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Insights into the National Prevention and Control Strategies of Major Animal Epidemic Diseases in China-Analysis from the Point View of Social System and Economic Management

¹Kerong Zhang and ^{2,3}Wuyi Liu

¹School of Economics and Management, Fuyang Normal University, China

²Department of Science and Technology, Fuyang Normal University, King He West No. 100, Fuyang 236037, China

³Department of Biology Sciences, Faculty of Biological and Food Engineering, Fuyang Normal University, Fuyang, China

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Corresponding Author:

Wuyi Liu

Department of Science and Technology,

Fuyang Normal University,

King He West No. 100,

Fuyang 236037, China

Tel: +86-558-2596562

Fax: +86-558-2596561

ABSTRACT

In recent years, some significant animal epidemic diseases (especially major diseases) occur frequently. Animal epidemic diseases are not only the key restricting factors of the healthy and sustainable animal husbandry industry in China but also are the great impacting influencers on the development of upstream and downstream industries of Chinese animal husbandry, such as the industries of feed, food processing and tourism. Furthermore, animal epidemic diseases even become the crucial environmental factors threatening human health. Therefore, the strategies of major animal epidemic diseases prevention and control are meaningful and significant concerning the influences of animal epidemic diseases on the healthy development of national animal husbandry, public health security and social stability in China. In the present study, an in depth analysis is carried out to get insights into the prevention and control of major animal epidemic diseases from the economic perspective, taking advantages of the theories of public goods, public choices, games, social system, risk management and the economic compensatory system and the principal agent model. It is aimed to provide the rationale theoretical instruction and policy guidance for prevention and control animal epidemic diseases.

Key words: Animal epidemics, animal diseases, prevention and control, system, management

INTRODUCTION

Animal diseases have long been concerned and tentatively studied (Schachter *et al.*, 1973; Orriss, 1997; Staskawicz *et al.*, 2001; Davidson, 2002; Schmitt and Henderson, 2005; Salman, 2009; Patil and Suresh, 2009; Abd Ellah, 2010; Wen, 2011; Xia *et al.*, 2011; Siembieda *et al.*, 2011; Feng *et al.*, 2012; Zhao, 2012; Videnova and Mackay, 2012; Lin, 2013; Boussini *et al.*, 2014; Morris, 2015). The influence of animal diseases is proved to be very huge, complicated and severe

(Dijkhuizen *et al.*, 1995; Orriss, 1997; Staskawicz *et al.*, 2001; Bengis *et al.*, 2002; Salman, 2009; Abd Ellah, 2010; Videnova and Mackay, 2012; Zhao, 2012; Lin, 2013; Field, 2014; Morris, 2015). In recent years, significant animal epidemic diseases, especially major diseases, occurred frequently in the world (Pike *et al.*, 2014; Boussini *et al.*, 2014; Field, 2014; Osbjer *et al.*, 2015; Thumbi *et al.*, 2015). As many studies reported (Dijkhuizen *et al.*, 1995; Bengis *et al.*, 2002; D'Andrea *et al.*, 2009; Cohen *et al.*, 2009; Pike *et al.*, 2014; Boussini *et al.*, 2014; Wang *et al.*, 2015; Osbjer *et al.*, 2015;

Thumbi *et al.*, 2015), animal epidemic diseases are presently not only one of the key restricting factors of the healthy and sustainable animal husbandry and livestock breeding industry but also are great economic impacting influencers on the development of upstream and downstream industries of the animal husbandry and livestock breeding industry as well as the human health both in China and in the world. For instance, animal epidemic diseases, such as influenza, may bring great impacts on the industries of feeds, food processing, environmental engineering and even ecological tourism (Pike *et al.*, 2014; Osbjør *et al.*, 2015; Thumbi *et al.*, 2015). In Africa, the healthy livestock play key roles in meeting the household nutritional and socio-economic needs for most rural households but it has been averting the household burden associated with zoonotic diseases too (Thumbi *et al.*, 2015). Thumbi *et al.* (2015) found that 93% of the households owned at least one form of livestock, while digestive disorders were the most common syndromes observed in cattle, goats and sheep that accounted for 56% of all livestock syndromes, followed by respiratory illnesses (18%) accounting for 54% of all illnesses reported in humans and by acute febrile illnesses (40%) and diarrhea illnesses (5%). Osbjør *et al.* (2015) reported the household practices related to disease transmission between animals and humans in rural areas of Cambodia, since Cambodia has experienced numerous fatal human cases of zoonotic influenza. Their result showed a few respondents (6%) perceived a likelihood of disease transmission in their village between livestock, humans and wildlife, despite household practices related to zoonosis transmission being common and more than one-fourth of households practiced behaviors, such as culling sick animals for consumption, eating animals found dead and allowing animals to enter sleeping areas and food preparation areas (Osbjør *et al.*, 2015). Furthermore, animal epidemic diseases have actually brought about great economic losses and many restricts to the healthy development of animal husbandry both in China and in the world. Emerging pandemics of animal epidemic diseases are increasing in frequency and have threaten the global health and economies. The globally coordinated strategies to combat and mitigate pandemics are largely necessary and adaptive, similar to those strategies addressing the climate changes (Pike *et al.*, 2014). Pike *et al.* (2014) found that the coordinated combating strategies for the mitigation of pandemics of major animal epidemic diseases would be optimally implemented within 27 years to reduce the annual rise of global emerging infectious disease events by 50% at an estimated one time cost of \$343.7 billion or so. In China, when there are particularly some inherent issues (such as the backward modes of production, the low degree of centralization and the security system of unreasonable support) existing in the traditional animal husbandry, many major animal epidemic diseases will rise and get an opportunity to bring much economic loss to the industries of animal husbandry and livestock production. For

