MEASURING THE BENEFIT OF REDUCING FOOD-BORNE ILLNESS

Valuing symptoms rather than pathogens

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Abstract

The food safety issue is becoming an important public health burden and food safety agencies are spending millions of dollar to deter cases of food-borne illness. Such programs come with costs; therefore this paper focuses on an important component that assesses how much consumers are willing to pay for programs that aim to improve food safety standards. The purpose of the paper is twofold. First, it discusses and evaluates all existing valuation techniques applied to food safety. The second goal of the paper challenges researchers by proposing an alternative approach that values the symptoms rather than pathogens. The paper finds that cost of illness (COI) is the most commonly used valuation method, followed by the contingent valuation method while only a handful of studies utilize either experimental market auction or willingness to pay's (WTP) revealed preference techniques. COI suffers in terms of theory and practice. Other studies using contingent valuation, experimental market auctions and averting behavior are limited to few food risks and small population samples, which makes their results localized, and extrapolating to all food-borne illness and all population is problematic. The proposed approach paves the way for better elicitation of individual WTP to avoid all food risk by valuing from symptoms' point of view. The approach also side-steps the issue of valuation of morbidity risks and eliminates the concerns of using incomplete measures of benefits in cost-benefit analysis when evaluating the efficacy of food safety programs.

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I. Introduction

Food-borne illness poses a significant public burden in terms of medical care expenditure, lost productivity, anxiety, pain and suffering of the affected individual and their family members. Food-borne illness can also lead to business disruption (losses) and opportunity cost of government resources directed to food safety (Roberts, 2007). Regulatory agencies responsible for overseeing food safety programs aim to maximize the expected health benefits to consumers given their limited resources. The optimal solution to such agencies is to allocate their limited budget to different enforcement and inspection activities so that the marginal benefits per unit of spending on all activities are equal (Henson and Traill, 1993 and 2000). To demonstrate efficacy in various programs, agencies must assess the expected costs and benefits of different alternatives (Arrow et al, 1996; Antle, 1999; Golan and Kuchler, 1999; Varshney, 2011).

The expected cost consists of the cost of compliance which eventually is transferred to consumers in the form of higher prices or less variety of food commodities as well as government enforcement and inspection costs borne the taxpayers (Golan and Kuchler, 1999; Trail and Koenig, 2010).

The expected benefit of food inspection activities depends not only on the monetary value of avoiding food-borne illness, but also the effectiveness of programs in minimizing the risk of food pathogens, or the percentage of food products in markets that do not abide by the prescribed mandate. Lastly, the expected benefit also depends on the proportion of food-borne illness that is a result of foods or in other words, the probability of "non-mandate" abiding food that can lead to adverse health impacts on consumers.

Mauskopf and French (1991) illustrate this in a hypothetical example whereby the regulatory agency chooses between inspecting two different food commodities depending on the expert's "gut feeling". Then they identify the pathogen-dose amount in each food and finally, they assume the proportion of food types that can lead to adverse health effects when an individual eats. The product of pathogen-dose amount and the proportion of contaminated food that cause illness multiplied by the estimated dollar value of avoiding food risks gives the total expected benefit of food safety programs.

Most of the empirical studies in the literature put more emphasis on estimating the incidence of food-borne illness and associated monetary value; however few studies estimate the total expected benefits of reducing food pathogen risks. Adding program effectiveness into the equation will allow in calculating the actual monetary benefit of reducing food-borne illness. As such the total value can be used in cost-benefit analysis (Mauskopf and French, 1991; van Ravenswaay and Hoehn, 1996; Starbird, 2000; Scharff et al. 2009).

Despite the undisputable role of government intervention in correcting market failure to ensure efficiency and to enhance food safety, these programs come with costs. This paper focuses on an important component that assesses how much consumers are willing to pay for programs that aim to improve food safety standards. The purpose of the paper is twofold. First, it provides a critical review of existing empirical literature in an attempt to estimate consumer willingness to pay for reduced food-borne illness. By doing so, the paper discusses and evaluates all existing valuation techniques applied to food safety. The second goal of the paper is to challenge researchers to focus on symptoms[1] rather than food pathogens when measuring consumer's

[1] Most food-borne illnesses result in the same symptoms and the general population does not know the causing pathogens but every one can tell the symptoms they experience. Since

willingness to pay (WTP) to avoid food-borne illness. The paper will lay a foundation for this new approach that was not considered in the literature.

Economic analysis on food safety benefits from the environmental economics and health economics literature that employs different estimation techniques to assign dollar value for improvement in human health due to better access to environmental quality. Therefore most of the models in economic analysis on food safety have already been developed and applied either in environmental economics or health economics. These theoretical models are derived from a WTP expression for reducing health risks such as morbidity and mortality. The WTP expression for morbidity reduction is the sum of four components[2]: the value of lost time (both from work and leisure), cost of mitigating the illness, the disutility associated with the illness, and the value of averting the illness (Harrington and Portney, 1987; Cropper and Freeman, 1991; Berger et al., 1987; Freeman 2003).

The literature on measuring food safety improvement can be grouped into two main bodies. The first employs *Cost of illness (COI) approach*, which is the most commonly used estimation method. The approach principally aggregates out-of-pocket expenses such as the observed medical care expenditure and wage loss value. Some studies modified the COI method by including the *Quality adjusted life year* (QALY) lost value to capture the ignored intangible costs such as the disutility value associated with pain and suffering. The second group uses the *WTP* elicitation technique and can be divided into two categories: those using *WTP's stated-preference* method and those that utilize *WTP's revealed-preference* technique. The WTP's

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symptoms of all pathogens are the same, researchers can simply ask people their willingness to pay to avoid such symptoms instead of a change of food risks.

[2] For more information on how to derive this model and the components of WTP expression, see Cropper and Freeman, 1991, p. 197.

stated-preference method can be sub-divided into: the *contingent valuation method* (CVM) and the *experimental market auction* approaches. The former is based on hypothetical direct questioning while the latter are non-hypothetical in nature. Most studies quantifying expected benefit for reduced food-borne illness acknowledge the dollar value they derive may underestimate or overestimate the true value of the willingness to pay for improved food safety standards.

