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Expert vs. public perception of population health risks in Canada

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In the field of risk analysis, there is ongoing tension between expert risk assessment and public risk perception. This paper presents the results of a health risk perception survey administered to Canadian health experts as a follow-up to a previous survey. A total of 125 experts (75 physicians and 50 toxicologists) recruited through professional organizations completed a self-administered questionnaire in 2004. Experts were asked to provide ratings of perceived risk of 30 health hazards as well as detailed ratings of five health hazards (motor vehicles, climate change, recreational physical activity, cellular phones, and terrorism) and five health outcomes (cancer, long-term disabilities, asthma, heart disease, and depression) in terms of perceived health risk, personal control, knowledge, uncertainty, worry, and acceptability. Sources of information on health risks, confidence in those information sources, as well as health risk beliefs were also examined. Experts perceived behavioral health hazards, such as cigarette smoking, obesity, and physical inactivity, posed the greatest health risk, and medical technologies, including vaccines, medical X-rays, and laser eye surgery, posed the least risk. Experts reported receiving 'a lot' of information from university scientists/scientific journals and medical doctors and reported having 'a lot' of confidence in those sources. High levels of environmental and social concern were observed, as well as a high degree of personal agency over health risks. Health risk perceptions varied by professional affiliation but not gender. Results are compared to a recent public risk perception survey in Canada. Differences between public and expert risk perceptions may hold instructive pointers for risk management and risk communication strategies designed to improve population health.

Keywords: risk perception; expert risk assessment; determinants of health; health hazards; information sources

1. Introduction

Individuals form attitudes and opinions about human health risks in a number of ways, such that perceptions of risk among the public may not correspond with scientifically determined characterizations of risk. Public perceptions of risk are often amplified relative to expert risk perceptions (Hansen et al. 2003; Sjöberg 1999;

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Slovic 1999). Such differences can have important consequences for risk management and risk communication strategies designed to improve population health.

1.1. Public perception of risk

Numerous studies conducted over the past several decades have helped to elucidate factors related to how members of the public perceive risks to health. The psychometric paradigm, which suggests that risk perceptions are multi-dimensional and reflect various factors such as dread, uncertainty, familiarity, and controllability surrounding the hazard (Fischoff et al. 1978), has emerged as a leading theory in this field. However, it has also been suggested that other personal and societal factors are of importance, including various demographic factors, worldviews, beliefs, attitudes, and media portrayals of hazards and risk (Bouyer et al. 2001; Sjöberg 2000; Slovic 1999). Although controversial, the cultural theory of risk perception suggests that specific cultural biases that arise out of social structure including egalitarianism, individualism, hierarchism, and fatalism are related in a self-reinforcing way with differing social and technological concern (Douglas and Wildavsky 1982). Other studies have focused on the role of social linkages and networks in public risk perception (Scherer and Cho 2003; Yardley, Wright, and Pearman 1997). Public perceptions of risk and associated risk behaviors may be amplified (or attenuated) by various social and cultural processes, possibly leading to higher-order effects and unanticipated impacts on society (Kasperson et al. 1988). Since risk perception lies at the interface between government risk regulators and the public, it is a unique aspect of risk analysis. Understanding public perceptions of risk, how they may change over time, as well as the personal and societal factors that may contribute to such variation, is a key component in the design of successful risk management and risk communication strategies, and in engendering support for chosen actions. There are ongoing debates as to whether the public misjudges 'real' risk estimates and whether experts should be the sole risk management drivers.

In order to better understand public perception of risk in Canada and to investigate contemporary risk issues, a public risk perception survey was conducted in 2004 as a follow-up to a previous survey conducted in 1992 (Krewski et al. 1995a, 1995b). The survey examined perceptions of population health hazards and outcomes, information sources on health risks, as well as various worldviews and beliefs. Results revealed that Canadians perceived behavioral health hazards (such as cigarette smoking, obesity, and unprotected sex) presented the greatest risks to the health of Canadians, while medical devices or therapies (such as prescription drugs, vaccines, and laser eye surgery) presented the lowest risk (Krewski et al. 2006). Perceptions of risk, control, knowledge, uncertainty, and worry, varied across health hazards and health outcomes, whereas levels of risk acceptability were unequivocally low (Krewski et al. 2009). Results also pointed to a high degree of environmental and social concern (Krewski et al. 2008). Relative to the previous 1992 survey, perceptions of trust in risk governance increased. A factor-analytic investigation revealed that health risk perceptions reflected population health determinants (biochemical, lifestyle, and social) and were differentially associated with perceptions of health risk control. More specifically, biochemical and social risk perceptions were most strongly associated with a government locus of health risk control, while lifestyle risk perceptions were associated with an internal locus of health risk control (Lee et al. 2008).

1.2. Expert perception of risk

Research in a variety of areas including food (Hagemann and Scholderer 2009; Hansen et al. 2003), nuclear power (Purvis-Roberts, Werner, and Frank 2007), nanotechnology (Siegrist et al. 2007), and biotechnology (Savadori et al. 2004) have documented expert–lay differences in risk perceptions, with the public generally demonstrating higher perceptions of risk. Baron, Hershey, and Kunreuther (2000) observed that although concern for action was driven by worry both among members of the public and experts (members of the Society for Risk Analysis); there were also significant differences in risk perception observed between these two groups. Sjöberg (2002) observed expert–lay differences in the perception of nuclear waste but noted that the factors explaining the risk perceptions were similar. In addition to differential risk perceptions, expert–lay differences in risk management preferences have also been observed (Krystallis et al. 2007).

In 1993, a risk perception survey was conducted among members of the Society of Toxicology of Canada (SOTC) (Slovic et al. 1995) to replicate a prior US study (Kraus, Malmfors, and Slovic 1992). Results revealed that members of the Canadian public perceived that most health hazards posed higher levels of risk compared to toxicologists. There was also a tendency for female toxicologists to report higher risk perceptions than male toxicologists, particularly those related to asbestos, breast implants, chemical pollution, and nuclear waste. In regard to risk management, members of the public assigned the greatest responsibility in health protection to medical doctors and other health professionals, while toxicologists assigned this responsibility to individuals themselves. Additional differences in risk beliefs were observed regarding dose–response relationships for chemical carcinogens, the use of animal studies in health risk assessment, and attitudes towards chemical safety. Finally, 60.9% of the public agreed that a risk-free environment was an attainable goal compared to 20.0% of toxicologists, pointing to a differential risk acceptability threshold.

A number of factors have been proposed to contribute to expert–lay differences in risk perception including self-selection, professional socialization, perceived levels of control and familiarity with the hazard, and professional role (Sjöberg 1999). Alternatively, expert–lay differences may relate to motivational and cognitive biases (Otway and von Winterfeldt 1992; Wright, Pearman, and Yardley 2000). For example, discrepancies may result from a differential conceptualization of risk, with experts focused on notions of probability and members of the public focused on the nature of the adverse consequences (Sjöberg 1999; Slovic 1999). Since public risk perceptions are broad and complex, adopting a knowledge-deficit approach to health promotion and educational efforts is likely insufficient (Hansen et al. 2003). Expert risk perceptions may also be related to worldviews, beliefs, or attitudes surrounding risk (Sjöberg 2000; Slovic 1999). Trust in institutions may play a role in determining risk perceptions and compliance with risk management interventions (Hagemann and Scholderer 2009; Siegrist et al. 2007; Sjöberg 1999; Slovic 1999).

Beyond expert–lay differences, there are also documented variations in risk perception by expert group. In one study of radiation and nuclear testing in Kazakhstan, villagers demonstrated the highest level of risk aversion, followed by physicians then research scientists (Purvis-Roberts, Werner, and Frank 2007). The discrepant risk perceptions were attributed to differential frames of reference regarding nuclear risks.