instance, there was an outbreak of bird flu disease (i.e. avian influenza) during 2003 and 2004 and great loss was brought about in China, according to statistics collected by the national animal husbandry and veterinary station (<http://www.cav.net.cn/>) and the national bureau of statistics (<http://www.stats.gov.cn/>). From January to May 2004, the national poultry disease statistics showed that there were totally no less than 143159 sick animals (i.e. 78810 chicken, 14700 ducks and 1457 goose) and 127595 animal deaths (i.e. 70179 chicken, 8031 ducks and 1127 goose) and 8417105 culled and killed poultry animals, including 5367011 chicken, 1774933 ducks, 215482 goose and more than 1.11 million birds (data resources obtained from the official website of China animal husbandry and veterinary information network: <http://www.cav.net.cn/>). The final assessment and statistics revealed that the avian influenza occurred in 2004 had caused a direct economic loss of 19.640164 billion Yuan in China (data resources obtained from the website of the people's health network in China: <http://health.people.com.cn/>). Moreover, the avian influenza had a great impact on the export trade of poultry products too. According to the statistics of Chinese customhouse, at the beginning of the avian influenza outbreak, the export value of poultry products was as much as \$83.8438 million and finally down 33.49% year on year. And the export values of processing poultry exports were 13900 t and \$39.9772 million and later decline 40.29 and 36.90% year on year respectively. In total, the poultry exports were down 23.72% in 2004 compared to that in 2003 for the whole year of 2004 and the proportion of poultry and livestock exports fell more than 50% in China (data resources obtained from the official website of China agriculture information network; <http://www.agri.gov.cn/>). In addition, the threat of animal epidemic disease to public health is found great too (Staskawicz *et al.*, 2001; Bengis *et al.*, 2002; Salman, 2009; Tao *et al.*, 2013a, b; Pike *et al.*, 2014; Osbjør *et al.*, 2015; Thumbi *et al.*, 2015). Animal diseases are currently believed to be the biggest resources bringing harm and threat to human health (Salman, 2009; Tao *et al.*, 2013a, b; Pike *et al.*, 2014; Osbjør *et al.*, 2015; Thumbi *et al.*, 2015). According to the world health organization, there are presently more than 200 kinds of animal epidemic diseases and no less than 70% are known to be infectious diseases to human. In China, there were six people reported died of bird flu in Hong Kong city in 1997, 13 people died of streptococcus suis infection in Nantong city of Jiangsu Province in 1998 and more than 8400 people died of rabies in recent years in China (data retrieved from the official website of China agriculture information network; URL:<http://www.agri.gov.cn/>). Therefore, many scholars are interested and engaged in the research on the prevention and control strategies and tools of animal epidemic diseases, especially major animal diseases (Davidson, 2002; Lu *et al.*, 2005; Schmitt and Henderson, 2005; Li and Liu, 2007; Patil and Suresh, 2009; Wang, 2009; Yang and Hu, 2009; Guo *et al.*, 2010; Yao *et al.*, 2010;

Bai *et al.*, 2011; Xia *et al.*, 2011; Yan *et al.*, 2011; Zhang *et al.*, 2011; Siembieda *et al.*, 2011; Wen, 2011; Yan and Wei, 2011; Feng *et al.*, 2012; Videnova and Mackay, 2012; Wang *et al.*, 2012; Zhang and Jiang, 2012; Zhao, 2012; Duffield *et al.*, 2013; Lin, 2013; Zhang and Zhang, 2013; Field, 2014; Morris, 2015). However, these scholars' case reports as mentioned above in China are either incomplete or incomprehensive at present. The present study was designed to systematically explore and fully analyze the current status, characteristics, strategy and decision making issues of the national animal epidemic disease prevention system in China. It is aimed to provide insights into the national prevention and control strategies of major animal epidemic diseases in China from the point view of social system and economic management.

MATERIALS AND METHODS

Data resources: The data referred in the study are retrieved from both the research's survey data and Chinese government sectors and their official websites. In the study, three Chinese provinces (i.e. Shandong, Henan and Anhui provinces) are selected to be researched and the surveyed people mainly include the rural epidemic prevention station staff and the farmers raising chicken and pigs in these areas. Besides of the survey data, other relevant data sets are retrieved and collected from the following website resources of Chinese animal husbandry information networks: China national animal husbandry information network (URL: <http://www.caaa.cn>), China animal husbandry and veterinary information network (URL: <http://www.cav.net.cn>), China veterinary drug information network (URL: <http://www.ivdc.gov.cn>), Chinese people's health network (URL: <http://health.people.com.cn/>), China agriculture information network (URL: <http://www.agri.gov.cn/>), Shandong provincial animal husbandry information network (URL: <http://www.sdxm.gov.cn>), Henan provincial animal husbandry information network (URL: <http://www.hnxmy.gov.cn>) and Anhui provincial animal husbandry information network (URL: <http://www.ahxmshy.com>; Alias URL: <http://www.ahxm.com.cn>), etc.

