Factor analytic investigation of Canadians' population health risk perceptions: the role of locus of control over health risks

Jennifer E.C. Lee* and Louise Lemyre

GAP-Santé Research Unit,
University of Ottawa,
1 Stewart Street, Room 312,
Ottawa, Ont. K1N 6N5, Canada
E-mail: jeclee@tricolour.queensu.ca
E-mail: louise.lemyre@uottawa.ca
*Corresponding author

Louise Legault

Social Research and Demonstration Corporation,
55 Murray Street, Suite 400,
Ottawa, Ont. K1N 5M3, Canada
E-mail: llegault@srdc.org

Michelle C. Turner and Daniel Krewski

McLaughlin Centre for Population
Health Risk Assessment,
University of Ottawa,
1 Stewart Street, Room 320,
Ottawa, Ont. K1N 6N5, Canada
Email: mturner@uottawa.ca
E-mail: dkrewski@uottawa.ca/cphra@uottawa.ca

Abstract: To better understand how health risks are conceptualised by the Canadian public, exploratory and confirmatory factor analytic techniques were applied to data from a recent national telephone survey on health risk perception ($N = 1503$). Hazards assessed comprised an array of 30 items selected *a priori* by a panel of experts to represent the following five determinants of population health: the physical environment, biology, lifestyle, the social environment and healthcare. Respondents in the survey rated each hazard in terms of perceived risk to the health of Canadians. Rather than the hypothesised five-factor model, findings supported a three-factor model, with biochemical, lifestyle and social health risk perceptions emerging as key factors explaining the public's health risk perceptions. Although the observed model differed from expectations, it maintained some elements of current population health models. Further analyses revealed that biochemical, lifestyle and social health risk perceptions were differentially associated with beliefs about the locus of control over health risks. Findings are contrasted with those of a similar analysis of data from a comparable national survey conducted in Canada in 1992, and are discussed in relation to trends in discourse on health risk over the past decade.

Keywords: beliefs; Canada; factor analysis; population health; risk regulation; risk perception.

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Biographical notes: Jennifer E.C. Lee recently earned her Doctorate in Experimental Psychology at the University of Ottawa. She obtained her Bachelors degree in Psychology from Queen's University, Kingston, Ont. Her research focuses on the relationship between risk perception and health behaviour, emphasising its implications for risk communication. Her research has appeared in *Human and Ecological Risk Assessment, Health, Risk, and Society* and *WORK: A Journal of Prevention, Assessment, and Rehabilitation.*

Louise Lemyre, FRSC is a Full Professor at the School of Psychology and the McLaughlin Research Chair on Psychosocial Aspects of Risk and Health at the Institute of Population Health of the University of Ottawa, where she leads GAP-Santé, a Research Unit on Psychosocial Analysis of health. She is also a member of the Royal Society of Canada. She obtained her Masters degree from the University of British Columbia (UBC) and her Doctorate at Laval University in Social Psychology. Then, she went for an interdisciplinary post-doctorate in Social Epidemiology and Medical Sociology at the British MRC Social Research Unit, University of London, UK.

Louise Legault is a former Research Coordinator at the GAP-Santé Research Unit at the University of Ottawa, where she obtained her Doctorate in Experimental Psychology. Currently, she is a Senior Research Coordinator at Social Research and Demonstration Corporation. Although she has diverse research interests, her passion lies in the domains of human motivation, social support, education and resilience. She is skilled in field research methodologies and both qualitative and quantitative statistical methods. Her current research focuses on childhood resilience and organisational learning.

Michelle C. Turner, MSc is an Epidemiologist and a Research Coordinator at the McLaughlin Centre for Population Health Risk Assessment at the University of Ottawa. She obtained her Masters degree from the Department of Epidemiology and Community Medicine at the University of Ottawa. Her research interests include environmental and cancer epidemiology as well as risk perception.

