Biosecurity and Disease Management in China's Animal Agriculture Sector

Xinjie Wei, Wanlong Lin, and David A. Hennessy

Working Paper 13-WP 542
October 2013

Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Xinjie Wei is an Associate Researcher at the China Animal Health and Epidemiology Center Qingdao, China. E-mail: weixinjie@cahec.cn

Wanlong Lin is Professor at the College of Economics & Management China Agricultural University. Beijing, China. E-mail: linwanlong@vip.163.com

David A. Hennessy is Professor of Economics at the Department of Economics & Center for Agricultural and Rural Development, Iowa State University.

For questions or comments about the contents of this paper, please contact David A. Hennessy, 578C Heady Hall, Dept. of Economics, Iowa State University, Ames IA 50011-1070. *hennessy@iastate.edu.*

Biosecurity and Disease Management in China’s Animal Agriculture Sector

Abstract: China’s livestock production sector is changing rapidly to meet a variety of challenges. At the same time, China’s domestic consumers have begun to demand better quality and safer dietary protein sources; potential for international food market penetration has been compromised by food scandals; and her animal agriculture sector remains a concern for emergence of zoonotic diseases. The country is in the process of a major public animal health infrastructure upgrade, and is seeking better integration with international public animal health governance structures. The intent of this article is two-fold. We provide an overview of and commentary on China’s animal husbandry sector and animal disease control policies. We also assess weaknesses in its animal health and biosecurity infrastructure. China’s animal health administration countenances institutional weaknesses that are shared with higher-income countries, but her problems are more pronounced. Administrative failings include poorly demarcated and inconsistent oversight as well as failings in accountability. The need for professionalization of animal health careers, emphasis on quantity goals over qualitative metrics, as well as a want in scientific analysis and follow-through when prioritizing are other weaknesses. Government policy has been to promote larger-scale production, primarily to better secure wholesome food domestically. Production is changing in ways that may pose intermediate-term threats to animal and human health, but the longer-term outcome may be a production base that poses fewer concerns for global health.

Keywords: animal health, global public goods, industry structure, public administration

Biosecurity in China's Animal Agriculture Sector

Animal agriculture in Southern China, and Southeast Asia more generally, has long raised concerns about zoonotic implications, in part because of mixing between farmed species, humans and migratory birds (Shortridge, 1; Sonnberg et al., 2) and in part because of the popularity of live animal markets (Greger, 3; Sims et al., 4). China's comparatively recent rapid economic development has, if anything, expanded these concerns. Many view transition from small-scale to large-scale animal production systems as a central driver of livestock and zoonotic diseases (Perry et al., 5; Bogich et al., 6), especially when linked with environmental change (Jones et al., 7), high population density (Jones et al., 8), stressed production support infrastructure and increasing movement of both animal and human populations.

At the same time, food users have begun to insist on higher standards among China's animal protein producers. An increasingly affluent and educated domestic market is demanding more wholesome food. Animal product safety events that were widely reported in the last decade have been many and varied. One of the most significant was melamine adulteration in pet food, circa 2007, and milk, circa 2008 (Sharma and Paradakar, 9). Illegal additives fed to pigs that passed through Shuanghui Group up to 2011, mercury in milk that passed through Yili Group in 2012 and the mystery of thousands of dead farm animals floating down a Shanghai area river in 2013 are other examples. Such events have highlighted weaknesses in China's food production system. They have also shaped provisions in the United States FDA Food Safety Modernization Act of 2011 (Levitt and Pape, 10) that pose increased impediments to China's food export potential (Broughton and Walker, 11).

History relates similar events for other economies in rapid transition, especially when food chains extend to growing cities so that opportunistic middle agents can take advantage of poorly monitored links in a rapidly reorganizing food system (Collins, 12). Responses in Europe and

North America during the 19th and 20th Centuries came in part from the private sector through emphasis on accountability, product branding and food distribution system rationalization. In the public arena, responses came through strengthening fundamental science and the extension of consequent findings to investigate emerging problems. Stronger science also allowed for public and private sector measurement of product attributes to control quality directly and to support prudently designed regulations.

Similar responses can be seen today in China (Gale and Hu, 13). Concerning melamine in milk, public outrage at and lost profits for companies associated with adulteration has made the industry recognize the need for deep-rooted change (Qian et al., 14). In 2013 Shuanghui made a bid for the largest U.S. pork producer and processor Smithfield, where a widely reported rationale for the deal was access to Smithfield's brand quality and quality assurance capabilities (Bensinger and Hsu, 15). Far-ranging government policy responses to the suite of concerns have also occurred, including major regulatory reform and coordinated responses regarding food industry structure (Pei et al., 16; Jia et al., 17). It is now government policy to encourage larger, more standardized and vertically integrated production systems (Gale et al., 18).

More broadly, the Chinese government's approach to international cooperation and coordination regarding global health concerns has evolved in the past decade as the country has begun to accept and sought to shape its growing role in international governance of health and product safety (Lo, 19). The turning point occurred with the SARS epidemic in 2003, followed in 2004 by heightened concerns about Avian Influenza. Chinese authorities came to see that health anxieties could create social panic and destabilization (Morrison, 20; Wishnick, 21). Poverty and limited human health infrastructure in rural areas as well as increased mobility between urban and rural areas have exacerbated these concerns (Kaufman, 22).

Through partnerships, personnel exchanges and participation in surveillance networks,

China has sought to share its experiences and better integrate with global preparedness and disease outbreak response efforts (Rambhia and Cicero, 23; Morse, 24), and has greatly strengthened its human health surveillance and reporting systems (Yang et al., 25). The People's Republic of China (PRC) has taken full part in the World Organization for Animal Health (OIE) activities since 2007. Comparatively few studies exist in the public domain for bioterrorism and biosecurity challenges that China faces (Huang, 26), although some work has sought to identify emerging weaknesses in training (Peng et al., 27). Our interest is in the state and evolution of China's preparedness in the arena of farm animal biosecurity, where published studies are almost non-existent. Given the widely acknowledged need for a global perspective on health biosecurity and aforementioned particular concerns about the human-animal interface in China, this oversight requires attention. We intend to provide context and analysis on the matter.

The paper proceeds with an overview of China's livestock sector, followed by considerations of major diseases afflicting in the sector. We then outline China's animal disease control administration and infrastructure. After explaining the country's disease control policies, we address some weaknesses in the system. The paper concludes with a brief discussion.

FARMED ANIMAL SECTOR

China's animal husbandry sector assumed a free market approach early after the shift toward reform and opening policies in China in 1978, and the sector has developed rapidly since then. Livestock sector gross output value reached 2.58 trillion Chinese Yuan (CY) in 2011, or about $416 billion US. Its share in total agricultural output value increased uniformly from 15% in 1978 to 32% in 2011. China is now the world's largest pork and poultry meat producer.[1]

However, animal disease and related biosecurity issues are major constraints to the sector's

[1] The above data are from the China Statistic Yearbook of 2012 as published by the China National Statistics Bureau.

development. Direct economic losses each year caused by animal deaths due to disease are estimated to exceed 40 billion CY, while indirect economic losses (including waste of feedstuff, labor and drugs) are estimated to exceed 100 billion CY (Xia, 28). Avian Influenza alone in 2004 triggered a loss of about 177 billion CY in domestic trade (Xie et al., 29), including as many as 1 million lost jobs (NDRC, 30). The spread of animal diseases also severely impacted public health and national security. As a result, in 2008 the Chinese Government decreed that the development of an improved animal disease control system should be expedited, investments in system development should be increased, and the compensation mechanism for animals culled due to major diseases should be improved.[2]

Table 1 shows changes in production of the major farmed livestock species between 1985 and 2011. Pig and poultry production in China has grown rapidly over the past 27 years, with the number of marketed hogs increasing nearly three-fold and the number of marketed poultry increasing seven-fold over the period. Rate of growth in pig production has slowed since about 2000, in some part due to rising costs and low technical efficiency (Xiao et al., 31). Although traditionally located along the Yangtze River, see Figure 1, limited access to feed has meant that this region's hog production share has declined from about 64% to about 40% between 1980 and 2009 (Xiao et al., 31), with some production relocating to the North and Southeast where imported soybean is easier to obtain.

Since 2007, government policy has emphasized a more industrialized and integrated format, with eventual exit by smaller producers. Hog production policies have included grants for genetic improvement and operation enlargement as well as subsidized insurance and a subsidy per sow (Chen and Wang, 32). The trend toward larger production units is likely to continue.

[2] Several opinions of the Central Party Committee and the State Council on Constructing Agricultural Infrastructure to Promote Agricultural development and Farmers' Income Growth, http://www.ce.cn/xwzx/gnsz/szyw/201201/30/t20120130 _23027605.shtml

Large farms can better substitute machines for China's increasingly expensive labor, can pay to access better genetics, and likely can better work with downstream processors concerned about quality issues. Government policy also extends to disease management. It is compulsory to immunize pigs against classical swine fever (CSF), Porcine Reproductive and Respiratory Syndrome (PRRS), and Foot and Mouth Disease (FMD) but vaccines are heavily subsidized (Gale et al., 18). Compensation is provided for pigs that must be removed for disease management purposes while dead animal disposal costs are borne by local government.

