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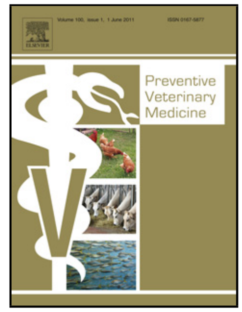

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Chinese Farmers' Willingness to Accept Compensation to Practice Safe Disposal of HPAI Infected Chicken

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Abstract

Highly Pathogenic Avian Influenza (HPAI) is a high morbidity and mortality zoonotic disease, which threatens poultry and human health. An outbreak of disease in China requires strict slaughter and disposal of all chickens within a three-kilometer radius, incurring large private costs for farmers and encouraging black market transactions. A stated preference survey of 331 farmers across six provinces in China was conducted in 2015, in order to measure the responsiveness of farmers to accept various compensation prices for safely disposing of HPAI infected chicken. Findings suggest that about 25% and 40% of farmers in South and North China respectively would not adopt safe disposal at the current compensation price (10 yuan/bird) offered by the government. However, 80% of farmers would adopt safe disposal if the compensation price increased to 14.1 yuan in South China and 18.9 yuan in North China. The adoption of safe disposal by farmers was positively and significantly influenced by compensation price ($p = 0.000$) and regular contact with epidemic prevention staff ($p = 0.094$). However, adoption was negatively and significantly influenced by net farm income ($p = 0.100$) and chicken production income percentage ($p = 0.014$). Although half of (51%) of farmers were willing to receive zero compensation, a reasonable compensation scheme along with strengthened supervision, may be considered the most effective strategy to encourage safe disposal of HPAI infected chicken and reduce the risks associated with black market transactions.

Keywords: willingness to accept; biosecurity; animal disease; stated preference; non-market valuation; economic analysis

1. Introduction

In China, the total production of poultry meat between 1978 and 2013 ranked second in terms of volume throughout the world after the USA (FAO, 2016). Major animal epidemics, such as Highly Pathogenic Avian Influenza (HPAI) are a serious threat to poultry farms and human health. HPAI virus subtype H5N1 outbreaks occurred 108 times on poultry farms in China between 2004 and 2015. In that period, the number of poultry infected by HPAI was 391,032, and the number of poultry culled was 32,660,585 (Shou Yi Gong Bao, various years). There is currently a lack of reliable data in terms of how many culled birds end up in the black market across China. Nevertheless, if dead poultry is carelessly disposed of or sold, it may result in various health and environmental hazards (Kalbasi et al., 2005; Karen et al., 2009). For example, the HPAI virus may spread if infected dead birds are not disposed of properly. The disease has infected humans in China; there have been three confirmed cases of human infection with HPAI subtype H5N1 since 2002 (WHO, 2016). Therefore it is important to study the willingness of poultry farmers to practice safe disposal options that have minimal health and environmental risks.

In China, the first HPAI case took place in Guangxi province in 2004. Between 2004 and 2015, there were 94 occurrences of HPAI in chicken flocks across 21 provinces, each of which may have involved several holdings (Shou Yi Gong Bao, various years). Of these provinces, Hubei contained the most outbreaks followed by Xinjiang. Once HPAI was reported and confirmed by authorities, all poultry within a three kilometer radius of the epidemic point, whether infected or not, were required by law to be killed and then buried deeply or incinerated by local epidemic prevention staff, in order to prevent HPAI from spreading further. Currently, the official compensation rate paid to farmers per culled bird is 10 yuan (approximately 1.54 US dollars), which is comprised of central government and local government funding, the proportion of which varies by region. The compensation price is much lower than the current broiler production cost (on average 48% and 36% of the production cost of white-feathered and yellow-feathered broilers respectively), as well as the retail market price (approximately 27% of the average Chinese retail market price in 2015) (China Animal Husbandry Information Network, 2015). As a result, farmers would incur significant economic losses if they were located within three kilometers of an HPAI outbreak.

As rational agents, farmers compare the cost and benefits of disposal alternatives for HPAI infected chickens. One of the disposal methods is selling diseased chicken meat on the illegal black market, which is then resold to restaurants or chicken dealers. This method is also present in other countries; e.g. Bangladesh, where chicken farmers slaughtered infected chicken and either ate or sold them (Rebeca, 2012). Unsafe disposal methods give rise to two kinds of negative externality with a much greater cost to society. The first is that the chicken meat market may be impacted by diseased meat in the food chain, which is a negative externality on those producers selling healthy birds. Secondly, the untreated carcass may be a threat to human health if chicken meat was traded on the black market and then appeared in the consumer market. There is also a potential threat to the environment, such as the quality of soil, water and air (Bergeron and Gagnon, 2006).

Large positive externalities exist for epidemic disease prevention, yet private precautionary efforts are often lower than the socially optimal level (Stiglitz, 1988). Numerous countries have introduced policies that require farmers to adopt safe disposal. One such policy is to design economic incentives that motivate farmers to maximize public benefit, while pursuing their own profit maximization. However, if the compensation price does not meet the farmer's reservation price (minimum price they would expect, which varies from farmer to farmer), there is a risk the farmers will not dispose of chicken safely, while overcompensation imposes a heavy financial burden on the government and may provide a disincentive to prevent disease. Thus to set a proper compensation price, both feasibility and efficiency should be taken into account.

