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Health Risk Perceptions, Averting Behaviour, and Drinking Water Choices in Canada

by

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ABSTRACT

Following the economic theory of averting behaviour, this thesis examines preferences for drinking water in Canada. Probabilistic mortality risk perceptions and other perceived water quality measures are included in econometric models of choice, and assessed for their impact, and value. The perceived risk variable is tested for adherence to the theoretical prediction of proportionality in risk reduction values. Data were gathered through an online survey where individuals reported water quality perceptions, mortality risk perceptions and expenditures on drinking water. Risk perceptions were gathered using a risk ladder. Resulting models suggested the existence of two classes within the Canadian population. A risk-sensitive class produced a significant coefficient on the perceived mortality risk variable. A second, risk-insensitive, non-compensatory class did not produce a significant risk coefficient, and analysis suggests that these individuals primarily consume tap water. Contrary to theoretical predictions, tests for proportionality suggest favourability of models with non-linear coefficients on risk variables.

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1.0 Introduction

Every day individuals make tradeoffs for their health and well-being. People buy sunscreen and bottled water, at least in part in an effort to avoid sunburns while sun tanning, or to avoid illness from poorly treated tap water. The functioning of the human body requires that we drink water, and therefore clean drinking water is necessary to the maintenance of good health. Similar to the food one eats and air that one breathes, the water that one drinks is a potential avenue for ingestion not only of pollutants or contaminants, but for microbiological pathogens as well. These pathogens can lead to illness or even death. Keeping in mind the differences in quality, the choice between drinking water alternatives is a textbook example of an averting behaviour, where the individual makes decisions and tradeoffs based on the potential presence of contaminants, or the risk of illness and death associated with water alternatives.

As drinking water is essential to our everyday functioning, it is no wonder, then, that the water from one's tap is treated, filtered, and regulated by governments to ensure that it is safe for drinking. However, despite the regulation and standards for drinking water in Canada, a few cases of drinking water contamination have increased awareness of potential health risks associated with tap water. This increased awareness, coupled with regulated maintenance of the water supply, and dollars spent on additional filtration or bottled substitutes, suggests the importance and value of safe drinking water to the public. The quantification of public benefits or losses, from changes in regulation affecting drinking water quality, may then be useful for making informed decisions about this public service such as investments in water treatment infrastructure, or regulatory changes.

Fortunately, econometric models of averting behaviour and health protection can be estimated to assess preferences for risk reductions. Grounded firmly in economic theory, with the use of health risk perceptions to help understand individual choices, econometric models of choice can provide useful estimates of the perceived monetary benefits or losses from changes in water quality, and health risks. Furthermore, estimates from these models can inform decision makers and administrators, and provide sound information for future policy directives. In this study, drinking water choices and expenditures on drinking water are analyzed, along with perceived risks from drinking water, to help understand averting behaviour in the Canadian public and to provide estimates of the value of health risk reductions in the context of drinking water.

1.1 Background: Drinking Water in Canada

Canadian drinking water offers an interesting case for study of averting behaviour. Relative to many other parts of the world, Canadian drinking water is regarded as clean and safe to drink. Despite this fact, there are rare occasions when contamination of water supplies has lead to illness and even death. Although these events are few and far between, it is likely that they have had a lasting impact on the choices that Canadians make between drinking water alternatives.

Health Canada provides guidelines for Canadian drinking water quality (Health Canada, 2009). These guidelines offer acceptable maximum concentrations of chemical, radiological and microbiological contaminants. The guidelines are a portion of a multi-barrier approach to water treatment, where all systems involved in the collection, treatment, and distribution of water are considered for their potential contribution to water quality degradation. All known potential hazards are addressed with barriers to reduce the risk of contamination of the water supply. Therefore, drinking water is regulated to avoid contamination from both outside sources such as arsenic, which may enter the drinking water supply through industrial effluent or from atmospheric deposition; and from by-products from the treatment and maintenance of drinking water, such as trihalomethanes, which are produced when chlorine reacts with organic matter already suspended in water. These and many more potential contaminants are included in the federal guidelines.

The guidelines are, however, not enshrined into federal law and regulation of day-to-day provision of safe drinking water is left in the hands of provinces and territories. In some cases, the guidelines provided by the federal government may be incorporated in to provincial law, thereby establishing legally binding standards. This, for example, is the case in Alberta (Environmental Protection and Enhancement Act: Potable Water Regulation, 2003).

The human body needs approximately 84 litres of water in a month, and therefore guarantees regular consumption of water (McConnell & Rosado, 2000). Any contaminants in the water supply therefore would be ingested by a great number of individuals. Research on potential contaminants present in our water produced estimates of approximately 90 deaths and 90,000 illnesses annually in Canada from contaminated drinking water (Boyd, 2006). Although this still represents a very low risk to the public, issues related to, and concerns with water quality and drinking water frequently make headlines. In some cases these are severe contamination events. Most notable are the events in Walkerton, ON, where, in the spring of 2000, E. Coli contamination in local drinking water supplies lead to seven deaths, and many more hospitalizations implying total costs of nearly $65 million (CBC, 2000). North Battleford, SK suffered a similar contamination event in 2001, where the presence of cryptosporidium, a parasitic organism, led to an estimated 4 to 7 thousand illnesses in the region (Public Health Agency of Canada, 2001). In 2006, yet another contamination event was recorded, this time in the aboriginal community of Kashechewan, located in northern Ontario. In this case the contaminant, again, was E. coli and resulted in the evacuation of the community and a total cost of over $16 million (CBC, 2006).

The costs and gravity of these events have not only increased awareness of the potential health risks from drinking water, but as a result may have had an impact on choices that individuals make with their drinking water alternatives. The majority of Canadian water supplies, however, have not suffered such serious failures. Therefore, media coverage of water quality issues may produce, in some cases, unwarranted concern. This concern can translate directly into observable averting behaviours, where individuals are trading off quality characteristics and health risks in their water choices. These tradeoffs and expenditures can suggest values that individuals place on quality improvement and therefore can be used as a measure of public benefit or loss from quality changes.

1.2 Economic Models of Environmental Quality Changes

Decisions about the water one drinks are dependent not only on the perceived quality of a baseline such as tap water, but on the perceived quality of other water options as well. Perceived quality, in turn, is based on the quality characteristics of a good, some of which may be health related, and some of which are not. For the study of averting behaviour and water alternatives, measurement of health related quality characteristics and perceived changes are essential. One method for measuring health related quality changes is to address the absolute level of a specific pollutant or microbiological pathogen. Another method would be to address perceived mortality or morbidity risks associated with one or more pollutants or microbiological pathogens. Two streams of economic models are applicable to the valuation of this type of variation in environmental quality. Those derived from expected utility theory involve measurement of risks, and those falling under the category of averting behaviour models primarily involve measurement based on absolute levels of pollutants.

Models derived from expected utility theory have been developed to characterize behaviour under risk. In these models, utility is calculated as the expectation of two uncertain events. For example, if one drinks tap water, there is a risk of illness associated with consumption. Utility in a state of illness is assumed to be less than that in a state of health. Therefore as an individual consumes risky water the expected value of utility will decrease. Under this circumstance, one would be motivated to drink less of the contaminated water to avoid reductions in the expectation of utility.

Another stream of economic models has been developed to analyze the individual's response to absolute changes in environmental quality. These are models of averting behaviour and are focused on the costs imposed by poor environmental quality. Typically in these models, the measure of environmental quality is a variable indicative of a level of contamination, as opposed to the risk level that one would note in a model of expected utility. Again, in the case of water contamination, one would be motivated to drink less of the contaminated water to avoid ingestion of contaminants. The objective of these models is not only to better understand tradeoffs between health protection and consumption but also to develop estimates of the monetary value of improvement of environmental quality for use in policy analysis. Averting behaviours can be used to obtain willingness-to-pay values (WTP) for health protection. Averting expenditure estimates of public benefit or loss are often preferred in policy analysis because of their basis in real market decisions, and because of a proposed theoretical property as a lower bound to willingness-to-pay, which when put together can provide a conservative and realistic estimate of benefits.

Although both expected utility and averting behaviour models are considered as approaches to the valuation of quality changes, they differ in their measurement of quality. Where expected utility models deal with risk explicitly, averting behaviour models are often concerned with contamination levels. The case of drinking water is most often framed as an averting behaviour problem, but rarely has it seen quality measurement based in risk dimensions. In the uncommon case where health risks are evaluated, a qualitative scale often approximates these risks (e.g. Not risky to Very risky) rather than a pure probabilistic risk value. However, models of averting behaviour may benefit from exploration of the use of probabilistic risk estimates in place of absolute contamination levels. Whereas individuals may be unfamiliar with technical names and effects of specific contaminants, it may be the case that they are familiar with probability and risk, which can provide more depth to statistical implementation of the theoretical model. With a foundation in averting behaviour theory, a number of econometric models can be estimated. Of interest here is the application of this theory to the estimation of a consumer choice model.

1.3 Risk Perceptions

Objective risk estimates associated with water alternatives would be ideal for inclusion in a model of averting behaviour. However, these are difficult to obtain for water alternatives, and moreover, in Canada, are likely to approach zero. In the case that these estimates were available, to study valuation of risk reductions and in turn quality improvements, one would be forced either to conduct a stated preference study or to study consumption levels under the assumption that individuals know these objective risk values. The former, though based in the economic theory of averting behaviour, will no longer retain the benefit of basis in real-market decisions. The latter, though retaining a real-market basis, makes a strong assumption about public knowledge of risk values.

To maintain the benefits of basis in real-market decisions, the coupling of consumption information with risk perceptions may be an appropriate solution to the absence, or lack of public knowledge of objective risk values. Furthermore, the use of perceived risks may provide a more accurate picture of behaviour to the researcher. Perceptions of both risk levels and other attributes, as opposed to unknown objective values, are more likely to be the variable on which tradeoffs and consumption are based.

In the analysis of the valuation of perceived risk reductions, economic theory predicts that WTP for risk reduction should change according to the rules of proportionality and appropriate magnitude (Hammit & Graham, 1999). Given a set of estimated models, the evaluation of adherence of WTP to proportionality and magnitude are testable hypotheses. Unfortunately, investigation of appropriate changes in magnitude lends itself best to experimental survey methods. Therefore with the use of averting expenditures and perceived risks, only tests for proportionality can be easily implemented.

1.4 Joint Production

Another concern in the implementation of models of averting behaviour is potential bias due to joint production of utility. WTP values obtained in the absence of joint production are considered to be best. In short, the WTP value reported in a study should be controlled so as to avoid potential confounding elements. For example, if an individual were to purchase a bottle of water because they are concerned about health risks associated with their tap water, they may have made their choice because the bottled water also provided improved taste. The improved taste is a non-health related property, and if it is not controlled for, this property will bias the WTP estimates of health protection.

1.5 Study Objectives

Using an averting behaviour framework, there are three main objectives for this study:

1. To analyze Canadian drinking water preferences through the estimation of an econometric model of drinking water choices.
2. To elicit risk perceptions associated with drinking water and analyze the value of risk reductions through the inclusion of these risk perceptions in an averting behaviour framework.
3. To assess the adherence of risk reduction valuation to the theoretical prediction of proportionality.

Perceived mortality risk will be used in these models. This type of risk variable not only can be investigated for its adherence to the theoretical predictions, but can also be used to calculate the value of mortality risk reductions. The value of mortality risk reduction will enable comparison with, and contrast to, prior estimates and studies. The inclusion of a probabilistic risk variable extends work from other studies, and provides insight into the nature of measurement of environmental quality in averting behaviour models.

1.6 Data

Analysis of drinking water consumption and assessment of the presence of averting behaviour in Canada requires data summarizing consumption, costs, perceived quality, and perceived risk. An online survey is used to collect the necessary variables. Collection of additional perceived quality characteristics will account for issues arising from joint production. Due to the delicate nature of probabilistic risk, and risk perceptions data, the collection of perceived risks is completed using a risk ladder. The use of risk communication devices, such as risk ladders, allows the respondent to more effectively communicate their perceived risk levels. The data were gathered from the Ipsos-Reid online panel. The data content for this project accounts for only a portion of the information gathered in the online survey. Other information gathered in the survey focused on perceptions, and acceptability of reclaimed water for various uses. Researchers from both the University of Alberta, and Brock University were involved in the design and implementation of the survey.

1.7 Expected Outcome

Quality characteristics and expenditure information will be coupled with perceived risk values in the econometric model. Outcomes of the estimated models will offer a snapshot of Canadian preferences for drinking water, will suggest whether the inclusion of a risk variable is suitable in this instance, and will provide insight on the valuation of risk changes. These results will indicate the presence or absence of averting behaviour. It is expected that despite Canada's relatively high quality of tap water, evidence will be found to support averting behaviour with drinking water, and the perceived risk variable will be a significant predictor in the choice between water alternatives.

1.8 Thesis Organization

This thesis is organized as follows. Chapter 2 covers the theoretical framework and predictions for averting behaviour and risk reduction, and reviews the existing empirical research on averting behaviour and water quality. Chapter 3 covers the role of health risk perceptions in this study, and documents all aspects of the design of the risk ladder including analysis of broad level data on mortality in Canada. Chapter 4 describes the implementation of the survey and preliminary results from survey responses. Chapter 5 details the econometric model and the specifics of the data used for estimations. Chapter 6 presents individual model specifications, results of estimation, and interpretations. Chapter 7 is a concluding chapter that summarizes the results from the study, covers limitations and caveats, and outlines directions for future research in the area.

2.0 Theory and Literature Review

In order to value changes in Environmental Quality, statistical models must be grounded firmly in economic theory. The case of drinking water contamination is traditionally framed as a theoretical averting behaviour problem. Economic models, such as the averting behaviour model, are used for the design of statistical estimations, and dictate how calculations of public benefits are obtained. Models of averting behaviour produce very particular problems when calculating WTP values or welfare measures. That is, WTP values produced from averting expenditures are theorized to be a lower bound, but this is only the case in the absence of joint production. Standard economic theory predicts that the values of risk changes adhere to rules of proportionality and magnitude. Therefore, the use of a probabilistic risk variable suggests the need to investigate these predictions. Fortunately, a model of averting behaviour with the inclusion of risk perceptions has been adapted for use in the context of water quality. Averting behaviour theory, subsequent theoretical considerations, and a review of pertinent empirical research are presented in this chapter.

2.1 Averting Behaviour Theory

Economic theory pertaining to health protection is well documented. However, theories of health protection and risk reduction are not unified with theories of averting behaviour. Each must be treated in turn. Typically, health protection (death or morbidity risk) models are framed as an expected utility problem (M. Jones-Lee, 1974; Freeman, 1993). For the case of death risk in these models, the probabilities of each event relate to life and death. In order to measure willingness to pay, the tradeoff between consumption and risk are examined. In other words, as with other welfare analyses, utility is maintained at a constant level, and compensation, or payment amounts are identified that will maintain utility for changes in risk levels. In the case of death risk, this payment or compensation amount depends on whether it is a risk increase or risk reduction respectively. It follows from standard economic theory that the larger the risk reduction the higher the WTP. In the case of a risk increase, it is expected that a willingness-to-accept (WTA) would be observed.

Averting behaviour models are more often framed in terms of environmental quality. That is, typically averting behaviour models do not involve uncertainty. Instead of the treatment of death or morbidity risk, these models focus more on the cleanliness of the personal environment (Courant & Porter, 1981; Bartik, 1988). In the case that perceived risk is analyzed in this framework, applications have seen risk analyzed in a discrete, qualitative (e.g. safe vs. risky) form as opposed to the absolute form (e.g. 5/100,000 vs. 10/100,000) that one might see in a study of risk valuation using theory of expected utility. This may be primarily because the theoretical development of averting behaviour was not tailored to the quantitative analysis of risk.

These models speak more to the assessment of the impact of pollution on personal wellbeing, and clearly document an individual's aversion to some negative characteristic associated with the state of their environment. For example, the disutility from perceived impurity of one's water, insofar as it tastes bad, makes one feel ill or contains pollutants, might be addressed. However, in theory, averting behaviour studies usually do not address the consequences of impurities in drinking water that may lead to a quantitative increase in the risk of illness or death. Although the theoretical development of averting behaviour has not focused on mortality or morbidity risk reduction in particular, the objective of both the expected utility framework and averting behaviour is similar. The differences lie in the specification of variables. Whereas in an expected utility model, the treatment of quality is addressed through the characterization of a risk component of "quality," in averting behaviour models other components of quality (e.g. appearance, contamination levels) might be included in the analysis.

These differences, however, appear only on the surface of the problem. For example, an individual choosing between bottled water and tap water may choose bottled water because it "appears" to be cleaner. In reality, the appearance of the water may allow the individual to form a perception of the risk of illness associated with that water. In other words, if the water looks dirty, one might be likely see it as a potential cause of illness. Therefore the theoretical treatments, though seemingly different, are both targeted towards the analysis of quality changes; consequently, the division between other quality characteristics, and risk, is a grey area.

Courant and Porter (1981) were among the first to frame the averting behaviour problem. The model developed in their treatment involves production of utility from cleanliness. Cleanliness is dependent on the original state of personal environmental quality, and the impact of averting behaviours on personal environmental quality. However, as indicated above, their analysis is completed without mention of risk, or the impact of averting behaviours on risk. Bartik (1988) also contributed to the theory of averting behaviour, and drew upon previous theoretical analyses. The contribution here, however, was also not framed in terms of risk reduction. The assessment by Bartik (1988) focused on non-marginal changes to personal environmental quality, and assessed the impact of these changes on defensive expenditures. Bartik suggested assumptions under which an averting cost measure would be a reliable partial measure of willingness-to-pay. The main assumptions include that the averting activities demonstrate non-jointness in production, and that no significant adjustment costs are incurred with reducing the level of investment in defensive expenditures.

Whereas prior study in the area has focused mainly on valuation of absolute levels of contaminant or pollutants, the present study extends this work through the explicit inclusion of quantitative risk measures. These are included as a method of analysis of changes in expenditures and willingness-to-pay values for small changes in risk. In addition to these properties, the models by Bartik (1988) and Courant and Porter (1981) suggest that under the right conditions averting expenditures can serve as a lower bound to WTP values. These values are derived as lower bounds only when the averting behaviour demonstrates non-jointness in production. That is, if there are other positive benefits associated with the averting behaviour that do not explicitly relate to the change in environmental quality, there is potential for confounding elements to enter any estimated WTP. Willingness-to-pay values for health protection derived from averting expenditures are often preferred in policy analysis because of this proposed theoretical lower bound property. In addition, WTP values estimated from averting expenditures are often based in real-market decisions. The aforementioned theoretical contributions to models of averting behaviour are by and large the basis for most averting behaviour studies.

Recent theoretical contributions to averting behaviour have been made using a household production approach with a focus on morbidity. Dickie and Gerking (1991) developed this method for valuing reduced morbidity. They use their framework in a study that addresses the use of perceived risk information, and addresses joint production of utility through experimental design (Dickie and Gerking, 1996). That is, additional confounding elements that may result in bias in WTP estimates were controlled for in survey design to ensure that the resulting WTP estimates were unaffected by joint production. This method has been used in subsequent work in the valuation of water quality, and is partly the basis of the empirical model implemented in the present study.

2.1.1 Averting Behaviour and Willingness to Pay

Costs incurred by an individual as a result of averting behaviour are theoretically considered as a lower bound measure of willingness to pay. That is, cost of aversion is only a portion of what an individual might be willing to pay for the improved environmental quality level that they have chosen.

The lower bound property of averting expenditures received its primary treatment by Courant and Porter (1981). In this study the authors arrived at two important conclusions. The authors indicate that the bound that averting expenditures place on willingness-to-pay (upper or lower) is dependent on the functional characteristics of the goods that are used to produce personal environmental quality. Furthermore they suggest that there is no assurance that averting expenditures are an accurate approximation to willingness to pay. Despite the limitations described by the study, the application of this framework to water quality, and risk reduction, is often used as material for example and therefore is considered both straightforward, and fitting.

Following Courant and Porter (1981), utility is a function of a numeraire good, *X*, and cleanliness, *C*. Cleanliness in this case would be personal water quality, in other cases it may be described as personal environmental quality:

$$U = U(X, C) \tag{1}$$

In the case of the original model, cleanliness is defined as a function of two variables.

These include a variable that defines the given level of environmental quality, *A*, and an averting behaviour, *S*.

$$C = C(S, A) \tag{2}$$

Given the current level of environmental quality, the individual would choose their level of personal environmental quality via the averting behaviour. In this model it is assumed that for a given level of ambient environmental quality, *A*, cleanliness is purchased at a constant cost, *P(A)*. The problem is analyzed through the use of the indirect utility function:

$$V = V(Y, P(A)) \tag{3}$$

To examine the implications of a change in environmental quality, *A*, the indirect utility function is differentiated with respect to environmental quality and set equal to zero. This allows for the assessment of corresponding changes that maintain utility at a constant level. This follows in expression (4):

$$\frac{dV}{dA} = \frac{\partial V}{\partial Y}\frac{\partial Y}{\partial A} + \frac{\partial V}{\partial P}\frac{\partial P}{\partial A} = 0 \qquad (4)$$

Rearranging this equation, and solving for the change in income with respect to the change in environmental quality we develop the WTP measure:

$$\frac{\partial Y}{\partial A} = C \cdot \frac{\partial P}{\partial A} \qquad (5)$$

The measure presented in equation (5) is the averting expenditure needed to maintain constant utility for a change in the environmental quality.[1] If one were to interpret *A* as a measure of tap water quality, (5) indicates the averting expenditure needed to maintain utility for a change in the quality of one's water.

2.1.2 A Lower Bound on Willingness-to-pay

Courant and Porter (1981) explain that although the measure in expression (5) is the welfare measure that we are searching for, the observed change in averting expenditure is a different measure. The validity of the estimate as a lower bound will depend on the elasticity of the demand curve for cleanliness. The authors formalize this through treatment of the averting expenditure function. The product of price, *P*, and Cleanliness, *C*, defined above, generate the averting expenditure:

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[1] $C = -\frac{\partial V/\partial P}{\partial V/\partial Y}$ by Roy's Identity, See Courant and Porter (1981)

$$E = P \cdot C \qquad (6)$$

For a change in environmental quality, A, this expenditure function will change accordingly:

$$\frac{dE}{dA} = P \cdot \frac{\partial C}{\partial A} + C \cdot \frac{\partial P}{\partial A} \qquad (7)$$

The authors point out that the first term on the right hand side of (7) will determine whether the measure observed is a lower bound or not. For an increase in environmental quality, the second term in (7), which is equivalent to the income change in (5), will be negative; the price of cleanliness will decrease as baseline environmental quality increases. As the authors suggest, the result of the decrease in price will induce an increase in the consumption of cleanliness, and therefore the first term in (7) will be positive. This suggests that the measure from observed averting expenditure will be a lower bound to willingness to pay for the change in environmental quality. The elasticity of the demand curve for cleanliness could be such that the above case does not hold, and the change in averting expenditure may be positive.

Testing for the lower-bound property of averting behaviour estimates is uncommon. Laughland (1996) addresses the potential errors in averting behaviour estimates through the development of correlational predictions between averting expenditure estimates and willingness-to-pay values from a contingent valuation study. Laughland assumes validity of contingent valuation estimates of willingness-to-pay and gauges the averting behaviour estimates by testing whether they are below the values indicated by the contingent valuation study. Conclusions drawn from this study indicate that averting behaviour estimates have construct validity under the assumption that contingent valuation methods can accurately measure willingness- to-pay. Wu and Huang (2001) also test for the lower bound property in an application of averting behaviour to drinking water quality, but results from this study were inconclusive in the demonstration of this property.

Courant and Porter (1981) also point out that certain characteristics of the cleanliness production function must also hold for the observed change to be a lower bound:

$$C_{SA} > 0 \tag{8}$$

$$C_{SS} < 0 \tag{9}$$

When (8) and (9) hold, the lower bound property will hold as well. The first expression, (8), can be interpreted as an increasing marginal product of the averting behaviour in environmental quality. In other words, the extent to which baseline environmental quality will alter the effectiveness of the averting behaviour must be positive for the measure to be a lower bound. Expression (9) indicates that returns to averting behaviour should be non-increasing.

2.1.3 Joint Production and Averting Behaviour

Joint production of utility may invalidate the use of averting expenditure as a measure of willingness-to-pay. Joint production was addressed by Courant and Porter (1981) and is a frequent consideration in studies of averting behaviour. There are two forms of joint production. Conceptually, the first form is a description of the situation in which environmental quality enters the utility function directly as well as through the production of cleanliness. A second form is described by a situation in which utility derived from the averting activity yields both direct utility from some non-cleanliness related characteristics such as taste or odour, as well as utility from the averting characteristics or those that enter through the production of cleanliness. One consideration that may be of importance in the assessment of joint production, is the production of utility that may arise if a water option is considered as a luxury good. That is, the status associated with the product may be another service provided by the averting behaviour. Bottled water might be of most concern for this joint product. Furthermore, in recent times the purchase of bottled water has been frowned upon due to the waste caused by used water bottles. This, too, may be another contributor to utility or, in this case, likely disutility from this water option.

The example used by Courant and Porter is that where environmental quality enters the utility function twice. That is, it will enter the function directly, as well as through the cleanliness production function. This can alter averting expenditure estimates of willingness-to-pay. Courant and Porter (1981, p. 328) suggest that the estimate will change depending on the "complementarity-substitutability relationships among the three elements of the utility function."[2] When environmental quality enters the utility function directly we are presented with an additional term in monetary measurements associated with quality changes. For example, consider utility as a function of the numeraire good, X, cleanliness, C, and environmental quality, A:

$$U = U(X, C, A) \tag{10}$$

[2] See Courant and Porter (1981) for a more complete derivation.

In this case, the indirect utility function becomes:

$$V = V(Y, P(A), A) \tag{11}$$

A change in environmental quality produces the following:

$$\frac{dV}{dA} = \frac{\partial V}{\partial Y}\frac{\partial Y}{\partial A} + \frac{\partial V}{\partial P}\frac{\partial P}{\partial A} + \frac{\partial V}{\partial A} = 0 \tag{12}$$

Expression (12) would replace expression (4) in the presence of joint production. When joint production occurs, the analysis of willingness to pay for quality improvement becomes more complicated because of the additional third term in (12). The willingness to pay expression for the quality change is:

$$-\frac{\partial Y}{\partial A} = -C \cdot \frac{\partial P}{\partial A} + \frac{\frac{\partial V}{\partial A}}{\frac{dV}{dY}} \tag{13}$$

Notice that expression (13) contains an additional term (in comparison with expression (5)). The additional term, the second term on the right hand side of (13), is the direct effect of environmental quality on utility. Courant and Porter (1981) indicate that the reduction in averting expenditure will be greater or less than WTP depending on the inequality presented here:

$$0 \lesseqgtr P \cdot \frac{\partial C}{\partial A} + \frac{\frac{\partial V}{\partial A}}{\frac{dV}{dY}} \tag{14}$$

The second term in the inequality, as indicated by the authors, is positive. However the sign of the first term is that which "depends on the complimentary-substitutability relationships among the three elements of the utility function."

2.1.4 Water Quality: Joint Production and Risk Perceptions

Abrahams, Hubbell and Jordan (2000) adapt the model developed by Courant and Porter (1981) for direct applicability to the problem of drinking water quality and the alternatives that individuals are faced with. They develop a model which controls for a joint product situation in which the averting behaviour provides other "services" to the individual. If one considers drinking water, the averting behaviour is often defined as water that comes from a source other than tap water, or water that has been self-treated. Different sources therefore, in addition to providing improved cleanliness might also offer improved taste, or improved appearance. These characteristics may then obscure the averting expenditure as it will no longer be a reaction to changes in environmental quality alone. Environmental quality is assumed only to enter the utility function through the production of health. In addition to separating the utility derived from quality characteristics from the utility derived from health, the authors use perceived risk as the measure of cleanliness.

They define utility as being a function of consumption of each water source, W_i, a perceived health production variable, H^*, the quality characteristics of each water source, q_i, and a numeraire good, X:

$$U = U(W_1, W_2, W_3, X, H^*, q_1, q_2, q_3) \quad (15)$$

Where subscripts 1, 2, and 3 are indicative of tap water, filtered water, and bottled water respectively.

The researchers point out that this formulation assumes that individuals gain utility both directly through the consumption of water, and indirectly through the production of health. Health production is analogous to the production of cleanliness in the treatment of the original averting behaviour model of Courant and Porter (1981). Joint production from other "services" provided by the averting behaviour is accounted for by separating standard quality characteristics out from those that produce health. The perceived expected health variable, H^* is then produced based on exposure (consumption) to each water alternative. Actual expected health, H, is related to the perceived variable through the use of risk perceptions. Actual expected health uses objective risk measures, π_i :

$$H = H(W_1, W_2, W_3, \pi_1, \pi_2, \pi_3) \tag{16}$$

Whereas for expected health, actual risk values are replaced with perceived risk values, π_i^*:

$$H^* = H(W_1, W_2, W_3, \pi_1^*, \pi_2^*, \pi_3^*) \tag{17}$$

The authors follow Dickie and Gerking (1996) and place perceived risk as a function of the objective risk, as well as attitudes, α, and experiences, β, with water safety:

$$\pi_i^* = \pi_i^*(\pi_i, \alpha, \beta) \tag{18}$$

Where i=1,2,3 for tap, filtered and bottled water respectively. Abrahams et al. (2000) note that both water quality and health risk are weakly complementary to water consumption. Following this, the consumer will maximize utility over X, and W_i subject to, non-negativity constraints on W_i and X, as well as the budget constraint:

$$Y = W_1 p_1 + W_2 p_2 + W_3 p_3 + X \tag{19}$$

This differs slightly from the formulation in the original Abrahams et al. study. In the original study this budget constraint included the average cost of a filter, and specified the same "price" for both tap water and filtered water. In the present study the price associated with each alternative will correspond to the monthly cost associated with adopting that alternative. This will be determined through calculations with the collected data. The price for filtered water will be reflected by the cost of the filtration system, the cost of replacement filters, and the frequency of replacement. The price for bottled water will be the monthly cost for consumption of drinking only bottled water.