The share of poultry meat in all China's meat production has increased from 8% in 1985 to 21% in 2009 (Zhou et al., 33), reflecting impressive penetration into the country's diet. Per capita consumption of broiler meat now exceeds 9 Kg/year while it is about 3 Kg/year and 1 Kg/year for duck and goose meat, respectively. Poultry production occurs throughout China although most broiler production occurs in the coastal provinces of Shandong, Guangdong, Jiangsu and Liaoning while duck and geese production are somewhat regionally concentrated in the inland Sichuan Basin (Prosser et al., 34). The continued importance of the live trade is reflected in production pockets around large cities. China is by far the world's largest egg producer with 2.7 billion laying hens.[3] Egg laying has seen some relocation from North China, around Shandong and Hebei Provinces, toward the South while the egg production chain has become more specialized (Han, 35). The sector continues to be vulnerable to disease. Following culling losses, market closures and reduced demand arising from the H7N9 bird flu events of April 2013, the government sought to stave off bankruptcies through direct handouts and subsidized loans to poultry breeders and processors.

Ruminant production has increased, but at a slower and more variable rate over the period than has been the case with pigs and poultry. China has not had a strong tradition in milk or beef

[3] According to *China Animal Industry Yearbook 2012*.

production or consumption. However, demand for dairy products has expanded with the country's increasing prosperity and awareness of bodily needs for calcium and protein balance. Demand has been met by imports and domestic production, with a strong government preference for domestic production. In 2011 the country had 7.6 million dairy cows located mainly in the North, just south of Beijing, and the Northeastern provinces (Figure 1). Farms have been small, with average cow inventory at five in 2002, see Table 2. The melamine scandal was a fundamental shock to the sector, strengthening preferences for imports.

In response, the government sought structural remedies (Dobson et al., 36) as codified in the Dairy Industry Policy Revision of 2009. Similar to hog sector policy revisions, subsidies were provided for promoting the genetic contribution to productivity through animal and semen imports. Vertical integration is being encouraged, in part so that milk production can be better monitored by processors and by the authorities. In particular 'cow hotels' are supported where small producers and their cows would relocate to centralized facilities in which resources could be shared and technology transfer could presumably occur more rapidly (Mo et al., 37). International investment that fosters consolidation and best management practices in domestic production are also encouraged. As for other animal products, drivers for these changes have been concerns about food security and quality assurance. Adulteration and other quality concerns have been central motivations for the policy push, while animal and zoonotic disease concerns are barely mentioned. One wonders about how the prevalence of brucellosis, bovine tuberculosis and Johne's disease have been affected by cow hotels?

Over the past 30 years, unit scale of production on China's livestock farms has increased significantly and large-scale animal farmers have gradually replaced small holders. The number of farm households has decreased while the amounts of all kinds of livestock have increased. Table 2 shows changes in average farm size over time for major farmed livestock species.

Animal husbandry is very important to China's agricultural economy and farmers' income. The sector's output value increased six-fold in real value between 1985 and 2011 while its share in total agricultural production value increased from 22.0% in 1985 to 31.7% in 2011, see Table 3. However, income from animal husbandry as a share of total net income from agriculture has remained at about 20% between 1991 and 2011. Income per unit output has declined, reflecting financial stress among those small-scale farmers that remain in production. Table 3 also shows that the proportion of income derived from animal husbandry in total net income to farm households has dropped markedly between 1991 and 2011. This is mainly because income to farm households from non-farming sectors has increased over time, reflecting rural migration and local off-farm labor.

Occurrence of Major Animal Diseases

Perhaps because of trade isolation for much of the 20th Century, China has had a comparatively good record on many globally problematic animal diseases. For example, China has never had a confirmed case of scrapie, bovine spongiform encephalopathy, African horse sickness, African swine fever, vesicular stomatitis, lumpy skin disease or rift valley fever.[4] However, there is much internal trade in livestock and livestock products. Given the state of infrastructure, it should be no surprise that major animal diseases have frequently broken out and spread. These include FMD in cattle, pigs and sheep after 1999, the highly pathogenic avian influenza (HPAI) pandemic since 2004, the *streptococcus suis* outbreak in Sichuan in 2005, and the swine PRRS-like outbreak in 2006. According to estimates (Xiong and Xu, 38), the annual death rate due to various diseases is about 8-12% among pigs, 12-20% among poultry, 2-5% among cattle, and 7-9% among sheep where about half of these are attributable to contagious and parasite

[4] Official Veterinary Bulletin, Vol. 3(1), January 2001, Ministry of Agriculture of PRC.

diseases.

In some cases China's animal disease control management has performed well historically. For example management controls for animal brucellosis, which can significantly reduce productivity, have been in place since 1952 (Shang et al., 39). An important zoonotic disease, humans can contract it from pigs, cattle or sheep but contagion among humans is rare. The disease is most prevalent in the pastoral north, in areas bordering Mongolia and Russia (Chen et al., 40), and reported human incidence has grown from 0.7 notifications per 100,000 per year in the 1990s to about 10 since 2005. Controls appear to have been quite effective until about 1980. Controls have involved testing and slaughter as well as quarantine at international borders. Animal and human vaccination has been in place as a strategy since the 1950s and seems to have been the reason for decline in prevalence through to the 1980s. Since 1980, some provinces have conducted human and animal surveillance while animal movement controls have become more stringent since implementation of animal quarantine regulations after 1997.

China had for many years adopted strict measures to keep animal epidemics confidential. Thus it is difficult to assess the historical extent of disease control and management efficacy. Since the early 1980s information on most, but by no means all, animal epidemics has been made public. Due to concerns about poor transparency regarding animal diseases, many countries continue to bar livestock product imports from China (Zhao, 41). The official channel for disclosing epidemic diseases in China is the Veterinary Bulletin of the Ministry of Agriculture (MoA). Initiated in 1999, the Bulletin discloses monthly the occurrence of major animal diseases in China. Table 4 presents nationwide data reported in the Bulletin on the number of cases of six major diseases nationwide during 2000-'11. Five of these are Class A animal diseases in China while brucellosis is a Class A human disease.[5]

[5] These six diseases are all OIE notifiable. According to *List of Class A, B and C Animal*

The table shows that Newcastle disease (among poultry) and Classical Swine Fever have been the two most common. In recent years Newcastle disease outbreaks have been effectively controlled. Incidence has declined subsequent to the implementation of vaccination measures. Commencing 2008 the incidences of Classical Swine Fever and PRRS, which are also included in the nationwide compulsory vaccination policy, have declined markedly.

The years 2003-2004 saw a major outbreak and spread of H5N1 avian influenza throughout Southeast Asia. In 2005 alone, in excess of 160,000 birds were infected in China. Prevalence decreased after the PRC implementing comprehensive prevention and control measures including compulsory vaccination, culling, disinfection, movement controls and surveillance, but the outbreak was not fully controlled until 2009. Among the six diseases, brucellosis and FMD have yet to be brought under effective control. When compared with 2000, the number of brucellosis cases was 11 times higher in 2010. In 2011, records identify a severe brucellosis breakdown among cattle and sheep in pastoral Inner Mongolia. FMD broke out in the summer of 2006 and again in the first half of 2010 in China. In summary, even though China continues to face significant animal disease challenges, its government has sought to strengthened animal disease control and this is reflected in successes against several major diseases.[6]

LEGAL AND INSTITUTIONAL STRUCTURE

China is firmly committed to developing a comprehensive veterinary regulatory and legal system, see Table 5. The PRC's fundamental law on Animal Disease Prevention took effect after State Council regulations were formulated in 1997, and a major amendment took effect in 2008. It sets down explicit provisions on various aspects, including reporting, notification and release

---

Diseases, which was promulgated by MoA in December 2008, Class A animal diseases are of greatest impact and importance.

[6] Before 2006 China did not disclose complete information concerning FMD (Zhao, 41), so data reported in the Veterinary Bulletin may be misleading.

of animal disease information, control and eradication of animal diseases, inspection of animals and animal products, diagnosis and treatment of animals, and administration of animal disease prevention measures. On the basis of this law, the State Council established rules and plans for emergency response management, regulations over animal and plant entry and exit quarantine as well as many other domains (Xiang and Wang, 42; Veterinary Bureau MoA, 43). The MoA's Veterinary Bureau (VB) has formulated supportive rules for many activities, such as disease reporting, management of veterinary drugs, emergency response management, veterinarian management, bio-safety management for veterinary laboratories, surveillance and early warning, as well as inspection and supervision.

Since 2004, China has developed emergency response plans such as the nationwide emergency response plan for the prevention and control of HPAI. In 2010, an emergency response plan for control of FMD was issued. Meanwhile, emergency response plans for major animal diseases have been developed at provincial, municipal and county levels, covering their respective administrative areas (VB MoA, 44).

Figure 2 outlines China's institutional system for animal disease control. The MoA is the national authority in charge of organizing and supervising national animal disease prevention and control work, publicizing animal disease information, mobilizing stamp-out activities, veterinary drug control and inspection work, and overseeing public and private sector veterinarians. The Chief Veterinary Officer (CVO) is located in the MoA's Veterinary Bureau and is in charge of veterinary administration across the country. Veterinary authorities have been established in every province, prefecture and county for animal disease control, inspection and quarantine, veterinary drug administration and residue control as well as other duties within their respective jurisdictions. In 2011, veterinary administrative agency employment across province, prefecture and national levels summed to 34,000 (VB MoA, 44).

