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MANAGEMENT AND CONTROL PROGRAM FOR SUPPRESSION AND ERADICATION OF CLASSICAL SWINE FEVER IN SERBIA

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Classical swine fever (CSF) has been present in Serbia for a long period of time as an endemic disease, and it occurs with lesser or greater intensity from year to year. Since it is a highly contagious disease of domestic and wild pigs, the outbreaks of the disease causes severe consequences for animal welfare, livestock production and economic losses to the national economies in countries where it occurs. Therefore, CSF has a great epizootiological and economic importance to the swine production, primarily because of trade restrictions for live pigs and pork products. CSF eradication and control programmes are generally based on vaccination strategies in countries with endemic occurrence of CSF or non-vaccination policies in contries wich successfully eradicated or are free of CSF. Whatever the general eradication stategy is in place, in the case of an outbreak of CSF the stamping-out method is used for suppression and eradication of the disease, with strict implementation of specific veterinary-sanitary measures in the infected and surveillance zones, clearly defined by legal provisions.

In the period before 2006, there were certain regions in Serbia where CSF occurred almost every year, including regions where pig farming was not the primary branch of animal husbandry. Pig identification and implementation of vaccination, as well as the control of trade of pigs from infected areas to other parts of the country were not very successful. Due to the serious losses inflicted by the disease, a new Programme of CSF control was adopted in 2006, which inter alia included the obligatory identification of pigs, registration of pig holdings and free of charge vaccination of all susceptible animals in the country, as well as the implementation of other statutory measures, including obligatory evidence of veterinary activities in the national Veterinary information system. The results obtained in the period after the implementation of the Programme of CSF control (2007, 2008 and 2009) indicate a positive impact on the reduction of outbreaks of CSF, as well as on the reduction of prevalence ($p<0.001$). Also, the effectiveness of vaccination of pigs in 2007 compared to the period

before and after the implementation of the Programme was the highest (97.78%), as well as the costs of its implementation.

Key words: Classical swine fever, Economics, Programme of control

INTRODUCTION

Classical swine fever (CSF) is an extremely dangerous viral infectious disease of pigs, both domestic and wild. Due to the large epizootiological and economic importance to swine production and the environment, CSF was classified on the List A by the World Organization for Animal Health (Office International des Epizoothies – OIE) (Edwards *et al*., 2000). From 2007 it is on the national list of highly dangerous animal diseases in Serbia, as well as the list of compulsory notifiable animal diseases in Serbia, EU and OIE. The method and the dynamics of transmission, high contagiousness and speed of the disease transmission when it occurs, causes severe direct and indirect economic losses in the economy of every country (Mangen *et al*., 2001; Tešić *et al*., 2002). Direct damages are represented as deaths, culling of all pigs on the positive farm and contact holdings and costs arising from the implementation of veterinary-sanitary measures in the process of suppression of CSF, while indirect damages cause market disruptions arising from the prohibition of the trade of pigs and pork products. Rapid identification and response mechanisms are therefore of paramount importance when such an outbreak occurs.

Damages that arise in the case of occurrence of CSF in a country with developed pig farming and a high pig population density are in excess of hundreds of millions or even billion euros, which was registered at the end of the last century in the European Union. The disease is widespread throughout the world, and it occurs with different dynamics in nearly a quarter of countries worldwide and it is present in some European countries (Terpstra and de Smit, 2000; Stegeman *et al*., 2000).

CSF has a great significance from the standpoint of international trade, according to whose rules it is prohibited to trade live pigs and pork products from countries where the disease appears or where vaccination is in place. CSF causes disruptions in production and domestic trade of pigs, as well as a variety of problems that follow the ban on trade outside the country (Zepeda *et al*., 2001; Mangen *et al*., 2002; Tešić *et al*., 2003; Klinkenberg *et al*. 2005). This is particularly important for countries that have a market surplus of pork and pork products, and that are exporting to other countries. A similar situation happens in other countries by limiting domestic trade, or prohibiting trade of pigs and pork products in certain areas, which is regulated by a special regulation (Elbers *et al*., 2001; Mangen *et al*., 2002).