The COI method seems to be an intuitively appealing and straightforward method of estimating for most analysts and practitioners (Rice, 1967). The reason is clear: the method only measures direct components that arise from illness. Basically, it claims if illness creates medical costs and income loss, a reduction in such illness is expected to save the same amount of money (Kenkel, 1994; Koopmanschap, 1998). Despite its popularity, the COI approach suffers several shortcomings, including its exclusion of disutility value due to anxiety, pain, suffering and other discomfort as well as the inability to consider non-labor market participants such as retired people and young children (Shiell et al., 1987; Tarricone, 2006). The value derived using this technique is not approximately equivalent to the WPT value and it's not always guaranteed to be a lower bound of WTP estimated value mainly because COI don't successfully capture all incurred medical expenditure and income losses due to lack of data (Harrington and Portney, 1987; Berger et al., 1987; and Kenkel, 1994). Hence using such value in a cost benefit analysis will bias the measured benefit results (Kenkel, 1994).

The second frequently used method after the COI approach is the traditional WTP's stated-preference approach, which either employs CVM or experimental market auction technique. The CVM studies use hypothetically designed surveys (Lin and Milon, 1995; Buzby et al., 1995; Hammit and Haninger, 2007; Haninger and Hammit, 2011), while experimental auction studies are nonhypothetical in nature and appear to be a more real-world situation (Fox et al., 1995; Hayes et al., 1995; Stenger, 2000; Fox et al., 2002; Rozan et al., 2004; Nayga et al., 2006). Although contingent valuation studies can capture direct individual preferences, there are some concerns related to the reliability of such studies, particularly the design of the questionnaire and the ability of the respondents to truly assess the relationship between food risks and their assigned dollar value (Mitchell and Carson, 1989; Belzer and Theroux, 1995; Klose, 1999; Carson et al., 2001). Both of these techniques focus on different small sampled populations, while others aim to measure only specific food risks. Hence extrapolating their values to all population, all food types and their associated pathogen risks may not be appropriate.

Moreover, these studies are more sensitive especially when the considered risk reduction has different severity magnitude. Hammitt and Graham (1999) reviewed 14 contingent valuation studies from 1980 to 1998 and found such studies inadequately sensitive to the magnitude of risk reduction. Such concern has direct consequences on food-borne risk reduction studies since the majority of food-borne illnesses are mild cases and safety programs can be expected to reduce more of mild cases than severe. Hence most of the WTP's stated preference studies may confound estimates of the sensitivity to severity of end-point (Corso et al., 2001). Despite the methodological concerns, the method is grounded from welfare economics and is a convenient way to reveal individual WTP for a reduction of food-borne illness.

Unlike the COI and the stated preference methods, the WTP's revealed-preference valuation technique attempting to estimate the benefits associated with reducing food-borne illnesses are limited in number. Although it is difficult to estimate how much extra time is spent to properly cook meat or other food types to kill all food pathogens to reduce food risks, some studies used time-series data to follow changes in consumer demand as a result of reported food outbreak information or new information on the risks associated with a specific type of food to infer the risk-averting behavior of individuals, which can be used as proxy of the WTP value.

The paper also adds a new perspective into the literature that pulls the attention from pathogens to symptoms or, in other words, the paper calls researchers to consider valuing symptoms rather than pathogens. The approach also side-steps the issue related to morbidity risks. Most food-borne illnesses lead to the same symptoms, including diarrhea, vomiting, nausea, abdominal cramps and fever resulting in reduced activity and a few sick days. Unlike other goods such as ecological preservation, goose hunting, etc., food-borne illness is something that every one has probably experienced and individuals can correctly express their WTP to avoid the symptom days. The derived WTP value will cover all pathogens, since people recall the illness symptoms instead of the causing pathogen agent. The approach also eliminates the problem of either using incomplete COI value into cost-benefit analysis of food safety policies or regulations, or extrapolating WTP values of few food risks to all food risks to feed into cost-benefit analysis of such programs.

The next section briefly describes the categories of health effects currently valued in food-borne illness studies. The third section discusses and evaluates existing approaches and techniques used to estimate the monetary value of avoiding foodborne illness. The fourth section presents a new prospective that lays the foundation when eliciting consumer’s WTP to avoid food-borne illness. The last section concludes the paper.

II. Description of Food-borne Health Effects

1. Difference between food risks and other risks

Unlike environmental studies focusing on the health impact of air pollution, where the risk is at least visible or explicit and the individual has the option to remain indoors during a day with bad air quality to mitigate such risks, the amount of microbial pathogens and other chemical hazards in food are invisible and individuals cannot observe the health risk of any food items. Individuals have some caution in their mind and are even more careful when facing air pollution or driving a car. However, when it comes to food, the general population perceives that food risks are minimal. Thus, it seems that there is attitudinal or perception differences when comparing different risks.

On the other hand, epidemiologists clearly acknowledge the uncertainty surrounding the officially estimated incidence rates of food-borne illness due to two main reasons (Lake et al., 2010; Scallan et al., 2011). First, most of the food pathogens that cause illness are still unknown and second, the percentage of unreported and under-diagnosed food-borne illness is very high, simply because many people that experience mild food poisoning do not seek medical attention. Annually, in Canada there are approximately 4 million food-borne illness cases and only 1.6 million are caused by scientifically or clinically known food pathogens (Thomas et al., 2013).

2. Classification of Food-borne Health Effects

Most food-borne illnesses have acute symptoms, which result in reduced activity and a few sick days. Diarrhea, vomiting, stomach cramps and fever are the common symptoms for mild, moderate and severe cases of the illness. Some severe cases may develop into long-term health consequences known as chronic sequelae in the medical literature. All these cases lie under morbidity since such cases only result in nonfatal illness (Todd, 1989; and Mead et al., 1999). Mortality or premature deaths in food-borne illness are not very prevalent but often occur in people with comorbidity, infants, elderly and immune-compromised individuals. It is not clear whether food pathogen is the primary cause of death; however it is obvious that the food-borne illness contributes to the deterioration of health condition for such individuals (Batz et al., 2013).

