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EXPERT RISK ASSESSMENT OF FMD INTRODUCTION TO THE RUSSIAN FEDERATION FROM INFECTED COUNTRIES

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SUMMARY

Predictive assessment of possible risks of FMD introduction from neighboring countries to the territory of eight RF Federal Districts was presented. The risk quantitative parameters were determined by experts, specialists in the field of FMD epidemiology. To implement the expert survey method most significant routes of infection introduction to the RF were determined. The experts performed FMD introduction risk assessment for each federal district and determined its score. As a result of statistical analysis the greatest probability was determined for the Far-Eastern Federal District. The North Caucasus and Siberian Federal Okrugs demonstrate lower probability. Basing on the obtained data the major routes of FMD introduction to the territory of the country were determined. Preventive vaccination of susceptible animal population is carried out in order to prevent FMD occurrence and spread in the zones at risk of its introduction. It is aimed at FMD outbreak prevention in the specified RF Subjects by inducing protective immunity in at least 81% of immunized cattle and at least 95% of immunized pigs.

Key words: FMD, epidemic situation, expert assessment, introduction risk, anti-epidemic measures.

INTRODUCTION

Due to global deterioration of FMD situation, in 2012 FAO/OIE developed the *Progressive Control Pathway* for *Foot and Mouth* Disease Control (PCP-*FMD*) for affected countries in order to reduce the impact and large-scale spread of the infection [4]. This approach forms the backbone of the OIE/FAO Global Strategy for FMD Control, used by the countries to develop national FMD control programs, and envisages several successive phases. Currently many national veterinary services implement their regional strategies covering control and prevention measures, monitoring tests and establishment of relevant agencies. If a whole country or individual regions are recognized FMD free (where vaccination practiced or not), the critical issue for them is the maintenance of this status under the circumstances of permanent FMD infection of neighboring and bordering countries or countries, involved into import/export operations and trade in animal products. There are several factors presenting risk of FMD introduction to the Russian Federation from affected countries, despite the compliance with the OIE and national requirements for trade operations. Likelihood evaluation of these factors in some Russian regions is a rather topical task today, as it is associated with the need to carry out FMD vaccination in susceptible populations to prevent the disease outbreaks.

MATERIALS AND METHODS

Cartographic analysis of FMD infected countries and reported outbreaks in Asian countries and in the Russian Federation was made using ArcGIS 10.1 software (ESRI, USA). The study is based on the OIE WAHIS available publications [10] and the livestock disease outbreak notification database of the RF MoA. FMD introduction risk into the country was assessed using approved expert assessment technique [3].

RESULTS AND DISCUSSION

Based on the OIE data related to FMD outbreak notifications in 2016 – 2017, the map of affected countries during this period was made (Fig.1). As it is seen on the map FMD, type O and A outbreaks were reported in such neighboring countries, like China and Mongolia. FMD outbreaks registered within this period in Turkey, Iran, and Afghanistan also raise concerns, because Russia has trade relations with these countries in agricultural products, including animal ones.

The fact that some neighboring countries/bordering territories are FMD infected, poses a real threat of infection entry into the Russian Federation. To evaluate the likelihood of FMDV introduction to Russia, the possible ways of its penetration to the country, subdivided into the following categories, were studied:

1. Illegal import of infected (during incubation period) or convalescent animals from affected neighboring countries;

2. Import of animal products (meat, milk, offal, skins and hides, etc.) from diseased (infected) livestock;

3. Import of virus-contaminated animal products and feeds;

4. Migration of infected (diseased) wild animals from neighboring countries;

5. Introduction with seasonal workers or tourists, been in contact with infected animals or animal products;

6. Aerogenic virus transfer from foreign infected settlements/sites to the Russian settlements, located close to the state border;

7. FMD infection of Russian susceptible animals by contact with diseased animals (virus carriers) at common pastures/watering sites of bordering countries;