Research methods: Based on the theoretical knowledges and principles of the theories of public goods, public choices, games, social system, risk management, the economic compensatory system and the principal agent model and other economic models, this study use the mixed cross method of empirical interviews, the cost benefit decision, the game analysis and the social system and other theories in the comprehensive analysis and understanding of the current national animal epidemic disease prevention system and corresponding government's management regimes in China.

RESULTS AND DISCUSSION

Analysis of the current composition, status and existing issues of the national animal epidemic disease prevention system in China

Brief description of the structure of Chinese national animal epidemic disease prevention system: Chinese national animal epidemic disease prevention system is currently composed of the animal and veterinary administration institutions, the animal epidemic disease prevention teams and their related infrastructures. Those institutions, teams and infrastructures at different levels come into an organism, in which the administrative agencies are at the core and the veterinary officer system is the basis of technical support to ensure the national biological safety in China. On the other hand, the national animal epidemic disease prevention system can also be artificially divided into the levels of the national scope, provinces, cities, counties and townships. Among them, the national and provincial agencies of animal epidemic monitoring and early warning are very important in charge of making and controlling the plans and organizing the implementations, while the agencies of cities, counties and townships mainly undertake the animal epidemic disease prevention and quarantine, supervision and slaughter of the discovered sick animals.

Institution and organization of Chinese national animal epidemic disease prevention system: According to the official document "State council on several opinions to push forward the reform of animal and veterinary management system" issued by the State Council in May, 2005. China has launched the working plan and opened the reform prelude of the national animal and veterinary system. After 10 years of endeavor, China, totally 30 provinces and autonomous regions and municipalities directly subordinate to the central government have launched the working plan and issued the official reform opinions of the institution and organization of the local animal and veterinary management systems and administrative agencies devoted to animal epidemic disease prevention except Hainan Province. Among these 30 administrative districts (i.e. provinces, autonomous regions and municipalities), 29 administrative districts have accomplished the provincial reform of animal husbandry and veterinary working institutions and 67% of their local agencies of cities and counties have completed the reform too, while 15 administrative districts have just achieved the establishing and perfecting of their animal and veterinary management systems and local animal husbandry and veterinary stations in villages and towns (data resources: Chinese national animal husbandry information network; URL: <http://www.caaa.cn/>). The animal husbandry and veterinary working institutions can be divided into three categories, i.e. the administrative

agencies, the law enforcement and supervision agencies (or the administrative law enforcement agencies) and the technical support and animal disease prevention institutions in accordance with their functions. Among these institutions and/or agencies, the administrative agencies are responsible for the guidance and supervision of the regional animal epidemic disease prevention and quarantine. The law enforcement and supervision agencies are actually the administrative law enforcement agencies in the local animal epidemic disease prevention system working for the local people's government at or above the county level and they are mainly in charge of the enforcement of local animal epidemic disease prevention and quarantine according to the law and animal product safety supervision and the administrative laws. The technical support institutions are also important agencies of the technology resources and guiders of local animal husbandry and veterinary administrative and law enforcement supervision and biological safety. They mainly work to undertake the animal epidemic monitoring, diagnosis, epidemiological investigation and case study, epidemic situation report, animal and veterinary medicine, animal feed and product quality inspection, biological safety and other technical support.

Working team and infrastructure construction of Chinese national animal epidemic disease prevention system: The working teams are regarded as the most critical part of the entire animal epidemic disease prevention system. They are the terminal operators and implementers of various animal epidemic disease prevention laws and policy in the whole system. The personnel quality of the animal epidemic disease prevention institutions directly determines the operation effect of the entire animal epidemic disease prevention system and their specific roles and functions in the regional animal epidemic disease prevention, especially at the grass roots level and in the rural animal and veterinary services. According to the statistics in Chinese animal husbandry yearbook, the national animal husbandry and veterinary station personnel and composition at the levels of counties and townships was recorded as the following: The total number of employees were 251347 people, of which 161807 people are at workplaces and 89962 people are from retiree. In the national animal husbandry and veterinary stations, 2457 people obtained senior technical titles, 29352 people obtained intermediate technical titles, 80451 people obtained junior technical titles and 51269 people were technicians. In the infrastructure construction, there are good equipments and facilities in the management system and development agencies of Chinese animal epidemic disease prevention. Especially after 1998, the central government in China implements a proactive fiscal policy which significantly increased the investment in infrastructure construction and development for animal epidemic disease prevention. China has successively implemented the animal protection projects in 23 provinces

and the construction plans of the demonstration area of none animal epidemic disease districts without laws in six administrative provinces. The implemented construction of Chinese national animal epidemic research labs (i.e. laboratories), such as the reference labs on foot and mouth diseases, swine fever, avian influenza, Newcastle diseases and other disease diagnoses have been completed. Those research labs have made great progress in both domestic and foreign animal disease tracking and testing. Furthermore, in the western provinces of China, there are implementing the infrastructure construction and cold chain system development of regional animal epidemic disease prevention too and animal husbandry and agriculture infrastructure have been primarily established for animal epidemic disease prevention in the western 12 administrative province to solve the epidemic prevention issues of cities, counties and townships. Moreover, there are many working agencies and academic institutions established at the grass-roots level in the subsystems of the national animal disease prevention and control in China (Zhao, 2012; Lin, 2013). At present, the country has built 300 provincial diagnosing and testing stations of animal epidemics, 150 tracking and monitoring stations of animal epidemics along the border in China (data resources obtained from the official website of Chinese veterinary drug information network; URL: <http://www.ivdc.gov.cn>). For instance, there are totally more than 450 people working in 19 stations and 88 laboratories established for animal epidemic diagnosing and testing in Guizhou province (Zhang and Zhang, 2013). Among these workers, 38 are senior technicians and 152 are intermediate technicians, while the other people are junior technicians (Zhang and Zhang, 2013).