Local governments at the county-level or above have also established animal health supervision institutions. They are responsible for disease inspection of livestock and livestock products, as well as administration and law enforcement related to animal disease prevention. In 2011, aggregate employment at these institutions was 149,000 (VB MoA, 44).

In addition, China has established veterinary technical support institutions at various levels. Country-level veterinary technical support institutions include three public institutes directly affiliated to the MoA. These are *i*) China Animal Disease Control Center which is responsible for surveillance and control; *ii*) China Institute of Veterinary Drug Control which is charged with assessing drug quality and regulating use; *iii*) China Animal Health & Epidemiology Center which investigates specific outbreaks and more generally seeks to identify risk factors. Country-level laboratories include dedicated national diagnostic and reference laboratories for each of AI, FMD, Bovine spongiform encephalopathy (BSE), Classical swine fever, Newcastle disease and Contagious Bovine Pleuropneumonia.[7] The MoA has also set up 304 national animal disease surveillance and reporting stations to undertake surveillance and epidemiological investigation assignments from MoA or provincial veterinary authorities. The 146 border animal disease surveillance stations carry out similar duties along border regions.

Local animal disease control institutions are also in place. Provinces, municipalities and counties have their own animal disease control institutions for disease prevention, control and eradication as well as surveillance, testing, epidemiological investigation and reporting within their jurisdiction. Finally, county veterinary authorities supervise offices at town and township levels. They are responsible for disease prevention, inspection, and technical extension services.

The General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) is responsible for inspection and quarantine of animals and animal products that enter and exit the

[7] Diseases outbreaks are be confirmed by the pertinent reference laboratory and information is then released by the government. All reference laboratories are Biosafety level 3 (BSL3).

PRC. AQSIQ exercises vertical management over its entry and exit inspection and quarantine institutions. AQSIQ supervises 35 entry and exit inspection and quarantine bureaus directly under it in all provinces, autonomous regions and municipalities as well as at major ports. There are nearly 300 branches and over 200 offices at seaports, land ports and airports as well as shipment distribution centers, with total staffs of more than 30,000 (VB MoA, 44).

Animal Disease Control Policy

Approaches to control

In line with the National Long and Middle-term Animal Disease Control Plan for 2012-2020, the general approach across major diseases is that infectious animal disease control in China advance from blanket vaccination to near disease-free with vaccination and, relying on 1997 quarantine regulations, from there to disease-free without vaccination. In terms of scope of control, it is intended that a regionalized approach to endemic disease control will be followed for diseases where such an approach is practical. Commencing with disease-free regions, the intent is to expand geographically toward disease-free at the national level (State Council, 45). Heavy reliance on vaccination can be problematic for many diseases, including FMD. Multiple FMD virus variants exist where vaccines are not effective across all. Distinguishing between a vaccinated animal and an infected animal can be difficult and can lead to problems when identifying and managing an outbreak. Furthermore, outbreaks have likely occurred during the course of vaccine development (Li and Lui, 46; Hui and Leung, 47). Blanket vaccination is not widely applied for many major diseases in OECD countries because it can diminish quality of test information. Most OECD countries do apply herd lock up and regional movement control strategies when seeking to eradicate a disease.

The PRC is committed to sharing information on animal health events across various

governmental levels, and with international organizations such as OIE and WHO. Its disease surveillance and reporting system and the outbreak response system are depicted in Figures 3 and 4, respectively (VB MoA, 48). For zoonotic diseases, the national government's focus includes Brucellosis, Bovine Tuberculosis, Schistosomiasis (a parasite), Coenurosis (a parasitic infection) and rabies. Regarding foreign animal diseases, the MoA cooperates closely with related agencies to strengthen border controls and foreign animal disease surveillance. The government also cooperates across national borders in prevention and control measures, where instances include control programs for African Swine Fever and Peste de Petits Ruminants (PPR). The MoA is also placing emphasis on training in emergency response and preparedness of emergency response (VB MoA, 43).

Financial support policy

Since 2005, funding needed for veterinary administration, animal health supervision, disease prevention and control institutions and township veterinary stations has been incorporated into government budgets at corresponding administrative levels (Xiang and Wang, 42). The National Animal Disease Control System Development Plan (2004-2008) was supported by 4.5 billion CNY from central government finances. Plan priorities were two-fold. One was to speed up construction projects that support central animal disease prevention and control infrastructure, and also technological transformation of biological products enterprises. The second was to strengthen the presence and effectiveness of local veterinary stations. Some of the funds were used to build animal disease prevention systems, infrastructure for quarantine and monitoring, and controls on drug quality and residues at central, provincial, county and township levels.

Financial support for veterinary medicine can be summarized as a 'three policies' approach (Wei et al., 49; Sun, 50) as laid out below. These policies have facilitated the implementation of compulsory vaccination and culling through reducing resistance by farmers and through

stabilizing the local animal disease control infrastructure. The policies are:

(1) Financial assistance for compulsory animal vaccination: The central government provides financial assistance for compulsory vaccination against four major animal diseases. China has implemented compulsory vaccination against FMD since 2001, AI since 2005, Highly Pathogenic PRRS (HP-PPRS) since 2007 and swine fever since 2007. These vaccinations are preventive, rather than as part of an emergency response strategy.

(2) Compensation for compulsory culling: compulsory culling is implemented for livestock infected by HPAI, FMD, HP-PRRS and PPR, as well as dairy cows that test positive for brucellosis and tuberculosis. Some monetary compensation, but generally considerably below market price, is provided to owners.

(3) Central government financial support for local animal disease control: In 2001 the MoA and the Ministry of Finance jointly agreed to increase support for compulsory vaccinations carried out by local animal disease control workers. In 2008 the central government commenced providing financial support for more general animal disease control at the local veterinary station level. Through procurement of labor services, the country in total recruited 645,000 village animal disease control workers who vaccinate, tag livestock, establish vaccination records and report animal diseases. These activities are partly paid for through a 650 million CNY government allocation. In addition, local government finances provide matching support for village disease control workers.

ISSUES FOR ANIMAL DISEASE MANAGEMENT

Animal disease control programs in China are intended to first establish effective disease control and eradication. But these are not the only goals that China's public animal health administration seeks to address. As is the case with many other countries, a fundamental change

in the mission of China's veterinary medicine profession is taking place. A primary focus on cheap protein is being replaced by a broader view that also includes animal well-being, food safety and public goods in line with evolving commercial contracts, international standards and domestic civic concerns. Consistent with its rapid growth and increasing presence in international food markets, China's imperative to upgrade public animal health infrastructure has been far stronger than for most countries. Outlined below are some specific areas where China's veterinary service and animal disease control system seems to be particularly weak.

Issues related to administration

The veterinary administration reforms initiated in 2005 were limited. Although the reform largely resolved institutional issues, there remain many weaknesses. Comments A)-D) below rely heavily on critiques by Sun (50) and also Xiang and Wang (42):

A) *Unclear domains of administrative jurisdiction:* At present, although the MoA is assigned responsibility for veterinary administration, in practice some authority lies with agencies not overseen by MoA. Control of disease among wild animals is under the National Forestry Bureau, while farmed and legally hunted animals are the remit of MoA. Border controls for animals and animal products are the responsibility of AQSIQ. Supervision of animal health and animal products, animal husbandry and transportation are administered by MoA. Slaughter and processing are also MoA responsibilities while industry development planning, industry standards and industry supervision are overseen by the Ministry of Commerce. Once meat products enter the market, the State Administration for Industry and Commerce assumes responsibility. When meat products entered the catering sector, supervision becomes the responsibility of public health authorities.

However, in practice demarcation of responsibilities is unclear and some stages fall between

the cracks. Ill-defined boundaries of control may lead to wasted resources when bureaucracies contest for control as well as when seeking to deflect accountability in the aftermath of a crisis. Similar inconsistencies exist elsewhere, as in the United States where the federal Department of Agriculture is responsible for meat, poultry and processed egg food safety but the federal Food and Drug Administration is responsible for the safety of most other foods. However, concerns about communication failures should be more acute for a rapidly developing country with comparably brisk marketing chain reconfigurations.

B) *Domestic and border quarantine activities are separated and policies are issued by multiple government agencies:* In 1998, and in compliance with State Council regulations, China's internal and external quarantine activities were separated. Entry and exit quarantine for plants and animals, formerly administered by the MoA, were handed over to the newly established AQSIQ and responsibilities for wildlife protection were handed over to the National Forestry Bureau. Consolidating supervision at borders mitigates many other problems. However, as with unclear administrative jurisdiction in item A) above, failures in coordination and accountability, inter-agency disputes and gaps in administrative oversight are frequent.

C) *Loss of institutional focus and conflicts of interest.* China's current veterinary administration does not effectively separate public functions and profit-driven activities. For example, the availability of public financial resources remain very limited at the local level. Partly as a result, and in order to support obligatory public animal disease management activities, veterinary administrators engage in cost recovery and profit-making activities. These include disease diagnosis and treatment as well as feedstuff and drugs sales. Retailing to producers that are also supervised leads to conflicts of interest.

D) *Quality assessment needs further improvement.* Quality assessment procedures have never been adequately developed and implemented for China's veterinary administration units.