Morbidity cases are classified by severity. Food pathogen-specific cases can be divided into different severity groups, but the most common categories found in the literature groups severity levels into three. The first level is mild cases and can be defined as self-limiting illnesses that do not require a visit to the doctor. The second level is moderate cases, which consist of cases that require medical consultation either from clinics or emergency departments. Lastly, there are severe cases, which require hospitalization resulting in recovery after hospitalization or death due to complication. Some of the hospitalization cases can develop chronic long-term complications immediately or after few years (Buzby, 2002; Lake et al., 2010; Mangen et al., 2010; Hoffmann et al., 2012 and Batz et al., 2014).

From an economics perspective, the valuation of the above noted food-borne health effects depends on whether individuals reveal or state a willingness to pay value to avoid such health effects. The estimated value depends on the severity level of the health outcome as well as the duration for each defined health state. Clearly, two studies estimating the total dollar value of avoiding the same illness will present different values, with a greater amount for the one that considers moderate to severe levels, that has longer duration, and occurs at early age, and develops chronic long-term complications. Therefore, how to define health effects, whether to consider only acute cases or acute and chronic, influences the economic valuation of food-borne illness since these affect the duration and severity weights for each illness. Also, other socioeconomic factors such as age, gender, education, income, and physical and psychological ability of individuals all influence the estimated dollar value to avoid food-borne illness.

III. Valuation methods

The following section will discuss different valuation methods used to quantify the economic benefits associated with a reduction of food-borne illness.

1. *Cost of Illness Studies*

a. *Origin and types of COI*

Rice (1967) was one of the first who presented a sort of "accounting" framework for calculating annual cost of disease or injury for a given society. The methodology divides the cost into two types: the direct cost (health care expenditure) and indirect cost (income loss due to unworked days). The framework evolved over time and has gone through several methodological refinements, including an addition to capture some of the intangible cost i.e. value for pain and suffering.

Koopmanschap (1998) critically reviewed the approach and despite its critics pointed out the usefulness of the method. First, the approach has the ability to provide some baseline pictures on how big the burden of a specific disease could be. Second, the method has the power to rank disease or illness according to its cost. And finally the method can provide complete and detailed information regarding different health care resources used for each illness. However, many criticize the usefulness of COI and its contribution to the decision-making process (Shiell et al., 1987; Kenkel 1994; Mooney and Wiseman, 2000; Tarricone, 2006).

Depending on the specific objective, most COI studies of food-borne illness base their calculations on the estimated prevalence or incidence rates of the considered disease (Cooper and Rice, 1976; Smart and Sanders, 1976). Prevalence-based studies focus on the annual cost of all existing diseases, while an incidence approach, which is commonly used in food-borne illness studies, attempts to estimate only the rate of disease that appears for the specified period. The incidence approach excludes cost of illness that currently exists but occurred in previous years.

Prevalence-based COI studies are suitable in nature to use top-down data, where per food pathogen expenditure data are identified and then summed up for all pathogen costs together. This is a macro level analysis, whereby health care expenditures are divided into different health sectors and each sector aims to treat different diagnostic diseases. Rice (1967) operationalized this approach. This type of framework is less common in food-borne cost estimation studies.

On the other hand, the incidence-based approach utilizes bottom-up data. Disease incidence rates are at the individual level. Such studies simply try to find the individual total cost associated with each food-borne illness. The next step is to add up all individual costs by disease type. Practically, the macro top-down procedure might sound like an easy approach but this may not be sufficient, especially when the purpose is to find the burden at the individual level or some part of the society.

b. Procedures for Food-borne Cost of Illness Estimation

Like all other fields that employ the method, agricultural and food economists also borrowed the COI method as a starting point to distinguish the burden associated with each food pathogen. Some of the first scholars that applied the COI to food-borne illness include Todd (1989), Roberts and Marks (1995), Buzby et al. (1998), Withington and Chambers (1997), and Roberts (1998). More recently Scott et al. (2000), Majowicz et al. (2006), Havelaar et al. (2007), Henson et al. (2008), Shin et al. (2010), Hoffman et al. (2012), and Scharff (2012) also used the COI method.

Most of the above studies classify food pathogen health effects according to severity level. First, they attempt to calculate per pathogen cost for each health state and later all costs are combined to come up with a single monetary value. Most of the studies focus on a single or a few important pathogens and may either include some acute, chronic symptoms or long-term complications. Perhaps the most well known cost calculator of food-borne illness is the United States Department of Agriculture's (USDA) Economic Research Service (ERS) online cost calculator. It only estimates five prominent food pathogens, which cost the US $6.9 billion in 2000 dollars. Currently available studies produce different estimates for the same pathogens; therefore it is difficult to compare the estimated monetary value of such studies.

Hoffmann et al. (2012) and Scharff (2012) have used data on annual pathogen-specific incidence. Such epidemiological data primarily comes from various surveillance data systems, hospitalization data, primary care data, laboratory stool tests and food pathogen-specific registration databases as well as expert solicitations. However, such data sources may only represent part of the true annual new cases due to under-reporting and under-ascertainment.

Scharff (2012) includes in his analysis all food-pathogens[3] and estimated an annual social cost of US $157 billion for all pathogens, for the US. Hoffmann et al. (2012) only considered 14 major known pathogens that account for 95% of food-borne illness and hospitalization and 98% of associated deaths in the US. These 14 food pathogens cost the US US$14 billion every year. Scharff's study addresses the magnitude and the overall economic burden due to both known and unknown food related pathogens, while Hoffmann and others aim to aid policy makers by providing economic cost estimates for the most prevalent food pathogens in the US. Therefore, the pathogen considered and the specific goal of the study contributes to the observed differences between existing costs of food-borne illness.