From the available data, it is difficult to assess how safe disposal adoption by chicken farmers is influenced by varying compensation levels, due to the reluctance of farmers to reveal non-adoption at existing compensation prices and insufficient (or no) variation of compensation prices across provinces and time. Hence a stated preference survey instrument has been designed to elicit the willingness to adopt safe disposal at different levels of compensation. The instrument ensures strict exogeneity of compensation prices with safe disposal adoption given the researchers selected the compensation levels exogenously. Meanwhile it is possible to investigate how willingness to adopt safe disposal is influenced by other farm and farmer characteristics, and whether there exists heterogeneity in farmers' willingness to adopt safe disposal.

2. Material and methods

2.1 Chicken Production and HPAI Prevention in China

Broiler production in China is characterized by white-feathered broilers in North China and yellow-feathered broilers in South China. Our survey data shows that white-feathered broilers' delivery age is 46 days on average and the production cost is 20.69 yuan per head, while for yellow-feathered broilers it is 102 days and 27.57 yuan. There were five provinces in North China and seven provinces in South China that made up the top 12 broiler production provinces between 2011 and 2013 (Table 1). Table 2 illustrates the provinces where HPAI occurred during the past 10 years, among which Liaoning suffered from the most infected dead and culled chicken on average per HPAI case.

Farmers have two alternatives, namely safe disposal or unsafe disposal of HPAI infected chickens. It is assumed they know the disease status of every chicken. Safe disposal is a biosecurity procedure on chicken carcasses that minimizes the risk of dissemination of infectious agents (OIE, 2016). Safe disposal methods frequently used include deep burial, incineration, industrial oil refining and aerobic fermentation (Linton and Van, 2006). The other alternative is selling HPAI infected chicken on the black market, assuming no traceability back to the farm operation or repeated interaction between farmers and buyers. The (prospective) cost per culled chicken if safe disposal is adopted (without considering government compensation) is: C_T

$=C_1+C_2$. C_1 is the safe disposal fee paid by farmers and C_2 is the opportunity cost of safe disposal, which has the market price as an upper bound. If farmers disobey the rules and choose to sell chicken meat on the black market, the cost per chicken would normally reduce to $-C_3+\alpha C_4$ (search costs not considered). C_3 is the price per chicken received on the black market, C_4 is the fine per chicken for violation (usually collected by medical officers if black market activity is detected), and α is the probability of being caught. However, enforcement in China is loose and C_4 is usually small, assuming farmers are actually caught. The penalty, once caught, is at most 3,000 yuan per holding (approximately 462 US dollars), which is regulated by the *Animal Epidemic Prevention Law*. The penalty accounts for around 5% of the mean annual net income calculated from our survey, which can be a considerable amount for some farmers while a negligible amount for others. Hence, given low expected penalties (probability of being caught times fine), some farmers are not deterred from operating illegally (selling chicken meat on the black market) if they wish to. Given that the cost of safe disposal and the cost of selling chicken meat on the black market are C_1+C_2 and $-C_3+\alpha C_4$ respectively, farmers compare the two costs and make a decision on which disposal method minimizes their private costs. The equilibrium for the safe disposal rate in this case would be sub-optimal because a numbers of farmers do not individually account for the social costs of using the black market in their decision-making.

While there are a few means for the government to use to increase the demand for safe disposal, economic instruments such as monetary incentives usually work well.

When considered in the framework of principal-agent theory (e.g. Ross, 1973) farmers, as the agent, are well informed about chicken meat infected by HPAI, while the government, as the principal, knows little in the way of information about the farmers. Farmers are liable to pursue their profit maximization and choose to sell chicken meat on the black market. This scenario creates a conflict of interest and asymmetric information between the government and farmers.

In an attempt to disentangle the principal-agent problem, society as a whole would be better off if farmers followed government requirements under a close contract relationship and supervisory role. For example, the veterinary public health bureaucracy can enhance social welfare by encouraging precautionary biosecurity practices (Hennessy, 2007). Nevertheless, public veterinary authorities have limited ability to monitor and influence farmers' biosecurity actions (Hennessy and Wolf, 2015). In rural China, the reality is that the government is often not fully aware of farmers' animal epidemic situations due to insufficient grassroots veterinary services (Cai, 2005).

2.2 Data collection

The questions on farmers' willingness to accept (WTA) from the pilot survey were readjusted according to Ruto and Garrod (2009)'s method[1]. Assuming the best

[1] Farmers' WTA was collected under eight compensation price levels from 0 to 20 yuan per culled chicken, in a pilot survey in Henan province in April 2015. It was found that eight levels of compensation price were too many and the interval between two prices too small for farmers to perceive any difference. The answers offered little variation on the price at which farmers were willing to adopt safe disposal.