Assessment indicators are often non-specific while those that are typically emphasize infrastructure construction. By contrast with management practices in other countries, procedures to measure progress, assemble informative data and objectively compare alternative approaches have generally not been put in place. For example, in prevention and control of major animal diseases the only data that have been collected are indicators of success in vaccination coverage. Other useful data, such as costs by farm, are not generally collected.[8]

Issues related to legal safeguards and human capital

E) *Absence of basic laws on licensing:* A document issued by the State Council of China in 2005 made clear that an official system of licensing and oversight for the veterinary profession is to be developed. To this end, in 2009 the MoA commenced developing exam protocols for obtaining the qualification (see Table 5). However, basic laws on veterinary licensing are not in place so that professional responsibilities and scope of work have yet to be defined. It is also difficult to preclude entry by those that are not well-qualified. Thus, incentives are weak for practitioners to invest in professional growth or to specialize. In addition, the government does not have available to it advice from a well-motivated professional body concerned with advancing the vocation's performance and contribution to society.

F) *Regulatory omissions and inconsistent implementation:* China relies on government departments to promote the formulation and amendment of laws and regulations. But agendas differ and inter-departmental conflict is common. In some cases, political considerations supersede the integrity of laws while in other cases no law applies. For example, wild animal disease prevention and control is not covered by any law. This has been problematic for HPAI

[8] The OIE tool for the evaluation of Performance of Veterinary Services (PVS) is newly introduced into the PRC. Presently an imperfect data collection network is in place at the local level and insufficient funds have been allocated for data collection.

control. Furthermore several general problems likely affect issue identification and definition. One is weakness in the veterinary profession, as outlined in item E) above. Another is limited opportunities for public discourse, whether because of concerns about conflict with administration or because of limited education on the part of many farmers.

G) *Accountability systems are not well established:* In prevention and control of major animal diseases, responsibility lies to some extent with administrators responsible for processing the initial report. As a result, the official may not have strong incentives to act in the public good. False, inadequate and delayed reports occur from time to time (Wei, 51). Missing are implemented procedures for more discerning information gathering, auditing and personnel management that might encourage officials to report problems when found.

H) *Local animal disease control workforce quality needs upgrading:* In 2009 China had 645,000 village animal disease control workers. Non-veterinary personnel accounted for 63.5% of these while personnel with less than middle school education accounted for 35.2%. In general, local disease control workers have had insufficient training to meet job requirements. Some village disease control workers have limited knowledge about pertinent scientific principles, specific animal diseases and their modes of transmission. Detection and reporting delays as well as misdiagnosis are all too frequent, leading to disease spread and inefficient use of scarce public animal health resources.

Issues related to financial support

I) *Low levels of gross financial support:* In recent years, public sector financial inputs into animal disease control in China have accounted for less than 0.2% of gross output value from animal husbandry. This is lower than in the United States, at about 0.6%, or Switzerland, at about 0.53% (Wei, 51). Expenditures on veterinary measures for each livestock unit [one

livestock unit equals to 1 bovine (adult), 4 pigs, 10 sheep or 100 chickens] are as high as 21 USD in Switzerland and are 5 USD in the United States, compared with 1.6 USD in China (Wei, 51). The disparity could be for a variety of reasons. China's animal species mix is less concentrated on ruminants than countries in Western Europe and North America. Labor costs differ too. Animal productivity is comparatively higher in these other countries while it is arguable whether public animal health input productivity is higher elsewhere. But the numbers do suggest that if China strengthens its performance in providing public animal health inputs then increased investment into the area might be warranted.

J) *Inertia in disease control resource allocations:* Three diseases have accounted for the large majority of central fiscal expenditures over the past 10 years. FMD control has accounted for about 50% of total expenditures, followed by AI at 29% and HP-PRRS at 15%, with 6% allocated to all other diseases. Investment in the control of other diseases has not increased for many years. For example, annual expenditures on screening and treatment of livestock Schistosomiasis, a zoonotic disease, has remained at 5 million CNY annually from 2003 to 2010, while expenditures on testing for brucellosis and equine infectious anaemia has been static in nominal terms since before 1990 (Wei et al., 49).

K) *Irrational allocation of expenditures:* At present, China implements compulsory vaccination against four major animal diseases. Earmarked funding from central finance for animal disease prevention and control focuses largely on vaccine subsidies, which account for over 92% of category expenditures. Compensation for culling, disease outbreak surveillance, livestock product safety, health supervision, and approval of veterinary drugs are major components of the remainder (Wei et al., 52). Typically the final stages of disease containment and control require movement controls, culling and significant compensation budgets. Despite glaring weaknesses, disease outbreak surveillance and capacity building at the local level

through personnel training and technological extension receive little attention. As with item J) above, effective procedures for risk and vulnerability assessment do not appear to be in place.

L) *Low compensation for culling and farmer noncompliance:* Under current animal loss compensation standards, compensation to farmers is much lower than market value. Net compensation for culled beef cattle and dairy cows are 1,200 and 2,400 CNY/head, respectively, compared with average market prices of about 7,000 and over 10,000 CNY/head, respectively, for beef cattle and dairy cows (Wei et al., 52). It should be no surprise that veterinary authorities continue to have difficulty in eliciting farmers to self-report and otherwise comply with disease control activities. In addition, some animals suffer severe adverse reactions to a vaccine (Sun, 50) while no insurance scheme covers this risk. Motivated by concerns about productivity side effects, some farmers manage to avoid the vaccination mandate.

M) *Capital investments not matched with operational support:* As is common through many other parts of the public sector in China and elsewhere, allocations to public animal health often focus on putting infrastructure in place rather than on maintenance or supporting the programs intended for the infrastructure.[9] Recurrent costs for maintenance generally have to be raised by local governments, which is difficult for China's less developed western regions. Consequently infrastructure is poorly maintained and ineffective in these regions. Some local laboratories are unable to use their facilities when fulfilling their surveillance and survey obligations, dispatching instead their samples for analysis at other institutes.

General issues

N) *Further investment needs in diagnosis and allied epidemiology capabilities:* While China's human health disease detection infrastructure has improved markedly in recent years,

[9] This concern was also raised as Conclusion 7 in the U.S. National Academies report on replacing Plum Island (McElwain et al., 53).

many analysts hold that important gaps remain. Infrastructure in place is largely for identifying syndromes via public health monitoring, but capability to diagnose the responsible pathogens is limited (Feng et al., 54). Given limited abilities to deal with biological samples, surveillance signals are noisy while ex-post epidemiology is poorly informed. Such capabilities will likely first emerge in human medicine before translating to animal health. Public health authorities have come to realize that particular weakness exists in this area and, more generally, that public animal health and human health activities need to be better integrated (Fearnley et al., 55). A response has been interdisciplinary One Health initiatives in China, commencing about 2012, including extensive veterinary epidemiology training courses. Similar to item M) above, capacity development needs to be supported with a commitment to subsequent investments in maintenance and operational support.

O) *Insufficient knowledge of produce origin and on-farm practices:* Smaller-scale agricultural production persist in part because they are flexible in managing labor inputs and utilizing a wide array of feedstuffs. Governments have a reasonable interest in understanding how agricultural production practices affect food quality and biosecurity. Their capacity to understand is impeded to the extent that the production base is comprised of small, spatially dispersed and heterogeneous firms whose produce is not readily traced. Thus, melamine adulteration and use of illegal additives can go undetected for an extended period because this is not the practice of all firms and even if produce is found to be defective it is difficult to identify the source. Regulators have limited ability to relate cause with effect. There are therefore public needs for capacity to associate produce with producing farm, and to obtain structured information about what happens on farms.

In recent decades, European and North American food processors have sought to protect their reputations for product quality by strengthening information flows from and control over

the farms they procure from (Pouliot and Sumner, 56). While altered contractual relations may better protect firms and consumers, more is needed to ensure that any regulatory interventions are prudent. Governments have sought to obtain relevant information in a variety of ways. Through NAHMS surveys sent out to growers since 1983, the U.S. Federal government has sought to better understand production practices as they relate to animal health. ARMS surveys, sent out to growers since 1996, serve more general purposes but have also been called upon to obtain baseline understandings of on-farm antibiotics use (Key and McBride, 57). Comparable structured information gathering endeavors do not exist in China. Production statistics for poultry are particularly unreliable, where large discrepancies between official statistics and vaccines used confound vaccine subsidy management.

Discussion

Periods of rapid industry change almost invariably give rise to concerns about system failure. Teething problems may arise when firms learn about new technologies used in new contexts. The mindset suited to the approach being supplanted may not fit the novel approach and a workforce that cannot adapt may need to be replaced if the new approach is to work. In addition, system change-over will involve a protracted period when industry participants are very heterogeneous. During this time the industry may prove difficult to monitor and regulate. There may also be market mediated consequences of change-over. China's melamine adulteration system failure was likely due in part to the profit squeeze faced by small producers when the advent of larger-scale production pushed milk prices down (Yu, 58).