8. Introduction of virus with contaminated vehicles, equipment, tools and packaging materials.

Taking into account the possible ways of FMD entry from neighboring/bordering countries to the RF Administrative Units, the scoring of their likelihood was made with a scoring system grading from 0 to 10 for each probable introduction way. The likelihood of each FMD entry way into the Federal Districts increased with a higher scoring point. Thirteen scientific fellows of the FGBI "ARRIAH", who are experts in different areas of FMD study, like epidemiology, virology, diagnosis and biotechnology, took part in the inquiry. The likelihood of all abovementioned entry ways for each out of eight Federal Districts using a developed expert judgment method was evaluated [3]. Each expert ($N = 1…13$) gave an appropriate probability scoring point ($x_{i,j}$) for each FMD introduction way ($j = 1…8$) in all Federal Districts ($i = 1…8$). The following scale of mean assessment values was taken as a probability feature of obtained points [7]:

$$X_{i,j} = (\Sigma_{n=1}^{13}(x_{i,j})/13 \text{ for } i, j = 1…8$$

If $\overline{X}_{i,j} \le 3$ is a low likelihood of an entry way;
$3 < \overline{X}_{i,j} \le 5$ is a moderate likelihood;
$5 < \overline{X}_{i,j} \le 7$ is a significant likelihood;
$7 < \overline{X}_{i,j} \le 9$ is a high likelihood;
$\overline{X}_{i,j} > 9$ is a very high likelihood.

The table shows a mean scoring point given by the expert panel for likelihood of different FMD entry ways into the RF Federal Districts.

According to the expert panel responses, the highest likelihood of the infection entry by the studied ways from infected bordering countries to the Russian Federation referred to the Far East Federal District, where four ways of FMD introduction are probable. The likelihood of ways associated with an illegal import of infected (during incubation period/convalescent) animals from affected neighboring countries and animal products from diseased/infected livestock is high and associated with the import of virus-contaminated animal products and feeds and migration of infected (convalescent) wild animals from neighboring countries is significant.

