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A Split-Sample Revealed And Stated Preference Demand Model To Examine Homogenous Subgroup Consumer Behavior Responses To Information And Food Safety Technology Treatments

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Abstract

The combination and joint estimation of revealed and stated preference (RP/SP) data approach to examining consumer preferences to relevant policy-based measures typically fail to account for heterogeneity in the data by considering behavior of the average individual. However, in policy-based analyses, where the research is often driven by understanding how different individuals react to different or similar scenarios, a preferred approach would be to analyze preferences of homogenous population subgroups. We accomplish this by developing a split-sample RP/SP analysis that examines whether homogenous subgroups of the population, based on individual health and behavioral characteristics, respond differently to health-risk information and new food safety technology. The ongoing efforts by the US Food and Drug Administration (FDA) to reduce illness and death associated with consuming raw Gulf of Mexico oysters provide an ideal platform for the analysis as the health risks only relate to a very specific consumer subgroup. Results from split-sample demand models indicate that educational information treatments cause vulnerable at-risk consumers to reduce their oyster demand, implying that a more structured approach to disseminating the brochures to the at-risk population could have the desired result of reducing annual illness levels. Also, findings across all subgroups provide strong empirical evidence that the new FDA policy requiring processing technology to be used in oyster production will have a detrimental effect on the oyster industry.

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1 Introduction

In the 1990s, a combination and joint estimation of revealed preference and stated preference (RP/SP) data approach to non-market valuation was developed. As the contrasting strengths of allowing the measurement of preferences outside of an individual's historical experience while also anchoring the stated preference responses to actual behavior were validated, researchers developed RP/SP models to value a variety of environmental amenities. 1,2 Typically, research utilizing RP/SP models also examines the welfare effects of changes in consumer preferences to relevant policy-based measures.3 Yet, welfare estimates derived from these studies fail to account for heterogeneity in the data. As constant or varying SP scenarios may affect individuals' preferences in different ways, considerable information regarding the behavior of subgroups within the sample is not observed. Specifically for policy-based analyses, where the research is often driven by understanding how different individuals react to different or similar scenarios, interpretation of welfare effects and the policy implications may be tenuous.

Despite the increased popularity of RP/SP demand models, little research considers the role of individuals' heterogeneous preferences on consumer behavior in this framework.5 The purpose of this research is to examine whether homogenous subgroups of the population, based on individual health and behavioral characteristics, respond differently to health-risk information and new food safety technology. Our application is to the oyster industry and attempts by the US Food and Drug Administration (FDA) and the Interstate Shellfish and Sanitation Conference (ISSC) to reduce the annual number of deaths from consuming raw, Gulf of Mexico oysters.6 Approximately 36 consumers die each year in the US from consuming raw oysters infected by a bacterium (*Vibrio vulnificus*) (Scallan et al. 2011).7 As the ingestion of the *V. vulnificus* bacteria typically poses little risk of illness when consumed by a healthy adult with a normally functioning immune system, most consumers are not at risk from a *V. vulnificus* infection. However, there is a small percentage of the oyster consumer population that is immune-compromised (such as those with chronic liver disease, iron overload disease, diabetes, cancer, orHIV/AIDS). For these individuals, consumption of raw Gulf of Mexico oysters infected by *V. vulnificus* can be fatal. Risk of life threatening illness from consuming oysters arises primarily if the oysters are consumed raw or in an undercooked state. While healthy individuals have little life threatening infection risk from eating shellfish, those that are at risk can avoid infection by eating only shellfish that have been thoroughly cooked or post-harvest processed to reduce *V. vulnificus* to non-detectable levels.

In 2001, under the National Shellfish and Sanitation Program (NSSP), the FDA and ISSC adopted a 7-year *V. vulnificus* Risk Management Plan for Oysters with a specific goal to reduce the annual incidence of *V. vulnificus*-related illness by 60%. A primary component of the plan was to produce and disseminate *V. vulnificus* fact sheets or brochures detailing the risks associated with raw oyster consumption in an attempt to educate at-risk consumers. Another element was to encourage the use of post-harvest processing (PHP) technologies for reducing *V. vulnificus* bacteria levels.8 Despite this and various other efforts, by 2008, the frequency of *V. vulnificus* illness at the national level remained constant. Due to the ineffectiveness of the 7-year Risk Management Plan, in October 2009, the FDA proposed a controversial new policy designed to improve oyster safety and reduce illnesses and human mortalities from consuming raw Gulf oysters.[9] The policy, initially set to be effective in May 2011, required raw Gulf oysters, intended for sale in the half-shell market during the summer months to be treated by PHP methods. Due to concerns associated with the potential negative economic impact of implementing the policy without first examining consumers' acceptance of a PHP oyster, the proposed mandate received a backlash of criticism from the ISSC and industry representatives.[10,11] Based on these concerns, the FDA has since issued a letter postponing implementation until research into the consequences of such a ban can be completed.

To provide feedback to the ongoing policy debate, we examine the impact of a PHP-only policy and educational information treatments on oyster consumer behavior. We do this with split-sample models in which sample responses from 1,849 oyster consumers are split into four categories: (1) at-risk, raw oyster consumers; (2) at-risk, cooked oyster consumers; (3) not at-risk, raw oyster consumers; and (4) not at-risk, cooked oyster consumers.

Results show that at-risk, raw oyster consumers, when presented with the educational informational brochure reduce their demand for oysters. This suggests that contrary to actual reported incidence of illness, the educational brochure information should have had the desired effect on the at-risk consumer population and reduced annual illness levels. As such, it seems that the previous ineffectiveness of brochures in reducing annual illness/death levels may be more a function of ineffective dissemination of the material, rather than the information itself. We further find that the same information provided in the form of a video also reduces oyster demand for the at-risk population. Also, raw oyster consumers reject PHP oysters while the policy has no effect on demand for consumers that cook their oysters. Further, all four consumer groups reduce their oyster demand if there is a price premium associated with PHP oysters.