Despite these findings, expert–lay differences in health risk perception are controversial. Research on the perception of the occurrence of hazardous events in the North Sea oil and gas industry revealed no notable differences between experts and non-experts (Wright, Pearman, and Yardley 2000). It was suggested that expert–lay differences in risk perception may be more prominent for hazards of an extreme nature. Wright, Bolger, and Rowe (2002) observed only small differences between experts (life insurance underwriters) and the lay public in the accuracy of mortality estimates for various health hazards and conditions. A critical review of the literature concluded that the strength of the evidence-base for expert–lay differences in risk perception is weak and is likely due to underlying differences in key social and demographic characteristics (Rowe and Wright 2001).

1.3. Study objectives

Since experts play a dominant role in shaping the discourse surrounding population health risks and their management, an expert risk perception survey was conducted in Canada in 2004 as a follow-up to the previous 1993 survey of Canadian toxicologists (Slovic et al. 1995). The objectives of the survey were to document changes in expert risk perception over time, investigate perceptions of new or emerging health risks, and compare results to the 2004 general risk perception survey conducted among members of the Canadian public. A better understanding of expert risk perceptions will provide valuable information to better understand the dynamics of risk perception in Canada as well as aid in the design of risk management and risk communication initiatives.

This paper presents a descriptive account of expert ratings of perceived risk of 30 health hazards, as well as a detailed assessment of expert perceptions of five health hazards (motor vehicles, climate change, recreational physical activity, cellular phones, and terrorism) and five health outcomes (cancer, long-term disabilities, asthma, heart disease, and depression) in terms of perceived health risk, personal control, knowledge, uncertainty, worry, and acceptability. Since expert–lay discrepancies in risk perception may reflect a variety of knowledge, motivational, or cognitive factors, sources of information on health risks, confidence in those information sources, as well as health risk beliefs were also examined.

2. Methods

2.1. Survey content

The present survey was designed as a follow-up to the 1993 survey of members of the SOTC (Slovic et al. 1995), which was conducted in conjunction with the 1992 Canadian general risk perception survey (Krewski et al. 1995a, 1995b). The present survey, as well as the 2004 Canadian general risk perception survey (Krewski et al. 2006, 2008, 2009), were designed to retain a number of original items from the previous 1992/1993 surveys, however they also included a number of additional items in order to assess perceptions of emerging hazards. The survey was also designed to assess perceptions of hazards related to the broad determinants of population health (the physical environment, the social environment, lifestyle factors, biology/genetics, and health care), and the use of new sources of information on health risks such as the internet.

The survey questionnaire consisted of three major sections. Respondents were asked to indicate their opinion regarding the degree of risk posed by 30 health hazards using a four-point ordinal Likert scale (1=almost no health risk, 2=slight health risk, 3=moderate health risk, and 4=high health risk). The survey also included questions to assess perceptions of five specific health hazards (motor vehicles, climate change, recreational physical activity, cellular phones, and terrorism) and five specific health outcomes (cancer, long-term disabilities, asthma, heart disease, and depression) in terms of risk to both the Canadian public and to their own personal health, as well as associated levels of personal control, knowledge, uncertainty, worry, and acceptability.

Respondents were also asked to indicate the amount of information about health risks they receive from nine different sources (1=no information, 2=a little information, 3=a fair amount of information, and 4=a lot of information), as well as their level of confidence in each information source (1=no confidence, 2=little confidence, 3=a fair amount of confidence, and 4=a lot of confidence). Respondents could decline to respond, do not know/no opinion (0), for each health hazard or information source.

Finally, respondents were asked to indicate their level of agreement (1=disagree strongly, 2=disagree somewhat, 3=agree somewhat, 4=agree strongly, and 0=no opinion), with a range of statements designed to reflect health risk beliefs regarding environmental, social, and genetic concern; dependence on regulators; locus of health risk control (internal, powerful others, and chance); risk acceptability; and technological enthusiasm.

Information on the demographic and health risk behavior profile of respondents was also compiled. The survey tool was pre-tested with volunteers. Ethics approval was obtained from the Research Ethics Board of the University of Ottawa.

2.2. Survey recruitment

Canadian physicians and toxicologists were recruited to participate in the survey through the inclusion of paper copies of survey invitation letters and survey questionnaires in a random sample of 1500 newsletters of the Canadian Medical Association as well as in all ($n \sim 128$) newsletters of the SOTC in the spring of 2004. Invitation letters and survey questionnaires were provided in both official languages (English and French). Completed questionnaires were returned to the study team by mail. One reminder letter was provided to SOTC members in the summer of the same year.

2.3. Survey sample

A total of 125 experts completed the survey questionnaire. The sample included 75 physicians and 50 toxicologists. A total of 66.4% of experts were male and 33.6% were female; 19.2% were between 18 and 34 years of age, 39.2% were between 35 and 54 years of age, and 41.6% were 55 years of age or greater. The majority of experts reported having completed at least some graduate school (81.6%), were residents of the province of Ontario (54.1%) or Quebec (17.2%), and were never smokers (89.3%). A total of 84.0% of surveys were completed in English and 16.0% were completed in French.

3. Results

3.1. Perception of risk to the Canadian public

Ratings of perceived risk to the Canadian public are presented in Figure 1, with hazards ranked according to the percentage of 'high health risk' responses. As in the 1993 survey, cigarette smoking was perceived as posing the greatest health risk.

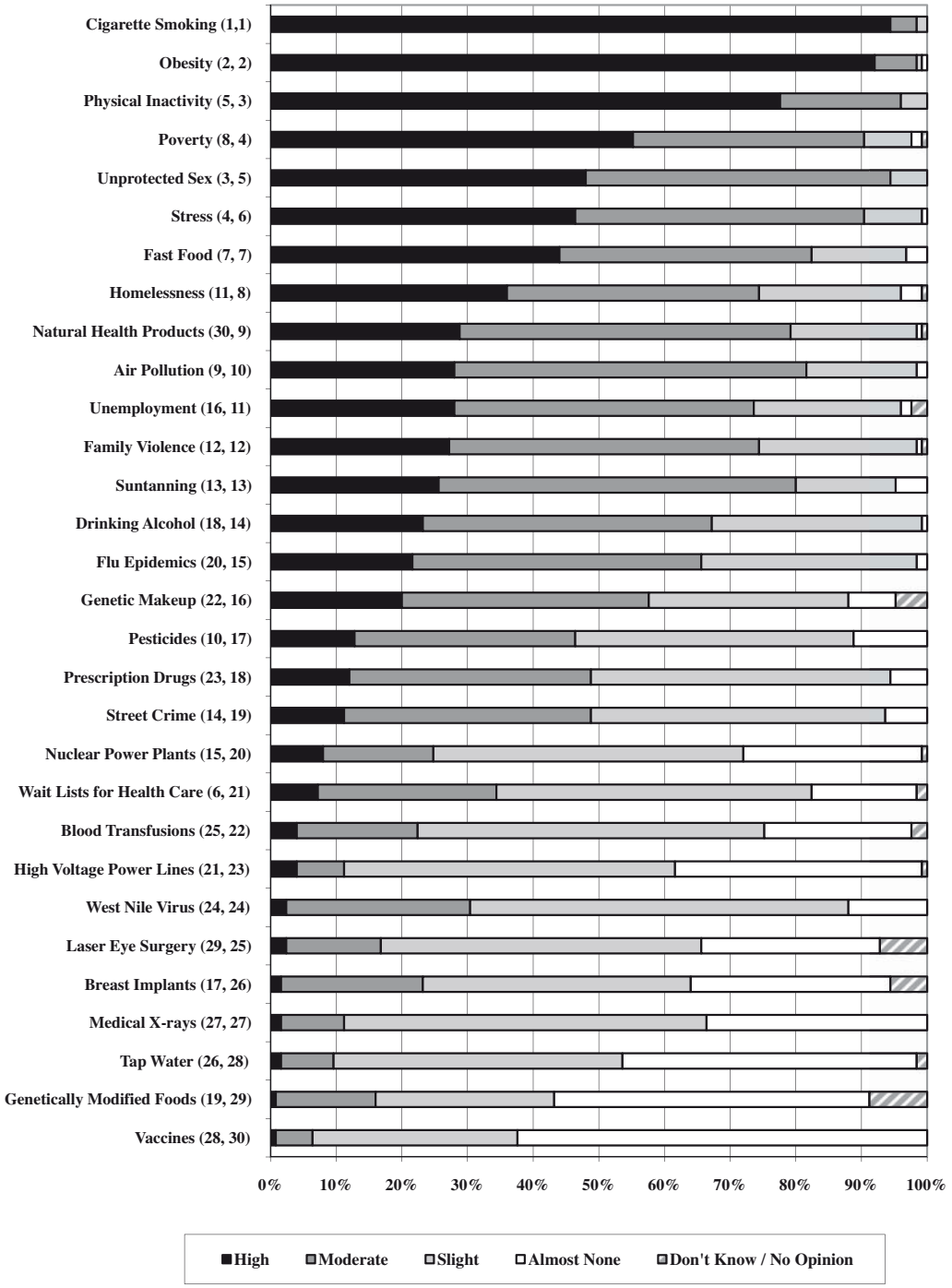

Figure 1. Expert perceptions of health risk to the Canadian public (rank order of health hazards: the public, experts).

