How can reporting on foreign animal diseases affect meat purchases? The case of African swine fever

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Misleading headlines that draw attention to the deadly aspects of animal disease can cause fear in consumers. We utilize an online survey experiment with U.S. pork consumers to assess how prior knowledge of African swine fever (ASF) and how news reporting headlines and article content can affect pork demand. We find that consumers are generally unaware of ASF, and almost half of respondents, who are all typically pork consumers, would be unwilling to purchase pork if there were an ASF outbreak in the United States. The impact of a slightly misleading headline on willingness to pay does not show a statistically significant difference from direct messaging of food safety assurance, but we find that headlines can still cognitively impact consumers' perceptions of food safety. Meanwhile, the results emphasize the role of prior knowledge and perceptions, which relays the importance of media cooperation to proactively inform the public about ASF outbreaks and highlight the nonimpact on human health as part of preparation efforts for a potential outbreak.

Key words: African swine fever, Willingness to pay, Food safety information

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Highlights

- Only about 27% of survey respondents are aware of the recent global outbreak of ASF.
- Just over 30% of respondents consider ASF a potential threat to humans.
- Nearly 46% of respondents said they would not buy pork if ASF was found in the U.S.
- Slightly misleading headlines affect cognition but not willingness to pay.
- Media cooperation is required to inform the public proactively about ASF outbreaks.

1. Introduction

African swine fever (ASF) is a highly contagious foreign animal disease and deadly viral disease in pigs (USDA-APHIS, 2021a).[1] ASF has never occurred in the United States, but is not a new swine disease globally.[2] It has proliferated rapidly across Asia after the first known outbreak in China in 2018 (FAO-EMPRES-AH, 2021a), and the number of countries affected by ASF has increased in Asia, Europe, and Sub-Saharan Africa (OIE - Europe, 2020). The detection of ASF virus in the Dominican Republic on July 27, 2021 and in Haiti on September 20, 2021 (Cole and Stepien, 2021a, 2021b), represents the first cases in the Western Hemisphere in forty years and has further heightened concerns the disease may continue to spread into disease-free regions, including the United States. The major economic consequences of an ASF outbreak would include the cost of disease

[1] Along with foot and mouth disease (FMD) and classical swine fever (CSF), ASF is classified as Tier 1 disease as they have the highest risks and consequences (USDA-APHIS-VS, 2013). ASF is considered the most serious current global threat to pork production worldwide (Niederwerder et al., 2021).

[2] ASF was first identified in Kenya in the 1920s and has become widespread and endemic in sub-Saharan Africa, parts of West Africa, and Sardinia. Spain and Portugal eradicated ASF in the mid-1990s after outbreaks in 1957 and 1960. It was also eradicated from the Caribbean in the early 1980s following outbreaks from 1977–1980.

control and the loss of status for international trade (Berthe, 2020). Adverse economic impacts of an ASF outbreak could increase exponentially if domestic consumers reduce pork consumption.

Despite the potentially devastating economic consequences and production losses for the pork industry, ASF is not a public health threat or food safety concern. However, a report from China mentioned that a 10% to 15% drop in pork consumption after the first ASF outbreak was probably due to food safety concerns (Pan, 2019). In Viet Nam, domestic pork demand was noted to be reduced owing to ASF-related health concerns (E.D. Solutions, 2019), and media in the Philippines reported that consumers were avoiding pork despite the fact that ASF does not harm human health (Rivas, 2019). One popular press article points out that confusing headlines about the ASF outbreak prompted German consumers, unfamiliar with the virus, to question the safety of pork (Shike, 2021). Moreover, the Korea Pork Producers Association issued a statement calling for media cooperation on ASF reporting. They referred to the past experiences with FMD and stated that stimulating words caused damage to the farms as they invoked consumers' anxiety about food safety and pork consumption (Korea Pork Producers Association, 2019).[3]

In the United States, government, private industries, and producers have strengthened the guard against the entry of ASF into the country (FDA, 2020). For example, the pork industry is increasing biosecurity and working with the U.S. Department of Agriculture (USDA) and U.S. Customs and Border Protection to help prevent the spread of ASF (Lindsey, 2021), and vaccine candidates are making progress towards commercialization (USDA-ARS, 2021). Nonetheless, there is limited information on consumer awareness of ASF and, in general, their

[3] Examples of these included: [Chosun] “First African swine fever case confirmed: 100% mortality rate- No vaccine available” (Park, 2019a); [Hankyoreh] “Experts predict “virus storm” regarding African swine fever, no vaccine has been developed for ASF” (Park, 2019b); and [Koreatimes] “Animal groups: 'Infected pigs were buried alive, splattering blood. (Ko, 2019)

perceptions about foreign animal diseases. News articles can be a primary mode to reduce the information asymmetry within consumers and producers in the food industry (Venbeke, 2005; McCluskey and Swinnen, 2011). However, to the other extreme, news articles can cause unintended consequences by spreading misperceptions among the public, especially through misleading headlines that can cause bias among readers. Moreover, when the media report on animal disease outbreaks, negative connotations typically appear in news articles (Shih et al., 2008; Ruth et al., 2005). As such, proper communication can be crucial in minimizing public fear of emergencies and adverse impacts on meat demand.

In this study, we utilize an online survey of U.S. pork consumers to help fill several knowledge gaps. We first compare respondents' perceptions and prior knowledge of ASF with other swine diseases to check for consistency in judgment and evaluate relative awareness of ASF. Knowing respondents' perception of the recent global ASF outbreak along with prior knowledge of other swine diseases helps to document baseline knowledge about swine diseases before being exposed to information treatments used in the study. Contingent valuation experiments are then used to examine purchasing decisions and perceptions of food safety when exposed to alternative news articles where the headline and the body of the article is framed differently. Understanding possible consumer actions after being exposed to differently framed and curated information can help design strategies to prevent or lessen demand impacts and avoid further serious economic implications for producers and the broader economy.

2. Literature review

The reporting of foreign animal disease outbreaks can operate as an information shock to the related meat markets. Houser and Karali (2020), in particular, emphasized that the first occurrence of an animal disease outbreak contributes to

market uncertainty in livestock markets. Meanwhile, previous research has shown media impacts of food safety events on consumers, with studies mostly focusing on food recalls or contamination (Piggott and Marsh, 2004; Mash, Schroeder, and Mintert, 2004; Dahlgran and Fairchild, 2002). For example, Piggot and Marsh (2004) gauged the impact of prominent food safety events on meat demand as significantly large but short-lived. Similarly, Wang and de Beville (2017) found that U.S. consumers reduced poultry demand when an avian influenza outbreak was reported negatively by the media. The literature has rarely discussed consumer responses associated with animal diseases that do not have human health impacts and/or food safety concerns. However, adverse meat demand impacts are possible regardless of the actual severity of food safety concerns, if any, and this can depend on how the information is delivered to the public.

How information is framed matters for consumers' attitudes about food purchases. Previous research includes pro or anti framing, gain or loss framing, and benefit or risk framing. (Fox et al., 2002; Hayes et al., 2002; Lusk et al., 2004; Marette et al., 2008; Mitchell et al., 2015; Britwum and Yiannaka, 2019). When both positive and negative information on food irradiation was offered to consumers at the same time, Hayes et al. (2002) found that negative information outweighed positive information. In this context, McCluskey and Swinnen (2011) proposed that media companies who care about profits would offer more negative stories to meet the demand for negative news. Stronger demand for negative framing aligns with prospect theory (Kahneman and Tversky, 1979), because readers' expected value of additional information would be higher when an article dealt with a negative impact on their welfare than when it dealt with a positive impact.

Cannon and Irani (2011) investigated how foot and mouth disease (FMD) was framed in major daily newspapers during the FMD outbreak in the U.K. in 2001 and 2007 and confirmed that framing of fear dominates. They cautioned that the use of frames in media has the potential to invoke unnecessary fear among

consumers who already have limited knowledge regarding agricultural production practices. From a psychological experiment, Ecker et al. (2014) found that a slightly misleading headline used in factual articles affects a reader's memory, which was difficult to correct even after reading an article's factual content. They defined slightly misleading headlines as ones focusing on one negative aspect of the issue rather than the article's main issue.

Prior knowledge can also alter food consumers risk perceptions and purchase intentions (Radecki and Jackard, 1995; Verbeke, 2005). According to Rao and Sieben (1992), consumers evaluate product quality as lower when they perceive certain information about a product is missing. Also, consumers with less prior knowledge of a product are more likely to be risk averse than more knowledgeable consumers because the perception of missing information causes uncertainty in purchase decisions. In a similar vein, the public seems to overestimate food risks even when experts evaluate the actual risk to be low (Miles and Frewer, 2003; Miles et al., 2004). In addition, Jin and Han (2014) found that when exposed to a differently framed news article on a food hazard with varying degrees of information, a group of individuals with less subjective knowledge of food safety issues showed a greater variation in purchase intentions. Our research builds upon these prior studies, and adds to foreign animal disease preparation efforts, by investigating how consumers' perceptions and the framing of information in news articles can affect their purchase decisions. Resiliency of all meat industry participants, in the aftermath of a foreign animal disease outbreak, will hinge critically upon consumer demand.

3. Survey Data

3.1. Survey instrument

An online survey was developed to collect information about U.S. pork consumers. We developed the survey collaboratively with the Center for Survey Statistics and Methodology (CSSM) at Iowa State University. Dynata, an international marketing company, programmed the survey instrument into a web-based format and distributed it through their database of survey panelists. The survey sample was balanced for age, gender, race, income, and region of the United States according to the U.S. Census. A screening question was included at the beginning of the survey to identify pork consumers. A household that does not eat pork was not included in the sample. In total, 2,017 completed responses were obtained from April 29, 2020, to May 4, 2020. Among total respondents to the survey, 1,052 participants were randomly assigned to the survey experiment designed for this study. Table 1 shows select summary statistics of survey participants. About 46% of respondents were female, mean age was 46 years with a range of 18 to 93 years, and 28% of respondents had a bachelor's degree or higher. Income was classified into five categories, and four categories for region of the United States. Two-thirds of respondents eat pork at home more than once a month and selected pork chops as a pork product that they typically buy. Forty percent of respondents eat pork away from home more than once a month.

3.2. Awareness of ASF and other swine diseases

To our knowledge, there is little published evidence on consumer awareness and perceptions of ASF or other swine diseases. The first part of the survey consisted of questions that evaluated how much pork consumers know about various swine diseases. Specifically, three questions allowed us to infer the degree to which

consumers were aware of ASF. The first question asked how much they were aware of various swine diseases, using a Likert scale. Swine diseases included swine influenza, porcine epidemic diarrhea (PED), porcine reproductive and respiratory syndrome (PRRS), ASF, classical swine fever (CSF), and FMD. Common causes of foodborne illness, such as E. coli and salmonella, were also included in the list. To account for possible order bias, swine diseases were provided in a randomized order to survey participants.

There was a general lack of awareness of ASF, with almost 50% of respondents answering that they were not at all aware of ASF (Figure 1). ASF was less known to the public than E. coli, salmonella, swine influenza, and the other Tier 1 swine diseases of FMD and CSF, but was better known than the production diseases of PED and PRRS. It is reasonable that respondents are more knowledgeable of E. coli and salmonella as they can cause foodborne illness. As can be rationalized, awareness of swine influenza, E. coli, and salmonella were similar. Humans are rarely infected by swine influenza viruses (CDC, 2014) but they have garnered attention, often because of confusion. The 2009 H1N1 influenza was first called "swine flu" because many of the genes in the virus resembled those found in pigs in North America. Even after the illness was renamed H1N1, many media outlets continued to refer to it as "swine flu," and consumers did not fully grasp that H1N1 and pork consumption were unrelated (Attavanich et al., 2011).