outcome farmers can expect is full compensation of the explicit production cost if they adopt safe disposal, compensation levels were revised to 0%, 25%, 50%, 75% and 100% of the explicit production cost for that particular farm. This approach effectively divided the compensation into four quartiles, and expressing the compensation level as a proportion of production cost, was much better understood by farmers[2]. Using production cost as the compensation scale also offers a sufficiently large range, with the current official compensation level (10 yuan/bird) being between 25% and 50% of the production cost on average. Farmers were informed what the explicit production cost consisted of during the interview. The multiple-bounded dichotomous choice (Herriges and Shogren, 1996) was used. The procedure carried out by interviewers involved telling respondents about a hypothetical circumstance: 'HPAI has occurred on your farm and many broilers have died of the disease'. During the interview, respondents were not informed of the consequences if safe disposal was not carried out. Then, farmers were asked whether they would like to adopt safe disposal without compensation, such as deep burial, incineration, industrial oil refining or aerobic fermentation. If they agreed to adopt safe practice, no more questions were asked on this matter. If not, farmers were asked about their willingness to adopt safe disposal if the compensation paid was 25% of the average production cost per boiler; and so forth up to 50%, 75% and 100% of the average production cost (assuming the farmer answered no to the previous compensation level). The percentage pattern was not stated during the interview and was kept hidden by trained

[2] An alternative reference easily understood by farmers would be the price per bird they normally receive. However, this was not used since production cost as a reference worked well with farmers.

interviewers to ensure farmers made their choices as honestly as possible, when presented with the various levels of compensation. A shortened version of the questionnaire is provided in Appendix A.

With regards to the choice of survey sites, Hebei, Jilin and Shandong in North China were chosen, while Hubei, Guangxi and Guangdong in South China were selected. All questionnaires were conducted face-to-face between June and August 2015, by interviewers consisting of one professor and four Ph.D. students in the research field of poultry farm management. A face-to-face interview is the most effective way to collect information on Chinese farm households and only the farm decision-makers were interviewed. Both the stratified sampling method (each of the six provinces being a stratum) and simple random sampling method were employed to decide the sample frame. Within each stratum, all of the chicken production towns were selected and codes made for them. Four to five towns were randomly chosen by lottery. In each chosen town, a complete list of broiler farmers was obtained and codes made for each farmer. Eventually, there were 27 randomly selected towns with 15 farmers randomly selected from each town by lottery, resulting in a sample frame of 405 farmers, including five farmers who refused to participate in the interview. In the end, 373 questionnaires were conducted, providing a response rate of 92% and, after checking the validity of the returned questionnaires, 331 were deemed as complete and usable, resulting in a valid response rate of 82%. The final cross-sectional sample was proportionally distributed between North China (154 farmers) and South China (177 farmers).

2.3 Analytical methods

The Contingent Valuation Method (CVM) was judged to be the most suitable tool available to use to measure non-market value. It has often been used to measure public goods and services (Loomics et al., 2000), and can also reveal farmers' participation preference (Dupraz et al., 2003). However, there are few examples of farmers' WTA for animal disease control (Bennett and Balcombe, 2012). In China there is no empirical investigation into farmers' WTA for safe disposing of HPAI infected chicken, particularly in regard to different government compensation prices. Farmers' WTA for safe disposal is mainly based on their private cost of safe disposal, and can be expressed as a latent variable influenced by their risk preference and subjective participation cost (Parks, 1995). Poultry belongs to farmers' private goods, the price of which can be measured by the market. However, culled chicken infected by HPAI do not have a market value and their value can only be revealed by either black market transactions or compensation paid for safe disposal. Since black market data is not available, CVM is appropriate to measure their value through farmers' WTA for safe disposal.

Regression is a commonly used method to analyze CVM data. Farmers' WTA was expressed as a binary classification, one representing adoption and zero otherwise.

A logit regression model is illustrated below (Judge et al., 1988). Let *p* indicate farmers' willingness probability for adopting safe disposal:

$$\mathrm{p} = \frac{e^{f(x)}}{1 + e^{f(x)}} \tag{1}$$

$$1 - \mathrm{p} = \frac{1}{1 + e^{f(x)}} \tag{2}$$

Odds ratio of farmers' compensation willingness for safe disposal is obtained:

$$\frac{\mathrm{p}}{1 - p} = \frac{1 + e^{f(x)}}{1 + e^{-f(x)}} = e^{f(x)} \tag{3}$$

Equation (3) was converted to a linear equation through the logistic function form as follows:

$$y = \ln\left(\frac{p}{1 - p}\right) = X\beta + \mu \tag{4}$$

where y denotes a latent variable for safe disposal, and a farmer would adopt if $y>0$ and not adopt if $y\leq 0$, X represents a vector of observed explanatory variables that influence farmers' WTA including compensation, net breeding income, regional dummy, dependency on farm income, etc. β is a vector of parameters to be estimated and μ is a stochastic disturbance.

The models were built based on the independent variables identified in the literature and are as well available in the survey. As a robustness check, a step-wise backward method was also used to individually exclude the insignificant variables. No insignificant variables became significant, nor did significant variables become insignificant. The coefficient on compensation remains highly robust. Hence the final models are displayed with all independent variables in the paper.

Compensation was measured firstly as a percentage of each broiler production cost; 0%, 25%, 50%, 75% and 100%, and secondly as a nominal cost (yuan /bird) expressed as a percentage, multiplied by the per broiler production cost that each respondent reported in the survey. The two measurements are used as independent variables in Models I and II respectively. Since the marginal effect is not linear with regards to compensation percentage or price, the marginal effect of one percentage point change in compensation was calculated, on the probability of safe disposal adoption at a range of compensation levels, from the regression results (Stata's 'margins' command). As the current compensation level (10 yuan) represents 48% and 36% of the production cost per bird in North and South China respectively, the marginal effects were calculated at compensation levels over the range of 30% to 70%, at an interval of 10%. The change in safe disposal adoption probability with regards to a 1% change in compensation price was also calculated, from 10 yuan to 26 yuan at an interval of 4 yuan.