However, the percentage of experts indicating that cigarette smoking posed a 'high health risk' increased from approximately 60% in 1993 to 94.4% in 2004. Obesity, physical inactivity, poverty, unprotected sex, and stress were also rated as high health risks. Hazards related to the social environment were ranked comparatively highly in terms of health risk, as were chemicals in the form of air pollution and pesticides, although ratings for street crime declined somewhat relative to the previous survey (~30% in 1993 vs. 11.2% in 2004). Natural health products were perceived to present a greater risk to the health of Canadians than prescription drugs, while industrial sources of radiation (nuclear power plants) and medical sources of radiation (medical X-rays) were perceived as presenting comparatively low health risks. In contrast, vaccines and genetically modified foods ranked as the lowest health risks, followed by tap water, medical X-rays, and breast implants. Tap water and medical X-rays were also ranked as low health risks in the 1993 survey. The perceived risk of breast implants decreased markedly from 1993, possibly reflecting intense media coverage of the issue at the time of the previous survey.

3.1.1. Comparison with public survey

Although the rank ordering of the 30 health hazards (according to the percentage of 'high health risk' responses) was similar between experts and the public (Spearman's rank correlation coefficient=0.74, $p<0.0001$), health risk perceptions were significantly higher among the general public for most of the health hazards considered, $F(30,1135)=29.56$, $p<0.0001$ (Figure 2). The overall mean (SD) across all 30 health hazards for the public and experts were 3.02 (0.42) and 2.68 (0.33), respectively. Differences in the proportion of 'high health risk' response were greatest for waiting lists for health care, pesticides, and breast implants. In contrast, experts perceived poverty, cigarette smoking, physical inactivity, obesity, and natural health products as presenting a greater population health risk than did members of the public. No significant differences in perceived health risk were observed for genetic makeup, homelessness, prescription drugs, flu epidemics, and unemployment.

3.1.2. Professional affiliation

Risk perceptions varied significantly by professional affiliation, $F(30,68)=3.24$, $p<0.0001$. Toxicologists perceived greater risks than medical doctors associated with stress, mean (SD)=3.62 (0.55) vs. 3.21 (0.66), genetic makeup, mean (SD)=3.00 (0.78) vs. 2.56 (0.90), waiting lists for health care, mean (SD)=2.57 (0.83) vs. 2.15 (0.81), blood transfusions, mean (SD)=2.24 (0.83) vs. 1.90 (0.69), breast implants, mean (SD)=2.16 (0.76) vs. 1.73 (0.71), medical X-rays, mean (SD)=1.95 (0.70) vs. 1.66 (0.65), and vaccines, mean (SD)=1.51 (0.73) and 1.27 (0.45), respectively. In contrast, medical doctors perceived greater risks than toxicologists associated with pesticides, mean (SD)=2.58 (0.86) vs. 2.14 (0.75), and genetically modified food, mean (SD)=1.79 (0.81) vs. 1.41 (0.64), respectively.

3.1.3. Gender

In contrast to the 1993 survey, which revealed a tendency for female experts to demonstrate higher risk perceptions compared to male experts, health risk perceptions did not differ significantly by gender in the present survey, $F(30,68)=1.11$,

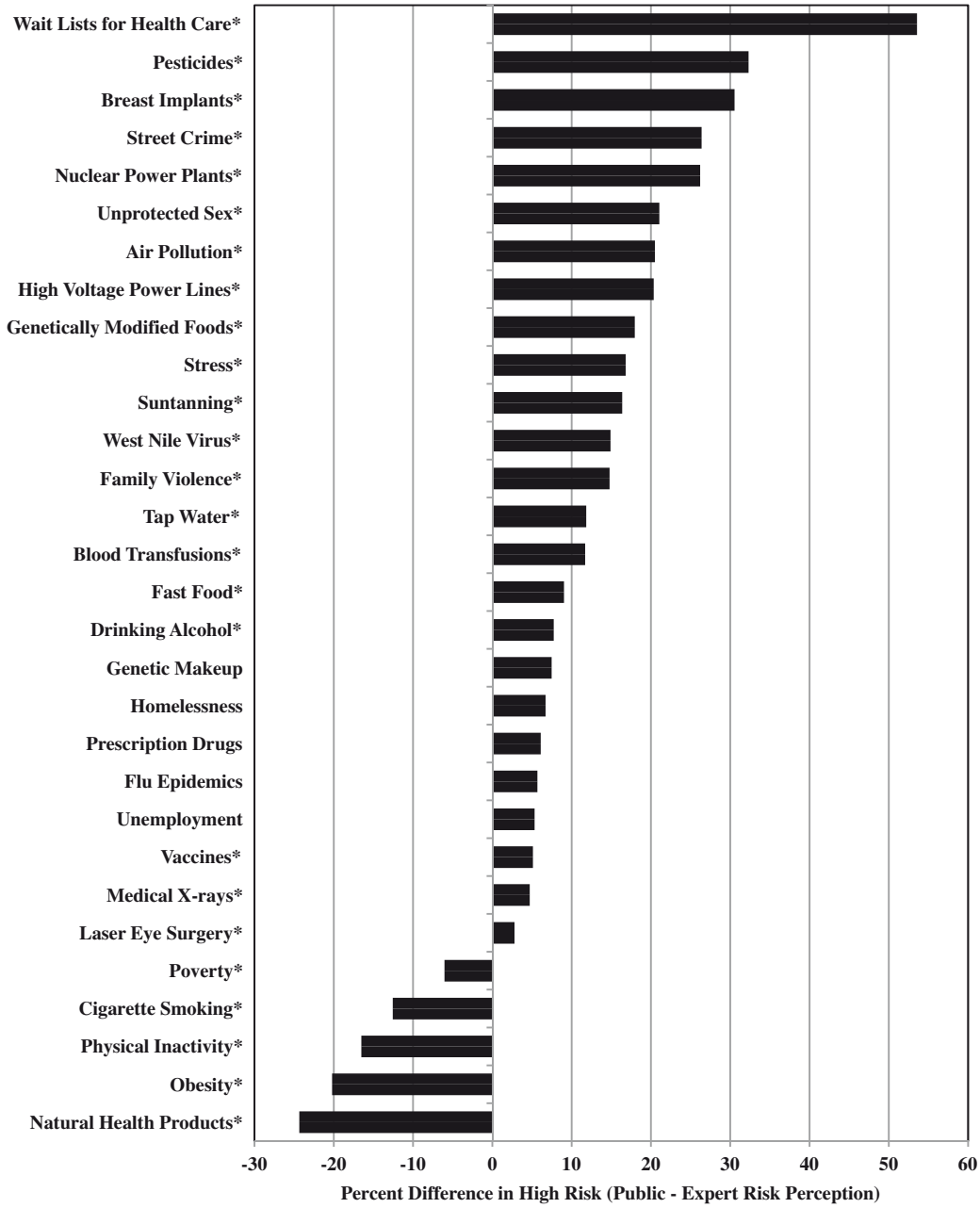

Figure 2. Perceived health risk to the Canadian public: differences between the public, experts. Positive values represent higher public risk perceptions; negative values represent higher expert risk perceptions. *Indicates mean score significantly different between the public and experts using *post hoc* Tukey-Kramer test ($p < 0.05$).

p=0.36, mean (SD) across all 30 health hazards=2.71 (0.29) vs. 2.67 (0.36), respectively.