Abrahams et al. consider bottled and filtered water to be perfect substitutes for tap water, following the Hanneman (1984) framework, such that these products only differ in their quality characteristics. As a result, at any instant, only one of the goods is chosen for consumption. Given that the objective risk associated with each water type is difficult to attain, the authors assume that the perceived risk is the actual risk and the conditional demand for each water source becomes a function of price, income, perceived risk, quality characteristics, and attitudes and experience about water safety:

$$X_i = X_i(p_i, Y, \pi_i^*, q_i, \alpha, \beta) \qquad (20)$$

Conditional indirect utility functions are obtained through substitution of the conditional demands in to the utility function. The resulting conditional indirect utility functions are:

$$V_1 = V_1(Y, \pi_1^*, q_1, \alpha, \beta\ ) \qquad (21)$$

and:

$$V_i = V_i(p_i, Y, \pi_i^*, q_i, \alpha, \beta) \quad (22)$$

Where i= 2, 3 for tap, bottled, and filtered water respectively. Notice that the conditional indirect utility function for tap water does not include a price. This is because tap water is treated as though it is free. Consumers choose water alternatives if the utility of that choice is greater than that of each alternative (i.e. choose k if $V_k > V_i$ for all $i \neq k$).

2.1.5 Risk Valuation: Proportionality and Magnitude

Willingness-to-pay for personal health protection can be used as an indication of the benefits of publicly provided health protection. In the analysis of risk behaviour, theory predicts two observable expectations for the corresponding willingness-to-pay. These include proportional changes in willingness to pay for changes in risk level (M. Jones-Lee, 1974), as well as corresponding changes in the magnitude of willingness-to-pay for changes in the risk level. For example, for a small mortality risk reduction (e.g. 0.0001%) the individual might express a willingness-to-pay of *x*. If the risk reduction is doubled, then the theoretically predicted change in willingness-to-pay will be double. The new willingness to pay will be approximately 2*x*. Changes of appropriate magnitude are determined by the baseline risk. For example, the WTP for a risk reduction from 100% to 80% probability will be larger than the WTP for a risk reduction from 40% to 20%. This suggests diminishing returns to risk reduction and is an extension of standard economic theory (Hammit & Graham, 1999).

Hammit and Graham (1999) conducted a study in which they provide a summary of both the predictions of proportionality and magnitude, as well as a summary of studies conducted prior to theirs. They provide an overview of 24 studies of health protection. In this overview they summarize whether the estimated models were subjected to an external (between sample) magnitude test, a test for proportionality, and whether the WTP changes in the appropriate direction. External (between sample) magnitude tests refer to a situation in which the respondents are asked about their WTP for only one risk reduction without posing any risk reduction valuation questions prior to the main valuation task. This is done to reduce any error in estimation that may arise from respondents anchoring on previous answers. Of the studies included by the authors, only eight included an external magnitude test. Eleven of fourteen studies that addressed directional concerns showed that the WTP followed the appropriate directional predictions. However, none of the studies summarized demonstrated the predicted proportional change in WTP.

Andersson (2008) suggests that cognitive ability may be the best predictor for WTP answers consistent with economic theory. He indicates that theoretically inconsistent answers may be due to cognitive constraints of individuals. In Andersson's study the cognitive ability of each respondent was assessed by examining both probability knowledge as well as computational ability. With a sample of individuals who were more cognitively able, proportionality could not be rejected. The author briefly discusses results from Hammitt and Graham (1999). Contrary to findings by Andersson (2008), Hammitt and Graham (1999) indicate that probability knowledge did not improve consistency of WTP answers with economic theory. Hammitt and Graham (1999) did, however, indicate that those respondents with a greater deal of confidence surrounding their answers provided more theoretically consistent responses (i.e. demonstrated proportionality). The difference in results here may be attributed to the fact that the study by Andersson (2008) contained a much more rigorous test of individual ability with probabilities and computations.

Hammitt and Graham (1999) point to two other reasons as potential explanations for failure to demonstrate magnitude and proportionality. First they state that psychological research suggests that most people have a poor appreciation for numerical differences in magnitude. Second, and possibly most importantly for this study, it is possible that subjects in any health valuation study do not accept the given risks as applicable to themselves. That is, as suggested by Viscusi (1985), they follow a Bayesian learning process in which they form personal risk beliefs with help from prior risk beliefs and given information. Given these issues it is often suggested that perception information be used as opposed to objective measures of risk. In fact, it is well documented in psychological as well as economic literature that individuals systematically overestimate the frequency of low probability events, and underestimate the frequency of high probability events (Viscusi, 1993, Hakes & Viscusi, 2004).

2.1.6 Summary

This section has outlined a theoretical framework that can be applied to a model of drinking water choices and averting behaviour. This framework outlines that data on consumption, expenditures, perceptions and demographics are required for the estimation of the value of risk reduction. In the analysis that follows, an online survey will provide the necessary data. The framework suggests the inclusion of a risk variable as the measurement of environmental quality and addresses measurement errors created by joint production. Analysis of resulting values will indicate whether the data gathered upholds the predicted theoretical property of proportionality. Reported expenditures in the survey will approximate actual expenditures on water. Therefore, any willingness-to-pay values obtained through resulting econometric models will retain the desirable properties of (1) arising from a real market, and (2) being lower-bound measures associated with models of averting behaviour.

2.2 Averting Behaviour and Water: Empirical Applications

Averting behaviour is associated with many different market choices; some applications include air pollution and noise pollution as well as water pollution. However, averting behaviour is commonly associated with water pollution due to the easily identified behaviours. Therefore a number of studies have focused on water quality. There are two streams in this literature. One stream strives to characterize the choice of averting actions and values implied by those actions.

The other aims to analyze the influence of variables on willingness-to-pay and expenditure values.

2.2.1 Analysis of Expenditures

Abdalla, Roach and Epp (1992) used averting expenditures to approximate the economic costs to households affected by a specific groundwater contamination event in southeastern Pennsylvania. They gathered data during a specific contamination event to ensure only costs associated with the particular contamination event were gathered, and to avoid any impurities resulting from joint production. The decision to avert or not was modeled. The study indicated that the averting decision was significantly affected by the perceived cancer risk related to trichloroethylene (TCE), the amount of information received by the household about TCE contamination, and the presence of children in the household between the ages 3 and 17. The study also attempted to identify factors affecting averting expenditure increases. The authors indicate that the intensity of averting expenditures was significantly affected only by the presence of children under 3 years of age in the household (though this particular model had little explanatory power).

Jordan and Elnagheeb (1993) conducted a study that aimed to explore perceptions of drinking water, and what factors affected willingness-to-pay for improved drinking water quality. These authors used the contingent valuation method to address their research problem. In terms of perceptions, the survey used for the analysis contained a question asking individuals to rate the quality of their water. The authors analyzed the willingness-to-pay value as a function of income, water perceptions, and a number of socio-demographic variables. For both urban and rural water users, the risk perception variable was not significant in their analysis. Education and income were both found to have a significant impact on willingness-to-pay values. Water quality, however was treated in only one dimension, and therefore any estimate of willingness-to-pay will be confounded due to problems with joint production.

Some analysis has focused on the idea of coping costs, rather than pure averting expenditures. In these studies, the goal has been to both characterize averting behaviours for quality issues, but also to characterize any behaviour related to ensuring supply of water. Pattanayak, Yang, Whittington, and Kumar (2005) investigated coping costs, as well as willingness-to-pay values for improved water quality in Kathmandu, Nepal. Multivariate regression models were used to identify factors affecting coping costs. The values measured by Pattanayak et al. (2005) are not directly comparable to the current study, as coping costs for the participants in this study were associated with the aversion of negative health effects from their water as well as an unreliable supply of water. The expected lower bound relationship between WTP and averting expenditures was maintained by the data. Zerah (2000) characterized access to safe drinking water in Delhi in a similar fashion. Zerah (2000) analyzed all coping strategies for water supply problems including both quantity and quality issues. Income and education were particularly important for the decision to treat water in Delhi households.

Hagihara, Asahi, and Hagihara (2004) conducted a study evaluating WTP for publicly provided water quality improvements. Hagihara et al. (2004) gathered data on risk perceptions that characterized whether the individual believed their water quality to be higher, lower, or equal to the standard water quality described by the World Health Organization. The author implemented a conceptual framework by Freeman (1993) in which the willingness-to-pay value for public investment on quality improvement is that which equalizes the marginal rate of technical substitution between private spending and public spending on environmental quality improvements. In this case, the environmental quality improvement being studied was reduction in the risk of developing cancer. They found that when individuals felt risk to be high, the valuation of public investment was lower. That is, the higher the risk, the more likely an individual will be to spend money on averting behaviours, and the less likely they might be to pay for a publicly supplied quality improvement. They report values for annual willingness to pay for reduction of risk of suffering from cancer caused by municipal water supply.

Jakus, Shaw, Nguyen, and Walker (2009) conducted the most recent study of averting expenditures. The study by Jakus et al. (2009) uses similar methods to those used in the present study for collection of a continuous risk perception variable, through the use of a risk ladder. This study was targeted at the impact of risk perceptions associated with arsenic exposure, on bottled water expenditures. Data was gathered from communities with known exposure to arsenic levels that were higher than the legal standard. Perceived risk values were modeled as a function of perceived exposure to arsenic, among other demographics, and were included in a Heckman selection model to investigate expenditures. Results from the study suggested that perceived risks were not a significant variable in the choice to buy bottled water, but were a significant predictor of expenditures on bottled water. The choice to buy bottled water was better explained by other quality characteristics such as taste, or odour.

2.2.2 Analysis of Behaviour

Other researchers have chosen to study averting behaviour values through direct analysis of the behaviour, rather than analysis of the costs. Larson and Gnedenko (1999) analyzed averting behaviours for drinking water in Moscow. Perceptions of quality were gathered from each respondent, and individual logit models were estimated for each behaviour in order to analyze the impact of each variable. However, the quality perception variables were only significant in two of the four behavioural models. McConnell and Rosado (2000) use a nested logit model to estimate the value of discrete improvements in water quality. The logit model is used, in this circumstance, to analyze first, the consumption choices of the respondents, and second, the implied WTP values associated with those choices. This model first addressed the decision to avert or not, then following that decision the choice of water source was modeled. The decision to avert was significantly affected by the presence of young children (5 years old or younger) in the household, income, education, and occupation. The specific averting action undertaken by the household was estimated with only the inclusion of an alternative specific constant and the cost associated with the averting action, both of which were significant. In order to assess the impact of the increase in water quality, they used the value associated with those who boiled their water. This value was used as it was considered the most pure, and free from any joint production, as most respondents considered it to be the safest water, but also felt that it had poor taste and was lacking in other qualities. Respondents rated the "Safety" of each averting option, and in this way the study did gather a form of perception information.

Abrahams et al. (2000) assessed averting expenditures through the use of a choice model. They employed the choice model's ability to address characteristics in order to untangle any errors in valuation that would result from joint production of utility. Information was gathered on perceived risk in a qualitative form. That is, respondents were asked to rate water types on a scale indicating whether they felt each water source was safe or unsafe. The results of the multinomial logit model indicate that risk, race, and age all significantly impact the use of bottled water as an averting action. Information about local water problems, risk, and income were found to significantly affect the choice of filtration as an averting action. Education and age reduced the likelihood of averting in both cases, as did the presence of children under the age of 18, and being non-Caucasian for the filtration option. Information about local water problems, risk perception, and quality (a measure of satisfaction) all increased the likelihood of the two averting options.

More recently, Um, Kwak, and Kim (2002) investigated averting behaviour choices using perception information. They introduce a theoretical model called a perception-ABM, where they used a perceived level of pollution instead of an observed, objective measure. In the Bartik (1988) model, personal environmental quality is replaced with a perceived personal environmental quality, and the pollution level is replaced with a perceived pollution level. The authors analyzed the decision to avert or not for each averting activity using a probit model, as well as the decision to avert or not. The authors found that approximately 75% of the respondents who chose to avert were either exactly, or rationally consistent with their perception of pollution. An averting cost function was also specified in the study. Averting expenditures were significantly affected by current and future perceptions of water quality, both of which increased averting expenditures. Other significant variables are similar to others found in the literature such as, the number of individuals in the household, age, and experience with water problems in the past. Wu and Huang (2001) estimate models of averting behaviour with the aim of testing averting expenditures as a lower bound to willingness-to-pay. Results did not fully support this theoretical prediction.

Rosado, Cunha-e-Sa, Ducla-Soares, and Nunes (2006) approach the valuation of drinking water treatment through the combination of contingent valuation data and revealed preference data. The decision of individuals to treat, or not treat, their drinking water was characterized in a random utility framework, and estimated using a bivariate probit model. These authors found significant differences between WTP values from the two types of data. The WTP estimates associated with the revealed preference data are found to be much higher than those associated with the contingent valuation task. The authors indicate that there was a very small “yes” response overall in the valuation task. In fact, only 19% of households indicated that they would pay for drinking water treatment in this study. This may be due to poor bid design, with a distribution of bids biased towards larger amounts. For example, the bid levels reported in the study included the following: $3, $6, $12, $20, $26, $32, $38, $42, $48. The authors report that for revealed preference data, estimates of monthly WTP were in a $15-$19 range, whereas the monthly WTP from the contingent valuation data were in a $2-$5 range. One would expect that any bid values presented to a respondent that were below the WTP estimated from revealed preference data would produce a ‘yes’ answer for that respondent. However, only three of the bid levels used in the contingent valuation design were below the $15-$19 range. Furthermore, the average treatment cost for an individual to attain the quality improvement specified in the CV task was calculated at $11. Therefore most bid values presented to individuals would either be higher than the WTP estimated from revealed preference data or higher than the individual cost to attain the same benefits as the proposed program. These two factors suggest an overwhelming “no” response would be expected for bid levels above $6. This would in turn bias the estimate received from the contingent valuation data downward, and is a possible explanation for the difference between these two estimates.

Lee and Kwak (2007) completed a Bayesian analysis of a multinomial probit model of drinking water averting behaviours in Korea. Information on perceived quality, or risk was not used in the model of choice. Significant variables for choices were consistent with other studies (young children in the household, education, gender, job, cost). Following McConnell and Rosado (2000) the boiling option was used in order to compute a lower-bound WTP for improved drinking water quality because of the absence of joint products associated with the boiling option (individuals rate the taste as being poor).

2.2.3 Summary

Averting behaviour theory and its empirical application is a well-documented field of economic study, and is well-suited for application in a study of WTP for improved water quality. Upon review, estimated values of quality improvements are variable. By and large these values are not comparable across the literature. This is due to the variability in specification of the environmental quality variable, and the nature of the studies being conducted in the developing world. Of the studies reviewed here, Lee and Kwak (2007), Rosado et al. (2006), McConnell and Rosado (2000), Um et al. (2002), Wu and Huang (2001), Zerah (2000), Pattanayak et al. (2005), and Larson and Gnedenko (1999) were all conducted in the developing world. The other studies such as Abdalla et al. (1992), or Jakus et al. (2009) focus on averting behaviours during specific contamination events, or in specifically affected communities. With the exception of Abrahams et al. (2000) few studies known to the researchers have characterized averting behaviour in the developed world under normal circumstances. Using a continuous risk variable as a measure of environmental quality is an uncommon but attractive approach to measurement in a model of averting behaviour. Jakus et al. (2009) remains the only the study to implement the use of continuous risk variables in the context of water quality. The low popularity of this approach is likely due to the difficulty of collecting the requisite risk perception data. Therefore careful attention must be paid to the risk communication device used to gather these data, as well as to the role of risk perceptions in estimation. Collection of data on individual costs and quality characteristics in addition to a risk perception variable should allow for analysis of the value of water quality improvement that is consistent with the theoretical underpinnings of the choice of drinking water. In addition, such an approach will provide further insight into the behaviour of individuals under risk. Prior estimates of WTP for water quality improvement from the pertinent studies reviewed here are presented in table 2-1.

Table 2-1- Summary of Past Willingness-to-pay Estimates for Water Quality Improvements

Author	Data Source	Reported WTP Value (Per Person/ Per Year)	Type
Abdalla et al. (1992)	Averting Expenditures	$ 20.80	Annual increase in averting expenditures during contamination event.
Jordan et al. (1993)	CVM, WTP for reduction in water pollutant	$ 65.88	Mean of median annual WTP for those on public water supply
McConnell and Rosado (2000)[3]	Averting Expenditures in Brazil	~ $ 150.00	Mean annual WTP for safe drinking water
Abrahams (2000)	Averting Expenditures in Georgia	$ 47.00	Mean annual WTP per person
Um et al. (2002)[4]	Averting Expenditures in Korea (objective change in pollutant)	$ 3.64 - 88.40	Mean annual WTP for a 10mg/l (~3%) reduction in suspended solids.
	Averting Expenditures in Korea (subjective change in pollutant)	$ 218.40 – 317.20	Mean annual WTP for change from current quality to perceived drinkable quality
Rosado et al. (2006)[5]	Averting Expenditures	$ 810.52 – 1013.74	Mean annual WTP for treating drinking water.
	Contingent Valuation Data	$ 147.68 – 271.91	Mean annual WTP for treating drinking water.
Hagihara et al. (2004)[6]	Averting Expenditures	$293.71 – 587.42	Mean annual WTP for reduction in risk of suffering from cancer from municipal water supply.

[3] Note that this study reported a wide variety of willingness-to-pay values, and that which is reported here approximates the lower bound of these values. Values were calculated through comparison and removal of the boiling option.
[4] Variation in value is on account of the method used for valuation of time.
[5] Variation is explained by different heteroskedastic structures of the error term.
[6] Originally reported in Japanese Yen. This value was converted from 2004 Yen value to 2004 USD. Note that the value reported here is that for individuals that had a reasonable evaluation of risk associated with their drinking water.

3.0 Health Risk Perceptions

The theoretical model detailed in the previous chapter specifies the use of risk perceptions as the measure of environmental quality in a model of averting behaviour. In the case of water quality, due to the extremely low probability of illness or death, an objective measure of health risks related to water is difficult to obtain. The correct elicitation of risk perceptions is particularly important to the case of filtered or bottled water, as the implied objective risk value approaches zero. The role of risk perceptions as a determinant in behaviour, as well as empirical applications, measurement, and use of risk perception data are reviewed first in this chapter. The final portions of the chapter first review the design and implementation of risk communication devices, and then detail the development and data analysis completed for the design of the risk ladder used to gather risk perception data in the survey.

3.1 Risk Perceptions

Risk perceptions play a very important role in determining the behaviour of individuals. The use of risk perceptions, as opposed to objective risk information, may be best for the valuation of risk reduction. This is a widely acknowledged suggestion and concern when conducting health risk studies (M. Jones-Lee, 1974; Freeman, 1993; Hammit & Graham, 1999). The perceptions of risk are the foundation of consumption decisions where risk is a characteristic of the good. That is, subjective risk perception is most important to the decision being considered, not objective risk (often known by the researcher). Perception information is often collected for risk valuation studies. However the nature of the perception information is variable.

Some studies use a direct and discrete approach to gathering perceptions of risk. Johannesson, Jonsson, and Borgquist (1991) used a discrete number of risk levels (1%, 2%, 5%, 15%, and 25%). Respondents were instructed to choose the level that most closely represented their baseline risk of heart attack. Johannesson, Johansson, and Oconnor (1996) gathered another discrete type of risk perception to include in estimation. Respondents were asked whether they felt that their risk of death in a traffic accident was higher, lower, or the same as the average driver. Lee, Liljas, Neumann, Weinstein, and Johannesson (1998) used a more continuous approach for the elicitation of risk values, and had respondents indicate verbally where their risk for need of a blood transfusion would fall between very unlikely (1%) to very likely (99%). Abdalla et al. (1992) gathered risk perception values by asking respondents to indicate risk of cancer, from levels of a pollutant in their drinking water, on a rating scale (1=insignificant risk to 5=very serious risk). Hagihara et al. (2004) simply asked individuals whether they thought that their quality of tap water was higher, lower, or at the World Health Organization standard for drinking water quality. The methods summarized thus far primarily involve a direct statement by the respondent or researcher of a probability value. Other methods are available to aid communication of risks between researchers and respondents to more effectively gather, and communicate risk values.

3.2 Risk Communication and Communication Devices

Risk communication devices are increasingly being used with individuals in a variety of scenarios. The primary consideration, in this case, is for those individuals participating in experimental economic surveys to help elicit risk perceptions. However, these communication devices also hold their place in healthcare applications in order to communicate to patients the potential risk accompanied with treatment options. A number of communication devices could be considered for application in an economic survey context. Risk communication devices used previously include iconic representations, grids, risk ladders, pie charts, as well as both direct text and verbal communication accompanied by indirect probability analogies, the latter four of which have been used in valuation experiments and surveys. Risk ladders are risk communication devices that provide a scale with which risks are communicated to the individual. Typically this is a vertical scale, similar to a ladder, with each rung representing a different risk level from low risks, at the bottom of the ladder, to high risks, at the top of the ladder. Grids are another graphical representation of risks for more effective communication with the respondent. These are a square graph where risks are communicated by shading the number of cells that would be representative of the probability. For example, a grid composed of 1,000 cells with 7 cells shaded would indicate a probability of 7 in 1,000. Careful attention must be paid to implications of the chosen device on theoretical predictions of proportionality, psychological effects, and design features in the communication of risk.

Communication with the use of a grid was first applied by Jones-Lee, Hammerton, and Philips (1985) in a study which assessed the value of safety from a variety of hypothetical injuries as well as death. The use of risk ladders to communicate quality changes, though not specific to risk is often credited, in the literature, to have been first applied in a study by Mitchell and Carson (1986) to value drinking water quality changes. Smith and Desvousges (1987) first applied pie charts to communicate risk and risk changes in a survey evaluating hypothetical reduction of the risk of death. Hammit and Graham (1999) analyzed verbal probability analogies,[7] as supplements to the numerical probabilities, to communicate probabilistic changes. Iconic representations are discussed in depth by Ancker, Senathirajah, Kukafka, and Starren (2006) for use in eliciting behavioural changes in hospital patients (e.g. communicate the benefits of quitting smoking).

Attention should also be drawn to the fashion in which risks are represented with risk communication devices. Typically, for the economic study of risk valuation the researcher is concerned with absolute risk levels. However communication devices, such as a risk ladder, also represent risks in relative terms. This can create distortions in risk perceptions of individuals using the communication device. Although a grid may somewhat eliminate this problem by giving a risk representation in terms of frequency, often individuals prefer to have relative risk information available to them. Relative risk information and the

[7] Each numerical risk was accompanied by an analogy. The authors use minutes in a year as an analogy. For example, “a 20/100,000 annual risk is like 105 minutes a year.” This analogy was chosen based on response from focus groups.

chosen communication device can both facilitate the interpretation and placement of personal risks.

Recently Corso, Hammitt, and Graham (2001) conducted a study in which they sought to compare different communication devices for use in economic surveys. Primarily they investigated differences between linear scale risk ladders, logarithmic scale risk ladders, an array of dots, and strict verbal or text communication of risk. The purpose was to evaluate whether communication devices would enhance sensitivity of estimated WTP to the magnitude of risk reduction. The study by Corso et al. (2001) indicated that the array of dots, which are functionally similar to a grid, yielded estimates consistent with economic theory[8], and the logarithmic scale risk ladder yielded results that were not statistically significantly different from what would be predicted by economic theory. The authors suggest that the performance of the dots might have been better on account of its representation to the respondent as a frequency of occurrence, as opposed to a probability. Similar results with regards to differences between probabilities and frequencies have been found prior to the results reported by these authors (Siegrist, 1997). Loomis and duVair (1993) carried out a similar study in which they compared the effectiveness of risk pies, and risk ladders for eliciting WTP responses. The authors reported that each communication device resulted in the estimation of a statistically significantly different logit equation, but that each performed as one would expect in terms of magnitude of risk, and that both were relatively consistent with consumer demand

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[8] Proportionately with the risk reduction at small risk levels, and that higher baseline risks elicited higher WTP values.

theory. Despite occasional consistency with consumer demand theory, it has been shown by some authors that theoretical predictions with regards proportionality and magnitude of risk valuation, in fact, do not hold in the case of some contingent valuation risk reduction surveys (Hammit & Graham, 1999).

A lack of consistency with theoretical predictions may be linked to the “affect heuristic” described in detail by Slovic, Finucane, Peters, and MacGregor (2004). Slovic et al. (2004) indicate that when consequences have significant affective meaning (examples used here include both cancer, and winning a lottery jackpot) the variation in probability carries very little weight. That is, for a given event the imagery generated in the mind of the reader will be identical whether the probability of such an event is 1 in 10,000 or 1 in 1 million. This is similar to the issue of scope encountered in many contingent valuation studies. This particular effect has not been addressed by any of the risk communication devices, and has the potential to affect the validity of risk measures gained through survey responses. Careful attention should be paid to the mitigation of influence from this psychological effect. For a complete description, see Slovic et al. (2006). In the same vein, Itaoka, Saito, Krupnick, Adamowicz, and Taniguchi (2006) investigate the impact of what they call “disaster aversion.” They describe disaster aversion in a similar fashion to the affect heuristic, where the individual bases choices on the losses they would experience if a disaster occurs, rather than the probability of the disaster. Evidence of disaster aversion was found, where the effect of probability on WTP was insignificant, and it seemed that respondents focused on the number of deaths, or the extent of the disaster, rather than the probabilistic representation of the disaster.

Further consideration with regard to risk communication has been researched in the vein of “mental models” for risk representation. Morgan, Fischhoff, Bostrom, Lave, and Atman (1992) proposed a mental model for risk communication. They suggest that most individuals are not to be considered as trained risk analysts, and therefore it is difficult to decide what information they might need for decision making. Therefore, they suggest a representation that is consistent with the existing mental model that a person might have for the risk being considered. Atman, Bostrom, Fischhoff, and Morgan (1994) explain that in effect “a risk communication device” should complete a recipient’s mental model of the relevant risk processes, which means both adding critical missing information and dispelling misconceptions that might affect decisions” (pg. 779). A complete description of this method as well as its application can be found in Morgan et al. (1992).

Ancker et al. (2006) conducted a review of design features for risk communication devices. This particular study was focused primarily on the application of these communication devices to healthcare. The authors discussed the use of verbal/text communication, iconic representations, risk ladders, risk scales, and survival curves. “Iconic representations” included communication using a grid. The authors point to risk ladders or other “sequentially arranged icons” as being successful for respondents placing individual risks in the context of other risks, or for the purpose of comparison. The part-to-whole relationship of the device was emphasized as important for comprehension. Grid-like representations were reported with less conclusive results. Respondents were able to match a numeric proportion to an icon array with that proportion coloured in. However, they were relatively inaccurate when asked to mark the proportion on a blank icon survey (accuracy rates of 51%-98%). Harrison and Rustrom (2006) investigated the effect of financial incentives on the communication of risk from respondent to researcher under the hypothesis that financial incentives would improve the accuracy of responses. Respondents were required to order a number of risky events. They were penalized for the size of difference between what they had marked and what were, in reality, the true risk levels. They conclude that financial incentives had no effect on these responses.

The most popular method for risk communication in recent publications has been the use of a grid, or graph paper (Alberini & Chiabai, 2007; Bhattacharya, Alberini, & Cropper, 2007; Tsuge, Kishimoto, & Takeuchi, 2005, Adamowicz, Dupont, & Krupnick, 2004; Carlsson, Johansson-Stenman, & Martinsson, 2004). Although not specifically in the form of graphical cells, Hammit and Zhou (2006) used an array of 10,000 dots as a visual aid for risk communication. This visual aid has similar characteristics to those held by a grid with a large number of cells due to the representation as a frequency of occurrence, as opposed to a probabilistic representation. Krupnick et al. (2002) used audio aides in addition to the use of a grid. Despite the popularity of these devices some recent studies continue without the use of visual aids (Liu, Hammitt, Wang, & Tsou, 2005; Hultkrantz, Lindberg, & Andersson, 2006).

Research has also been done in the area of fish consumption advisories and the proper form of risk communication for these purposes. It should be noted that the purpose of much of this literature is directed towards the encouragement of behavioural change (reduction in fish consumption). Conelly and Knuth (1998) report the preference of anglers for a quantitative risk ladder over a qualitative representation. Further research by Knuth, Connelly, Sheeshka, and Patterson (2003) suggests the preference for risk-risk comparisons in the communication to the respondents. This is potentially a quality held by risk ladders, particularly in comparison to communication by grid. By and large, the studies summarized above have primarily focused on the communication of risks from researcher to respondent.

For the current project what is of most interest is the ability of a communication device for accurate communication from respondent to researcher. A fair number of studies have already implemented some of the aforementioned risk communication devices for the collection of risk perceptions. Hammit (1990) had focus group participants place their personal risks on a risk ladder, with rungs indicating other death risks. This study gathered both baseline risks and changes in risk based on hypothetical consumption scenarios explained to the respondent. A similar method was employed by Gegax, Gerking, and Schulze (1991) in a wage-risk study where respondents were asked to indicate their perceived risk level for fatal accidents in their workplace on a risk ladder. Dickie and Gerking (1996) also employed this method by having respondents indicate on a risk ladder, their personal risk of skin cancer. Another variation would have individuals circle a rung on the risk ladder that most closely represented their risk (Lanoie, 1995). Other researchers have asked respondents to indicate risk levels by filling in a certain number of squares on a grid in order to communicate their perceived risk level (Persson 2001). Jakus et al. (2009), similar to implementation in the present study and that by Dickie and Gerking (1996), uses a risk ladder to gather perceived lifetime mortality risk from exposure to arsenic in water supplies. The ability of the risk communication device to adequately communicate risk between researcher and respondent is fundamental to the efficiency of data collection.

Visschers, Meertens, Passchier, and de Vries (2009) conducted a literature review of the communication of probability information. The study was mainly directed at communication from researcher to respondent. Pertinent recommendations from this study included the presentation of numerical risk information in terms of probabilities, as well as frequencies with a common denominator. In particular to the use of risk ladders, the authors suggested that anchoring on the risk ladder could bias risk estimates in respondents. However, this particular recommendation was directed at the researcher's presentation of a cause-specific risk to the respondent and future recollection of this value by the respondent, as opposed to the respondent specifying the risk. This effect, however, may highlight the potential for anchoring on the relative risk information presented on the graphic. That is, the perceived risk response may be dependent on the comparative risk that the individual identifies with most, or perhaps noticed first when interpreting the graphic.