A separate issue is whether a system of larger-scale production is safer than one of smaller-scale production. This is a complex and multi-faceted matter. It is clear that many consider larger-scale production to pose the greater risk (pp. 321-322 in Greger, 59; Graham et

al., 60), seeing larger farms as venues for huge virus loads to grow and adapt. Things may not be so simple, however. Many biosecurity measures are cheaper per unit animal when implemented on larger farms so that larger facilities can better justify investments in these measures (Sims, 61; Hennessy and Wang, 62). In addition, although confined animals may have less robust immune systems by contrast with backyard production, species are segregated from other domestic species and wild members of their own species.

Perhaps the largest effect that China's development will have on the health risks its livestock sector poses will arise from the infrastructure that growing wealth can eventually support. The London of Dickens was foul with disease not so much because of overcrowding, but because of inadequate sanitary infrastructure. Potable water and contained sewage systems deny germs the opportunity to spread while demand for live birds would decline were infrastructure sufficient to ensure that wholesome processed animals reach the consumer.

References

1. Shortridge KF. The next pandemic virus? *Lancet* 1995; 346(November 4):1210-1212.
2. Sonnberg S, Webby RJ, Webster RG. Natural history of highly pathogenic avian influenza H5N1. *Virus Research* 2013; forthcoming.
3. Greger M. The human/animal interface: Emergence and resurgence of zoonotic infectious diseases. Critical Reviews in Microbiology 2007;33(4):243-299.
4. Sims LD, Domenech J, Benigno C, Kahn S, Kamata A, Lubroth J, Martin V, Roeder P. Origin and evolution of highly pathogenic H5N1 avian influenza in Asia. *Veterinary Record* 2005; 157(Aug. 6):159-164.
5. Perry BD, Grace D, Sones K. Current drivers and future directions of global livestock disease dynamics. *PNAS USA* 2011; 10.1073/pnas.1012953108.
6. Bogich TL, Chunara R, Scales D, Chan E, Pinheiro LC, Chmura AA, Carroll D, Daszak P, Brownstein JS. Preventing pandemicsvia international development: A systems approach. PLOS Medicine 2012;9(12):1-4.
7. Jones BA, Grace D, Kock R, Alonso S, Rushton J, Said MY, McKeever D, Mutua J, McDermott J, Pfeiffer DU. Zoonosis emergence linked to agricultural intensification and environmental change. *PNAS USA* 2013;110(21):8399-8404.

8. Jones KE, Patel NG, Levy MA, Storeygard A, Balk D, Gittleman JL, Daszak P. Global trends in emerging infectious diseases. *Nature* 2008;451(Feb. 21):990-993.

9. Sharma K, Paradakar M. The melamine adulteration scandal. *Food Security* 2010;2(1):97-107.

10. Levitt JA, Pape SM. FDA Food Safety Modernization Act: The road to passage. In: *The Food Safety Modernization Act: A Comprehensive, Practical Guide to the Landmark Legislation*, Woodlee JW, Ed. Food and Drug Law Institute, Washington DC, 2012.

11. Broughton EI, Walker DG. Policies and practices for aquaculture food safety in China. *Food Policy* 2010;35(5):471-478.

12. Collins, EJT. Food adulteration and food safety in Britain in the 19th and 20th Centuries. *Food Policy* 1993;18(2):95-109.

13. Gale HF, Hu D. Food safety pressures push integration in China's agricultural sector. *American Journal of Agricultural Economics* 2011;94(2):483-488.

14. Qian G, Guo X , Guo J, Wu J. China's dairy crisis: Impacts and policy implications for a sustainable dairy industry. *International Journal of Sustainable Development & World Ecology* 2011;18(5):434-441.

15. Bensinger K, Hsu T. Chinese form to buy pork producer Smithfield Foods. *Los Angeles Times* 2013;(May 29).

16. Pei X, Tandon A, Alldrick A, Giorgi L, Huang W, Yang R. The China melamine milk scandal and its implications for food safety regulation. *Food Policy* 2011;36(3):412-420.

17. Jia X, Huang J, Luan H, Rozelle S, Swinnen J. China's milk scandal, government policy and production decisions of dairy farmers: The case of Greater Beijing. *Food Policy* 2012;37(4):390-400.

18. Gale F, Marti D, Hu D. China's volatile pork industry. United States Dept. of Agriculture. ERS report LDP-M-211-01, February 2012.

19. Lo SS-H. SARS and avian influenza in China and Canada: The politics of controlling infectious disease. In: *Innovations in Global Health Governance: Critical Cases*, Cooper AF, Kirton JJ, Eds., pp. 83-104. Ashgate Publishing Group, Farnham UK, 2009.

20. Morrison JS. The prospects for engaging China with global health issues. In: *China's Capacity to Manage Infectious Diseases: Global Implications*, Freeman CW, Lu X, Eds., pp. 93-96. Center for Strategic & International Studies, Washington DC, 2009.

21. Wishnick E. Dilemmas of securitization and health risk management in the People's Republic of China: The cases of SARS and avian influenza. *Health Policy and Planning* 2010;25(6):454-466.

22. Kaufman J. Infectious disease challenges in China. In: *China's Capacity to Manage Infectious Diseases: Global Implications*, Freeman CW, Lu X, Eds., pp. 3-16. Center for Strategic & International Studies, Washington DC, 2009.

23. Rambhia KJ, Cicero A. Improving epidemic response: Building bridges between the US and China. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*

2012;10(3):328-331.

24. Morse SS. Public health surveillance and infectious disease protection. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 2012;10(1):6-16.
25. Yang W, Li Z, Wang J, Ma J, Jin L, Sun Q, Lu W, Lai S, Liao Y, Hu W. A nationwide web-based automated system for outbreak early detection and rapid response in China. *Western Pacific Surveillance and Response Journal* 2011;2(1):10-15.
26. Huang Y. Managing biosecurity threats in China. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 2011;9(1):31-40.
27. Peng H-J, Zhang C, Wang C-M, Chen X-G. Current status and challenges of human parasitology teaching in China. *Pathogens and Global Health* 2012;106(7):386-390.
28. Xia X. Strengthening animal disease control to safeguard human health and sustainable development of livestock sector. *Proceedings of the Second China Animal Husbandry S&T Forum*. China Agricultural Publishing House, Beijing, 2005:9-11.
29. Xie Z, Yang N, Wei X, Sun X, Shen C, Huang B, Wang Z, Wen Z, Wang X, Lin W, Shan H, Wang J, Lu C, Li X, Sun C, Zhang Z, Cai L, Wang X, Fu T, Wang J, Zhang L, Jiang X, Wu Z, Pu H, Zhao L, Wang L, Guo X, He B, Jia Z. *Economics of Animal Health*. China Agricultural Publishing House, Beijing, 2006.
30. National Development and Reform Commission (NDRC). National Plan for the Development Animal Disease Control System (2004-2008). NDRC, Paper number N. 2837, 2006.
31. Xiao H, Wang J, Oxley L, Ma H. The evolution of hog production and potential sources for future growth in China. *Food Policy* 2012;37(4):366-377.
32. Chen K, Wang J. Hog farming in transition: The case of China. The Pig Site 2013, February 28, http://www.thepigsite.com/articles/4262/hog-farming-in-transition-the-case-of-china
33. Zhou G, Zhang W, Xu X. China's meat revolution: Challenges and opportunities for the future. *Meat Science* 2012;92(3):188-196.
34. Prosser DJ, Wu J, Ellis EC, Gale F, van Boeckel TP, Wint W, Robinson T, Xiao X, Gilbert M. Modelling the distribution of chickens, ducks, and geese in China. *Agriculture, Ecosystems and Environment* 2011;141(3-4):381-389.
35. Han RY. Overview of the China Poultry Industries. American Soybean Association, http://www.thepoultryfederation.com/public/userfiles/files/Poultry%20Nutrition%20and%20Production%20in%20China%20Han.pdf
36. Dobson WD, Dong F, Jesse EV. The Dairy Sector of China: A Country Study. Babcock Institute Discussion Paper No. 2011-2. University of Wisconsin, Madison 2011.
37. Mo D, Huang J, Jia X, Luan H, Rozelle S, Swinnen J. Checking into China's cow hotels: Have policies following the milk scandal changed the structure of production? *Journal of Dairy Science* 2012;95(5):2282-2298.
38. Xiong Z, Xu D. Status of epidemics of major animal diseases and prevention and control

strategy of China. *Hubei Journal of Animal and Veterinary Sciences* 2007;(l2):22-24.