Fig. 1. FMD outbreaks registered in the world in 2016 – 2017

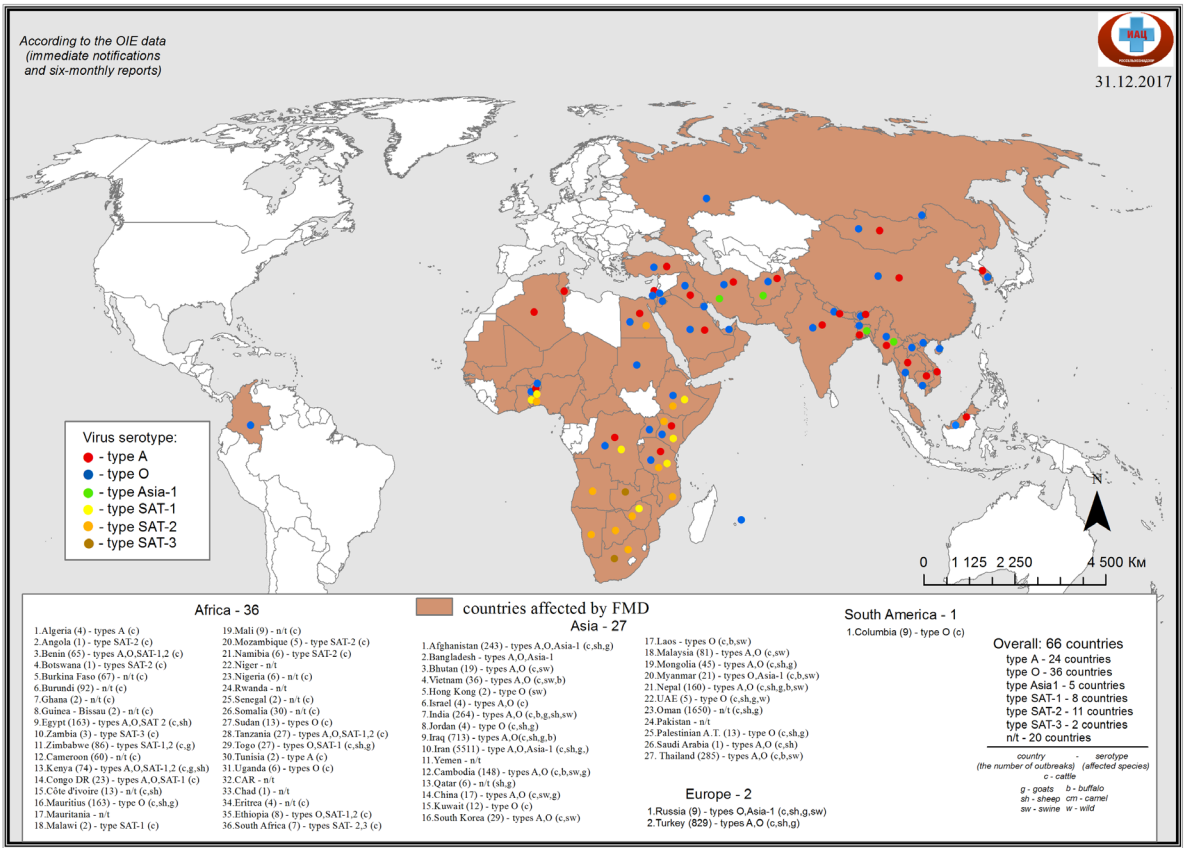

Table
Expert Panel Points

No.	Federal District	Mean scoring point of possible FMD entry ways into RF Federal Districts ($_{i,j}$) from infected neighboring/bordering countries								
		1	2	3	4	5	6	7	8	Y_i
1	North Caucasus	8.2	6.3	4.7	4.8	3.4	3.5	6.5	4.1	0.519
2	South	7.3	5.7	4.3	3.4	3.2	2.5	3.0	3.3	0.409
3	Siberia	7.2	5.8	3.9	5.5	3.6	3.5	4.9	3.3	0.471
4	Far East	8.2	7.5	5.3	5.3	4.8	3.9	4.8	4.0	0.547
5	Central	3.5	3.0	2.7	0.5	3.7	0.5	0.5	1.6	0.020
6	Ural	5.3	4.8	3.4	3.0	2.5	1.4	2.1	2.4	0.311
7	Volga	5.7	4.6	4.4	2.5	2.8	1.7	2.2	2.8	0.334
8	Northwest	1.5	2.5	2.0	0.4	2.1	0.4	0.3	1.8	0.137

With regard to the Siberia Federal District the likelihood of FMD introduction with an illegal import of infected (during incubation period/convalescent) animals from affected neighboring countries is high. Entry of FMD with the migration of infected (convalescent) wild animals and with animal products from diseased/infected livestock presents a significant likelihood.

There is a high likelihood of FMD introduction with an illegal import of infected (during incubation period/convalescent) animals from affected neighboring countries for the North Caucasus and South Federal Districts. The likelihood related to the import of animal products from diseased/infected livestock is significant. Besides the likelihood of FMD introduction with Russian susceptible animals, infected by contact with diseased or convalescent animals at common pastures or watering sites of bordering countries, was recognized significant for the North Caucasus Federal District.

Speaking about the Ural and Volga Federal Districts, the likelihood of FMD entry with illegal import of infected/