The rest of the paper is organized as follows. We begin by detailing the relevant food safety and consumer behavior literature. Then the survey design is described before outlining the methodological framework for explaining consumer responses to health-risk information and food safety technology. Finally, results from split-sample RP/SP demand models are presented, together with concluding remarks.

2 Background

Research examining consumer responses to favorable or unfavorable health-risk or product contamination information suggests that information is subjectively evaluated by consumers and impacts risk perceptions, attitudes, and ultimately behavior. Research findings have demonstrated that negative media coverage can cause consumers to react defensively and reduce their demand for the good, e.g., news of a ban on harvesting oysters from contaminated waters decreased oyster demand (Swartz and Strand 1981). Similar behavior was observed following news of a heptachlor contamination ofmilk in Hawaii (Smith et al. 1988), cholesterol media coverage associated with egg consumption (Brown and Schrader 1990), and news of domoic acid contamination of mussels (Wessells and Anderson 1995). Consequently, consumers accrue welfare losses, or avoidance costs as the negative news associated with consumption of the good heightens risk perceptions and decreases consumer demand.

Researchers, interested in examining potential policy implications, have also considered the effect of positive counter-information treatments, designed to reassure consumers about the product's safety, on risk perceptions and consumer behavior. Generally, these studies find that counter-information treatments have a negligible effect on consumer demand, so welfare losses persist.

In a RP/SP framework, we quantify the effects of different positive and negative information treatments on oyster consumer behavior. Three positive information treatments were provided to respondents, all designed to present the facts associated with *V. vulnificus*; the necessary health conditions required to be considered at risk; potential illnesses; diagnosis and treatment; and risk prevention recommendations. The first is the actual *V. vulnificus* brochure fact sheet entitled "The Risk of Eating Raw Molluscan Shellfish Containing *V. vulnificus*," produced by the ISSC.15 The second is a video treatment designed, developed, and produced to provide the same information as the brochure. The purpose of providing two different treatments is to test whether the media form of the information influences consumer behavior. With four out of five US adults online, streaming video is a relatively new tool for information dissemination.16 Two professional actors and a videographer were hired to shoot a three-minute video, which disseminated the same *V. vulnificus* information as the ISSC brochure.17,18 That is, we wanted the severity of the threat, or fear appeal, from consuming raw oysters to be constant across the brochure and standard video treatments. In the social psychology literature, Protection Motivation Theory (PMT) describes adaptive and maladaptive coping behaviors of individuals to health threats (see Rogers 1975). Within this literature, it has been shown that the severity of the threat and how vulnerable an individual is to the threat can change the probability of behavioral modification (Maddux and Rogers 1983; Abraham et al. 1994). The third information treatment is an alternative video that was created and is identical to the standard video with the exception that the level of threat was reduced by not mentioning the possibility of death from consuming raw oysters. Instead, only the possibility for illness was disseminated. Analyzing oyster demand behavior in response to both video treatments will provide an examination of changes in consumer behavioral responses based on the severity of a threat.

As well as varying the media form across across the *V. vulnificus* information treatments, the source of the information content was also varied. Again referring to the social psychology literature, the role of the source of information, and in particular, source credibility has been shown to influence consumer behavior with the potential to create the asymmetrical effects associated with negative and positive information treatments (for example, see Hovland and Weiss 1951; Johnson and Steiner 1968; Sternthal et al. 1978). Findings from this area of research indicate that more credible sources of information are more likely to induce greater behavioral compliance. Others have demonstrated that third-party information (from independent or not-for-profit groups without a financial interest in influencing consumer behavior) has a greater impact on consumer behavior than information from interested parties (Huffman et al. 2002; Rousu et al. 2004). These findings are also supported by research into the demand for ecolabelling and genetically modified food products that find consumers to be generally distrusting of information attributed to government organizations but can be influenced by independent third-party information (Milgrom and Roberts 1986; Huffman and Tegene 2002; Huffman et al. 2004; Johnston et al. 2001; Morgan et al. 2009).

Another associated issue is whether consumers perceive the provider of the information to have conflicting responsibilities. That is, some public sector institutions have been identified by the public as a risk information generator as well as a risk regulator, with the dual responsibility of communicating risk information for which it has responsibility to regulate (Eiser et al. 2003). In such circumstances, the public may perceive some degree of vested interest with the public institution disseminating risk information and discount the information accordingly. For the brochure and video treatments, to test for source credibility effects, we varied information treatments across four different source groups. These are (1) no source (the control group); (2) the FDA; (3) the ISSC; and (4) a researcher-created fictitious not-for-profit group called the American Shellfish Foundation (ASF). By randomly varying the treatments and source type across respondents, we examine and quantify the most effective informational treatment, by source type, that influences oyster consumer demand.

To investigate the potential asymmetrical impacts of positive and negative information treatments and to quantify the potential welfare effects associated with news of the health risks associated with consuming raw oysters, survey respondents are also presented with a news article of a recent consumer illness and death from eating raw Gulf of Mexico oysters. The article is hypothetical but based on actual events. It describes a middle-aged man that fell ill from consuming raw oysters, spent a week in hospital but then died from his sickness. At this stage, and again drawing from the PMT literature on behavioral compliance, we varied the location of the incident across respondents. As such, we also investigate whether the location of the death announcement matters to consumers. The PMT literature suggests that individuals are more responsive to a local event than the same incident outside of their region (Neuwirth et al. 2000). To test this, we disseminated two news treatments. One describes an illness and death in the locality of the respondents' residence while the second depicts an illness and death to a consumer in Chicago, IL, which, based on our geographical sample is a non-local event to all respondents.