Both grids, and risk ladders are likely among the best options for application to gathering risk perceptions. Grids are well documented and have proven useful for communication of risks from researcher to respondent. However it is yet to be concluded if this type of communication would be equally as effective in communication of perceived risk from respondent to researcher. Risk ladders, on account of their ability to communicate other risks for comparison, are likely the most appropriate for communication from respondent to researcher. However, these might be subject to biases as well. For example with a large number of small risks being represented on the risk ladder, the individual might be led to under-represent their perception of the risk being studied. In addition to the comparison between these two methods, the "affect heuristic" should be of concern for any study that might elicit strong mental images for the respondent. Certainly studies involving mortality or serious illness could be counted under this category.

3.3 Risk Ladder Design and Risk Analysis

As a main component of this study hinges on the ability to accurately gather risk perceptions from respondents, substantial effort was targeted at the design of an appropriate risk communication device. Following review of the prominent risk communication devices designed and used in the literature, it was concluded that a risk ladder including relative risk information would be the most appropriate tool for gathering risk perception data. By including information on relative risks to the individual, the respondent will be able to specify their own risks more easily. In order to complete the risk ladder, data on deaths grouped by cause were used to specify risks to the average Canadian from a number of different causes. Brief analysis of the available data suggests that death rates are variable from year to year. Changes and highlights of this data will follow in the discussions below.

3.4 Risk of Death Updates

The crude death rate, over the 2000-2004 period, in Canada is approximately 7.3 deaths for every 1000 Canadians. This is in comparison to a crude rate of 7.2 deaths for every 1000 Canadians reported for 1994 (Thomas & Hrudey, 1997). Despite a relatively static crude death rate, the distribution of deaths in Canada among causes would serve as an indicator of changes over time. Table 3-1 summarizes this distribution for both 2004 and 1994. Deaths in 1994 were taken from a similar table presented by Thomas and Hrudey (1997). Values for 2004 were retrieved from Statistics Canada data on mortality.

Table 3-1- Causes of Death[9]

Causes of Death	Males	Females	Both (2004)	1994	1994(%)	2004(%)
All Causes	**114513**	**112071**	**226584**	**207077**	**100.0%**	**100.0%**
Infectious Diseases	2032	1961	3993	3197	1.5%	1.8%
Cancer	**35864**	**32458**	**68322**	**58311**	**28.2%**	**30.2%**
Blood Diseases	319	481	800	713	0.3%	0.4%
Endocrine and Others	5093	5079	10172	6610	3.2%	4.5%
Mental Disorders	2576	4264	6840	4673	2.3%	3.0%
Nervous System Diseases	4041	6217	10258	5974	2.9%	4.5%
Circulatory System	**36048**	**36695**	**72743**	**78573**	**37.9%**	**32.1%**
Respiratory System	**9985**	**9622**	**19607**	**18342**	**8.9%**	**8.7%**
Digestive System	4279	4381	8660	7679	3.7%	3.8%
Skin Diseases	118	212	330	188	0.1%	0.1%
Musculo-Skeletal Diseases	409	1024	1433	923	0.4%	0.6%
Genitourinary System	2365	2514	4879	3361	1.6%	2.2%
Pregnancy	0	20	20	14	0.0%	0.0%
Perinatal Conditions	543	481	1024	1059	0.5%	0.5%
Congenital Anomalies	424	441	865	1157	0.6%	0.4%
Ill-Defined	1392	1293	2685	3107	1.5%	1.2%
External Causes	**9020**	**4921**	**13941**	**13196**	**6.4%**	**6.2%**

The four causes that are listed in bold are the leading causes of death in Canada. “All Causes” is listed in bold as a reference point. The number of deaths in Canada increased by just fewer than 20,000 between 1994 and 2004. This, for the most part, is likely a natural increase related to the increase in Canada’s population. Deaths resulting from Cancer and Circulatory System combined accounted for 62.3% of all of the deaths in Canada in 2004. Comparison of the distribution in 1994 with the distribution in 2004 would indicate only small changes from year to year in most categories. This is with the exception of deaths

[9]*Source: CANSIM II: Table 1020551- Deaths, by selected grouped causes, age group and sex, Canada, annually, and Thomas and Hrudey (1997)*

associated with the circulatory system, cancer, and the nervous system. These categories each saw relatively large changes when compared to the 1994 data. Cancer related deaths, and deaths related to nervous system diseases each increased over the period, by 2% and 1.6% respectively. Given an aging population such as that in Canada, changes of this nature are to be expected. Deaths related to the circulatory system would also be expected to have increased with an aging population. However, this category experienced the contrary, with deaths resulting from illness in the circulatory system decreasing by 5.8%. In 1994 these deaths accounted for 37.9% of all deaths, whereas in 2004 this figure had decreased to 32.1%. This corresponds to approximately 13,000 fewer deaths in 2004, compared to 1994.

3.5 Implications for Risk Ladder Design

Typically, risk ladders will contain comparative risk information so that the respondent can more easily understand the relative placement of their own risks. For the most part, these ladders are used to communicate risk from researcher to respondent. In this study, however, respondents are required to interpret the risks presented on the risk ladder and then indicate their own personal risk. Review of the pertinent literature suggests that for a risk ladder to be most effective it must not only use a scale that is relatively easy to interpret, but comparative risk information should be as individually accurate as possible. However, achieving this level of accuracy with the available data is challenging for a number of reasons, including the accuracy of the mortality data, and individual specific risk factors related to risk levels. After consideration, the final measure presented on the risk ladder is the risk to the "Average Canadian" for the included causes.

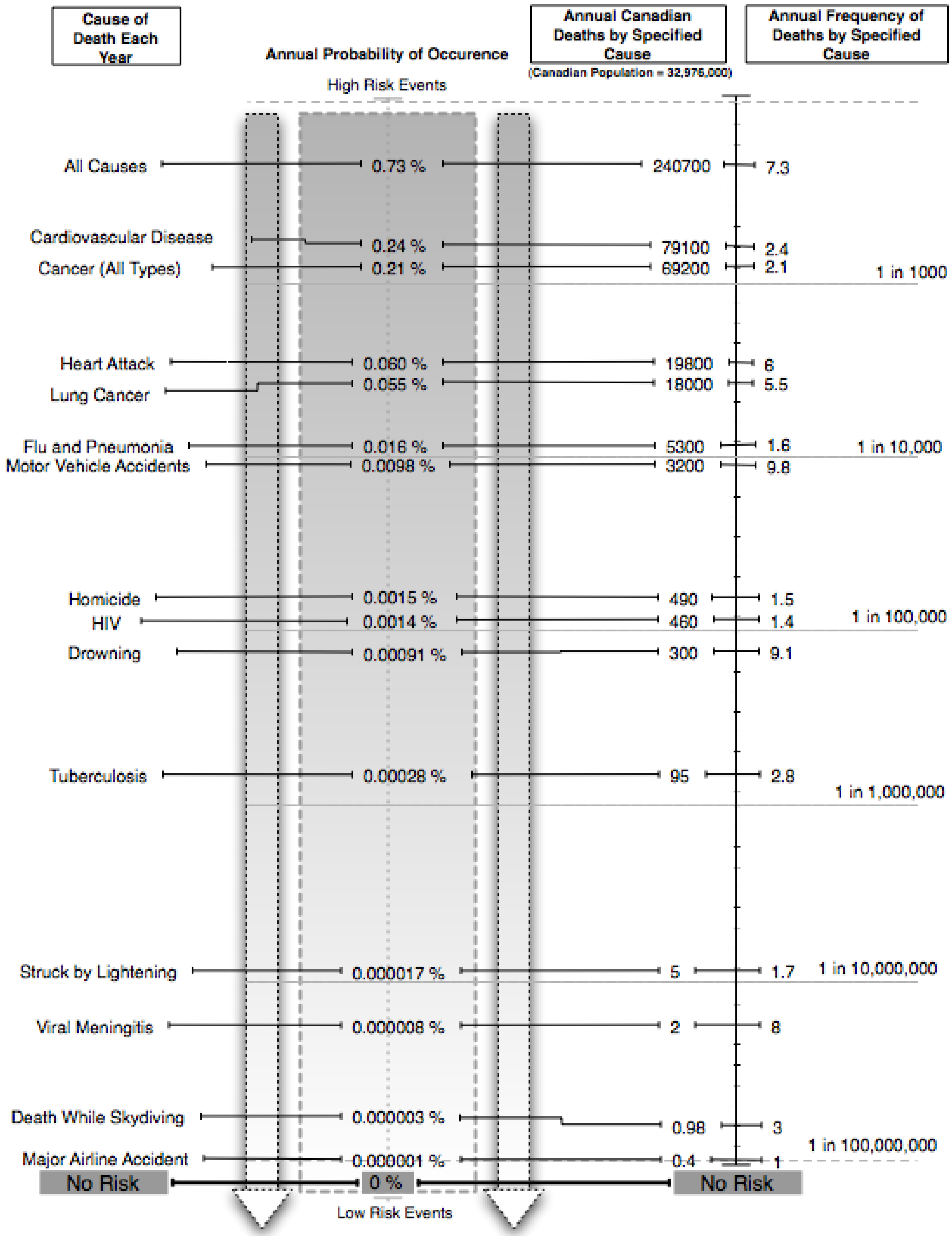
The data available on deaths in Canada are reported by Statistics Canada, and the accuracy of the risk estimates obtained through study are reliant on the accuracy of the data gathered. This is particularly important for comparison over time, because definitions of causes may change from year to year. For example, a number of deaths are reported under the category heading "ill-defined." As improvements are gained in identification of illnesses, the number of deaths reported under this heading is sure to decrease. Although this would likely account for a small amount of the variation from year to year, this may be a source of some change in reported risk levels. Age-specificity is a second factor for consideration in the design of the risk ladder graphic. Brief study of the data suggested that age groups account for a large degree of variation in risk-level.[10] In addition to the age specific dimension of death-risk, individual risk factors play an important role in personal risk levels. A large amount of variation on the level of personal risk is due to risk factors or lifestyle choices including, but not limited to, such things as exercise and diet. In summary, for those individuals with health, and lifestyles that sufficiently deviate from the average, as well for those whose age falls towards either end of the Canadian age distribution, the risk ladder will be less individually accurate.

As a result of the variability in cause-specific death rates from year-to-year, as well as age specificity, and the role of individual risk factors, difficulty arises

[10] See Appendix A for summary graphs detailing risk of death across age groups from selected causes.

in the choice of the risk estimate to include on the risk ladder. Conceptually, an age-specific risk ladder might be most effective, as it would be more individually accurate for the respondent. . However, faced with the objective of creating a graphic that is relatively easy to comprehend both numerically and aesthetically, the resulting decision was the use of cause-specific risks to the "Average Canadian" on the risk ladder. That is, the number of deaths for each cause as a fraction of the total population of Canada expressed as an average over the 2000-2004 period. An alternative measure that could have been used is an age-standardized death risk. This type of measure would account for the age distribution of the Canadian population. The downfall of the inclusion of an age-standardized risk level would be the difficulty of interpretation for respondents of the survey. Simon P. Thomas and Steve Hrudey, in their book, Risk of Death in Canada: What We Know and How We Know it, examine these data as well and indicate that the nature of the data is such that "it is not possible to develop frequency-based estimates on individual risks. Rather, we can only infer what we may expect for any individual from observing frequencies in a population" (19). The measure chosen for this risk ladder is relatively easy to understand for most individuals, and allows the respondents to consider their age and health independently. In particular, it is not possible for the researcher to know the risk factors for each respondent prior to survey implementation, and the complexity that arises from the interaction between age and risk factors may undermine the effectiveness of age-specificity in the risk ladder presentation. The risk ladder used in the study is depicted below in figure 3-1.

Figure 3-1- Risk Ladder



Given the data available, the final design of the risk ladder followed a quasi-logarithmic scale with risks represented both as a probability and frequency. Frequency representations included both the average number of deaths in Canada, as well as translation of the probability into the number of deaths in increasing group sizes (e.g. 1000, 10,000, 100,000 etc.) The scale is linear within each group, and logarithmic between each group.

3.6 Conclusions

Given the state of literature on risk communication devices, and the collection of perceived risk information, the chosen risk communication device for this study was a risk ladder. Analysis of data on mortality in Canada suggested variability in mortality risk due to age, and many other risk factors. In an effort to effectively communicate risks to respondents, the cause-specific mortality risk to the average Canadian was the metric for comparative risks on the final risk ladder. Details on risk perceptions, as well as other quality characteristics and consumption were gathered using an online survey. This graphic was used in the online survey to collect risk perceptions associated with water alternatives. It was modified slightly from its original state to be an interactive graphic, where individuals could choose their perceived risk levels by clicking and dragging a slider up and down the risk ladder. Preliminary results and descriptive statistics from the collection of risk perceptions and other data are presented in the following chapter.

4.0 Survey Implementation and Survey Results

Based on the averting behaviour framework outlined in chapter two, the empirical study of this framework applied to drinking water requires data on water consumption, perceived quality, perceived risks, and monthly costs associated with water options. An online survey was fielded to collect this data. In this chapter, the details of this survey are discussed, followed by brief interpretation of descriptive statistics associated with variables pertinent to the study. Please see Appendix B for a copy of the survey.

4.1 Survey

In order to adequately measure risk perceptions and values associated with water quality, a survey was designed and implemented. The survey was fielded online to a national sample. The survey collected data on consumption behaviour, costs for filtration and bottled water, quality perceptions, attitudes and experience with water quality issues, and demographics as would be needed for study of water choices. As indicated, the data for this study falls within a larger-scale project involving researchers from both the University of Alberta, and Brock University. A secondary focus of the survey was on perceptions and acceptability of reclaimed water for various uses. Therefore, other researchers from these institutions were involved in the design and implementation of the survey, and as such the data summarized here represents only a portion of that which was gathered. The survey was developed using the aid of 7 focus groups, and a pretest with follow-up calls. The pretest was implemented by Ipsos-Reid, and resulted in

128 completed surveys. Particular consideration was given to the design of the risk ladder for gathering risk perception information. The final survey was implemented online using the Ipsos-Reid online panel and garnered 1304 completed responses from which analysis could be carried out.

4.1.1 Behaviour and Cost Information

First, information on experiences with water quality issues, as well as consumption behaviours was gathered. Respondents specified what water sources they considered to be their primary sources. They were also asked for perception information on health risks from their drinking water both personally and in their community, and about specific pollutants, and problems that they may have encountered in their community water supply. To gather consumption information, the respondent indicated the proportions of each type of water that they drink in an average month (Bottled, In-home Treated, or Regular Tap water). Following these questions, information on the cost incurred for purchased or treated water was gathered. For an average month, the respondent was asked to indicate how much money he or she spent on bottled water. For filtration systems, the respondents were asked to indicate the initial cost of the system in use, the amount of money they would spend on replacement filters, and the frequency of replacement.

4.1.2 Perception Information

Drinking water type-specific perception information was gathered with rating scale questions for taste, smell, appearance, and convenience. These data were gathered for bottled, in-home treated (filtered), and regular tap water. In addition to this information two health-risk related variables were gathered in the survey. The first gathered perceived risk of illness, while the second gathered perceived risk of death.

In order to gather the perceived risk of death respondents were presented with the risk ladder. The risk ladder was developed following recommendations from the literature, and used a "quasi-logarithmic" scale[11]. Logarithmic scales were reported as being effective at eliciting the predicted theoretical properties for risk valuations (Corso et al. 2001). The risk ladder contained various types of annual death risks based on Canadian data. The respondents were asked to indicate their perceived personal annual risk of death from each water source. Respondents were asked to provide this number for their current consumption proportions, as well as for a hypothetical situation in which they drink only one type of water (e.g. only bottled water or only filtered water). The risk ladder was an interactive graphic presented in the online survey in which the individual could use a sliding mechanism to choose, and lock in their perceived risk level for each water source. A fully logarithmic scale could not be implemented effectively as it did not allow

[11] That is, each exponential decrease (ex. 10^{-5} to $10^{-6)}$ in the level of risk was given its own linear section in the risk ladder, in which the appropriate decreases (ex. 0.00045% to 0.00040%, a decrease of 0.00005%) were represented in a linear fashion. The "semi-logarithmic" property of the risk ladder describes the appearance of the change between each exponential section.

for the adequate display of other death risk information, therefore the "semi-logarithmic" design was used.

4.1.3 Recruitment and Selection Bias

Members of the Ipsos-Reid online panel were recruited for the survey via E-mail. Recruits were chosen at random from the internet panel. However a suitable distribution, comparable to the Canadian population, in terms of age, income, region, and gender were requested for the sample. Beyond these criteria, participation was at the discretion of the respondent. The use of online survey panels presents the opportunity for bias in the sample. Bias can result from the nature of the individuals that agree to complete the survey, as they may not truly be representative of the Canadian population. First and foremost, these individuals have access to the internet, and E-mail, and may possess other characteristics that are associated with this access. For example, we might then observe a difference in income, or education. Selection bias may also be present because recruitment relies on self-selection, where it may be the case that only individuals interested in drinking water or those with a strong opinion on the subject choose to activate their survey link. Moreover, compensation was offered for survey completion through the Ipsos-Reid point system. This can encourage individuals to complete surveys in the interest of the incentive without regard to survey content, and as a result may be cause for erroneous responses. Consequently the potential for bias in estimation and interpretation should be noted.

4.2 Survey Results

4.2.1 Representativeness of the Sample

Data were gathered in February and March of 2009. The goal for the survey was 1000 respondents. In order to achieve this, 5556 invites were sent out to the Ipsos-Reid online panel. 1304 individuals completed the survey, which would indicate a response rate of 23.5%. The 4251 non-responders include those who quit the survey partway through, as well as those that did not choose to activate their survey link. There were 608 individuals who began the survey, but quit partway through, 50 individuals who activated their survey link after the quota had been filled and 4909 individuals that did not activate their survey link. Table 4-1 compares the data gathered to the 2006 Canadian census for median and mean income, mean age, and household size. Income levels are similar upon comparison of mean values. In the survey sample, the mean household income is $66,899.41, whereas in the 2006 Canadian Census the mean household income is reported as $69,548.00. The mean household income of the survey sample is not statistically significantly different from the mean household income of the 2006 Canadian Census at an alpha-level of 0.02, or 2%. The median household income values, however, are quite different from one another, with median household income in the survey sample being nearly $9000.00 (16.5%) higher than that in the 2006 Canadian Census (See Table 4-1). The median age, and mean household size are also higher than those in the 2006 Canadian Census. The median age in the survey sample is 45, in comparison with a median age of 39.5 in the census.

The mean household size in the survey sample is 2.95 persons, whereas the census indicates a mean household size of 2.50 persons.

Table 4-1- Comparison of Survey Sample to Canadian Census 2006 (Income, Age, Household Size)

Category	***Sample***	***2006 Census***
Mean Household Income ($)	$ 66,899.41	$ 69,548.00
Median Household Income($)	$ 62,499.50	$ 53,634.00
Median Age (Yrs)	45.0	39.5
Mean Household Size (Persons)	2.95	2.50

The regional distribution of respondents in the survey sample was also compared to the regional distribution of population according to the 2006 Canadian Census. Table 4-2 provides the comparison of the survey sample with census data. Each province is treated separately, with the exception of the Canadian Territories. These were grouped, and represent a small portion of the Canadian population. Upon comparison, with the exception of Quebec[12], differences in regional population between data sources are within 1% and the 1305 completed surveys are a statistically representative sample of the Canadian population.

[12] When compared, for Quebec the difference in regional population between data sources is 1.45% and is overrepresented in the survey sample.

Table 4-2- Comparison of Survey Sample to Canadian Census 2006 (Regional Distribution of Population)

Region	***Sample (%)***	***2006 Census***
AB	9.97	10.41
BC	13.65	13.01
MB	2.91	3.63
NB	1.38	2.31
NL	1.15	1.60
NS	3.45	2.89
ON	39.19	38.47
PE	0.23	0.43
QC	25.31	23.87
SK	2.76	3.06
Territories	0.00	0.32

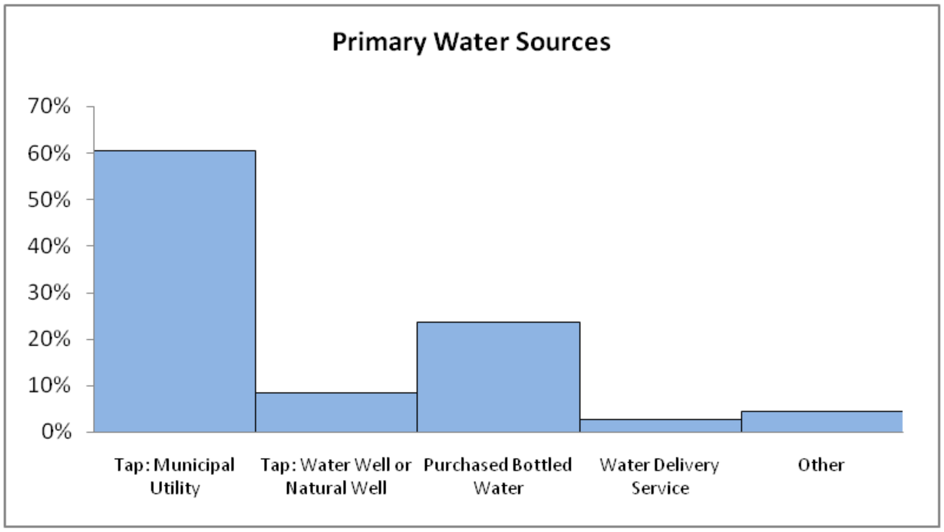
4.2.2 Source of Drinking Water

Respondents were first asked about their sources of drinking water, and were then probed for their "primary" source of drinking water. Figure 4-1 is a histogram summarizing the primary sources of drinking water for the individuals who completed the survey. These values are included in table 4-3.

Table 4-3- Primary Water Sources

Source	***Percent***
Tap: Municipal Utility	60%
Tap: Water Well or Natural Well	9%
Purchased Bottled Water	24%
Water Delivery Service	3%
Other	4%

Figure 4-1- Primary Water Sources: Proportion of Sample



As indicated by the figure 4-1 and table 4-3, the majority of Canadians use tap water as their main source of water, accounting for 60% of primary sources. Bottled water and water from a delivery service are the second largest group accounting for 27% (combined). Water wells or Natural wells account for only 9% of what individuals consider to be their primary sources of drinking water. Those in the "other" category were able to indicate, in a text box, what their primary source of water was. Brief study of the text responses revealed that the majority of those in the "Other" category indicated that their main source of water was filtered water. These individuals would be classified under either "Tap: Municipal Utility" or "Tap: Water Well or Natural Well."

4.2.3 Drinking Water: Consumption and Characteristics

Variables related to each water type are detailed in table 4-4. This table includes the average and standard deviation for the percentage consumption of each water type, expenditures for 100% consumption of each type of water for one month, as well as descriptive statistics for the quality perception variables for taste, odour, appearance, and convenience.

Table 4-4- Variables by Water Type, Average and Standard Deviation

Variable		Tap Water	Filtered Water	Bottled Water
Consumption	*Mean*	**0.51**	**0.20**	**0.29**
	St. Dev.	*0.42*	*0.35*	*0.36*
Monthly Cost*	*Mean*	**$0.00**	**$10.79**	**$101.01**
	St. Dev.	*$0.00*	*$27.98*	*$161.50*
Taste	*Mean*	**4.27**	**4.86**	**5.42**
	Median	*4.00*	*5.00*	*6.00*
	St. Dev.	*1.86*	*1.42*	*1.38*
Odour	*Mean*	**4.28**	**4.94**	**5.57**
	Median	*4.00*	*5.00*	*6.00*
	St. Dev.	*1.87*	*1.46*	*1.33*
Appearance	*Mean*	**4.86**	**5.27**	**5.88**
	Median	*5.00*	*5.00*	*6.00*
	St. Dev.	*1.73*	*1.45*	*1.26*
Convenience	*Mean*	**6.00**	**4.97**	**4.82**
	Median	*7.00*	*5.00*	*5.00*
	St. Dev.	*1.39*	*1.56*	*1.80*

* Monthly Cost is assumed to be zero for tap water. For both filtered and bottled water, this average monthly cost was calculated with outliers removed from the data. Data points that were greater than three standard deviations from the mean were removed for the calculation.

4.2.4 Consumption Proportions

The average respondent in the survey specified a water consumption bundle of approximately 51% tap, 20% Filtered, and 29% bottled water. However, the large standard deviation associated with these variables indicates a high degree of variation throughout this variable. For example, although the average tap water consumption is calculated as 51%, the case may be that a large portion of individuals that drink tap water drink tap water the majority of the time. In the survey sample, 1048 individuals indicated that they drink tap water. Of those individuals approximately 66% of them drink tap water the majority of the time. This trend is apparent in consumption of filtered water as well. In the survey sample, 459 individuals indicated that they drink filtered water. Of those individuals, approximately 59% of them drink filtered water the majority of the time. This trend does not hold as strongly for those who indicated that they drink bottled water. In the survey sample, 943 individuals indicated that they drink bottled water. Of these individuals, approximately 41% indicated that they drink bottled water the majority of the time. This trend indicates strong preferences in the choice of drinking water.

4.2.5 Water Expenditures

The monthly cost reported in Table 4-4 is the average cost for 100% consumption of each alternative for one month. In this study, the cost of tap water is treated as zero. A similar approach was used by Abrahams et al. (2000). The monthly cost of filtration is the sum of costs associated with the purchase or rental of the filtration system itself, and those associated with filters and filter replacements. Respondents provided information on these costs, including: the type of filtration system they use (tap mounted, container style, or refrigerator style), the cost indicated for purchase of the filtration system, the monthly rental cost of the filtration system, the cost of a replacement filter for the system, and the frequency of filter replacement in each system. Each respondent that indicated that they drank filtered water was given the opportunity to answer these questions. In addition to text boxes for numerical input, respondents were given a “don’t know” option, and a “no cost ($0.00)” option for all questions about costs and expenditures. Respondents were also provided with a “don’t know” option for the question on frequency of filter replacement. A high degree of accuracy in the calculation of mean filtration cost is desired for this study. It will be this cost that is used in a model of choice for those individuals that either did not answer the filtration system questions, or for those who do not currently filter their water. In order to calculate the most accurate mean filtering costs, all “don’t know” responses to any of the filtration system information questions were replaced with the median for that question.

In order to calculate a monthly cost associated with the filtration system, provided the system was purchased, the cost of the system (container style, or tap attachment) was amortized over the useful life the product. Abdalla et al. (1992) considered the useful life of a filtration system to be 10 years. In our case, 10 years or equivalently 120 months was used in the calculation of monthly costs for tap attachment filters only. For container style filters, which are likely to see much more wear and tear, 5 years or equivalently 60 months was considered the useful life of the product. The respondent's internal discount rate was used for the amortization calculation. Depending on responses given to questions 46, 47, and 48 of the survey, the respondent's internal discount rate will assume an annual rate of 10%, 20%, 45%, or 65%. The equivalent monthly rate was used in an amortization calculation to produce a monthly cost. These rates are slightly high, however they are consistent with responses in the survey, and on average only a small decrease (less than $1.00) was noted when the same calculations were done using 10% rates for all respondents. No calculation was needed for rental systems. Costs for refrigerator filtration systems were assumed to be zero. Although there may be an implicit cost associated with this feature of a refrigerator, the cost of the appliance was not gathered in the survey. 82 individuals reported themselves to be refrigerator water filter users. This study assumes that those individuals did not purchase the appliance directly for its ability to filter water.

In order to calculate monthly costs associated with maintenance or filter replacement, the reported cost of a replacement filter was amortized over the number of periods indicated by the individual as a replacement frequency. In most cases, this value was between two and three months. For individuals that indicated that they never replace their filters, the lifetime of the product was used. For container style water filters, this was 5 years or 60 months, and for tap attachment or refrigerator filters, this was 10 years or 120 months. Although there is a large variance around frequency of replacement, by and large inspection of the data revealed no correlation between the frequency of replacement, and the extent of use. For example, some individuals indicated that they drank 100% filtered water, but replaced their filters very infrequently, and some individuals indicated that they drink no more than 10% filtered water, but replaced their filters more frequently. Therefore, it is assumed that the percentage of filtered water that one drinks is independent of the frequency of filter replacement. The monthly filtration cost is then the sum of both maintenance costs, and system rental or purchase costs. The average filtration cost for respondents in the survey is $10.79 per month. The standard deviation around the mean, $27.98, is quite large and indicates significant variability in this value.

The monthly cost for 100% consumption of bottled water was calculated by using information on the current cost, and the current proportion of consumption reported by each individual. Costs were inflated to represent 100% monthly consumption of bottled water. For example, if an individual reported spending approximately $1.00 for 1% of their monthly consumption, 100% consumption would cost them approximately $100.00. The average monthly cost for 100% consumption of bottled water was calculated to be approximately $101.01 per month. Again, this value has a relatively large standard deviation of approximately $161.50 indicating significant variability. Both cost values are the products of internal calculations based on survey responses. As a result outlier values will have been created and may skew these averages upward. However, these averages are representative of the sample with the removal of outliers greater than three standard deviations from the mean.

4.2.6 Quality Characteristics

Respondents were also required to indicate their perception of quality of each water type on four dimensions. Each type of water was given a rating between 1 and 7 on taste, odour, appearance, and convenience where 1 is poor, 4 is neutral, and 7 is excellent. The average response, median response, as well as standard deviation for each category is organized by water type in table 4-4. In addition to this value, in figures 4-2 to 4-13, histograms of responses to these questions are presented below. The average responses indicate a preference for the taste, odour, and appearance of bottled water, followed by filtered water and tap water. The convenience rating appears to be a reversal of this trend, with individuals strongly preferring the convenience of tap water, followed by filtered water, and bottled water.