Six components of Chinese national animal epidemic disease prevention system

Animal disease monitoring and early warning system: The system is the foundation of the national animal epidemic disease prevention system. It is composed of many subsystems e.g., the state animal epidemic monitoring center, the foreign animal epidemic information center, the provincial animal epidemic monitoring center, the prefecture level diagnosing and testing stations and tracking and monitoring stations of animal epidemic animal diseases, the national border and wildlife endemic disease monitoring stations, etc. These subsystems form the complete state animal epidemic monitoring and early warning networks, taking charge of dynamic monitoring the outbreak of major or major animal epidemic diseases and the related early warning and forecasting.

Animal disease prevention and control system: It is the core element of the animal epidemic disease prevention systems in China, including the national center and the provincial centers of animal disease prevention and control and the county and township animal epidemic disease prevention stations. The

national center of animal disease prevention and control is responsible for monitoring the major outbreaks, any new and exotic animal epidemics and making rapid response and real time dynamic commands. The provincial centers of animal disease prevention and control are in charge of dynamic monitoring all the major animal epidemics and taking rapid response to emergency and timely dynamic control within the provincial districts. The county and township animal epidemic disease prevention stations are responsible for the animal disease prevention and control at the grass-roots level and take charge of rapid response to emergency and handling the possible sudden outbreak. In fact, the township veterinary stations mainly undertake the compulsory immunization, the animal epidemic monitoring and emergency disposal and the animal quarantine.

Animal epidemic disease prevention and quarantine supervision system: This system mainly undertakes the relevant supervision and law enforcement functions. It includes five types of supervising agencies for the animal epidemic disease prevention and quarantine, i.e., the central, provincial, prefecture and county and township agencies and/or stations. These supervising agencies take charge of animal epidemic disease prevention supervision and inspection between and within provinces, the entry and exit inspection and quarantine of animals and animal products, isolation and treatment facilities, etc. Furthermore, these supervising agencies responsible for animal epidemic disease prevention and quarantine should also in charge of animal feed, circulation, processing, slaughtering and monitoring the whole regional process of supervision and management to take animal epidemic disease prevention and ensure the safety of animal products and the products' quality. It is crucial for the county and township grass-roots animal epidemic disease prevention supervision and inspection stations to make the entry and exit inspection, quarantine of animals and animal products, control and prevent the spreading of cross regional outbreaks and diffusion of major animal epidemic diseases.

Veterinary drug quality supervision and the veterinary drug residue monitoring system: This monitoring system includes the national primary standards of veterinary drug residue laboratory, the national veterinary drug safety evaluation laboratory, the national center for veterinary medicine standard material preparation, the national institutions monitoring inbound and outbound means of drug residues and the provincial agencies monitoring and supervising veterinary drug quality, etc.

Technical support for animal epidemic disease prevention system: The system is responsible for the diagnosis and basic research on major animal diseases and epidemiology to provide technical support in animal epidemic disease

prevention. Its subsystems mainly include the reference laboratories of foot and mouth disease, avian influenza, Newcastle disease, swine fever, anthrax, exotic animal epidemics and other regional professional diagnostic laboratories of major animal epidemics, such as the foot and mouth disease and avian flu and other major diseases (Yang and Hu, 2009; Xia *et al.*, 2011; Yan and Wei, 2011; Yan *et al.*, 2011; Feng *et al.*, 2012), the entry and exit quarantine diagnostic laboratories, the national center of veterinary microorganism and the key laboratories of aquatic animal diseases, libraries and other teaching and scientific research units of animal disease monitoring and diagnostics.

Material support system for animal epidemic disease prevention system: The system takes charge of the material support of animal epidemic disease prevention and any sudden or newly found or foreign major animal epidemic disease prevention and control and treatment. Its main jobs include the compliance of veterinary biological products production enterprises with the good manufacturing management and specification of Good Manufacturing Practice (GMP) standards and the self-containing units of animal epidemic emergency preparedness and supplies reserve systems.

Relevant laws and regulations on the animal epidemic disease prevention in China At present, the developed countries and many international organizations generally attach great importance to the construction of laws and regulations on animal epidemic monitoring and prevention. The Office International Des Epizooties (OIDE) specially organized experts to compile and code the international animal health statute book and this book was most popular in the OIDE member states. Suggestions about the basic principles of animal health have been followed by many countries. The laws and regulations on animal health in United States and European Union are very perfect as well as those in China. Since the reform and opening up of China, the legislative work has made great achievements in animal epidemic disease prevention and initially formed a legal system with the animal quarantine mentioned as the core of animal epidemic disease prevention. The major laws and regulations of animal epidemic disease prevention currently running in China are listed in Table 1.