3.2. Health hazards and health outcomes

Ratings of perceived risk, personal control, knowledge, uncertainty, worry, and acceptability for five health hazards and health outcomes are presented in Tables 1 and 2, respectively.

Table 1. Mean perceptions of five health hazards among the public, experts (SD in parentheses).

	Motor vehicles	Climate change	Recreational physical activity	Terrorism	Cellular phones	df	*F*	*p*
To what extent are (is) _____ a risk to the *health of Canadians*?	3.20 (0.78), 3.16 (0.72)	2.77 (0.92), 2.41 (0.85)*	2.19 (0.88), 2.15 (0.74)	2.39 (0.92), 2.04 (0.72)*	2.51 (0.99), 1.97 (0.86)*	5,1480	9.11	<0.0001
To what extent are (is) _____ a risk to your *personal health*?	2.63 (0.91), 2.63 (0.67)	2.36 (1.01), 1.97 (0.78)*	1.80 (0.86), 1.90 (0.72)	1.78 (0.90), 1.56 (0.70)*	1.65 (0.92), 1.43 (0.69)*	5,1542	5.52	<0.0001
How much *personal control* do you feel you have over _____ risks?	2.65 (1.00), 2.85 (0.70)*	1.80 (1.00), 1.59 (0.78)*	3.19 (1.05), 3.57 (0.53)*	1.43 (0.83), 1.49 (0.84)	2.83 (1.28), 3.23 (1.04)*	5,1556	5.73	<0.0001
How much *knowledge* do you feel you have about _____ *risks?*	3.27 (0.75), 3.25 (0.69)	2.70 (0.89), 2.65 (0.79)	3.18 (0.85), 3.30 (0.64)	2.53 (0.91), 2.48 (0.90)	2.54 (0.99), 2.76 (0.96)	5,1565	2.11	0.06
How much do you *worry* about _____ risks?	2.50 (1.04), 2.28 (0.85)	2.17 (1.08), 2.01 (0.89)	1.82 (0.95), 1.71 (0.75)	1.91 (0.97), 1.74 (0.85)	1.71 (0.96), 1.49 (0.73)	5,1580	1.79	0.11
What level of *uncertainty* do you think there is, in general, about _____ risks?	2.74 (0.87), 2.56 (0.92)*	2.75 (0.92), 3.15 (0.89)*	2.33 (0.88), 2.14 (0.77)*	2.92 (0.90), 3.17 (0.80)*	2.53 (0.98), 2.56 (0.94)	5,1401	7.97	<0.0001
What level of risk from _____ do you think is *acceptable*?	2.05 (0.88), 2.05 (0.62)	2.14 (0.84), 1.92 (0.62)*	2.27 (0.84), 2.23 (0.64)	1.58 (0.84), 1.47 (0.62)	1.79 (0.87), 1.47 (0.61)*	5,1394	3.93	0.002

*Indicates mean score significantly different using *post hoc* Tukey–Kramer ($p<0.05$).

Table 2. Mean perceptions of five health outcomes among the public, experts (SD in parentheses).

	Heart disease	Cancer	Depression	Asthma	Long-term disabilities	df	*F*	*p*
To what extent are Canadians at risk of _____?	3.50 (0.59), 3.59 (0.53)	3.38 (0.63), 3.01 (0.57)*	3.14 (0.72), 2.99 (0.64)*	2.98 (0.74), 2.73 (0.64)*	2.73 (0.76), 2.53 (0.63)*	5,1511	13.30	<0.0001
To what extent are you at risk of _____?	2.63 (0.93), 2.63 (0.85)	2.76 (0.90), 2.68 (0.70)	2.22 (0.97), 2.22 (0.91)	2.01 (1.03), 1.79 (0.91)	2.27 (0.94), 2.15 (0.75)	5,1553	1.35	0.24
How much *personal control* do you feel you have over _____ risks?	3.09 (0.87), 3.11 (0.66)	2.33 (0.97), 2.42 (0.76)	2.90 (0.97), 2.70 (0.85)*	2.44 (1.05), 2.64 (0.95)*	2.43 (1.01), 2.51 (0.83)	5,1565	2.48	0.03
How much *knowledge* do you feel you have about _____ *risks?*	3.21 (0.78), 3.66 (0.54)*	3.07 (0.82), 3.53 (0.56)*	3.11 (0.84), 3.30 (0.71)*	2.82 (0.95), 3.33 (0.76)*	2.79 (0.88), 2.98 (0.78)*	5,1586	12.72	<0.0001
How much do you *worry* about _____ risks?	2.33 (1.05), 2.11 (0.82)*	2.44 (1.06), 2.05 (0.78)*	2.11 (1.04), 1.81 (0.86)*	1.85 (1.00), 1.49 (0.76)*	2.07 (1.02), 1.94 (0.84)	5,1598	4.83	0.0002
What level of *uncertainty* do you think there is, in general, about _____ risks?	2.97 (0.73), 2.47 (0.68)*	3.14 (0.74), 2.95 (0.71)*	2.87 (0.83), 2.76 (0.74)	2.67 (0.82), 2.53 (0.77)	2.69 (0.83), 2.58 (0.74)	5,1473	9.76	<0.0001

*Indicates mean score significantly different using *post hoc* Tukey–Kramer ($p<0.05$).

3.2.1. Health hazards

Experts considered motor vehicles to pose the greatest risk to the health of Canadians, followed by climate change, recreational physical activity, terrorism, and cellular phones. Although similar rankings were observed for perceived risk to their own personal health, perceptions of personal health risk were generally lower than perceptions of risk to the health of Canadians. Experts reported the greatest level of personal control and knowledge in relation to health risks from recreational physical activity. Health risks from recreational physical activity were also the most acceptable. In contrast, experts reported worrying the most about health risks from motor vehicles and climate change. These health risks were also perceived to be associated with the greatest levels of uncertainty.

3.2.2. Health outcomes

Experts perceived heart disease as posing the greatest risk to the health of Canadians, followed by cancer, depression, asthma, and long-term disabilities. Although similar rankings were observed for perceived risk to their own personal health, perceptions of personal health risk were generally lower. Experts perceived the greatest personal control, knowledge, and worry in relation to heart disease risks. Perceptions of knowledge, worry, and uncertainty were also high for cancer risks.

3.2.3. Comparison with public survey

For health hazards, perceptions of perceived risk to Canadians, $F(5,1480)=9.11$, $p<0.0001$, risk to personal health, $F(5,1542)=5.52$, $p<0.0001$, personal control, $F(5,1556)=5.73$, $p<0.0001$, uncertainty, $F(5,1401)=7.97$, $p<0.0001$, and risk acceptability, $F(5,1394)=3.93$, $p=0.002$, varied significantly between the public and experts. Specifically, the public tended to perceive higher levels of risk (to both the health of Canadians and to their own personal health) than did experts, as well as lower levels of risk acceptability. In contrast, experts perceived greater levels of personal control over the health hazards (with the exception of climate change risks) than the public. For perceptions of uncertainty, members of the public perceived greater levels of uncertainty in relation to motor vehicles and recreational physical activity risks while experts perceived greater levels of uncertainty in relation to climate change and terrorism risks.

For health outcomes, significant differences were observed between the public and experts for perceived risk to the health of Canadians, $F(5,1511)=13.30$, $p<0.0001$, personal control, $F(5,1565)=2.48$, $p=0.03$, knowledge, $F(5,1586)=12.72$, $p<0.0001$, worry, $F(5,1598)=4.83$, $p=0.0002$, and uncertainty, $F(5,1473)=9.76$, $p<0.0001$. Specifically, the public tended to perceive higher levels of risk to the health of Canadians, worry, and uncertainty in relation to health outcomes. However, they also reported having lower levels of knowledge about the health outcomes than did experts. The public also perceived greater levels of personal control over depression risks, but lesser control over asthma risks.