Figure 4-2- Tap Water – Taste Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

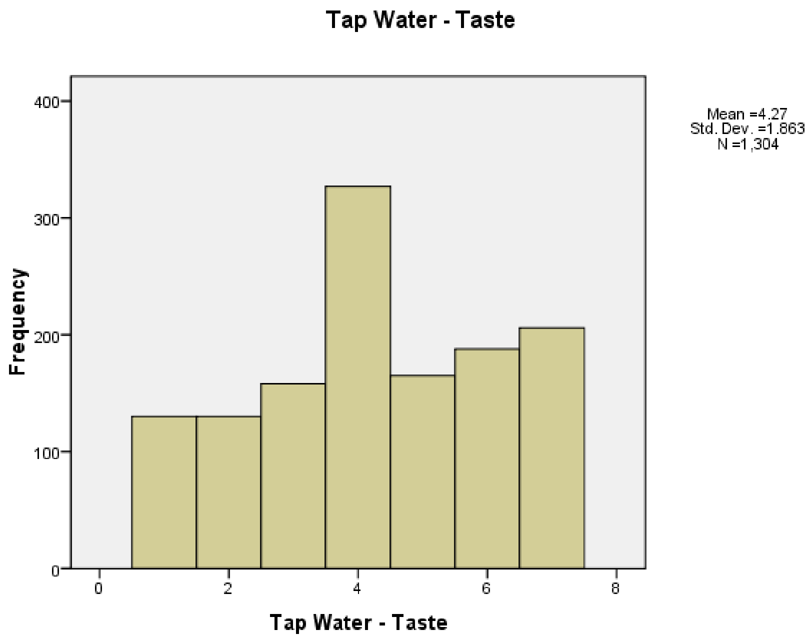


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Figure 4-3- In-home Treated Tap Water – Taste Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

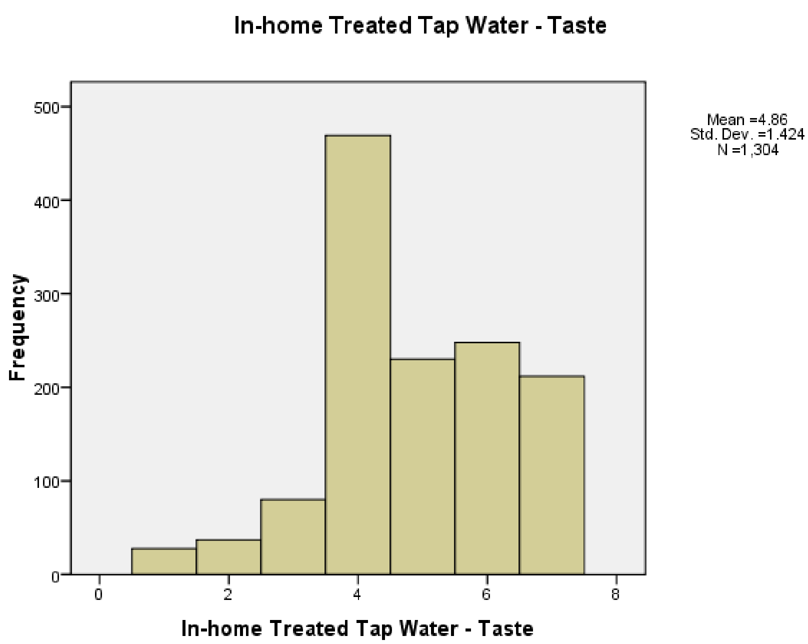


Figure 4-4- Purchased Water – Taste Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

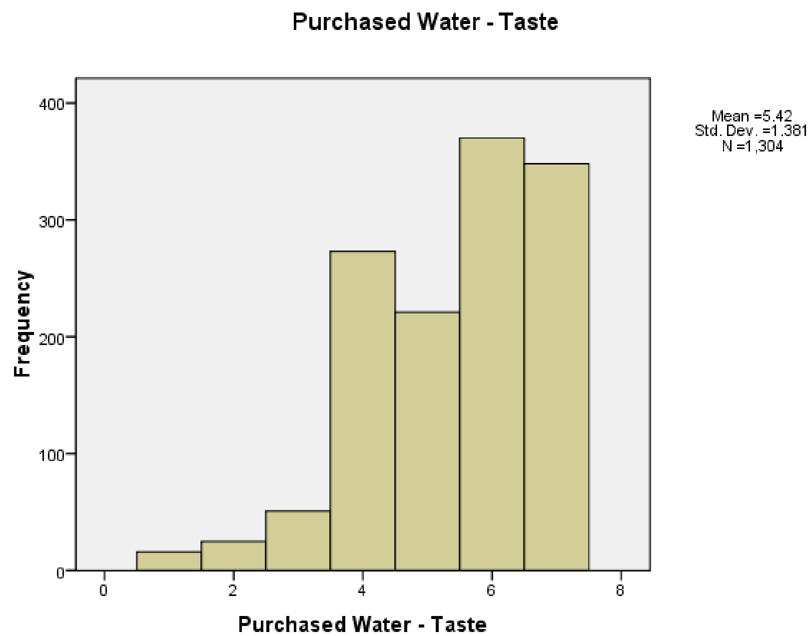


Figure 4-5- Tap Water – Odour Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

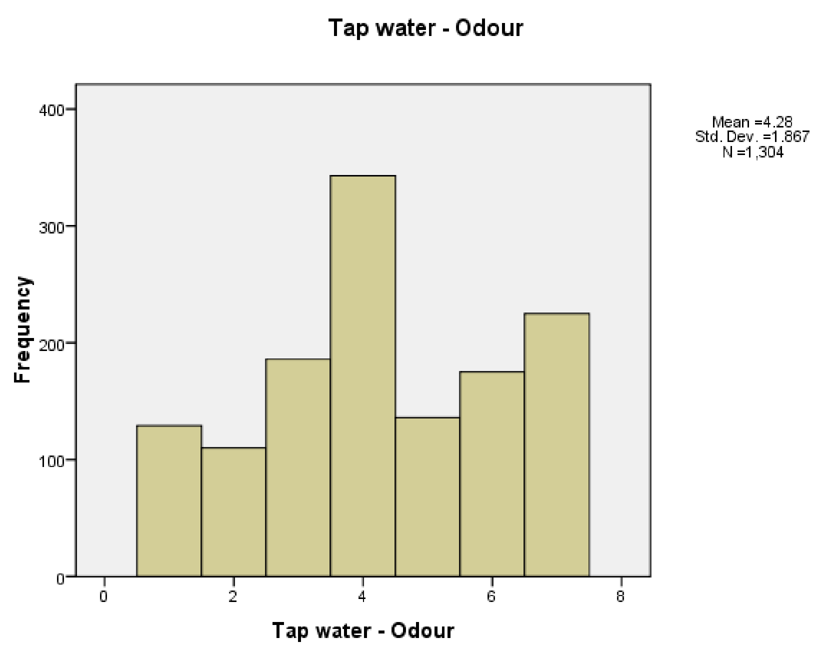


Figure 4-6- In-home Treated Tap Water – Odour Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

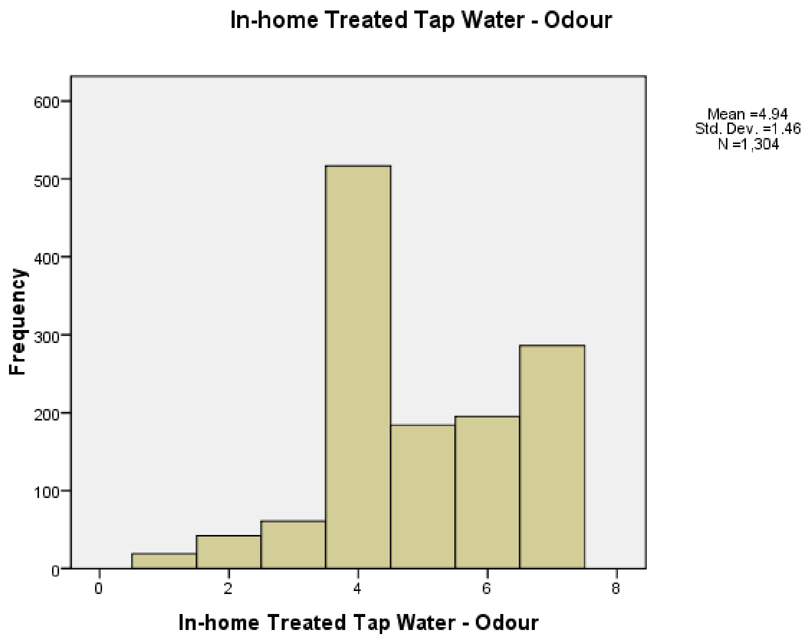


Figure 4-7- Purchased Water – Odour Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

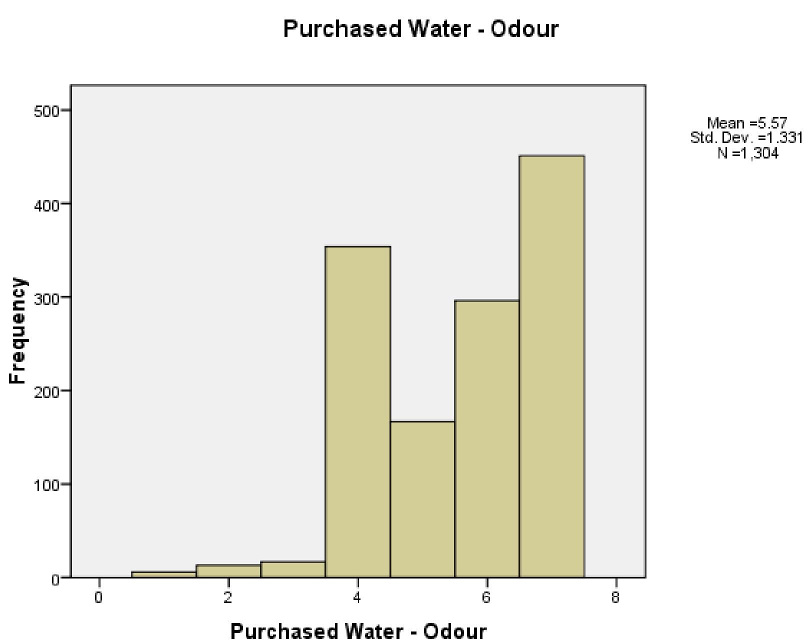


Figure 4-8- Tap Water – Appearance Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

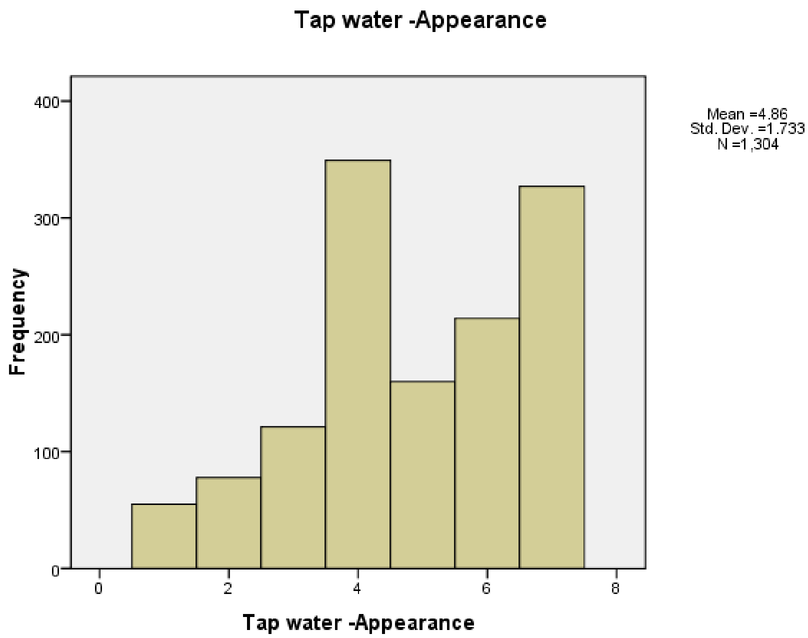


Figure 4-9- In-home Treated Tap Water – Appearance Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

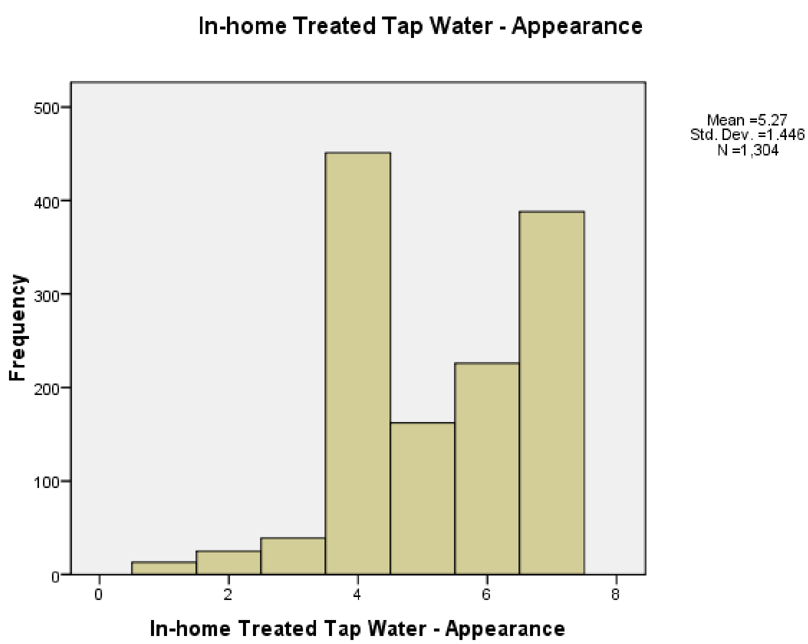


Figure 4-10- Purchased Water – Appearance Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

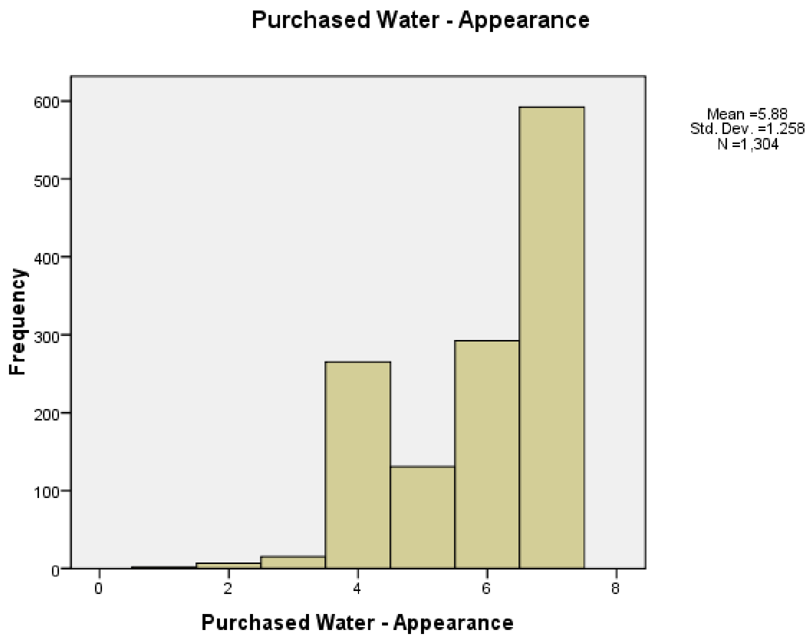


Figure 4-11- Tap Water – Convenience Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

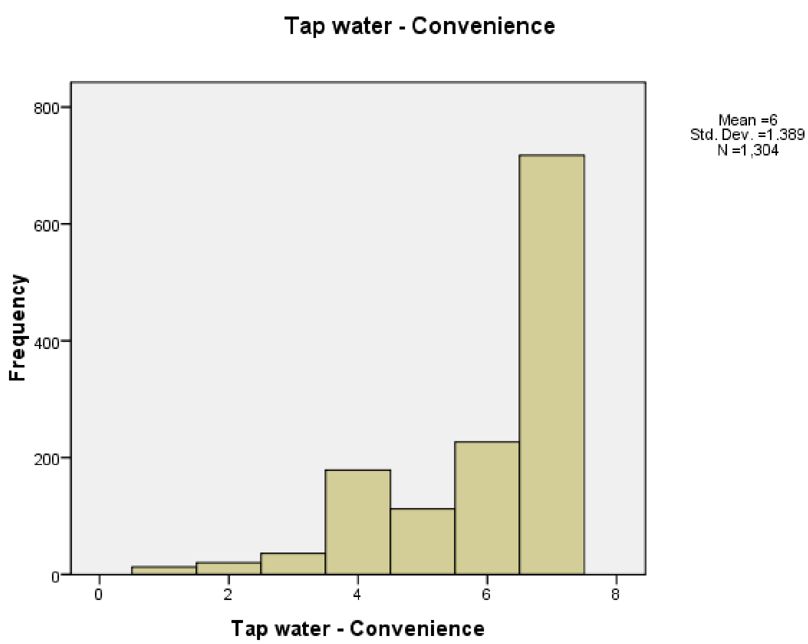


Figure 4-12- In-home Treated Tap Water – Convenience Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.

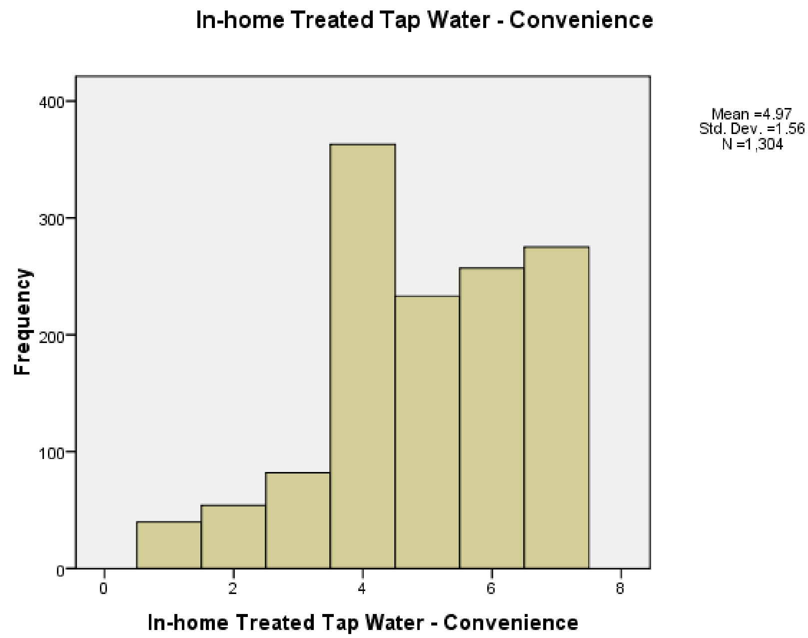
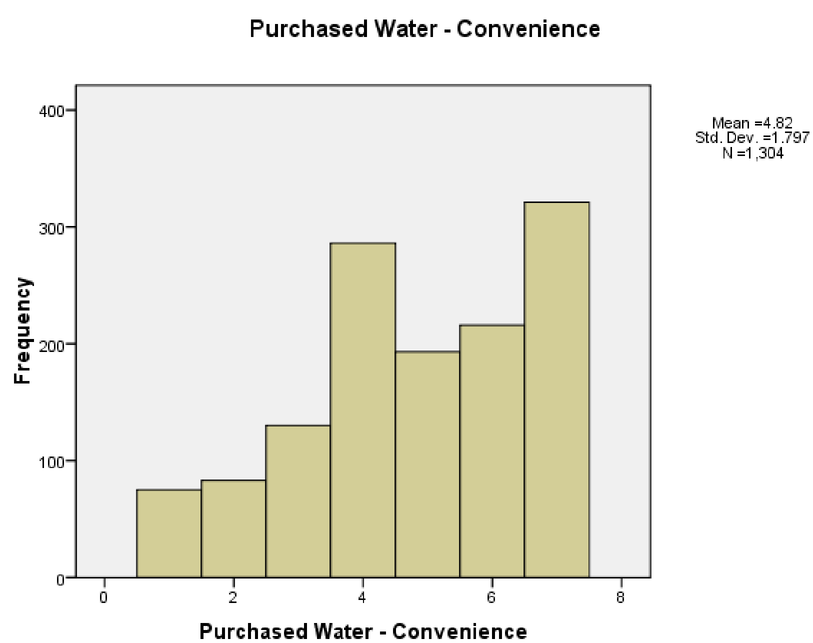


Figure 4-13- Purchased Water – Convenience Responses: A 1 to 7 point scale was used with 1 being poor, and 7 being excellent.



4.2.7 Health Risk Perceptions

Health related variables that will be used in the analysis include responses to the risk ladder questions as well as responses to those questions which gathered both attitudes and experiences with health related variables. The risk ladder was used to gather risk perception data. Individuals were asked to indicate their perceived annual risk of death if they were to consume 100% of each type of water. Because of the scale used on the risk ladder, individuals had access to a large range of values. Several orders of magnitude separated the top portion and the lower portion of the ladder. Due to the potential answers on the risk ladder being bounded from 0-1%, outliers could not be filtered out as they were with other variables, using a rule based on standard deviation. Therefore, in order to reduce the impact of relatively large outliers, the 95th percentile from the tap water risk responses was used as a cut-off point for outlier removal. With this method, 88 of 1304 responses were removed. Table 4-5 details the average perceived risk of death for each water type.

Table 4-5- Perceived Annual Risk of Death: 100% Consumption by Water Type

Water		**Full Sample (%)**	**Risks < 95 Percentile of Tap (Percent)**	**Frequency**		
Tap	**Mean**	**0.013260**	**0.000111**	**11.1**	**in**	**10,000,000**
	Median	0.000002	0.000002	2.0	in	100,000,000
	Stdev	0.095780	0.000571			
Filtered	**Mean**	**0.010395**	**0.000067**	**6.7**	**in**	**10,000,000**
	Median	0.000000	0.000000	0.0	in	100,000,000
	Stdev	0.087094	0.000424			
Bottled	**Mean**	**0.007444**	**0.000059**	**5.9**	**in**	**10,000,000**
	Median	0.000000	0.000000	0	in	100,000,000
	Stdev	0.071046	0.000402			

A second method for removal of outliers was based on a rule of rejection if the response fell above the 97.5th percentile, or below the 2.5th percentile. The 2.5th percentile for all water types was 0%. Therefore, approximately 2.5% of responses with a 0% perceived risk were removed from each category. With this method, 96 of 1304 responses were removed when the same 0% perceived risk responses were removed from each category. That is, individuals that responded with 0% perceived risk for all categories were those chosen for removal. The resulting statistics, using this method, are presented in table 4-6.

4-6- Perceived Annual Risk of Death: 100% Consumption by Water Type Outlier Removal: 2.5% < Risk < 97.5%

Water		2.5 < Risk < 97.5 Percentile (%)	Frequency		
Tap	**Mean**	**0.000744**	**74.4**	**in**	**10,000,000**
	Median	0.000002	2.0	in	100,000,000
	Stdev	0.004784			
Filtered	**Mean**	**0.000109**	**10.9**	**in**	**10,000,000**
	Median	0.000000	0.0	in	100,000,000
	Stdev	0.000681			
Bottled	**Mean**	**0.000069**	**6.9**	**in**	**10,000,000**
	Median	0.000000	0.0	in	100,000,000
	Stdev	0.000433			

In tables 4-5 and 4-6, the average perceived annual risk of death is reported for the full sample, with the uppermost outliers removed, and finally, using a rejection rule keeping responses above the 2.5th percentiled and below the 97.5th percentile. All versions of these values indicate the same relative ranking of these risks, with tap water being reported as most risky, followed by filtered water, and bottled water being reported as the least risky. However the removal of outliers altered the absolute value of the calculated averages significantly. The average perceived annual risk of death from tap water for the full sample is 0.013260% or

1326 in 10,000,000. With the upper 5% of responses removed, this value is reduced to 0.00011% or 11.1 in 10,000,000, and using the final rejection rule this value was approximately 0.000744% or 74.4 in 10,000,000. The average perceived annual risk of death from filtered water for the full sample is 0.010395% or 1039.5 in 10,000,000. Again with the upper 5% of responses removed, this value is reduced to 0.000067% or 6.7 in 10,000,000, and using the final rejection rule, this value was approximately 0.000109% or 10.9 in 10,000,000. Finally, the average perceived annual risk of death from bottled water is 0.007444% or 744.4 in 10,000,000. With the upper 5% of responses removed, this is reduced to 0.000059%, or 5.9 in 10,000,000, and using the final rejection rule this value was approximately 0.000069% or 6.9 in 10,000,000. Although slightly different in terms of average values, overall, both methods for outlier removal maintain the same ranking of water-specific perceived risks.

Finally, attitudinal and experiential variables relating to water quality are needed for inclusion in a model which details risk perceptions (Dickie and Gerking 1996). Several instruments of this type were gathered for use in modeling. From a list of potential pollutants, respondents were asked to indicate whether they had heard about any of those listed, as a concern both personally and in their community. Respondents were also asked to indicate whether they considered that their tap water posed a risk to them or their family's health, whether anyone in their home had fallen ill from the water that they drink, and whether they had any negative experience with their tap water quality. Tables 4-7 and 4-8 summarize some of the results from these responses.

Table 4-7- Reports of Illness

Water	Illness
Tap Water	59
Filtered Water	19
Bottled Water	12
Total	90
N	1304

Table 4-8- Health Concerns: Tap Water

Health Concern	Count
Minor Concern	288
Moderate Concern	108
Serious Concern	41
Total	437
N	1304

In general, very few respondents reported experiencing illness themselves or in their household that they had confirmed to be from the water that they drink. Tap water was reported to be the cause of illness with 59 individuals, filtered water with 19 individuals, and bottled water with 12 individuals. In all, only 90 respondents reported illness associated with the water that they drink. A much larger portion of the sample, however, did report concerns about their tap water. Overall, 437 individuals indicated that they considered tap water as a health concern. Although the majority of these individuals indicate that their concern is minor, a substantial number of these individuals indicated that tap water was either a moderate or serious concern. Finally, individuals were provided a list of potential water quality problems and were asked to indicate whether they had heard of each as a drinking water concern in their community. The list included: E. coli, Cryptosporidium, Giardia (Beaver Fever), Fluoride, Trihalomethanes, Metals (Iron, Lead, Mercury), and Pesticides. In total, 493 individuals reported having heard of at least one of the above water quality concerns in their community, 259 of which reported having heard of 2 or more as a concern in their community.

4.2.8 Discussion

The descriptive statistics and summary data presented in this section provide insight into the data gathered. The resulting statistics indicate a minor to moderate concern with drinking water quality, and imply some form of averting behaviour in the population, and strong preferences for drinking water in the home. Alternatives to tap water, on average, seem to provide improvements on most quality dimensions listed, and a small perceived risk reduction. This data can be implemented in a choice model to assess more precisely the preferences for drinking water in Canada. The following chapter details the mathematics of the econometric choice model, and the necessary modifications to variables included in the model.

5.0 Econometric Methods and Data

A frequent method for analysis of changes in environmental quality is the use of a discrete choice model that examines choices of alternatives. Empirical analysis arising from averting behaviour theory can be conducted in this fashion. Review of the literature indicates a preference for this method in analysis of averting behaviour. Given that data was gathered for three water options, this analysis will be accomplished through the estimation of multinomial choice models. Furthermore, estimation of latent class formulations of the multinomial choice models will be implemented to account for preference heterogeneity in the sample. The nature of the gathered consumption data as a percentage breakdown requires that these models treat responses as grouped data. The mathematics of these models and the differences that arise with the use of grouped data is detailed in this chapter. Following this, the final transformed version of the survey data, to be included in estimation, is presented.

5.1 Random Utility and the Multinomial Logit Model

Data gathered through the survey will be used to estimate a model of choice between water alternatives. Modeling of choices with more than two options in the choice set is conducted using a multinomial or conditional logit model. Estimation of this model type is based on random utility theory. In general terms, a consumer is assumed to choose alternatives that offer the greatest utility. That is, as the utility associated of a good increases, the more likely an individual will be to choose that alternative. For example, assuming disutility from risk of death, as risk of death from tap water increases, the lower the utility derived from tap water and the less likely and individual will be to choose tap water over other water alternatives.

The following exposition primarily follows Hensher, Rose and Greene (2005). In random utility theory, the utility function is assumed to be a function of both the attributes associated with the chosen alternative, as well as an error term that corresponds to a portion of the utility function that is not observable:

$$U = V_i + \varepsilon_i \quad (22)$$

Furthermore we assume that the individual will choose an alternative, j, if the utility associated with that alternative is greater than the utility of another alternative:

$$V_{jn} + \varepsilon_{jn} > V_{in} + \varepsilon_{in} \text{ for all } \quad i \neq j \quad (23)$$

One can define a variable $\Psi_j = 1$ for the consumers' choice of an alternative, j. The probability that individual n chooses an alternative is the probability that $\Psi_j = 1$:

$$\Pr\left(\Psi_j = 1\right) = \Pr\left(\left(V_{jn} + \varepsilon_{jn}\right) > \left(V_{in} + \varepsilon_{in}\right) \forall\, j \neq i,\ i, j \in C_n\right) \quad (24)$$

$$= \Pr\left(\left(V_{jn} + \varepsilon_{jn}\right) - \left(V_{in} + \varepsilon_{in}\right) \leq 0\right) \quad (25)$$

(25) can be rearranged to obtain:

$$\Pr\left(\Psi_j = 1\right) = \Pr\left(\varepsilon_{jn} - \varepsilon_{in} \leq V_{in} - V_{jn}\right) \quad (26)$$

Following Greene (2003), if the error terms are independent and identically distributed with a type I extreme value distribution, $F\left(\varepsilon_j\right) = \exp\left(-e^{-\varepsilon_j}\right)$ using maximum likelihood the probability of choosing option j can be estimated with the multinomial logit model:

$$\Pr(\Psi_j = 1) = \frac{e^{V_j}}{\sum_{j=1}^{J} e^{V_J}} \quad (27)$$

Note that the subscript for individuals, n, has been suppressed.

5.1.1 Estimation with Grouped Data

The above formulation assumes that data are individual choices from a set. That is, it assumes binary responses for each respondent. The likelihood function for this formulation with J alternatives, and N observations is:

$$L = \prod_{i=1}^{N} \prod_{j=1}^{J} P_{ij}^{\psi_{ij}} \quad (28)$$

Where P_{ij} is the probability expression in (27).

However, recall that the method for gathering data on water choices was proportional in nature. For each individual the proportion of each type of water consumed in an ordinary month was specified. Therefore, we do not have an indicator variable such that $\Psi_j = 1$, and consequently the data more closely resemble grouped data. Fortunately, the extension of the estimation of a multinomial logit model using groups and proportions data is straightforward. The main difference lies in the specification of the likelihood function. Guimaraes and Lindrooth (2007) give an exposition on the log likelihood function for grouped data with *G* groups, and *J* choices, where n_{jg} corresponds to the number of individuals within each group, *g*, that chose option *j*:

$$L = \prod_{g=1}^{G} \prod_{j=1}^{J} P_{gj}^{n_{gj}} \quad (28)$$

Unfortunately this particular formulation is not directly applicable to estimation with the use of proportions data. However, if one assumes that each group size is the same then this likelihood function is nearly identical to that which uses proportions.