Finally, with the recent FDA mandate on PHP oysters on hold pending research into consumer acceptance of processed oysters, we examine consumers' acceptance of PHP oysters. Throughout the 1990s, in line with the rising incidence of food-borne illness, research examining the role of technological innovation in food production developed. To generalize findings from this literature, while the type of technology (such as irradiation or pasteurization) used is likely to be an important factor in explaining consumer acceptance of emerging technologies, it's the tangible benefits of the technology that drive consumer acceptance or rejection of its use (Hamstra and Smink 1996; Frewer et al. 1997). For raw oyster consumers, understanding the perceived benefits of a PHP oyster is complicated by the fact that most consumers prefer to eat their oysters raw. The perceived benefits from processing the oyster will then be a function, not only of the expected decrease in health risk, but also the perceived change in taste.19 For the average oyster consumer, as the decrease in risk for treating the oyster is negligible, any perception that treating the oyster will deteriorate the taste/texture of the product may cause the consumer to reject the PHP oyster. Analyzing and quantifying consumer behavior in response to a policy that makes only

PHP oysters available in the market will provide important feedback to the current FDA policy. Finally, as processing the oysters will increase producers' costs of production, consumers' oyster demand for PHP oysters and an associated price premium is also measured.

3 Survey, Sampling, and Study Design

We developed an internet-based survey of oyster consumers (aged 18 and over), sampled from the US Center for Disease Control-designated "case states."20 These are Florida, Alabama, Mississippi, Louisiana, Texas, and California. Due to a request from Georgia Sea Grant Program, we also sampled consumers in Georgia. The sample was drawn from a panel of online respondents maintained through Online Survey Solutions, Inc. (OSS) and the survey was administered between March and April, 2010. Due to the low incidence rate of oyster consumption in the general population, and the lack of any known data base of oyster consumers, we relied on several screening questions to select a sample of those who had either consumed oysters in the past and stopped, or those who were current consumers of oysters in any form. Due to the design of our overall study, past oyster consumer respondents were limited by quota to about 8.4% of the total usable sample.

Potential respondents in our panel (selected to be representative of the population of interest, residents of the targeted geographical areas aged 18 and over) were first screened on selected demographic variables (residence location, age and gender) in order to fill quotas based on population size and age and gender proportions in the targeted geographic areas. Thus, an effort was made to select a sample that was as representative as possible of the population as a whole on these basic demographic parameters.

Those accepted by these demographic screeners were then asked a second screening question to determine if they had ever eaten oysters. Those who indicated that they currently consume oysters make up the sample used in the current study. In total, there were 1,849 completed responses from oyster consumers across the seven states.

Demographics of this sample, when compared to geographical area baselines, are generally similar, though they do differ in some key respects. Part of this difference is attributable to differences in population access to and use of the internet as in all online samples, while there are also effects due to differences in those who comprise the consumer market for oysters from the population as a whole. Current oyster consumers tend to have higher levels of educational attainment and higher incomes than non-consumers. Current oyster consumers tend to include fewer minorities. The gender balance of current consumers is similar to the population as a whole. Finally, our sample of current oyster consumers includes slightly more individuals aged 65 and over than the population as a whole.

The issue of whether the reported raw oyster consumption rate (62%) and "at-risk" rate (18%) is representative of rates in the population of current oyster consumers is difficult to answer definitively. To the extent that our sample as a whole represents the general population, the sample of current oyster consumers should represent the total population of oyster consumers. Thus, rates of raw consumption and "at-risk" characteristics in our sample should be representative of those extant in the total population of oyster consumers.

Some evidence to support this claim for the raw consumption rate may be found in comparing results from the most comprehensive study that presented similar data in the past (ORC MACRO 2004). This study reported a 68% rate of raw consumption among current oyster consumers. Additionally, the mean age of raw consumers in the current study and the 2004 study are comparable (43 and 44, respectively) as are gender (male, 56 and 53%) and race (white, 70 and 73 %).

Similarly, we can compare at-risk rates between the ORC MACRO study and the current study. In 2004, the authors reported a 15% at-risk rate based on the incidence of liver disease, diabetes and/or a weakened immune system. Our rate of 18% is somewhat higher, but we added (based on newer medical standards) the additional qualifiers of cancer (including lymphoma, leukemia, or Hodgkin’s Disease), a stomach disorder, and iron overload disease (hemochromatosis).

The survey had two parts. First, respondents were asked questions to generate data on attitudes, preferences, awareness, perceptions, and knowledge of oyster consumption health risk as well as relevant demographic data. Second, to meet our research objectives, respondents were asked a series of stated preference questions regarding their annual oyster consumption based on current conditions and having been provided with different information treatments.

Before the stated preference demand elicitation questions, respondents were asked about their current annual consumption frequency to generate pretreatment baseline data for oyster consumption experience. To aid the respondent in determining the annual amount, they were asked how many months in a year they typically consumed an oyster meal, and then, in a typical month in which they ate oyster meals, about how many oyster meals did they eat.22 The survey software then computed the annual number of meals and respondents were offered the opportunity to adjust the number if desired.