Fig. 2. Probable routes of FMD introduction to the RF

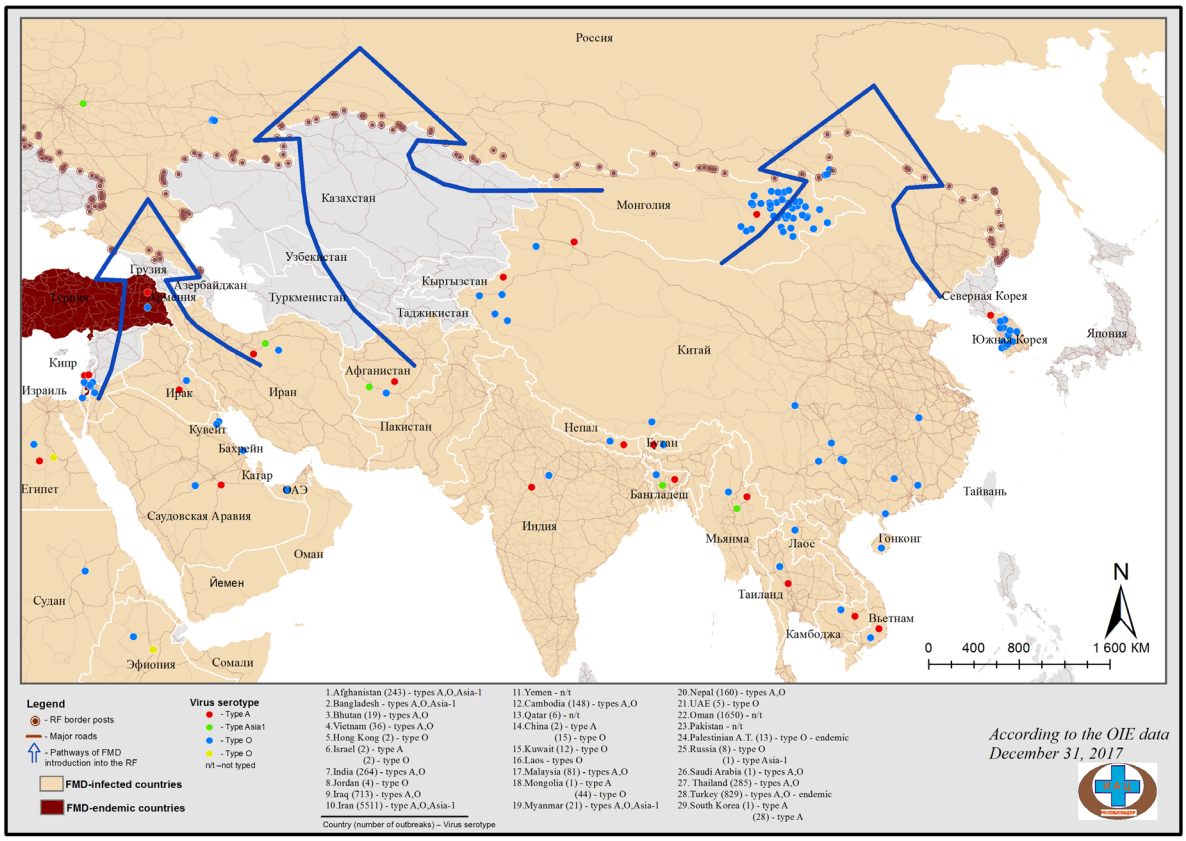

Fig. 3. RF Administrative Units where FMD (A, O, Asia-1) vaccination and monitoring were carried out

convalescent animals from affected neighboring or bordering countries was considered significant.

The common scores of the event likelihood (*"FMD entry likelihood"*) were obtained for all Federal Districts (Y_i), by summarizing all abovementioned ways of the infection introduction into their territories. This value was calculated using the following formula:

$$Y_i = (\Sigma_{j=1\ldots8} \overline{X}_{i,j})/80 \text{ for } i = 1\ldots8.$$

It means the obtained mean scores for all studied ways of FMD introduction for each Federal District were added together (sums of values in each line of the Table) and the total sum was divided by the highest acceptable value equal to 80 score points. Judging by the figures shown in the Table the highest likelihood of FMD introduction is calculated for the Far East Federal District, bordering FMD infected China. Within the last decade, there have been two reports of FMD outbreaks in the region. The annual likelihood is 0.2 (2/10) and this suggests that at least one event is likely to occur within the next five years [1].

