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Poultry producer's willingness to invest in on-farm carcass disposal

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Primary Audience: Researchers, Poultry Industry, Public Animal Health Officials, Economists

SUMMARY

Foreign animal diseases (**FAD**) can cause substantial economic losses in production, consumption, and the supply chain. These diseases are typically highly pathogenic and lead to disruptions in normal business practices and to demands for higher investment in biosecurity practices. For poultry producers this can lead to changes in bird pick-ups, chick placements, and length of out time on farms as well as changes in day-to-day operations. When an FAD is reported, poultry producers that rely on off-premises carcass disposal (e.g., renderers or landfills) may be required to develop on-farm disposal capacity (e.g., incinerators or burial) rapidly if their operation falls within movement restriction zones. While preemptive planning is suggested, not all producers have an environmentally approved plan given disruptions in business continuity. This study estimated poultry producers' willingness to pay (**WTP**) for on-farm carcass disposal methods for routine, non-catastrophic mortality during an FAD outbreak to understand what factors contribute to the investment decision. Poultry producers were surveyed about their operations' characteristics, their disease perceptions, and were presented with a hypothetical disease scenario. The estimated mean WTP for additional disposal capacity was $15,651. Besides indicating that a market for on-farm carcass disposal exists, our findings also provide information that can be used when creating policy to simultaneously incentivize farm-level biosecurity and carcass disposal protocols while continuing to encourage disease reporting, which together, improves overall livestock disease management in the United States.

Key words: poultry carcass disposal, biosecurity, willingness to pay, interval regression

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DESCRIPTION OF PROBLEM

Poultry represents a valuable sector of the U. S. agricultural economy. According to the 2017 Census of Agriculture (U.S. Department of Agriculture, National Agricultural Statistics Service, 2019), in 2017 there were 450,620 poultry farms in the United States, including 42,858 broiler operations, 232,500 layer farms, and 23,173 turkey farms. The

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U.S. Department of Agriculture, National Agricultural Statistics Service (2021) reports a U.S. poultry sale value of $35.5 billion in 2020 with 61% of those sales coming solely from broiler production. Poultry consumption has been growing in the United States and globally. In 2015, United States per capita poultry consumption (105.2 pounds per capita) surpassed red meat consumption (104.2 pounds per capita) for the first time since before 1960 (National Chicken Council, 2021). Growing information on the healthfulness of poultry, the relative environmental impacts of poultry production compared to red-meat production, changes in household dynamics, and changes in prices and preferences of other goods has contributed to the increase in consumption of poultry products (Kennedy et al., 2004; Tonsor et al., 2010). Because poultry is a major component of Americans' diet and an important sector of the U.S. agricultural economy, producers have additional pressures to protect their livestock to ensure a healthy and consistent supply of poultry products. One disease outbreak can cause substantial disruptions for the poultry producer and potentially the entire supply chain resulting from depopulation and transportation restrictions. Under a disease outbreak, the use of quarantine areas and movement restrictions are used. Operations under movement restrictions may have limited business operations leading to changes in typical carcass waste management. In order to limit disruptions, producers can make on-farm investments and adopt practices that limit risks and facilitate business continuity during a disease. This analysis estimates poultry producers' willingness to invest in on-farm carcass disposal capabilities to provide a better understanding of what factors contribute to producers' investment decisions.