The other factor that can contribute to the differences between studies is the valuation method used. Theoretical economic models that measure benefits of reducing morbidity derive a WTP expression, which consists of four main elements: the value of lost time (both from formal work, leisure and household activities), the cost of mitigating the illness, the disutility associated with the illness, and the value of averting or preventing the likelihood of contacting the illness (Harrington and Portney, 1987; Berger et al., 1987; Cropper and Freeman, 1991; Freeman 2003). Explicitly, this expression contains some cost of illness value. Thus, it became a standard reference on the theoretical relationship between the COI and the WTP valuation methods (Harrington and Portney, 1987).

In practice, the COI valuation captures health care expenditure and income loss due to unworked days. The approach disregards the disutility value associated with illness. Value of lost time is always underestimated in the COI method since this time includes not only work time but also

[3] There are only 30 food pathogens that are scientifically known and have a diagnostic name, while the majority of food-borne illnesses are caused by unknown pathogens.

leisure time and time spent on household activities. However, most agricultural and food economists using the COI valuation technique view it as a lower bound of true willingness to pay since all components of the COI measure can be related to what individuals would be willing to pay for a reduction in food risks. However, such views are not always plausible and the cost of illness is not a good approximation of preference-based WTP measure for health risk reduction since it may not fully capture all medical expenses and income losses due to lack of sufficient data. Therefore, due to such conceptual and methodological problems, the monetary value from COI method may underestimate the true benefits associated with reduction in food risks (Kenkel, 1994).

Most studies estimating the cost of food-borne illness either include an estimate of income lost by working individuals as part of valuing of lost time or both the income lost of the sick individual as well as their caregiver. The COI studies that only estimating productivity lost raises conceptual and methodological issues including: its approach of measuring individuals based on their net consumption ability (their production ability), issue related to omission of non-labor market participants, and finally how to discount lost value for children and adults (Landefeld and Seskin, 1982; Brookshire and Coursey 1987; Antle 2000; Freeman 2003).

Another issue related to the cost of illness and particularly to the cost of food-borne illness studies relate to the controversies surrounding individual versus societal willingness to pay issues. The common practice in economic analysis of food safety favors the societal viewpoint (Roberts et al., 1998; Roberts, 2007). As noted above, COI approach also used a bottom-up approach whereby basically costs are constructed from the individual cost of illness and finally summed up to all individuals experiencing food-borne illness in a given year. The question is: can these costs be viewed as what society is willing to pay for a reduction of food risks? To illustrate, if for example an older person's medical costs and forgone income are calculated to represent his willingness to pay to reduce food risks, is society at large willing to pay the same amount to reduce such risks for that person? Clearly, these type of analyses fall under individual versus social willingness to pay fallacy[4].

2. COI and Quality Adjusted Life Years (QALY)

Several empirical studies attempt to solve some of the evident drawbacks of the COI by incorporating their cost estimation into quality adjusted life year (QALY) loss value to represent the disutility loss associated with the illness. First, the QALY was originally developed to estimate the results of different health care programs. QALY value is extensively used for cost-effectiveness analysis and sometimes appears in cost-benefit analysis of safety regulations. Basically, individual health states change over time and each health state has value attached to it. Normally, health states can be scaled from one to zero; one being in perfect health at a specific period of time and zero is associated with death (Torrance 1986; and Gold et al., 2002). The QALY is a measure used to quantify difference in health states. The concept can be linked to individual preference, since a health state that is more desirable has greater value and thus a rational individual prefers more of such a health state.

How QALY and preference based individual WTP are related is another issue that sparks debate in the empirical literature (Haninger and Hammitt, 2007 and 2011; Pennington et al., 2013). But,

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[4] This issue reflects the difference between altruistic belief and individualistic motives. Altruistic motives consider any member of the society should be willing to pay for a reduction of risks to individual health. Whether to consider individual cost to be a societal problem is an open question. It's up to the COI researcher to be aware of this issue when dealing with situations where employers pay sick leave days and individuals have medical insurance coverage.

this paper will only focus on how the method can be applied in estimating the benefit of reducing food-borne illness.

Generally, to derive QALY metrics, health outcomes are defined in terms of different health states and each health state is valued at a particular point in time, then these values are summed over time to yield a QALY single value. Discounting can be applied when QALY numbers are used either in cost-benefit analysis or cost-effectiveness analysis (Hirth et al., 2000; Pinto-Prades et al., 2009).

Hoffmann et al. (2012) and Batz et al. (2014) recently computed comprehensive QALY values for 14 known food pathogens by taking a series of recursive steps. They first built a detailed quantitative pathogen-specific disease outcome tree, characterizing different health states and their outcomes, then scored each health state in the disease outcome tree on the EUROQUL-5 (EQ-5D) domain scale. EQ-5D assesses five domain health states. Each domain scale is categorized by 5 health states: mobility, self-care, usual activity, pain/discomfort and anxiety/depression. Then once the domains are defined, researchers ask people to rate their illness by one of the EQ-5D three scales. For example, if a respondent says he has a problem of mobility, he can choose to rate the level of his problem by either selecting one of these scales: no problem in walking, some problem in walking or confined to a bed. Once EQ-5D for every health state is constructed, researchers converted each EQ-5D weight to general population-based health related quality lost (HRQL) preference weights. To illustrate, studies report that Listeria monocytogenes food-borne disease has 21222 EQ-5D scores and population-based HEQL weight is 0.7080 (Batz at al., 2014). Then QALY loss due to food-borne illness will be the difference between HRQL weight for each health state and the HRQL[5] weight for condition prior to illness. Then QALY numbers are multiplied by the value of statistical life year (VSLY).

Although monetized QALY can be considered an important measure that can estimate an individual's value for a single day with compromised health, most food-borne illness studies use illness severity weights that were estimated from healthcare professionals but not truly based on actual measurements of food-borne patients' quality loss values (Haninger and Hammitt, 2011). Even though healthcare professionals and other experts may certainly be aware of the clinical nature of food-borne diseases and the burden they can cause, it is unlikely that they can judge a patients' real disutility loss value (Weinstein et al., 2009).