The first stated preference question asked respondents whether, compared to the number of meals they revealed they consume in a typical year, did they expect to eat more, less, or the same number of oyster meals next year? Respondents were then prompted to state how many more or less as required. In estimation, inclusion of a stated preference count under existing conditions provides a means to control for potential hypothetical bias in individual responses. After each SP treatment question, respondents were also given a follow-up question asking them to state their perceived chances of getting sick from eating these meals.23 To derive the oyster demand curve for the sample, respondents were also asked to state whether they would eat more, less, or the same number of meals under both a price increase and a price decrease scenario (while being informed that the price of all other food products remained the same), where the price changes were varied randomly across respondents. Each respondent received a price increase of $1, $3, $5, or $7, or a price decrease of either $1, $2, $3, $4.

Respondents were then randomly assigned and presented with either a *V. vulnificus* brochure or a *V. vulnificus* informational video, the source of whichwas varied randomly between no source, the FDA, the ISSC, or a not-for-profitAmerican Shellfish Foundation.24 The source is clearly identified to the respondent before reading/viewing the treatment, plus the source is also clearly labeled on the brochure and in the bottom-right corner of the screen for the video treatment. Further, respondents were also informed of the source's mission. For example, if a respondent was presented with a brochure or video sourced to the ISSC they were then informed:

"The mission of the ISSC is to foster and promote shellfish sanitation through the cooperation of state and federal control agencies and the shellfish industry to seek to insure the safety of shellfish products consumed in the United States. The ISSC is partially funded by the US government."

Respondents were then asked a follow-up SP question as to the number of annual oyster meals they expect to consume having read/viewed the *V. vulnificus* informational material, again followed by a question regarding their expected chance of getting sick from consuming those meals.

Next, respondents read a fictitious newspaper article regarding a recent consumer illness and death associated with eating raw oysters. Again, follow-up SP annual oyster meal and expected sickness questions followed.

The final stage of the survey investigated respondents' behavioral response to treating oysters to reduce the actual risk of *V. vulnificus* contamination. Prior to the SP expected oyster meal count question, respondents were presented textual material on PHP treated oysters. The material informed respondents that there are currently four FDA-approved PHP methods, all of which reduce *V. vulnificus* to non-detectable levels. An SP question then elicited respondents' annual oyster meal count having read about PHP and assuming that the only oysters available are those that have been post-harvest processed. To further examine whether respondents would pay a premium for PHP oysters that eliminate the risk of death from consuming raw oysters, we asked the same SP question on expected annual oyster meals consumed but with an increase in price. Price premiums were varied randomly across respondents as $1, $3, $5, or $7. Table 1 summarizes the seven SP questions.

Table 2 provides sample definitions and descriptive statistics for variables used in the analysis for the sample. On average, respondents eat 16 oyster meals per year. The average respondent in the sample is 44 years of age, Caucasian, and earning a household income of $69,000. Just over half of the sample was female. In terms of the behavioral and health variables, over 62% of the sample consumed raw oysters with 18% classified in the at-risk category for potential illness from consuming raw oysters.

Table 3 details some summary statistics for consumers' responses to the different treatments. The majority of consumers do not change their consumption behavior following the information and PHP treatments. The largest behavioral change is induced by the PHP policy plus a price premium, with 36% of respondents decreasing their consumption and 10% discontinuing consumption altogether. Table 3 also shows how respondents' mean risk perceptions (chance of getting sick) increased from their baseline (stated preference status quo) level of 1.70 to 1.89 and 1.99 after being presented with the educational information and news treatment, respectively.26 The mean level after reading about PHP was 1.91.

Table 1 Seven SP questions with varying informational treatments

SP question	Text
SP1: expected meals consumed next year	Now we'd like to ask about the number of oyster meals you expect to eat *over the next 12 months*, starting from today. Thinking of the [NUMBER] oyster meals you told us that you typically eat in a year, if the average price of your oyster meals *stays the same*, do you think you will eat more, less, or the same number of oyster meals over the next year? *Then*, about how many more or less oyster meals do you expect to eat over the next year?
SP2 and SP3: expected meals consumed next year with a price increase (decrease)	Oyster prices change over time. For example, if oyster harvests are large, prices go down. When oyster harvests are smaller, prices go up. Suppose the price of your portion of your typical oyster meal goes up (down) by [DOLLAR_UP] [(DOLLAR_DOWN)] but the prices of all other food products stay the same. Compared to the [NUMBER_SP1] oyster meals you said that you expect to eat over the next year, do you think you would eat more, less, or the same number of oyster meals over the next year with the higher (lower) price for each meal? *Then*, about how many more or less oyster meals do you expect to eat over the next year?
SP4: with brochure/video	Thinking about oyster meals again, suppose that the average price of your oyster meals stays the same. Compared to the [NUMBER_SP1] oyster meals you previously told us you expect to eat next year, do you think you will eat more, less, or about the same number of oyster meals in the next year, having read or watched the information from [INSERT SOURCE] on how you can reduce the risk from eating oysters? *Then*, about how many more or less oyster meals do you expect to eat over the next year?
SP5: news of illness and death	Thinking about oyster meals again, suppose that the average price of your oyster meals stays the same. Compared to the [NUMBER_SP4] oyster meals you previously told us you expect to eat next year, do you think you will eat more, less, or about the same number of oyster meals next year after learning about the recent illness and death reported in the article you just read? *Then*, about how many more or less oyster meals do you expect to eat over the next year?
SP6: PHP oysters	Suppose that the average price of your oyster meals stays the same. Compared to the [NUMBER_SP5] oyster meals you previously told us you expect to eat next year, do you think you will eat more, less, or about the same number of oyster meals next year *assuming that the only oysters available are those that have been Post-Harvest Processed*? *Then*, about how many more or less oyster meals do you expect to eat over the next year?
SP7: PHP Oysters with price premium	Continue to assume that the *only* oysters available are those that have been Post-Harvest Processed. Now suppose that the price of your portion of your average oyster meal using PHP oysters goes up by [DOLLAR_UP], but the prices of all other food products stay the same. Compared to the [NUMBER_SP6] oyster meals you previously told us you expect to eat next year, do you think you will eat more, less, or about the same number of oyster meals next year assuming that the only oysters available are those that have been Post-Harvest Processed? *Then*, about how many more or less oyster meals do you expect to eat over the next year?