2.4 Variables influencing farmers' WTA

Besides compensation levels for safe disposal, other influences on farmers' willingness to adopt safety disposal were also collected, such as gender, age, education level, farm size, net income, percentage of total income that is earned from chicken production, and whether the farmer has had regular contact with epidemic prevention staff. These variables were selected based on the review of relevant literature presented below.

Studies on farmers' willingness to accept compensation for environment protection measures, animal epidemic disease prevention and control measures were reviewed with a particular focus on the influences on farmers' WTA. Tender price is widely believed to have a positive influence on farmers' WTA (Cooper and Keirn, 1996; Cooper, 2003; Ruto and Garrod, 2009). With respect to farmer demographics, the role of gender and age on WTA has been studied extensively but appears to be inconclusive within the literature. For example, Dare (2014) found that male farmers' WTA for forest protection was stronger than female. However, Willingnessiams et al. (2015) noted that female farmers' WTA for dry saline lake recovery was stronger than males. Findings of Mooney and Barham (2013) suggested that older farmers had stronger WTA. Furthermore, Kathiravan (2007), Ruto and Garrod (2009), and Kumar et al. (2011) outlined that farmers' WTA became weaker as their age increased. With regards to education, it is generally agreed within the literature that highly educated farmers have significantly weaker WTA (Mooney and Barham, 2013).

Farm traits are also significantly associated with farmers' WTA. For example, Ruto and Garrod (2009) found that farm size had a positive influence on farmers' willingness to participate in agricultural environment planning. Bateman et al. (1996) showed that net farm revenue per acre had a positive influence on farmers' WTA for land expropriation. The possible reason is that larger farms are more likely to afford such programs without a significantly negative impact on their profitability. However, if farm size became larger, farmers' WTA bioenergy crops would decrease (Mooney and Barham, 2013). The argument is that larger farms would also incur much higher costs than smaller farms to implement or adopt certain practices, which makes larger farms, or those heavily dependent on 'on-farm' income, reluctant to adopt innovations or environment-friendly practices.

One of the key biosecurity approaches to prevent serious animal epidemics is for farmers to keep in frequent contact with their veterinary or livestock animal health specialist (Hernández-Jover et al, 2012). In every Chinese country town, epidemic prevention staff, employed by the government, provide official HPAI prevention services, and education and training to farmers regarding correct prevention measures. They also supervise regulation compliance and enforce legal provisions, such as culling chickens once an HPAI outbreak occurs. Hence we would expect that Chinese farmers, who are in regular contact with local epidemic prevention staff, to be more likely to practice safe disposal.

3. Results

Figure 1 displays the proportion of farmers willing to adopt safe disposal under different compensation levels in South and North China respectively. With the increase in compensation expressed as the percentage of production cost per bird paid to farmers, the proportion of farmers willing to adopt safe disposal has seen a sustained rise. The proportion in South China is also consistently higher than that in

North China under the same compensation level, except where all growers in North China and 98% of growers in South China are willing to adopt safe disposal at the 100% compensation level of production cost. This tends to suggest that chicken producers from South China have a stronger WTA than those from North China.

3.1 Safe disposal adoption rate by compensation level and farmer sub-group

Farmer adoption rates vary enormously by farmer and farm characteristics at a given compensation price, as shown in Table 3. The adoption rate of smaller sized farms is generally higher than that of larger sized farms. The adoption rate ranges from 34% (the big farm group with more than 50,000 birds) to 74% (the small farm group with 2,000-9,999 birds) at zero compensation. This may partly be due to the 3,000 yuan penalty per holding for black market trading, which many small size farmers would be unable to afford. Female respondents were more willing to accept zero compensation than male respondents. Older farmers appear to have a stronger WTA than younger farmers. Adoption rates at the 0% and 100% compensation levels do not appear to vary much among farmers with differing educational attainment, while at other compensation levels, farmers with lower education have higher adoption rates than farmers with higher education attainment. With regards to net income per bird, farmers in the second lowest net income per bird category (1 to 2 yuan/bird) have the lowest adoption rate. In general, farmers are less likely to adopt safe disposal if their income from chicken production accounts for at least 50% of their total income. Farmers who maintain regular contact with epidemic prevention staff also seem to have a higher adoption rate. These farm and farmer characteristics, together with the compensation level, will be used as independent variables in the subsequent regression analysis. The effect of each variable on adoption will be modeled simultaneously, so that the marginal effect on adoption of every variable can be calculated.

3.2 Regression results

Table 4 presents the detailed definitions and summary statistics for the dependent and independent variables. The dependent variable is binary and there are five observations per farmer, showing whether the farmer is willing to adopt safe disposal at each of the five compensation levels.

