https://doi.org/10.29326/2304-196X-2024-13-3-282-291

Situational analysis on porcine diseases: general risk assessment and prioritization of epizootic threats to biosecurity systems of pig establishments in the Russian Federation

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ABSTRACT

The results of the situational analysis on porcine diseases in the Russian Federation and the expert assessment prioritizing the list of porcine pathogens significant for the pig industry of the country are presented. The method applied to analyse the expert estimates in the situational analysis allows for rapid assessment and interpretation of the situation with identification of priority diseases to be further addressed. The calculations demonstrated the sufficient degree of agreement among the experts (coefficient of concordance $W = 0.61$), and Pearson's chi-squared test statistic $\chi^2 = 51.33$ (≥ 21.02607) indicated that the concordance is not random and the results can be used in subsequent studies. The specific features of epizootiology of the agents of African swine fever, classical swine fever, porcine reproductive and respiratory syndrome that can impact the effectiveness of biosecurity systems of pig establishments, as well as further ways for improving biosecurity management measures are discussed. The overall risk for the pig industry in the Russian Federation that is associated with external sources is currently characterized as permanently high, requiring maintaining risk management measures at the pig establishments by both the managerial staff of the establishments and the State Veterinary Service. It is recommended that biosecurity measures against external threats should focus on diseases such as African swine fever (weight $\lambda = 0.52$), porcine reproductive and respiratory syndrome ($\lambda = 0.071$), classical swine fever ($\lambda = 0.068$) and infections considered emerging for the Russian Federation ($\lambda = 0.05$) according to the weights based on the expert estimation results. The biosecurity systems of the establishments should equally address other threats significant for the pig industry of the country: swine enzootic pneumonia, porcine pleuropneumonia (*Actinobacillus pleuropneumoniae*), Aujeszky's disease, streptococcosis (*Streptococcus suis*), porcine circovirus infection, foot-and-mouth disease, leptospirosis, transmissible gastroenteritis, cysticercosis ($\lambda = 0.02\ldots0.05$). The improvement of the governmental policy for eradication of African swine fever, porcine reproductive and respiratory syndrome, classical swine fever (including the substantial modification of the existing official pig turnover control, zoning, diagnosis and prevention quality, as well as the implementation of biosecurity standards) is the most significant factor, without which the disease eradication perspective is questionable.

Keywords: porcine diseases, epizootic situation, pig industry, biosecurity, veterinary and sanitary measures

Acknowledgements: The study was funded by the Federal Centre for Animal Health within the research topic "Veterinary Welfare". The authors express their gratitude to the following staff members of the Federal Centre for Animal Health (Vladimir) for expert participation in the survey: K. N. Gruzdev, Dr. Sci. (Biology), Professor, Chief Researcher; D. A. Biryuchenkov, Cand. Sci. (Veterinary Medicine), Head of Laboratory for Porcine Disease Prevention; A. S. Igolkin, Cand. Sci. (Veterinary Medicine), Head of Reference Laboratory for African Swine Fever, Deputy Head of Laboratory and Diagnosis Centre.

For citation: Oganesyan A. S., Shibayev M. A., Petrova O. N., Baskakova N. Ye., Karaulov A. K. Situational analysis on porcine diseases: general risk assessment and prioritization of epizootic threats to biosecurity systems of pig establishments in the Russian Federation. *Veterinary Science Today*. 2024; 13 (3): 282–291. https://doi.org/10.29326/2304-196X-2024-13-3-282-291

Conflict of interests: The authors declare no conflict of interests.

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УДК 619:616.9:631.145:636.4:616-036.22(470)

Ситуационный анализ по болезням свиней: общая оценка рисков и приоритизация эпизоотических угроз для систем биозащиты свиноводческих предприятий в Российской Федерации