Management system of animal disease prevention and control in China

Scheme and measures of the major animal disease prevention and control: Animal disease has the characteristics of transmissibility and creeping and it can happen anywhere as long as there are appropriate ecological conditions and routes of transmission, such as the processes of animal breeding, slaughtering, animal production processing and trade circulation, transportation and storage, etc. Every

Table 1: Laws and regulations of animal epidemic disease prevention in China

Titles	Policy making time	Policy implementing time
Import and export animal and plant quarantine law of the People's Republic of China	October 30, 1991	April 1, 1992
Animal immune identity management solution in China	May 24, 2002	May 24, 2002
Regulations of biological safety of pathogenic microorganism biological laboratories in China	November 12, 2004	November 12, 2004
Several regulatory opinions about promote the reform of the veterinary management system in China	May 14, 2005	May 14, 2005
Emergency regulations of major animal epidemic diseases in China	November 18, 2005	November 18, 2005
Animal husbandry law of the People's Republic of China	December 29, 2005	July 1, 2006
National emergency early warning plan of major animal epidemic diseases in China	February 27, 2006	February 27, 2006
Evaluation measures and regulations for the animal epidemic areas in the absence of administration provisions	January 23, 2007	March 1, 2007
Animal epidemic disease preventions of the People's Republic of China (revised in 2007)	2007-8-30 (Revision version of 2007)	January 1, 2008 (Revision version of 2007)
Measures and regulations for the administration of animal quarantine (revised in 2010)	January 4, 2010 (Revision version of 2010)	March 1, 2010 (Revision version of 2010)

link may spread the pathogens and diseases spread. Therefore, each link of the epidemic prevention and supervision is essential and inseparable. The complicated characteristics of animal diseases and relevant animal epidemic disease prevention determine the scheme and technical route of the major animal disease prevention and control. Herein, the scheme and technical route are artificially divided into three stages before and after outbreaks of animal diseases, such as the prevention and control model of major animal diseases in pig farms (Yao *et al.*, 2010; Yan and Wei, 2011).

In the first stage, before the outbreak of animal diseases, the first step of prevention and control is to make compulsory immunization and prepare the relevant quarantine and supervision to ensure the implementation of effective compulsory immunization. Then, it is also crucial to do the job of animal epidemic monitoring and inspection before the outbreak of animal diseases. During the period of monitoring, if no abnormalities are found, the inspected animal products can enter the market through quarantine after slaughter and processing. Otherwise, when the monitor suspected any possible outbreaks or abnormalities in animal epidemic monitoring, animal products can not enter the market and an epidemic situation report should be generated.

In the second stage, the discovery of animal diseases should be reported to managers and administrators before outbreaks in the first place. The reported samples or specimen of animal diseases and/or epidemic resources will be transmitted to all the disease control and prevention centers, the national reference laboratories and the regional laboratories for diagnosis and analysis. According to the diagnosis and analysis, the foci, epidemic areas and threatened areas of animal epidemics will be delimited. The division standards of the foci, epidemic areas and threatened areas for animal epidemic disease prevention are very serious in China. After the delimitation of the foci, epidemic areas and threatened areas, administrators should take steps of corresponding blockade, forced culling, emergency immunization and disposal etc.

In the third stage, when the outbreak of animal disease is under control, the next steps of animal epidemic disease

prevention and control are gradually to resume production and related trades after the incubation period of blockade and qualified lift of animal products. Another important thing is to sum up the experiences of former animal epidemic disease prevention and control and to build a long-standing prevention and control mechanism of major animal diseases. The long-standing prevention and control mechanism of major animal diseases should include many aspects, such as improvement of the animal epidemic disease prevention system, establishment of the early warning system and emergency mechanism, construction of the relevant technical support and material guarantee system, building of the subsidy policy and system and the modernized changed livestock breeding ways, etc.

Management system of animal disease prevention and control in China: In order to prevention and control the outbreak of major animal epidemic diseases, according to the characteristics of the major animal epidemics and epidemic prevention work, Chinese government and its sectors have established a series of management systems including rules and regulations and policies of animal disease prevention and control, such as the compulsory immunization system, the animal immune identification system, the quarantine system and the system of official veterinarians and veterinarians, etc. Here, we will take a look at the compulsory immunization system and the animal immune identification system.

Compulsory immunization system in China: The compulsory immunization system refers to the mandatory measures and actions to control animal epidemics that cause serious damage to animal breeding production and human health. In the system, the states take compulsory immunization planning to determine the immune with biological products and procedures and the corresponding effect on the immune monitoring. And later, a series of mandatory measures of the animal epidemic disease prevention and control are taken in order to achieve the previously planned steps to prevent, control and make extermination of animal epidemics. The objects of the compulsory immunization are those major

animal epidemic diseases that cause serious damage to the breeding production and human health in China, mainly including avian influenza, foot-and-mouth disease, mad cow disease, Newcastle disease and blue ear disease and so on. At present, China implemented the vaccine free policy to compulsory immunization according to the recent version of Chinese animal quarantine regulation revised in August, 2007.

Animal identification system in China: The animal immune identification system is a smart tag (i.e., identity) used to mark animals after immunization for the immune recognition and tracking. Animal immune identification includes both the immune ear tag and immune archives. In China, animals like pigs, cattle and sheep are to wear ear tags, while other livestock must be marked and their immune archives should be established in the management system. Animal identification system is an important part of the animal epidemic disease prevention network. It is also an important means of implementing the compulsory immunization and one of the main elements and bases of animal epidemic disease prevention supervision and management. The immune identification system facilitates the management of animal epidemics and the implementation of animal product quality tracing and controlling and prevention.