In addition to that, the above recursive steps are not always practically feasible and part of estimation may rely on assumptions. QALY numbers are sensitive to severity weights, duration of the illness, age, individual perception of the illness and whether survey respondents are the true people experiencing the illness or other members of the community (Gold, 2002; Dolan and Kahneman, 2008; Torrance, 2006). Thus such an attempt of improving the COI may still require a lot of work to do when it comes to the inclusion of cost associated with pain, suffering and other disabilities.

The final issue related to all food-borne cost estimation using either solely the COI method or its modified version involves medical expenditure data such as cost of physician services, pharmaceutical and laboratory costs. These data are used to measure costs associated with mitigating food-borne illness from top-down estimates and are not intended to apply to the bottom-up approach (costing from individual level). This may create inconsistencies since all

[5] Average US population has HRQL of 0.8810; the QALY loss of Listeria monocytogenes will be 0.713 (0.8810 - 0.7080).

food-borne illness data are bottom-up in nature while cost data are available only at aggregate level i.e. top-down.

The evaluation and review of the above methods leads to the conclusion that there is unbalanced effort in the literature on the three universally accepted elements of the WTP valuation technique. That is, the direct cost which contains health care expenditure, the indirect cost which captures forgone income and lastly the intangible cost which represents the value for pain, suffering and other discomforts. Most reviewed empirical studies focus on the first two with limited emphases on the last. Therefore, such studies are not particularly precise, comparable or reliable. Moreover, both modified and basic COI are not exclusively equivalent to the classical WTP estimation approach, but can be used as a component of the total WTP valuation as long as it captures the whole medical expenditure and income losses. The reason why cost of illness is very appealing is due to the perceived relation with the more theoretically preference-based WTP valuation method and also practically, it seems as a straightforward estimation method with clear and market observable data quantities.

3. *WTP technique*

a. *Stated Preference Based Studies*

Contingent Valuation Method

Hypothetical survey based studies designed to elicit individual's WTP for reduced food risks are a steadily growing body of literature. The approach has also benefited from lessons learned in contingent valuation literature for environmental goods. The technique circumvents the non-market existence for different health outcomes associated with food risks and presents respondents with hypothetical markets. Based on these hypothetical markets, respondents assess and state their willingness to pay value for each presented scenario (Mitchell and Carson, 1989; Lin and Milon 1995; Buzby et al., 1995; Fu et al., 1999; Cranfield and Magnusson, 2003).

The most commonly used approach is a discrete choice format where respondents are asked both dichotomous-choice and open-ended valuation questions (Cox et al., 1982; Corrigan et al. 2009). Most studies demonstrate two scenarios: namely, two types of food commodities differing in only two ways: the quality attribute such as risk of illness or death and the associated price (Hayes et al., 1995; Fox et al., 2002; Carson et al, 2007). Then respondents are assumed to be rational and choose only the food that maximizes their utility (Lust and Hudson, 2004; Liu et al., 2005). Alternatively, respondents may be asked to reveal the maximum additional dollar they are willing to offer for the less risky food commodity (Stenger, 2000; List, 2003, Rozan et al., 2004).

Lin and Milon (1995) use a direct questioning survey with a goal to extract consumer's willingness for reduced risk from toxins in shellfish. Henson (1996) studies salmonella in chicken and eggs. Others also studied pesticide residues in food (Buzby et al., 1995 and 1998), while Crutchfield et al. (1997) obtains estimated WTP dollar value for nitrates in drinking water.

Most of the dollar values for reduced food-borne illness derived through CVM particularly focus on only a few pathogens and do not measure all known 30 pathogens as the case of cost of illness studies. Therefore, these values present only part of the cost related to food-borne illness. This is a research area that can be explored in the future and it will allow comparability between cost of illness and contingent valuation approaches.

The CVM is grounded in the theory of welfare economics, which principally argues that rational individuals are willing to pay more as long as they can get a greater utility or can improve their welfare. Others also found that hypothetical survey questions could yield results that are similar in magnitude to the observed market behavior (Hammit and Haninger, 2007). But still there are several problems that arise in the CVM that measures the willingness to pay value to avoid food-borne illness (Cropper 1995; Belzer and Theroux 1995; Carson, 2001; Gyrd-Hanson et al. 2013).

Hammit and Haninger (2007) report relative variation in consumer willingness to pay across different severity level as well as duration of illness, which is not always the case, since people that have the illness for a long time develop some coping mechanism and their WTP will be less then others. Therefore WTP should vary with the level of severity and duration of the illness. This clearly relates to two important factors. The first factor arises from survey design and concerns how different food commodities and their expected risks are communicated in the hypothetical questions. The second factor depends on the ability of the respondent to calculate conditional probabilities associated with different food pathogens, a concept that many people find difficult to understand (Bishop and Herberlein, 1979; Mitchel and Carson, 1981; Klose, 1999; Shogren 1994; Shogren et al., 1999). Undoubtedly, it is difficult for ordinary respondents with the amount of time available to answer all survey questions, to completely assess or understand both the probability of supposedly eating food contaminated with a given pathogen and the probability of getting sick given that such food is contaminated (List and Gallet, 2001; Loureiro et al., 2003). Thus, such methodological bias hinders the overall reliability of using contingent valuation approaches.

The other concern is related to whether the CVM captures all four elements of willingness to pay. This depends on whether study questions are worded to distinguish each component of the WTP so that respondents can at least be able to base their valuation on not only the disutility due to pain, suffering and other discomforts but also consider the cost of mitigating illness, time loss due to illness and cost of averting or preventing actions. This concern is linked to the conceptual debate surrounding the overall willingness to pay itself (Shogren et al., 1994; Cropper and Freeman, 1994; Freeman 2003; Nayga et al., 2005).

Because of the hypothetical nature of the contingent valuation approach, another criticism related to the general CVM is whether survey respondents carefully think of the budget consequences associated of their choice (Mitchel and Carson, 1989; Hayes et al., 1995). This "yea say" type[6] of response usually leads to either an overestimate or an underestimate of the true WTP.