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РЕЗЮМЕ

Представлены результаты ситуационного анализа по болезням свиней в Российской Федерации и экспертной оценки, в которой приоритизирован список значимых для промышленного свиноводства страны патогенов. Использованный способ оценки экспертного мнения в ситуационном анализе позволяет быстро реализовать и интерпретировать ситуацию, выделяя приоритеты по болезням для дальнейшего обсуждения. Произведенные расчеты показали достаточный уровень согласованности мнений экспертов (коэффициент конкордации $W = 0{,}61$), а расчетный критерий согласия Пирсона $\chi^2 = 51{,}33$ ($\geq 21{,}02607$) указывал на то, что конкордация не случайная и результаты могут использоваться в дальнейших исследованиях. Обсуждены особенности эпизоотологии возбудителей африканской чумы свиней, классической чумы свиней, репродуктивно-респираторного синдрома свиней, способные повлиять на эффективность систем биозащиты свиноводческих предприятий, а также дальнейшие пути по улучшению мер управления биозащитой. Совокупный риск для промышленного свиноводства в Российской Федерации со стороны внешних источников в настоящей ситуации охарактеризован как перманентно высокий, требующий поддержания мер управления рисками на свиноводческих предприятиях как администрацией, так и государственной ветеринарной службой. Меры биозащиты для противодействия внешним угрозам рекомендовано акцентировать на таких заболеваниях, как африканская чума свиней (вес $\lambda = 0{,}52$), репродуктивно-респираторный синдром свиней ($\lambda = 0{,}071$), классическая чума свиней ($\lambda = 0{,}068$) и эмерджентных для Российской Федерации инфекциях ($\lambda = 0{,}05$) соответственно полученному весу по итогам экспертной оценки. Остальным значимым для свиноводства страны угрозам: энзоотическая пневмония свиней, актинобациллезная плевропневмония свиней, болезнь Ауески, стрептококкоз (*Streptococcus suis*), цирковирусная инфекция свиней, ящур, лептоспироз, трансмиссивный гастроэнтерит свиней, цистицеркоз ($\lambda = 0{,}02\ldots0{,}05$) – представляется возможным уделить равное внимание в системах биозащиты предприятий. Наличие государственной политики эрадикации африканской чумы свиней, репродуктивно-респираторного синдрома свиней, классической чумы свиней (с основательным изменением существующего официального контроля оборота поголовья, зонирования, качества диагностики и профилактики, внедрения стандартов биозащиты) является наиболее значимым фактором, без которого перспектива искоренения болезней сомнительна.

Ключевые слова: болезни свиней, эпизоотическая ситуация, свиноводство, биозащита, ветеринарно-санитарные меры

Благодарности: Работа выполнена за счет средств ФГБУ «ВНИИЗЖ» в рамках тематики научно-исследовательских работ «Ветеринарное благополучие». Авторы выражают благодарность сотрудникам ФГБУ «ВНИИЗЖ» (г. Владимир) за экспертное участие в опросе: К. Н. Груздеву, д-ру биол. наук, профессору, главному научному сотруднику; Д. А. Бирюченкову, канд. вет. наук, заведующему лабораторией профилактики болезней свиней; А. С. Иголкину, канд. вет. наук, заведующему референтной лабораторией по африканской чуме свиней, заместителю руководителя лабораторно-диагностического центра.

Для цитирования: Оганесян А. С., Шибаев М. А., Петрова О. Н., Баскакова Н. Е., Караулов А. К. Ситуационный анализ по болезням свиней: общая оценка рисков и приоритизация эпизоотических угроз для систем биозащиты свиноводческих предприятий в Российской Федерации. *Ветеринария сегодня*. 2024; 13 (3): 282–291. https://doi.org/10.29326/2304-196X-2024-13-3-282-291

Конфликт интересов: Авторы заявляют об отсутствии конфликта интересов.

Для корреспонденции: Оганесян Андрей Серожович, канд. вет. наук, заведующий сектором информационно-аналитического центра ФГБУ «ВНИИЗЖ», мкр. Юрьевец, г. Владимир, 600901, Россия, *oganesyan@arriah.ru*

INTRODUCTION

Biosecurity, as defined by the World Organisation for Animal Health (WOAH), is a set of measures and managerial solutions designed to reduce the risk of introduction, establishment and spread of diseases, infections or infestations to, within and from an animal population. The set of measures is also aimed at reducing microbial/viral load, blocking pathogen transmission routes inside the establishment and preventing infection introduction from the outside. It includes specific and non-specific measures such as maintenance of the animal disease free status of the establishment (sanitation of facilities, feeds, water, personnel and animal hygiene, veterinary treatments); compliance with appropriate practices of animal farming, sanitary treatment of premises, vehicles, fomites, feeding lines and water pipelines (cleaning, washing and disinfection); prevention of infection introduction (ensuring that the staff members of the establishment, as well as animals, feeds, equipment, etc. introduced to the establishment comply with the relevant veterinary and sanitary requirements, the implementation of disinfection, insect and rodent control measures). As part of animal disease control activities, the biosecurity of establishments globally serves to gain the time required for early detection of an infectious agent in the production flow and at the start of the implementation of disease eradication measures in the zone or country in order to prevent an epizootic.

The most important thing in this regard is the availability of information on external threats (animal disease situation in the territory of location, seasonal disease absence/presence in the populations of domestic and wild animals and birds), as well as on factors predisposing to changes in the extent of external threats (orientation of the livestock industry of the region, feed production and animal product processing; orientation of the quarantine policy of the veterinary authority of the region; seasonal, socially and economically determined activity of various groups of urban and rural population, the structure of protected livestock and their contact patterns). Studying the specific features of the epizootiology of porcine diseases in the pig industry and prioritizing their significance will allow for the development of adequate biosecurity measures for the pig production sector [1].

Therefore, the description and assessment of external epizootic threats to pig establishments and prioritization thereof remains an urgent topic for situational analysis within the framework of discussing the arrangement and development of biosecurity measures for pig establishments in the Russian Federation.

MATERIALS AND METHODS

The assessment of external epizootic threats to the pig industry was carried out in the form of situational analysis with discussion of the characteristics of pathogens, which made it possible to identify gaps in biosecurity measures. Official data on porcine diseases, data from open official sources and specialized mass media were used for the work [2, 3].