3.2.4. Professional affiliation

For health hazards, significant differences in personal control, $F(5,110)=2.75$, $p=0.02$, and uncertainty, $F(5,104)=2.52$, $p=0.03$, were observed by professional

affiliation. Specifically, medical doctors perceived greater levels of uncertainty than toxicologists surrounding the health risks of motor vehicles, mean (SD)=2.72 (0.89) vs. 2.33 (0.93), but less uncertainly surrounding the health risks of climate change, mean (SD)=2.98 (0.91) vs. 3.40 (0.81), respectively.

For health outcomes, perceptions of risk to Canadians, $F(5,108)=3.95$, $p=0.003$, risk to personal health, $F(5,107)=2.64$, $p=0.03$, knowledge, $F(5,114)=3.63$, $p=0.004$, and worry, $F(5,114)=2.37$, $p=0.04$, varied by professional affiliation. More specifically, medical doctors perceived greater risks associated with depression than toxicologists for the health of Canadians, mean (SD)=3.12 (0.59) vs. 2.80 (0.69), as well as to their own personal health, mean (SD)=2.37 (0.97) vs. 1.98 (0.77), respectively. They also reported greater knowledge than toxicologists about heart disease, mean (SD)=3.76 (0.49) vs. 3.50 (0.58), depression, mean (SD)=3.49 (0.63) vs. 3.02 (0.73), asthma, mean (SD)=3.46 (0.75) vs. 3.15 (0.74), and long-term disability risks, mean (SD)=3.15 (0.82) vs. 2.73 (0.64), respectively.

3.2.5. Gender

For health hazards, there were no significant gender differences in risk perceptions. For health outcomes, perceptions of risk to personal health, $F(5,107)=3.23$, $p=0.009$, and knowledge, $F(5,114)=3.12$, $p=0.01$, varied significantly by gender. Here, men perceived greater risks to their personal health than did women associated with heart disease, mean (SD)=2.79 (0.78) vs. 2.32 (0.90), and long-term disabilities, mean (SD)=2.27 (0.79) vs. 1.92 (0.59). Men also reported greater levels of knowledge than women surrounding the risks associated with cancer, mean (SD) =3.63 (0.51) vs. 3.31 (0.61), and long-term disabilities, mean (SD)=3.11 (0.74) vs. 2.72 (0.79), respectively.

3.3. Sources of information on health risks and confidence in information sources

Figure 3a summarizes the extent to which experts reported consulting various sources of information about health risks. Experts reported receiving 'a lot' of information from university scientists/scientific journals and medical doctors and little information from industry and friends and relatives. Figure 3b summarizes the amount of confidence experts reported in the information sources. Experts reported having 'a lot' of confidence in university scientists/scientific journals and medical doctors and 'little' confidence in industry and friends and relatives. There was also little confidence expressed in the news media as an information source.

3.3.1. Comparison with public survey

The public differed significantly from experts in terms of information sources they reported consulting about health risks, $F(9,1618)=35.47$, $p<0.0001$ (Figure 4). Specifically, members of the public reported consulting the news media, friends and relatives, and health brochures/pamphlets more often than experts. In contrast, experts reported consulting university scientists/scientific journals more often than members of the public. The public also differed significantly from experts in terms of their level of confidence in these sources, $F(9,1618)=23.15$, $p<0.0001$. Specifically, the public reported significantly greater levels of confidence in the news media,

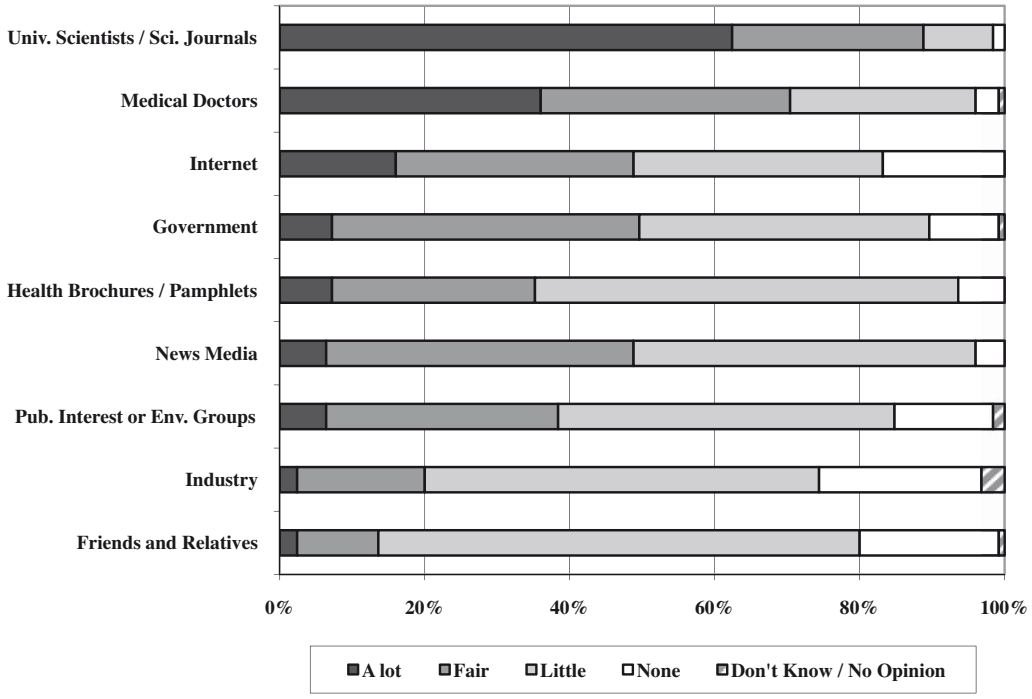

Figure 3a. Sources of information about health risks used by Canadian experts.

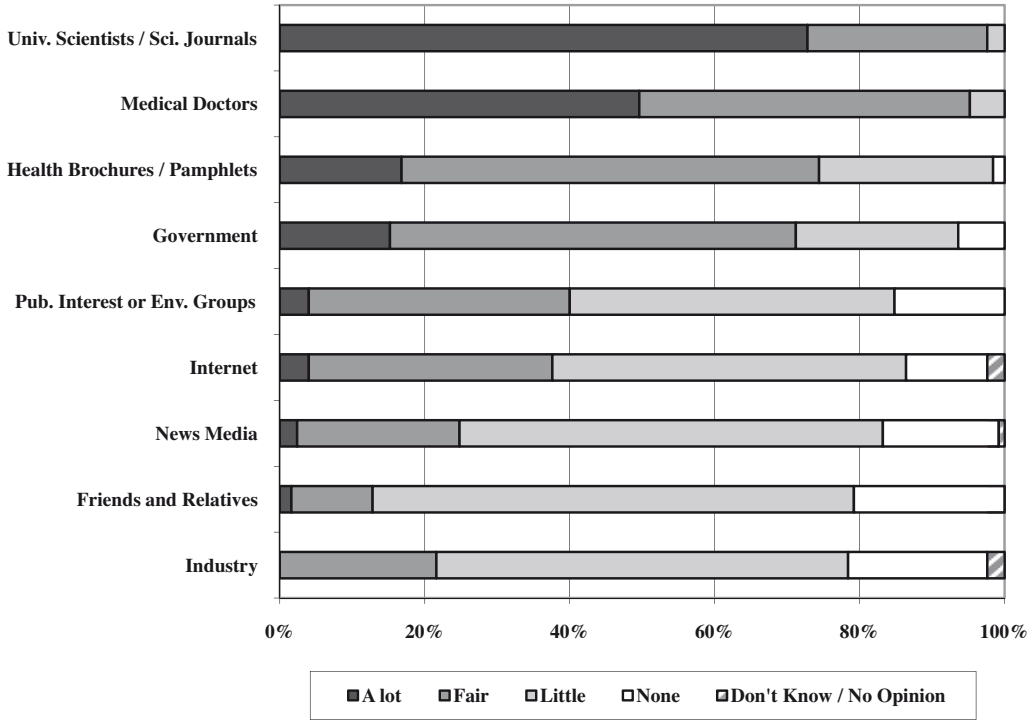

Figure 3b. Confidence in information source about health risks used by Canadian experts.

industry, public interest/environmental groups, friends and relatives, and health brochures/pamphlets than experts, but less confidence in university scientists/scientific journals.