With proportions data, the proportion of individuals within each group that chose option j is used, as opposed to the total number of individuals within the group that chose option j. Furthermore, in the present study individuals are not grouped into like-categories. Therefore, for our problem, we assume that the proportional breakdown of water consumption for each individual is analogous to a group of individual specific responses. That is, we can view a grouped observation as ρ replications of an individual observation (Greene, 2003). Modification of the n_{jg} variable in (28) is then required to produce an exponent congruent with the number of choice occasions. The new likelihood function, for use with proportions follows the form:

$$L = \prod_{i=1}^{N} \prod_{j=1}^{J} P_{ij}^{n_{ij}} \quad (29)$$

Where n_{ij} is the number of times individual i chose option j in the specified number of choice replications ρ. The exponent n_{ij} in (29), then, is the product of the number of replications, ρ, and the corresponding proportion of choice of option j for individual i:

$$n_{ij} = \rho\pi_{ij} \quad (30)$$

This final formulation in (29) is the form of the log-likelihood function for use with proportions data. With the exception of assumptions about choices, and the nature of the data, it is identical to (28) with equal group sizes. This process converts the proportions data into equivalent proportions of binary choice indicators.

Estimation using this method imposes three main assumptions about choices. First, this method assumes that at each choice occasion within an ordinary month, all three water options being modeled are available to the individual. Second, using a variable to indicate the number of replications imposes a predetermined number of replications on each individual. Unfortunately, without the reproduction of such occasions in an experimental fashion, knowledge of the number of choice occasions for drinking water that one faces in a month is difficult to obtain in a survey format[13]. Third, this also assumes that each individual consumes the same amount of water in each month.

5.1.2 Heterogeneous Preferences: Latent Class Model

A matter of concern with estimation of the utility parameters in models of choice is the imposition of homogeneous preferences. That is, in the basic conditional logit model in equation (27), each individual is assumed to have the same marginal utility associated with various alternative specific characteristics. While the inclusion of individual specific variables (demographics) may condition the individuals' choice probability and produce a type of measure of predisposition towards certain options, it does not completely account for heterogeneity in value of choice characteristics across the sample. Latent class models are an extension to basic multinomial logit models which attempt to account for preference

[13] Most individuals are not likely to know how many times they drink water in each month.

heterogeneity. These models relax the assumption of homogenous marginal utilities and are implemented in two models estimated in the present study.

Following Swait (2006) it is assumed that all individuals in the population fall in to S (unknown) classes. While we observe all choices, and the characteristics of each choice, we do not observe class membership. This leads to the specification of a two-stage model, which includes a choice model conditional on class membership, as well as a class membership model. Following the notation provided by Swait (2006), the probability of observing a choice, i, for a given class, s, is:

$$P_{in} = \sum_{s=1}^{S} P_{in|s} W_{ns} \tag{31}$$

Where $P_{in|s}$ is the probability of individual n choosing alternative i given membership in class s, and W_{ns} is the probability of class membership in class s.

The conditional probability of a choice, i, given membership to class s, follows the same random utility, multinomial logit formulation outlined in (22)-(30). Following Swait (2006), the second portion of (31), W_{ns}, is a model of probability of class membership. Probability of class membership is determined by individual specific demographic-like variables, D_n, and an error term, ν_{ns}. A membership scoring function Y_{ns}^{*} is then defined as:

$$Y_{ns}^{*} = \tau_s^{'} D_n + \nu_{ns} \tag{32}$$

Where τ_s are the estimated parameters. An individual is placed in class s iff Y_{ns}^{*} is greater than the factor scores for all other classes:

$$n \rightarrow s,\ s = 1, \dots, S: Y_{ns}^{*} > Y_{nj}^{*},\ j = 1, \dots, S,\ j \neq s \tag{33}$$

Given (32), and assuming error terms are independent and identically distributed with a type I extreme value distribution, probability of membership in classes can be estimated with a multinomial logit model:

$$W_{ns} = \frac{e^{Y_{ns}^*}}{\sum_{j=1}^{J} e^{Y_{ns}^*}} \quad (34)$$

Therefore, with this specification, both class membership parameters, τ_s, as well as class specific utility parameters are estimated.

5.2 Data Transformation

In order to properly estimate the multinomial logit, and latent class models detailed here, data were transformed from the original form in the presentation of survey results.

Recall from chapter two that the conditional indirect utility functions are specified as:

$$V_1 = V_1(Y, \pi_1^*, q_{1j}, \alpha, \beta) \quad (21)$$

and:

$$V_i = V_i(p_i, Y, \pi_i^*, q_{ij}, \alpha, \beta) \quad (22)$$

Where i=1,2,3 for tap, filtered, and bottled water respectively.

Estimation of the corresponding choice model requires the formulation of costs, quality characteristics, demographic data, as well as risk perceptions as defined by Dickie and Gerking (1996) into equations 21 and 22 above. Some of the variables used in estimation are modifications of those described in the survey results. Short descriptions of the included variables and any modifications to these variables are presented here. Transformations were completed with quality characteristic variables, demographics, and risk perceptions. This provides for the relaxation of various assumptions made about these variables in estimation. With the exception of risk perceptions, another motivation for these transformations was to scale variables to an appropriate size for ease of interpretation and to facilitate the estimation of the latent class models. In similar fashion to the presentation of risk perceptions in the survey results section, the outliers in the risk category have been removed for estimation. The original sample consisted of 1304 observations. With the removal of outliers, this was reduced to 1216. Variable descriptions are presented in table 5-1, and summary statistics for the included variables are presented in table 5-2.

5.2.1 Costs

Utility functions described by (21) and (22) specify the inclusion of a "price" variable. For the gathered data, a price per unit of consumption is not specified, but rather the internal estimate of a monthly cost for 100% consumption of each water alternative was calculated. In some cases, individuals indicated a positive consumption amount, but did not know the costs they incurred for that consumption. These cases mostly arose in filtering expenditures, as there are many components to expenditures on filtration for which "don't know" was a possible answer (e.g. replacement cost, replacement frequency, system cost). In the case where an individual indicated positive consumption, but did not know a specific expenditure, the average cost specific to each water alternative was used (see survey results for details on calculation). Note that the costs included in estimation, presented in table 5-1, have altered means and standard deviations when compared with descriptive statistics presented in chapter 4. This is due in part to the removal of observations with outliers for the risk perception variables. Another difference, in comparison with the values in chapter 4, is the presence of cost outliers. The averages presented in the survey results section of chapter 4 are calculated with the removal of expenditure values greater than three standard deviations from the mean. The resulting averages were used to replace "don't know" responses. In estimation, however expenditure outliers are reintroduced, and this is reflected in the statistics presented in table 5-1. Removal of expenditure outliers prevents convergence in latent class estimations and as consequence these are included.

5.2.2 Quality Characteristics

The use of a single estimator for the seven-point scale of each quality characteristic imposes assumptions of both continuity and linearity on valuation. In order to avoid this imposition, the seven-point scale used for definition of quality characteristics was segmented into three parts: low, medium, and high. Dummy variables were then used to indicate responses. A rating response of one or two fell in the low category, responses of three to five fell in the medium category, and responses of six or seven fell in the high category. This was completed for each quality characteristic and allows for the approximation of non-linear values across levels of the characteristic, and relaxes the assumption that the scale is continuous. Therefore the resulting set of dummy variables is more indicative of perceived levels, instead of a continuous number.

5.2.3 Demographics

Demographics including age, education, and income were also modified to ensure that the scale of these variables was in a similar range to other variables included in estimation. Other demographics relating to risk perceptions were included in latent class models, and included cognitive ability, financial risk aversion, and perceived annual mortality risk from skin cancer.

The age of each respondent was divided by the mean, producing a variable with a range of approximately 0.5 to 1.5 (‘Age’). Education level was coded into a single dummy variable indicating whether an individual had attended any college (‘college’). Income was modified to a dummy variable form. The ‘income’ dummy variable is indicative of annual household income greater than $70,000.

Cognitive ability is a dummy variable indicating an incorrect response when tasked with the assessment of a probability (labelled as ‘Wrong’). Financial risk aversion is a dummy variable indicating a negative response to a game show type question where respondents were asked if they would gamble their winnings (‘Risk Averse’). Finally, the perceived annual mortality risk from skin cancer was included in estimation as well (‘Skin Cancer’). This variable was not transformed from its original form as a percentage probability.

5.2.4 Water Risk Perceptions

Risk perceptions, as outlined by Dickie and Gerking (1996) require not only a perceived probabilistic risk measure, but also attitudes and experience about water safety. For the attitudinal variable towards water safety, health concerns regarding tap water were re-coded into a dummy variable indicating whether individuals expressed any concern about their tap water. This included all responses from minor to serious. For a variable indicative of experience with water safety problems, a dummy variable was created indicating whether individuals had heard of any of a list of pollutants or microbes as a water safety concern in their community. The probabilistic representation of perceived risk gathered with the risk ladder was scaled. Risk perceptions were multiplied by 10,000 to ensure that the resulting variable fell approximately within the (0,10) interval. However, due to the large range of values available on the risk ladder, guaranteeing that all values fall within this range is not possible. As another consequence to the large range of values, preliminary estimation of the choice models produced a coefficient on the risk variable that was extremely small, and insignificant. Therefore, in a similar fashion to the representation of descriptive statistics for risk perceptions, risk outliers in each water category greater than the 95th percentile of risk responses for tap water were rejected in estimation The second method of removal of risk outliers, detailed in chapter 4, used both the upper 2.5th, and lower 2.5th percentiles as cut-off values. Though potentially less biased to lower risk values, this method produces econometric issues that arise in the choice of data points for removal. In all categories the perceived risk that corresponds to the 2.5th percentile is 0%. Furthermore, a great deal more than 2.5% of responses corresponded to 0% risk values. Therefore the removal of responses, at or below the lower 2.5th percentile, which would maintain the sample as representative is a delicate choice and further analysis would be necessary. Consequently this method was not used in estimation.

For estimation of models 4 and 5, risk perceptions were further modified into a series of four dummy variables indicating perceived zero, low, medium, and high levels of risk. With the exception of zero risk, each of these variables corresponded to responses grouped within sections of the risk ladder. Perceived risk responses of 0% were coded as such, responses from 0.000001% to 0.000099% were coded as low, responses from 0.0001% to 0.0099% were coded as medium, and responses from 0.01% to 1% were coded as high.

Table 5-1- Variable Definitions

Variable		Type	Description
Wrong		Dummy	Dummy variable indicating an incorrect response when tasked with the assessment of a probability.
Risk Averse		Dummy	Dummy variable indicating a negative response to a game show type question where respondents were asked if they would gamble their winnings.
Skin Cancer		Continuous	Perceived annual mortality risk from skin cancer.
Income		Dummy	Dummy variable indicative of annual household income greater than $70,000.
College		Dummy	Dummy variable indicating whether an individual had attended any college.
Age		Continuous	Age of each respondent divided by the mean.
Monthly Cost	*Bottled*	Continuous	Internal estimate of a monthly cost for 100% consumption of bottled water.
	Filtered	Continuous	Internal estimate of a monthly cost for 100% consumption of filtered water.
Quality Characteristics: Taste, Odour, Appearance, Convenience	*Medium*	Dummy	Dummy variable indicative of a response of three to five on the seven point rating scale.
	High	Dummy	Dummy variable indicative of a response of six to seven on the seven point rating scale.
Perceived Risks: Tap, Filtered, Bottled	*Probability*	Continuous	Probabilistic representation of perceived risk multiplied by 10,000.
	Zero	Dummy	Perceived risk responses of 0%.
	Low	Dummy	Perceived risk responses from 0.000001% to 0.000099%.
	Medium	Dummy	Perceived risk responses from 0.0001% to 0.0099%.
	High	Dummy	Perceived risk responses from 0.01% to 1%.
Attitudes		Dummy	Dummy variable indicating whether individuals expressed any concern about their tap water - all responses from minor to serious.
Experience		Dummy	Dummy variable indicating whether individuals had heard of any of a list of pollutants or microbes as a water safety concern in their community.

Table 5-2- Descriptive Statistics for Included Variables

Variable		Type	Mean	Standard Deviation
Wrong		Dummy	0.150	0.357
Risk Averse		Dummy	0.754	0.431
Skin Cancer		Continuous	0.026	0.106
Income		Dummy	0.415	0.493
College		Dummy	0.184	0.388
Age		Continuous	0.979	0.329
Monthly Cost	Bottled	Continuous	$ 110.78	212.725
	Filtered	Continuous	$ 13.96	84.085
Taste: Tap	Medium	Dummy	0.504	0.500
	High	Dummy	0.313	0.464
Taste: Filtered	Medium	Dummy	0.590	0.492
	High	Dummy	0.360	0.480
Taste: Bottled	Medium	Dummy	0.416	0.493
	High	Dummy	0.553	0.497
Odour: Tap	Medium	Dummy	0.512	0.500
	High	Dummy	0.319	0.466
Odour: Filtered	Medium	Dummy	0.582	0.493
	High	Dummy	0.376	0.484
Odour: Bottled	Medium	Dummy	0.411	0.492
	High	Dummy	0.576	0.494
Appearance: Tap	Medium	Dummy	0.479	0.500
	High	Dummy	0.430	0.495
Appearance: Filtered	Medium	Dummy	0.496	0.500
	High	Dummy	0.478	0.500
Appearance: Bottled	Medium	Dummy	0.313	0.464
	High	Dummy	0.681	0.466
Convenience: Tap	Medium	Dummy	0.243	0.429
	High	Dummy	0.736	0.441
Convenience: Filtered	Medium	Dummy	0.516	0.500
	High	Dummy	0.414	0.493
Convenience: Bottled	Medium	Dummy	0.472	0.499
	High	Dummy	0.410	0.492
Risk: Tap	Probability	Continuous	1.111	5.714
	Zero	Dummy	0.490	0.500
	Low	Dummy	0.421	0.494
	Medium	Dummy	0.089	0.285
	High	Dummy	0.000	0.000
Risk: Filtered	Probability	Continuous	0.671	4.242
	Zero	Dummy	0.569	0.495
	Low	Dummy	0.375	0.484
	Medium	Dummy	0.056	0.230
	High	Dummy	0.000	0.000
Risk: Bottled	Probability	Continuous	0.591	4.019
	Zero	Dummy	0.548	0.498
	Low	Dummy	0.402	0.490
	Medium	Dummy	0.050	0.218
	High	Dummy	0.000	0.000
Attitudes		Dummy	0.316	0.465
Experience		Dummy	0.370	0.483
Number of Observations	1216			

6.0 Model Specifications, Estimation, and Welfare Estimates

With the data gathered in the online survey, econometric models of choice are estimated. Results summarize preferences for drinking water in Canada. Coefficients from the estimated models are then used in the calculation of welfare estimates including WTP values for overall quality improvements, and value of statistical life (VSL) estimates representing willingness to pay for mortality risk reductions. All results and calculations from the estimated models are presented in this chapter.

6.1 Model Specifications and Estimation

Five models of choice were estimated with the survey data. Model 1, a preliminary regression including all terms specified in the indirect utility functions resulting from the theoretical framework, was estimated first. However, in this formulation, attitudes towards, and experience with, water safety issues were suspected to be endogenous to the model. Consequently, in the estimation of model 2 both attitude and experience variables were removed. Furthermore, preliminary regression results suggested the presence of heterogeneity in the sample, particularly with regards to the probabilistic risk variable. Therefore in addition to the second simple multinomial choice model, the third model estimated was a latent class model following the formulation of model 2. The class membership equation included both typical socio-demographic variables, as well as some variables specific to the perception of risk. Demographic variables related to risk perceptions were included to investigate heterogeneity around the risk variable.

Theory predicts the valuation of risk reductions to be proportional (linear) (Hammit and Graham 1999). While this proportionality is imposed in all prior models, further treatment of the risk variable was needed to investigate the validity of this prediction. In model 4, the risk variable was recoded into a series of dummy variables corresponding to zero, low, medium and high levels on the risk ladder. Division of the risk variable in to dummy variables allows for investigation of potential non-linearity in valuation. In a similar fashion to extension from model 2 to model 3, the fifth and final model presented here is a latent class model following the formulation of model 4. The same class membership equation is used in this model as that in model 3, including both typical socio-demographic variables, as well as some variables specific to the perception of risk. Results from estimation of models 1 through 3 are presented in Table 6-1, and results from estimation of models 4 and 5 are presented in Table 6-2. Statistics generated during estimation of these models are presented in Table 6-3. The specification and interpretation follows below for each model.

Table 6-1- Results: Models 1 through 3

Model		Model 1	Model 2	Model 3: Latent Classes	
				Class A: Risk Sensitive (76.2%)	Class B: Risk Insensitive (23.8%)
Indirect Utility Variables		Coefficient	Coefficient	Coefficient	Coefficient
Taste	*Medium*	1.2069 ***	1.2890 ***	1.1895 ***	1.1866 ***
		(0.2652)	(0.2651)	(0.3419)	(0.3747)
	High	2.4132 ***	2.5253 ***	2.4217 ***	2.3885 ***
		(0.2947)	(0.2952)	(0.3826)	(0.4082)
Odour	*Medium*	0.4873 *	0.6255 **	0.6698 *	0.5728
		(0.2642)	(0.2616)	(0.3453)	(0.3658)
	High	0.6807 **	0.8264 ***	0.8585 **	0.7724 *
		(0.2986)	(0.2958)	(0.3913)	(0.4166)
Appearance	*Medium*	-0.1580	-0.0460	-0.1675	0.1814
		(0.3024)	(0.2994)	(0.3728)	(0.4728)
	High	0.2843	0.4554	0.4843	0.4824
		(0.3208)	(0.3168)	(0.3926)	(0.5152)
Convenience	*Medium*	0.6012 **	0.5803 **	0.5910 *	0.5042
		(0.2490)	(0.2496)	(0.3171)	(0.3965)
	High	1.1973 ***	1.1669 ***	1.1905 ***	0.9785 *
		(0.2444)	(0.2449)	(0.3120)	(0.3854)
Risk	Probability	-0.0093	-0.0094	-0.0324 *	0.0186
		(0.0123)	(0.0120)	(0.0194)	(0.0146)
	Low	-	-	-	-
		-	-	-	-
	Medium	-	-	-	-
		-	-	-	-
Attitudes		0.6731 ***	-	-	-
		(0.1635)	-	-	-
Experience		0.0558	-	-	-
		(0.1491)	-	-	-
Cost		-0.0069 ***	-0.0068 ***	-0.0180 ***	-0.0009
		(0.0012)	(0.0012)	(0.0023)	(0.0009)
Bottled	*Constant*	-0.9308 ***	-0.7924 ***	-0.1177	-1.2504 ***
		(0.1475)	(0.1396)	(0.1855)	(0.2149)
Filtered	*Constant*	-1.3203 ***	-1.1529 ***	-1.0887 ***	-1.1796 ***
		(0.1081)	(0.0931)	(0.1126)	(0.1577)
Class Membership Variables		Coefficient	Coefficient	Coefficient	
Constant		-	-	-2.9146	-
		-	-	(2.5553)	-
Age		-	-	6.0879	-
		-	-	(3.7586)	-
College*		-	-	6.2182 *	-
		-	-	(3.7059)	-
Income		-	-	1.3499	-
		-	-	(1.1349)	-
Wrong*		-	-	-6.6618 *	-
		-	-	(3.6881)	-
Risk Averse		-	-	-0.8903	-
		-	-	(1.2528)	-
Skin Cancer		-	-	-9.0509	-
		-	-	(7.0059)	-

* Denotes significance at 10%, ** Denotes significance at 5%, *** Denotes significance at 1%, Parenthesis denote standard deviation

Table 6-2 Results: Models 4 and 5

Model		Model 4	Model 5: Latent Classes Class A: Risk Sensitive (75.8%)	 Class B: Risk Insensitive (24.2%)
Indirect Utility Variables		Coefficient	Coefficient	Coefficient
Taste	*Medium*	1.2600 ***	1.1040 ***	1.1999 ***
		(0.2664)	(0.3456)	(0.3793)
	High	2.4673 ***	2.3103 ***	2.3640 ***
		(0.2975)	(0.3887)	(0.4158)
Odour	*Medium*	0.5706 **	0.6182 *	0.6001
		(0.2618)	(0.3486)	(0.3667)
	High	0.6962 **	0.7359 *	0.6975
		(0.2971)	(0.3970)	(0.4152)
Appearance	*Medium*	-0.1783	-0.2907	0.0642
		(0.3040)	(0.3754)	(0.4831)
	High	0.2321	0.2247	0.3555
		(0.3215)	(0.3964)	(0.5248)
Convenience	*Medium*	0.5971 **	0.5978 *	0.5050 *
		(0.2536)	(0.3228)	(0.3993)
	High	1.1596 ***	1.1578 ***	0.9933 **
		(0.2491)	(0.3180)	(0.3881)
Risk	Probability	-	-	-
		-	-	-
	Low	-0.9148 ***	-0.9751 ***	-0.6654 ***
		(0.1488)	(0.1894)	(0.2293)
	Medium	-1.0815 ***	-1.3166 ***	-0.4507
		(0.2970)	(0.3950)	(0.4323)
Attitudes		-	-	-
		-	-	-
Experience		-	-	-
		-	-	-
Cost		-0.0065 ***	-0.0176 ***	-0.0010
		(0.0012)	(0.0024)	(0.0009)
Bottled	*Constant*	-0.8260 ***	-0.1411	-1.2826 ***
		(0.1407)	(0.1924)	(0.2151)
Filtered	*Constant*	-1.2147 ***	-1.1422 ***	-1.2419 ***
		(0.0950)	(0.1157)	(0.1603)
Class Membership Variables		Coefficient	Coefficient	
Constant		-	-2.3528	-
		-	(2.7533)	-
Age		-	5.0367	-
		-	(3.8763)	-
College*		-	5.2954	-
		-	(3.5974)	-
Income		-	1.4745	-
		-	(1.1553)	-
Wrong*		-	-5.7584 *	-
		-	(3.4404)	-
Risk Averse		-	-0.8080	-
		-	(1.2979)	-
Skin Cancer		-	-7.6900	-
		-	(8.3483)	-

* Denotes significance at 10%, ** Denotes significance at 5%, *** Denotes significance at 1%, Parenthesis denote standard deviation

Table 6-3- Estimation Statistics: All Models

Model		Model 1	Model 2	Model 3: Latent Classes	Model 4	Model 5: Latent Classes
Log Likelihood	*Current*	-907.1661	-916.61	-893.1642	-896.23	-875.9283
	At Start Values	-	-	-916.6088	-	-896.2255
Restricted log likelihood		-	-	-1335.91	-	-1335.91
Chi-Squared		664.53	645.71	885.50	686.41	919.97
Pseudo R-squared		0.2681	0.2605	0.3314	0.2769	0.3443
Number of Observations		1216	1216	1216	1216	1216

6.1.1 Model 1 Specification and Estimation: Base Model

With the exception of an income variable, the conditional indirect utility functions for model 1 follow the convention established in (20) and (21):

$$V_1 = \gamma_{11} + \gamma_{3j} q_{1j} + \gamma_4 \pi_1 + \varepsilon_2 \tag{26}$$

$$V_2 = \gamma_{21} + \gamma_2 p_2 + \gamma_{3j} q_{2j} + \gamma_4 \pi_2 + \gamma_5 \alpha + \gamma_6 \beta + \varepsilon_2 \tag{27}$$

$$V_3 = \gamma_{31} + \gamma_2 p_3 + \gamma_{3j} q_{3j} + \gamma_4 \pi_3 + \gamma_5 \alpha + \gamma_6 \beta + \varepsilon_3 \tag{28}$$

Where i=1,2,3 for tap, filtered, and bottled water respectively.

All equations include a constant, γ_{ij}, quality characteristics, q_{ij}, and the probabilistic risk measure, π_i. The price variables, p_i, attitudes towards water safety, α, and experiences with water safety issues, β, only enter the equations for filtered and bottled water. The "price" for tap water will be zero, therefore the price (p_i) coefficient, γ_2, will be interpreted in relative terms, with tap water serving as baseline. This is true in estimation of all subsequent model specifications. Attitudes,α, and experience, β, are invariant across alternatives and therefore must be dropped from one equation (tap water). These coefficients are also interpreted relative to the baseline (tap water). It is likely that both attitudes and experience are endogenous variables. That is, they are a latent indicator of preference for tap water. Significance of these variables will serve as a confirmation that the model is functioning as expected.

The estimated model is significant as a whole, and the pseudo r-squared is reported as 0.2891. With the exception of appearance, risk, and experiences with water safety issues, all variables are significant, and display the signs that one would expect. Coefficients are presented in the first column of numerical values in table 6-2.

Coefficients on quality characteristic variables suggest that these have a significant impact on choice. Of the quality characteristics, taste variables are the largest. The coefficient on medium taste is 1.2069, and the coefficient on high taste is 2.4132. Both are significant at the 1% level. These coefficients suggest an increasing relationship along the scale from low to high, with the coefficient on high taste being approximately twice that on medium taste. These coefficients have positive effects on choice suggesting that as taste improves the probability of choice increases. Odour variables have a less pronounced, but significant impact on choice as well. The coefficient on medium odour is 0.4873 and is significant at the 10% level. The coefficient on high odour is 0.6807 and is significant at the 5% level. These coefficients also demonstrate positive effects, suggesting that as odour improves the probability of choice increases. Appearance variables were not shown to have a significant impact on water choice. The coefficient on medium appearance is -0.1580, and the coefficient on high appearance is 0.2843. These variables are not statistically significant, and only when the high level of the scale was chosen did the statistical effect prove to be positive. Convenience too, has a statistically significant effect on water choice. The coefficient on medium convenience is 0.6012 and is significant at the 5% level. The coefficient on high convenience is 1.1973 and is significant at the 1% level. Again, similar to taste coefficients, these are positive effects and suggest that as convenience improves the probability of choice will increase.

Risk perception variables, overall, are not significant in this model formulation. The coefficient on the probabilistic risk variable is -0.0093 and although it possesses the expected negative sign, it is not statistically significant. Recall that both attitude and experience variables only enter the estimation through the bottled and filtered equations, and therefore are interpreted relative to the baseline (tap water equation). The coefficient on experience with water safety issues is 0.0558, and although positive was also not a significant variable in the choice model. The coefficient on attitudes towards water safety is 0.6731 and is significant at the 1% level. The significance of the attitudinal variable signifies that the model is working as expected. However, for the remaining models, these variables are removed from the regression to avoid potential issues arising from endogeneity.

Monthly cost associated with water alternatives is significant in its effect on water choice. The coefficient on the monthly cost variable is -0.0069 and is significant at the 1% level. The estimated effect is negative, and indicates that as the cost of a water option increases, the probability of choice will decrease. Alternative specific constants included in both the filtered and bottled equations are negative and significant at the 1% level. The constant in the bottled equation is -0.9308, and the constant in the filtered equation is -1.3203. The significance of these variables suggests the some elements of the utility function were not captured in this formulation and that with all other variables held constant, individuals prefer tap water. This mirrors findings through observation of descriptive statistics, where tap water was the largest consumption category, followed by bottled water, and filtered water.

6.1.2 Model 2 Specification and Estimation: Exogenous Variables

Model 2 follows the convention established in model 1. However, in this case only exogenous variables are included in estimation. That is, both attitudes towards, and experience with water safety issues were removed from the estimation. The conditional indirect utility functions for model 2 are:

$$V_1 = \gamma_{11} + \gamma_{3j} q_{1j} + \gamma_4 \pi_1 + \varepsilon_2 \quad (29)$$

$$V_2 = \gamma_{21} + \gamma_2 p_2 + \gamma_{3j} q_{2j} + \gamma_4 \pi_2 + \varepsilon_2 \quad (30)$$

$$V_3 = \gamma_{31} + \gamma_2 p_3 + \gamma_{3j} q_{3j} + \gamma_4 \pi_3 + \varepsilon_3 \quad (31)$$

Where subscripts i =1,2, and 3 are indicative of tap, filtered, and bottled water respectively, each with q_{ij} quality characteristics and a perceived mortality risk, π_i.

With the removal of attitudes and experiences towards and with water quality, the estimated model, maintains most characteristics present in the base model. The model is significant overall and again, with the exception of appearance and risk, all variables are statistically significant. With the removal of the endogenous variables, we see a decrease in the log-likelihood function. The pseudo R-squared is estimated as 0.2605, still representing a relatively good fit. Results from estimation are presented in column 2 of numerical values in table 6-2.

The impact of quality characteristics on choice are maintained in this model, with taste variables showing the largest impact. The coefficient on medium taste has increased to 1.2890, and the coefficient on high taste has increased to 2.5253. Both are significant at the 1% level. The effect on odour, in this case appears to have increased slightly. The coefficient on medium odour is 0.6255 and is significant at the 5% level. The coefficient on high odour is 0.8264 and is significant at the 1% level. Appearance is maintained as an insignificant variable in the equation. The only change has been a shift upward in value. The same effects are noted from model 1. The effect of convenience is also similar to the base model in size and effect. These display the same positive coefficients. The coefficient on medium convenience is 0.5803 and is significant at the 5% level. The coefficient on high convenience is 1.1669 and is significant at the 1% level. The probabilistic risk variable is nearly identical to that in the base model, and although negative, remains insignificant in this estimation.

Monthly costs, too, show little change in size and effect from the base model. The coefficient on monthly cost is -0.0068 and is significant at the 1% level. The negative effect of monthly cost is retained from the base model. The alternative specific constants in the filtered and bottled water equations have shifted downwards in value. The constant in the bottled equation is -0.7924, and the constant in the filtered equation is -1.1529. Both are significant at the 1% level. The familiar conclusion from the base model is maintained where, with all variables held constant, individuals prefer tap water to bottled, and filtered water.

6.1.3 Model 3 Specification and Estimation: Exogenous Variable Latent Class Model

Both the base model and model 2 assume homogeneity of preferences. That is, each respondent in the sample is assumed to have the same marginal utility associated with any one attribute. However, in the case of heterogeneous preferences, subsets of individuals are hypothesized to have preferences that deviate from the norm. In the case of model 2, heterogeneity of preferences is accounted for through the use of a latent class model. Two classes were specified for estimation. The specification of a larger number of classes prevented convergence in estimation. Moreover, even with the specification of two classes, one of these represents a small proportion of the sample.