Each respondent received a randomly assigned price increase of "DOLLAR_UP" equal to \$1, \$3, \$5 or \$7 and a randomly assigned price decrease of "DOLLAR_DOWN" equal to \$1, \$2, \$3 or \$4

Table 2 Descriptive statistics

Variable	Description	Mean	SD	Min	Max
Price	Price of oyster meal	0.80	2.11	−5.00	7.00
Quantity	Average annual oyster meals consumed	16.18	28.16	0.00	200.00
Age	Age of respondent	44.41	16.31	18.00	87.00
Gender	Respondent is male (= 1)	0.49	0.50	0.00	1.00
Race	Respondent is Caucasian (= 1)	0.77	0.42	0.00	1.00
Inc	Household income of respondent ($thousands)	69.04	38.38	8.00	150.00
SP	Stated preference question (= 1)	0.88	0.33	0.00	1.00
Sick	Chance of getting sick	1.57	1.14	1.00	5.00
Missick	Inputed missing chance of getting sick	0.03	0.16	1.00	1.00
Broc	Brochure with no source (= 1)	0.05	0.21	0.00	1.00
BrocFDA	Brochure sourced to FDA (= 1)	0.05	0.21	0.00	1.00
BrocISSC	Brochure sourced to ISSC (= 1)	0.05	0.21	0.00	1.00
BrocASF	Brochure sourced to ASF (= 1)	0.05	0.22	0.00	1.00
Vid	Video with no source (= 1)	0.05	0.22	0.00	1.00
VidFDA	Video sourced to FDA (= 1)	0.05	0.22	0.00	1.00
VidISSC	Video sourced to ISSC (= 1)	0.05	0.22	0.00	1.00
VidASF	Video sourced to ASF (= 1)	0.05	0.22	0.00	1.00
Alt	Alternative video with no source (= 1)	0.03	0.18	0.00	1.00
AltFDA	Alternative video sourced to FDA (= 1)	0.04	0.19	0.00	1.00
AltASF	Alternative video sourced to ASF (= 1)	0.03	0.18	0.00	1.00
News_loc	News of local illness and death	0.18	0.39	0.00	1.00
News_Chi	News of non-local illness and death	0.12	0.32	0.00	1.00
PHP	Post-harvest processed oysters	0.25	0.43	0.00	1.00
PHP_Prem	Post-harvest processed oysters with price increase	0.50	1.54	0.00	7.00
Raw	Raw oyster consumers	0.62	0.49	0.00	1.00
At-risk	At-risk oyster consumers	0.18	0.39	0.00	1.00

Sample size = 1,849 respondents

Table 3 Summary of changes in annual consumption per treatment

Treatment	Percent decreasing consumption	Percent increasing consumption	Percent not changing consumption	Percent discontinuing consumption	Mean change in consumption	Mean chance of getting sick
Baseline	N/A	N/A	N/A	N/A	N/A	1.70
Price increase	41.16	2.11	56.73	6.7	–2.82	N/A
Price decrease	2.60	37.48	59.92	0.65	3.51	N/A
Brochure/video	11.63	2.38	85.99	2.43	–1.14	1.89
News	11.36	0.56	88.10	3.67	–0.70	1.99
PHP	9.95	5.14	84.91	3.62	–0.41	1.91
PHP+Premium	35.91	4.92	59.17	10.06	–2.55	N/A

Sample size = 1,849 respondents

4 The Conceptual Framework

The online survey instrument collects RP and SP data for analysis in split-sample oyster demand models. The RP data is based on actual annual number of oyster meals consumed and the SP data is used to stimulate a change in oyster meals consumed resulting from price changes and the provision of different information treatments. SP meal questions are asked about future meals consumed: (1) under status quo conditions, (2) with a price increase and decrease scenario, (3) with the provision of a brochure or video, (4) with news of a *V. vulnificus*-related death, (5) with a mandatory PHP policy, and (6) with a mandatory PHP policy and associated price premium.

As the dependent variable is a nonnegative integer with a high frequency of low meals consumed, a count panel data model is estimated. A basic count model is assumed and is written as

$$\Pr\left(x_{it}\right) = \frac{e^{-\lambda_{it}}\lambda_{it}^{x_{it}}}{x_{it}!}, x_{it} = 0, 1, 2, \ldots$$

The natural log of the mean number of meals is assumed to be a linear function of prices, the perceived chance of becoming ill from consuming oysters, income, and scenario dummy variables. To allow for variation across oyster consumers that cannot be explained by the independent variables, we assume that the mean number of meals also depends on a random error, *ui* . The RP/SP Poisson demand model is:

$$ln\lambda_{it} = \beta_0 + \beta_1 P_i + \beta_2 c_i + \beta_3 y_i + \beta_4 s_i + \beta_5 I + \beta_6 N + \beta_7 PHP \\ + \beta_8 PHP_{prem} + \beta_9 SP + \mu_i$$