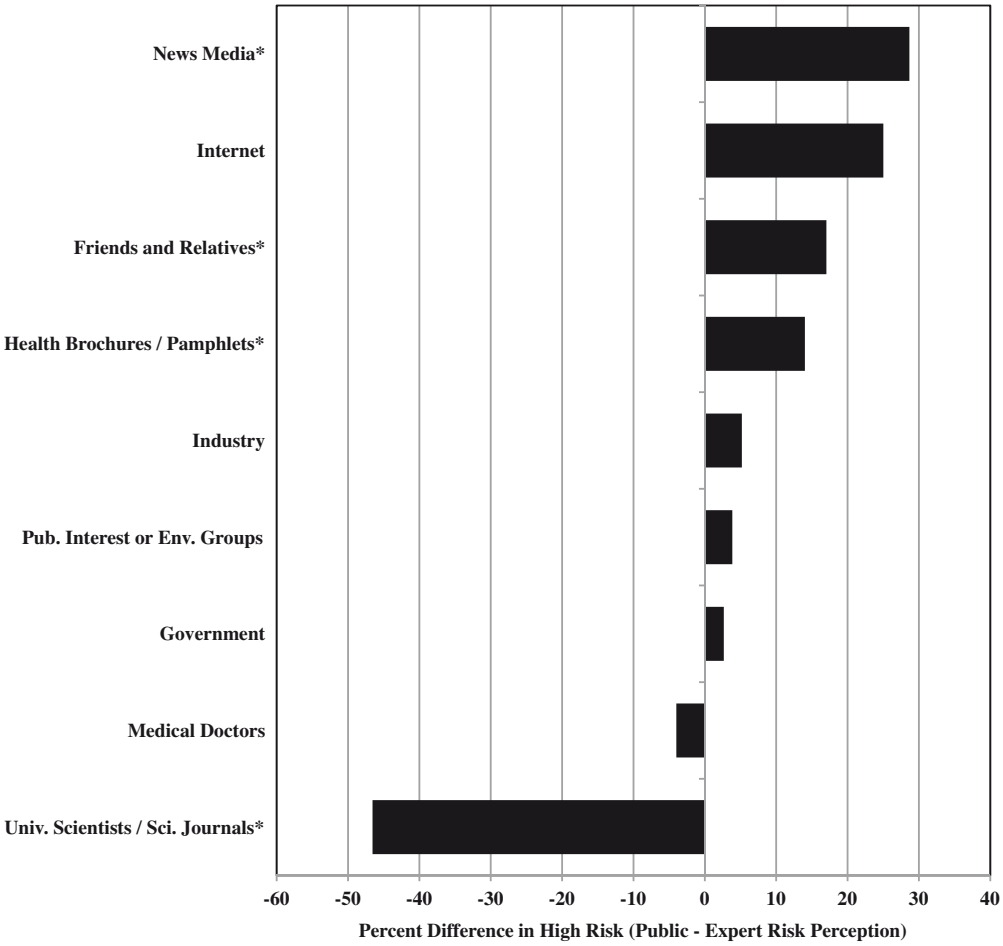

Figure 4. Sources of information about health risks: difference between the public, experts. Positive values represent higher public risk perceptions; negative values represent higher expert risk perceptions. *Indicates mean score significantly different between the public and experts using *post hoc* Tukey-Kramer test ($p < 0.05$).

3.3.2. Professional affiliation

The use of information sources and confidence in these sources varied significantly by professional affiliation, $F(9,115)=10.68$, $p<0.0001$; and $F(9,115)=10.50$, $p<0.0001$, respectively. A marked difference was observed for the use of medical doctors as an information source, a source consulted more often by medical doctors themselves, mean (SD)=3.41 (0.72), than by toxicologists, mean (SD)=2.42 (0.84). In contrast, toxicologists reported consulting more often than medical doctors, university scientists/scientific journals, mean (SD)=3.68 (0.59) vs. 3.37 (0.80), the internet, mean (SD)=2.88 (0.96) vs. 2.21 (0.86), and the news media, mean (SD)=2.66 (0.66) vs. 2.41 (0.68), respectively. Confidence in information sources also varied significantly by professional affiliation, with greater confidence in medical doctors reported by medical doctors themselves, mean (SD)=3.72 (0.45), as compared to toxicologists, mean (SD)=3.04 (0.53), and greater confidence in the government, mean (SD)=3.00 (0.61), and industry, mean (SD)=2.20 (0.67), reported by toxicologists than medical doctors, mean (SD)=2.67 (0.84) and 1.83 (0.70), respectively.

3.3.3. Gender

The use of information sources and confidence in these sources did not vary significantly by gender, $F(9,115)=1.16$, $p=0.33$; $F(9,115)=1.85$, $p=0.07$, respectively.

3.4. Health risk belief statements

Agreement with health risk belief statements is presented in Table 3.

3.4.1. Environmental concern

The majority of experts (72.0%) agreed that 'the land, air, and water around us are, in general, more contaminated now than ever before.' However, few agreed (27.2%) with the statement that 'there are serious environmental health problems where I live.' A similar finding was observed in the 1993 survey, in which 23.3% of experts agreed with this statement. Few experts in the current survey agreed (32.8%) with the statement that 'getting cancer mostly depends on the environment.'

3.4.2. Social concern

The majority of experts (82.4%) agreed with the statement that 'work-related stress is a more serious problem than ever before.' Experts also tended to agree that 'poverty is the single most important determinant of health' (69.9%). Agreement with the statement that 'getting cancer mostly depends on lifestyle' was evenly split (48.8% in agreement). In 1993, most experts agreed (84.6%) that 'the risk of getting cancer from lifestyle factors such as smoking and diet is much greater than the risk of cancer from chemicals in the environment.'

3.4.3. Genetic concern

Although experts were equivocal in their responses to the statement that 'getting cancer mostly depends on genetic makeup' and that 'most diseases depend on genetic makeup,' most experts agreed (71.2%) that 'genetic screening has benefits for the health of Canadians.'

3.4.4. Dependence on regulators: trust

Experts were unsure as to whether 'government agencies are well qualified to regulate health risks' (50.4% in agreement). Nonetheless, they generally agreed (62.4%) that 'experts are able to make accurate estimates of health risks.' In 1993, reactions to a similar statement that 'experts are able to make accurate estimates of health risks from chemicals in the environment' were more evenly split (53.3% in agreement). When asked in the current survey as to whether the government would regulate a serious health problem when it occurred, 30.4% of experts agreed, representing an increase from 15.3% in 1993.

3.4.5. Internal locus of health risk control

Virtually all experts (99.2%) agreed with the statement that 'people can offset health risks by improving their individual lifestyle, such as exercising and eating properly,'

Table 3. Percent agreement (agreement plus strong agreement) with health risk belief statements among the public, experts.