FMD is a disease that affects many species with cloven hooves, including cows, pigs, sheep, goats, and deer. It was eradicated from the United States in 1929 (USDA-APHIS, 2021b). The virus is not a threat to public health or food safety (USDA-APHIS, 2021b). Only 20% of respondents said they were not aware of FMD, which is consistent with the findings of a previous study on U.S. residents' awareness of animal diseases, in which 76% of respondents indicated familiarity with FMD (Byrd et al., 2015). CSF, also known as hog cholera, is a Tier 1 disease that poses no risk to human health or food safety (OIE, 2021b). The United States

eradicated CSF in 1978 (USDA-APHIS, 2020); still only 30% of respondents said they were not aware of it. Conceivably, it could be that CSF is being confused with another swine disease. Among foreign animal diseases related to swine, respondents appear to be the least aware of ASF.

PRRS and PED are two of the most costly diseases in the U.S. swine industry (Holtkamp et al., 2013; Schweer et al., 2016). However, 60% and 57% respondents answered that they were not all aware of PED and PRRS, respectively. Following the first PED cases in the United States in April 2013, Schulz and Tonsor (2015) assessed that the virus was a supplying impacting disease and the outbreaks received little attention from the major national media and there was no noticeable effect on consumer demand for pork. ASF, on the other hand, has garnered mass, wide-spread media attention in countries with outbreaks.

Using the same list of swine diseases, survey participants were asked to indicate which diseases, if any, they thought were a possible threat to human health. Both E. coli and salmonella were chosen by nearly 70% of the respondents, while 55% chose swine influenza (Figure 2). About 24% of respondents answer that PED and PRRS are potential human health threats. For Tier 1 diseases, 31% answered ASF as a human health threat, while 34% and 37% responded CSF and FMD as potential threats to human health, respectively. This is an extremely noteworthy finding as despite considerable efforts by several government agencies (OIE, 2021a; FAO-EMPRES-AH, 2021b; USDA-APHIS, 2021a) and others (Pork Checkoff, 2021; SPS Plan, 2021) to publicize that FMD, CSF, and ASF are not public health or food safety concerns and that pork will still be safe to eat in the event of a disease outbreak, some consumers have strong beliefs to the contrary.

The August 2018 outbreak of ASF in China and subsequent outbreaks in other countries has dramatically changed the global epidemiological conditions of ASF and has caused concerns the disease may continue to spread into disease-free regions, including the United States (Sundberg, 2019). Only 27% of respondents

were aware of this situation when the survey was conducted in the spring of 2020. The cross tabulation for respondents' awareness of the recent global outbreak of ASF and their belief that ASF is not a threat to human health, shown in Table 2, indicates that only 16% of respondents who were aware of ASF believed it was not a threat to human health.

We used three survey questions to assess prior knowledge of ASF. However, it is likely that there exist latent or hidden patterns between answers to the questions, as respondents with similar answers will tend to cluster within the same latent class. We identified these latent classes among respondents. The minimum BIC criteria indicated the existence of two classes related to prior knowledge of ASF. We found that an individual's awareness of the global ASF outbreak was a key response that determines which latent class a respondent is more likely to belong to. To help retain brevity of the article, Appendix 1 contains details of the latent class analysis.

3.3. *Experimental design: Information treatments*

A survey experiment was designed to assess how news reporting and the degree of information exposure about an unfamiliar animal disease outbreak can affect meat demand. The hypothetical situation is impossible to test in a real-world setting. Without a controlled environment, it is also difficult to ensure that consumers are actually exposed to specific news items or messages. The benefit of the stated preference methodology is that we can directly compare the effect of media coverage and food safety information on consumers' behavioral changes in pork purchases during a hypothetical outbreak of ASF while accounting for respondents' prior knowledge.

When an ASF outbreak occurs, depending on how the outbreak is reported, some consumers may only be informed of the occurrence of the outbreak, while some consumers may learn more about the disease. Even if sensational headlines are

avoided, a negative framing in the headlines can have a cognitive effect on consumers' perceptions, resulting in them avoiding the consumption of pork. Moreover, consumers may seek further assurances that eating pork is safe.

The news article format in our experiment, reporting the first occurrence of ASF in the United States, serves as the information treatment. We specified in the instructions as follows:

> The following article describes a HYPOTHETICAL SITUATION. The article is what you may see if there is an outbreak of African swine fever in the United States. You will be asked to respond to a hypothetical scenario. Please answer the questions as if you were actually facing the situation.

To eliminate the source of bias in treatments, each respondent was randomly assigned to one of four treatments or a control group. A control group received no headline or corresponding news article content. Four treatment groups received news articles, and a two-by-two factorial design was used to compare the relative effects of the combinations of two types of content and two types of headlines.

For the body of the news article, we prepared two different paragraphs of approximately 200 words each. General information about ASF was included and it was explicitly stated that ASF was not a potential threat to human health. The difference between the two types of contents was that we included additional food safety assurance messaging in one, but not the other.

We considered two possible headlines that may be used when reporting on an ASF outbreak. One headline may be focused on food safety, stating it is "still safe to eat pork." The other headline may state that "no vaccine is available" but does not specify to whom the vaccine was unavailable. According to Ecker et al. (2004), the latter headline is slightly misleading because it emphasizes one negative aspect

rather than the dominant point of the accompanying content about the non-impact to human health.

Boneless pork chops were used for the study because they are a familiar cut of fresh pork (USDA-AMS, 2021; US-BLS, 2021) and have been frequently utilized in previous studies (Sanders et al., 2007; Olynk et al., 2010; Pozo et al., 2012; Lusk et al., 2018). Table 3 presents a summary of the experimental design based on a mix-and-match of two news article contents and two headlines. Instructions, headlines, and the news articles provided for the contingent valuation experiment are provided in Appendix 2.

4. Methodology

4.1. *Double-bounded dichotomous contingent valuation methodology*

We used the double bounded contingent valuation methodology (Hanemann et al.,1991) in the survey to determine how willingness to pay differs by exposure to different information treatments. We provided survey participants with the average retail price of $3.35 per pound for boneless pork chops, which was based on the National Retail Report – Pork, published by USDA's Agricultural Marketing Service, for the third week of February 2020 (USDA-AMS, 2020).[4] The price served as a representative, prevailing price for normal market conditions. Then, each respondent was asked if they would buy a boneless pork chop for a lower price (B_i) per pound during an ASF outbreak in the United States. If a participant answered 'yes' to the first question, the price was raised by $0.50 ($B_i^h = B_i + 0.5$) and the question was asked again. If a participant answered 'no' to the first question, the price was reduced by $0.50 ($B_i^l = B_i - 0.5$) and the question was

[4] The National Retail Report - Pork provides advertised weekly pork prices at major retail supermarket outlets. We used the weighted average of the price for center cut chops boneless, which was a national store summary from February 14th to February 20th. It was comparable to the price of all pork chops per pound (453.6 gm) from the U.S. Bureau of Labor Statistics (BLS) Average Retail Food and Energy Prices, U.S. and Midwest Region report for January 2020 (US-BLS, 2020).

asked again. Survey participants were randomly assigned to three initial lower prices: $2.00, $2.35, and $2.70.

We used initial prices lower than the reference price of $3.35 per pound. This reflects the notion that countries with confirmed cases of ASF would be subject to international trade restrictions. As a result, an outbreak of ASF in the United States would lead to a significant reduction in U.S. pork exports. This would result in immediately larger supplies of pork in the domestic market, putting downward pressure on prices throughout the pork supply chain (Carriquiry et al., 2020).

The theoretical framework in Aizaki et al. (2014) is adapted for this study. We assume an individual's indirect utility function $U_i(q_i, m_i)$, where q_i was the perceived safety of the pork chop, and m_i was the individual's income. Suppose an individual compares the perceived safety of a pork chop in normal condition (q_{0i}) to the perceived safety after the individual hears about an ASF outbreak in the United States (q_{1i}). Learning about an ASF outbreak may or may not change individuals' perceptions of the safety of pork. If individuals think they will gain utility from purchasing pork chop at a proposed price, they would answer 'yes' to the question, and we can write it as an equation:

$$U_i(q_{1i}, m_i - B_i) \geq U_i(q_{0i}, m_i) \tag{1}$$

where B_i is a price which is further assumed to be $B_i = 3.35 - D_i$, and D_i reflects the perceived discount in the value of the pork chop evaluated by individuals due to an ASF outbreak.

We assumed a logistic distribution to account for both positive and negative ranges for willingness to pay. This reflects Bass et al. (2021)'s suggestion that it may not be reasonable to focus only on the positive value of a willingness to pay for market goods since a market good may not always provide marginal utility when

it reflects consumer sentiment, such as food safety concerns which are relevant to this study. Therefore, the responses to the double-bounded valuation questions can be partitioned into four intervals. For example, if a respondent answered 'yes' to both valuation questions ('yes, yes'), then the respondent's willingness to pay is considered higher than the last price, and the willingness to pay interval is classified as $[B_i^h, +\infty)$. An interval for a ('yes, no') answer is $[B_i, B_i^h)$, an interval for a ('no, yes') answer is $\left[B_i^l, B_i\right)$, and an interval for a ('no, no') answer is $(-\infty, B_i^l)$.

4.2.*Willingness to pay estimation*

To estimate willingness to pay, we assume an individuals' indirect utility function (U_i) has a systematic component (V_i) and a random component (e_i), based on the random utility model. Therefore, equation (1) can be written as:

$$V_{1i}(q_{1i}, m_i - B_i) + e_{1i} \geq V_{0i}(q_{0i}, m_i) + e_{0i} \tag{2}$$

We use the linear utility model $V_i = a_i + b_i m_i + e_i$, where b_i represents the marginal utility of income. An individual's maximum latent willingness to pay in the hypothesized situation satisfies:

$$a_{0i} + b_i m_i + e_{0i} = a_{1i} + b_i(m_i - y_i^*) + e_{1i} \tag{3}$$

Rearranging the equation yields $y_i^* = \frac{\alpha_i + e_i}{\beta_i}$, where $\alpha_i = a_{1i} - a_{0i}$ and $e_i = e_{1i}$,- e_{0i}. An individual would say 'yes' to a price if the individual perceives that purchasing pork chops at the proposed price provides greater utility during an ASF outbreak, such that $V_{1i} - V_{0i} = \alpha_i - b_i B_i + e_i \geq 0$. To account for other consumer characteristics that may influence the change in utility, we replace α_i with $\alpha_i + \gamma_i D_i + \beta_i x_i$, where D_i is information treatments assigned to an individual, x_i is a

vector of the explanatory variable associated with consumer characteristics (such as demographic information, frequency of pork chop consumption), and, α_i, γ_i, β_i are parameters to be estimated. The error term e_i is a stochastic component with a standard logistic distribution.