Table 5 presents the marginal effects of independent variables on safe disposal adoption. Stata12.0 was the software package used for estimation. There was no serious multicollinearity in the models, and robust clustered standard errors were used to mitigate the effect of heteroscedasticity and account for the fact that each farmer has multiple observations within the dataset. Both Models I and II have reasonable prediction accuracy, i.e. 73% correctly predicted. Prediction accuracy increases as compensation percentage increases in general, for example, 64%, 66%, 64%, 73% and 99% correctly predicted for each of the compensation levels 0 to 100%. Both measurements of compensation are highly significant and the results of other variables are very similar between the two models, suggesting the results are robust.

The estimated marginal effect of ‘compensation percentage’ suggests that if compensation increases by one percentage point from the mean (50%), the probability that farmers would adopt safe disposal will increase by 0.4 of a percentage point, assuming all other variables are unchanged. In Model II, if the 'compensation price' increases by one yuan from the mean (12.18 yuan) the probability of adoption will increase by two percentage points, again, assuming all other variables are unchanged. As expected, other factors significantly associated with a stronger WTA include: being located in South China, having a smaller net breeding income per bird, being less dependent on on-farm income, and having regular contact with local epidemic prevention staff. Finally, variables such as gender, age, education and breeding scale were found not to be significantly related to farmers' WTA.

The results in Table 6 show that the marginal effect of compensation on the WTA of South Chinese farmers decreases with compensation percentage, and the biggest increase in probability (0.42 of a percentage point per one percentage point increase) occurs at 30%. The biggest increase from North China occurs at 40%, where the probability of farmers' WTA increases by 0.67 of a percentage point per one percentage point increase in compensation. In model II, as the compensation price increases, the change in safe disposal adoption probability also increases, with a maximum change occurring at 22 yuan for South China and at 18 yuan for North China. This suggests that, at the official compensation price (10 yuan), the response of farmers to safe disposal adoption based on a 1% increase in compensation price is not maximized.

The effect of compensation on WTA is further explored by farmer sub-groups, given a high level of heterogeneity exists among farmers. For brevity, the marginal effects were calculated based on Model I in Table 5 at the current average compensation level (10 yuan), being 48% of the production cost for North China and 36% for South China. In North China, farmers with higher education attainment are more responsive to an increase in compensation percentage than farmers with lower education attainment, while in South China the opposite is true (Table 7). In both North and South China, farmers with a breeding scale of more than 10,000 birds (or maintaining regular contact with local epidemic prevention staff) are more responsive than farmers with a smaller breeding scale (or with no regular contact with local epidemic prevention staff). In North China, farmers who receive less than 50% of their income from chicken production are more responsive than those receiving at least 50% of income from chicken production.

Using the regression results of Model II in Table 5, we can predict that in the event of an HPAI outbreak, more farmers in South China (75.83%) would be willing to adopt safe disposal than those from North China (58.54%) at the current compensation level of 10 yuan (Figure 2). This indicates there are almost 25% of farmers in South China and over 40% of farmers in North China who might sell chicken meat on the black market. Possible explanations for this difference are that chicken farmers in South China have a higher level of awareness because more HPAI cases have occurred (62 cases including Tibet between 2004 and 2015) compared to North China (32 cases over the same period). In addition, farmers in South China may perceive a higher risk of a HPAI outbreak than North China, given the much denser network of rivers and lakes that are the habitats of poultry and waterfowl.

4. Discussion

As Hennessy and Wolf (2015) argued, farmers are unlikely to comply with mandatory programs if the compensation does not provide them with a greater financial return than alternative action. Therefore, governments can expect there will always be a proportion of farmers who are unwilling to adopt safe disposal, when a compensation price is set. The results are useful for policy-makers to determine a compensation price level that encourages a reasonable proportion of farmers to adopt safe disposal, given local government budget constraints. For example, Figure 2 suggests that in order to achieve a target of 80% of farmers adopting safe disposal, the compensation price should increase to 14.1 yuan in South China and 18.9 yuan in North China, indicating that most chicken producers in South China are likely to accept 51% of the production cost on average. For a target of 90% adopting safe disposal, the compensation price should be increased to 28 yuan in South China and 25.8 yuan in North China, both prices being greater than their respective average production costs. The government, under this scenario, would incur a heavy financial burden. Another reality in China is that the epidemic prevention authorities do not always consider chicken farmers' interests as a priority. Minimizing administrative costs is often pursued rather than allocating resources in HPAI management and epidemic prevention, or providing monetary assistance to farmers to reduce catastrophic losses. Nonetheless, whilst a high compensation price would ensure a higher safe disposal adoption rate, it is likely that overcompensation also provides a disincentive to prevent disease (Hennessy and Wolf, 2015). Hence local authorities need to weigh up the cost and benefits of alternative compensation prices and, in the meantime utilize other effective measures, such as further development of the biodiesel market.

Furthermore, allowing every province to set their own price, or a fixed compensation percentage based on each farmer's production cost, may also be used by policy-makers to encourage safe disposal. Given the heterogeneity amongst Chinese chicken farmers (i.e. average net breeding income is 27,808 yuan for farmers in Jilin province and 90,423 yuan in Hubei province), each province may set their own price based on key characteristics of their chicken farms, in order to achieve a targeted safe disposal adoption rate. A fixed compensation percentage based on each farmer's production cost is another approach to deal with the heterogeneity among chicken farmers. This would avoid the situation of over-compensation to farmers with low costs, or under-compensation to those having high costs (i.e. free range, organic, etc.).