39. Shang D, Xiao D, Yin J. Epidemiology and control of brucellosis in China. *Veterinary Microbiology* 2002;90(1-4):165-182.
40. Chen Z, Zhang W, Ke Y, Wang Y, Tian B, Wang D, Cui B, Zou W, Li S, Huang L, Song H. High risk regions of human brucellosis in China: Implications for prevention and early diagnosis of travel-related infections. *Clinical Infectious Diseases* 2013;57(2):330-332.
41. Zhao D. Analysis of animal diseases control strategies in China. *Review of China Agricultural Science and Technology* 2006;8(5):1-4.
42. Xiang C, Wang Y. Study of China's Veterinary Administration System Reform. China Agricultural Publishing House, Beijing, 2011.
43. Veterinary Bureau, Ministry of Agriculture. Animal Health in China 2011. China Agricultural Publishing House, Beijing, 2013.
44. Veterinary Bureau, Ministry of Agriculture. Animal Health in China 2010. China Agricultural Publishing House, Beijing, 2011.
45. State Council. *Circular of the General Affairs Department of the State Council on Issuing the National Long and Middle-term Animal Disease Control Plan* (2012-2020). State Council Office No. 31, 2012.
46. Li Z, Lui J. The current state of vaccines used in the field for foot and mouth disease virus in China. *Expert Review of Vaccines* 2011;10(1):13-15.
47. Hui RK, Leung FC. Evolutionary trend of foot-and-mouth disease virus in Hong Kong. *Veterinary Microbiology* 2012;159(1-2):221-229.
48. Veterinary Bureau, Ministry of Agriculture. Animal Health in China 2008. China Agricultural Publishing House, Beijing, 2009.
49. Wei X, Liu Y, Chen W, Huang B, Lin W, Wu J, Yang H, Cao M, Kang J, Li L, Sun X, Shen C, Yang N, Wang D, Zhu D, Zhang Z, Jia Z, Qu S, Fei Y, Yu Y, Liu G, Liu J, Liu D, Zhao H, Tian F. Study on financial support policy. In: Ministry of Agriculture. *Study on the National Long and Medium-term Strategy for Animal Disease Control*. China Agricultural Publishing House, Beijing, 2012.
50. Sun Y. Overseas experiences – Enhancing China's Development of Veterinary Service *World Agriculture*, 2010(6):5-10.
51. Wei X. Technological Economic Analysis of Highly Pathogenic Avian Influenza Control Strategies. PhD thesis, China Agricultural University, Beijing, 2011.
52. Wei X, Chen W, Lin W, Wu J. Policies and motivations for financial support to animal disease control in developed countries. *Agricultural Economic Issues* (in Chinese) 2011;7: 99-105.
53. McElwain T, Connell N, Hennessy DA, King LA, Le Duc J, MacLachlan NJ, Marsh B, Salman M, Torres A, Wolf C. *Meeting Critical Laboratory Needs for Animal Agriculture: Examination of Three Options*. National Research Council, Washington, DC, June, 2012.

54. Feng Z, Li W, Varma JK. Gaps remain in China's ability to detect emerging infectious diseases despite advances since the onset of SARS and Avian Flu. *Health Affairs* 30(1);127-135.

55. Fearnley L, Wilcox BA, Sims LD, Martin V. *An Eco-system Health Approach to Address Emerging Infectious Diseases in China*. Report on the UN China One Health event, Beijing, 29-30 June, 2011.

56. Pouliot S, Sumner DA. Traceability, liability, and incentives for food safety and quality. *American Journal of Agricultural Economics* 2008;90(1):15-27.

57. Key N, McBride W. Sub-therapeutic antibiotics and the efficiency of U.S. hog farms. *American Journal of Agricultural Economics* 2014;96, forthcoming.

58. Yu X. Productivity, efficiency and structural problems in Chinese dairy farms. *China Agricultural Economic Review* 2012;4(2);168-175.

59. Greger M. *Bird Flu*. Lantern Books, New York NY, 2006.

60. Graham JP, Leibler JH, Price LB, Otte JM, Pfeiffer DU, Tiensin T, Silbergeld EK. The animal-human interface and infectious disease in industrial food animal production: Rethinking biosecurity and biocontainment. *Public Health Reports* 2008;123(3):282-299.

61. Sims LD. Strategies for controlling animal influenza and implications for human health. *Influenza and Other Respiratory Viruses* 2011;5(Suppl. 1):2-53.

62. Hennessy DA, Wang T. Animal disease and the industrialization of agriculture. In: *Health and Animal Agriculture in Developing Countries*, Zilberman D, Otte J, Roland-Holst D, Pfeiffer D, Eds., pp. 77-100. Springer, New York NY, 2012.

63. National Station of Animal Production, Department of Animal Production. *China Animal Industry Statistics 2011*. Ministry of Agriculture, Beijing, 2012

Table 1. Change in production of major livestock species in China, 1985-2011 (million head)

Year	1985	1991	2001	2011	Average annual growth rate
Marketed poultry	1,579[1/]	2,824	8,088	11,327	8.20%
Marketed pigs	237	329	549	662	4.02%
Stock of cattle	86.8	104.6	128.2	103.6	0.68%
Stock of sheep	155.9	206.2	298.3	282.4	2.31%

1/: data for 1986.

Data source: marketed volume of poultry from 1986 to 2010 is from the China Animal Industry Statistics 1949-2001; the rest is from China Rural Statistics Yearbook (of related years).

Table 2. Changes of average farm size of major livestock species, 2002-2010 (head per farm or household)

Year	2002	2007	2010
Marketed broilers	99.2	249.2	378.1
Stock of egg layers	39.9	82.5	127.6
Marketed pigs	5.8	6.9	10.8
Marketed beef cattle	3.1	3.6	4.4
Stock of dairy cattle	5.0	5.6	6.1

Data source: China Animal Industry Yearbook, various years.

Table 3. Importance of animal husbandry in China's economy

Year	1985	1991	2001	2011
Gross production value of animal husbandry (100 million CNY)	797	2,159	7,963	25,771
Income from animal husbandry as share of total value of agricultural output	0.22	0.265	0.304	0.317
Total value of international trade in meats (million USD)	299	659	2,062	4,484
Income from animal husbandry as share of net farm household income	/	0.133	0.090	0.066
Income from animal husbandry as share of net income derived from agriculture	/	0.204	0.182	0.184

/: data unavailable for that year.
Data sources: China Rural Statistic Yearbook (over years); of which, "Total international trade value of meats" is from China Foreign Economic and Trade Yearbook (several years) and now titled China Commerce Yearbook.

Table 4. Occurrences of major animal diseases in China: 2000-2011 (Units: head)

Year /Disease	AI	FMD	Swine fever	PRRS	Newcastle disease	Brucellosis
2000	0	0	42,121	3,182	1,963,504	678
2001	0	0	34,149	208	744,218	0
2002	0	0	98,038	0	2,077,262	0
2003	0	0	75,934	6,280	1,144,480	662
2004	132,099	0	40,002	10,199	439,349	1,622
2005	161,183	536	82,446	28,234	1,402,563	2,154
2006	93,531	836	69,691	114,048	1,195,795	2,031
2007	27,160	151	148,007	96,933	646,049	1,247
2008	9,428	123	60,571	7,410	596,907	3,138
2009	2,951	813	39,277	6,885	302,173	4,676
2010	0	3,943	9,562	17,191	155,906	7,715
2011	290	823	4,535	1,069	46,338	124,730

Data source: Veterinary Bulletin, various years, MoA of PRC.

Table 5. China's Veterinary Laws and Regulations, and Dates they Came into Effect

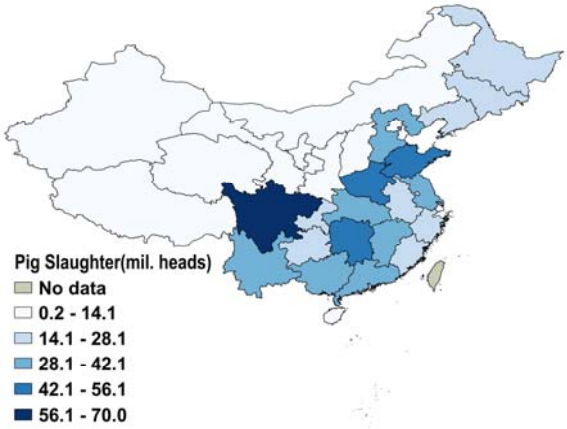
Category	Name	Effective
LAWS AND BROADLY APPLIED REGULATIONS		
Law	PRC Law PRC on Entry and Exit Ani. and Plant Quar.	1992
	PRC Law on Agric. Product Quality and Safety	2006
	PRC Law on Ani. Production	2006
	PRC Law on Ani. Dis. Prevention	2008
State Council regulations	Regs on Implementation of PRC Law on Entry and Exit Ani. & Plant Quar.	1997
	Regs on Admin. of Veter. Drugs	2004
	Regs on Bio-safety Manage. of Pathogenic Microbe Labs	2004
	Regs on Emergency Response to Major Ani. Dis.	2005
SECTORAL REGULATIONS		
Disease monitoring & reporting	Admin. Meas. for Ani. Dis. Reporting	1999
	Rules on Manage. of Nat. Ani. Dis. Surveillance & Reporting System (Trial)	2002
	List of Category A, B and C Ani. Dis.	2008
	List of Zoonoses	2009
Emergency responses	Nat. Conting. Plan for HPAI	2004
	Conting. Plan for Entry and Exit of Major Ani. Dis.	2005
	Conting. Plan of Agric. Authorities for Human Cases of HPAI	2005
	Nat. Conting. Plan for Sudden Outbreaks of Major Ani. Dis.	2006
	Conting. Plan for Prevention and Control of PPR	2010
	Conting. Plan for Prevention and Control of FMD	2010
Veterinary laboratory bio-safety management	List of Veter. Categories of Ani. Pathogenic Microbes	2005
	Meas. for Examination and Approval of Bio-safety Manage. of Highly Pathogenic Ani. Pathogenic Microbe Laboratories	2005
	Admin. Meas. for Storage of Seed Bacterial/Viral Strains of Ani. Pathogenic Microbes	2009
Inspection & supervision	Admin. Meas. for Highway Ani. Dis. Insp. Stations	2006
	Meas. for Manage. of Ani. Id. & Ani. Farming Records	2006
	Evaluation Meas. for Specific Ani. Dis. Free Zones	2007
	Admin. Meas. for Ani. Inspection	2010
	Meas. for Examination of Ani. Dis. Prevention Conditions	2010
Veterinary drug oversight	Regs on Sampling for Quality Supervision of Veter. drugs	2001
	Norms for Manage. of Veter. drug Production and Quality	2002
	Admin. Meas. for Veter. drugs Approval Document Numbers	2005
	Meas. for Registration of Veter. drugs	2005
	Admin. Meas. for Development of New Veter. drugs	2005
	Admin. Meas. for Ani. Bio-products	2007
	Admin. Meas. for Imported Veter. drugs	2008
	Insp. & Acceptance Meas. for Quality Manage. Standards in	2010