The programme of CSF control is essentially based on the vaccination or non-vaccination of pigs. At the outbreak of the disease in both cases the stamping-out method is used for suppression and eradication of the disease, and certain veterinary-sanitary measures are implemented in the infected and

endangered areas that are clearly defined by legal regulations (Panjević, 1994; Rajković, 2005; Plavšić *et al*., 2009). A program of mandatory vaccination of pigs that was implemented for a long time generally did not achieve the expected results, therefore in the EU countries, as well as in the most countries in the world, vaccination of pigs is no longer applied (Klinkenberg *et al*., 2003). None of the existing programmes of CSF control that were applied in the European countries and the world, has so far proved to be highly efficient with regard to the occasional occurrence of the disease. In the EU countries stamping-out is implemented as a basic measure of suppression, while the emergency vaccination could be allowed only in endangered areas by strictly defined rules (Saatkamp *et al*., 2000, Klinkenberg *et al*., 2003).

The appearance of CSF in Serbia has a different dynamics, appearing more frequently in some regions and very rarely in others. The reason for this situation lies primarily in the nonhomogeneity of areas and different ways of keeping pigs with a very high number of pig holdings. However, if we bear in mind that the national program for identification and registration of pigs in Serbia is performed only since 2006, then it is quite logical that the uncontrolled trade of pigs from areas where this disease occurs endemically was very difficult to control, which was crucial for the spread of the disease (Panjević, 1994; Nedić *et al*., 2002; Rajković, 2005). These reasons have led to the development of new strategies for the eradication of CSF in Serbia, which consists in the preparation of the Programme of disease control with the use of systematic identification and registration of pigs, registration of pig holdings (farms) and the implementation of free of charge vaccination, as well as with the use of certain veterinary-sanitary measures which are prescribed by legal regulations, together with obligatory evidence of all these activities in the central information system. Therefore, this paper will analyze the impact of the Programme of CSF control on the epidemiological situation of CSF in Serbia, with special emphasis on the effects achieved at the emergence of new outbreaks of the disease, prevalence, incidence and use of veterinary-sanitary measures for eradication of the disease in the period between 2007 and 2009.

MATERIAL AND METHODS

A retrospective review of data on outbreaks, prevalence and incidence of CSF in Serbia during 2005 and 2006 was used from the records kept by veterinary institutes, inspection and Veterinary Directorate. These data on the epidemiological situation of CSF were analyzed by countries from 2005 until 2009. New CSF control programme in Serbia stipulated a mandatory implementation of the identification of pigs prior to movement and/or vaccination, as well as compulsory vaccination of pigs which was free of charge for animal owners and keepers on the whole territory of Serbia. The implementation of the Programme started in the second half of 2006, and 2007 was regarded as the initial year for monitoring. Each veterinary organization authorized to implement the programme was required to keep accurate records of the number of tagged and vaccinated pigs and to notify and report to the Veterinary Directorate all

prescribed actions through the web-based Veterinary Information Management System (VIMS), i.e. to archive all activities in the central database.

The effectiveness of vaccination carried out at the national level was measured by putting the number of vaccinated pigs in a calendar year in the relation to the number of susceptible pigs in the current year. The approximate number of susceptible pigs for the observed calendar year was calculated from the balance sheet, which was kept by the official statistics, in a way that the sum of breeding pigs and newborn piglets was reduced by the number of dead pigs and pigs slaughtered in a calendar year. Economic losses per year are determined in their natural form, as the number of dead and culled animals. Direct costs for implementation of the programme, besides the cost of animal identification and vaccination (vaccine and work) include the costs of laboratory investigations, compensation for owners and implementation of veterinary-sanitary measures. The amount of these costs is defined in the nominal value on the basis of current records kept by the Veterinary Directorate through the VIMS. The costs of immunoprophylaxis were calculated as the product of the number of vaccinated pigs and vaccine price, labor costs and marking costs. We determined the prevalence as the total number of cases (or outbreaks) of CSF in a specific pig population in the whole country during the course of a given period (one year). The significance of difference in calculated prevalence, incidence and number of CSF outbreaks, was determined between the periods before and after the beginning of the Programme implementation, and the assessment of statistical significance was done at the level of accuracy between 0.05 and 0.001. Methods of descriptive statistics and the structure indices were used for data processing and for their presentation, while the assessment of significance was determined by the Student's t-test.