In this case, coefficients are conditional on membership to a class, g. Therefore each class will have a set of class-specific estimated parameters. Conditional indirect utility functions in model 3 are identical to those in model 2. The conditional indirect utility functions for this estimation conform to:

$$V_{1|g} = \gamma_{11|g} + \gamma_{3j|g} q_{1j} + \gamma_{4|g} \pi_1 + \varepsilon_2 \quad (29)$$

$$V_{2|g} = \gamma_{21|g} + \gamma_{2|g} p_2 + \gamma_{3j|g} q_{2j} + \gamma_{4|g} \pi_2 + \varepsilon_2 \quad (30)$$

$$V_{3|g} = \gamma_{31|g} + \gamma_{2|g} p_3 + \gamma_{3j|g} q_{3j} + \gamma_{4|g} \pi_3 + \varepsilon_3 \quad (31)$$

Where subscripts i =1,2, and 3 are indicative of tap, filtered, and bottled water respectively, each with q_{ij} quality characteristics, and perceived mortality risk, π_i. Again, each utility function is estimated given membership to a class, g ($V_{i|g}$).

Class membership is determined based on a set of demographic variables. The chosen class membership variables include three standard socio-demographic variables, as well as some included to investigate class membership around the risk variable. A preliminary regression result suggested heterogeneity in the valuation of risk and is the motivation for the inclusion of these variables. Socio-demographic variables included in the class equation are 'Age', a dummy variable indicative of attendance in college or any other post-secondary institution ('College'), as well as a dummy variable indicative of annual household income greater than $70,000 ('Income'). Risk related variables in the class equation include dummy variables indicative of the individual's cognitive ability to accurately assess probabilities ('Wrong'), and whether they are financially risk averse ('Risk Averse'). Finally, the individuals perceived annual risk of death from skin cancer ('Skin Cancer') was included in the class equation. The specification for the class membership equation is as follows:

$$G = \beta_1 + \beta_2 Age + \beta_3 College + \beta_4 Income + \beta_5 Wrong + \beta_6 RiskAverse + \beta_7 SkinCancer \quad (32)$$

The estimated latent class model provides a more interesting picture of averting behaviour in Canada and shows a marked improvement in the likelihood function. Overall the model is significant and the pseudo r-squared is approximately 0.3314 suggesting a relatively good fit. Two classes were specified in this estimation. Results suggest the existence of a risk-sensitive group, class A, that accounts for approximately 76.2% of the sample, and a risk-insensitive, non-compensatory group, class B, that accounts for the remaining 23.8% of the sample. These results are presented in columns three and four of table 6-2.

6.1.3.1 Model 3, Class A: Risk Sensitive

The estimated coefficients in class A bear many similarities to those presented in the base model and model 2. With the exception of appearance, and the alternative specific constant in the bottled equation, all variables are significant.

Quality characteristics maintain a significant impact on water choices in class A, and are close, in size and effect, to those in the base model. The coefficient on medium taste is 1.1895, and the coefficient on high taste is 2.4217. Both are significant at the 1% level. The familiar positive characteristics established in the base model and model 2 are retained. Odour variables are also significant in class A, and are approximately the same size as those in model 2. The coefficient on medium odour is 0.6698 and is significant at the 10% level. The coefficient on high odour is 0.8585 and is significant at the 5% level. These suggest the diminishing positive returns to improvements in this dimension that were established in the base model, and model 2. As in the base model, coefficients on appearance are not statistically significant. The coefficient on medium appearance is -0.1675, and the coefficient on high appearance is 0.4843. Convenience variables are significant in water choice in class A and are also close to those in both the base model, and model 2. The coefficient on medium convenience is 0.5910 and is significant at the 10% level. The coefficient on high convenience is 1.1905 and is significant at the 1% level. In class A, the probabilistic risk variable still has a negative effect on choice. However in this case the coefficient has increased to -0.0324 and is significant at the 10% level. As one would expect, this signifies that risk is perceived as a negative characteristic of drinking water and that in class A, and as perceived mortality risk increases, the probability of choice decreases.

Monthly costs associated with water choices remain a significant variable in the model. However, the negative impact of this variable, in comparison to the base model, and model 2, has shown a marked increase. The coefficient on monthly cost is -0.0180 and is significant at the 1% level. In this class, only the alternative specific constant in the filtered equation is statistically significant. The alternative specific constant in the bottled equation is -0.1177 and is not statistically significant. In comparison with the base model this is a substantially smaller effect. This indicates that for bottled water, in class A, utility has been mostly captured through the included variables. The alternative specific constant in the filtered equation is -1.0887 and is significant at the 1% level. This is a smaller effect than that in the base model, but still indicative of utility not captured through the included terms. These constants suggest that with all other variables held constant, individuals in class A prefer both tap water and bottled water to filtered water.

6.1.3.2 Model 3, Class B: Non-compensatory Interpretation

Class B has many differences in comparison to both class A, as well as the base model. In Class B, fewer variables are significant, and overall results suggest that individuals placed in this group are primarily tap water drinkers.

Quality characteristics are less significant in the choice of drinking water in this group. Significant coefficients appear only on taste, high levels of odour, and high levels of convenience. The coefficients on taste variables are positive, and close to those both in all prior models and classes. The coefficient on the medium taste variable is 1.1866 and is significant at the 1% level. The coefficient on the high taste variable, again, is approximately twice that of medium at 2.3885. It is significant at the 1% level. The coefficient on medium odour is 0.5728, and is not significant in this class. The coefficient on the high odour variable is 0.7724, and is significant at the 10% level. Both of these coefficients are lower than those in class A and model 2, and higher than those in the original model but retain their positive effects. Additionally, the insignificance of the coefficient on medium odour would suggest that for odour to have an impact on choice, it must be perceived at the highest level (likely as odourless). As with both the original model, and class A, the coefficients on both medium and high appearance are not significant. The coefficient on medium appearance is 0.1814. In contrast to the apparent statistically negative effects of this variable suggested by both the original model as well as class A, in class B this effect is positive. The coefficient on high appearance is 0.4824, and suggests a positive effect on choice as well. This is nearly identical to the coefficient reported in class A and is larger than those reported in the base model and model 2. Convenience is also shown to have a less pronounced effect in class B. The coefficient on medium convenience is 0.5042, and is not significant. This is a smaller effect relative to all prior models, and classes. The coefficient on high convenience is 0.9785, and is significant at the 5% level. Again, this is a smaller effect relative to all prior estimates. The probabilistic risk variable proved to be insignificant for individuals placed in class B. That is, individuals in Class B may be insensitive to the risk values[14].

The size and effect of both the monthly cost variable and alternative specific constants are different in comparison with both class A, and the base model. The coefficient on monthly cost is -0.0009 and is insignificant. This coefficient is significantly smaller in comparison to all prior estimations. The alternative specific constants in class B for both the bottled and filtered alternatives are negative and significant at the 1% level. The constant in the bottled equation is -1.2504. In comparison with all other models this is the largest constant reported for the bottled equation. In particular, this should be reported in contrast with class A, where this coefficient was insignificant and in absolute terms substantially smaller. The constant in the filtered equation is -1.1796 and is significant at the 1% level. In comparison to class A this coefficient is larger in absolute terms. The size and significance of these constants indicates that with all other variables held constant, individuals in class B prefer to drink tap water.

6.1.3.3 Model 3: Class Membership Equation

The class membership equation includes variables that account for heterogeneity within the sample. Both socio-demographic variables, as well as risk related variables were included in this equation. Both are shown to have an impact on

[14]In fact, if we ignore the insignificance of this variable, this would suggest a positive effect of risk on choice. The positive effect is likely a result of apparent preference for tap water with individuals in this class. Although individuals may have indicated a higher risk for tap water, they also are likely to be tap water drinkers. Therefore statistically this effect would appear to be positive in estimation.

class-membership. The estimated coefficients are presented in the bottom section of column 3 in table 6-2. This equation is a logit probability model of class membership, and is interpreted relative to a baseline. By default, this baseline is class B.

Socio-demographic variables in this equation included ‘Age’, ‘College.’ and income. The coefficient on the age variable is 6.0879 and is insignificant. Attendance at college is a significant predictor of membership for class A. The coefficient on the college variable is 6.2182, and is significant at the 10% level. This positive effect on membership in class A indicates that if the individual has attended any form of college or post-secondary institution, they are significantly more likely to be in class A. The coefficient on the income variable is 1.3499 and is insignificant.

The other variables included in the class membership equation are related to risk, and risk perceptions. These include ‘Wrong’, ‘Risk Averse’, and ‘Skin Cancer.’ The coefficient on “Wrong” is -6.6618 and is significant at the 10% level. This suggests that if the individual was unable to assess the probability measure given to them in the survey, they are more likely to be placed in class B.

6.1.4 Model 4 Specification and Estimation: Exogenous Variables/Risk Categories

The following 2 models were estimated with an aim at evaluating the nature of risk valuation. Both model 4 and model 5 are intended to assess any non-linearity in valuation of risk changes through the use of a series of dummy variables.

Interpretation, therefore, focuses on comparison of risk variables with those in prior estimations.

Model 4 uses a series of dummy variables in place of the single risk variable. The recoding of the variable corresponds to sections of the risk ladder. All models prior to this impose linearity on the risk variable. The division of risk responses into dummy variables allows for investigation of non-linearity in valuation. In theory, valuation of risk reduction is predicted to be proportional. Therefore comparison of the following three models with all prior estimations, and in particular the comparison between the two latent class estimates will give an indication of whether there is adherence to this prediction. The corresponding indirect utility functions estimated for model 4 conform to:

$$V_1 = \gamma_{11} + \gamma_{3j} q_{1j} + \gamma_4 \pi L_1 + \gamma_5 \pi M_1 + \gamma_6 \pi H_1 + \varepsilon_2 \quad (33)$$

$$V_2 = \gamma_{21} + \gamma_2 p_2 + \gamma_{3j} q_{2j} + \gamma_4 \pi L_2 + \gamma_5 \pi M_2 + \gamma_6 \pi H_2 + \varepsilon_2 \quad (34)$$

$$V_3 = \gamma_{31} + \gamma_2 p_3 + \gamma_{3j} q_{3j} + \gamma_4 \pi L_3 + \gamma_5 \pi M_3 + \gamma_6 \pi H_3 + \varepsilon_3 \quad (35)$$

Where subscripts i =1,2, and 3 are indicative of tap, filtered, and bottled water respectively, each with q_{ij} quality characteristics, and a perceived mortality risk that is classified as either low, πL_i, medium, πM_i, or high, πH_i. With outliers removed based on risk responses, all those in the ‘High’ category were rejected from the sample. Therefore in estimation, this variable was removed, and consequently only coefficients on low and medium are estimated.

Overall, the estimated model is significant. The pseudo R-squared is 0.2769, which again suggests a relatively good fit. With the exception of appearance, all variables in this estimation are significant.

The impact of quality characteristics in this estimation tells the same story reported for all prior estimations. The reported coefficients are mirrored very closely by those in the base model. Taste variables are significant at the 1% level, and odour variables are significant at the 5% level. Both of these attributes retain the effects reported in prior estimations. Coefficients on appearance are insignificant and mimic those in the base model in terms of sign. With the exception of comparison with coefficients in model 3, class B, convenience variables are of the same size in comparison with all prior estimates. The monthly cost variable is negative and significant and nearly identical in size to that in the base model. Constants in the bottled and filtered equations are also similar to those in the base model, though are slightly smaller in effect. Both are negative and significant.

In this estimation, both risk variables are negative and significant at the 1% level. The coefficient on low risk is -0.9148, and the coefficient on medium risk is -1.0815. The negative effect is intuitive. The change in magnitude between coefficients is also expected, as the risks grouped in the medium category will have been larger than those in the low category. The change in the coefficient size across categories is indicative of presence of non-linearity in valuation of this attribute.

A quick calculation of the mean risk value in each category (i.e. low and medium risk) can be used to investigate whether these coefficients are congruent with approximate proportional changes in the risk values. The mean risk value in the medium category for all water types is approximately 0.0017%, where as the mean risk value in the low category is approximately 0.000013%. The average risk reduction, then, from category to category is 99.3%, whereas the reduction in coefficient size is only approximately 15.4%[15]. This suggests that these coefficients are not likely to represent proportional changes in value to the respondent. Comparison between both the following latent class model, and that estimated for model 3 may provide further insight as to which formulation is comparatively more valid.

6.1.5 Model 5 Specification and Estimation: Exogenous Variables/Risk Categories Latent Class Model

Model five seeks similar benefits gained in model 3 through the relaxation of the assumption of homogeneous preferences. This model conforms to the indirect utility functions established for model 4. Again, in this case, coefficients are conditional on membership to a class, *g*, and will result in the estimation of a set of class-specific parameters. The specification of indirect utility functions for model 5 is as follows:

$$V_{1|g} = \gamma_{11|g} + \gamma_{3j|g} q_{1j} + \gamma_{4|g} \pi L_1 + \gamma_{5|g} \pi M_1 + \gamma_{6|g} \pi H_1 + \varepsilon_2 \quad (36)$$

$$V_{2|g} = \gamma_{21|g} + \gamma_{2|g} p_2 + \gamma_{3j|g} q_{2j} + \gamma_{4|g} \pi L_2 + \gamma_{5|g} \pi M_2 + \gamma_{6|g} \pi H_2 + \varepsilon_2 \quad (37)$$

$$V_{3|g} = \gamma_{31|g} + \gamma_{2|g} p_3 + \gamma_{3j|g} q_{3j} + \gamma_{4|g} \pi L_3 + \gamma_{5|g} \pi M_3 + \gamma_{6|g} \pi H_3 + \varepsilon_3 \quad (38)$$

Where subscripts i =1,2, and 3 are indicative of tap, filtered, and bottled water respectively, each with q_{ij} quality characteristics, and a perceived mortality risk that is classified as either low, πL_i, medium, πM_i, or high, πH_i. Again, each utility

[15] 1-(0.000013/0.0017) = 0.007, 1- (0.9148/01.0815) = 0.15

function is estimated given membership to a class, g ($V_{1 \mid g}$). The same class membership equation utilized in model 3, equation (32), is used for class membership here.

The latent class model estimated with the new risk specification retains most properties established in the original latent class model. Overall the model is significant, and the reported pseudo R-squared is 0.3443. The division of the sample between classes is very close to that in model 3, with 75.8% of the sample placed in Class A, and 24.2% of the sample placed in class B. Again, these roughly correspond to a risk-sensitive class (A), and a risk insensitive class (B). However, at low risk levels there are indications of risk sensitivity in class B as well. Results from this estimation are reported in the 2 right most columns of table 6-2.

6.1.5.1 Model 5, Class A: Risk Sensitive

Quality characteristics, costs, and alternative specific constants mirror effects established in the estimation of model 3. Quality characteristics in class A of model 5 are similar in size and effect, to those estimated in model 3. Taste coefficients are both significant at the 1% level. Odour variables remain significant in the model. Both are significant at the 10% level and display the same characteristics as prior estimations. As with all other models, appearance variables remain statistically insignificant in this model. Convenience variables have retained a positive effect on choice with the coefficient on medium convenience being significant at the 10% level, and the coefficient on high convenience being significant at the 1% level. Monthly cost has a nearly identical negative effect to that in model 3, and is significant at the 1% level. In comparison with model 3: class A, the alternative specific constant in the bottled equation remains insignificant in this model. The constant in the filtered equation, though slightly larger in absolute value suggests a similar effect to that in prior estimations and is significant at the 1% level. This is indicative of utility not captured through terms included in the function.

The estimated risk variables in this class are negative and significant at the 1% level. In comparison with model 4, the estimated coefficients show a larger effect on choice. The coefficient on low risk is -0.9751, and the coefficient on medium risk is -1.3166. The increasing effect from low to medium is expected. However, following the calculation used in the interpretation of model 4, we can see that although there is an average risk reduction between categories of 99.3% there is only a reduction of 25.6% from the coefficient on medium risk to that on low risk. Again this suggests non-linear valuation of risk changes and indicates that proportionality does not hold for this model. Similar to model 3 class A, this group of individuals is risk-sensitive, and indications from alternative specific constants suggest that with all other variables held constant, individuals in this group prefer tap and bottled water to filtered water.

6.1.5.2 Model 5, Class B: Risk-Insensitive

In class B, Quality characteristics, monthly cost, and alternative specific constants retain similar effects to those in model 3 as well. However model 3 includes a significant risk variable not present in the prior latent class estimation. Taste coefficients, as observed in all prior estimations, are positive, and remain significant at the 1% level. Both odour and appearance variables are insignificant in this class. Convenience variables, too, remain positive and significant with medium convenience significant at the 10% level, and high convenience significant at the 5% level. The cost variable, as in model 3, class B, is insignificant and very small in comparison with model 3, class A, and model 5, class A. As with model 3 class B, the alternative specific constants show large negative effects on choice and are indicative of utility not captured by included terms.

Risk variables in this class differ in comparison with the prior latent class model. In this case, the coefficient on low risk is -0.6654 and is significant at the 1% level, and the coefficient on medium risk is -0.4507 and is not statistically significant. This is in comparison with model 3 class B, where the risk variable was insignificant for this group. The size and effect of the alternative specific constants in this category suggest that with all other variables held constant, this group is comprised mainly of individuals that prefer tap water.

6.1.5.3 Model 5: Class Membership Equation

The class membership function used to account for heterogeneity in model 5 is identical to the formulation estimated in model 3. Very little difference is observed when drawing comparisons between these two estimated equations. Again, both socio-demographic variables and risk related variables were included in the equation. Results for this equation are presented in the bottom portion of column seven in table 6-2. Again, this is a logit probability model for class membership, and coefficients are interpreted relative to the baseline, class B.

The socio-demographic variables, ‘Age’, ‘College,’ and ‘Income’ are not significant in this equation. However, in comparison with model 3, each retains a similar size and effect on probability of class membership. The effect of ‘Age,’ ‘College,’ and ‘Income’ all being positive for membership in class A.

Risk related variables also display similar sizes and effects when compared with the class membership equation in model 3. ‘Wrong’ remains significant at the 10% level, and has a negative effect on membership for class A, but is of a similar size to that in model 3. Both ‘Risk Averse’ and ‘Skin Cancer’ retain their negative effects on membership to class A.

6.1.5.4 Testing Proportionality Predictions

Overall, model 5 and model 3 very closely resemble one another, and of the models estimated, are likely the best and most informative. The class membership equations follow identical formulations, and place approximately the same number of individuals in each class. The main difference between these two models lies in the specification of the risk variable. Whereas in model 3, proportionality was imposed through the estimation of a single linear risk coefficient, in model 5 this variable was estimated as a series of dummy variables. The dummy variable formulation allowed for the investigation of non-linearity in valuation of risk changes. Both models perform similarly in terms of significance of attributes, constants, and risk. Therefore it is of interest to test which model is better, as the risk variable is significant in both cases, and therefore provides inconsistent conclusions regarding proportionality in the valuation of risk reductions. Ben-Akiva and Lerman (1985) describe a non-nested test for comparison of two models using the adjusted likelihood ratio index, calculated as:

$$\bar{\rho}^2 = 1 - \frac{L(\hat{\beta}) - K}{L(0)} \qquad (40)$$

Where $L(\hat{\beta})$ the log-likelihood of the estimated model, K is the Akaike information criterion, and $L(0)$ is the log likelihood of the restricted model. For this test, only comparison of the adjusted likelihood ratios is needed. Following Ben-Akiva and Lerman (1985), to choose between the two models 3 and 5, under the null hypothesis that model 3 is the true specification, the following holds asymptotically:

$$\Pr(\bar{\rho}_5^2 - \bar{\rho}_3^2 > z) \leq \Phi\{-[2Nz \ln J + (K_5 - K_3)]^{1/2} \qquad (41)$$

Where $\bar{\rho}_l^2$ is the adjusted likelihood ratio index for model l=3,5, K_l is the number of parameters in model l, N is the number of observations, J is the number of alternatives, and Φ is the standard normal cumulative distribution function.

The adjusted likelihood ratio for model 5 is calculated as 0.3432, and that calculated for model 3 is 0.3302. The difference between these two adjusted likelihood ratios is 0.0129. The probability that this difference would be exceeded for a sample of 1216 with three alternatives approaches zero[16]. Therefore

[16] Calculations result in approximately 7.5 x 10^{-10}

proportionality, in valuation of risk reduction, is not maintained in this sample based on comparison between these two models[17].

6.2 Discussion of Estimated Models

The models estimated all provide insight into the nature of drinking water preferences in Canada. In particular, the estimated latent class models are the most informative for our purposes. They provide interesting information regarding class membership and preferences in subsets of the sample. Both models include significant risk coefficients, and therefore offer inconsistent conclusions regarding proportionality in the valuation of risk reduction.

Both latent class formulations suggested very similar findings with regards to quality characteristics, monthly costs, and alternative specific constants. In both cases, the sample was divided between a risk-sensitive class (A) and a risk-insensitive class (B), each accounting for approximately 76% and 24% of the sample respectively. Class A, in both cases, seemed to be relatively risk responsive, but in addition to this fact it is very clear from the number of significant coefficients, that individuals in this class make more tradeoffs in their water consumption decisions. Furthermore in class A of both latent class models, only the alternative specific constant in the filtered equation was significant. This,

[17] A quadratic model was estimated to investigate the risk variable more closely. This model followed the latent class formulation of model 3, however in addition to the risk variable, a risk-squared variable was included. The advantage of comparison between model 3, and this additional model lies with the similarity between the two models, which may provide further insight with regards to the test for proportionality. A likelihood ratio test between model 3 and the sixth model does not reject the null hypothesis that the quadratic model is no better than the base model.

again, indicates that individuals in this group are likely making more tradeoffs in quality, particularly between tap water and bottled water.

Although it was only labelled as risk-insensitive, in both model 3 and model 5, class B suffers from fewer significant quality characteristic variables, and an insignificant cost variable. This is at the expense of much larger, and highly significant alternative specific constants in both the filtered and the bottled water equation. The insignificance of the other variables, coupled with significant alternative specific constants is an indicator that many individuals placed in this class are likely to be tap water drinkers. That is, these individuals are probably not making quality tradeoffs. Rather, these individuals are likely to drink tap water regardless of the perceived gain in quality across the alternatives.

The class membership equation, on which the class stratification is based, is also very intuitive in its interpretation. In both cases, it suggests that individuals with some form of college education are likely to be placed in class A, whereas those who were unable to correctly assess probabilities were more likely to be placed in class B. In general this class membership speaks less to division based on typical socio-demographic characteristics, and more to division based on implicit cognitive ability or engagement in the survey associated with respondents. This result is not wholly unexpected, as similar findings are present in work by Hammit and Graham (1999).

Perhaps most interesting with the presented results are the inconsistent conclusions regarding proportionality in the valuation of risk reduction suggested by both model 3 and model 5. Although both models suggest significant risk variables, each implicitly values risk changes in a different manner. Model 3 imposes linearity in risk valuation. In contrast, model 5 allows for non-linearity across a series of dummy variable coefficients. However, the dummy variable formulation comes at the expense of precision. In comparison with model 3, in which proportionality was imposed, tests between these models suggested favourability of model 5.

Despite the indications of the non-nested test between models, model 3 is still favoured by the researcher in this study. Model 3 not only conforms to predictions suggested by economic theory, but also, due to the absolute probabilistic nature of the risk variable, is markedly more informative and useful as a model of drinking water choice. Use of model 3 allows for more precise welfare measure calculations and the calculation of the value of a statistical life around distinct probability values, as opposed to categorical averaging that would be necessary for these calculations using model 5.

6.3 Welfare Calculations

Models estimated in this chapter allow for calculations of welfare measures and willingness to pay values. Despite tests that suggest non-linear risk values, model 3 conforms to economic theory of risk, and will be more informative and useful for the calculation of welfare measures. Class A of this model displayed a significant coefficient on the probabilistic risk variable included in the estimation. This warrants its use in further welfare calculations. Both the value of statistical life (VSL) and WTP measures for risk reduction and improvement in other dimensions of quality can be derived using this model. In comparison with expenditures in the original data, and values suggested by prior work in the area of risk reduction, the values predicted here will provide insight into model predictions.

6.3.1 Value of Statistical Life

Willingness-to-pay for risk reductions is the metric used as the value of statistical life. The value of a statistical life is calculated as the marginal dollar value of risk reduction divided by the perceived risk reduction:

$$VSL = \frac{WTP_{\pi}}{d\pi} \tag{42}$$

The coefficients in model 3 are used to obtain the marginal dollar value of risk changes (WTP_{π}). The marginal dollar value of risk reductions is obtained by dividing the risk coefficient by the coefficient on monthly cost[18]. The resulting value is the WTP for a risk reduction of 1%. The VSL should represent the value of one statistical life saved. Therefore the resulting WTP_{π} need only be multiplied by 100 or divided by a $d\pi$ of 0.01%. The resulting VSL is $ 1.80 million. Using the Krinsky-Robb procedure (Haab and McConnell, 2002), simulations suggested a standard deviation around this estimate of approximately $1.13 million. One must be careful in interpretation of this VSL, as it is representative only of individuals that were grouped in class A of model 3. Recall that approximately

[18] Recall that in all estimated models presented in chapter here, the risk values were scaled by a factor of 10,000. Therefore the coefficient on risk will first be scaled upwards by 10,000. Following this conversion, the scaled risk coefficient can be divided by the marginal utility of money.

76.2% of individuals were grouped in this class. Therefore to more accurately reflect the value of statistical life for a representative sample of the Canadian population, this value could be discounted by 23.8%. When discounted for class membership the resulting VSL is $1.37 million.

In a meta-analysis of prior estimates, Viscusi and Aldy (2003) calculate an average VSL of approximately $6.7 million (though Canadian estimates are normally lower). In comparison with this estimate, both of the VSL estimates presented in this study fall below the mean estimate in the meta-analysis. However these values are not directly comparable to those produced in this study. The estimates produced in this study are based on averting expenditures and are lower bound estimates. As such, these VSL estimates are considered to be reasonable.

6.3.2 Welfare Measures

Measures of welfare will be calculated using the same model as used for VSL calculations. With the estimated coefficients, monthly willingness to pay values for changes in quality dimensions can be obtained. Of interest here is the monthly WTP for a risk reduction in tap water to the perceived risk level of other water options, and the monthly WTP for improvements in water quality to the level of other water options.

In a multinomial choice model, it is possible to assess the WTP for a change in both single, and multiple attributes at one time. This WTP value is calculated as the difference in utility between the two scenarios divided by the marginal utility of money income:

$$WTP = \frac{1}{\beta_{\$}}\left(ln\sum_{i=1}^{C} e^{V_i^1} - ln\sum_{i=1}^{C} e^{V_i^o}\right) \quad (43)$$

Where the first term in brackets, which includes V_i^1, is the model with utility functions that include any quality change and the second term in brackets, which includes V_i^o, corresponds to the base case. The bracketed expression is then divided by the marginal utility of money income, $\beta_{\$}$ to convert the utility difference into a dollar value.

Expression (43) was used to calculate monthly WTP values for risk reductions in tap water to the levels of both bottled and filtered water. Furthermore, the monthly WTP for improvement in tap water to the perceived quality of bottled and filtered water has been calculated. For these calculations, mean values for each characteristic were used. These values represent WTP values for class A of model 3 only. Class B did not produce a significant coefficient on monthly cost. Therefore WTP for quality improvements in this group is zero. Results from calculations are presented in table 6-1. Again, the Krinsky-Robb procedure (Haab and McConnell, 2002) was used to produce standard deviations around these estimates.

Table 6-4- Monthly Willingness-to-pay for Improvements in Tap Water Quality

Tap Water:		**Monthly WTP**	**Standard Deviation**	**Discounted For Class Membership: Class A**
Risk Reduction	*to Filtered Risk*	$ 0.43	0.332	$ 0.33
Risk Reduction	*to Bottled Risk*	$ 0.50	0.394	$ 0.38
Quality Improvement	*to Filtered Level*	$ 3.88	2.255	$ 2.96
Quality Improvement	*to Bottled Level*	$ 18.34	4.247	$ 13.97

The monthly WTP for risk reduction in tap water to the level of both filtered and bottled water ranges from $0.43 to $0.50. For improvement in tap water quality to the perceived quality of filtered water, the monthly WTP was calculated as $3.88. This same calculation for improvement to the perceived quality of bottled water yielded $18.34. These are indicative of the monthly payment, on average, that an individual in class A would be willing make to improve their tap water quality to the specified level. In a similar fashion to the treatment of the value of statistical life, these estimates can be discounted for class membership to obtain a more accurate picture of WTP for the Canadian population. These values are displayed in the last column of table 8-1 and represent a 23.8% reduction from the original value.

6.3.3 Discussion of Welfare Estimates

Due to the wide range of values, and various research questions that researchers have asked in averting behaviour studies, willingness–to-pay estimations presented here are not directly comparable. However, the estimated WTP values, particularly for overall quality improvement to the level of filtered or bottled water, appear to be reasonable. They suggest a preference for the perceived quality of bottled water, which produced the largest WTP estimate. Note also that the reported values are significantly lower than the mean expenditure on monthly supplies of each water source. VSL estimates, on the other hand, offer a more standardized metric for comparison, as these calculations only reflect WTP for reductions in mortality risk. In comparison with other VSL estimates, the estimates produced here appear to be relatively low. However, this is expected, as the VSL estimates were calculated using averting expenditures, and therefore should represent a lower bound. This estimate is also useful as a scenario-specific VSL. Hammitt (2007) underlines the importance of scenario-specific values, as individuals are likely to assign varying degrees of monetary value to reductions in mortality risk depending on the scenario. A scenario-specific effect would produce different average VSLs for equivalent risk reductions. Therefore this value is useful primarily in the consideration of changes in water quality, and water related policy initiatives.

6.4 Summary

Five econometric models of water choice were estimated and presented in this Chapter. Latent class formulations indicated a division in the sample into two groups. Results suggest the presence of a risk-sensitive group, where the coefficient on risk was proven to be negative and significant, and a risk-insensitive, non-compensatory group.

The second group of models estimated used a series of dummy variables for risk perception responses. This was done in order to investigate the theoretical prediction of proportionality in risk reduction values. The inclusion of these variables in a subsequent latent class formulation revealed similar conclusions regarding drinking water preferences. However, in this case, coefficients on risk perception variables suggested the presence of non-linearity in valuation. Results from tests and comparison primarily favoured the model with non-linear risk coefficients, and consequently proportionality was rejected for the sample. Despite this fact, model 3, which imposed proportionality by nature, was used in welfare estimates as it is considered to be more useful and informative for this task.