Poultry Disease Background

Birds are susceptible to many diseases that can have devastating impacts to producers, consumers, public-health, and the economy (Hennessy and Wolf, 2018). Two of the most common fatal bird diseases are Virulent Newcastle Disease (**VND**) and Highly Pathogenic Avian Influenza (**HPAI**). VND is a viral disease that can be contracted by all birds and has a high death rate. The latest outbreak of VND was from May 2018 to May 2020 in California where 476 premises were infected including 4 commercial flocks with one operation in Utah and Arizona which received birds from quarantined regions in California (U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2021). The costliest reported commercial VND outbreak in the United States was from 2002 to 2003 which cost the federal government approximately $180 million to control (U.S. Department of Agriculture, Agricultural Research Service 2016). HPAI also has a high mortality rate and can be carried by waterfowl and other wild birds (Hawkins et al., 2017). A catastrophic HPAI outbreak occurred in the United States from December of 2014 to June of 2015 and caused the most economic damage to U.S. livestock in recent history (Hagerman and Marsh, 2016). Over the course of the outbreak, 42.1 million egg-layer and pullet chickens and 7.5 million turkeys were depopulated, and the cost to the federal government exceeded $950 million in taxpayer dollars (U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2016). In addition to catastrophic mortality, movement restrictions were confining for poultry producers who were not infected but were in quarantined areas (Thompson and Pendell, 2016). Following the outbreak, preemptive business continuity plans were drafted for the event of a highly pathogenic outbreak including the Secure Broiler Supply Plan (Broiler Sector Working Group, 2017). More can still be done on both the farmer-level and policy-level, such as increased farm-level biosecurity awareness, training and protocols, increased surveillance for diseased birds, better mortality waste management, and more effective indemnity payment policies that incentivize the implementation of biosecurity measures and disease reporting.

Biosecurity is a set of measures, protocols, and actions implemented to limit the introduction of disease and minimize the negative effects of an outbreak (Muhammad and Jones, 2008). These may include physical barriers, carcass disposal management, or procedures for washing in and out of a farm. Biosecurity is considered a weaker link public good (Burnett, 2006;

Siekkinen et al., 2012; Hennessy and Wolf, 2018) because it is limited to the weakest effort and negative externalities could arise from a lack of adoption such as poor carcass disposal practices that lead to wildlife spread.

However, even with the best efforts of biosecurity, a disease event will occur if there is enough pathogenic pressure. When an outbreak occurs, the USDA-Animal and Plant Health Inspection Service (U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2016), outlines areas established around the infected premises to limit movement and spread of disease. The control area includes the infected zone (outbreak location and immediate area) and the buffer zone. The control area is approximately 6.21 miles (10 km) around the initial infected premises (Hawkins et al., 2017; U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2016). To stop a disease from spreading, movement, and transportation restrictions are placed on farms that lie within the control area. On-farm carcass disposal capacity is vital as farms that contract the disease are mandated to depopulate. This catastrophic mortality poses concerns for disposal capacity, transportation, and municipalities. However, this analysis focuses on the routine, or everyday mortality, on premises not infected by the disease but within the control area that cannot move their routine carcasses off farm.

Disposal Methods

Disposal methods are an important aspect of biosecurity and can influence both farming and supply chain outcomes in the face of an outbreak and for routine mortality. Over 50% of farms experience routine mortality rates of 4% or higher and producers need some method for disposal (USDA-NAHMS 2014). The most widely used carcass disposal methods are burial, incineration, composting, rendering, and landfill disposal (Council for Agricultural Science and Technology [CAST], 2008; Bonhotal and Schwarz, 2009; Gwyther et al., 2011; Hawkins et al., 2017). Anaerobic digestion and alkaline hydrolysis disposal methods were developed to address environmental concerns regarding carcass disposal, but can be very costly to implement and are used less frequently (CAST, 2008; Gwyther et al., 2011). The cost of these disposal methods varies greatly from $0.11 to $0.36 per pound for on farm incineration to $0.05 per pound for composting; see CAST (2008) or Henry and Bitney (2010) for a review of disposal methods and costs in the United States.

It is suggested that producers have an HPAI response plan to react in the event of a disease or movement restrictions. When a major disease outbreak occurs, producers within the control area that typically transport carcasses to a rendering facility or landfill (either themselves or by a third party) must find an alternative outlet to dispose routine mortality. If a producer does not have a biosecure method or supplies to dispose of routine poultry mortality on their farm, then they may resort to measures that could negatively affect the surrounding community and environment such as burying carcasses too close to the ground water table or using an open trench that can become a vector for disease spread (CAST, 2008; Henry and Bitney, 2010; Gwyther et al., 2011).

Beyond the producer, government intervention can help incentivize biosecurity investment, but it can be challenging to determine the appropriate incentive. Estimating poultry producers' willingness to invest in on-farm carcass disposal capabilities will provide a better understanding as to what incentives and disincentives policymakers could consider in preventing, controlling, and eradicating animal disease outbreaks in the future. To estimate producers' perception of proactive disease measures, this study focused on disposal capabilities of poultry producers that lie within a control area of a disease outbreak. Specifically, we used a one and one-half bound (**OOHB**) dichotomous choice question to model and estimate poultry producers' willingness to pay for expanded on-site mortality capacity.