Daniel Krewski is a Professor of Epidemiology and Community Medicine at the University of Ottawa, where he also serves as a Scientific Director in the McLaughlin Centre for Population Health Risk Assessment. His research interests include epidemiology, biostatistics, health risk assessment and risk management. He is a fellow of the Society for Risk Analysis, the American Statistical Association, and a national affiliate of the US National Academy of Sciences. Currently, he serves as a Chair of the Academy's Committee on Toxicity Testing and Assessment of Environmental Agents.

1 Introduction

Risk perception emerged as an important area of research in the late 1970s, a period marked with growing public concern over environmental issues and the increased the use of then novel technologies such as pesticides and nuclear power (Slovic, 2000). Although experts consistently suggested that health risks associated with these technologies were low, members of the public exhibited a high degree of concern over their potential adverse effects. In an effort to better understand the origin of this discrepancy, research began to focus on identifying psychosocial factors that shape the public's perception of health risk. Though research on this topic has predominantly relied on psychometric approaches (Fischhoff et al., 1978; Slovic, 1987), recent criticisms have called for the development of new approaches that are more sensitive to the uniqueness of perceptions surrounding different types of hazards. One proposed strategy involves studying empirically meaningful categories of hazards (Lemyre et al., 2006). More precisely, Lemyre et al. (2006) suggested that hazard categories be based on the population health framework, which identifies a relatively small number of interpretable factors as determinants of the health of populations: the physical environment, biology, lifestyle, the social environment and healthcare (Frank, 1995a,b). Moving beyond the traditional psychometric approach, the present study investigated health risk perceptions from this population health risk perspective.

2 Theoretical background

The psychometric approach has proven useful in numerous studies and in various national contexts (Schütz, Wiedemann and Gray, 2000). Its basic assumption is that the public's concern over potential hazards is a function of perceptions of the extent to which these are novel, known to science, controllable, dreadful; the extent to which exposure to them is unknown, or involuntary; and the extent to which their effects are immediate, catastrophic, or severe. Factor analytic investigations performed on individuals' ratings of hazards on these qualities have consistently demonstrated that two or three dimensions underlie risk perceptions: dread, novelty and catastrophic potential (Slovic, 1987, 2000; Sjöberg, 1996, 2000). Initially, high ratings on these three dimensions were thought to invariably contribute to concern across different types of hazards. However, subsequent research has shown that the nature of this relationship depends on the hazard in question (Gardner and Gould, 1989; Pidgeon, 1998).

Other authors have criticised the psychometric approach for overlooking the importance of individual differences in risk perception (Barnett and Breakwell, 2001; Siegrist, Gutscher and Earle, 2005). Accordingly, recent studies have emphasised the role of individual-level variables in moderating public concern about health risks (Bouyer et al., 2001; Lee et al., 2005). Among these, trust in risk regulators has received considerable attention, having been associated with lower risk perceptions in a number of contexts (e.g. in relation to genetically modified foods (Siegrist, 1999, 2000), radioactive waste repositories (Flynn et al., 1992) and chemical plants (Jungermann, Pfister and Fisher, 1996)).

A related variable entails individuals' beliefs about responsibility for the control of health risks. Dallaire's (2005) qualitative interviews with members of the Canadian public underlined their belief in the necessity of government controls over some types of health risks (e.g. those arising from environmental or food-related hazards) while simultaneously valuing personal freedom and choice for others. These findings clearly emphasise the fact that individuals may attribute responsibility for the control of health risks to either internal (i.e. themselves) or external sources (i.e. the government).

This internal–external dichotomy is not new to psychological research. A number of studies have demonstrated that individuals differ with respect to their tendency to attribute personal outcomes either to their own efforts and abilities or to external forces or situations (Rotter, 1966; Lefcourt, 1981). Deemed the locus of control, this construct was applied by Wallston, Wallston and DeVellis (1978) more specifically to the domain of health (Walker, 2001). Their multi-dimensional conceptualisation of health locus of control posits that individuals believe their health to be either a function of their own actions (internal locus of control) or of external factors such as the actions of health professionals (powerful others locus of control) or fate (chance locus of control). It might then seem reasonable to similarly conceptualise beliefs about responsibility for the control of health risks by distinguishing internal from governmental or chance locus of control. Some disparity might also be expected in the relative degree to which individuals' beliefs regarding internal, governmental and chance locus of control over health risks are associated with their health risk perceptions of different types of hazards.