Experimental Market Auction Technique

Unlike the CVM, this technique is nonhypothetical in nature and uses real food products, cash and actual transaction in a simulated market situation (Shogren et al., 1994; Hayes et al 1995; List, 2003). Participants face different food commodities with differing food-borne illness and the associated food prices. Each individual has a budget constraint and is expected to buy safer food items. Although this can be seen as a game with almost a complete similarity to real-world situation, it is something participants still believe is "a game" and therefore their behavior may differ from routine behavior when facing normal real-world trade-offs (Hayes et al., 1995).

The valuation of food-borne illness using lab experiments overcomes some of the hypothetical bias associated with the CVM. The method attempts to provide incentives by creating a normal market structure where buyers and sellers exchange money for food commodities. The stated preference based valuation literature suggests the more realistic design of surveys or experiments, the less hypothetical biasness and greater likelihood of more reliable and valid results (Blackburn et al., 1994; Brown et al., 1996; Fox et al., 1998; and Nayga et al., 2005).

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[6] Some respondents for whatever reason contradict themselves when answering the questions. In contrast to respondents that protest zeros, this group of accepts all offered price bids. Those types of respondents are normally called in the literature "yes say" or "yea say" type.

Most experimental auction studies estimating the WTP for reducing health risks of getting food-borne illness utilize either traditional open-ended WTP questions or closed-ended dichotomous series of questions. The former is very common and can provide detailed statistical information for each response but such format ignores the cognitive ability of the participants. The latter is less popular but considers the individual's ability and what is feasible or not to individuals when answering questions (Hanemann and Kannineth, 1991).

A single bounded (SB) model, double bounded (DB) model as well as one and one-half bounded (OOHB) model are used to estimate WTP[7] for reduced food-borne illness (Herriges and Shogren, 1996). Despite the inconsistencies associated with each of these models, the models offer some advantages in measuring risks related to food. First, the revelation of truthful values is encouraged through the strict rule of the game as well as the use of an incentive-compatible experimental auction mechanism, where the person with the highest bid buys the good at the second highest price (Vickrey, 1961). The benefit of using Vickrey's second-price sealed bid auction is that each participant submits a bid equal to his actual value, which is entirely independent of other participants of the auction. Hence, revelation of truth is a dominant strategy (Vickrey, 1961; Cox et al. 1982; Brookshire and Coursey, 1987). Second, others like Shogren et al. (1999) state that lab experiments have the potential to be replicated to either control for or further understand the ramification of different considered effects in the auction setting. Lastly,

[7] Bishop and Heberlein (1979) is among the first studies using a SB approach in which each respondent is presented with a single monetary amount and the amount is varied across respondents. The DB version is presented as SB format, but after choosing the first-bid, respondents are presented with a second bid with different price and asked whether they would be WTP that amount. While the OOHB approach is slightly different from DB approach by giving respondents two prices up-front and were told the price of the good lies within the range bounded by these two prices. If the respondents choose a price that is below the range, there will be no second price bid.

as Golan and Kuchler (1999) note, the technique incorporates the recognition that individual preferences are unique and that consumer' demands for risk reduction vary.

Although the stated preference valuation method can provide better estimate than the COI method when estimating the benefits for food risk reduction, the potential drawback to both CVM and the experimental auction technique is that it is unclear how far their results can be extrapolated from a one-meal study to a study for all food types. Clearly, group dynamics and composition have certain levels of influence in both methods. For example, Fox et al. (1995) employed the experimental auction method and found the WTP value between US$0.50 and US$1.40 for a pork sandwich that had a lower risk of salmonella contamination. The study used a sample of undergraduate students in four regions of the United States. Generalizing such a WTP value to other food pathogen risks or to the entire population may misrepresent the true value of avoiding food-borne illness. Most stated preference studies in measuring benefits of food safety either focus on a small part of the population or a few food-borne illnesses, which limits their role in cost-benefit analysis of food safety regulations.

b. Revealed Preference Studies

Unlike other described methods, a limited number of studies used WTP's revealed-preference valuation technique to estimate the benefits associated with reducing food-borne illness. Observed market data is used to retrieve individual choices since individuals buy goods and services that yield the highest utility. Hammitt (1993) used market price cross-sectional data for 27 types of fresh produce consisting of organic and non-organic food. He argues that prices of organic fresh produce are always higher so people who buy more of organic reveal their willingness to pay higher price for safer food.

It is clear that part of preferring organic produce might relate to risk-averting behavior; however, it is unlikely that safety is the only reason inducing people to buy more expensive organic food products as there are conjoint factors that individuals value for organic produce such as taste, and other traditional or cultural reasons.

On the other hand, some revealed-preference studies use time-series data containing information about specific food recalls due to violation of mandated regulations to infer changes in the consumption of such food type over time. For example, van Ravenswaay and Hoehn (1991) analyzed how individual WTP for Alar-free apples changed due to changes in information related to the health risks associated with the type of chemical used to grow apples. Foster and Just (1989) used a similar approach to derive a WTP value for milk in Hawaii.

An obvious shortcoming of using market based demand data is that individuals may overreact to new information conveying the level of risk associated with food. The other issue is that consumers may have other unobservable motives to increase or decrease the demand for food for a given period. Hence such issues might overestimate or underestimate the true WTP value.

IV. WTP Survey

The following section will present a new perspective when estimating the expected benefits of reducing food-borne illness. The goal is to draw the attention of agri-food economists to consider valuing symptoms rather than individual pathogens. The last part of the section will highlight the WTP survey instrument.

1. Valuing Symptoms

This paper suggests a new perspective that is not considered in the existing literature that measures the reduction of food-borne illness. The new approach attempts to value symptoms rather than individual pathogens. Since most food-borne pathogens lead to similar symptoms such as gastrointestinal illness causing diarrhea, vomiting, nausea, abdominal cramps and fever lasting a few days, one can ask individuals their WTP to avoid the symptoms. Unlike the cost of illness method, which presents only a piece of the cost, and the other stated and revealed preference studies that only focus on changes in a few food risks, the proposed approach can elicit the true individual WTP to avoid all food-borne illness regardless of the pathogen.