Estimates were obtained through a survey of experts of the Laboratory and Diagnosis Centre (3 persons) and Information Analysis Centre (4 persons who are the authors of this paper, except N. Ye. Baskakova) of the Federal Centre for Animal Health. The authors of the paper (5 persons) summarized and discussed the results, described special aspects relevant for infection management based on the prioritized list.

The experts ($m = 7$) assessed the degree of significance of threats for the domestic pig industry by assigning them a rank. In total, 13 threats ($n = 13$) were assessed: 12 diseases/pathogens and 1 category – emerging diseases (exotic for the Russian Federation and not reported previously). The threat considered to be the most significant by an expert was ranked 13. When several factors were recognized as equally significant, they were assigned an equal rank. On the basis of the data from the questionnaire-based survey, a summary matrix of ranks was compiled, the ranks given by the experts were rearranged without changing the opinion of the experts. The reformatted rank matrix was used to make a ranked list of sums of the ranks and mean ranks for 13 threats; based on the sums of the ranks, the weights of the threats were calculated, and the survey matrix was converted into a matrix of transformed ranks. The evaluation of the results of the expert survey was carried out by calculating Kendall's coefficient of concordance (W) [4] for cases where there are tied ranks (identical rank values among the estimates from one expert), using the following formula:

$$W = \frac{S}{\frac{1}{12}m^2(n^3 - n) - m\sum T_i},$$

where S is the sum of squared deviations of all ranks of each object of expert assessment from the mean value;

n is the number of assessed threats;

m is the number of experts;

T_i is the number of ties (types of repeated elements) among the estimates from the i-th expert:

$$T_i = \frac{1}{12}(\Sigma(t_l^3 - t_l)),$$

where t_l is the number of elements in the l-th tie for the i-th expert (the number of repeated elements).

The significance of Kendall's coefficient of concordance was evaluated using Pearson's chi-squared test statistic (χ^2). The weights of the assessed threats (λ) were obtained by converting the survey matrix into a matrix of transformed ranks (using the formula $S_{ij} = X_{max} - X_{ij}$, where $X_{max} = 13$).

The prioritization results were presented graphically in the form of a ranked list of threats and a diagram based on the weights (λ) reflecting threat significance, as well as through the discussion of the most significant threats.

RESULTS AND DISCUSSION

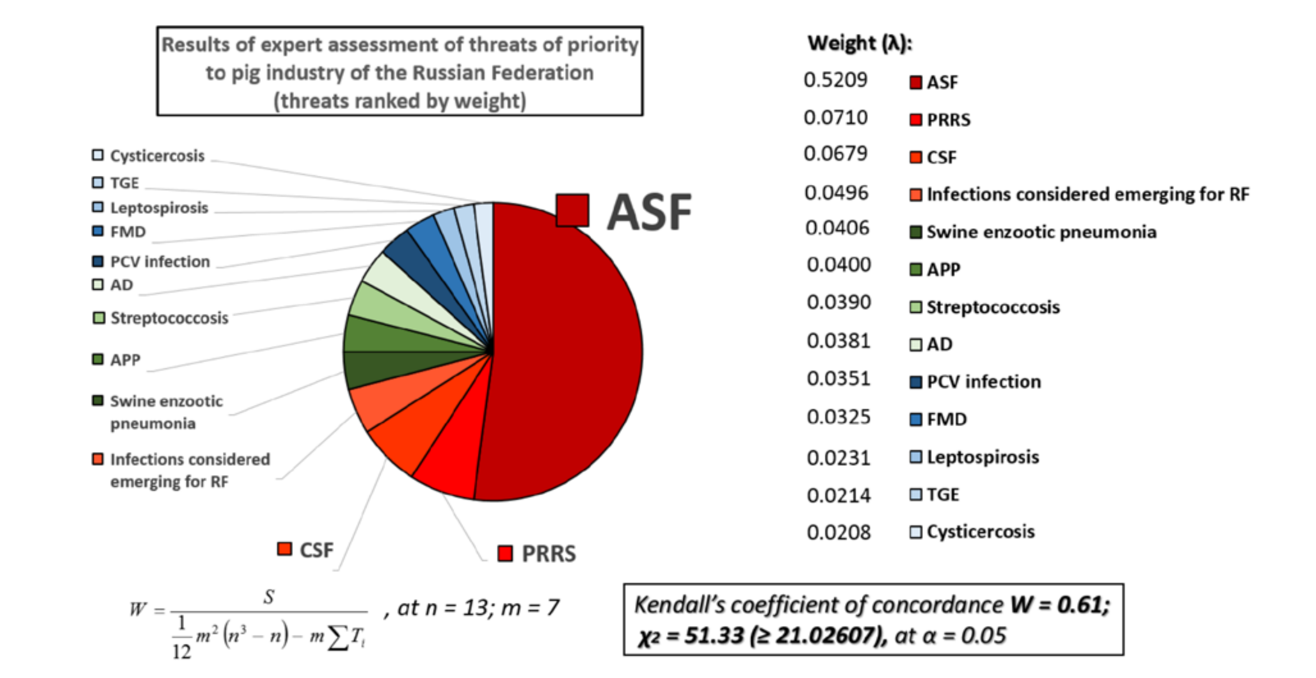
The following are epizootically significant threats, including transboundary ones, to the pig industry: 1) anthrax; 2) foot-and-mouth disease (FMD); 3) Aujeszky's disease (AD); 4) classical swine fever (CSF); 5) African swine fever (ASF); 6) porcine reproductive and respiratory syndrome (PRRS); 7) swine vesicular disease (SVD); 8) Nipah virus infection; 9) cysticercosis; 10) swine brucellosis; 11) rabies; 12) trichinellosis; 13) tuberculosis; 14) transmissible gastroenteritis (TGE); 15) porcine epidemic diarrhea (PED); 16) swine erysipelas; 17) swine enzootic pneumonia (*Mycoplasma hyopneumoniae*); 18) porcine parvovirus (PPV) infection; 19) porcine circovirus (PCV) infection; 20) porcine pleuropneumonia (*Actinobacillus pleuropneumoniae*, APP); 21) Teschen disease; 22) Glässer disease (*Haemophilus parasuis*); 23) streptococcosis (*Streptococcus suis*); 24) leptospirosis; 25) Seneca Valley virus infection; 26) swine dysentery; 27) swine influenza; 28) opportunistic bacterial infections [2, 3, 5, 6].