RESULTS

The number of outbreaks of CSF in 2005 was quite high with 342 focuses, in 2006 it was higher by 17.25%, while in 2007 the number of outbreaks was reduced by sixteen times compared to the first and nineteen times compared to the second year, respectively (Table 1). In the following years there were no new cases of CSF registered. Considering that in two years prior to the beginning of the implementation of the Programme of CSF control there was a high number of registered foci, hence the number of endangered animals was high as well, and in 2006 it was higher by 85.07%. However, in 2007 the largest number of endangered animals was registered since the CSF appeared on a high capacity commercial pig farm. The number of dead pigs, since the appearance of CSF, was highest in 2006 and lowest in 2007, while the number of culled pigs on infected holdings or farms was highest in 2007, and lowest in 2005. During the second and third years of the implementation of the Programme (2008 and 2009) no outbreak of CSF was registered in Serbia. The high significance of differences in the number of CSF outbreaks was determined after the implementation of the Programme in relation to the previous period 2005-2006 ($p<0.001$), as well as the significant difference in the endangered, dead and killed pigs ($p<0.001$).

Table 1. The outbreak of CSF in the period 2005-2009.

No.	Year	Outbreaks	Endangered	Died	Stamped out
1.	2005	342	8 271	5 370	2 901
2.	2006	401	15 307	6 361	8 946
3.	2007	21	21 712	5 040	16 672
4.	2008	0	0	0	0
5.	2009	0	0	0	0
6.	2005-2009	152.80	9 058.00	5 590.33	3 467.67

The high significance of differences in the number of appearances of CSF foci, as well as was in the endangered, dead and culled pigs was determined after the implementation of the Programme in relation to the previous period 2005-2006 (Figure 1).

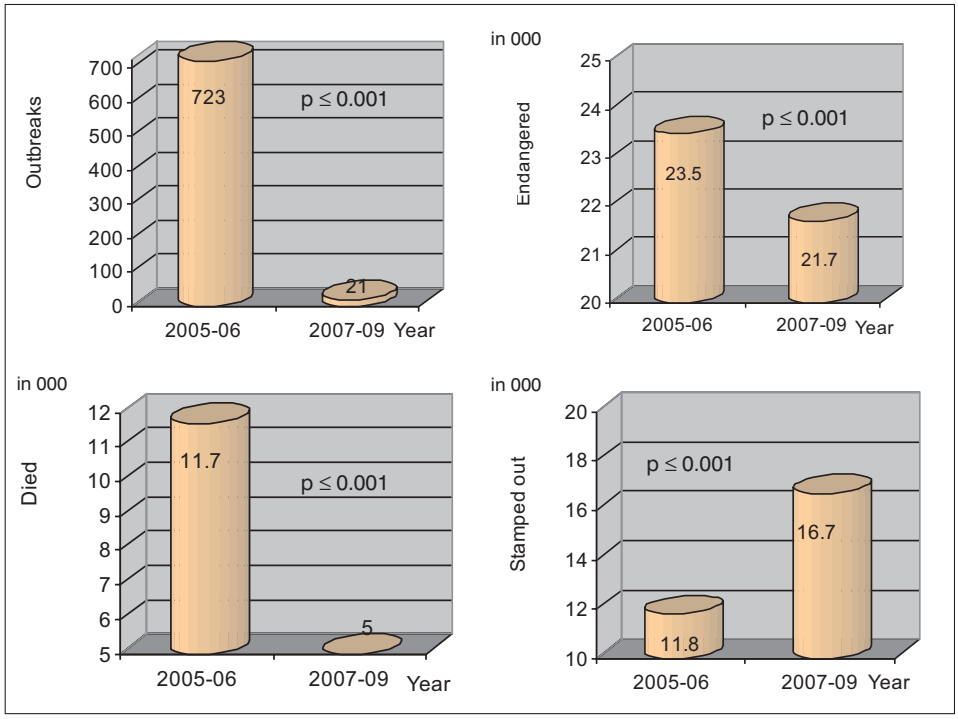

Figure 1. Assessment of the significance of CSF appearance

The trend of prevalence in the period prior to the beginning of the implementation of the Programme of CSF control was growing until 2007, and then it becomes negative, i.e. there are no endangered animals, $p<0.001$ (Tab. 2).

Table 2. The occurrence of prevalence of CSF in the period 2005-2009.

No.	Year	Prevalence
1.	2005	0.1695
2.	2006	0.3427
3.	2007	0.5178
4.	2008	0
5.	2009	0

Significant differences in the occurrence of prevalence of CSF between the periods before and after the implementation of the Programme of disease control is very high ($p<0.001$), as well as in the occurrence of incidence between the two periods (Figure 2).