	Production of Veter. drugs	
	Norms for Business Operation & Quality Manage. of Veter. drugs	2010
	Admin. Meas. for Labels & Instructions of Veter. drugs	2010
Veterinarian oversight	Admin. Meas. for Ani. Clinics	2009
	Admin. Meas. on Licensed Veter.	2009
	Admin. Meas. on Rural Veter.	2009
	Interim Admin. Meas. on Licensed Veter. Qualification Examination	2009
Inspection protocols & technical guidelines	Technical Norms for Prevention & Control of Rabies	2006
	Technical Norms for Prevention & Control of 15 Ani. Dis., including HPAI, FMD, EIA, Glanders, Brucellosis, TB, Pseudo Rabies, Classical Swine Fever, ND, IBD, MD, Sheep pox, Anthrax, ALV-J & HPPRRS.	2007
	Slaughter Insp. Prot. for *i*) Pigs, *ii*) Poultry, *iii*) Cattle, *iv*) Sheep/Goats	2010
	Bee Insp. Prot.	2010
	Insp. Prot. on place of origin for *i*) Pigs, *ii*) Ruminants, *iii*) Poultry, *iv*) Equines	2010
	Insp. Prot. in place of origin for *i*) Canines, *ii*) Felines, *iii*) Rabbits	2011
	Insp. Prot. in place of origin for *i*) Fish (trial), *ii*) Crustaceans (trial), *iii*) Shellfish (trial)	2011
Regulation of animal and animal product entry & exit	Admin. Meas. for Sampling of Entry & Exit of Ani. & Ani. Products for Quar.	1992
	List A and List B Contagious & Parasitic Dis. for Ani. Imported from Other Countries to PRC	1992
	Admin. Meas. for Interim Isolated Quar.	1996
	Admin. Meas. for Insp. & Quar. of Meat Product Entry & Exit	2002
	Admin. Meas. for Insp. & Quar. of Aquatic Product Entry & Exit	2002
	Admin. Provisions on Risk Analysis of Ani. & Ani. Product Entry	2003
	Admin. Meas. for Approval of Quar. of Entry (Transit) Ani. & Ani. Products	2008

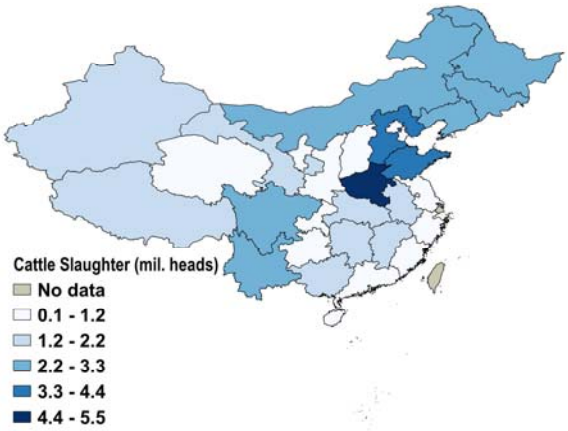
Data source: *Animal Health in China 2011* (VB MoA, 43)

Abbreviations: Admin.=Administrative, Ani.=Animal, Conting.=Contingency, Dis.=Disease, Insp.=Inspection, Manage.=Management, Meas.=Measures, Nat.=National., Prot.=Protocol, Quar.=Quarantine, Regs=Regulations, Veter.=Veterinary or Veterinarian.

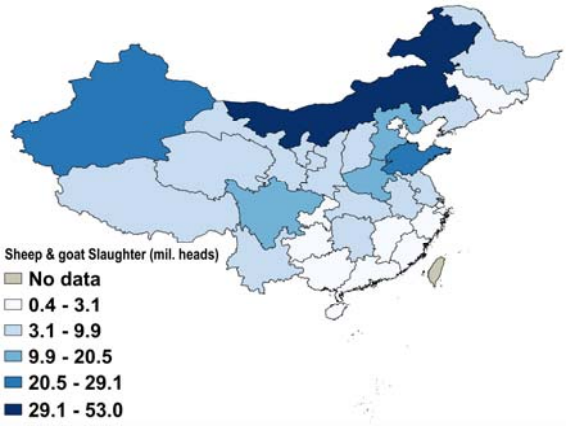
Pig slaughter



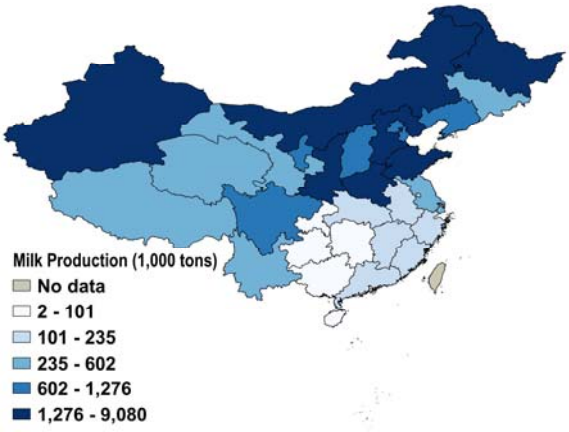
Cattle slaughter



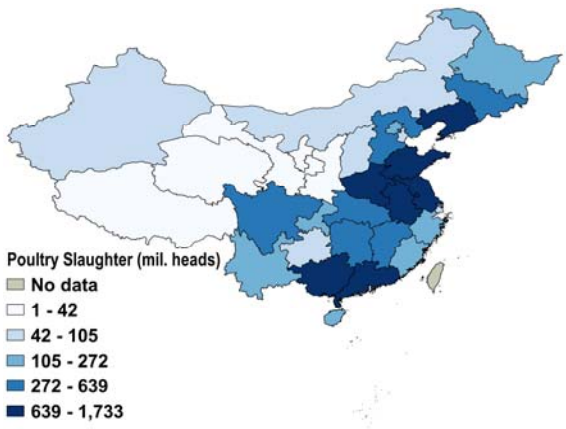
Sheep and goat slaughter



Milk production



Poultry slaughter



Egg production

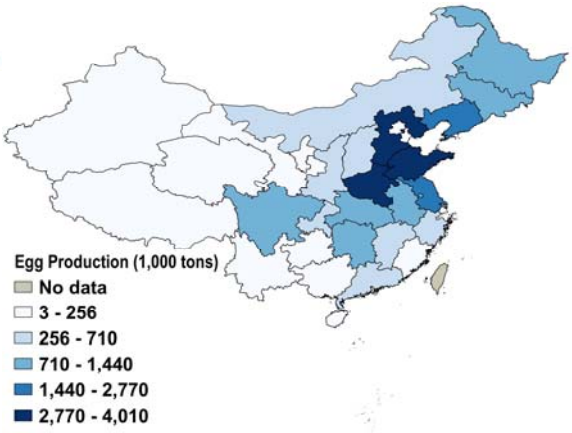


Figure 1. Distribution of livestock production in China, 2011

Data source: *China Animal Industry Statistics 2011* (National Station of Animal Production, Department of Animal Production, MoA, 63)