Although the majority of food pathogens lead to the above symptoms, some of these pathogens may lead to complications that cause long-term disability, yet it is not clear whether there are other factors such as comorbid disease or weak immune system that contribute to the complications. Epidemiologists underline that in Canada, sixty percent of food-borne illness originate from unknown pathogens, while in the US the number is as high as 90 percent (Scallan et al., 2011) Cleary, studies using pathogen specific cases to estimate the monetary value to avoid food-borne illness fail to capture the unknown pathogens. Consequently, food safety agencies should use the derived value of WTP to avoid the symptoms, which aggregates all pathogens that trigger food-borne illness, in their cost-benefit analysis to evaluate the efficiency of proposed food safety policies.

The proposed method also side-steps the valuation of small changes in risks. Methods of obtaining monetary values for improvement in health were originally motivated to value reduction in the risk of death. Early scholars developed two approaches to measure policies that aim to save lives or reduce the probability of death. The first was the human capital approach, which values people based on their productivity level or lifetime earnings (Cropper and Freeman, 1991). Then later economists realized that the best approach involves measuring people's WTP for change in the risk of death. This approach avoided the necessity of putting a direct value on human life (Cropper and Freeman, 1991).

In contrast, unlike policies that affect the risk of death, the valuation of policies that affect food-borne illness is simpler because individuals can experience the adverse health effect and use this experience to inform their WTP to avoid subsequent experiences. Therefore we can ask respondents their WTP to avoid symptoms directly, without requiring them to value changes in risks.

To derive the individual's WTP[8] for food safety policy that aims to prevent food-borne illness we assume that individual utility depends on c and s where c is consumption of daily goods and services, and s is health state measured by symptom days with $s = 0,1, \dots, S,$ where $s = 0$ corresponds to no symptom days i.e. perfect health and S is the highest sick days. Since individuals are rational their expected utility function can be expressed as $U(c, s)$. When the duration of food-borne illness symptoms increases, expected utility declines, or in other words

[8] The author thanks to Professor Leslie Shiell, for developing the expression of individual WTP to avoid the illness.

utility diminishes with the number of sick days i.e. $U(c,0) > U(c,1) > \cdots > U(c,S)$; consequently the individual will be worse off.

Individuals aim to maximize their utility by choosing options that yield the highest possible welfare gains. Now suppose that individuals are told that government will announce a new medication pill and the pill will prevent food-borne illness with probability 1. Individuals who buy the pill will not be sick, while those who do not buy the pill will be sick for s days (Alberini et al., 2004). Note that the pill will not be covered by a health insurance plan. Let v be the individual's WTP for the pill. Hence, v reveals the maximum amount that the individual is WTP for the pill to avoid food-borne illness. It follows that:

$$U(c-v,0) = U(c,s) \tag{1}$$

The above function implicitly defines $v = v(c,s)$ where v is the individual WTP for the pill.

A first-order approximation of $U(c-v,0)$ around $v = 0$ gives;

$$U(c-v,0) \approx U(c,0) - U_c(c,0)v \tag{2}$$

In reality, in the absence of the pill, a person does not know with certainty what health state he or she will be in during the period under consideration. To incorporate uncertainty into the model, let p represent the probability that a person can experience food-borne illness, i.e. $s\,\epsilon\,[1,\ldots,S]$, and $(1-p)$ be the probability that he/she does not experience any food-born sickness, i.e. $\mathrm{s} = 0$. For a person who gets sick, it is reasonable to assume the symptom duration is randomly distributed and follows some known distribution. Thus, s is conditional on the individual's expected utility given by

$$E\{u\} = pU(c,s\ ) + (1-p)U(c,0) \tag{3}$$

By plugging (1) and (2) into (3), expected utility can be re-written as;

$$\mathrm{E}\{\mathrm{u}\} \approx \mathrm{p}[\mathrm{U}(\mathrm{c},0) - \mathrm{U_c}(\mathrm{c},0)v\,] + (1-\mathrm{p})\mathrm{U}(\mathrm{c},0) = \mathrm{U}(\mathrm{c},0) - \mathrm{pU_c}(\mathrm{c},0)v \qquad (4)$$

To express the individual's expected utility into monetary terms, $U_c(c,0)$ will be divided into equation (4)

$$\frac{\mathrm{Eu}}{\mathrm{U_c}(\mathrm{c},0)} \approx \frac{\mathrm{U}(\mathrm{c},0)}{\mathrm{U_c}(\mathrm{c},0)} - pv \qquad (5)$$

Note that the marginal effect of a change in probability p is $\frac{\partial[\mathrm{Eu}/\mathrm{U_c}(\mathrm{c},0)]}{\partial p} \approx -v$.

The above model yields an individual WTP expression for a unit change in p as: $\frac{\partial[Eu/U_c(c,0)]}{\partial p} \approx -v$. The derived WTP expression represents the amount of money to be taken away from an individual to keep his/her expected utility constant.

There are two ways that p can influence expected individual utility: (1) if the probability of food risk is low then the expected individual utility will be high since health state directly enters into the utility, (2) if food risk is still low, expected expenditure on health care decreases, consequently the amount of resources or income left for consumption will be high.

If the proposed food safety regulation or policy reduces the probability of acquiring food-borne illness, then the total benefit of such regulation will be equal to:

$\frac{\partial[Eu/U_c(c,0)]}{\partial p}\Delta p \approx -v\Delta p$. In other words, where the WTP expression for a unit change in p is multiplied by the actual change in p resulted from the proposed food safety regulation. The derived monetary benefit will be positive since $\Delta p < 0$. Economists can calculate how much individuals are WTP for such a safety policy, but the total benefit of the policy will depend on the effectiveness of the policy to reduce the level of the risk i.e. Δp. Epidemiologists must provide the anticipated $\Delta \mathrm{p} < 0$.

2. Survey Instrument

The survey will employ a referendum elicitation technique, which consists of dichotomous-choice valuation questions, where respondents decide whether to purchase a medication pill that prevents food-borne symptoms. The survey is organized into three sections. The first section assesses the experience of the respondents with food-borne illness symptoms by asking the respondents whether they had food poisoning in the past 12 months. To help respondents understand the symptoms properly, the questionnaire begins with a section that describes symptoms associated with food-borne illness. Mentioning each pathogen will not add any value to respondents' judgment since people are not familiar with food pathogens but can understand and express how they feel when eating contaminated food.