The likelihood of FMD introduction to the Siberia Federal District remains high. Within the last decade (2009–2018) FMD has been regularly registered in the Zabaikalsky Krai for seven years. It means the corresponding qualitative likelihood of the event occurrence is about 0.7 (7/10). According to the RF Emergencies Ministry classification [1], this means "the event would be likely to occur" (FMD outbreak is likely to occur) and its exposure (spread) will cover one or several regions.

Next in the FMD introduction risk come the North Caucasus and South Federal Districts, because their territories border such FMD infected countries as Turkey and Iran. Within the abovementioned period of study, FMD was reported there once, in 2013. Based on annual likelihood of 0.1 (1/10), the event would likely to occur at least once within the subsequent period (2014–2023).

Using the mentioned scale, the likelihood of FMD introduction into the Ural and Volga Federal Districts is recognized as "moderate", taking into account the fact that during a long period (more than 30 years) these territories have been FMD free. In 2017, FMD was reported in Bashkortostan for the first time (Volga Federal District). Thus, there is a certain likelihood of the event (FMD entry) during the next ten-year period.

To summarize, the analysis of expert responses showed that in the light of endemic FMD infection of some neighboring countries, threat of FMD introduction to the Russian Federation by three routes, still remains (Fig. 2).

Far East Route implies likelihood of FMD, types O and A introduction from South East Asia infected countries.

North Caucasus Route implies likelihood of FMD, types A, O and Asia-1 A introduction from Turkey and Iran.

Central Asia Route implies likelihood of FMD, types O and A introduction from bordering south countries, as well as from China and Mongolia.

One of the tools to prevent probable FMD occurrence, resulting from the virus introduction from infected countries is vaccination of susceptible animals in the administrative units of the RF Federal Districts, which are involved into large-scale economic links with such countries or are adjacent to their borders. Common territory of the units where animals were vaccinated in 2017 is shown in Figure 3.

As it is shown by Figure 3, all cattle and small ruminants were vaccinated against FMD, types A, O and

Asia-1 along the whole southern border of the Russian Federation.

When assessing risks of FMD introduction into the Russian Federation and analyzing the effectiveness of preventive vaccination in risk zones, the evaluation of immunity level in the population becomes a topical task in order to stop the spread of the disease in case of its introduction.

To calculate an appropriate vaccination coverage (P), which will ensure the prevention of FMD spread, the following common formula was used [8]:

$$P = 1 - (1/R_0),$$

where R_0 is the basic reproduction number [2] (the average number of new infections caused by one typical infectious individual, during its entire infectious period, introduced into a population, made up entirely of susceptible individuals).

R_0 was determined by the analysis of available publications on FMD spread in animal population, infected by different means. For example according to C. Bravo de Rueda et.al. [6], the highest R_0 was six when infection was transmitted from infected sheep to cattle. R_0 calculated for FMD transmission to calve population from infected animals or contaminated environment was assessed as 4.6 [9]. Taking into account these two data subsets, the basic reproduction number for cattle is 5.3. For non-vaccinated pig populations the lowest R_0 turned out to be 20 [5].

Thus, if $R_0 = 5.3$, then $R_0 = 1 - (1/5.3) = 0.81$, In other words, 81% FMD vaccine coverage is necessary to stop the spread of the disease in a population, provided that all animals develop protection immunity.

For pigs this value is the following: $R_0 = 1 - (1/20) = 0.95$, it means 95% of animal population should be vaccinated on risk farms to protect pigs from FMD.

CONCLUSIONS

The obtained expert evaluation results for FMD introduction to the RF territory from infected neighboring countries demonstrate high likelihood of the event occurrence in some Federal Districts, primarily in Far East and North Caucasus Federal Districts.

To prevent FMD outbreaks and spread it is necessary to vaccinate at least 81% of susceptible cattle population. The ratio for pigs will be higher and is approximately equal to 95%.

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