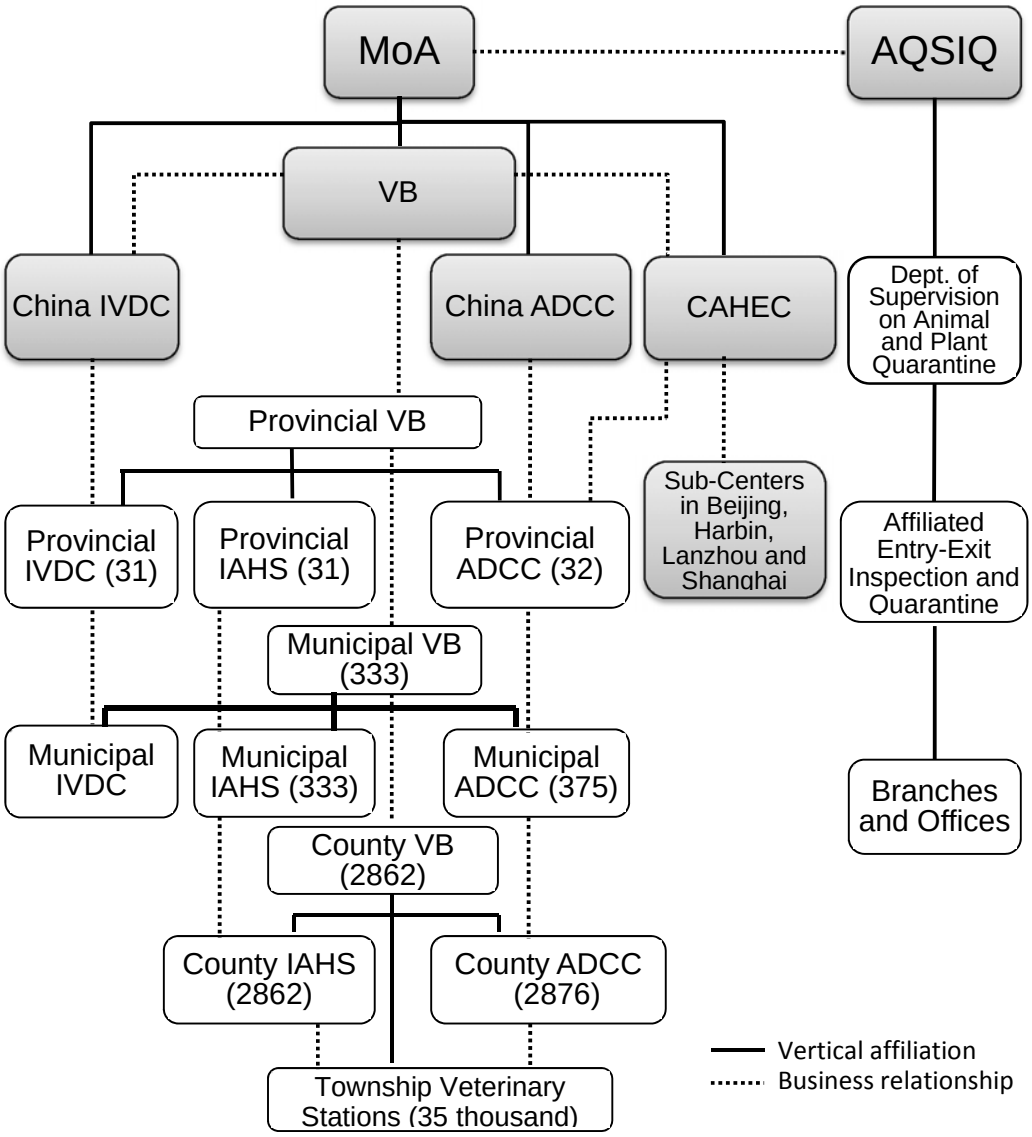


Figure 2. Organizational chart of Public Sector Veterinary Services in China
Source: *Animal Health in China 2010* (VB MoA, 44); the number of institution cited from *A Study on Veterinary Administration System Reform in China* (Xiang and Wang, 42)
Abbreviations: ADCC=Animal Disease Control Center, AQSIQ=General Administration of Quality Supervision, Inspection and Quarantine, CAHEC= China Animal Health and Epidemiology Center, IAHS=Institute of Animal Health Supervision, IVDC=Institute of Veterinary Drug Control, MoA=Ministry of Agriculture, VB=Veterinary Bureau.

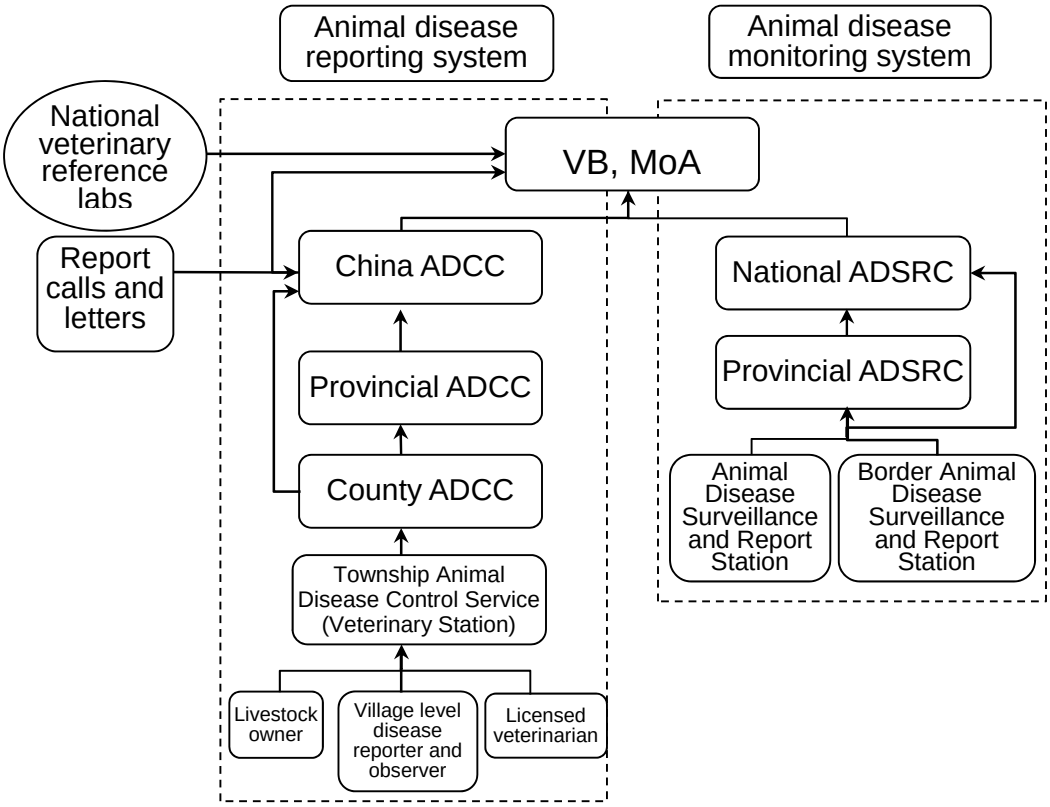


Figure 3. China's Animal Disease Reporting and Surveillance System
Source: *Animal Health in China 2008* (VB, MoA, 48)
Abbreviations: ADCC= Animal Disease Control Center, ADSRC= Animal Disease Surveillance and Report Center, MoA=Ministry of Agriculture, VB=Veterinary Bureau.

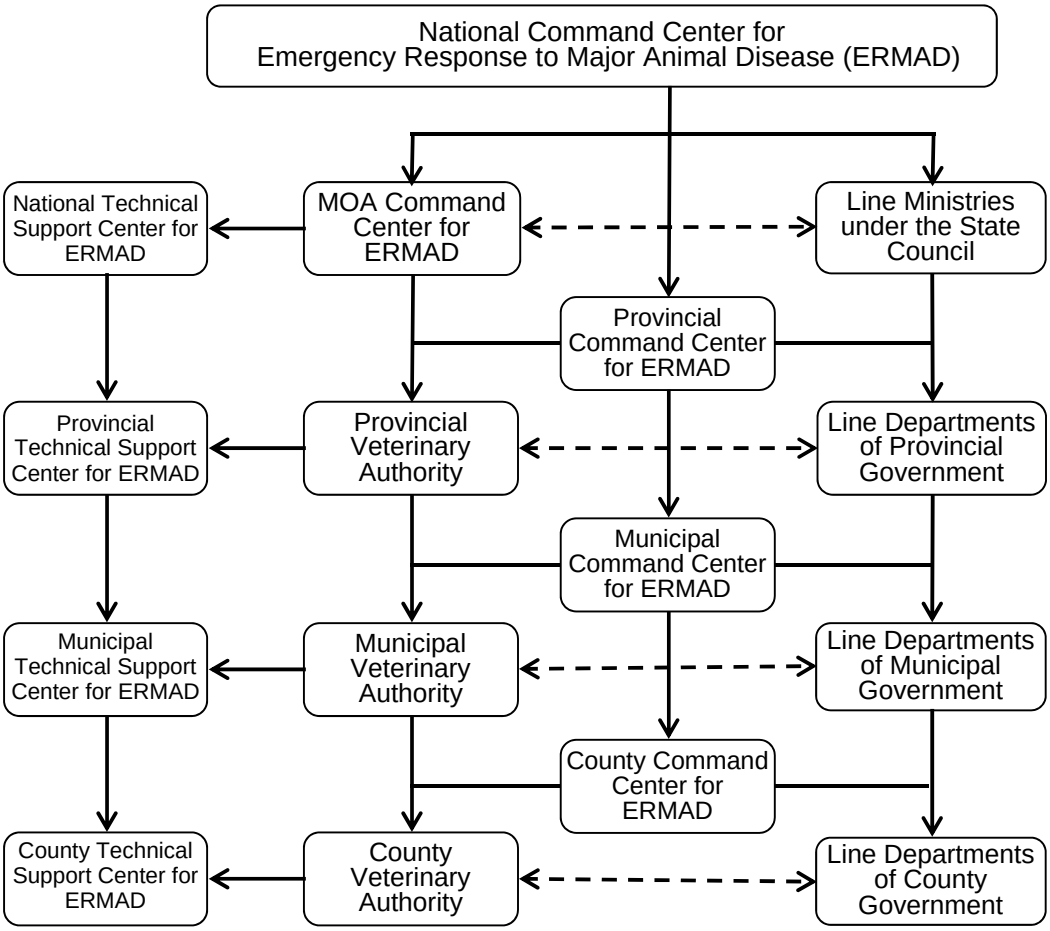


Figure 4. Organizational Chart for Emergency Response to Major Animal Disease Outbreaks in China

Source: *Animal Health in China 2010* (VB MOA, 44)