According to official data on porcine diseases for 2022, cases of swine erysipelas (1), rabies (2), chlamydiosis (2), mycoplasmosis (3), pasteurellosis (4), pseudomoniasis (6), trichinellosis (6), echinococcosis (6), Aujeszky's disease (10), tuberculosis (16), porcine parvovirus infection (20), leptospirosis (42), edema disease (ED) (383), colibacillosis (2,394) and African swine fever (6,626) were reported in the pig and wild boar populations in the Russian Federation [2].

Anthrax, rabies, trichinellosis, tuberculosis and brucellosis in pigs are subject to control by the veterinary authorities of the Russian Federation in accordance with the surveillance pattern that has historically proven to be reliable and that covers all epizootiologically significant areas. Thus, the country has comprehensive measures in place to ensure protection of both animals and humans. The situation for these porcine diseases in the Russian Federation as a whole is stable (controlled risk with sustained surveillance and prevention), the epidemic thresholds have not been exceeded in the past 3 years (from 2020 to the 1st quarter of 2023) [2]. It is expectable that at a particular establishment, the risk level would be most heavily influenced by the veterinary surveillance coverage of domestic and wild pig populations in the pig farming areas, isolation of populations and vaccination quality, where applicable. In case of detection of any of these diseases in the industrial pork production chain, immediate measures shall be introduced to identify and eliminate the source. Regardless of the local significance of these diseases for the establishments, in view of risks to humans, the significance of these diseases is assumed to be high and is not discussed further.

The results of the assessment of 13 main threats ranked by the experts according to their significance for the pig industry of the country (Fig.) showed that ASF has the prevailing priority based on the relative weight (λ) (52%).

Besides, PRRS (7.1%) and CSF (6.8%) occupy a relatively significant place. Infections considered emerging for the Russian Federation (5%) also have a higher priority than other threats (swine enzootic pneumonia, APP, AD, streptococcosis (*S. suis*), PCV infection, FMD, leptospirosis, TGE, cysticercosis), which were assessed as being of moderate or low priority to the pig industry of the country



$$W = \frac{S}{\frac{1}{12}m^2(n^3 - n) - m\sum T_i}, \text{ at } n = 13;\ m = 7$$

Fig. Results of assessment of threats (n = 13) ranked by experts (m = 7) according to their significance for the pig industry of the Russian Federation

(relative weight < 5%). Kendall's coefficient of concordance $W = 0.61$ demonstrates the sufficient degree of agreement among the experts, and the calculated chi-squared statistic $\chi^2 = 51.33$ (≥ 21.02607) indicates that the concordance is not random and the results can be used in subsequent studies. The Figure shows that there are three pathogens prioritized as significant external threats, so we will focus on the discussion of ASF, PRRS and CSF (Table).

African swine fever. By 2023, an ASF panzootic had overtaken 36 countries of the world, including wide areas in Eurasia. Russia has been facing the problem of ASF virus spread in domestic and wild pigs for 16 years [2, 3]. There is no commercially available ASF vaccine that meets the WOAH recommendations regarding safety and effectiveness requirements. The major factor contributing to the transboundary spread of the infection is the human factor (in our country, it is also officially recognized as the main factor according to Resolution of the Federation Council of the Federal Assembly of the Russian Federation No. 207-SF of 28 June 2017[1]), which in some cases can include not only neglect of and intentional disregard for biosecurity rules, lack of competencies, but also a protracted delay in carrying out preventive and eradication activities. Special attention is paid to studying possible ASF virus vectors, including mechanical ones, which, in the light of the global trends of changes in climate and environmental factors, is a task that is gaining relevance for the Russian Federation [7]. The detection of African swine fever virus in susceptible animals in ASF free areas, as well as the detection of ASF virus genome in the ready-to-eat product samples may indicate a continuing trend of ASF persistence.