Welfare estimates calculated and presented here include WTP for water quality improvement, as well as VSL estimates. WTP estimates appear to be reasonable, given the data. VSL estimates, in comparison with other studies appear to be low. However, on account of a basis in averting expenditures a lower bound result, such as that presented, is expected. The estimated models, and resulting welfare estimates are can be useful tools in the analysis of public investment, and public benefits.

7.0 Summary and Conclusions

The purpose of this study was to investigate preferences for drinking water in Canada, and the presence of averting behaviour. With economic theory of averting behaviour as a foundation, objectives outlined for the study included the estimation of a choice model for water alternatives, the inclusion of a probabilistic health risk variable as a measure of environmental quality, and to assess the adherence of risk reduction valuation to the theoretical prediction of proportionality. Whereas few studies prior to this use a probabilistic measure of perceived risk, we explicitly include this risk value in estimation and investigate the theoretical predictions surrounding the model as a whole, and the risk variable independently. Furthermore, the implementation of an online interactive risk ladder to elicit perceived risks is a novel methodological advancement in the collection of perceived risk values. With data gathered through an online survey a series of choice models were estimated in the study. Results suggested the presence of averting behaviour with water options in Canada, and perceived mortality as a significant predictor of choice between water alternatives. In this instance the inclusion of perceived mortality risk, as the measure of environmental quality in an averting behaviour framework, was proven to be a useful approach. Estimates obtained from this study, and others like it, can be helpful in both policy analysis and public investment decisions as they provide a conservative, lower bound on public benefits. The precision of these estimates, however, is limited by assumptions and qualifications present in the interpretation of the model.

The probabilistic risk variable was gathered using an interactive online risk ladder. The implementation and use of the ladder in elicitation of perceived mortality risk worked well for the purpose of the study. By and large the recorded risk values for all water sources were very low. Based on the high quality of Canadian tap water this was expected. However, on average, in comparison with the perceived mortality risk associated with tap water, responses indicated perceived risk reductions associated with consumption of bottled and filtered water alternatives. The gathered probabilistic risk estimates were included as the environmental quality measure in choice models based on an averting behaviour framework. These models were targeted at characterizing preferences for drinking water in Canada.

A series of five choice models were estimated and analyzed. The estimation of latent class models revealed stratification in the sample focused primarily around the risk variable. The class equation suggested a division in the sample based on cognitive ability to assess probability values and education. These models suggested the existence of two classes. One class was a risk-sensitive group. In this group, in addition to the significance of other quality characteristics, perceived mortality risk was a significant predictor of water choices. The second class of individuals revealed in the latent class models was a group of risk-insensitive, non-compensatory individuals. In this class, neither risk nor monthly costs were significant predictors of water choice. Additionally the significance and size of constants in the bottled and filtered equations suggested that individuals in this group were primarily tap water drinkers. Approximately 76%

of respondents were placed in the risk-sensitive class, while the remaining 24% were placed in the risk-insensitive non-compensatory group. Additional estimations revealed more information regarding risk valuation.

The theoretical prediction of proportionality in valuation of risk reduction was tested through the estimation and comparison of additional models. Initial estimations of the choice model contained a single risk variable. This formulation imposes proportionality on the model, and although the variable was significant in the latent class estimation this is not sufficient for conclusion that risk reductions are valued proportionately. In order to further evaluate the nature of risk reduction values, estimation of additional models used a risk variable that had been separated into a series of dummy variables corresponding to sections of the risk ladder (i.e. low to high). In these estimations, a similar pattern emerged as from the latent class model with a single risk coefficient. That is, approximately 76% of individuals were placed in a risk-sensitive group, and approximately 24% of individuals were placed in a non-compensatory group. The risk coefficients estimated in this formulation were also significant, and contrary to theoretical predictions, suggested non-linearity in valuation of risk reduction. Therefore these two model estimations provided inconsistent results with regards to proportionality in the valuation of risk reduction. Statistical tests indicated favourability of the latter model, with multiple non-linear risk coefficients. However, the model with a single risk variable offers a more informative characterization, and overall is a more parsimonious presentation of drinking water preferences in Canada. Therefore this model was favoured for use in welfare calculations.

Welfare calculations completed included VSL estimates, and estimates of monthly WTP for improvement of water quality to the perceived levels of bottled and filtered water. These estimates were only calculated for the risk-sensitive group in the latent class model with a single risk variable. The risk coefficient, as well as the monthly cost coefficient, was not significant in the non-compensatory group and therefore WTP for this group was effectively zero. The VSL estimate was approximately $1.80 million with a standard deviation of approximately $1.13 million. When discounted for class membership this value is reduced to approximately $1.37 million. In comparison to other estimates, the VSL estimates in this study are considered to be relatively low. However, as this VSL is calculated from voluntary averting expenditures, this estimate is expected to be a lower bound. Monthly WTP for improvement of tap water quality to the level of filtered water was estimated as approximately $3.88. Monthly WTP for improvement to the level of bottled water was approximately $18.34. These values suggest a preference for bottled water overall, and are indicative of a monthly payment that individuals would be willing to make for quality improvement of their tap water. Comparison of WTP estimates for improvement in quality characteristics, with WTP estimates for risk reduction highlight an implicit relative value and importance of risk reduction. The monthly WTP for risk reductions is in the range of $0.40 to $0.50 per month. This makes up a small fraction, in particular with bottled water, of the WTP for overall quality improvement, and indicates that the WTP for improvement in other quality dimensions may carry more importance.

As a measure of public benefits, these calculations and estimates can be useful for both public policy analysis, and public investment decision making. Individuals engage in averting behaviour because their desired level of cleanliness is not met by the ambient environmental quality. Averting expenditures, then, are the amount of money that the public is willing to spend to achieve this desired level of cleanliness. Therefore, in the case of public investment, estimates obtained from econometric models, such as those here, can provide a measure of benefit for weight against cost in the decision to allocate public spending. Contrary to other estimates of willingness-to-pay, the estimates derived here are theorized to provide a lower bound on willingness-to-pay. This is due to averting expenditures being voluntary, and averting "technologies" being readily available. In many other studies of willingness-to-pay and the value of statistical life, these measures are obtained not through real-market activities, but rather through experimental methods such as contingent valuation tasks, or choice experiments. The estimates produced in this study, then, are interpreted as conservative and therefore may provide for prudent decision making, particularly in a case where the minimum benefit to the public is desirable. Obvious applications include investment decisions in water treatment facilities, and policy regarding water quality standards and guidelines.

These results, however, do not imply a large value to the public for improvement in health related aspects of drinking water. Welfare calculations produced a relatively small WTP for health risk reduction. It is not likely, then, that the public would be found in favour of investment for improvements in municipal water treatment facilities and infrastructure, insofar as they provide health risk reductions. Rather, given the low level of perceived health risks associated with tap water, improvements in water treatment facilities that benefit characteristics like taste, or odour may be those which are most attractive. That is, although perceived health risks are significant predictors in the estimated choice models, non-health related quality characteristics and potential gains in these dimensions appear to be more valuable to the public. Therefore, in the case of very low perceived health risks, changes to water treatment that do not produce improvements in non-health related characteristics of tap water, are not likely to be worth the necessary investment.

However, various limitations and qualifications are present in the interpretation of these results. Noteworthy issues include potential bias created through the use of an online panel, unaccounted for joint products, and the potential for endogeneity in the estimated models. Furthermore, the nature of the risk variable in the model with regards to the theoretical framework, and the effectiveness of the risk ladder for collection of risk perceptions may each have a significant impact on the results obtained in the study. The use of a probabilistic risk variable in an averting behaviour framework is a departure from traditional methods. Moreover this is a departure, perhaps, from the original intent of the averting behaviour model. Risk perceptions data, on the other hand, may be the main area that must be considered upon interpretation of estimated models.

Data collection using a risk ladder in an online survey presents a number of unique issues associated with risk perception responses. That is, regardless of the introductory text to the use of the risk communication device, or the risks communicated on the risk ladder, it is difficult to ascertain precisely what the gathered risk may represent in terms of time frame, consumption level or contaminants. One hopes that individuals are able to incorporate risk factors, such as age, that they can envision a case in which they were to only drink one type of water, and that they have understood the specified time period. However, these assumptions may be faulty. For example, the use of an annual time frame may not have been the most appropriate approach for gathering perceived mortality risks. It could be that individuals are not concerned with annual mortality risk, but rather, are more concerned with lifetime risk. In which case the risks gathered may be erroneous, or results may be interpreted incorrectly. Another issue relates to the link between specific contaminants and mortality risk. We address mortality risk from all things related to drinking water. It is implicitly assumed, then, that on some level individuals translate all types of water contamination into a mortality risk. In reality this may not true. It may be the case that the translation of contamination into risk is more suitable to risk of illness, as opposed to mortality. Furthermore, the lack of specificity in terms of contaminants and pathogens may be cause for difficulty in response and, again, contribute to potential error in response and interpretation.

Another area for consideration, in regards to bias, is the use of an online panel for data collection. Despite the request for a comparable distribution to the

Canadian population in terms of age, income, region and gender, it is possible that the sample is not truly representative of the Canadian population. Participation in the survey was voluntary and as such creates the potential for bias from self-selection based on interest in the survey topic or strong opinions on drinking water. Other biases can arise from the inclusion of individuals who completed the survey solely for the incentive provided by Ipsos-Reid where individuals may not have been engaged in the survey content. Finally, respondents recruited with an online panel are those with access to the internet and E-mail. As a result of this access we may expect other related demographic characteristics in these individuals that may be an inaccurate representation of the Canadian population. These elements were not controlled for, and the potential for misrepresentation of the Canadian population should be noted as a potential confounding aspect of this method and the resulting models.

Although accounted for in estimation, through the inclusion of taste, odour, appearance and convenience variables, other joint products may be a source of imprecision in both the estimated models and the resulting welfare calculations. In estimation, and formulation, water options were not considered for their contributions to utility as an indicator of social status, or as a luxury good. This might be a concern for bottled water, which in some cases commands a price premium and is likely to be perceived as luxury. Bottled water is also the victim of a recent consumer backlash due to the waste produced by used water bottles. The disutility arising from the environmental impact of consumption of this water option is another joint product unaddressed in these models. Furthermore, only joint production arising from other ‘services’ provided by the averting behaviour were controlled for. If the ambient drinking water quality is suspected to enter the utility function directly, the accuracy of the models and resulting welfare calculations may be further obscured.

The potential endogeneity of variables included in estimation, in particular the perceived risk variable, should also be considered for impact on results. Although attitudes towards water safety, and experiences with water quality issues were included and subsequently removed from the models due to the likelihood of endogeneity, the remaining variables are potentially endogenous. That is, these variables may be latent indicators of preference for water options, or may be determined jointly with consumption. Of particular concern is the perceived risk variable. Unfortunately, due to the nature of this variable, and the large range of values captured using the risk ladder, suitable instruments were not readily available for substitution.[19]

A few avenues exist for future research in this area. One area for future research lies in the link between specific contaminants and perceived risk values. Whereas the present study focused on an overall annual perceived risk value, useful information may be gathered through the linkage of lifetime mortality risk with exposure to certain contaminants. Jakus et al. (2009) has conducted the only study, that we are aware of, that has attempted to investigate this linkage. This link may provide a familiar probabilistic platform on which respondents and individuals can evaluate absolute levels of contaminants in their water. Further

[19] Both auxiliary regressions, and additional variables were assessed for suitability as instrumental variables but did not produce consistent results.

research might also be suggested in the valuation of reduction in risk of illness, as opposed to mortality. Risk of illness will likely be a much larger value and consequently will facilitate interpretation. Further research, therefore, may not necessarily need focus on technical methodological advancement, but rather on the nature of the interpretation of risk values and the formation of the risk beliefs and risk perceptions that are included in models of averting behaviour.

The estimation of choice models in this study, and subsequent evaluation of the value risk reduction, was derived from an averting behaviour framework. Contrary to evaluation of averting behaviour using absolute levels of contamination, the focus here was the use of a probabilistic risk variable. The inclusion of this variable was useful in interpretation of model output and worked well for the purposes of this study. In comparison with other averting behaviour studies, this study was completed neither in the developing world, nor with a community or group of individuals specifically affected by a water contamination event. However, results still suggest that a large subset of individuals in Canada is concerned with the quality of their tap water. As a consequence these individuals exhibit values both for improvement of tap water quality, and for reduction in mortality risks.

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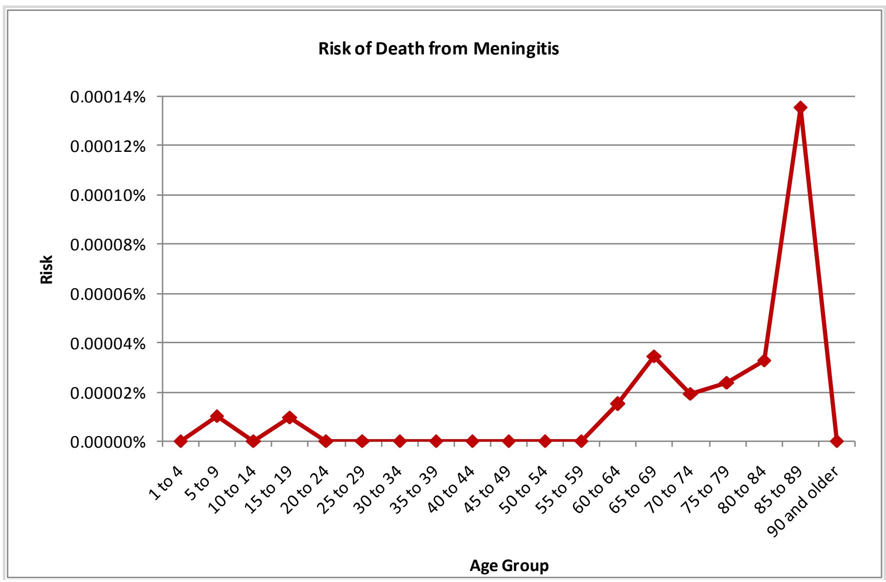
Appendix A: Selected Annual Risk of Death by Age Group

Selected Annual Risk of Death by Age Group, *Illness and Disease***: *2000-2004***

Note: Careful attention should be given to the interpretation of figures A-1 through A-7, as the intent was to show the relationship of death risk with age. As a result the y-axis scale is different for each graph.

Figure A 1- Risk of Death from Meningitis[20]



[20] *Source: CANSIM II: Table 1020521- Deaths, by cause, Chapter I: Certain infectious and parasitic diseases (A00 to B99), age group and sex, Canada, annually (Number).*

Figure A 2- Risk of Death from Tuberculosis[21]

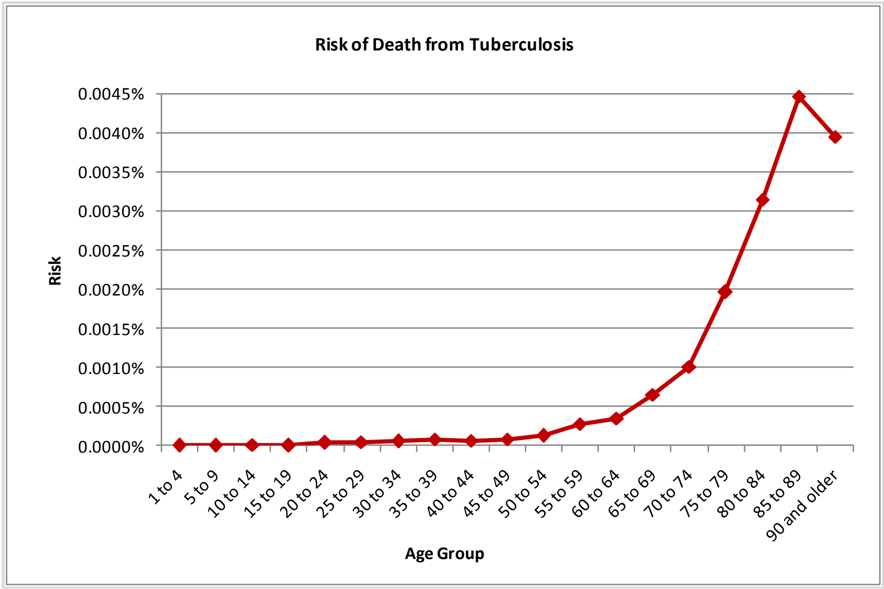
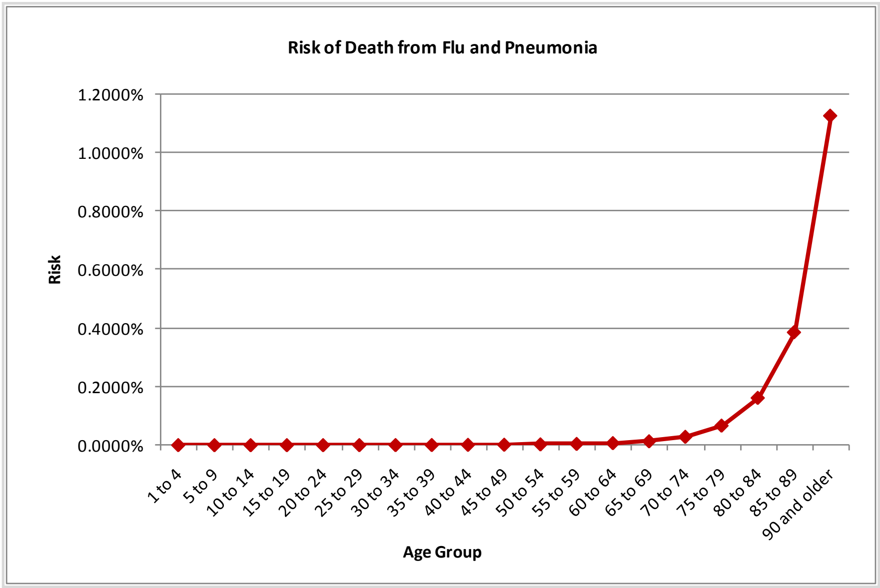


Figure A 3- Risk of Death from Flu and Pneumonia[22]



[21] *Source: CANSIM II: Table 1020521- Deaths, by cause, Chapter I: Certain infectious and parasitic diseases (A00 to B99), age group and sex, Canada, annually (Number).*

[22] *Source: CANSIM II: Table 1020521- Deaths, by cause, Chapter I: Certain infectious and parasitic diseases (A00 to B99), age group and sex, Canada, annually (Number).*

Figure A 4- Risk of Death from Heart Attack[23]

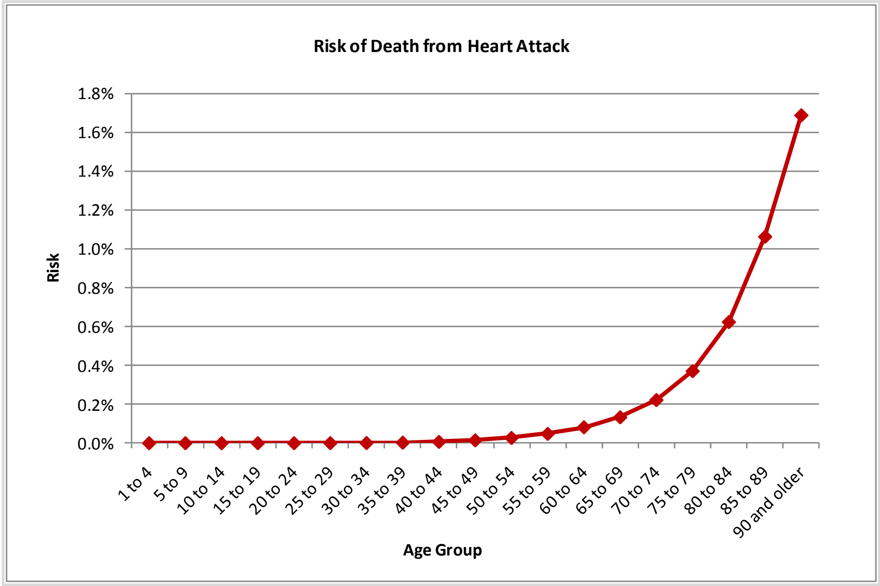
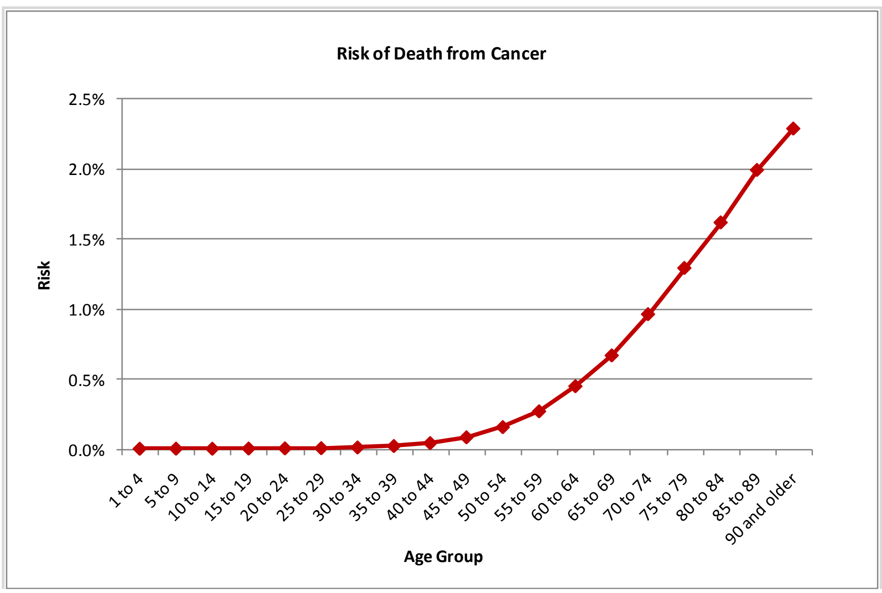


Figure A 5- Risk of Death from Cancer[24]



[23] *Source: CANSIM II: Table 1020529- Deaths, by cause, Chapter IX: Diseases of the circulatory system (I00 to I99), age group and sex, Canada, annually (Number).*

[24] *Source: CANSIM II: Table 1020522- Deaths, by cause, Chapter II: Neoplasms (C00 to D48), age group and sex, Canada, annually (Number).*

Figure A 6- Risk of Death from Skin Cancer[25]

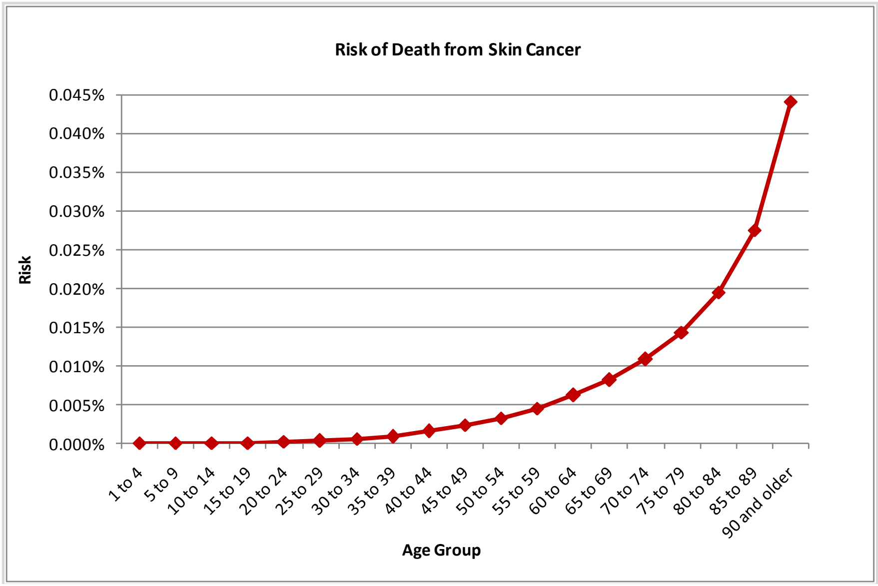
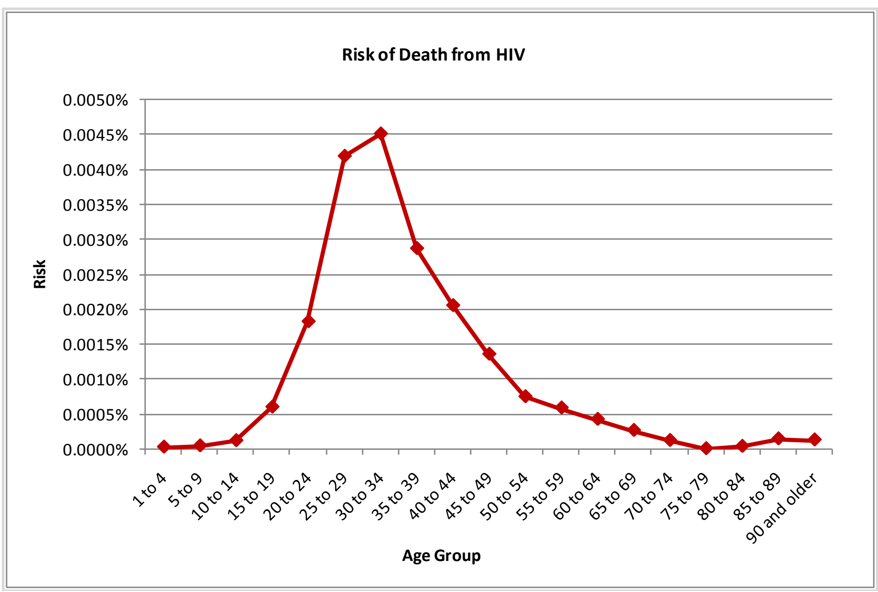


Figure A 7- Risk of Death from HIV[26]



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[25] *Source: CANSIM II: Table 1020522- Deaths, by cause, Chapter II: Neoplasms (C00 to D48), age group and sex, Canada, annually (Number).*

[26] *Source: CANSIM II: Table 1020521- Deaths, by cause, Chapter I: Certain infectious and parasitic diseases (A00 to B99), age group and sex, Canada, annually (Number).*

Selected Annual Risk of Death by Age Group, *External Causes***: *2000-2004***

Figure A 8 - Risk of Death from Homicide[27]

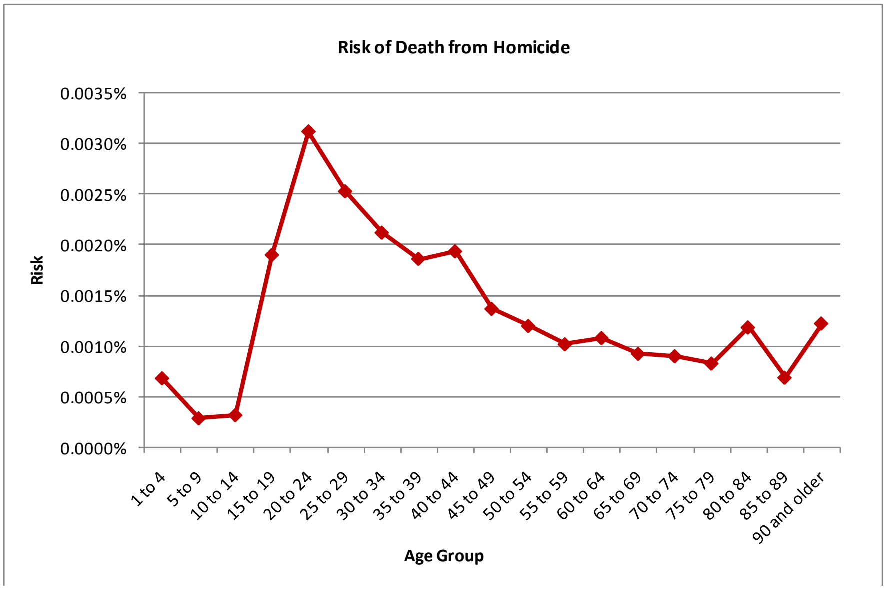
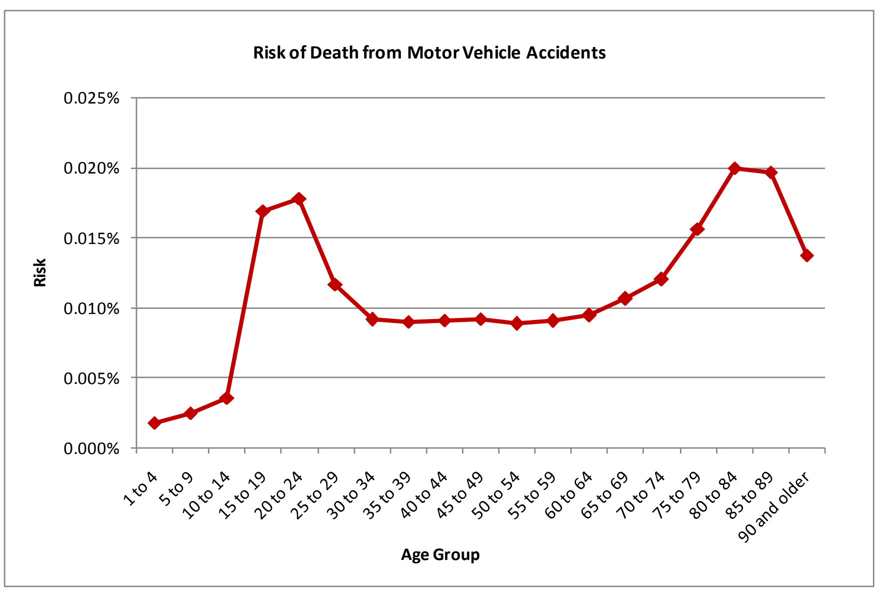


Figure A 9- Risk of Death from Motor Vehicle Accidents[28]



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[27] *Source: CANSIM II: Table 1020540- Deaths, by cause, Chapter XX: External causes of morbidity and mortality (V01 to Y89), age group and sex, Canada, annually (Number).*

[28] *Source: CANSIM II: Table 1020540- Deaths, by cause, Chapter XX: External causes of morbidity and mortality (V01 to Y89), age group and sex, Canada, annually (Number).*

Appendix B: Survey

Consumer Views on Urban Water Management

A research project to support policy making and decision making. Sponsored by the Canadian Water Network. Conducted by researchers from the University of Alberta and Brock University.

[INSERT STANDARD I-SAY INTRODUCTION]

Study Overview

Consumer Views Urban Water Management

Principal Investigators:
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You are invited to participate in a study that involves researchers in Ontario and Alberta and is being supported by the Canadian Water Network, a network of Canadian researchers who have joined together to look at water issues.