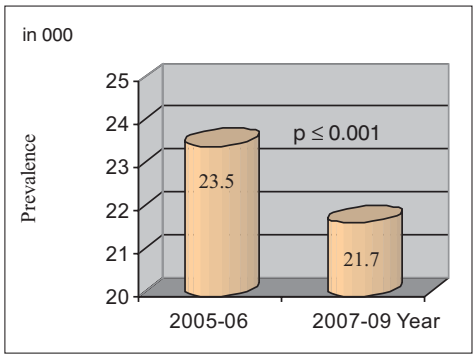

Figure 2. Assessment of the significance of prevalence the occurrence of CSF

Number of vaccinated pigs in the period before the implementation of the Programme of CSF control was significantly lower than in the year of implementation, as well as in the following years after the implementation of the programme (Table 3). The highest number of vaccinated pigs was in 2007, the lowest in 2006, and in the period after the implementation of the Programme of CSF control, the number of vaccinated pigs was reduced by 25.72% and 30.66% respectively. However, the effectiveness of the implemented vaccination of pigs against CSF in Serbia showed that in the year prior to the programme implementation of 56.18% of the population of susceptible pigs were included in vaccination, and in 2007 97.78%, so that in the next two years the immunoprotection of pigs was reduced.

Costs of implementation of the Programme of CSF control in Serbia were high and in average for the observed period amounted to 265 714 644.50 RSD (Table 4). Having in mind that the vaccination costs had the largest share in the cost structure in the implementation of the Programme of CSF control, the changes in total costs were in proportion with the number of vaccinated animals.

Table 3. The effectiveness of vaccination of pigs against CSF in the period 2006-2009

No.	Year	Pigs marked	Pigs vaccinated	
			No.	%
1.	2006	2 520 702	2 509 289	56.18
2.	2007	4 093 997	4 099 167	97.78
3.	2008	3 045 952	3 045 152	84.17
4.	2009	3 045 952	2 842 509	75.92

Table 4. Costs of the Programme of CSF Control in the period 2005-2009

(in %)

Year	Total, RSD	Vaccinat. of pigs	Disease diagnostic	Damage compensation	Vet-san measures
2006.	194 642 780	91.46	0.55	3.65	4.34
2007.	330 944 639	96.97	0.13	1.88	1.02
2008.	266 778 861	98.12	0.11	1.11	0.66
2009.	270 492 298	99.83	0.17	–	–
Ø	265 714 644.50	96.89	0.21	1.08	1.82

DISCUSSION

Classical swine fever (CSF) appears in Serbia in the observed period with a lesser or greater intensity (Panjević, 1994; Simić *et al*. 1998; Nedić *et al*., 2002; Rajković, 2005). If we compare these results with the data from other authors we will see that the situation is very similar in other European countries (Stegeman *et al*., 1999; Laddomada, 2000; Fritzemeier *et al*., 2000; Mintiens *et al*., 2001; Elbers *et al*., 1999). The data quoted by these authors in their researches, as well as the results of our study indicate that the CSF occurs every year, and that the epizootic situation is, generally speaking, quite unsatisfactory. The number of outbreaks increased in 2005 and 2006, and in 2007 it drastically decreased, while in the following two years no CSF outbreaks were registered.

The prevalence increased in the first three years, and in 2008 and 2009 it was negative, i.e. there was not a single case of endangered animals. However, the highest prevalence rate (0.5178%) was recorded in the year of the beginning of the implementation of the Programme of control because CSF occured on one commercial farm where 15 055 pigs died or were culled. Trends in incidence during the first three years of the study showed a decrease, so that in the last two years after the implementation of the Programme there were no new cases. Certainly, the number of outbreaks has significance only in terms of timely response to disease suppression and eradication, while for the unimpeded

functioning of the international trade it is essential to know whether the CSF is present or not (Zepeda *et al*., 2001).

Starting from the economical importance of pig farming for the national economy, it is very important to prevent the occurrence of CSF in the country, and if it has already appeared it is necessary to take all necessary measures for eradication and unimpeded trade (Elbers *et al*., 2001; Mangen *et al*. 2002; Tešić *et al*., 2003; Klinkenberg *et al*., 2003). Considering that the CSF occurs in Europe in some countries or in 25% of the countries on the global level, then the epidemiological situation of the disease requires a serious analysis in order to undertake certain measures to mitigate the economic consequences arising from its appearance.

All this suggests the need for a strategic approach when developing programmes for the control of CSF at the national and regional level. However, most authors coming from the countries which had a problem with CSF in the last decade of the previous century (Germany, Belgium, the Netherlands) emphasized that the improvement of existing control programmes and their adaptation to the new scenario of events should be the basis for the control and eradication of diseases (Horst *et al*. 1997; Laddomada, 2000; Terpstra and de Smit, 2000; De Vos *et al*., 2004; Karsten *et al*., 2005).