The probability that individual *i* answers 'yes, yes' to the first and second questions is given by $P^{yy}(B_i, B_i^h) = Pr\left(B_i^h \leq y_i^*\right) = 1 - F(B_i^h;\ \alpha_i,\ \gamma_i,\ \beta_i, b_i)$. Similarly, the probability of answering 'yes, no' is $P^{yn} = F\left(B_i^h; \alpha_i, \gamma_i, \beta_i, b_i\right) - F(B_i; \alpha_i, \gamma_i, \beta_i, b_i)$, and the probability of answering 'no, yes' is $P^{ny} = F(B_i; \alpha_i,\ \gamma_i, \beta_i, b_i) - F\left(B_i^l; \alpha_i, \gamma_i, \beta_i, b_i\right)$. Lastly, the probability of answering 'no, no' is $P^{nn}\ (B_i, B_i^h) = F(B_i^l; \alpha_i,\ \gamma_i\ ,\ \beta_i, b_i)$. Therefore, the log-likelihood for estimation can be specified as:

$$
\begin{aligned}
(4) \qquad \ln L = \ \sum_{i=1}^{N} \{\ & D_i^{yy} \ln\left[\, 1 - F\left(\, B_i^h;\ \alpha_i, \gamma_i, \beta_i, b_i\right)\right]] \\
& + D_i^{yn}\ ln\left[\, F\left(B_i^h; \alpha_i, \gamma_i, \beta_i, b_i\right) - F(B_i; \alpha_i, \gamma_i, \beta_i, b_i)\right] \\
& + D_i^{ny}\ ln\left[\, F(B_i; \alpha_i, \gamma_i, \beta_i, b_i) - F\left(B_i^l; \alpha_i, \gamma_i, \beta_i, b_i\right)\right] \\
& + D_i^{nn}\ ln[F\left(B_i^l; \alpha_i, \gamma_{i,}, \beta_i, b_i\right)]\}
\end{aligned}
$$

where $D_i^{yy}, D_i^{yn}, D_i^{ny}, D_i^{nn}$ are indicator variables that have a value of 1 when the respondent answers 'yes, yes', 'yes, no', 'no, yes', or 'no, no', respectively. F(·) is defined to have a standard logistic distribution. Maximum likelihood is used to estimate the model.

4.3. Follow-up questions to the contingent valuation questions

Respondents who said 'no' to the initial prices and subsequent lower prices were prompted to answer follow-up questions. Specifically, we asked "Would you buy a boneless pork chop for any price below the last suggested price?" For those who

answered ‘no,’ to that question we also asked, “You responded you would not buy a boneless pork chop during an outbreak of African swine fever in the United States at any price. Is your choice mainly due to concerns about food safety?” This particular question was included to evaluate whether exposure to differently framed reporting of an ASF outbreak could alter perceptions of food safety, even if consumers were unwilling to purchase pork. Figure 3 depicts how the double-bounded contingent valuation and follow-up questions were provided.

5. Results

Table 4 demonstrates the distribution of responses to the contingent valuation questions when learning about ASF. As can be seen, a substantial proportion of consumers responded ‘No, No’ to the suggested prices and were directed to the follow-up questions. We discuss these results with follow-up questions in more detail, examining respondents’ perception of food safety after being exposed to different news reporting of ASF, but first, we focus on the willingness to pay results.

5.1. *Willingness to pay estimation*

We estimated the parameters of the log-likelihood function to evaluate how willingness to pay differs depending on exposure to different combinations of headlines and news articles (information treatments). The results in Table 5 show coefficient estimates from four different model specifications. Model (1) is a baseline model that only includes price effects and the variables that capture the effect of the information treatments. Model (1) shows a statistically significant negative value for the price coefficient, indicating that consumers are less likely to purchase pork as the price increases. This is consistent with theory. Demand for pork is a schedule of quantities consumers are willing, and able, to buy over a range of prices. As you would expect, consumers buy less when prices rise.

Regarding the effect of information treatments, respondents who received one of the four headline and news article combinations have a higher willingness to pay than the control group who were not provided with any news article that included messaging that ASF is not a threat to human health. Considering that we proposed lower prices following an ASF outbreak, the higher willingness pay estimates can also be interpreted as lower discounts. These results suggest that exposure to detailed information, as opposed to simply learning about an ASF outbreak, could help mitigate adverse demand impacts.

Results of linear hypothesis tests that compare the difference of effect between treatment groups are included at the bottom of Table 5. We examined whether the two types of headlines had a different effect on willingness to pay when the article contents were identical, and whether the two types of article contents had a different effect on willingness to pay when the headlines were identical. We do not find any statistical difference in willingness to pay. That is, provided that information regarding the human health impact is included in the body of the article, the impact of a slightly misleading headline does not show a statistically significant difference from direct messaging of food safety information.

Model (2) in Table 5 controls for individuals' prior knowledge of ASF, by adding variables related to their awareness of the global ASF outbreak and perceptions of ASF as a non-threat to human health. Being aware of the global outbreak results in a smaller discount than being unaware, and perceiving ASF as a non-threat to human health is associated with a lower discount than believing that ASF is a threat to human health. The interaction term between the two variables, however, was not statistically significant, and was therefore not included in the model.

Meanwhile, changes in the statistical significance of the information treatment coefficients imply that there may be potential heterogeneity among respondents based on their prior knowledge. According to the latent class analysis, a

respondent's probability of belonging to one of the two identified latent classes is dependent on their response to the awareness of the global ASF outbreak question. Thus, the information treatment variables are interacted with awareness of the global ASF outbreak variable in Model (3). The results reveal that the respondents who were unaware of the global ASF outbreak were the ones impacted by the information treatments. This result is in line with the finding of Jin and Han (2014), who showed that individuals with greater subjective knowledge were less influenced by information framing.

Upon controlling for respondent characteristics in Model (4), statistical significance emerged for interaction terms between awareness of the global ASF outbreak and being provided with direct messaging of food safety information in the headlines. The coefficient for the variable associated with awareness of the global ASF outbreak remained statistically significance and positive. The interaction terms between the information treatment variables and awareness of the global ASF outbreak variable capture the additional effect of awareness on willingness to pay in each treatment compared to the control group. The results suggest that awareness of the global outbreak results in a smaller discount for respondents who received direct messaging about food safety in the headlines compared to respondents who did not receive a news article. Another possibility is that respondents aware of the global outbreak might react critically to the tone of the direct messaging of food safety, which attempts to convince them that a certain risk is tolerable (McCluskey and Swinnen, 2011), by stating 'still safe to eat pork.' However, the difference is statistically significant only at the 10% level, and those aware of ASF show little difference in their responses.

With respect to respondent demographics, the results suggest that females and younger individuals would have a lower willingness to pay or greater discount of pork chops during an ASF outbreak. The result supports previous research that women are more concerned with food safety (or perceived food safety in our case)

(Yu et al., 2018; Hammitt and Haninger, 2007; McCluskey and Loureiro, 2003). In addition, the result is also in line with the finding of Yu et al. (2018) regarding age which shows that younger respondents are more willing to pay for a reduction in foodborne illness in fresh cut produce. Furthermore, consumers with higher annual household incomes or who purchase pork chops more than once a month had higher willingness to pay. Education level did not have a statistically significant impact on willingness to pay.

We use Model (4) to estimate mean and median willingness to pay, as likelihood ratio tests identify it as the preferable model. Table 6 provides these estimates. The mean and median were predicted separately based on respondents' awareness of the global ASF outbreak and the information treatments. The average willingness to pay for all respondents was $2.28 per pound, representing a 32% decrease from the price of $3.35 per pound provided to respondents as a prevailing price. If a respondent was unaware of ASF and was not given a news article (both headline and contents), the average willingness to pay was estimated to be $1.53 per pound, a 54% discount from the prevailing price. On the contrary, if an individual was aware of the global ASF outbreak but did not receive a news article, the average willingness to pay was $2.97 per pound, an 11% discount from the prevailing price.

5.2. *Responses to follow-up questions to the contingent valuation questions*

Table 7 shows the distribution of responses to the two follow-up questions. Respondents who indicated 'yes' to the first follow-up question regarding their willingness to pay for a pork chop at any price lower than the last suggested price are considered to have a positive willingness to pay for a pork chop during an ASF outbreak in the United States. When we estimate conditional willingness to pay using only the sub-set of consumers who have a positive willingness to pay (data

not shown), the mean conditional willingness to pay is $3.35 per pound, with a 95% confidence interval of ($3.22, $3.51), which is comparable to the prevailing price.

However, the majority of consumers who were in the 'no, no' group answered 'no' again to the first follow-up question. That is, about 46% of entire respondents, who are all typically pork consumers, indicating they would not buy pork if an ASF outbreak occurred in the United States. This implies the potential for significant adverse demand impacts, which is also in line with a poll from the Pork Checkoff that more than half of consumers still said they would stop eating pork if ASF was found in the United States (Heslip, 2020). Given the high proportion of consumers who expressed an unwillingness to purchase pork during an ASF outbreak, it is critical to further examine respondents' perceptions of food safety after being exposed to different news reporting of ASF. Understanding the cognitive impact of different levels of information and their placement within reporting may help develop effective communication strategies.

In Table 7, of the survey respondents who would not buy a boneless pork chop during an ASF outbreak in the United States at any price, the majority of individuals came to this conclusion based on concerns about food safety. This suggests that consumers may be highly likely to assume that an animal disease outbreak will result in a food safety issue, regardless of its actual severity and the scientific evidence. However, when a direct message about food safety was included in the headline, fewer respondents indicated their unwillingness to purchase pork was due to food safety concerns.

To determine whether the differences in responses due to being exposed to alternative information treatments are statistically significant, we utilized a bivariate probit model with sample selection introduced by Heckman (1979), which accounts for the second follow-up question not being observed by all survey participants but only by those who indicated an unwillingness to purchase at any offered price levels. Therefore, the first follow up question represents the selection

process. Among all respondents, the dependent variable in the selection equation has a value of 1 when a respondent indicates an unwillingness to purchase by responding negatively to the first follow-up question, and 0 otherwise. The second follow-up question represents the outcome process, the dependent variable has a value of 1 when a respondent answered 'yes' to the follow-up question regarding food safety concerns, and 0 otherwise. To explain the selection process, the independent variables are adapted from the willingness to pay estimation, and variables related to the information treatments are mainly tested in the outcome equation. Appendix 3 contains details on model estimation.

Table 8 presents the coefficients and marginal effects from the baseline model, where the effects of information treatments are tested in the outcome equation. The results show that placing direct messaging of food safety either in the headline or article contents had a cognitive impact on perceptions of food safety compared to the control group. For example, when respondents see direct messaging about food safety in both the headline and the article content, the marginal effects indicate that they are about 20% less likely to respond that food safety is their primary concern. Individuals who were not exposed to direct food safety information in the headline or body of the article did not differ from those in the control group who were not exposed to any news article.

Further testing of linear hypotheses showed that individuals exposed to direct messaging about food safety in the headline responded differently to those exposed to a misleading headline. Individuals exposed to explicit messages about food safety information in the headline were less likely to respond 'yes' to whether their unwilling to purchase was based on food safety concerns. This implies that those groups recognized that ASF is not a food safety concern and gave more thought to the headline before answering the question, in contrast to the individuals receiving misleading headlines. The result remained robust when the variables associated

with awareness and prior perceptions of ASF were controlled for in the outcome equation, which is presented in Appendix 3.[5]

Our findings are consistent with Ecker et al. (2014) that the message in the headline affects the reader's memory of the factual content in the news articles. It is worth highlighting that the difference in the two headlines was not captured when we compared willingness to pay, even though there exists a cognitive effect when the food safety message is included in the headline and article contents. This result may imply that consumer attitudes or purchase intentions are more difficult to influence than their perceptions, as news about animal disease outbreaks appear to shape attitudes towards an unwillingness to purchase, even when consumers perceived the animal disease not to be a food safety concern.