In addition, the results suggest measures other than compensation need to be implemented in order to maximize farmers' safe disposal adoption rates, such as closer supervision by epidemic prevention staff, particularly of farmers with higher net income and higher percentage of income from chicken production. The issue of penalties for black market trading and increased government supervision of black markets should also be considered, as any effective epidemic prevention strategy should be a balance between penalties and positive incentives. When penalties become significant and detection of black market trading is likely, it would considerably increase the cost of selling on the black market and increase the demand for safe disposal. Although the issues of penalties and government black market supervision have not been taken into account in the empirical investigation, they are still important areas for policy makers to focus on. In particular, it is critical to explore the underlying reasons for loose government control, poor law enforcement and lack of black market supervision.

A few limitations still apply to this study, which need to be addressed by future research. Firstly, the survey scenario of ‘HPAI is occurring on your farm’ implies that chickens have already been infected, which may explain the high safe adoption rate even at the zero compensation level. One would expect for farmers not infected, yet within a 3km radius of an infection site, to consider the situation 'unfair' and therefore these farmers are likely to be less willing to accept low compensation amounts. Secondly, many chickens died during the breeding process but the compensation rate was calculated based on the cost of chickens delivered. If the breeding age of chickens was short when dying of disease, the real production cost was much less than the delivered cost. Therefore, any compensation percentage or price set by the authorities would be more favorable to farmers whose chickens died of disease in the early breeding age. For effective safe disposal, setting compensation rates based on different breeding ages of HPAI infected chickens, may be of interest for further study. Thirdly, our study examines farmers’ intention (or willingness) to adopt safe disposal, which is not equivalent to actual adoption. The intention may not be put into practice if the farmer does not have complete control to perform the action (Ajzen, 1991). Finally, future studies may consider testing the robustness of setting different intervals and starting points[3], if a large sample can be collected, or attempt to use a

[3] For example, an unequal interval questioning design may reduce the possibility that farmers observe the pattern and simply wait for higher compensation levels.

non-hypothetical experiment, such as an auction experiment or real choice experiment with monetary payoffs to estimate WTA.

This study was the first attempt in China to investigate farmers' WTA compensation for safe disposal of HPAI infected chicken. Extensions of this methodology and subsequent results could be important for other developing countries affected by bird flu and confronted with the same problem, such as Indonesia (Simmons, 2006) and Nigeria (Ojimelukwe et al., 2016).

5. Conclusions

Highly Pathogenic Avian Influenza is a disease that can be transmitted from animals to people and poses a serious threat to poultry and human health. An outbreak of HPAI requires strict infection control measures, such as the immediate slaughter and safe disposal of all chickens within a specific area. These controls incur large private costs for farmers, which in turn can encourage black market transactions, further increasing health risks.

This study investigated the influences on farmers' willingness to accept safe disposal methods of HPAI infected chicken, by examining responses to different hypothetical compensation prices. Farm and farmer characteristics were taken into account, and cross-sectional data was randomly collected from 331 broiler farmers across six Chinese provinces in 2015. Descriptive analysis suggests that safe disposal adoption differs greatly across farmer groups such as region, age, education level, farm net income, farm size, chicken production as a percentage of income, etc. However, regression analysis suggests that only compensation, region, farm net income, chicken production as a percentage of income and contact with epidemic prevention staff are significantly associated with safe disposal adoption.

Results suggest that at the current official compensation level, safe disposal practices for diseased chickens will not be maximized if compensation is increased only marginally. It is also evident that if the compensation rates are increased significantly, as outlined within the study, the adoption of safe disposal practices will be much greater. This is an important finding in managing what is a major threat to animal and human health, both within China and globally.

Note

Yuan is Chinese currency unit (1US $=6.494yuan) on 13^{th} March 2016.

Conflict of interest

None.

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Figures

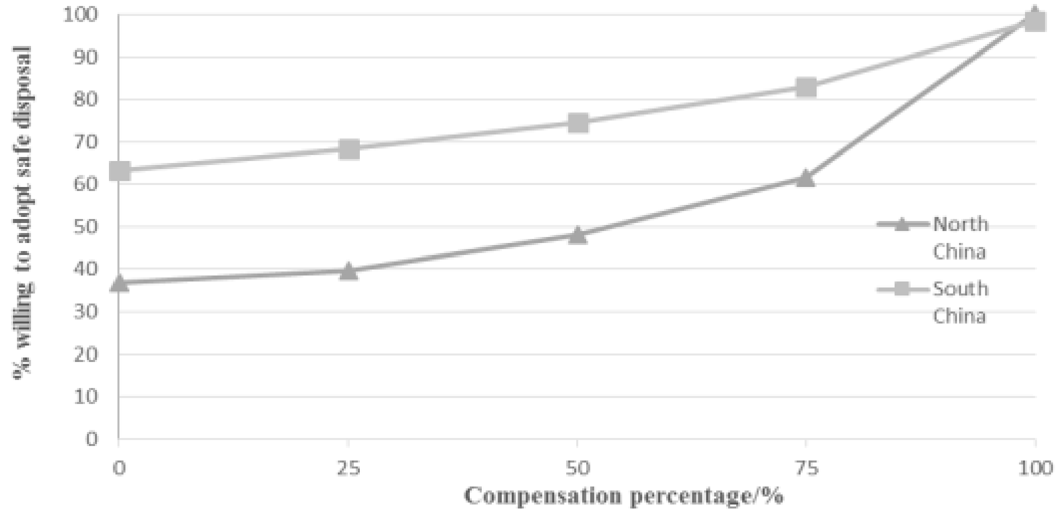

Figure 1. Proportion of farmers' WTA in different regions

Source: Authors' own illustration.