More frequent occurrence of CSF is registered in municipalities with extensive swine production, which confirms the fact that the problem of classical swine fever in this area is a consequence of trade of pigs or swine products from zones where the disease is constantly present (Valčić *et al*., 1995; Simić *et al*. 1998; Nedić *et al*., 2002; Rajković, 2005). The most common source of the disease were the animals that come from illegal movement, of unknown origin, unidentified and with no data on previous vaccinations. The disease was spread both directly and indirectly. In the infected municipalities and settlements the spread of the disease to the neighboring areas and the formation of secondary outbreaks was rarely taking place, because the measures for its eradication were timely undertaken (Nedić *et al*., 2002; Rajković, 2005). The following authors referred to the problem of trade of pigs in their works: Horst *et al*., 1999; Fritzemeier *et al*., 2000; Elbers *et al*., 2001; Mintiens *et al*., 2001, and stated that illegal trade and inadequate measures implemented in trade posed a constant threat to the re-emergence and spread of the classical swine fever.

The level of economic damages occurring by the outbreak of the disease is shown in Table 1. In the period between 2005 and 2009 the average annual mortality of pigs amounted to 5 590.30, and 3 467.67 were culled, i.e. total losses or endangeredness of pigs amounted to 9 058.00 pigs, while after the program in 2008 and 2009 there were no registered losses. The value level of economic damages caused by the occurence of CSF was highest in 2007, as the disease occured in one commercial farm which had a large number of pigs, while it was lowest in 2005. Comparing the level of damage incurred from the death and killing of pigs in Serbia with the damages of countries with intensive swine production (Germany, Belgium, the Netherlands), we come to the conclusion that the level of damage here is far lower, since the number of pigs in individual farms is much smaller. Also, the reason for this is certainly a difference in the concept of control

and accepted program of non-vaccination of pigs in the EU countries, and the implementation of "stamping-out" method (Bernard *et al*., 1999; Stegeman *et al*., 2000; De Vos *et al*., 2004). We implemented the suppression of the disease only in the infected area, while in those countries which used the non-vaccination program, stamping-out measures were implemented in a much wider range, and therefore the damages were far greater (Mintiens *et al*., 2001).

Programme of CSF control in Serbia so far has been based on the preventive vaccination of all susceptible pigs according to defined vaccination program, and, if an outbreak occurs, implementation of number well prescribed veterinary-sanitary measures, which include the depopulation of pigs in infected and contact holdings and other measures in protected and surveillance zones.

Analyses of eradication programs in Serbia during last two decades show that the programme was not conducted in an adequate way, because the number of vaccinated pigs was not high, and the percentage of protected animals was average. In the period between 1994 and 2004 in Serbia the average of 55.82% of susceptible animals were vaccinated, while during the time when the owners had to pay for the vaccination of their pigs, between 2002 and 2004, only 32.25% of pigs were vaccinated, and in the period between 1994 and 2001 when the vaccination was free for animal owners 64.66% of pigs were vaccinated (Rajković, 2005). However, according to our research in the period 2007-2009, when the new programme of CSF control was introduced a substantially larger number of pigs were vaccinated in relation to these indicators. The costs of vaccination of pigs against CSF varied from year to year, and they are proportional to the number of vaccinated animals. Within the total costs of implementing the programme for control and eradication of CSF, the vaccine costs were accounted for 18.40%, and labor costs for 81.60% as indicated by the results cited by Rajković (2005) in his research. Klinkenberg *et al*. (2003) stated that the introduction of emergency vaccination during the CSF epidemic was an unavoidable option, both for ethical, as well as for social reasons. They propose the introduction of marker vaccine in the model presented on the basis of the data on the outbreak of CSF epidemic, which occurred in the Netherlands in 1997/1998.

National Strategy for the control of CSF should be based on good knowledge of the epidemiological situation of disease, the application of modern mathematical and statistical methods in developing control programs and economic evaluation of proposed programs (Horst *et al*., 1999; Meuwissen *et al*., 1999; Tešić *et al*., 2002; Mintiens *et al*., 2003; Mangen *et al*., 2003). Identification and registration of pigs, registration of pig holdings and systematic record keeping of the number of pigs in the country is very important for the successful control of CSF (Saatkamp *et al*., 1997). Analyzing the system of pigs identification in Belgium, the authors suggest that identification of animals in the control of CSF directly affects the reduction of economic losses and frequency of the disease occurence, and that it can be used to control other diseases. Within the Programme of CSF control in the EU the greatest attention is devoted to the analysis of the current strategy, which is based on the non-vaccination of pigs and control of ten kilometers (Saatkamp *et al*., 2000).