The factors that contributed to ASF spread in the Russian Federation by 2013 included the diverse structure of pig farming in all federal districts of the Russian Federation and a high proportion of backyards [15], which declined significantly as of 2023. During the ASF epizootic of 2007–2023, the number of compartments and the sizes of herds in the indoor-keeping pig production systems in the Russian Federation were increased, biosecurity plans were introduced. However, population management and biosecurity management were not established systematically along the entire chain. Therefore, it was not possible to completely reduce the increased risk of the disease spread correlating with an increase in the number of farms/links and the expansion of pig and pork turnover in the context of the formation of the "grey market" of animals and meat outside and around the production systems.

The pork production system existing in the Eastern European countries is a combination of large and small pig farms, which is typical for ASF endemic countries [16]. ASF eradication in Spain, Portugal and the Czech Republic went hand in hand with a complete reshaping of the government policy of the disease surveillance, pig population recording, implementation and control of zoning, qualitative changes in diagnosis and establishment biosecurity. The assessment of risk in the biosecurity systems of the establishments plays a key role in the consideration of ASF risk [17], and compliance with the WOAH recommendations on ASF compartmentalization principles can serve as a mechanism for the establishments to contain the spread of the disease [18]. The main components of ASF control are timely and accurate diagnosis, stamping out of infected herds, establishment of restriction zones and tracing of possible contacts. In the future, ASF control should focus on enhanced restrictive measures, compensation of losses, tracing, wild boar control programmes, strict hygiene and biosecurity measures [19, 20, 21]. Activities undertaken to ensure the biosecurity of systems/establishments are aimed at isolating pigs kept there from wild boars [22, 23] and domestic pigs kept in the backyards.

Taking into account the opinions of foreign and domestic experts and summarizing the experience of pork

[1] https://base.garant.ru/71706886/?ysclid=lz81cejes4538929535 (in Russ.)

producers in implementing effective measures to prevent ASF in the pig industry [24, 25, 26], the following recommendations can be made.

1. The origin and movement of feeds, animals, vehicles and other objects, rodents, birds and persons entering the territory of a pig production establishment and having contact with pigs and fomites should be controlled by the biosecurity system of the establishment.

2. Monitoring of the area around the farms is required to demonstrate ASF absence and to maintain the ASF free status of the boundaries/zones. The involvement of backyards in pork production and pig turnover against the background of rising meat prices will remain a factor influencing the unauthorized pig and pork turnover.

3. The use of non-invasive samples from animals and laboratory control of the effectiveness of cleaning, washing and disinfection procedures may be recommended for early detection of ASF virus in the production flow.

4. Future vaccines against ASF shall not only be safe for the pig population and protect animals from death, but shall also be highly effective for routine use in the pig industry (they shall not reduce weight gain or cause abortions and shall prevent the circulation of field and vaccine strains in the pig population). The recognition of the safety and effectiveness of ASF vaccines shall take into account the international standards laid down by the WOAH.

Porcine reproductive and respiratory syndrome. Considerable attention is paid to the prevention of and protection against PRRS [27, 28, 29], given the high contagiousness of the pathogen, its ability to spread between pig farms over considerable distances through airborne transmission, with pigs, feeds and contaminated fomites and to

Table
Situation for priority epizootic threats to pig industry in the Russian Federation