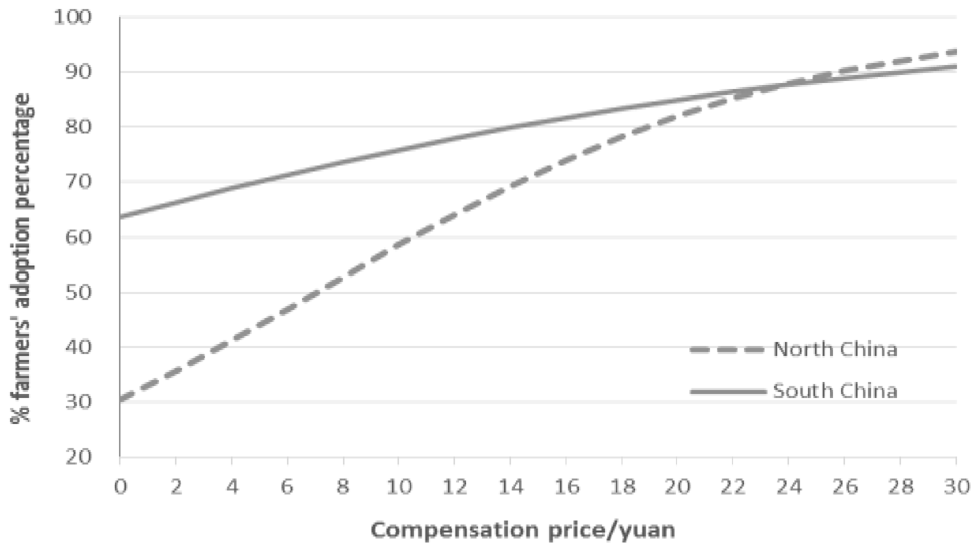

Figure 2 Percentage of farmers' safe disposal adoption under various compensation prices

Source: Authors' own illustration.

Tables

Table 1 Top 12 boiler production provinces from 2011 to 2013

District	Province	2011		2012		2013	
		Production/ 10,000t	Rank	Production/ 10,000t	Rank	Production/ 10,000t	Rank
North China	Shandong	178.18	1	192.99	1	188.16	1
	Liaoning	87.64	5	91.21	5	89.67	5
	Henan	77.98	6	85.54	6	85.61	6
	Hebei	52.16	9	59.57	9	60.62	9
	Jilin	47.47	10	50.33	10	49.21	10
South China	Guangdong	105.20	2	107.45	2	100.10	2
	Jiangsu	97.21	3	102.27	3	92.33	4
	Guangxi	90.19	4	95.20	4	94.71	3
	Anhui	76.34	7	79.87	7	81.20	7
	Sichuan	60.82	8	65.10	8	66.92	8
	Hubei	52.16	11	46.90	11	49.07	11
	Jiangxi	39.97	12	41.23	12	42.84	12

Source: Authors' own calculations from *China Animal Industry Yearbook* (2012-2014).

Table 2 Chinese provinces affected by HPAI and epidemic prevention staff (2004-2015)

District	Province	HPAI chicken cases	Average infected chicken	Average chicken culled	Number of chicken farms each technical staff is in charge of
South China	Anhui	8	3437	63,941	202
	Guangdong	5	1579	53,831	434
	Guangxi	2	366	9806	630
	Guizhou	4	4317	148,369	214
	Hubei	13	1426	61,020	20
	Hunan	6	1238	49,171	202
	Jiangsu	2	2198	57,982	45
	Jiangxi	4	989	4924	68
	Sichuan	1	1800	12,900	246
	Yunnan	8	11,491	580,846	168
North China	Gansu	2	230	399,638	84
	Henan	1	790	1810	102
	Heilongjiang	1	17,790	68,884	36
	Liaoning	5	115,405	19,958,777	1019
	Inner Mongolia	4	1002	25,128	66
	Ningxia	2	615	86,165	142
	Shanxi	3	8501	575,182	6
	Shaanxi	2	1148	58,405	114
	Tianjin	1	236	1287	9
	Xinjiang	11	1354	106,302	630

Source: *ShouYi Gong Bao* (2004-2015) and *China Animal Industry Yearbook* (2004-2015).

Note: There were 9 cases in Tibet in the same period. However, other statistics were not available for Tibet.