6. Conclusion

African swine fever has never occurred in the United States. The virus is lethal to the pig population, but it poses no threat to public health or food safety (USDA-APHIS, 2021a). Due to its highly contagious nature, high mortality rate, and the economic consequences of an outbreak, the swine industry has strengthened its defenses against its entry into the United States. Even so, the probability of an ASF outbreak in the United States is non-zero (Jurado et al., 2019; USDA-APHIS-CEAH, 2019). In the event of an ASF outbreak in the United States, it will most certainly garner wide-spread media attention due to the potentially devastating impact on the pork industry and related businesses. If the drop in domestic demand due to concerns about the perceived safety of pork products cannot be mitigated, this will exacerbate an already desperate situation caused by the disease control,

[5] We also checked the impact of controlling for consumer characteristics in the outcome equation, but including additional variables in the outcome equation is not recommended. According to Achen (1986, page 27), "with quasi-experimental data derived from nonrandomized assignments, controlling for additional variables in a regression may worsen the estimate of the treatment effect, even when the additional variable improves the specification." Therefore, we interpret the results only using the variables related to the information treatment effect and show the results of robustness check by adding prior perception variables in Table 3.1 in Appendix 3.

loss of export, and price reductions (Carriquiry et al., 2020). [6] Therefore, understanding potential consumer reactions is critical for any response and recovery plan.

Using an online survey with 1,052 U.S. pork consumers, we first investigated how much consumers were aware of ASF. We confirmed that consumers were generally unaware of ASF in comparison to the pork production community's enhanced attention and prevention efforts. From the survey, about 31% of respondents misperceived ASF as a human health impact, and only about 27% of them were aware of the global ASF outbreak. Moreover, when we examined possible consumer responses to an ASF outbreak in the United States using a contingent valuation experiment, nearly 46% of respondents, who typically consume pork on a regular basis, stated that they would avoid purchasing pork. This particular finding indicates that there is still information asymmetry in the marketplace that should be reduced in preparation of a possible ASF outbreak.

Previous research has shown that the public tends to overestimate food risks and the literature has emphasized the role of prior knowledge in risk communication (Miles et al.,2004; Verbeke, 2005). The results from this study also suggest that increasing public awareness in advance of a foreign animal disease outbreak can be an important part of the preparation to reduce ambiguity. Adding to the current effort on public communication and response planning for when ASF is detected (USDA-APHIS-VS, 2020), our results emphasize the importance of getting ahead of an outbreak and increasing consumer familiarity with the disease in advance. In this context, media cooperation will be required in proactively informing the public about ASF outbreaks and highlighting the nonimpact of ASF on human health and food safety.

[6] For example, Paarlberg, Lee, and Seitzinger (2002) estimate that if only 7% of U.S. consumers cut meat consumption during an FMD outbreak (i.e., in the mistaken belief that FMD if a human health concern), the national welfare losses from the outbreak would be more than double the amount of losses with no such consumer response.

By examining the effectiveness of different information used in news reporting, we hope to contribute to the design of a more effective public communication strategy. 'No threat to human health' is a critical piece of information to deliver to those not aware of the global ASF outbreak and should be prioritized. In addition to this, we examined the effect of slightly misleading headline, even in cases where the news article content contains information explicitly stating that ASF is not a threat to human health. This particular assessment was conducted to determine whether consumers may still avoid consumption when certain details such as food safety information are omitted or when the headline is misfocused by emphasizing negative aspects. However, provided that the human health impact information is delivered in the content, slightly misleading headlines or omission of food safety assurance does not show a different impact on willingness to pay.

Although we do not capture differences in willingness to pay caused by misleading headlines, further examination of the responses suggests that headlines still have cognitive impact on perceptions of food safety. If more sensational headlines were used or if blatantly incorrect information was used in the headline, the cognitive impact may have resulted in significant differences in willingness to pay. This especially may be the case, given the public's unfamiliarity with foreign animal diseases. This is, however, beyond the scope of our study, and the results presented here can be used as a launching point for further study.

REFERENCES

Achen, C. H. (1986). The statistical analysis of quasi-experiments. University of California Press.

Aizaki, H., Nakatani, T., & Sato, K. (2014). *Stated preference methods using R*. CRC Press.

Attavanich, W., McCarl, B. A., & Bessler, D. (2011). The effect of H1N1 (swine flu) media coverage on agricultural commodity markets. *Applied Economic Perspectives and Policy*, *33*(2), 241-259.

Bass, D. A., McFadden, B. R., & Messer, K. D. (2021). A case for measuring negative willingness to pay for consumer goods. *Food Policy*, *104*, 102126.

Berthe. (2020). OIE bulletin (panorama 2020–1). World Organization for Animal Health. https://doi.org/10.20506/bull.2020.1.3119

Britwum, K., & Yiannaka, A. (2019). Consumer willingness to pay for food safety interventions: The role of message framing and issue involvement. *Food Policy*, *86*, 101726.

Byrd, E., Widmar, N. O., & Lee, J. (2015). US Residents' Awareness of Animal Diseases. Center for Animal Welfare Science at Purdue University RP.2015-05. August 2015

Cannon, K. J., & Irani, T. A. (2011). Fear and loathing in Britain: A framing analysis of news coverage during the foot and mouth disease outbreaks in the United Kingdom. *Journal of Applied Communications*, 95(1), 6–22.

Carriquiry, Miguel; Elobeid, Amani; Swenson, David; and Hayes, Dermot. (2020). Impacts of African Swine Fever in Iowa and the United States. *CARD Working Papers*. 618. https://lib.dr.iastate.edu/card_workingpapers/618

Centers for Disease Control and Prevention. (CDC) (2014, August 19). Key facts about swine influenza (swine flu) in pigs. Centers for Disease Control and Prevention. Retrieved November 8, 2021, from https://www.cdc.gov/flu/swineflu/keyfacts_pigs.htm.

Cole & Stepien (2021a, July 28). USDA Statement on Confirmation of African Swine Fever in the Dominican Republic. Retrieved from https://www.aphis.usda.gov/aphis/newsroom/news/sa_by_date/sa-2021/asf-confirm.

Cole & Stepien (2021b, September 21). USDA Statement on Confirmation of African Swine Fever in Haiti. Retrieved from https://www.aphis.usda.gov/aphis/newsroom/stakeholder-info/sa_by_date/sa-2021/sa-09/asf-haiti.

Dahlgran, R. A., & Fairchild, D. G. (2002). The demand impacts of chicken contamination publicity—a case study. Agribusiness: An International Journal, 18(4), 459-474.

Ecker, U. K. H., Lewandowsky, S., Chang, E. P., & Pillai, R. (2014). The effects of subtle misinformation in news headlines. *Journal of Experimental Psychology: Applied*, *20*(4), 323–335. https://doi.org/10.1037/xap0000028

E.D. Solutions (2019, June 28). *African swine fever: pig prices might fly?* The Economist Intelligence Unit. http://country.eiu.com/article.aspx?articleid=978169681&Country=Vietnam&topic=Economy

FAO emergency prevention system for animal health (FAO-EMPRES-AH). (2021a, April 17). *African swine fever (ASF).* http://www.fao.org/ag/againfo/programmes/en/empres/ASF/situation_update.html.

FAO emergency prevention system for animal health (FAO-EMPRES-AH). (2021b, November 2). *African swine fever (ASF).*Retrieved November 17, 2021, from https://www.fao.org/AG/AGAInfo/programmes/en/empres/ASF/FAO_Actions.html.

FDA. (2020, August 7). African swine fever. Retrieved March 11, 2021, from https://www.fda.gov/animal-veterinary/safety-health/african-swine-fever

Fox, J. A., Hayes, D. J., & Shogren, J. F. (2002). Consumer preferences for food irradiation: how favorable and unfavorable descriptions affect preferences for irradiated pork in experimental auctions. *Journal of risk and Uncertainty*, *24*(1), 75-95.

Hammitt, J. K., & Haninger, K. (2007). Willingness to pay for food safety: sensitivity to duration and severity of illness. American Journal of Agricultural Economics, 89(5), 1170-1175.

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American journal of agricultural economics*, *73*(4), 1255-1263.

Hayes, D. J., Fox, J. A., & Shogren, J. F. (2002). Experts and activists: how information affects the demand for food irradiation. *Food policy*, *27*(2), 185-193.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica: Journal of the econometric society*, 153-161.

Heslip, Nicole. (2020, Feb 26) *Consumer Poll Finds ASF Would Halt Pork Purchases*. Brownfield Ag News. https://brownfieldagnews.com/news/consumer-poll-finds-asf-would-halt-pork-purchases.

Holtkamp, D.J., J.B. Kliebenstein, E.J. Neumann, J.J. Zimmerman, H.F. Rotto, T.K. Yoder, C. Wang, P.E. Yeske, C.L. Mowrer, and C.A. Haley. (2013). Assessment of the economic impact of porcine reproductive and respiratory syndrome virus on United States pork producers. *Journal Swine Health and Production*. 21:72–84.

Houser, M., & Karali, B. (2020). How Scary Are Food Scares? Evidence from Animal Disease Outbreaks. *Applied Economic Perspectives and Policy*, *42*(2), 283-306.

Jin, H. J., & Han, D. H. (2014). Interaction between message framing and consumers' prior subjective knowledge regarding food safety issues. *Food Policy*, *44*, 95-102.

Jurado, C., L. Mur, M.S. Pérez Aguirreburualde, E. Cadenas-Fernández, B. Martínez-López, J.M. Sánchez-Vizcaíno, and A. Perez. (2019). "Risk of African swine fever virus introduction into the United States through smuggling of pork in air passenger luggage." Scientific Reports 9, 9914423:1-7. Available online at: https://doi.org/10.1038/s41598-019-50403-w

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47(2), 263-292.

Ko. (2019, Sep 26). *Animal Groups: 'Infected Pigs Were Buried Alive, Splattering Blood'*. The Korea Times. https://www.koreatimes.co.kr/www/nation/2021/08/119_276242.html.

Korea Pork producers Association. (2019, September 18). *한돈농가 두 번 울리는 아프리카돼지열병 선정적 보도행태 자제해야 [Press release, Media should refrain from sensational reporting of African swine fever]*. Korea Pork producers Association. Retrieved from http://www.koreapork.or.kr/board/view1?Ncode=bodo&number=37022&gubuncode=&gubun=&keyfield=&keyword=&page=21

Lindsey, R. L. (2021, September 3). *Pork industry Redoubles efforts against African Swine fever*. National Hog Farmer. Retrieved November 8, 2021, from https://www.nationalhogfarmer.com/news/pork-industry-redoubles-efforts-against-african-swine-fever.

Linzer, D. A., & Lewis, J. B. (2011). poLCA: An R package for polytomous variable latent class analysis. Journal of statistical software, 42(1), 1-29.

Lusk, J. L., House, L. O., Valli, C., Jaeger, S. R., Moore, M., Morrow, J. L., & Traill, W. B. (2004). Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: evidence from experimental auctions in the United States, England, and France. *European review of agricultural economics*, *31*(2), 179-204.

Lusk, J. L., Tonsor, G. T., Schroeder, T. C., & Hayes, D. J. (2018). Effect of government quality grade labels on consumer demand for pork chops in the short and long run. *Food Policy*, *77*, 91-102.

Marette, S., Roosen, J., Blanchemanche, S., & Verger, P. (2008). The choice of fish species: an experiment measuring the impact of risk and benefit information. *Journal of Agricultural and Resource Economics*, 1-18.

Marsh, T. L., Schroeder, T. C., & Mintert, J. (2004). Impacts of meat product recalls on consumer demand in the USA. Applied Economics, 36(9), 897-909.

McCluskey, J. J., & Loureiro, M. L. (2003). Consumer preferences and willingness to pay for food labeling: A discussion of empirical studies. *Journal of Food Distribution Research*, *34*(856-2016-57150), 95-102.