Purpose: The goal of this research is to determine public preferences for improved water quality and to avoid adverse health outcomes associated with drinking water supply.

Methods: We are asking you to take part in a survey being held across Canada. This information could be used to structure more efficient water pricing schemes for municipal water utilities and to aid these utilities in their infrastructure and health risk reduction investment decisions. The survey should take about 25 minutes of your time.

Benefits: Survey participants will assist the researchers in obtaining estimates of the public's perceptions of water quality and the importance of clean water to Canadians. There are no known or anticipated risks associated with participation in this study.

Confidentiality: All information you provide is considered confidential and grouped with responses from other participants. Names will not be associated with survey responses. Access to the data will be restricted to investigators.

Withdrawal: Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study. Further, you may decide to withdraw from this study at any time and may do so without any penalty or loss of benefits to which you are entitled.

Publication of Results: Grouped results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available December 2008 from the principal investigators using the contact information provided above.

Contact Information and Ethics Clearance: If you have any questions about this study or require further information, please contact the Principal Investigators using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University (file #07-320). If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550, Ext. 3035, reb@brocku.ca. Thank you for your assistance in this research project. Please keep a copy of this form for your records.

1. From which of the following sources do you get the water you and members of your household drink at home? *Please select all that apply.*

Tap water from a municipal utility
Tap water from a water well or natural well
Purchased bottled water
Water delivery service of spring, pure or distilled water (e.g. Culligan, Canadian Springs, Sparkling Springs, etc.)
Other (*Please type in your response*)
Don't know
[INSERT TEXT BOX AFTER "OTHER"]

[ASK Q2 IF MORE THAN ONE ITEM SELECTED IN Q1]

2. From which source do you get <u>most</u> of the water you and members of your household drink at home? *Please select one.*

[INSERT LIST OF ITEMS SELECTED IN Q1]

3. What are the primary characteristics that you consider when you choose your drinking water? *Please select all that apply.*

Taste
Smell
Appearance
Convenience
Health Concerns (e.g. risk of illness or death from your source of drinking water)
Other (*Please type in your response*)
[INSERT TEXT BOX AFTER "OTHER"]

There are three sources of <u>drinking water used in the home</u> that will be discussed in this survey:

(i) Tap water
(ii) In-home Treated Tap Water (In-home filtration using a tap attachment, container style filtration system, refrigerator attachment or boiling)
(iii) Purchased water (bottled or from home delivery)

4. Which, if any, of the following have you experienced with the **tap water** in your home over the past year? *Please select all that apply.*

Rusty colour
Sediment (particles at the bottom of a glass)
Unpleasant smell (e.g., musty, chlorine)
Unpleasant taste (e.g., musty, chlorine)
Hard water / mineral deposits
Pollutants or other contamination
Other (*Please type in your response*)
None of the above

[INSERT TEXT BOX AFTER "OTHER"]

5. Looking forward two years, do you expect the quality of your tap water at home to be...? *Please select one response only.*

Worse than today
Same as today
Better than today
Don't know

6. Which of the following statements best reflects your personal opinion about health concerns you might have with the tap water in your home? *Please select one response only.*

Drinking tap water **does not** pose a problem for my health or my family's health
Drinking tap water poses a **minor** problem for my health or my family's health
Drinking tap water poses a **moderate** problem for my health or my family's health
Drinking tap water poses a **serious** problem for my health or my family's health

7. To the best of your knowledge, have you or anyone in your household ever become sick from drinking any of the following types of water in your home? *Select one from each row.*

Grid Rows:
Tap water
Purchased water (bottled water)
In-home treated tap water (filtered water)

Grid Columns:
Yes
No
Don't Know

8. For each of the following items that may be present in a household's tap water, please indicate if you have **heard** about it as a concern with drinking tap water and if any of these items has been a special concern in **your community**. *Please select all that apply for each column.*

Rows (Health Concern):
Microbe – E. coli
Microbe – Cryptosporidium
Microbe – Giardia (Beaver Fever)
Chemical – Fluoride
Chemical – Trihalomethanes
Metals – Iron, Lead, Mercury
Chemical – Pesticides
None of the above

Columns:
Heard About it as a Drinking Water Concern
Drinking Water Concern in My Community

9. Considering each of these, how much of a health concern do you personally believe each poses in your home's tap water? *Please select one for each row.*

Rows (Health Concern):
Microbe – E. coli
Microbe – Cryptosporidium
Microbe – Giardia (Beaver Fever)
Chemical – Fluoride
Chemical – Trihalomethanes
Metals – Iron, Lead, Mercury
Chemical – Pesticides
None of the above

Columns:
No Health Concern
Minor Health Concern
Moderate Health Concern
Serious Health Concern
Don't Know/Uncertain

The following question presents some measures of health risk and is included in the survey in order to ensure that we are communicating our ideas correctly.

10. a. Suppose you are given the choice of living in one of two communities that are identical except for their risk of death. Community **A**'s risk of death is 5 in 100,000, whereas community **B**'s risk of death is 1 in 10,000? Which community would you choose to live in? *Please select one response only.*

Community A: 5 in 100,000 risk of death
Community B: 1 in 10,000 risk of death

[ASK 10B if "COMMUNITY B" IN 10A OTHERWISE SKIP TO Q11]

10b. Community A has a risk of death of 5 in 100,000. Comparatively, Community B has a risk of death of 1 in 10,000. 1 in 10,000 is equivalent to a risk of 10 in 100,000. Therefore, Community B has a higher risk of death. Would you still choose Community B over Community A?" *Please select one response only.*

I choose Community A: 5 in 100,000 risk of death
I choose Community B: 10 in 100,000 risk of death

11. For the three water sources mentioned below, please indicate the percentage of water you personally consume at home that comes from each source in any given month both now and 1 to 2 years ago. *If your answer is zero in any category you must select 0% in the drop-down box.*

[MUST ENTER WHOLE NUMBER AND TOTAL 100]

Columns (Water Type):
Tap water
In-home Treated Tap Water
Purchased Water
Total (100%)

Rows:
% Consumed Now
% Consumed 1 to 2 Years Ago

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW. TOTAL SHOULD ADD AUTOMATICALLY AND MUST ADD UP TO 100%]

Water Type	**% Consumed Now**	**% Consumed 1 to 2 Years Ago**
Tap water		
In-home Treated Tap Water		
Purchased Water		
Total (100%)	100%	100%

12. Thinking about **your own personal water consumption at home** from all sources, would you say you are drinking...? *Please select one response only.*

More than the amount consumed 1 to 2 years ago
About the same amount of water as 1 to 2 years ago
Less than the amount consumed 1 to 2 years ago
Don’t know

13a. Do you have any children under the age of 18 living at home?

Yes
No

[IF “YES” AT Q 13A, ASK 13 B OTHERWISE GO TO Q15]

13b. What is the age of the youngest child living at home? *(Please select one from the drop-down menu)*
Under age 1
1 to 18
[DROP DOWN MENU]

14. For the three water sources mentioned above, please indicate the percentage of water consumed by **your youngest child <u>at home</u>** that comes from each of the following sources in any given month.

<u>Columns (Water Type)</u>
Tap water
In-home Treated Tap Water
Purchased Water
Total (100%)

<u>Rows (scale)</u>
% Consumed Now

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW. TOTAL SHOULD ADD AUTOMATICALLY AND MUST ADD UP TO 100%]

Water Type	% Consumed Now
Tap water	
In-home Treated Tap Water	
Purchased Water	
Total (100%)	100%

[IF PURCHASED BOTTLED WATER OR WATER DELIVERY SERVICE SELECTED AT Q1, ASK Q15. OTHERS SKIP TO Q17]

15. If you purchase bottled water, or receive your water from a delivery service, what is the primary reason you use purchased water? *Please select one response only.*

Convenience
Taste
Health concerns about tap water
Other (*Please type in your response*)
Don't know
[INSERT TEXT BOX AFTER "OTHER"]

16. In an <u>average month</u>, how much money do you estimate that you spend on **purchased water (bottled water or delivery service) to drink <u>at home</u>**? *Please enter your best estimate to the nearest dollar.*

[INSERT TEXT BOX $]
Don't know

17. Which, if any, of the following types of water filtration or treatment systems do you use at home? *Please select all that apply.*

Container style water filter (e.g. Brita type systems)
Water filtration system that is attached to a tap
Water filtration system attached to a refrigerator
Water softener system
Fluoridation not already in your municipal water
None/No filtration or treatment systems
Other (*Please type in your response*)
Don't Know
[INSERT TEXT BOX AFTER "OTHER"]

[IF CONTAINER STYLE WATER FILTER (Code 1) OR "WATER FILTRATION SYSTEM ATTACHED TO A TAP" (Code 2) AT Q17 CONTINUE. IF "WATER FILTRATION SYSTEM ATTACHED TO REFRIGERATOR" (Code 3) at Q17, GO TO Q21a. ALL OTHERS SKIP TO Q22]

18. Do you own or rent your…

[INSERT ITEM: WATER FILTRATION SYSTEM ATTACHED TO TAP/CONTAINTER STYLE WATER FILTER FROM Q17]

Own
Rent
Don't know

[**ASK Q19 FOR EACH ITEM <u>OWNED</u> IN Q18**]
19. Approximately how much did you spend to buy your**…**
[INSERT ITEM FROM Q18]
Please enter your best estimate.

[PROGRAMMER NOTE: MAY BE A RANGE]

Nothing (we did not purchase it)
[INSERT TEXT BOX $]
Don't know

[**ASK Q20 FOR EACH ITEM <u>RENTED</u> IN Q18**]
20. Approximately, how much do you spend per month to rent…
[INSERT ITEM FROM Q18]?
Please enter your best estimate.

[PROGRAMMER NOTE: MAY BE A RANGE]

[INSERT TEXT BOX $]
Don't know

[ASK Q21a and b. ONLY IF "CONTAINER STYLE WATER FILTER" OR "WATER FILTRATION SYSTEM – TAP OR REFRIGERATOR" SELECTED IN Q17.]
[ASK FOR EACH OF THESE ITEMS SELECTED IN Q17]

21. a) How much do you spend for EACH replacement filter for your…
[INSERT ITEM FROM Q17]
Please enter your best estimate to the nearest dollar.

[INSERT TEXT BOX $]
Don't know

21. b) And, how frequently do you replace the filters for this system? *Please select one response only.*

Weekly
Once a month
Once every two to three months
Once every four months
Twice a year
Once a year
Less than once a year
Never
Don't know

22. How often, if ever, do you boil your tap water at home before drinking it (i.e., to make it safer or taste better, not for making a hot beverage such as tea)? *Please select one response only.*

Daily
Weekly
Monthly
Never
Don't know

[SEPARATE SCREEN]

In the following questions we would like to evaluate your perceptions of microbial illness from each water source described above (Tap water, In-home Treated Tap Water and Purchased Water).

Symptoms of Microbial Illness may include:

- ***Stomach pain or cramps***
- ***Nausea or vomiting***
- ***Diarrhea***
- ***Blood in stools***
- ***Low-grade fevers***

Symptoms appear soon after infection and the average person experiences approximately 20 days each year where they have some or all of these symptoms and the cause is microbial illness. Examples of waterborne microbial illnesses are: giardia (Beaver Fever), cryptosporidiosis, and E. coli.

In the following questions, please indicate the number of days in which you felt one or more of these symptoms.

23. How many days in each year do you experience any microbial illness symptoms from any cause? *Please enter one number from 0 to 365.*

[INSERT TEXT BOK]

Earlier, you reported that the percentage of water you personally consume at home comes from:
[INSERT ANSWERS FROM Q13]
X% tap water
Y% in-home treated tap water
Z% purchased water

24. Out of the number of days you indicated in the previous question, how many of these days do you suspect could be a result of the water you drink at home? *Please enter one number from 0 to 365..*

[INSERT TEXT BOX]
[RANGE: 0 to [INSERT VALUE FROM Q23]]

The following questions will ask you about microbial illness symptoms that may result from each of the three water sources discussed previously (tap water, in-home treated tap water and purchased water).

[SKIP Q25 IF "100% TAP WATER" IN Q11]

25. If your home water consumption were to consist of **100% tap water** how many days with microbial illness symptoms do you suspect you would experience in one year using only this water source for drinking? *Please enter one number from 0 to 365.*

[INSERT TEXT BOX]

[SKIP Q26 IF "100% IN-HOME TREATED TAP WATER" IN Q11]

26. If your home water consumption were to consist of **100% in-home treated tap water** how many days with microbial illness symptoms do you suspect you would experience in one year using only this water source for drinking? *Please enter one number from 0 to 365.*

[INSERT TEXT BOX]

[SKIP Q27 IF "100% PURCHASED WATER" IN Q11]

27. If your home water consumption were to consist of **100% purchased water** how many days with microbial illness symptoms do you suspect you would experience in one year using only this water source for drinking? *Please enter one number from 0 to 365.*

[INSERT TEXT BOX]

28. Comparing health effects from drinking bottled water (purchased water) to health effects from drinking your home's tap water, do you think that **bottled water** is…? *Please select one.*

Much more safe than tap water
A little safer than tap water
About as safe as tap water
A little less safe than tap water
Much less safe than tap water
Don't know/not sure

[SEPARATE SCREEN]

Some people are concerned about health risks from drinking water. We would like to know your views on health risks from drinking water versus other types of health risks. To do this we will be using a picture that describes different risks. This picture is called a risk ladder.

The risk ladder illustrates the risk of death within any year to the average Canadian. The risks are presented for a number of different causes identified on the far left of the graph. The middle column of the graph shows the annual percentage chance (probability) of each cause of death. The highest probability or highest risk events are shown at the top of the graph and the lowest probability or lowest risk events are shown at the bottom. On the far right hand side of the graph we also show these risks in terms of the average number of deaths in Canada in a given year by the specified cause, and the average number of deaths in increasing group sizes (e.g. 1000, 10,000, 100,000 etc.). Please take a moment to consider the risks being represented on this graphic.

[INSERT RISK LADDER ILLUSTRATION]

Click to indicate you have read the risk ladder explanation.

[INSERT CLICK BUTTON FOR HAVE READ THIS INFORMATION]

Before we ask you specifically about risks with regards to your drinking water, please answer the following question. This will help us to categorize your responses and will serve as a quick lesson on using the risk ladder.

29. On the following risk ladder, please indicate what you feel your personal risk of death from skin cancer this year would be. *Click, and drag the red line on the slider up and down the scale to select your personal risk level.*

[INSERT RISK LADDER]

30. On a scale from 1 to 5, where 1 is uncertain and 5 is certain, how certain are you of the risk you selected on the risk ladder in the previous question. *Please select one response only.*

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW.]

	Uncertain		Somewhat Certain		Certain
Certainty of Response	1	2	3	4	5

The following questions will ask you about risks specific to <u>your drinking water.</u>

31. Earlier you indicated that your present consumption of water was:

[PROGRAMMER NOTE: PLEASE INSERT RESPONDENTS' VALUES SELECTED AT Q11 HERE]

What do you feel your ***<u>personal</u>*** risk of death this year is from your consumption of drinking water?

Using the slider, please mark on the risk ladder what you feel your **<u>personal</u>** risk of death from your drinking water to be this year. To do this please click, and drag the slider up and down the scale and select your personal risk level.

[INSERT NEW RISK LADDER]

[Q32 ON A NEW SCREEN]

32. On a scale from 1 to 5, where 1 is uncertain and 5 is certain, how certain are you of the risk to you that you identified on the risk ladder in the previous question? *Please select one response only.*

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW.]

	Uncertain		Somewhat Certain		Certain
Certainty of	1	2	3	4	5

Response					

[IF "100% TAP WATER" IN Q11 SKIP Q33 AND GO TO Q34. OTHERS CONTINUE]

33. Instead of your current consumption of **[INSERT VALUE FROM Q11]** imagine that 100% of the water you drink is **tap water.** That is, you **do not** consume any in-home treated tap water (filtered or boiled in the home) or purchased water (bottled or from home delivery).

[PROGRAMMER NOTE: SHOW ANSWER FROM Q31 NUMERICALLY AND GRAPHICALLY BY INSERTING A FIXED COLOURED LINE ON THE RISK LADDER INDICATING THEIR SELECTION]

What do you feel your ***personal*** risk of death this year would be if 100% of the water you drink is tap water?

Using the slider, please mark on the risk ladder what you feel your ***personal*** risk of death this year would be if 100% of the water you drink is tap water. To do this please click, and drag the slider up and down the scale and select your personal risk level

[IF "100% IN-HOME TREATED TAP WATER" IN Q11, SKIP Q34 AND GO TO Q35. OTHERS CONTINUE]

34. Instead of your current consumption [INSERT VALUE FROM Q11] imagine that 100% of the water you drink is **in-home treated tap water** (filtered or boiled in the home). That is, you **do not** consume any tap water or purchased water (bottled or from home delivery).

[PROGRAMMER NOTE: SHOW ANSWER FROM Q31 AND Q33 NUMERICALLY AND GRAPHICALLY BY INSERTING A FIXED COLOURED LINE ON THE RISK LADDER INDICATING THESE SELECTIONS]

What do you feel your ***personal*** risk of death this year would be if 100% of the water you drink is in-home treated tap water?

Using the slider, please place an additional mark on the risk ladder indicating what you feel your ***personal*** risk of death this year would be if 100% of the water you drink is in-home treated tap water. To do this please click, and drag the slider up and down the scale and select your personal risk level

[INSERT NEW RISK LADDER]

[SKIP Q35 IF "100% PURCHASED WATER" IN Q11 AND GO TO Q36]

35. Instead of your current consumption [INSERT VALUE FROM Q11] imagine that 100% of the water you drink is **purchased water (bottled or**

from home delivery). That is, you **do not** consume any tap water or in-home treated tap water (filtered or boiled in the home).

[PROGRAMMER NOTE: SHOW ANSWER FROM Q31, Q33 AND Q34 NUMERICALLY AND GRAPHICALLY BY INSERTING A FIXED COLOURED LINE ON THE RISK LADDER INDICATING THESE SELECTIONS]

What do you feel your ***personal*** risk of death this year would be if 100% of the water you drink is purchased water?

Using the slider, please place an additional mark on the risk ladder indicating what you feel your ***personal*** risk of death this year would if 100% of the water you drink is purchased water. To do this please click, and drag the slider up and down the scale and select your personal risk level

[INSERT NEW RISK LADDER]

[IF "YES" (Code 1) SELECTED AT Q 13a CONTINUE. OTHERS SKIP TO Q 38]

36. You told us the present water consumption for your child is: **[INSERT RESPONSE FROM Q14]**

You have indicated your ***personal*** risk of death from drinking water to be **[INSERT VALUE FROM RISK LADDER Q31].**

Compared to your own risk would you say you consider the risk of death from drinking water for your youngest child to be…?

Greater
The Same
Less

37. Once again, using the slider, please mark on the risk ladder where you feel the risk of death to be for your youngest child this year from his/her consumption of drinking water. To do this please click, and drag the slider up and down the scale and select **your child's** personal risk level. We have included the risk level you specified for your personal consumption on the ladder.

[INSERT NEW RISK LADDER]
[INCLUDE VALUE FROM Q31 ON THIS RISK LADDER]

38. Using a scale from 1 to 7, where 1 is poor and 7 is excellent; please rate the quality of each characteristic for each of the three water sources. The characteristics include taste, odour, appearance, and convenience. *Please select one from each row.*

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW.]

TASTE	**Poor**			**Neutral**			**Excellent**
Tap water	1	2	3	4	5	6	7
In-home Treated Tap Water	1	2	3	4	5	6	7
Purchased Water	1	2	3	4	5	6	7

ODOUR	**Poor**			**Neutral**			**Excellent**
Tap water	1	2	3	4	5	6	7
In-home Treated Tap Water	1	2	3	4	5	6	7
Purchased Water	1	2	3	4	5	6	7

APPEARANCE	**Poor**			**Neutral**			**Excellent**
Tap water	1	2	3	4	5	6	7
In-home Treated Tap Water	1	2	3	4	5	6	7
Purchased Water	1	2	3	4	5	6	7

CONVENIENCE	**Poor**			**Neutral**			**Excellent**

Tap water	1	2	3	4	5	6	7
In-home Treated Tap Water	1	2	3	4	5	6	7
Purchased Water	1	2	3	4	5	6	7

[SEPARATE SCREEN]

We would like to turn your attention now to water availability in Canada. Over the last few years many parts of Canada have experienced water shortages, particularly in the summer. During these times households are usually asked to reduce their use of water (e.g., reduce the amount of lawn or garden watering, car washing, pool filling, etc.). Scientists are now concerned that summer droughts will become more frequent and severe in Canada.

Other countries have been experiencing these types of water shortages for a longer time than us (Australia and the American Southwest). They have identified ways to ensure more steady and reliable water supplies.

One solution is to use reclaimed water. Reclaimed water is community wastewater that has been filtered and disinfected at a wastewater treatment facility and made suitable for further beneficial use. Reclaimed water is delivered from a water treatment facility through a separate system of underground pipes using its own pumping and storage system.

There are a number of different sources of wastewater:

1. ***Sink, laundry, and bath water from homes***
2. ***Toilet water from homes***
3. ***Water from businesses (this includes sink water and water from operations)***

The Federal/Provincial/Territorial Committee on Health and the Environment (CHE) has asked Health Canada to lead the development of guidelines for reclaimed water treatment, working in collaboration with other federal departments, provinces and territories and other experts. The work has been supported by Canada Mortgage and Housing Corporation.

Reclaimed water could be used in a number of ways to support water supplies. These include:

> ***Residential reuse** – This is where wastewater is filtered, treated and disinfected to a very high standard and piped to homes to be used in place of drinking quality water for watering the garden, flushing toilets, and possibly tap water.*
>
> ***Open space irrigation** – This is where wastewater is filtered, treated and disinfected to a high standard and piped to public parks, gardens, playing fields, and golf courses to be used in place of drinking quality water for irrigation.*
>
> ***Agricultural irrigation** – This is where wastewater is filtered, treated and disinfected to a moderate standard and piped to agricultural land to be used to irrigate new and existing plantings of crops, such as soybeans.*

Please click to indicate you have read this information.

[INSERT CLICK BUTTON FOR HAVE READ THIS INFORMATION]

39. Have you ever heard about “reclaimed water” or “recycled water” prior to reading the information on the previous screen? *Please select one response only.*

Yes
No

40. Consider **reclaimed sink, laundry, and bath water from homes**. For each of the possible end water uses below, please indicate whether you agree or disagree with using this type of community wastewater that has been reclaimed (filtered, treated and disinfected) as a source of water. *Please select one for each row.*

[RANDOMIZE ROWS LIST]

ROWS:
Residential Re-use: Toilet Flushing
Residential Re-use: Watering Grass or Flowers in Garden
Residential Re-use: Watering Vegetables in Garden
Residential Re-use: Tap Water
Open Space Irrigation: Watering of Public Parks
Open Space Irrigation: Watering of Golf Courses
Agricultural Irrigation

COLUMNS:
Strongly Agree
Somewhat Agree
Neither Agree nor Disagree
Somewhat Disagree
Strongly Disagree

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW.]

Possible End Uses for Reclaimed Sink, Laundry, and Bath Water from Homes	*Strongly Agree*	*Somewhat Agree*	*Neither Agree nor Disagree*	*Somewhat Disagree*	*Strongly Disagree*
Residential Re-use: Toilet Flushing					
Residential Re-use: Watering Grass or Flowers in Garden					
Residential Re-use: Watering Vegetables in Garden					
Residential Re-use: Tap Water					
Open Space Irrigation: Watering of Public Parks					
Open Space Irrigation: Watering of Golf Courses					
Agricultural Irrigation					

41. Now consider **reclaimed toilet water** from homes. For each of the possible end water uses below, please indicate whether you agree or disagree with using this type of community wastewater that has been reclaimed (filtered, treated and disinfected) as a source of water. *Please select one for each row.*

[RANDOMIZE LIZT]

Columns:
Residential Re-use: Toilet Flushing

Residential Re-use: Watering Grass or Flowers in Garden
Residential Re-use: Watering Vegetables in Garden
Residential Re-use: Tap Water
Open Space Irrigation: Watering of Public Parks
Open Space Irrigation: Watering of Golf Courses
Agricultural Irrigation

Strongly Agree
Somewhat Agree
Neither Agree nor Disagree
Somewhat Disagree
Strongly Disagree

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW.]

Possible End Uses for Reclaimed Toilet Water from Homes	*Strongly Agree*	*Somewhat Agree*	*Neither Agree nor Disagree*	*Somewhat Disagree*	*Strongly Disagree*
Residential Re-use: Toilet Flushing					
Residential Re-use: Watering Grass or Flowers in Garden					
Residential Re-use: Watering Vegetables in Garden					
Residential Re-use: Tap Water					
Open Space Irrigation: Watering of Public Parks					
Open Space Irrigation:					

Watering of Golf Courses					
Agricultural Irrigation					

The following questions are to help us understand your answers better.

42. Imagine that you're a contestant on a TV game show. You have just won $1,000. The host offers you a choice: You can quit now and keep the $1,000, or you can play again. If you play again, there is a 1 in 2 chance that you will win again, and wind up with $2,000. If you play again and lose, you lose the original $1,000 and take home nothing.

Please select which of the two choices below best expresses what you would do.
Select one.

Keep the $1,000 already won and not play again.
Play again with a 1 in 2 chance of winning $2,000 and a 1 in 2 chance of losing and going home with nothing.

[IF "KEEP" (CODE 1) CONTINUE. IF 'PLAY AGAIN" (Code 2) AT Q 42 - SKIP Q 43 AND GO TO Q 44]

43. You chose to keep the $1,000. How high would the amount of money you won on the second game have to be in order for you to be willing to play the second game, rather than keep the sure $1,000 already won?

[INSERT TEXT BOX $ _____]

44. You now find yourself on a new game show and you have just won $10,000. The host offers you a new choice: You can quit now and keep the $10,000 or you can play again. This time if you play again, there is a 1 in 2 chance that you will win again, and wind up with $20,000. If you play again and lose, you lose the original $10,000 and take home nothing.

Please select which of the two answers below best expresses what you would do. *Select one.*

Keep the $10,000 already won and not play again.
Play again with a 1 in 2 chance of winning $20,000 and a 1 in 2 chance of losing and going home with nothing.

[IF CODE 1 "KEEP THE $10,000 AND NOT PLAY AGAIN" IN Q44 CONTINUE. IF CODE 2 "PLAY AGAIN', GO TO Q 46]

45. How high would the amount of money you won on the second game have to be in order for you to be willing to play the second game, rather than keep the sure $10,000 already won? *Enter amount to the closest dollar – must be greater than $10,000.*

[INSERT TEXT BOX $ ______]
[AMOUNT MUST BE GREATER THAN $10,000]

46. Imagine that you have won a $100 prize. Suppose you were given the following options: You could either receive the $100 prize one month from now, or receive $116 seven months from now. Which option would you choose? *Please select one response only.*

$100 one month from now
$116 seven months from now

[IF CODE 1 “$100 ONE MONTH FROM NOW” IN Q46, SKIP Q47 AND GO TO Q48]

[IF CODE 2 “$116 SEVEN MONTHS FROM NOW” IN Q46, GO TO Q47 AND SKIP Q48]

47. Imagine again that you have won a $100 prize. Suppose you were given the following options: You could either receive the $100 prize one month from now, or receive $105 seven months from now? Which option would you choose? *Please select one response only.*

$100 one month from now
$105 seven months from now from now

48. Imagine again that you have won a $100 prize. Suppose you were given the following options: You could either receive the $100 prize one month from now, or receive $128 seven months from now? Which option would you choose? *Please select one response only.*

$100 one month from now
$128 seven months from now from now

Now we just have a few more questions to ask you that will help us understand your responses compared to other members of the public.

D1. Do you consider that the amount of income tax you pay is...? *Please select one response only.*

Too high
About right
Too low
Don’t know

D2. Do you consider that the amount you pay for your water bill is...? *Please select one response only.*

Too high
About right
Too low
Don’t know

D3. If a Federal election were held today, how would you vote federally? *Please select one response only.*

Conservative Party
Liberal Party
New Democratic Party
Bloc Quebecoise
Green Party
Not Eligible to Vote
I would not Vote
Other (*Please type in your response*)
Don’t Know
[INSERT TEXT BOX AFTER “OTHER”]

D4.Compared to others your age, would you say your health is? *Please select one response only.*

Much better
Somewhat better
About the same
Somewhat worse
Much worse
Don’t know

D5. In the past 12 months, have you ever been a patient overnight in a hospital, nursing home, or convalescent home?

Yes
No
Decline to respond

D6. Which, if any, of the following long-term health conditions do you or members of your family have? *Please select all that apply.* Please select at least one response (which could be none of the above) in each column.

[PROGRAMMER NOTE: FORMAT SHOULD BE AS BELOW]

Health Conditions	**Myself**	**Household Member**
Food allergies		
Any other allergies		
Asthma		
Arthritis or rheumatism		
Back problems, excluding arthritis		
High blood pressure		
Migraine headaches		
Chronic bronchitis or emphysema		
Sinusitis		
Diabetes		
Epilepsy		
Heart disease		
Cancer (Please specify type)		
Stomach or intestinal ulcers		
Effects of a stroke		
Any other long-term condition that has been diagnosed by a health professional (Please specify)		
None of the above		

[APPEND THE FOLLOWING FROM PANEL PROFILES: GENDER, AGE, HOUSEHOLD SIZE, HH COMPOSITION, PRIMARY GROCERY SHOPPER, EMPLOYMENT STATUS, EDUCATION, MARITAL STATUS, OCCUPATION, EMPLOYMENT INDUSTRY, BUSINESS OWNERSHIP, HOUSEHOLD INCOME, LANGUAGE OF CORRESPONDENCE, INTERNET ACCESS PRIMARY LOCATION, INTERNET USAGE FREQUENCY, INTERNET BROWSER USED, REGION, NUMBER OF CHILDREN IN HOUSEHOLD, POSTAL CODE, CITY/TOWN, PROVINCE]

E1. Please enter any additional comments you may have about this survey in the space provided.

[INSERT TEXT BOX]

E2. The researchers involved in this study would like to follow-up by telephone with a few study participants to discuss reactions to the survey itself. Are you willing to be contacted by telephone for a short interview?

Yes
No

[IF YES]: Please record your contact information below:

Name:
Phone Number:
[PHONE NUMBER REQUIRES 10 DIGITS]