The identification of pigs in Serbia started in 2006 and during that year 56.19% of the total number of pigs was marked, and this number was significantly higher in 2007 (97.76%) and then it decreased over the following two years by one-fifth. Introduction of information systems and software development in the control of infectious diseases are becoming essential parts of modern epidemiology and economics of animal health protection (Stark *et al*. 1998; Klinkenberg *et al*. 2003; Mangen *et al*. 2003; Plavšić *et al*., 2009). Veterinary Information Management System (VIMS) in Serbia enables the creation of the register of the animal owners/keepers and the number of identified pigs, thus creating preconditions for a structural approach to solving problems of disease control and timely decision-making on the choice and implementation of programs.

Programme of CSF control in Serbia that began with implementation in 2007 covered 97.78% of susceptible animals, and the total costs of the program amounted to 330 944 639 RSD. This program included the simultaneous implementation of the pig identification system and systematic keeping of records, vaccination of all susceptible animals, diagnostic investigations, compensation for owners and implementation of veterinary and sanitary measures in the infected holdings, protective and surveillance areas. In the cost structure of the above mentioned Programme of CSF control, vaccination in average accounts for 96.89%, diagnostic disease for 0.21%, demange compensation for 1.08%, and implementation of veterinary-sanitary measures accounts for 1.82%.Effects of the implementation of Programme of CSF control are evident in the period 2008-2009, so the occurence of new CSF outbreaks was not registered, as well as the prevalence and incidence ($p<0.001$). Costs of disease control were reduced by 60 452 341 RSD or in average by 20.00%.

Based on these results we can conclude that the implementation of a consistent Programme of CSF control in Serbia, which included the identification/registration of pigs, holding registration and keeping records of vaccination, created a favorable epidemiological situation in the country, which, from the standpoint of the development of swine production, trade of pork and pork products, had a very important economic justification.

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MENADŽMENT I KONTROLA PROGRAMA SUZBIJANJA I ERADIKACIJE KLASIČNE KUGE SVINJA U SRBIJI

NEDIĆ D, TEŠIĆ M, BALTIĆ M, PLAVŠIĆ B, TAJDIĆ NADA, MIRILOVIĆ M i RAJKOVIĆ M

SADRŽAJ

Klasična kuga svinja (KKS) je prisutna u Srbiji prisutna duži vremenski period i sa manjim ili većim intenzitetom javlja se iz godine u godinu. Kako je u pitanju infektivna bolest svinja, a polazeći od karaktera njenog širenja sama pojava bolesti nanosi velike ekonomske štete za privredu svake zemlje. Stoga KKS ima veliki epizootiološki i ekonomski značaj za svinjarsku proizvodnju, a pre svega za stvaranje nesmetane mogućnosti odvijanja prometa svinja i proizvoda od svinjskog mesa. Program kontrole KKS se može izvoditi vakcinacijom ili biti bez nje. Kod pojave bolesti se i u jednom i drugom slučaju za suzbijanje i iskorenjivanje primenjuje metod "stamping-out", i sprovode se određene veterinarsko-sanitarne

mere u zaraženom i ugroženom dvorištu koje su decidno definisane zakonskim propisima. U proteklom periodu u Srbiji su postojali određeni regioni gde se KKS javljala skoro svake godine, a naročito je bila zabrinjavajuća pojava širenja bolesti u regione gde svinjarstvo nije primarna grana stočarstva. Kontrola prometa svinja iz zaraženih područja u druge delove zemlje bila je na niskom nivou. Zbog ozbiljnih gubitaka koje je nanosila pojava bolesti, donet je novi Program kontrole KKS koji između ostalog podrazumeva obavezno obeležavanje svinja i besplatnu vakcinaciju svih prijemčivih životinja u zemlji, kao i sprovođenje drugih zakonom propisanih mera. Dobijeni rezultati u periodu posle sprovođenja Programa kontrole KKS (2008. i 2009. godine) ukazuju na pozitivan uticaj ovih mera na smanjenje pojave žarišta KKS, kao i na smanjenje prevalance ($p<0,001$). Takođe, efikasnost sprovođenja vakcinacije svinja bila je najveća (97,78%) u 2007. godini, u odnosu na period pre i posle sprovođenja Programa.