McCluskey, J., & Swinnen, J. (2011). The media and food-risk perceptions: Science & Society Series on Food and Science. *EMBO reports*, *12*(7), 624-629.

Miles, S. and Frewer, L. J. (2003). Public perception of scientific uncertainty in relation to food hazards. Journal of Risk Research 6: 267–283.

Miles, S., Brennan, M., Kuznesof, S., Ness, M., Ritson, C. and Frewer, L. J. (2004). Public worry about specific food safety issues. British Food Journal 106: 9–22.

Mitchell, V. W., Bakewell, C., Jackson, P., & Heslin, C. (2015). How message framing affects consumer attitudes in food crises. *British Food Journal*.

Niederwerder, M. C., Dee, S., Diel, D. G., Stoian, A. M., Constance, L. A., Olcha, M., ... & Rowland, R. R. (2021). Mitigating the risk of African swine fever virus in feed with anti-viral chemical additives. *Transboundary and Emerging Diseases*, *68*(2), 477-486.

OIE World Organization for Animal Health (OIE).(2021a, July 30). *Urgent action needed to curb the spread of African swine fever in the Americas* Retrieved November 17, 2021, from https://www.oie.int/en/urgent-action-needed-to-curb-the-spread-of-african-swine-fever-in-the-americas/.

OIE World Organization for Animal Health (OIE).(2021b, September 28). *Classical swine fever* Retrieved November 14, 2021, from https://www.oie.int/en/disease/classical-swine-fever/.

OIE World Organization for Animal Health (OIE – Europe).(2020, September 14). African Swine Fever OIE – Europe. https://rr-europe.oie.int/en/our-missions/animal-diseases/african-swine-fever/

Olynk, Nicole J., Glynn T. Tonsor, and Christopher A. Wolf. (2010). Consumer willingness to pay for livestock credence attribute claim verification. *Journal of Agricultural and Resource Economics*, 261-280.

Paarlberg, P.L., J.G. Lee, and A.H. Seitzinger. (2002). Potential Revenue Impact of an Outbreak of Foot-and-Mouth Disease in the United States. *Journal of the American Veterinary Medical Association* 220,7: 988-92.

Pan. (2019, Sep 17). *African Swine Fever Affects China's Pork Consumption*. RaboResearch. https://research.rabobank.com/far/en/sectors/animal-protein/african-swine-fever-affects-china-s-pork-consumption.html

Park. (2019a, Sep 19). 치사율 100%, 백신도 없어...아프리카돼지열병에 양돈농가 '속수무책' *[First African swine fever Case Confirmed: 100% Mortality Rate, No vaccine available]*. Chosun. https://www.chosun.com/site/data/html_dir/2019/09/17/2019091700953.html

Park. (2019b, Sep 19). *Experts predict "virus storm" regarding African swine fever*. Hankhoreh. http://english.hani.co.kr/arti/PRINT/910157.html

Piggott, N. E., & Marsh, T. L. (2004). Does food safety information impact US meat demand?. *American Journal of Agricultural Economics*, 154-174.

Pork Checkoff. (2021, September 10). *African swine fever*. Retrieved November 17, 2021, from https://porkcheckoff.org/pork-production-management/hot-topics/african-swine-fever/

Pozo, V. F., Tonsor, G. T., & Schroeder, T. C. (2012). How choice experiment design affects estimated valuation of use of gestation crates. *Journal of Agricultural Economics*, 63(3), 639-655.

Radecki, C. M., & Jaccard, J. (1995). Perceptions of knowledge, actual knowledge, and information search behavior. *Journal of experimental social psychology*, 31(2), 107-138.

Rao, A. R., & Sieben, W. A. (1992). The effect of prior knowledge on price acceptability and the type of information examined. *Journal of consumer research*, 19(2), 256-270.

Rivas, R. (2019, November 5). *Filipinos shift to chicken and beef as African swine fever spreads*. Rappler. https://www.rappler.com/business/filipinos-shift-chicken-beef-african-swine-fever-spreads

Ruth, A. M., Eubanks, E. E., & Telg, R. (2005). Framing of mad cow media coverage. *Journal of Applied Communications*, *89*(4), 3.

Sanders, D. R., Moon, W., & Kuethe, T. H. (2007). Consumer willingness-to-pay for fresh pork attributes. *Journal of Agribusiness*, 25(345-2016-15148), 163-179.

Schulz, L. L., & Tonsor, G. T. (2015). Assessment of the economic impacts of porcine epidemic diarrhea virus in the United States. *Journal of animal science*, 93(11), 5111-5118.

Schweer, W.P., K Schwartz, E.R. Burrough, K. J. Yoon, J. C. Sparks, and N.K. Gabler. (2016). The effect of porcine reproductive and respiratory syndrome virus and porcine epidemic diarrhea virus challenge on growing pigs I: Growth performance and digestibility. *Journal of Animal Science* 94(2): 514-522.

Shih, T. J., Wijaya, R., & Brossard, D. (2008). Media coverage of Public Health Epidemics: Linking framing and issue attention cycle toward an integrated theory of print news coverage of epidemics. *Mass Communication and Society*, *11*(2), 141–160. https://doi.org/10.1080/15205430701668121

Shike, J. (2021, July 29). *4 things tell your neighbor about African swine fever*. Porkbusiness.Com. https://www.porkbusiness.com/news/industry/4-things-tell-your-neighbor-about-african-swine-fever

SPS plan. Secure Pork Supply Plan. (2021). Retrieved November 17, 2021, from https://www.securepork.org/.

Sundberg, P. (2019). SHIC helps uncover risk for ASF introduction into the US via air passengers' luggage. Swine Health Information Center, April 1, 2019. https://www.swinehealth.org/shic-helps-uncover-risk-for-asf-introduction-intothe-us-via-air-passengers-luggage/

U.S. Bureau of Labor Statistics. (US-BLS). (2020, January). Average retail food and energy prices, U.S. and Midwest Region. U.S. Bureau of Labor Statistics. Retrieved November 8, 2021, from https://www.bls.gov/regions/mid-

atlantic/data/averageretailfoodandenergyprices_usandmidwest_table.htm#ro3xg01apmw.f.1.

U.S. Bureau of Labor Statistics. (US-BLS). (2021, November). Average retail food and energy prices, U.S. and Midwest Region. U.S. Bureau of Labor Statistics. Retrieved November 17, 2021, from https://www.bls.gov/regions/mid-atlantic/data/averageretailfoodandenergyprices_usandmidwest_table.htm

National Retail Report – Agricultural Marketing Service. (USDA-AMS). (2020, February). Retrieved November 9, 2021, from https://www.ams.usda.gov/mnreports/lswlnvfeatures.pdf.

National Retail Report - Agricultural Marketing Service. (USDA-AMS). (2021, November). Retrieved November 17, 2021, from https://www.ams.usda.gov/mnreports/lswlnvfeatures.pdf.

U. S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS). (2020, June 2). *Classical Swine Fever (CSF)* https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/swine-disease-information/classic-swine-fever/classic-swine-fever

U. S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS). (2021a, September 1). *African Swine Fever (ASF)* https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/swine-disease-information/african-swine-fever

U. S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) (2021b, February 24). *Foot and Mouth Disease (FMD)* https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/fmd/index

U. S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services (USDA-APHIS-VS). (2013). *High-consequence foreign animal diseases and pests*. Retrieved from https://www.hsdl.org/?view&did=735649

U. S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services (USDA-APHIS-VS). (2020). African Swine Fever

Response Plan: The Red Book. https://www.aphis.usda.gov/animal_health/emergency_management/downloads/asf-responseplan.pdf

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Center for Epidemiology and Animal Health, Risk Assessment Team (USDA-APHIS-VS-CEAH). (2019). "Qualitative Assessment of the likelihood of African swine fever virus entry to the United States: Entry Assessment." USDA-APHIS-VS-CEAH. Available online at: https://www.aphis.usda.gov/animal_health/downloads/animal_diseases/swine/asf-entry.pdf

U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS). (2021, September 30). USDA's Vaccine Candidate Successful in Blocking Spread of African Swine Fever Virus. Retrieved November 8, 2021, from https://www.ars.usda.gov/news-events/news/research-news/2021/usdas-vaccine-candidate-successful-in-blocking-spread-of-african-swine-fever-virus/.

Verbeke, W. (2005). Agriculture and the food industry in the information age. *European review of agricultural economics*, *32*(3), 347-368.

Wang, H. H., & de Beville, P. G. (2017). The media impact of animal disease on the US meat demand. *Agribusiness*, *33*(4), 493-504.

Yu, H., Neal, J. A., & Sirsat, S. A. (2018). Consumers' food safety risk perceptions and willingness to pay for fresh-cut produce with lower risk of foodborne illness. Food Control, 86, 83-89.

Table 1. Select summary statistics of survey participants

Variable	Description	Mean	Standard deviation
Female	1 if female; 0 if male	0.461	0.499
Age	Age of consumer (years)	46.163	17.994
Income	1 if annual household income is in between $0 to $24,999; 0 otherwise	0.241	0.428
	1 if annual household income is in between of $25,000 to $49,999; 0 otherwise	0.256	0.436
	1 if annual household income is in the range of $50,000 to $74,999; 0 otherwise	0.266	0.442
	1 if annual household income is in the range of $75,000 to $149,999; 0 otherwise	0.190	0.393
	1 if annual household income is over $150,000; 0 otherwise	0.047	0.211
Education	1 if bachelor's degree or higher; 0 otherwise	0.280	0.449
region	1 if lives in the Midwest region: West North Central (ND, SD, NE, KS, MN, IA, MO) and East North Central (WI, IL, MI, IN, OH); 0 otherwise	0.226	0.419
	1 if lives in the Northeast region: New England (ME, NH, VT, MA, RI, CT) and Middle Atlantic (NY, NJ, PA); 0 otherwise	0.180	0.384
	1 if lives in the West region: Pacific (WA, OR, CA, AK, HI) and Mountain (MT, ID, WY, NV, UT, CO, AZ, NM); 0 otherwise	0.230	0.421
	1 if lives in the South region: West South Central (TX, OK, AR, LA), East South Central (KY, TN, MS, AL), and South Atlantic (FL, GA, SC, NC, VA, WV, DC, MD, DE); 0 otherwise	0.364	0.481
Frequency of pork chop consumption	1 if eat pork at home more than once a month, and typically buy a pork chop; 0 otherwise	0.686	0.464
Pork away from home	1 if eat pork away from home more than once a month; 0 otherwise	0.400	0.490

Table 2. Awareness of the global ASF outbreak and perceived impact of ASF on human health

Variable	Description	Mean	Standard deviation
Perceive ASF as NOT a threat to human health	1 if perceive ASF as a potential threat to human health; 0 otherwise	0.691	0.462
Awareness of global outbreak of ASF	1 if aware of global outbreak of ASF; 0 otherwise	0.267	0.443
Aware of global ASF outbreak & perceive ASF not a human health threat	1 if aware of global outbreak of ASF and perceive ASF as NOT a potential threat to human health; 0 otherwise	0.162	0.368

Table 3. Design of information treatments (N=1052)

<table>
<tr><th colspan="2">Information Treatments as a news article
(Information about human health impact in the contents)</th><th>Control</th></tr>
<tr><td>Direct messaging of food safety in the headline and in the contents

Food safety information provided in the headline
Food safety reassurance provided in the contents
(N=211)</td><td>Direct messaging of food safety only in the headline

Food safety information provided in the headline
Food safety reassurance NOT provided in the contents
(N=210)</td><td rowspan="2">No news article

No headline or contents provided
(N=211)</td></tr>
<tr><td>Direct messaging of food safety only in the contents