Main problems of the animal epidemic disease prevention system in China

Production mode and farmers' consciousness of animal epidemic disease prevention are backward and weak: In China, farmers advocate the traditional cage-free mode of livestock production in China exist for a long time, which greatly enhances the difficulty of the prevention and control of major and infectious animal diseases. After 20 years of the intensive and large scale development of production, the degrees and scales of Chinese animal husbandry have greatly improved but the traditional way of cage free still accounts for high proportion in current livestock production in China, e.g., the poultry industry free-range way accounts about a proportion of 65%. In free-range farms, the animal epidemic disease risk and guard consciousness and preventing capability of animal raisers and farmers are all not strong or feeble (Lu *et al.*, 2005; Yang and Hu, 2009; Wen, 2011; Xia *et al.*, 2011; Yan and Wei, 2011; Yan *et al.*, 2011; Feng *et al.*, 2012; Zhao, 2012; Lin, 2013). In rural farms, the free-range mode is regarded as one of the weak links of animal disease prevention and control. However, the large range of this traditional mode of mass production greatly increased the difficulty of major animal epidemic disease prevention and control in China.

Local grass-roots animal epidemic disease prevention systems are feeble and slack in counties and townships: The weakness of grass-roots animal epidemic disease prevention system is mainly manifested in the following two aspects. First, the agencies and institutions of grass-roots animal epidemic disease prevention mechanism are poorly organized

and developed with no sound management ways, unclear positioning and unsuitable systems and rules. Moreover, there is lack of well established infrastructures (Wen, 2011; Zhao, 2012; Lin, 2013). According to the statistics recorded in Chinese animal husbandry yearbook there are about 30% of the county institutions of animal husbandry and veterinary are not working well and lack of the necessary means of animal quarantine, prevention, diagnosis and monitoring. Other agencies in counties and townships are revealed working ineffectively due to poor infrastructures and standards. Second, the personnel quality of the grass roots epidemic prevention team in counties and townships is not high and enough to work effectively. In addition, the personnel of rural veterinary and their teams engaged in veterinary play very important roles in animal epidemic disease prevention and control at the grass-roots level. However, they are currently paid with relatively low wage and/or salary levels. Therefore, the government should strengthen the management and guidance and make good welfares to the personnel and teams of rural veterinary services at the grass-roots level (Zhao, 2012; Lin, 2013).

Regional emergency response mechanisms of animal epidemics are imperfect: Presently there is little information collected on animal epidemics as the backward technology and measures and means are used in the animal disease prevention and control of China. Since the official management ways and feedback pathways of animal disease emergency are relatively lagging, especially the shortages of digital constructions for modern animal husbandry and livestock industry in China (Lu *et al.*, 2005; Zhang *et al.*, 2011; Zhang and Jiang, 2012), there is currently a small amount of information reported in China. Regarding the long statistical and reporting periods of animal epidemics and failing to reflect the animal epidemic dynamics, it is difficult to make the early warning and timely forecast of major animal epidemic diseases, particularly in animal endemic disease monitoring and early warning of terrestrial wildlife field. There are obviously inadequate facilities and equipments of rapid isolation, disinfection, culling, disposal and other animal epidemic processing jobs. Furthermore, there is also lack of the effective information and local exchange and coordination mechanisms among different departments and regions. Thus, the official zone spreading plan is difficult to be implemented. In addition, as the national materials reserve system of animal epidemics has not yet been established and effectively operated, it is difficult to meet the needs of major paroxysmal animal epidemic disease prevention and control in China.

Supervisions and barrier facilities of animal epidemic disease prevention are lagging behind: The supervision agencies of animal epidemic disease prevention at various levels lack the necessary means of law enforcement and supervision. In addition, there are presently insufficient supervision and workers on animal epidemic disease

prevention and quarantine. The provincial supervision and inspection stations and equipments of animal epidemic disease prevention is insufficient in animal products producing areas, especially lacking of the necessary inspection means and disinfection facilities between provinces and areas. Therefore, the regional executing ability of entry and exit quarantine doesn't meet the need of national import and export managements and the facility of inspection, quarantine, disinfection and further processing remains to be improved. Furthermore, at present, the national and provincial laboratories of animal disease diagnosis and biosafety is generally working at low levels in China, because of the incompatibility of facilities and lacking of a complete set of equipments, especially the digital facilities and means and terminals in modern livestock husbandry and industry (Lu *et al.*, 2005; Zhang *et al.*, 2011; Zhang and Jiang, 2012). Those laboratories of major animal epidemics are difficult to carry out the jobs of pathogen separation, monitoring, inspection, quarantine, disinfection and further processing, etc. Some laboratories of counties and townships lack the necessary laboratorial equipments and diagnostic reagents for animal disease clinical inspection and diagnosis and supervision, even in the experiments.

Legal system of animal epidemic disease prevention is not sound: With the rapid development of modern animal husbandry in China, there appear many problems and issues in the executing processes of laws and regulations on the animal epidemic disease prevention control. The operability of laws and regulations and the compatibility of Chinese legal system are relatively poor and fragile on the animal epidemic disease prevention and control after the accession of China to the World Trade Organization (WTO), compared with the international practice of animal epidemic disease prevention systems.