Statement (correlation with mean health risk perception rating)	Public	Experts	Difference (public-experts)
Environmental concern			
The land, air, and water around us are, in general, more contaminated now than ever before (0.26)	85.0	72.0	13.0*
There are serious environmental health problems where I live (0.34)	43.5	27.2	16.3*
Getting cancer mostly depends on the environment (0.24)	45.2	32.8	12.4*
Social concern			
Getting cancer mostly depends on lifestyle (0.24)	53.8	48.8	5.0
Work-related stress is a more serious problem than ever before (0.45)	92.1	82.4	9.7*
Poverty is the single most important determinant of health (−0.06)	58.8	69.6	−11.1
Genetic concern			
Getting cancer mostly depends on genetic makeup (−0.04)	47.6	48.8	−1.2
Genetic screening has benefits for the health of Canadians (0.07)	75.3	71.2	4.1*
Most diseases depend on genetic makeup (−0.10)	46.9	54.4	−7.5
Dependence on regulators: trust			
When there is a really serious health problem, the government will regulate it (−0.01)	57.7	30.4	27.3*
Experts are able to make accurate estimates of health risks (0.19)	74.3	62.4	11.9*
Government agencies are well qualified to regulate health risks (0.08)	56.4	50.4	6.0
Internal locus of health risk control			
People can offset health risks by improving their individual lifestyle, such as exercising and eating properly (0.15)	98.3	99.2	−0.9
The main thing that determines my exposure to health risks is what I myself do (−0.09)	84.2	88.0	−3.8
I feel I have very little control over risks to my health (0.13)	38.9	19.2	19.7*
Powerful others locus of health risk control			
Decisions about health risks should be left to the experts (0.24)	56.6	45.6	11.0*
Government agencies are responsible for controlling my exposure to health risks (0.34)	53.9	36.0	17.9*

(*Continued*)

Table 3. (*Continued*).

Statement (correlation with mean health risk perception rating)	Public	Experts	Difference (public-experts)
Health professionals are responsible for keeping me healthy (0.14)	38.8	28.0	10.8*
Chance locus of health risk control			
No matter what I do, I am likely to be exposed to health risks (−0.01)	85.6	91.2	−5.6
My exposure to most health risks is accidental (−0.04)	47.9	36.8	11.1*
When I become ill, it is a matter of fate (−0.21)	23.8	24.0	−0.2
Risk acceptability			
Canadian society is becoming too concerned about small health risks (−0.18)	48.4	67.2	−18.8*
Government agencies should decide what health risks are acceptable (0.16)	47.8	32.8	15.0*
I believe that a risk-free environment is an attainable goal in Canada (0.29)	44.7	12.8	31.9*
Technological enthusiasm			
A high technology society is important for improving our health and social well-being (0.07)	71.6	55.2	16.4*

Notes: Correlations between percentage agreement with health risk belief statement and the mean rating of perceived risk across all 30 health hazards. Correlations greater than 0.19 are significant at $p<0.05$. Correlations greater than 0.25 are significant at $p<0.01$.
*Indicates mean score significantly different using *post hoc* Tukey–Kramer ($p<0.05$).

with 77.6% of experts strongly agreeing. In contrast, in 1993, only 62.6% of experts indicated that 'people can offset health risks from pollution by improving their individual lifestyle, such as exercising and eating properly.' Experts also agreed in the current survey that the main thing that determines their exposure to health risks is what they themselves do (88.0%). Few experts (19.2%) agreed that they have very little control over risks to their health, representing a decrease from 31.1% in 1993.

3.4.6. Powerful others locus of health risk control

Although few experts agreed with the statements that 'health professionals are responsible for keeping me healthy' (28.0%) and 'government agencies are responsible for controlling my exposure to health risks' (36.0%), they were equivocal as to whether 'decisions about health risks should be left to the experts.' In 1993, only 31.3% of experts agreed with the statement 'that decisions about health risks should be left to the experts.'

3.4.7. Chance locus of health risk control

Experts agreed (91.2%) that they are likely to be exposed to health risks no matter what they do, with 56.0% in strong agreement. However, few agreed (24.0%) that when they become ill, it is a matter of fate. A total of 36.8% of experts agreed that their exposure to most health risks is accidental.

3.4.8. Risk acceptability

Expert tended to agree (67.2%) that 'Canadian society is becoming too concerned about small health risks.' However, few experts agreed (32.8%) with the statement that 'government agencies should decide what health risks are acceptable.' Only 12.8% of experts agreed with the statement that 'a risk-free environment is an attainable goal in Canada,' a decrease from 20.0% agreement in 1993.

3.4.9. Technological enthusiasm

Technological enthusiasm decreased in the current survey with 55.2% of experts agreeing that 'a high technology society is important for improving our health and social well-being' compared to 72.7% in 1993.

3.4.10. Comparison with public survey

Significant differences were observed between the public and experts in terms of the level of agreement with health risk belief statements, $F(25,1305)=7.84$, $p<0.0001$ (Table 3). In general, there was a tendency for members of the public to report higher levels of agreement with health risk belief statements compared to experts. Differences were most marked for statements that 'a risk-free environment is an attainable goal in Canada' (44.7% of the public agreed vs. 12.8% of experts), 'when there is a really serious health problem the government will regulate it' (57.7% of the public agreed vs. 30.4% of experts), 'I feel I have very little control over risks to my health' (38.9% of the public agreed vs. 19.2% of experts), and

'government agencies are responsible for controlling my exposure to health risks' (53.9% of the public agreed vs. 36.0% of experts). In contrast, the majority of experts (67.2%) felt that society is becoming too concerned about small health risks, compared to 48.4% of the public.

3.4.11. Professional affiliation

Agreement with health risk belief statements varied significantly by professional affiliation, $F(25,80)=2.29$, $p=0.003$. The largest differences were observed for the statement that 'government agencies should decide what health risks are acceptable' with 54.0% of toxicologists in agreement vs. 18.7% of medical doctors. Toxicologists also agreed more often that 'getting cancer mostly depends on lifestyle' (66.0% vs. 37.3% of medical doctors), and 'government agencies are well qualified to regulate health risks' (66.0% vs. 40.0% of medical doctors). In contrast, medical doctors were more likely than toxicologists to agree that the land, air, and water are more contaminated now than ever before (82.7% vs. 56.0% of toxicologists).

3.4.12. Gender

Agreement with health risk belief statements did not vary significantly by gender among experts, $F(25,80)=0.67$, $p=0.87$.

3.4.13. Correlations with risk perceptions

Correlations between health risk beliefs and mean ratings of perceived risk across all 30 health hazards are also presented in Table 3. Health risk belief statements were generally weakly correlated with overall risk perceptions. Correlations were strongest between belief statements that reflected environmental concern, social concern, and powerful others locus of health risk control. More specifically, the belief statement that 'work-related stress is a more serious problem than ever before' was most strongly correlated with overall risk perceptions ($r=0.45$), followed by 'there are serious environmental health problems where I live' ($r=0.34$), 'government agencies are responsible for controlling my exposure to health risks' ($r=0.34$), and 'a risk-free environment is an attainable goal in Canada' ($r=0.29$). Responses to statements reflecting environmental concern, social concern, and risk acceptability were also correlated with risk perceptions in the 1993 survey.

4. Summary and discussion

Overall, findings of the current survey revealed that Canadian toxicologists and medical doctors perceived that behavioral hazards (such as cigarette smoking, obesity, and physical inactivity) posed the greatest risk to the health of Canadians, whereas medical interventions (such as vaccines, medical X-rays, laser eye surgery, and blood transfusions) posed the least risk. Hazards related to biology/genetics or to the physical environment were perceived as low to moderate health risks. Differences in risk perception were observed by professional affiliation, but not gender, with toxicologists demonstrating somewhat higher risk perceptions than medical doctors. However, the magnitude of these differences was often small. Health risk

perceptions were also higher among members of the general public for most of the health hazards considered.

Previous research has pointed to higher risk perceptions among members of the public compared to expert groups (Hansen et al. 2003; Sjöberg 1999; Slovic 1999). In the present survey, such differences were most pronounced for waiting lists for health care and pesticides. Waiting lists for health care in Canada have been a major subject of public debate and widespread media coverage over recent years (Lewis et al. 2000; Sanmartin et al. 2000). A major recommendation of the 2002 Royal Commission on the Future of Health Care in Canada was to more effectively manage waiting lists and to communicate waiting time information more clearly to patients (Commission on the Future of Health Care in Canada 2002). Results of previous risk perception surveys in Canada have also pointed to a high degree of environmental concern and generally negative views of chemicals among members of the public (Krewski et al. 1995a, 1995b, 2006, 2008; Slovic et al. 1995). With regard to pesticides, several municipal and provincial jurisdictions in Canada have recently enacted legislation to prohibit the residential use of pesticides for cosmetic purposes, in part, due to public pressure as well as support from physician groups (Jones 2007; Sanborn et al. 2004).