where *P* is the change in price of an oyster meal; *y* is income; ***s*** is a vector of socio demographic variables; individuals are indexed i = 1, . . . , 1, 849; and t = 1, . . . , 8 denotes annual oyster meal demand under RP status quo, SP status quo, SP price increase, SP price decrease, SP information treatment, SP news treatment, SP PHP treatment, and SP PHP treatment with price premium, respectively, in the pseudo-panel data. Dummy variables *I* (*I* = 1 when *t* = 5), *N* (*N* = 1 then *t* = 6), *PHP* (*PHP* = 1 then *t* = 7), and *PHPprem* (*PHPprem* = 1 then *t* = 8) are demand shift variables for the information, news, and PHP treatment scenarios. The *SP* dummy variable is included to test for hypothetical bias (Whitehead et al. 2008a). *SP* = 1 for hypothetical meal data *(t* = 2*, . . . ,* 8*)* and 0 for revealed meal data *(t* = 1*)*. β0 −β9 are coefficients to be estimated in the model. Pooling the data suggests that panel data methods be used to account for differences in variance across sample individuals, *i*, and scenarios, *t*. The distribution of meals conditioned on *ui* is Poisson with conditional mean and variance, *λi t*. If exp*(λi t)* is assumed to follow a gamma distribution, then the unconditional meals, *xi t* , follow a negative binomial distribution (Hausman et al. 1984). The random effects Poisson model imposes positive correlation across the *t* scenarios (Landry and Liu 2011).

With the semi-log functional form, the baseline economic benefit per annual oyster meals consumed for the representative consumer as measured by average annual per-person consumer surplus (CS) is:

$$CS_{SP=0} = \frac{\hat{x}}{-(\beta_1)}$$

where ˆ *x*SP=0 is the annual number of predicted meals for the representative oyster consumer while controlling for potential hypothetical bias (corrected model) and all independent variables are set at sample means (Bockstael and Strand 1987).

In a corrected model, the change in annual per-person CS as a result of new *V. vulnificus* information is:

$$CS_{SP=0} = \frac{\left(\hat{x}|I=1\right) - \left(\hat{x}|I=0\right)}{-(\beta_1)}$$

The CS effects of the news treatment and PHP scenarios are estimated in a similar fashion with the respective dummies.

5 Estimation Results

We split the sample into four categories based on heath and behavioral characteristics: (1) at-risk, raw oyster consumers; (2) at-risk, cooked oyster consumers; (3) not at-risk, raw oyster consumers; and (4) not at-risk, cooked oyster consumers.

Tables 4 and 5 present the results from the four random effects Poisson demand split-sample models. Using results from the relevant model, we also present changes in CS estimates for the at-risk, raw oyster consumer subgroup. This is the only subgroup of the population for which we can discern whether a change in consumer behavior constitutes a gain or loss in welfare. For at-risk, raw oyster consumers, we consider a decrease (increase) in oyster meals consumed to represent a gain (loss) in welfare. For the other subgroups, as we have no way of interpreting whether a change in consumption in either direction is rational or appropriate, we cannot make inferences regarding welfare implications. Table 6 presents baseline and changes in the mean annual per-person CS estimates for a corrected (SP = 0) version of the model. Consumer surplus estimates are presented together with 95% confidence intervals constructed using a bootstrapping procedure (Krinsky and Robb 1986).27 The procedure generates 1,000 random variables from the distribution of the estimated parameters and generates 1,000 consumer surplus estimates. The estimates are sorted in ascending order and the 95% confidence intervals are found by dropping the bottom and top 2.5% of the estimates.

As expected, the price change coefficient is negative and statistically significant across all subgroups. The largest annual per-person CS measures from oyster consumption are attributable to raw oyster consumers ($556 and $442), while the at-risk, cooked oyster subgroup has the lowest annual welfare ($293). In terms of socio-demographic characteristic effects, income has no effect on demand for three of the subgroups with only not at-risk, cooked oyster consumers revealing oysters to be a normal good. The coefficients on the stated preference elicitation variables indicate that both raw consumer groups expect to eat more oyster meals next year, while the cooked oyster subgroups anticipate consuming fewer meals. For all subgroups, a perceived increased likelihood of illness from oyster meals reduces demand.

By splitting the sample, clear differences in consumers' reactions to the information treatments are observable. For the vulnerable (at-risk), raw oyster consumers, a striking result is that three of the four brochure treatments significantly reduce demand for oyster meals. Moreover, one of these effective brochure/source combinations is the brochure sourced to the ISSC (*BROCISSC*), which is the actual brochure/source combination that was disseminated under the 2001 *V.vulnificus* Risk Management Plan. Yet, under this plan, these brochures had a negligible impact on human illness and death. This finding implies that its ineffectiveness was perhaps not due to the information or source, but rather that the brochures were not disseminated appropriately. Between 2003 and 2010, the ISSC disseminated an average

Table 4 Results from Poisson regression with random effects—at-risk, raw and cooked oyster consumers