Threat	Situation in the Russian Federation: year of the last reported cases / vaccination / RF status	Special aspects relevant for infection management
ASF	2023 (104 outbreaks: 66 outbreaks in the domestic population and 38 outbreaks in the wild population) / vaccination: none / federal measures to control ASF (Decree of the Government of the Russian Federation No. 1159 of 29 September 2018[2]); compartmentalization (Order of the Ministry of Agriculture of the Russian Federation No. 482 of 11 May 2023[3]); regionalization (Order of the Ministry of Agriculture of the Russian Federation No. 635 of 14 December 2015[4])	Very high priority ($\lambda = 0.52$) 1. The human factor predominates in the epizootiology of genotype II ASF in the Russian Federation. 2. It is necessary to control the implementation of measures aimed at the prevention of contacts between livestock kept at the establishment and environmental objects, including possible mechanical vectors. 3. Surveillance in the populations around and within the establishment shall take into account the possibility of latent infection. Period covered by the retrospective study during the investigation – up to 60 days. Within-herd R_0: from 7.46 (5.68–9.21) to 9.8 (3.9–15.6); between-herd R_0: from 1.65 (1.42–1.88) to 2.5 (2.0–3.0) [8, 9]. Where small farms prevail: within-herd R_0: 10 (1.1–30.0); between-herd R_0: from 1.41 to 10.8. 4. The absence of an effective and safe vaccine; the leading role of diagnostic activities in the production flow and during zoning.
PRRS	2021 (4 outbreaks in the domestic population) / 12,836,888 animals vaccinated / there is no federal programme in place; the current instruction on PRRS control regulates the use of PRRS vaccines for preventive purposes (Order of the Ministry of Agriculture of the Russian Federation No. 625 of 26 October 2020[5]); regionalization; compartmentalization	High priority ($\lambda = 0.071$) 1. Airborne transmission and transmission through fomites between establishments may be underestimated. 2. Vaccination is an effective tool, but only as part of the set of preventive and diagnostic measures. 3. R_0 within seropositive herds: from 3.3 (2.9–4.3) to 7.1 (3.5–10.6) [10, 11]. R_0 for vaccinated against type 1 PRRS ($R_0 < 1$): from 0.3 (0.05–0.96) [12] to 0.53 (0.19–0.76) [13]; for type 2 PRRS – unknown [11]. 4. The need for monitoring (genotyping) of circulating viruses in the vaccinated herds.
CSF	2018 (1 outbreak in the wild population) / 91,679,227 animals vaccinated / the Russian Federation has no official CFS free status recognized by the WOAH; regionalization; compartmentalization	High priority ($\lambda = 0.068$) 1. Effective indirect and direct transmission and spread of the infection. Within-herd R_0: from 3.39 (1.54–7.45) to 7.77 (4.68–12.9) [14]. 2. Vaccination of domestic pigs in the Russian Federation has been enhanced in the last 5 years. The vaccine reliably protects against outbreaks and the development of clinical signs in pigs. There were no outbreaks in domestic pigs and wild boars in 2018–2023. 3. The need for monitoring of circulating CSF virus isolates and vaccination effectiveness in vaccinated pig herds and wild boar populations of the Russian Federation regions. CSF virus circulation in the vaccinated animals is extremely undesirable and dangerous. 4. Monitoring of vaccination quality at the establishment and in the population around the establishment is important for CSF management.

R_0 (basic reproduction ratio) is a metric of infection reproduction (indicator of contagiousness). For all diseases, the control of animal introduction to the establishment, feeds, fomites, disinfection, disinsection and deratization are significant for security management. There are no consolidated biosecurity requirements/rules/standards for pig establishments.

[2] https://base.garant.ru/72065765/?ysclid=lz81dxcy83438154883 (in Russ.)
[3] https://base.garant.ru/406957068/?ysclid=lz81g64bk5614070677 (in Russ.)
[4] https://www.garant.ru/products/ipo/prime/doc/71260810/?ysclid=lz81h1rvb3947478382 (in Russ.)
[5] https://base.garant.ru/74832093/?ysclid=lz81jjcega297725170 (in Russ.)

affect virtually all pig population groups. In cold climates (at t < 0 °C), PRRS virus is able to survive outside the host for a long time, which contributes to contamination and mechanical transmission of the virus with fomites. Livestock transportation vehicles, personnel vehicles, footwear and other objects may come into contact with the PRRS agent in potentially contaminated places (infected farms, commercial truck wash facilities, slaughterhouses, changing and showering facilities, animal care product warehouses, semen transportation, transshipment facilities for tools, food products for the personnel, etc.). In cold weather, PRRS virus can be spread with contaminated objects over long distances (at least up to 50 km) [11, 30], which is relevant for most of the Russian Federation territory with prolonged cold seasons.

According to official data, PRRS spread in the Russian Federation is limited to individual cases detected in different areas every year, which indicates an underestimation of more widespread latent circulation of the virus in the domestic pig population and the insufficiency of current measures to completely eradicate the disease. PRRS poses a great danger to large fully integrated pig establishments [29]. This is confirmed by the results of a study of a large-scale PRRS outbreak that occurred in 2020 on 24 out of 30 farms of a large pig production company located in four Oblasts: the Voronezh, Lipetsk, Tambov and Penza Oblasts. The disease was caused by two variants of wild subtype 1 type 1 PRRS virus (PRRSV-1-1) predominant in Europe and the Russian Federation. The clinical signs varied depending on the pig production stage rather than on the virus variant. Non-compliance with biosecurity measures, including the movement of animals from infected farms, contributed to the spread of the disease. Before spreading across the production system (pig farms, sow farms and fattening farms), PRRSV-1-1 variants were introduced to the region around 2019 [31]. It was at the same time that the co-circulation of type 1 PRRSV-1 (European type) and type 2 PRRSV-2 (North American type) was first reported in Russia. According to the observations of S. Raev et al. and data from the veterinary laboratories, PRRSV-2 is circulating in both the European and Asian parts of the country, and the detection of new subtype 2 of type 1 PRRSV (PRRSV-1-2) during the study of the 2019 outbreak in Siberia confirmed the wide territorial expansion of PRRSV-1-2 in Russia [32].