Issues existing in the governmental management of the major animal disease prevention and control in China: The difference between the government's public function and operational function is fuzzy regardless of the job specializations. Because there are chaos and lacking of funding for work in the animal epidemic disease prevention institutions, this case results in the fuzziness of the government's public function and operational function in the animal epidemic disease prevention management regardless of the government management organization. The government acts too much offside and becomes engaged in the medical services that should be borne by the market. This case inhibits the healthy development of modern medical service market in China. In fact, the work of animal epidemic disease prevention and quarantine and supervision is truly the government's job, while the services of diagnosis and treatment are more like to be the function and behavior of the medical service market. However, the veterinary epidemic prevention stations belong

to the self-raised units in the grass-roots animal epidemic disease prevention systems of China. To ensure the normal operation of these stations or institutions, these grass-roots institutions keep running by providing some medical services too at the grass-roots level. So, it creates a contradiction between veterinary epidemic prevention station and the medical service market and the development of specific functions and services of the medical service market for private veterinary are inhibited in China.

Problems existing in the administrative management of local governments in the process of prevention and control of animal epidemic diseases in China: Animal husbandry and livestock production are the important parts of modern agriculture and the healthy animal husbandry plays an important role and huge impacts in the national economy of China. Therefore, the national animal epidemic disease prevention and control system is currently the main basis of the prevention and control of major animal diseases. It is important to perfect the animal epidemic disease prevention and control system in China as soon as possible and measures should be taken to accelerate the reform and development of the national animal epidemic disease prevention and control system.

Analysis of the negative behaviors of local governments in the process of prevention and control of animal epidemic diseases: The negative behaviors of local governments are very bad and unfavorable for the work of early warning and guard and forecast of animal epidemics in the process of the prevention and control of animal epidemic diseases (especially major animal diseases) in China, since the local governments are rational economists too. There are many causes of this situation, such as the indefinite relationship between the central government and the local governments regarding the right and responsibility of effective animal epidemic disease prevention and control and governance of animal epidemic diseases which hits the enthusiasm of local governments, some local governments lack in the essential teams and infrastructures and the necessary financial support for the prevention and control of animal epidemic diseases, etc.

In China, the policy is generally are made by the central government and the local governments is the executor of various policies. In the practices of animal epidemic disease prevention and control, the effective guide and supervision capability of the central government to the local governments is limited. This serious case is related to the truth of natural complicated environment phenomena of animal epidemics. There are currently many influential factors of the outbreak and spread of animal epidemic diseases but the epidemic administration and supervision of local governments does not reach the designated positions of animal epidemic disease prevention and control and relevant managements in practices.

In addition, there is an indefinite relationship between the central government and the local governments regarding the right and responsibility of animal epidemic disease prevention and control and governance. So, it is difficult to implement the punishment and management measures for the responsibility investigation of local governments (Wen, 2011). The assumption is that the local governments' positive work in animal epidemic disease prevention and control required will get revenue with lower costs and their negative work will get punishment with high costs under the same conditions. Thus, there will actually form a commissioned agent system between the central government and the local governments, in which the central government is the principal and the local governments are the agents in China. It is assumed that the local governments are rational economic man engaged in the management affairs and taking their maximum benefit in principle. When their goals do not agree with those of the central government, there is the possibility of gaming between the central government and the local governments, due to the economic principle of maximum benefit. There might be a lack of enthusiastic or selective execution of the local governments to carry out the central government's policy in the cooperation of major animal disease prevention and control (Wen, 2011; Zhao, 2012; Lin, 2013). Meanwhile, the assignments and policies from the central government are compulsory for the local governments in animal epidemic disease prevention and control. The local governments will also be selective to carry out the policies from the central government to ensure their maximized interests. Therefore, the local governments encounter the dilemma in the game of economic choices between region costs and expected returns.

Analysis of the services market of animal epidemic disease prevention and control based on the public goods theory

Public goods (or services) are those that everyone's consumption of the goods does not lead to the reduced consumption of other people of these goods, such as those goods (or services) in the national defense, public roads and television broadcast, etc. In fact, the consumption of public goods is non competitive, non exclusive income and typical of indivisibility of utility. The non competitive nature of public goods refers to the nearly zero marginal cost of each additional consumer. The supply of the additional items of public goods should be free in accordance with the principle of free market of marginal cost pricing but the government can not afford the production cost of those public goods. The economic theory holds that the above mentioned characteristics of public goods determine that the public goods can not be fully provided by the market. That case is called the phenomenon of market failure. Therefore, it needs the intervening of the government to maximize the social welfare. Actually, there are a few firms engaged in pure public or private services of animal and veterinary services and most of companies are proved to be the mixed types of the public and private services and there are the

phenomena of market failure and government failure in the public and private service markets of animal and veterinary services, especially animal epidemic disease prevention and control, from the point of view of both the administrative government and the competing market. Therefore, because of the lack of competition and the incentive and supervision mechanisms and the rationality of government interventions in economic activities becomes naturally necessary and obligatory, when the government's decision makers unconsciously maximize their own interests as the decision criterion, i.e. the phenomenon of government failure. Therefore, the government should appropriately balance the shares between the public and private sectors to obtain better public goods and services. To some extent, the services of animal epidemic disease prevention and control provided by both the government sectors and private agencies should be classified and regarded as a kind of public goods. These services of animal epidemic disease prevention and control can be divided into four categories, i.e. the strong competitive and strong exclusive type, the strong competitive and weak exclusive type, the weak competitive and strong exclusive type and the weak competitive and exclusive type according to their attributes. Among the four types of services, those with strong competitiveness or strong exclusiveness (such as the sales services of veterinary drugs and vaccines) should be provided by the private agencies, while those with weak competitiveness or exclusiveness are suggested to be offered by the public sectors (such as the animal epidemic monitoring, control, quarantine and production of vaccine). Actually, studies from the health economics suggest that the appropriate positioning of the public sectors and private agencies in financing and providing services of animal epidemics can improve the service levels of animal epidemic disease prevention and control. Particularly, the private agencies will play a positive role in overcoming many issues (e.g. insufficient funds) if they are dominant in public services of animal epidemic disease prevention and control.