Food safety information NOT provided in the headline
Food safety reassurance provided in the contents
(N=210)</td><td>No direct messaging of food safety

Food safety information NOT provided in the headline
Food safety reassurance NOT provided in the contents
(N=210)</td></tr>
</table>

Table 4. Responses to willingness to pay question by treatment group

	'Yes,Yes'	'Yes,No'	'No,Yes'	'No,No'	Total
Direct messaging of food safety in the headline and contents	81	13	8	109	211
Direct messaging of food safety only in the headline	74	22	10	104	210
Direct messaging of food safety only in the contents	80	18	11	101	210
No direct messaging of food safety	82	18	14	96	210
No news article	58	10	14	129	211
Total	375 (35.65%)	81 (7.70%)	57 (5.42%)	539 (51.24%)	1052 (100.00%)

Table 5. Willingness to pay estimation results

Variable	Model (1) Estimate	S.E.	Model (2) Estimate	S.E.	Model (3) Estimate	S.E.	Model (4) Estimate	S.E.
Constant	0.531***	0.165	0.065	0.194	-0.034	0.209	0.256	0.363
Information treatments (Base: No news article)								
Direct messaging of food safety in the headline and contents	0.448**	0.192	0.467**	0.195	0.631***	0.221	0.626***	0.227
Direct messaging of food safety only in the headline	0.452**	0.190	0.292	0.195	0.509**	0.235	0.557**	0.242
Direct messaging of food safety only in the contents	0.530***	0.191	0.446**	0.193	0.475**	0.225	0.558**	0.231
No direct messaging of food safety	0.596***	0.190	0.549***	0.193	0.649***	0.226	0.695***	0.232
Awareness of global ASF outbreak			0.762***	0.137	1.199***	0.338	1.167***	0.343
interaction with:								
Direct messaging of food safety in the headline and contents					-0.749	0.475	-0.819*	0.487
Direct messaging of food safety only in the headline					-0.729*	0.432	-0.811*	0.440
Direct messaging of food safety only in the contents					-0.177	0.452	-0.370	0.462
No direct messaging of food safety					-0.433	0.442	-0.563	0.452
ASF not a threat to human health			0.501***	0.134	0.507***	0.135	0.496***	0.139
Frequency of pork chop consumption							0.513***	0.136
Gender							-0.607***	0.131
Age							-0.009**	0.004
Education							-0.074	0.153
Regional dummies (Base: Midwest)								
Northeast							-0.359*	0.200
West							-0.187	0.186
South							-0.146	0.166
Income dummies (Base:$0 to $25,000)								
$25,000 to $49,999							0.090	0.179
$50,000 to $74,999							0.415**	0.178
$75,000 to $149,999							0.509**	0.202
Over $150,000							0.748**	0.340
Price	-0.534***	0.042	-0.552***	0.044	-0.554***	0.044	-0.579***	0.046
Log likelihood	-1117.867		-1097.290		-1095.052		-1065.437	
Observations	1052		1052		1052		1052	
Linear hypothesis testing	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
Given the same content, there is no difference between two types of headlines	0.801	0.670	1.874	0.392	0.869	0.648	0.425	0.809
Given the same headline, there is no difference between two types of contents	0.126	0.939	1.131	0.568	0.889	0.641	0.446	0.800

*** 1%, ** 5%, * 10 % significant levels.

Table 6. Willingness to pay predictions

	Mean willingness to pay		Median willingness to pay	
Variable	**Estimate**	**Confidence interval (95%)**	**Estimate**	**Confidence interval (95%)**
Total	2.28	(2.11, 2.49)	1.74	(1.48, 1.95)
Unaware of global ASF outbreak				
Direct messaging of food safety in the headline and contents	2.24	(1.90, 2.67)	1.69	(1.14, 2.22)
Direct messaging of food safety only in the headline	2.16	(1.73, 2.63)	1.57	(0.95, 2.16)
Direct messaging of food safety only in the contents	2.16	(1.80, 2.62)	1.58	(1.02, 2.11)
No direct messaging of food safety	2.33	(1.96, 2.76)	1.81	(1.27, 2.36)
No news article provided	1.53	(1.23, 1.88)	0.61	(-0.03, 1.17)
Aware of global ASF outbreak				
Direct messaging of food safety in the headline and contents	2.70	(1.91, 3.55)	2.29	(1.20, 3.27)
Direct messaging of food safety only in the headline	2.62	(2.08, 3.23)	2.19	(1.44, 2.93)
Direct messaging of food safety only in the contents	3.24	(2.56, 4.07)	2.95	(2.14, 3.88)
No direct messaging of food safety	3.16	(2.42, 3.98)	2.86	(1.98, 3.78)
No news article provided	2.97	(2.13, 3.87)	2.63	(1.55, 3.63)
Observations	1052		1052	

Confidence intervals for willingness to pay were calculated using Krinsky-Robb bootstrapping techniques.

Table 7. Responses indicating an unwillingness to purchase due to food safety concerns

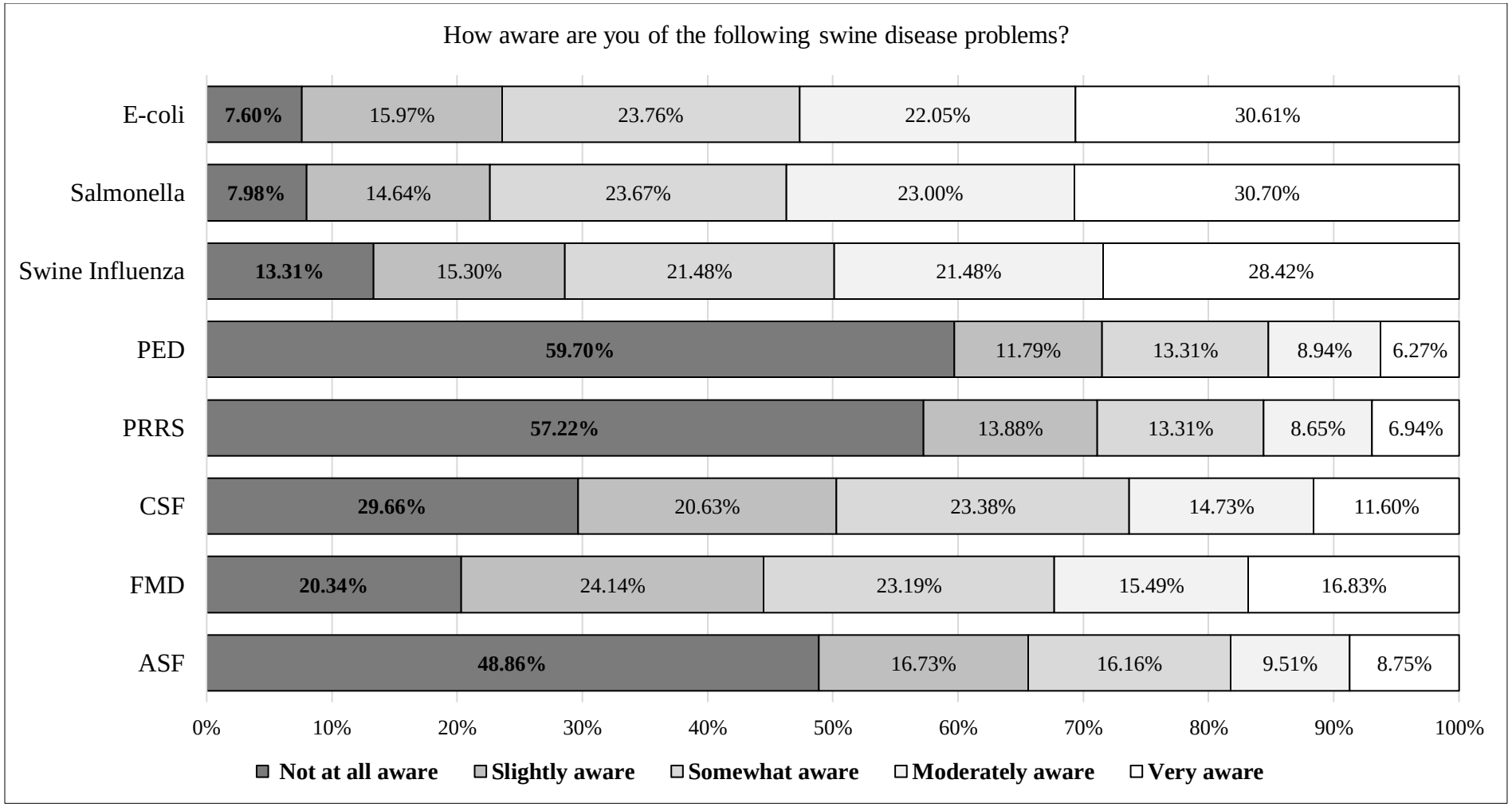
The first follow-up question: Would you buy a boneless pork chop for any price below the last suggested price?			
Respondents who answered 'No, No' to the contingent valuation questions (N=539)	Yes	No	Total
Direct messaging of food safety in the headline and contents	14	95	109
Direct messaging of food safety only in the headline	14	90	104
Direct messaging of food safety only in the contents	7	94	101
No direct messaging of food safety	8	88	96
No news article	8	121	129
Total	51	488	539
The second follow-up question: Is your choice mainly due to concerns about food safety?			
Respondents who answered 'No' to the first follow-up question (Unwilling to purchase) (N=488)	Yes	No	Total
Direct messaging of food safety in the headline and contents	69	26	95
Direct messaging of food safety only in the headline	67	23	90
Direct messaging of food safety only in the contents	76	18	94
No direct messaging of food safety	77	11	88
No news article	111	10	121
Total	400	88	488

Table 8. Coefficients and marginal effects from bivariate probit model with sample selection for the responses indicating an unwillingness to purchase due to food safety concerns

	Coefficients				Marginal effects	
	Selection equation		Outcome equation			
Variable	**Estimate**	**S.E.**	**Estimate**	**S.E.**	**Estimate**	**S.E.**
Constant	0.186	0.229	1.552***	0.190		
Information treatments (Base: No news article)						
Direct messaging of food safety in the headline and contents	-0.284**	0.131	-0.701***	0.220	-0.203***	0.056
Direct messaging of food safety only in the headline	-0.278**	0.134	-0.639***	0.235	-0.187***	0.057
Direct messaging of food safety only in the contents	-0.281**	0.131	-0.440*	0.228	-0.133**	0.058
No direct messaging of food safety	-0.345***	0.131	-0.152	0.236	-0.060	0.062
ASF not a threat to human health	-0.423***	0.089			-0.024	0.020
Awareness of global ASF outbreak	-0.415***	0.100			-0.023	0.020
Frequency of pork chop consumption	-0.238***	0.091			-0.013	0.012
Pork away from home	-0.167*	0.087			-0.009	0.009
Female	0.495***	0.087			0.028	0.023
Age	0.009***	0.003			0.001	0.000
Education	-0.002	0.101			0.000	0.006
Regional dummies (Base: Midwest)						
Northeast	0.198	0.131			0.011	0.012
West	0.208*	0.125			0.012	0.012
South	0.066	0.113			0.004	0.007
Income dummies (Base: $0 to $25,000)						
$25,000 to $49,999	-0.188	0.115			-0.010	0.011
$50,000 to $74,999	-0.231**	0.115			-0.013	0.012
$75,000 to $149,999	-0.305**	0.132			-0.017	0.015
Over $150,000	-0.247	0.225			-0.014	0.018
Log likelihood from bivariate probit model	-877.047					
Estimate of $E[y_1 \mid y_2 = 1]$	0.824					
Correlation coefficient (ρ)	-0.334	0.262				
Selected observation	488					
Linear hypothesis testing	Chi-square	p-value				
Given the same content, there is no difference between two types of headlines	6.44**	0.040				
Given the same headline, there is no difference between two types of contents	1.79	0.409				

*** 1%, ** 5%, * 10 % significant levels. Dependent variable in the outcome equation (y_1): 1 if answer 'yes' to the question that unwilling to purchase is mainly due to food safety concern, 0 otherwise. Dependent variable in the selection equation (y_2): 1 if unwilling to purchase, 0 otherwise.