Only few comparative data exist concerning the pathogenicity of the two types of PRRS virus and mixed infection under the field conditions in the Russian Federation; however, it is known that the isolates of PRRSV-1-1 (including the Russian group of viruses), PRRSV-1-2 and PRRSV-1-3 differ significantly in pathogenicity. Today, PRRSV-1 is a group of genetically diverse isolates from Eastern Europe, Belarus and Russia [33, 34].

The quantitative assessment confirmed that the disease caused by genotype 1 virus can be controlled with vaccines, but they provide only partial protection [11]. Vaccination constrains the dynamics of PRRSV transmission in the population and, according to some sources [12, 13], PRRS basic reproduction ratio within vaccinated herds is $R_0 < 1$ [from 0.3 (0.05–0.96) to 0.53 (0.19–0.76)], which means that the epizootic will eventually die out. On the other hand, some findings show that despite an almost two-fold decrease in mean R_0 values in the groups of vaccinated piglets, R_0 confidence intervals for vaccinated (2.43–39.7) and non-vaccinated (5.93–32.3) animals vary with significant overlap [35], which requires further research. In non-vaccinated endemic/seropositive populations within farms, R_0 ranges from 3.3 (2.9–4.3) to 7.1 (3.5–10.6) [10, 11]. The differences in R_0 values are explained by many factors, including the genetic difference between the vaccine strain and the challenge strain, the environmental/farm conditions (quality of segregation/ventilation) under which pigs are kept, and the difference in strains, to which pigs are adapted on farms.

Despite the absence of the federal target/sectoral programme for PRRS, the existing tools such as the compartmentalization of pig farms adopted in the country, the regionalization of the Russian Federation territory for contagious diseases and the current Veterinary Rules concerning PRRS (Order of the Ministry of Agriculture of the Russian Federation No. 625 of 26 October 2020[5]) are in line with contemporary understanding of PRRS in pig industry and aimed at maintaining PRRS freedom, including through the application of vaccines, and surveillance using diagnostic methods that take into account the vaccination status and allow for strain differentiation (paragraphs 8, 18 and 38 of the Veterinary Rules concerning PRRS). According to the WOAH recommendations (Article 15.3.3 [36]), a country or a farm is considered to be free from PRRS only when no vaccination against PRRS is practised, irrespective of the diagnostic capabilities of PRRS surveillance currently in place in the country.

The epizootiology of PRRS is far from being fully understood, but the available knowledge is sufficient to identify, at least qualitatively, the main sources of the infection on the farm, as well as to detect the main mechanisms of the virus transmission within the farm. The share of each transmission route in the virus introduction in different epizootiological scenarios is still unknown. The eradication of PRRS virus in the pig production systems is a difficult practical task, not just for an individual farm, and in most cases this process covers considerable administrative territories and involves all economic entities/farms [27].

PRRS eradication is a developed set of managerial solutions, including, as a rule, vaccination at the first stages. A combination of strict compliance with biosecurity measures and well-designed vaccination programmes can be useful for PRRS control at both the establishment and regional levels [11], which can be recommended.

Classical swine fever. CSF remains one of the most significant transboundary viral diseases of pigs worldwide and is taken into consideration when setting up surveillance, vaccination and biosecurity systems for farms. The basic reproduction ratio (R_0) for CSF virus, although varying across pig groups and establishments, always remains high: for weaner pigs between-pen R_0 and within-pen R_0 are 7.77 (4.68–12.9) and 100 (54.4–186), respectively, and for adult (slaughter) pigs they are 3.39 (1.54–7.45) and 15.5 (6.20–38.7), respectively [14].

CSF eradication on individual farms located in the CSF infected region/the region where vaccination is practised is an extremely costly policy, which cannot eliminate CSF risk for the region. CSF eradication in the pig production systems of the countries has historically included, as a rule, the depopulation of pigs across the entire regions, the implementation of zoning with progressive CSF eradication

[5] https://base.garant.ru/74832093/?ysclid=lz81jjcega297725170 (in Russ.)

in the zones and only then gaining the official CSF free status recognized by the WOAH. After the introduction of strict control measures, several countries have managed to eradicate CSF; nevertheless, CSF is present, at least sporadically, in most regions of the world with considerable pig production. Due to the proven effectiveness of vaccines currently used in the world against the circulating strains of CSF virus, immunization remains the main measure for pig death prevention [37].

The importance of compliance with the basic protective measures against CSF (control of animal and feed introduction, control of vaccination and immune status of animals, tracing of pigs, etc.), regardless of the reliability and quality of the vaccines used, is confirmed by the results of analysis of data from the surveillance implemented recently in various countries. The surveillance results for the period from 2014 to 2020 showed that in Ecuador, the risk factors that most strongly influenced the odds of CSF occurrence were swill feeding (odds ratio OR 8.53), time until detection (OR 2.44), introduction of new pigs (OR 2.01) and lack of vaccination (OR 1.82). The spatiotemporal model showed that vaccination reduces the risk of CSF spread by 33%. The complexity of CSF control programmes and the importance of improving the surveillance system were highlighted [38]. In 2019, in Laos, the system for porcine disease (brucellosis, PRRS and CSF) surveillance at the slaughterhouses using serological methods did not allow for the differentiation between seropositive vaccinated and infected pigs, which confirmed the need for animal tracing as the basis for surveillance programme implementation in the absence of DIVA strategy [39]. The problems related to the imperfection of diagnostic tests and sampling applied for CSF surveillance in the Russian Federation are also reported, and in this regard the usefulness of implementing both DIVA strategy and appropriate evaluation of vaccination programmes is underlined [37, 40]. It is most advisable that the biosecurity systems of the establishments should be based on the effective surveillance of CSF virus and animal immune status in the production flow.