MATERIALS AND METHODS

Data for this analysis was taken from an online poultry producer survey[1] disseminated

[1] Survey instrument available upon request.

Table 1. Summary statistics of select poultry producer survey response.

Variable	Description	N	Mean	Std. Dev.	Min	Max
Bio Q	1 if will adopt; 0 otherwise	21	0.476	0.512	0	1
Bio Cost[1]	Cost of adoption that producer was presented	53	24.703	13.903	2.057	47.428
Onsite	Current onsite carcass disposal %	53	40.189	49.009	0	100
Mortality rate	Operation's mortality rate	23	4.150	2.775	0	10
Small	1 if ≤149,999 birds; 0 otherwise	15	0.267	0.458	0	1
Midwest	1 if operation located in Midwest; 0 otherwise	53	0.057	0.233	0	1
Full own	1 if ownership of operation is ≥81%; 0 otherwise	53	0.113	0.320	0	1
Prob 1 or less	Producer perception of FAD[2] outbreak affecting individual operation once in next 100 yr	53	0.057	0.233	0	1
Prob 1 to 5	Producer perception of FAD[2] outbreak affecting individual operation once in next 25 yr	53	0.189	0.395	0	1

[1]In thousands of dollars.
[2]Foreign Animal Disease.

Table 2. Possible interval bounds for the one-and-one-half bound willingness to pay questions.

First answer	Second answer	Lower bound	Upper bound
Yes	Yes	Doubled price (*2X*)	.
Yes	No	Initial price (*X*)	Doubled price (*2X*)
No	n/a	.	Initial price (*X*)

Note: Open ended bounds are represented by periods.

by Watt Poultry USA and the U.S. Poultry and Egg Association in the fall of 2018 following approval by Kansas State University's Institutional Review Board. The 11-question survey was sent to poultry producers across the United States and focused on their current, individual poultry operation management practices, mainly, the producer's current carcass disposal methods/plans and their willingness to pay (**WTP**) to increase on-farm biosecurity efforts. Summary statistics are presented in Table 1. To estimate each producer's WTP, the survey includes a OOHB dichotomous choice question (Bateman et al., 2004; Tonsor et al., 2013; Thompson et al., 2018). A OOHB question follows an initial WTP response with additional follow-up questions to better refine the actual WTP. Producers were provided a scenario of a severe poultry disease (i.e., an FAD) near their farm in the next 10 yr that would result in off-farm movement restrictions in order to reduce the spread and duration of the disease and were asked, "Given knowledge of this situation and the implications it may present to your operation, if it costs $*X* in one-time, fixed expenses to establish this capacity on your operation to dispose on-site for at least 2 mo would you make this investment within the next 3 ys?" In the question, $*X* represents a randomized cost between $2,057 and $47,428 selected using the Mersenne Twister, Qualtrics native algorithm (Qualtrics, 2015). To better refine their WTP bound, those that indicated *YES* were presented a follow-up question with a cost of double the initial value. Those who answered *NO* was presented other questions in an effort understand if policies could reverse their initial decision from *NO* to *YES*. Table 2 presents the possible upper and lower bounds in response to the WTP questions.

We observed a response to a presented cost. From that observation we estimated the true WTP as a latent variable (i.e., not observable). The typical model to use for this type of estimation is a probit model similar to Hanmer and Kalkan (2013), Okpukpara (2016) and Mulwa et al. (2017). However, large samples sizes are needed for that type of model (Lopez-Feldman, 2012). Due to limited survey responses and small sample size for specific questions, an integral regression model was used to derive more precise WTP results with asymptotically consistent results. By using a model that includes upper and lower bounds, we are able to present a more accurate representation of the true WTP. The upper and lower bounds were the costs presented to survey takers in the OOHB question (Bateman et al., 2004).