Figure 1. General awareness of various swine diseases



Notes: All differences (mean awareness of ASF and mean awareness of another swine disease) statistically significant at $p \leq 0.01$.

Figure 2. Perceived human health impact of various swine diseases

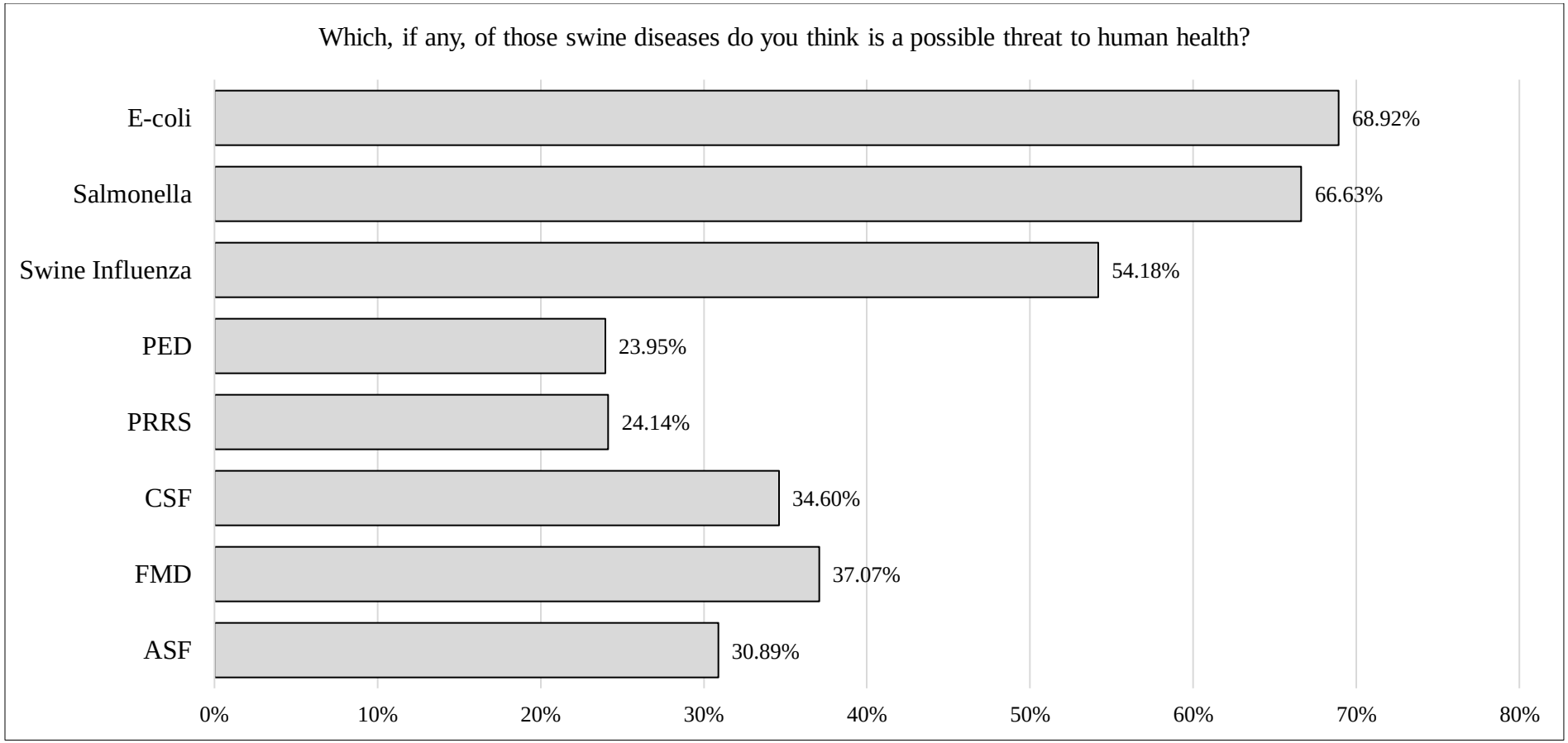
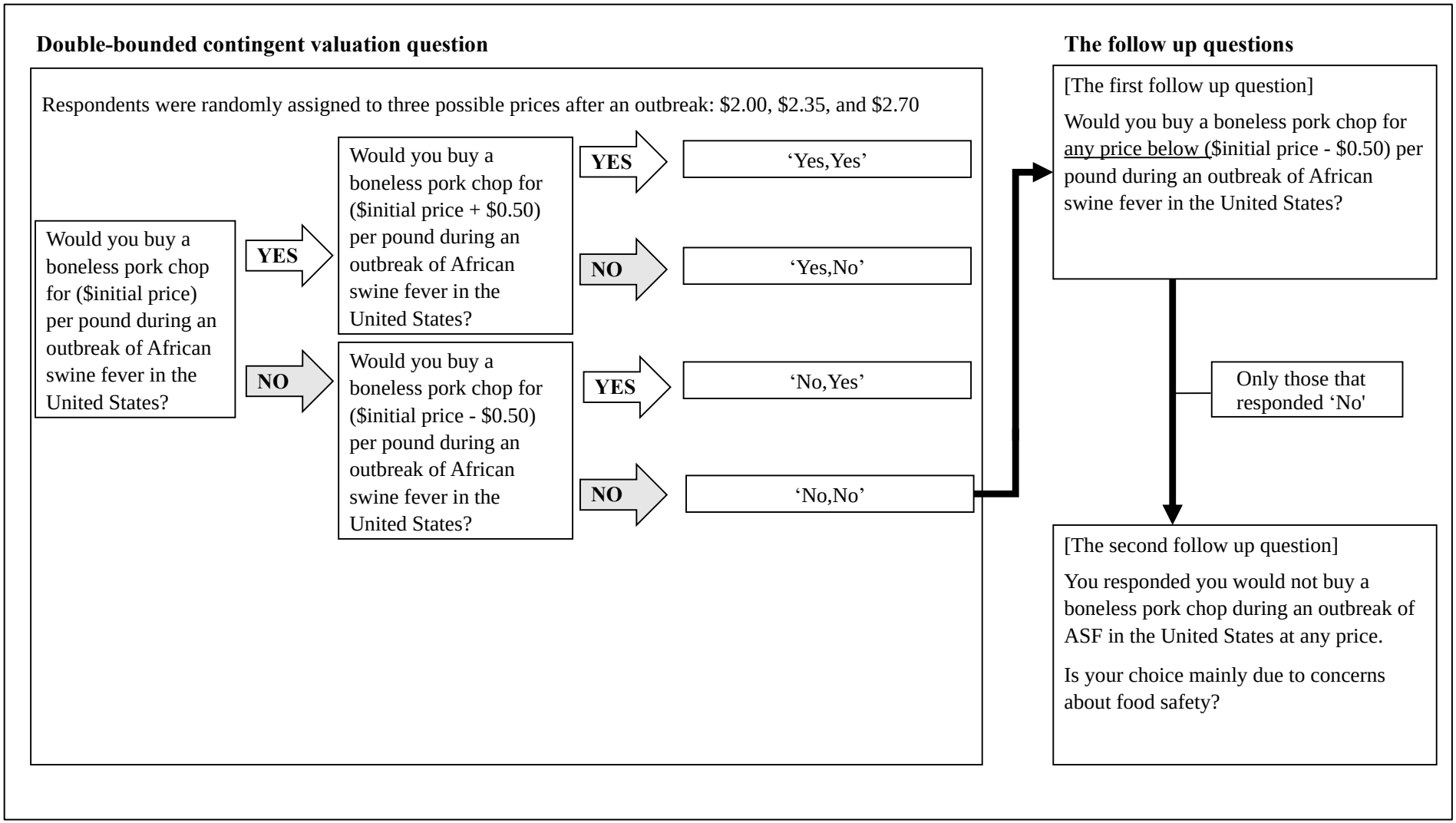


Figure 3. Double-bounded contingent valuation and follow-up questions



Appendix 1. Latent class analysis with observed variables associated with awareness of African swine fever (ASF)

To understand consumers' prior knowledge about ASF, we compared three questions which were related to both subjective knowledge and objective knowledge of ASF. However, the observed responses may be correlated with each other and there may be latent classes which could explain the patterns of observed responses. The latent class analysis investigates sources of confounding between the observed data and groups each consumer into a latent class with certain probabilities (Linzer and Lewis, 2011). The poLCA package in R was utilized for the latent class analysis.

If $Y_{ijk} = 1$ if a consumer i gives the kth response to the j th observed variable and $Y_{ijk} = 0$ otherwise, then $r = 1, \dots, R$ represents the class membership, and the latent class model approximates the prior probabilities of latent class membership (p_r) and outcome probabilities conditional on class r (π_r), as $\widehat{P_r}$ and $\hat{\pi}_r$, respectively. Using Bayes' formula, the posterior probabilities can be calculated as

$$p_{ir} = \hat{p}(r_i|Y_i) = \frac{\widehat{P_r} * f(Y_i\,;\hat{\pi}_r)}{\sum_{q=1}^{R} \widehat{P_q} * f(Y_i\,;\hat{\pi}_q)} \tag{1.1}$$

Each respondent has a different posterior probability of becoming a member of each class, conditional on the observed values of the answers to the three questions associate with awareness of ASF.

The minimum BIC criteria indicated the existence of two classes depending on consumers' answers related to prior knowledge on ASF. Table A1 shows the goodness of fit statistics when only constant is included in class membership prediction. The estimated class population shares ($\widehat{P_r}$) and the estimated class conditional response probabilities ($\hat{\pi}_{jrk}$) are reported in Table A2. Two classes can

be labeled as a class with higher prior knowledge on ASF and a class with lower prior knowledge, according to the class conditional response probabilities ($\hat{\pi}_{jrk}$), and the estimated class population shares ($\widehat{P_r}$) show that the prior probability of a consumer being a member of the class with lower prior knowledge on ASF is higher (72.9%).

The class with higher prior knowledge tends to believe that they are well aware of ASF, with a 0% chance of answering that they are not at all aware of ASF. Among this group, there is a 73% chance of answering that a member in this group has heard of the recent ASF outbreak in China and other countries. On the contrary, the class with lower prior knowledge has a 67% chance of answering that they are not at all aware of ASF and only has a 9% chance of answering that they have heard of the global ASF outbreak.

It was notable that among the respondents with a latent class indicating higher awareness, there was a 47% chance of selecting ASF was a potential threat to human health. This implies that even if individuals are aware of the global ASF outbreak, it is highly likely that they are uninformed of the human impact of ASF, and being aware of the global ASF outbreak and human health impact of ASF are uncorrelated.