Variable	At-risk, raw oyster consumers			At-risk, cooked oyster consumers		
	Coefficient	SE	*p* value	Coefficient	SE	*p* value
CONSTANT	2.866	0.366	0.000	2.030	0.451	0.000
PRICE	−0.037	0.002	0.000	−0.048	0.006	0.000
INC	0.002	0.003	0.518	−0.002	0.003	0.467
WHITE	−0.146	0.224	0.514	0.601	0.372	0.106
MALE	0.220	0.192	0.252	0.775	0.231	0.001
AGE	−0.002	0.005	0.760	−0.003	0.006	0.588
SP	0.066	0.009	0.000	−0.140	0.022	0.000
SICK	−0.107	0.004	0.000	−0.034	0.010	0.001
MISSICK	−0.125	0.099	0.207	−0.089	0.179	0.620
BROC	−0.212	0.034	0.000	−0.565	0.083	0.000
BROCFDA	0.023	0.038	0.549	0.204	0.100	0.041
BROCISSC	−0.097	0.034	0.004	0.026	0.085	0.757
BROCASF	−0.084	0.031	0.008	0.070	0.117	0.551
VID	−0.037	0.040	0.359	−0.288	0.104	0.006
VIDFDA	0.197	0.054	0.000	0.095	0.105	0.362
VIDISSC	−0.079	0.039	0.042	−0.039	0.122	0.748
VIDASF	−0.039	0.040	0.333	−0.089	0.111	0.425
ALT	−0.074	0.041	0.070	0.154	0.140	0.273
ALTFDA	−0.223	0.039	0.000	0.037	0.126	0.771
ALTASF	−0.199	0.040	0.000	0.156	0.104	0.134
NEWS_LOC	−0.024	0.045	0.594	−0.022	0.132	0.866
NEWS_CHI	−0.093	0.051	0.072	−0.066	0.132	0.615
PHP	−0.081	0.036	0.027	−0.028	0.088	0.753
PHP_PREM	−0.024	0.006	0.000	−0.037	0.012	0.002
Alpha	1.076	0.134	0.000	1.328	0.192	0.000
Sample size		189			141	
Periods		8			8	
Log likelihood		−5019.652			−3015.357	

of 35,000 brochures a year to various groups and organizations throughout the case states. These groups included public health organizations, medical centers, seafood outlets, state government consumer agencies, health organizations, aging councils, and higher education extension centers. Yet, our results suggest that if the at-risk, raw oyster consumer group is better informed about the risks of *V. vulnificus* via the informational brochure that currently exists, this could have the desired effect of decreasing demand for risky oysters and reducing annual illness and death rates. In terms of welfare effects, for the vulnerable subgroup the brochure sourced to the ISSC creates an average annual per-person welfare gain of $2 (with a decrease in demand for a risky good considered as a welfare gain). Similarly, the standard video sourced to the ISSC (*VIDISSC*) also significantly reduces demand. Interestingly, the same video sourced to the FDAincreases demand. In terms of the ongoing debate on reducing annual illness and death, it appears that the ISSC and FDA may consider pursuing a strategy

Table 5 Results from Poisson regression with random effects—not at-risk, raw and cooked oyster consumers

Variable	Not at-risk, raw oyster consumers			Not at-risk, cooked oyster consumers		
	Coefficient	SE	*p* value	Coefficient	SE	*p* value
CONSTANT	3.054	0.112	0.000	2.756	0.153	0.000
PRICE	−0.039	0.001	0.000	−0.038	0.001	0.000
INC	0.001	0.001	0.371	0.002	0.001	0.059
WHITE	−0.242	0.075	0.001	−0.589	0.099	0.000
MALE	0.250	0.066	0.000	−0.009	0.083	0.912
AGE	0.002	0.002	0.481	0.001	0.003	0.821
SP	0.044	0.003	0.000	−0.100	0.007	0.000
SICK	−0.056	0.001	0.000	−0.023	0.003	0.000
MISSICK	−0.058	0.024	0.017	0.020	0.063	0.753
BROC	−0.069	0.012	0.000	−0.085	0.033	0.010
BROCFDA	−0.036	0.009	0.000	−0.092	0.032	0.004
BROCISSC	−0.042	0.011	0.000	−0.360	0.026	0.000
BROCASF	−0.080	0.011	0.000	−0.031	0.031	0.318
VID	−0.037	0.010	0.000	0.012	0.028	0.661
VIDFDA	−0.061	0.010	0.000	0.010	0.030	0.739
VIDISSC	−0.047	0.011	0.000	−0.026	0.032	0.413
VIDASF	−0.116	0.009	0.000	0.088	0.031	0.005
ALT	−0.019	0.014	0.166	0.068	0.037	0.068
ALTFDA	0.008	0.017	0.625	−0.045	0.034	0.179
ALTASF	−0.008	0.013	0.523	0.045	0.048	0.354
NEWS_LOC	−0.097	0.016	0.000	0.006	0.047	0.904
NEWS_CHI	0.007	0.017	0.696	−0.099	0.046	0.032
PHP	−0.033	0.011	0.003	−0.048	0.028	0.087
PHP_PREM	−0.042	0.001	0.000	−0.018	0.003	0.000
Alpha	1.253	0.067	0.000	1.205	0.077	0.000
Sample size		957			562	
Time periods		8			8	
Log likelihood		−27,283.24			−12,859.38	

of improving the dissemination of brochures (sourced to the ISSC) and perhaps a new video treatment that can be readily streamed via the internet, specifically targeted to the at-risk, raw oyster consumer population.

The educational brochures and video have a strong impact on behavior for the not at-risk, raw oyster consumers. In fact, all brochure and video treatments reduce oyster demand from this subgroup. As this group is not at risk from consuming raw oysters, the fall in demand may reflect some uncertainty regarding the information or their personal health status, and as such, is influencing their avoidance behavior.

For consumers that cook their oysters, results are less consistent. For the at-risk consumers that only eat cooked oysters, the brochure and video treatments have little effect. Only the non-sourced brochure and video reduce demandwhile the FDAbrochure increases consumption. For the not at-risk, cooked oyster consumers, three of the four brochures significantly

Table 6 Baseline and changes in mean annual per-person consumer surplus estimates (with 95% confidence intervals)—corrected model

	At-risk, raw oyster consumers		
	Lower bound	Mean	Upper bound
Baseline	374.86	441.92	472.08
BROC	3.37	4.56	4.28
BROCFDA	−0.32	−0.32	−0.31
BROCISSC	1.80	2.00	2.29
BROCASF	1.63	1.83	2.07
VID	3.34	3.76	4.24
VIDFDA	−4.60	−4.01	−3.58
VIDISSC	1.18	1.32	1.51
VIDASF	0.85	0.94	1.08
ALT	0.69	0.78	0.88
ALTFDA	3.71	4.13	4.63
ALTASF	1.66	1.87	2.15
NEWS_LOC	12.93	14.48	16.40
NEWS_CHI	15.26	17.16	19.63
PHP	22.79	25.63	29.11
PHP_PREM	26.38	39.39	33.53

reduce demand, however, both the video sourced to the not-for-profit organization and the alternative video increase demand.