The log-likelihood equation[2] used to calculate the interval regression model is written as:

$$LLF = \sum_i \left\{ \begin{array}{l} d_i^N \ln\Phi(\lambda Z_i + \beta X_i) + d_i^{YN}[\ln\Phi(\lambda Z_i + \beta 2X_i) - \ln\Phi(\lambda Z_i + \beta X_i)] \\ + d_i^{YY}[1 - \ln\Phi(\lambda Z_i + \beta 2X_i)] \end{array} \right\} \quad (1)$$

where for the ith poultry producer: d_i^N=1 when the response was NO to the initial WTP question, d_i^{YN}=1 if the response was YES-NO, and d_i^{YY}=1 if the response was YES-YES, 0 otherwise; Z_i represented a series of explanatory factors, X_i were the prices presented, λ and β were vectors of conformable coefficients (Tonsor et al., 2010; Thompson et al., 2018). The surveyed producers' predicted mean WTP for the interval regression model was then estimated using Equation 2:

$$\hat{WTP} = \frac{1}{n}\sum_{i=1}^{n} x_i\hat{\beta} \quad (2)$$

where β_i represented the estimated coefficients in the model, n was the number of observations, and x_i represented the explanatory variables included in the model. All models were estimated with robust standard errors to adjust for heteroskedasticity.

Description of Explanatory Variables

The summary of selected responses is presented in Table 1. We consider variables from the survey that we a priori expect to have a significant effect on the producer's WTP to invest. The response to the initial WTP question is represented as *BioQ* in the analysis, where the presented randomized cost is represented by *BioCost*. To account for their current on-farm practices, *Onsite* is the percentage of current on-farm carcass disposal and *MortalityRate* is the farm's routine mortality rate (the loss of birds typically associated with the operation not including catastrophic losses due to disease).

In order to differentiate the size of operations, *Small* is a binary variable that represents the number of birds on the operation with 1 representing a farm size less than or equal to 149,999 birds and 0 being farm size greater than or equal to 150,000 birds. *FullOwn* is a binary variable describing the ownership of the operation with 1 indicating the producer's share of ownership is greater than or equal to 81% and 0 indicating ownership is less than or equal to 80%. To account for regional differences, *Midwest,* a binary variable that incorporates the location of the operation where 1 indicates location in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Wisconsin and 0 indicates an operation location elsewhere, is included.

An aspect of producers' decision to adopt additional on-farm disposal capacity is related to their personal risk perception. While the question was framed with a scenario where an FAD occurred, if a producer has higher risk tolerance, they may be likely to not invest. To account for the individual risk perception, a series of two binary variables describing the producer's individual perception of disease risk are included, where *Prob 1 or Less* represents the likelihood of a disease event happening once in the next 100 yr and *Prob 1 to 5* as happening once in 25 yr, and those who perceive a disease event happening more often are considered in the constant.

RESULTS AND DISCUSSION

From Table 1, 47.6% of respondents were willing to implement additional on-farm carcass disposal capabilities given their randomized cost of adopting on-farm carcass disposal (*BioCost*). This shows that given the appropriate price, there is some willingness to expand on-farm disposal capacity among poultry producers who participated in the survey, and the average farm mortality rate is 4.2% which is consistent with industry standards. Nearly all of the producers with on-farm disposal capacity had greater than 70% capacity (not presented). The results from the interval regression model are shown in Table 3 and indicate that several explanatory factors from the survey do

[2] For a full derivation of the log-likelihood equation see Bateman et al. (2004).

Table 3. Interval regression−producer willingness to adopt additional disposal capacity.

Variable	Coefficient	Robust std. err.	Significance
Onsite	−489	147.63	***
Mortality rate	1,145	2,195.07	
Small	−19,549	11,767.17	†
Midwest	−21,215	15,141.87	
Full own	−37,490	14,738.38	**
Prob 1 or less	20,428	18,270.09	
Prob 1 to 5	−36,460	6,907.46	***
Constant	83,304	21,532.86	***
Ln(Sigma)	10	0.546	***
Willingness to pay	15,651	8,061.346	*

Note: †$P \leq 0.10$, *$P \leq 0.05$, **$P \leq 0.01$, and ***$P \leq 0.001$; N = 15.

significantly impact WTP to invest in additional on-farm disposal capacity.