Table 1.1. Results from basic latent class models fit to the questions regarding prior knowledge of ASF (N=1052)

Number of Classes	Number of Parameters	Log likelihood	AIC	BIC
1	6	-2713.110	5438.220	5467.970
2	13	-2580.520	5187.039	5251.499
3	20	-2576.967	5193.934	5293.103
4	27	-2575.627	5205.254	5339.132

Table 1.2. Conditional item response probabilities by question for each class (N=1052)

	Class with higher prior knowledge on ASF		**Class with lower prior knowledge on ASF**	
	Estimated class population shares **($\widehat{p_r}$)** 0.271		Estimated class population shares **($\widehat{p_r}$)** 0.729	
Survey questions	**The estimated class conditional response probabilities ($\widehat{\pi_{jrk}}$)**	**S.E.**	**The estimated class conditional response probabilities ($\widehat{\pi_{jrk}}$)**	**S.E.**
Subjective knowledge on ASF				
Not at all aware	0.000	0.000	0.671	0.038
Slightly aware	0.149	0.031	0.174	0.016
Somewhat aware	0.270	0.034	0.121	0.017
Moderately aware	0.308	0.034	0.016	0.015
Very aware	0.273	0.033	0.019	0.015
Awareness of global outbreak of ASF				
Yes	0.732	0.089	0.094	0.013
No	0.268	0.089	0.906	0.013
Perceive ASF a human health threat				
Yes	0.469	0.038	0.249	0.017
No	0.531	0.038	0.751	0.017

Appendix 2. Experimental Instructions and information treatments

Group 1

The following article describes a HYPOTHETICAL SITUATION. The article is what you may see if there is an outbreak of African swine fever in the United States. You will be asked to respond to a hypothetical scenario. Please answer the questions as if you were actually facing the situation.

Deadly African swine fever found in pigs: Still safe to eat pork

African swine fever (ASF) has landed on our doorstep. The virus has been wreaking havoc in Asia since it was detected in northeastern China in August 2018 and could potentially kill up to 40-65% of the world's pig population.

ASF is a severe viral disease affecting domestic and wild pigs. This animal disease can be spread by live or dead pigs, either domestic or wild. Transmission can occur via contaminated feed and objects such as shoes, clothes, vehicles, knives, equipment, etc. A stop-movement order has been issued to ban the transport of pigs, feed, and manure. Export markets were immediately closed to our pork, flooding the domestic market and dragging down prices for farmers.

There is no approved vaccine against ASF. Among pigs, it spreads rapidly and kills in high numbers. It does not affect humans or other non-swine farm animals.

It is not a food safety issue. ASF cannot be transmitted from pigs or pork to humans. In addition, the United States Department of Agriculture (USDA) has measures in place to prevent sick animals from entering the food supply, including ASF.

Keeping the news article about the outbreak of African swine fever in mind, you will be asked whether you would be likely to buy a boneless pork chop with a given price. The average retail price of boneless pork chops was $3.35 per pound before the outbreak.

Group 2

The following article describes a HYPOTHETICAL SITUATION. The article is what you may see if there is an outbreak of African swine fever in the United States. You will be asked to respond to a hypothetical scenario. Please answer the questions as if you were actually facing the situation.

Deadly African swine fever found in pigs: Still safe to eat pork

African swine fever (ASF) has landed on our doorstep. The virus has been wreaking havoc in Asia since it was detected in northeastern China in August 2018 and could potentially kill up to 40-65% of the world's pig population.

ASF is a severe viral disease affecting domestic and wild pigs. This animal disease can be spread by live or dead pigs, either domestic or wild. Transmission can occur via contaminated feed and objects such as shoes, clothes, vehicles, knives, equipment, etc. A stop-movement order has been issued to ban the transport of pigs, feed, and manure. Export markets were immediately closed to our pork, flooding the domestic market and dragging down prices for farmers.

There is no approved vaccine against ASF. Among pigs, it spreads rapidly and kills in high numbers. It does not affect humans or other non-swine farm animals. According to Department of Agriculture, ASF is not a threat to human health and cannot be transmitted from pigs to humans.

Keeping the news article about the outbreak of African swine fever in mind, you will be asked whether you would be likely to buy a boneless pork chop with a given price. The average retail price of boneless pork chops was $3.35 per pound before the outbreak.

Group 3

The following article describes a HYPOTHETICAL SITUATION. The article is what you may see if there is an outbreak of African swine fever in the United States. You will be asked to respond to a hypothetical scenario. Please answer the questions as if you were actually facing the situation.

Deadly African swine fever found in pigs: No vaccine available

African swine fever (ASF) has landed on our doorstep. The virus has been wreaking havoc in Asia since it was detected in northeastern China in August 2018 and could potentially kill up to 40-65% of the world's pig population.

ASF is a severe viral disease affecting domestic and wild pigs. This animal disease can be spread by live or dead pigs, either domestic or wild. Transmission can occur via contaminated feed and objects such as shoes, clothes, vehicles, knives, equipment, etc. A stop-movement order has been issued to ban the transport of pigs, feed, and manure. Export markets were immediately closed to our pork, flooding the domestic market and dragging down prices for farmers.

There is no approved vaccine against ASF. Among pigs, it spreads rapidly and kills in high numbers. It does not affect humans or other non-swine farm animals. According to Department of Agriculture, ASF is not a threat to human health and cannot be transmitted from pigs to humans.

It is not a food safety issue. ASF cannot be transmitted from pigs or pork to humans. In addition, the United States Department of Agriculture (USDA) has measures in place to prevent sick animals from entering the food supply, including ASF.

Keeping the news article about the outbreak of African swine fever in mind, you will be asked whether you would be likely to buy a boneless pork chop with a given price. The average retail price of boneless pork chops was $3.35 per pound before the outbreak.

Group 4

The following article describes a HYPOTHETICAL SITUATION. The article is what you may see if there is an outbreak of African swine fever in the United States. You will be asked to respond to a hypothetical scenario. Please answer the questions as if you were actually facing the situation.

Deadly African swine fever found in pigs: No vaccine available

African swine fever (ASF) has landed on our doorstep. The virus has been wreaking havoc in Asia since it was detected in northeastern China in August 2018 and could potentially kill up to 40-65% of the world's pig population.

ASF is a severe viral disease affecting domestic and wild pigs. This animal disease can be spread by live or dead pigs, either domestic or wild. Transmission can occur via contaminated feed and objects such as shoes, clothes, vehicles, knives, equipment, etc. A stop-movement order has been issued to ban the transport of pigs, feed, and manure. Export markets were immediately closed to our pork, flooding the domestic market and dragging down prices for farmers.

There is no approved vaccine against ASF. Among pigs, it spreads rapidly and kills in high numbers. It does not affect humans or other non-swine farm animals. According to Department of Agriculture, ASF is not a threat to human health and cannot be transmitted from pigs to humans.

Keeping the news article about the outbreak of African swine fever in mind, you will be asked whether you would be likely to buy a boneless pork chop with a given price. The average retail price of boneless pork chops was $3.35 per pound before the outbreak.

Group 5

Suppose you are at the grocery store shopping for boneless pork chops for you or your household. The average retail price of boneless pork chops is typically $3.35 per pound. Please answer the following questions as if you were actually facing the situation.

Appendix 3.

Bivariate probit model with sample selection on the responses indicating an unwillingness to purchase due to food safety concerns

The dependent variable y_i^S in the selection equation is a binary response variable that has a value of 1 when a respondent has a non-positive willingness to pay and a value of 0 otherwise, where y_i^* is a latent willingness to pay. The independent variables for the selection equation x_i^S are adopted from the previous section's willingness to pay estimation. y_i^O is a binary response variable in the outcome equation, with a value of 1 when a respondent answered 'yes' to the question that their non-positive willingness to pay answers are mainly due to food safety concerns, and 0 otherwise. In the outcome equation, the effect of information treatments is of interest, and x_i^O represents independent variables in the outcome equation. Variables related to the frequency of pork chop consumption and eat pork away from home more than once a month are included as the exclusion restrictions that affect the selection process but not the outcome equation of interest. A bivariate probit model with sample selection model can be written as:

(3.1) $y_i^S = \beta^S x_i^S + \varepsilon_i^S$, ($y_i^S = 1$ if $y_i^* \leq 0$, 0 otherwise)

(3.2) $y_i^O = \beta^O x_i^O + \varepsilon_i^O$ ($y_i^O = 1$if answer 'yes' to the follow up question, 0 otherwise; observed only when $y_i^S = 1$)

where $\rho = cov[\varepsilon_i^S, \varepsilon_i^O]$, $\varepsilon_i^S, \varepsilon_i^O \sim BVN(0,0,1,1,\rho)$. $\varepsilon_i^S, \varepsilon_i^O$ are error terms for the selection equation and outcome equation, respectively. The log-likelihood for the bivariate probit model with selection is defined as

(3.3) $$\log L = \sum_{y_i^S=1,\, y_i^O=1}^{n} \log \Phi_2\left[\beta^O x_i^O, \beta^S x_i^S, \rho\right]$$

$$+\sum_{y_i^S=1,\, y_i^O=0}^{n} \log \Phi_2\left[-\beta^O x_i^O, \beta^S x_i^S, -\rho\right] + \sum_{y_i^S=0}^{n} log\ \Phi_2[-\beta^S x_i^S]$$

where Φ_2 is the cumulative distribution function of bivariate normal distribution. Maximum likelihood is utilized to estimate the parameters.

Table 3.1. Coefficient and marginal effect of the outcome equation from bivariate probit with sample selection for the responses indicating an unwillingness to purchase due to food safety concerns

	Coefficients				Marginal effects	
	Selection equation		Outcome equation			
Variable	**Estimate**	**S.E.**	**Estimate**	**S.E.**	**Estimate**	**S.E.**
Constant	0.437**	0.223	1.400***	0.298		
Information treatments (Base: No news article)						
Direct messaging of food safety in the headline and contents	-0.308**	0.131	-0.849***	0.205	-0.185***	0.051
Direct messaging of food safety only in the headline	-0.307**	0.133	-0.675***	0.215	-0.140***	0.054
Direct messaging of food safety only in the contents	-0.295**	0.131	-0.529**	0.212	-0.104*	0.054
No direct messaging of food safety	-0.361***	0.131	-0.400*	0.233	-0.064	0.060
ASF not a threat to human health	-0.406***	0.090	-0.614***	0.156	-0.114***	0.040
Awareness of global ASF outbreak	-0.428***	0.101	-0.539***	0.170	-0.092**	0.043
Frequency of pork chop consumption	-0.340***	0.087			0.037**	0.018
Pork away from home	-0.163*	0.085			0.018	0.012
Female	0.486***	0.085			-0.053**	0.024
Age	0.006***	0.002			-0.001*	0.000
Education	0.004	0.100			0.000	0.011
Regional dummies (Base: Midwest)						
Northeast	0.176	0.129			-0.019	0.016
West	0.203*	0.122			-0.022	0.015
South	0.048	0.109			-0.005	0.012
Income dummies (Base: $0 to $25,000)						
$25,000 to $49,999	-0.191*	0.112			0.021	0.015
$50,000 to $74,999	-0.310***	0.115			0.034*	0.019
$75,000 to $149,999	-0.343***	0.128			0.038*	0.022
Over $150,000	-0.100	0.198			0.011	0.022
Log likelihood from bivariate probit model	-868.105					
Estimate of $E[y_1 \mid y_2 = 1]$	0.860					
Correlation coefficient (ρ)	0.584***	0.183				
Selected observation	488					
Linear hypothesis testing	Chi-square	p-value				
Given the same content, there is no difference between two types of headlines	4.27	0.118				
Given the same headline, there is no difference between two types of contents	1.16	0.561				

*** 1%, ** 5%, * 10 % significant levels. Dependent variable in the outcome equation (y_1): 1 if answer 'yes' to the question that unwilling to purchase is mainly due to food safety concern, 0 otherwise. Dependent variable in the selection equation (y_2): 1 if unwilling to purchase, 0 otherwise.