The second section will make respondents familiar and comfortable with the constructed market scenario. Respondents will get an online tutorial session to understand the presented scenario. Since the survey will be administered through the internet, Visual aid containing colored pictures of someone experiencing symptoms of food-borne illness will be shown to the respondents to help them recall on how it feels when getting the symptoms of food-borne illness.

In the third section respondents will answer WTP elicitation questions, where respondents will be told to imagine a situation where tomorrow, with certainty, they will acquire symptoms of food-borne illness unless they purchase a pill that prevents the illness. Respondents will be shown a description of randomly selected symptom days that they will face tomorrow and a randomly drawn price of the pill. Research indicates that most bouts of food-borne illness last between 1 to 10 days (Scallen et al., 2011). Therefore respondents will be randomly assigned integer-value illness duration between 1 and 10. Symptoms days will be uniformly distributed among the respondents.

Similarly medication pill prices will be assigned randomly to respondents and the price will be drawn from a range of 0-100. The inclusion of zero in the price range may seem odd, but in fact it would be useful to include zero, since it enables to tease-out the group of respondents that decline to pay any price bid. Also one can divide the sample into two groups, a minority group, which receives a price of 0, and a majority group that receives a positive price between 0.5-100. The responses from the first group are useful to assess and validate how well respondents understood the survey questions and how serious they take it when answering the elicitation questions.

Once respondents have that information, WTP to avoid the symptoms will be elicited using double-bounded, dichotomous- choice questions, where each respondent is asked whether he/she is willing to purchase the medication pill at the offered price to avoid the symptom duration that he is facing. Then a follow-up question will be asked by adjusting the initial bid, where the new bid is equal to twice the initial bid if the respondent accepts the initial price or equal to half of the original price of the pill if the respondent rejects the initial price bid.

The intuition of asking respondents a "take it or leave it" offer with a follow-up question is that if the respondent accepts (refuses) the first bid then it is reasonable to assume that he might be willing to pay for a higher (lower) price. However, the follow-up question may influence the respondents' decision[9] of taking or refusing the first offer. Utilizing Internet technology can solve such a concern, since the survey is in online-based format, the questionnaire will be designed in a way that does not reveal to respondents the other questions that they will be asked to answer. Also Internet system allows deactivating or disabling both going forward and

[9] For issues specifically related to the follow-up question see Boardman et al. (2011).

backward to the pages of the online questionnaire. This will ensure the respondent provides his willingness to pay based on the information that is available.

Finally, the survey will use a household sample, where households will be randomly selected from the population aged between 18 and over. If the selected household includes children, the respondent will also be asked two similar sets of questions; one aimed to reveal his/her WTP for the pill to avoid the symptoms and one for the child in the house. Respondents will also be asked about their relationship with the child. To minimize concerns that emerge from survey design, the questionnaire must be structured in a way that conveys the following essential information (Klose 1999; Carson 2001):

- Part one will introduce the purpose of the survey to enable respondents to understand the context of the decision-making.
- Part two describes the good that is being valued i.e. medication pill that prevents food-borne illness symptoms including the price of the good. This part also presents the constructed market scenario and the associated risk probabilities.
- Part three presents the elicitation questions aimed to reveal respondents' maximum WTP to avoid the symptom days, depending on the elicitation format used i.e. single-bounded, double-bounded and one and one-half bounded. All questions must be presented in a form that do not allow respondent to see the following questions.
- The last part captures socioeconomic characteristics of the survey respondents. This section will capture income, gender, education, age, family size, health status, and attitude towards risk. These individual characteristics will be used together with the survey responses, to estimate a discrete choice model, from which the average WTP to avoid symptoms can be derived.

V. Conclusion

Based on the current empirical studies attempting to estimate the aggregate economic cost of food-borne illness, this review paper found that cost of illness is the most commonly used valuation method, followed by the contingent valuation method while only a handful of studies utilize experimental market auction and WTP's revealed preference techniques.

Despite the popularity and seemingly straightforward steps of the COI approach, most of the review studies ignore completely or partly the disutility value due to pain, suffering, functional disabilities and other anxieties, which impose a significant intangible cost on the infected individual. Thus, values derived using the COI technique are not equivalent to the WPT value and it is not always guaranteed to be a lower bound of WTP estimated value, since the reported medical expenses and income losses do not capture all of those costs due to lack of data.

Although an accurately estimated WTP value is ideal, all empirical studies using either contingent valuation or experimental market action and averting behavior technique to value the benefit of reducing food-borne illness are only limited to a few food risks and small population samples. This makes it difficult to extrapolate their findings to all food risks.

The above findings suggest that unless there is a value that considers all food risks and as well captures all significant elements including the WTP value, the efficacy of the proposed food safety programs cannot be assessed completely.

One principal conclusion is that the paper proposes an alternative way to measure the benefit of reducing food-borne illness. We argue to value the symptom rather than the individual pathogens. This approach also side-steps the issue of risk, since food-borne illness leads to the same symptoms where a majority of patients experience some form of diarrhea, vomiting, nausea, abdominal cramps and fever resulting in reduced activity and a few sick. Unlike other goods such as ecological preservation, goose hunting, etc. the novelty about food-borne illness is that it is an illness that every one has probably experienced and individuals can correctly express their WTP to avoid the symptom duration. The derived WTP value will cover all pathogens, since people recall the illness symptoms instead of the causing pathogen agent.

The proposed approach also provides useful information that can be used in cost-benefit analysis to evaluate the efficacy of food safety programs. Since most people have health insurance and do not lose wage pay from taking sick days, the individual WTP, obtained from the proposed survey, will cover pain and suffering. Therefore the full measure of benefits of food safety regulation aiming to reduce the incidence of illness will be equal to the elicited individual WTP to avoid the symptoms of food-borne illness, plus an appropriate measure of medical cost and productivity loss from employers' perspective and then multiplied by the actual change in food risk brought by the change of regulation i.e. Δp.

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