrax was not registered during the entire observation period in 4 subjects of the Russian Federation: Magadan Region, Chukotka Autonomous District, the city of federal significance Saint Petersburg, and Sevastopol.

In the process of updating, a characterization of 3185 AB located in 63 subjects of Russia (including the Republic of Crimea) and 129 “pestilence fields” in 3 northern regions (Nenets Autonomous District, Yamalo-Nenets Autonomous District, Krasnoyarsk Krai) was obtained. The geographical coordinates of the locations have been determined for more than 95% of the burials and 100% of the “pestilence fields”.

The analysis of data on AB identified a number of problematic issues. First and foremost, a decrease in the number of registered AB by 1,116 has been established, due to the removal of hazardous production facilities from the registry in 20 subjects. A significant

decrease in the number of registered AB was noted in 6 regions, including the Chuvash Republic (Chuvashia) (a decrease of 345 AB), the Sakha Republic (Yakutia) (239), the Mari El Republic (102), Tyumen Region (72), Stavropol Krai (45) and Kirov Region (33). A decrease in the number of registered cases of AB was also identified in the Jewish Autonomous Region (by 19), Belgorod Region (by 14), Kostroma and Kursk Regions (by 13 each), Tver Region (by 10), Primorsky Krai (by 9), Penza Region (by 2), as well as 1 case each in the Republics of Kalmykia and Karelia, and in Leningrad, Orenburg and Sakhalin Regions. Moreover, all registered AB were removed from the regional registers in the Republic of Adygea (114) and Voronezh Region (81). It is also known that even before the issuance of the List [6, 7], all 53 AB registered in the territory of 20 districts of the Volgograd region [17] and all 168 burial sites in the Tula region were removed from the records. The exclusion of AB from the lists of regional registers occurred in accordance with the resolutions of regional governments, veterinary departments (committees, agencies) on the liquidation of unused animal burial grounds in the territories of the subjects, considering that the burial sites of the ash remains of animals that died from anthrax do not pose a danger and are not AB. However, retrospectively establishing the fact of burning the carcasses of anthrax-infected animals to an epidemiologically safe inorganic residue is not feasible, nor is the burning of the carcasses of animals that died from anthrax to ash using improvised means, as practice shows that at the site of the documented burial of ash residues, unburned bone fragments of livestock are often found. The decrease in the number of AB was also due to their removal from the records because of the lack of data on their exact location.

It has been shown that more than 36% of AB do not have administrative or economic affiliation, and 20% of AB do not comply with the veterinary and sanitary regulations. Localization in areas at risk of flooding has been identified for 20 AB, and the presence of a flooding zone within the adjacent territory has been identified for 113. Economic use of land plots within a radius of 1000 meters from several burial sites has been identified: the presence of residential buildings and recreational areas — 892 (28%) AB, livestock enterprises and pastures — 478 (15%) AB; adjacent territories of 27 AB are planned for development.

The results of the data analysis confirmed the absence of a correlation between the number of SHA — markers of the presence of soil foci of anthrax — and the number of cases of *Yersinia pestis* infection. Thus, in the administrative territories of 31 subjects, with the presence of 14,884 SHA registering multiple manifestations of the infection, only 552 AB were recorded. In 18 subjects, with 8,025 SHA where more than 21.5 thousand anthrax outbreaks were registered, AB were not recorded at all: Omsk region (1,175 SHA), Sara-

tov region (1,040), Ryazan region (840), Voronezh region (81), Volgograd region (27), Tambov region (699), Smolensk region (572), Tomsk region (271), Tula region (155), Amur region (114), Sakhalin region (3), Republic of Bashkortostan (1,292), Republic of Adygea (75), Republic of Altai (61), Republic of Ingushetia (21), Chechen Republic (142), Khabarovsk Krai (41), Nenets Autonomous District (16), which indicates the presence of a significant number of unreported AB in Russia.

Conclusion

As a result of extensive information systematization, databases of anthrax foci and soil infection foci have been created for the first time, containing updated information on the characteristics and locations of 32,566 anthrax foci and 3,314 soil infection foci (3,185 anthrax foci and 129 “pestilence fields”) in the Russian Federation. The obtained data on anthrax SHA and soil foci will serve as a fundamental resource for enhancing the level of information support, the effectiveness of epizootiological-epidemiological monitoring, and the prevention of anthrax in the territories of the subjects of the Russian Federation.

Data analysis allowed for the assessment of current epidemiological risks associated with soil foci of anthrax. The facts of the practically ubiquitous presence of a significant number of unreported AB, the removal of AB from the records, the lack of reliable locations for accounted AB, the presence of unowned and non-compliant with veterinary and sanitary regulations AB, as well as the existence of “pestilence fields” in the northern regions of Russia against the backdrop of incomplete accounting and coverage of susceptible livestock with immunization, maintain a constant potential risk of complicating the epizootiological and epide-miological situation regarding AB.

The methods of solving these problems consist, first and foremost, of implementing measures aimed at eliminating removable (social) risk factors, including:

- arrangement of the AB in accordance with regulatory requirements using administrative resources;
- ensuring regular supervision of the veterinary and sanitary condition of the AB;
- establishment of the AB SPZ;
- prevention of removal from registration and liquidation of AB; restoration in regional registers of AB excluded from the list of supervised sites, implementation of a comprehensive set of supervisory activities;
- the use of information on the localization of “pestilence fields” in planning exploratory work and mineral extraction;
- the adoption of additional measures for the livestock census and annual vaccination of livestock;
- provision of specific immunization for at-risk groups.

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The article was submitted 18.04.2025;
accepted for publication 20.06.2025;
published 28.06.2025

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Статья поступила в редакцию 18.04.2025;
принята к публикации 20.06.2025;
опубликована 28.06.2025