No CSF cases have been reported in domestic pigs in the Russian Federation since 2015. The country practises routine vaccine prevention in domestic pigs [2]. According to data from the Cerberus Information System as of 1 January 2024, the Vladimir Oblast is declared to be CSF free with vaccination and the Chukotka Autonomous Okrug is declared to be CSF free without vaccination. All other regions of the Russian Federation have no official CSF free status (the status is undefined). Today, the vaccine reliably protects pigs against clinical CSF, and considerable vaccination coverage over the past 5 years contributes to the absence of outbreaks on the farms. Despite vaccination, the risk of latent circulation of the virus in the population remains high.

The main recommendations for CSF risk management at the establishments where vaccination is practised are as follows: 1) the origin and movement of feeds, animals, vehicles and other objects, rodents, birds and persons entering the territory of a pig production system and having contact with pigs and fomites should be controlled by the biosecurity system of the establishment; 2) the control of vaccination effectiveness (tests for immunity level) and targeted monitoring for early detection of possible CSF virus circulation in the immunized animals at the establishments should be an integral part of the surveillance system.

CONCLUSION

The method applied to analyse the expert estimates in the situational analysis allows for rapid assessment and interpretation of the situation with identification of priority diseases to be further addressed.

The overall risk for the pig industry in the Russian Federation that is associated with external sources is currently characterized as permanently high. At present, African swine fever is the absolute priority in terms of threat significance for the pig industry. Kendall's coefficient of concordance $W = 0.61$ demonstrates the sufficient degree of agreement among the experts, and the calculated chi-squared statistic $\chi^2 = 51.33$ (≥ 21.02607) indicates that the concordance is not random and the results can be used in subsequent studies. It is recommended that biosecurity measures against external threats should focus on diseases such as African swine fever ($\lambda = 0.52$), porcine reproductive and respiratory syndrome ($\lambda = 0.07$), classical swine fever ($\lambda = 0.068$) and infections considered emerging for the Russian Federation ($\lambda = 0.05$), which require the adoption and maintenance of risk management measures by both the pig establishments and the State Veterinary Service. The biosecurity systems of the establishments should equally address other assessed external threats significant for the pig industry of the Russian Federation: swine enzootic pneumonia, porcine pleuropneumonia (*Actinobacillus pleuropneumoniae*), Aujeszky's disease, streptococcosis (*S. suis*), porcine circovirus infection, foot-and-mouth disease, leptospirosis, transmissible gastroenteritis, cysticercosis ($\lambda = 0.02…0.05$). The specificities of the epizootiology of the pathogens may underlie gaps in the existing measures; therefore, the measures should be subject to regular re-assessment and adjustment within the biosecurity systems.

The improvement of the governmental policy for the eradication of African swine fever, porcine reproductive and respiratory syndrome, classical swine fever (including the substantial modification of the existing official pig turnover control, zoning, diagnosis and prevention quality, as well as the implementation of biosecurity standards) is the most significant factor, without which the disease eradication perspective is questionable, including given the continuing internal risk of pathogen persistence in the pig population of the Russian Federation or of a particular farm, which is constrained by vaccination that protects against the development of clinical signs. Any weakening / failure of vaccination regimens is likely to result in outbreaks and spread of infection.

At present, there are no consolidated requirements/rules for the biosecurity of the pig establishments. There is also no consolidated standard that establishes biosecurity requirements for production processes at the pig establishments. To a great extent, certain provisions of the current rules concerning diseases partly address the biosecurity of the establishments, which is aimed at preventing animal diseases, and are complemented by the existing requirements for compartmentalization, current rules for keeping pigs at the establishments and veterinary and sanitary requirements for livestock facilities. Excessiveness in the existing rules of requirements and standards related to the biosecurity of the establishments, in the light of their target orientation, cannot be confirmed, nor can their effectiveness and sufficiency for the biosecurity systems of the establishments be attested, especially in the absence of mandatory requirements for the biosecurity systems of the pig establishments.

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Received 15.04.2024
Revised 20.05.2024
Accepted 31.07.2024

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Contribution: The authors have made equal contribution to the study: data collection and analysis; determination of goals and objectives**,** methods of the study; formulation and scientific justification of conclusions, documentation of key outputs from the study in the paper.

Вклад авторов: Авторы внесли равный вклад в проведение исследования: сбор и анализ материала; определение целей и задач, методов исследования; формулирование и научное обоснование выводов, оформление ключевых результатов исследования в виде статьи.