Of the responding producers, those who had onsite capacity reported, on average, 40.2% of carcasses were disposed onsite. These producers were willing to pay $489 ± $147 less for each additional percent of current onsite carcass disposal to adopt additional disposal capacity than those who had no on-farm disposal capacity ($P < 0.01$). For example, a producer with 20% on-farm disposal capacity would be willing to pay $9,780 less than those who do not have on-farm capacity. This is consistent with rational profit maximizing behavior, where given prior disposal capacity investments, their marginal investment amount is lower than those who have not made any investments. This implies that autonomous producers with on-farm capacity are still willing to invest in additional capacity just at a marginally diminishing rate.

The size of operation has a statistically significant ($P < 0.10$) impact on willingness to adopt. The majority of respondents were larger operations, with only 26.7% of producers producing 149,999 birds or less annually. These smaller farms with 149,999 birds or less were less willing to adopt new capacity, which may indicate the lack of access to capital or disposable income to spend on implementing such measures for smaller farms. These smaller producers' WTP was $19,549 less on average when accounting for other explanatory variables. While the significance of this result is only at the $\alpha = 0.10$ level, it does signal that there may be some difference in investment related to size of operation.

Producers that have full ownership of their operation are less willing to invest by an average of $37,490 ± $14,738. Only 11.3% of surveyed producers own 81% or more of their operation. This low level of ownership may represent a dependence on financing. Alternatively, we speculate that sole-owners may be less willing to invest because they fully bear the financial burden which may require going into debt, whereas, a producer who shares ownership of a poultry operation may perceive the costs of new disposal capacity as shared, thus seeming to be a smaller financial burden. Additionally, a producer with large financing may be more willing to take on additional debt to invest in disposal capacity compared to those who fully own their operation and have little to no debt.

A quarter of producers (24.6%) believe the probability of an FAD affecting their individual operation is 5% or less, meaning that their farm would not be affected by an FAD outbreak within the next 25 yr. Producers who had a disease probability of 1 to 5% were willing to pay $36,460 ± $6,907 less, on average, than those who believed the disease probability is higher than 5%. While the WTP questions explicitly stated that producers were to consider a situation where a disease was going to occur in the next 10 yr, these significant results ($P < 0.00$) indicate that individual risk perceptions do impact their willingness to invest in on-farm carcass disposal capacity. It may be that these producers believe that current implementation costs are not recuperated by the discounted future benefits when factoring in their own perception of an FAD and the implications for their own operation.

Overall, poultry producer respondents have a statistically significant ($P = 0.05$) mean WTP to invest in on-farm carcass disposal capacity of $15,651. The WTP indicates that there is a market for adopting biosecurity practices among poultry producers, which may indicate a willingness to invest by poultry producers in general. If these findings hold for poultry producers at large, it could signal the importance of disposal capacity and biosecurity practices in addressing potential financial risks associated with interruptions to business continuity and an FAD exposure. The moral hazard associated with biosecurity and its characterization as a weaker-link public good have been noted in the literature (Burnett, 2006; Siekkinen et al., 2012; Hennessy and Wolf, 2018). Farms that do not have adequate biosecurity plans and protections in place can put surrounding farms, the community, and economy at risk. Poor carcass disposal can lead to economic, environmental, or epidemiological concerns. These results show that there is willingness for proactive investment in disposal capacity, but that it is heterogeneous amongst farm sizes, current disposal capacity, and producer's personal FAD risk perceptions. This study helps practitioners and policy makers better understand producers' willingness to invest in preemptive capacity which could be used when creating programs and policies.

CONCLUSIONS AND APPLICATIONS

1. Using responses from an online survey from U.S. poultry producers, there is willingness to invest in on-farm carcass disposal capacity and producers are willing to pay $15,651 on average.
2. Current investment and adoption of on-farm carcass disposal capacity reduces the amount producers are willing to invest in additional capacity, as does ownership status and the producer's personal FAD risk perception.
3. Biosecurity practices, including carcass disposal capacity and planning before, during, and after a livestock disease outbreak are important, and producers are willing to invest in them.

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DISCLOSURES

The authors declare no conflicts of interest.

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