In contrast, experts viewed natural health products as posing a greater risk to the health of Canadians than did members of the public. Natural health products are widely used by Canadians and, although rare, serious adverse reactions can occur (Hogan-Gow 2007; Murty 2007). Sharma et al. (2006) examined perceptions of natural health products in memory clinic patients. They observed that the majority of patients were current natural health product users, and that users perceived natural health products as more safe and effective than non-users. Hogan-Gow (2007) conducted a survey of five health professional groups (physicians, pharmacists, nurses, naturopaths, and dentists) in Canada. Health professionals perceived both prescription and non-prescription drugs as safe but not natural health products. However, there were differences in perception by professional affiliation where naturopaths perceived natural health products as more safe, and prescription drugs as less safe, compared to other professional groups.

Although several explanations have been proposed to explain discrepancies in risk perception between members of the public and expert groups, it is possible that underlying differences in socio-demographic variables may account for some of the differences observed (Rowe and Wright 2001). Compared to respondents in the public survey, experts had a higher level of educational attainment and were also somewhat older. In the public survey, respondents with a higher level of educational attainment (at least some college) reported lower risk perceptions, suggesting that differences in educational attainment could underlie some of the expert–lay differences observed in the present study. However, sensitivity analyses comparing only subjects with at least some college education in both surveys revealed that differences in risk perception between experts and the public remained, $F(30,810)= 26.02$, $p<0.0001$.

Variation in health risk perception among different professional groups may be due to a variety of factors including professional biases, availability, and frames of reference (Purvis-Roberts, Werner, and Frank 2007; Sjöberg 1999). Differences in risk perception among expert groups have also been noted elsewhere (Barke and Jenkins-Smith 1993; Hogan-Gow 2007; Purvis-Roberts, Werner, and Frank 2007). Recent research on expert assessments of blood safety in Canada revealed different

conceptualizations of risk and different risk management discourses among participants from eleven stakeholder groups (Eyles et al. 2011). While physicians tended to be concerned with patient safety, hospitals and suppliers tended to be concerned with liability and precaution. It was also noted that different heuristics including over-confidence, anchoring, and affect may play a role in driving risk management decision-making among the different expert groups. The role of analytical and experiential risk management decision-making in both experts and the public is described by Slovic, Finucane, Peters, and MacGregor (2004). Sjöberg (1999) proposed a protector vs. promoter typology of expert roles, which may lead to conflict in expert opinion on risk. Rowe and Wright (2001) point out that, at least in terms of the accuracy of expert judgments of risk, differences according to professional affiliation likely relate to the ecological validity and learnability of the task, such as whether experts are familiar with the hazard in question and whether regular appropriate feedback is provided leading to improved judgments in risk over time.

In a more detailed assessment of expert perceptions of five specific health hazards and health outcomes, perceptions varied according to levels of perceived risk, personal control, knowledge, worry, uncertainty, and risk acceptability. Results of both the expert and public surveys revealed that respondents perceived risks to their own personal health to be lower than risks to the health of Canadians. Such findings may be indicative of an 'optimistic bias' in risk perception (Weinstein 1980). Various factors, including perceived control, frequency of occurrence, or prior experience may be related to the degree of optimism in risk perceptions observed (Klein and Helweg-Larsen 2002; Price, Pentecost, and Voth 2002).

Surprisingly, with the exception of selected health outcome dimensions, significant gender differences in expert health risk perceptions were not observed here. Gender differences have been widely reported in studies of the lay public in Canada and elsewhere. Such differences have been attributed to various socio-political, among other factors (Dosman, Adamowicz, and Hrudey 2001; Finucane et al. 2000; Krewski et al. 1995a, 2006; Murty 2007; Slovic et al. 1995). Although the present findings may be a function of limited statistical power due to a relatively small sample size, they may also relate to the complexity of the relationship between gender, education, worldviews, and perceived risk.

Expert–lay differences in information sources on health risks were also observed. Respondents from the public survey reported seeking information on health risks most often from the news media (Krewski et al. 2006). In contrast, experts in the present survey most often reported seeking information from university scientists/scientific journals. Although friends and relatives were also a relatively important information source in the public survey, this was not apparent in the expert survey. Previous research has highlighted the potential role of the media in influencing public perceptions of risk, particularly for new or emerging technological risks (Vilella-Vila and Costa-Font 2008). In a study of foodborne risks, both experts and members of the public agreed that the media was an important information source (Krystallis et al. 2007). However, experts held more negative attitudes towards the media, and blamed them for creating public anxiety. The potential importance of social networks in risk perceptions (Scherer and Cho 2003) and health (Christakis and Fowler 2007) has been described. Experts also expressed greater confidence in the government as an information source. Sjöberg (1999) suggested variations in trust in institutions between experts and the public may lead to differences in risk perceptions between these two groups.

Additional differences between the public and experts were observed for agreement with health risk belief statements (Krewski et al. 2008). More specifically, although the public ascribed a greater degree of trust and responsibility in government for health protection than experts, they also expressed lower confidence in government as an information source. The public also reported lower control over risks to their own personal health. Results contrast those in Europe where food experts were more likely to highlight the role of government and industry in health protection compared to consumers who more often highlighted notions of self-protection (Krystallis et al. 2007). Results from a related qualitative study also revealed that the public believed the government should intervene to protect health, particularly when opportunities for personal protection may be limited (Dallaire et al. 2005). Differences in agreement with belief statements also remained when comparing only subjects with at least some college education, $F(25,923)=7.20$, $p<0.0001$.

Perceptions of trust in government and personal control over health risks among experts increased relative to the previous survey (Krewski et al. 1995b; Slovic et al. 1995) in contrast to other reports documenting decreasing levels of trust and confidence in government (Hansen et al. 2003; Sjöberg 1999). Perceptions that a risk-free environment is an attainable goal in Canada decreased, possibly reflecting a more realistic attitude towards risk reduction. Despite this trend, observed expert–lay differences in health risk beliefs will likely result in continued conflict over risk issues of public concern.

In accordance with results from the 1993 expert survey, responses to health risk belief statements were correlated with mean ratings of perceived risk across all health hazards, particularly for statements reflecting environmental concern, social concern, and powerful others locus of health risk control. Agreement with risk perception statements reflecting environmental and social concern were also correlated with risk perceptions in the general public survey (Krewski et al. 2008). Knight (2007) also observed that worldviews were related to support for biotechnology applications.

In sum, results of the current survey revealed high levels of perceived risk for behavioral hazards as well as lower levels of perceived risk for medical technologies. Experts reported receiving ‘a lot’ of information from university scientists/scientific journals and medical doctors and reported having ‘a lot’ of confidence in these sources. They also reported high levels of environmental and social concern, and personal agency over risks to health. Differences in risk perception were observed between members of the public and expert respondents, although it is possible that differences in survey modality (telephone surveys for the public survey vs. self-administered questionnaires in the expert survey) contributed to some of this variation. Differences in expert risk perceptions were observed by professional affiliation but not gender.

Potential limitations of the current study include low response rates and a relatively small sample size. Future research using alternative recruitment and administration strategies may aid to improve survey response rates. Nevertheless, implications include the continued need for public participation in risk management processes, such as priority setting and the design and dissemination of health risk communications. There may be opportunities to enhance personal control and knowledge over health hazards and health outcomes among the public while at the same time addressing perceptions of risk and worry. Careful consideration to the broader socio-political context, including health risk beliefs and ascribed

government and individual roles in health protection is required. Results also suggest the need for multidisciplinary collaboration among expert groups in risk management decision-making. Monitoring how expert risk perceptions, beliefs, and attitudes towards risk and regulation change over time will continue to inform our understanding of the dynamics and cultural context of risk in Canada.

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