Table 3 Safe disposal adoption rates by farmer sub-group and compensation level

	% of farmers adopting safe disposal				
	Compensation level				
Farmer sub-groups	**0%**	**25%**	**50%**	**75%**	**100%**
All (n=331)	51.06	54.98	62.24	73.11	99.09
Gender					
Male (n=286）	50.35	53.85	61.19	72.38	98.95
Female (n=45)	55.56	62.22	68.89	77.78	100
Age					
<=44 (n=149)	45.64	49.66	55.70	68.46	100
45~59 (n=152)	55.26	58.55	65.79	75.66	98.03
>=60 (n=30)	56.67	63.33	76.67	83.33	100
Education					
Primary school and below (n=41)	53.66	60.98	68.29	78.05	97.56
Junior school (n=195)	50.26	54.87	61.54	71.79	100
Senior school and above (n=95)	51.58	52.63	61.05	73.68	97.89
Farm size [a] (number of chicken)					
<=1999 (n=6)	66.67	66.67	66.67	66.67	100
2000~9999 (n=39)	74.36	76.92	76.92	79.49	97.44
10,000~49,999 (n=214)	51.87	57.48	64.49	76.17	100
>=50,000 (n=72)	34.72	34.72	47.22	61.11	97.22
Net income (yuan per head)					
<=1 (n=110)	47.27	51.82	60.00	72.73	98.18
1~2 (n=103)	42.72	49.51	58.25	68.93	100
2~3 (n=61)	59.02	59.02	67.21	78.69	100
>3 (n=57)	64.91	66.67	68.42	75.44	98.25
Farm income accounting for the total income%					
<50%(n=38)	60.53%	65.79%	73.68%	78.95%	97.37%
>=50%(n=293)	49.83%	53.58%	60.75%	72.35%	99.32%
Contact with local *epidemics prevention staffs*					
Regular contact (n=202)	52.97%	56.44%	63.37%	74.26%	99.50%
Non-regular contact (n=129)	48.06%	52.71%	60.47%	71.32%	98.45%

Source: Authors' own calculations.

[a] Raising 0~1999 head, 2000~9999 head, 10,000~49,999 head, over 50,000 head annually represents free-range, small scale, medium scale and large scale respectively.

Table 4 Variable measurement and descriptive statistics

Variables	Definition and assignment	Mean	Standard deviation	Min.	Max.
Dependent					
Safe disposal adoption	Unwillingness=0; Willingness=1	0.68	0.47	0	1
Independent					
Compensation price	Yuan/head	12.18	10.93	0	100
Compensation %	0%, 25%, 50%, 75%, 100% of production cost	50	35.37	0	100
South China	North China=0; South China=1	0.54	0.50	0	1
Contact with local epidemics prevention staff	Non-regular=0; Regular=1	0.61	0.49	0	1
Chicken production income %	% of total income	0.75	0.23	0.11	1
Male	Female=0; Male=1	0.86	0.34	0	1
Age	Years	45.10	9.72	24	70
Education	Primary school or below=1 (reference); Junior school =2; High school or above=3	2.16	0.62	1	3
Breeding scale	Ten thousand heads	1.31	2.65	0.03	30
Net farm income	Yuan per chicken head	2.65	4.38	0.01	33.33

Source: Authors' own calculations.

Table 5 Estimation results of farmers' WTA in logistic model

	Model I		Model II	
Independent variable	Dy/dx	Robust std.err.	Dy/dx	Robust std.err.
Compensation %	0.004***	0.0002		
Compensation price			0.02***	0.001
South China	0.21***	0.04	0.18***	0.04
Male	0.003	0.06	0.01	0.06
Age	0.003	0.002	0.003	0.002
Junior school education	0.03	0.07	0.04	0.07
High school education or above	0.01	0.07	0.04	0.07
Breeding scale (natural logarithm)	-0.04	0.02	-0.04	0.02
Net breeding income	-0.01*	0.01	-0.01**	0.01
Chicken production income percentage	-0.22**	0.09	-0.21**	0.09
Contact with local epidemics prevention staffs	0.06*	0.04	0.07*	0.04
Observation	1655		1655	
Waldchi2 (10)	375.23***		155.05***	
Pseudo R^2	0.17		0.14	
% Correctly predicted	73.17		72.81	

Note: *, **and*** indicate significance level of 0.10, 0.05, and 0.01, respectively.

Table 6 Change in probability of safe disposal given one percentage point change in compensation percentage (Model I) and one percent change in price (Model II)

Model I			Model II		
Percentage/%	SC dy/dx	NC dy/dx	Price/yuan	SC dy/ex	NC dy/ex
30	**0.42**	0.67	10	0.11	0.28
40	0.38	**0.67**	14	0.14	0.35
50	0.34	0.66	18	0.15	**0.36**
60	0.30	0.62	22	**0.16**	0.33
70	0.26	0.57	26	0.16	0.28

Note*:* SC: South China; NC: North China

Table 7 Marginal effect of samples in different characteristics at 10 yuan per culled chicken

	North China (at 48% of production cost)	South China (36% of production cost)
Education		
Primary school and below	0.30%	0.56%
Junior school	0.65%	0.39%
Senior school and above	0.85%	0.32%
Breeding scale/head		
<10,000	0.63%	0.33%
>=10,000	0.71%	0.53%
Net income/yuan		
<=1	0.65%	0.34%
1~2	0.76%	0.50%
2~3	0.57%	0.46%
>3	0.72%	0.26%
Chicken production income percentage		
>=50%	0.42%	0.40%
<50%	0.70%	0.38%
Contact with local epidemic prevention staff		
Regular contact	0.64%	0.35%
Non-regular contact	0.73%	0.45%

Source: Authors' own calculations.