Some considerations and suggestions for the reference of policy improvement and decision making

To accelerate the transformation of the traditional mode and enhance the risk early-warning and management of animal husbandry and livestock production: Animal husbandry and the following livestock production are the kind of relatively high risk industries accompanied by many major diseases and outstanding market risks. In practices, when the breeding level determines the level of prevention and control, the scale of breeding will be one of the most important factors affecting the quality and quantity of animal husbandry and livestock production and possibly the producers of animal epidemic factors. In the case of pig graze and husbandry, there are greater risks of swine diseases and a higher death loss in the populations of large scale pig farms than those of the household free range grazed pigs in China. Since there is often

a bigger public risk of animal diseases in the household free range grazing and farming than that in the animal breeding farms of large scales, the mode of large scale breeding and farming is preferred to be taken regarding the public health security. Therefore, it is important to pay attention to the appropriate scales and strengthen the risk management of large scale farms in the transformation of the traditional mode of animal husbandry and livestock production when the practices of modern animal breeding and farming on the way of development in China.

To complete and improve the current laws and regulations of the animal epidemics and disease prevention and control system: One of the key steps to complete and improve the laws and regulations of animal epidemics and diseases prevention and control is to introduce and implement more and more new laws and regulations and the compensation system in animal husbandry and livestock production to perfect and make up the deficiency of currently existing laws and regulations in China. The second step is to increase the intensity of law enforcement and punishment in animal disease prevention and control, especially to further implement the investigating mechanism of responsibility and the strict measures of law enforcement in illegal events. Another critical step is to draw lessons from the laws and legislative experiences of the developed countries and to promote and accelerate the laws and regulations of animal epidemics and diseases prevention and control in China come in line with the international standards gradually.

To give a full consideration of the local government's interest and handle well the relationship between the central government and local governments in the animal epidemics and disease prevention and control system: In the animal disease prevention and control, especially in the guard of major animal diseases, local governments are the specific critical practitioners and executors of the central government's policies and orders of animal disease prevention and control. The local government will selectively carry out relevant policies and orders of the central government mainly depending on its own interests to be protected and maximized. So, first of all in the process of policy-making, the central government must give a full consideration to the local government's interest. The central government should duly handle and clear the relationship of authority and responsibility and do it rightly. Second, the central government should step up the degrees of law enforcement and punishment to the local governments when they are lax, negative and misconducting in animal epidemics and diseases prevention and control, especially concealing outbreaks of animal epidemics and diseases, excessive penalties culling and mal-practicing.

To improve and expand the technical support and material security for the animal epidemics and disease prevention and control system: The technical support system should bear the tasks of major animal disease diagnosis and the basic research and/or study of epidemiology to provide technical support and material security for the whole animal epidemic disease prevention and control network. It is important to strengthen the national reference laboratories of animal epidemics, the national professional diagnostic laboratories, the national entry and exit quarantine laboratories, the national centers for veterinary microorganism and the aquatic animal disease key laboratories, relevant libraries and other major scientific research institutions with the digital facilities and terminals (Lu *et al.*, 2005; Zhang *et al.*, 2011; Zhang and Jiang, 2012) in China. It is also crucial to actively promote and standardize the GMP certification work of animal and veterinary drugs and conscientiously strengthen the consolidation of veterinary drugs and feed additives market. The governments should strictly and sternly combat with illegal production, sales, dealing and consumption of veterinary vaccines to guarantee a healthy animal and veterinary drug industry.

CONCLUSION

In the study, a detailed analysis is made for the prevention and control strategies of major animal epidemic diseases from the perspective of social system and economic management aiming to provide insights into the rationale theoretical instruction and policy guidance for both governments and farmers. The current national prevention and control system of Chinese animal epidemic diseases is self contained. However, through a systematic analysis, the production mode and farmers' consciousness of animal epidemic diseases are found to be relatively backward and weak and the local grass-roots animal epidemic disease prevention systems are revealed as feeble and slack in China. The regional emergency monitoring and responding mechanism and the legal system of animal epidemic disease prevention is presently imperfect, while the prevention supervision and barrier facilities of animal epidemic disease are revealed to be lagging behind in China, compared with those of developed countries. In addition, the behaviors of local governments are relatively negative and unfavorable in the prevention and control of Chinese animal epidemic diseases because of economic considerations. However, the national system is currently the administrator and executor of prevention and control of major animal diseases. It is important to perfect the national system of animal epidemic disease prevention and control in China and many urgent measures should be taken to accelerate the reform and development of the national system. Particularly, full considerations should be given to the local governments'

interests to handle the relationship between the central government and local governments. Furthermore, the behaviors of animal breeders and producers to major animal epidemic disease prevention and control fundamentally depend on the economic interests of animal breeders and producers. The governments should formulate and adopt appropriate measures and policies to make economic compensation of animal breeders and producers in the prevention and control of major animal epidemics and diseases. Meanwhile, it is important to accelerate the transformation of current product modes in farms as well as to improve the risk management of animal husbandry and production. Therefore, next studies should focus attention on the differentiated functions between the central government and local governments and the differentiated economic interests of different animal producers in the process of prevention and control of animal epidemic diseases.

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