Comparing the coefficients on the standard and alternative videos, there is mixed evidence regarding the severity of the threat effects. Recall, the standard video treatment disseminates the same information as the brochure, mentioning the potential risk of both death and illness from consuming raw oysters while the alternative video only mentions the risk of potential illness. For the not at-risk, raw oyster consumers, in line with the PMT literature, the severity of the threat does seem to influence behavior as all standard videos reduce demand while the alternative videos have no statistical influence.

Results from the *PHP* parameters provide the first feedback to the FDA and interested stakeholders regarding consumer acceptance of a treated oyster. In assessing individuals' acceptance of the use of technology in food production, the literature has identified the role of the perceived benefits from the new technology as a determining factor in driving acceptance. We hypothesize that consumer acceptance of PHP oysters are a function of both the change in perceived taste and the decrease in actual risk. Findings support our hypothesis. Both raw oyster consumer groups exhibit strong preferences for a traditional oyster product. This is particularly evident for the at-risk, raw consumer group as even though there are defined benefits (in the form of a health-risk reduction) from consuming PHP oysters, it seems that this is overwhelmed by the perceived change in taste, causing demand to fall. Based on this result, it would be expected that raw oyster consumers who are not at risk (and for whom PHP oysters do not change the actual risk) would behave in the same manner. Again, for this group, the coefficient on *PHP* is negative and statistically significant.

Conversely, consumers that cook their oysters are more accepting of PHP oysters. For both cooked oyster consumer groups, the coefficient on *PHP* is statistically insignificant at the 5% level. Again, it can be inferred that the perceived change in taste is the dominant factor in determining consumer acceptance of PHP oysters. Specifically comparing responses to a PHP-only policy for the not at-risk, raw and cooked oyster subgroups, any change in perceived risk should be constant. However, for consumers that cook oysters, any change in perceived taste between a PHP and traditional oyster is likely to be insignificant. Therefore, cooked oyster consumers are more accepting of processed oysters.

Also, as Muth et al. (2011) found that PHP will likely increase the price of a dozen raw half-shell oysters by between $0.48 and $0.84 to the consumer, we consider consumer responses to PHP-only oysters with an associated price premium. With the coefficients on *PHP_prem* negative at the 1%level across all models, even cooked oyster consumers that are more accepting of PHP oysters are not willing to pay a premium for them. This is contrary to the findings of Shogren et al. (1999) and Fox et al. (2002) who found that consumers were willing to pay a premium for cooked irradiated food (chicken and pork sandwiches, respectively).

Finally, news of a *V.vulnificus*-related death has a mixed effect on subgroup behavior. Surprisingly, only the non-local news treatment significantly reduces demand for at-risk, raw oyster consumers, generating annual welfare gains of $17 per person. Not at-risk, cooked oyster consumers respond in a similar fashion while not at-risk, raw oyster consumers only reduce demand due to news of a local death. The news treatment has no impact on the consumption behavior of at-risk, cooked oyster consumers.

6 Conclusion

This research develops a split-sample revealed and stated preference (RP/SP) modeling approach to examine the effects of different health-risk information treatments as well as a recent FDA proposal for the use of food safety technology on oyster consumer behavior. We extend previous RP/SP research by analyzing how homogenous subgroups of the population, based on individual health and behavioral characteristics, respond differently to the treatments. This extension provides both an interesting academic investigation and strong policy input as the FDA and ISSC are committed, under the NSSP, to reduce the annual number of deaths associated with consumption of raw oysters and *V. vulnificus* infection.

We find that at-risk, raw oyster consumers decrease demand for the traditional, risky product after reading an educational brochures sourced to the ISSC.Yet, this finding is at odds with the lack of effectiveness of these brochures under the 7-year *V.*

vulnificus Risk Management Plan. We surmise that the FDA and ISSC may want to continue the use of the brochures but to disseminate the information more effectively by specifically targeting at-risk consumers. Also, as this subgroup also reduces demand following the ISSC-sourced video information treatment, a strategy of streaming the information to at-risk consumer via the internet could be effective.

Results clearly indicate that a policy requiring all oysters to be processed before market will have a detrimental effect on the industry. Based on other literature into consumer acceptance of technology in food production, we hypothesized that the actual benefits of reduced risk are outweighed by the perceived change in taste from treating the oyster. As such, on average the net benefits of PHP oysters are negative. This is highlighted by responses from at-risk, raw consumers, for whom there are defined health-risk benefits from processing oysters, yet, they reject PHP oysters. Our hypothesis is further supported as consumers that cook their oysters are more accepting of a PHP oyster.We argue that for this group, any change in taste will be negligible, so they do not alter their purchase behavior. However, all subgroups reduce quantity demanded for oysters if the PHP product increases the price of their oyster meals. This provides important feedback toward a FDA policy on treated oysters that is currently on hold pending research on consumers' acceptance of the product. Our result indicates that if the policy is put into practice, certain consumer subgroups will not change their demand for oysters; however, all consumers will reduce their quantity demanded if only PHP oysters are available at a price premium. As processing oysters will increase production costs, a portion of which will invariably be passed on to the consumer, the oyster industry will suffer from the negative economic effects of reduced consumer demand under the new FDA mandate.

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