In light of observed and expected differentials in relationships between health risk perceptions and their correlates across hazards, one might conclude that it is best to study them individually rather than taking a general approach. While this strategy may enable further insights into the genesis of the public's risk perception of a specific hazard, it does not capture the complexity of individuals' life experience of health risk. At any given time, individuals are exposed to a number of potential health hazards simultaneously, which thus requires some mode of condensing the information in order to more successfully and strategically cope with ensuing health risks. With this in mind, Lemyre et al. (2006) suggested a more parsimonious approach; namely, the study of health risk perceptions and their correlates by empirically meaningful hazard groupings.

In a principal components analysis of data from a 1992 national survey on health risk perception (Krewski et al., 1995a,b; Slovic et al., 1995), Lemyre et al. (2006) found that Canadians' health risk perceptions comprised three components: environmental (e.g. nuclear waste, PCBs, or dioxins), therapeutic (e.g. contact lenses and medical X-rays) and social health risk perceptions (e.g. motor vehicle accidents and street crime). Most notably, strong parallels were observed between the structure of Canadians' health risk perceptions and determinants of health specified in the population health framework (Evans, Barer and Marmor, 1994; Hayes and Dunn, 1998). Specifically, environmental health risk perceptions reflected the physical environment, therapeutic health risk perceptions reflected biology and healthcare and social health risk perceptions reflected the social environment and lifestyle. It was noted that not all population health determinants clearly surfaced as latent constructs (i.e. biology and the social environment), possibly as the survey included too few of these types of health hazards.

3 Study objectives

In a more recent survey designed and conducted as a follow-up to this 1992 study, a better equilibrated set of population health hazards was assessed (Krewski et al., 2006). Included in this newer survey was a modified list of hazards generated by the project team, and further informed by a series of group discussions. This process resulted in the theoretically driven selection of 30 hazards, six to represent each of the five health determinants stipulated in the population health framework. The aim of the present study was to uncover the underlying structure of individuals' health risk perceptions and evaluate the extent to which it is reminiscent of this framework. A five-factor model was expected to emerge from factor analyses performed on individuals' risk ratings of the 30 hazards, with each factor representing a distinct population health determinant. The relationship between individuals' health risk perceptions and their beliefs about the locus of control over health risks was also examined for each category of hazards identified in the factor analyses.

4 Method

4.1 Participants

A total of 1,503 Canadians (48% men and 52% women) responded to the survey questionnaire, providing a representative sample of the Canadian population in terms of province of residence, gender and age. A relatively equal proportion of respondents were 18–44 years of age and 45 years of age or older. Sixty-one percent of participants obtained at most a high school education and 39% had at least some college education. Seventy-eight percent of the interviews were conducted in English and 22% were conducted in French.

4.2 Measures

4.2.1 Health risk ratings

Respondents were asked to rate each of the 30 health hazards in terms of potential health risk to the Canadian public using a four-point Likert-type scale (1 = almost no health risk; 2 = slight health risk; 3 = moderate health risk; 4 = high health risk). A fifth choice was also provided for respondents who did not know or had no opinion about a given risk. Each of the 30 hazards was selected to theoretically reflect one of the five population health determinants:

1. The physical environment was represented by tap water, high voltage power lines, air pollution, nuclear power plants, genetically modified foods and pesticides.
2. Biology was represented by vaccines, breast implants, flu epidemics, West Nile virus, genetic makeup and obesity.
3. Lifestyle was represented by cigarette smoking, drinking alcoholic beverages, unprotected sex, fast food, physical inactivity and sun tanning.
4. The social environment was represented by street crime, family violence, unemployment, homelessness, poverty and stress; finally
5. Healthcare was represented by prescription drugs, laser eye surgery, natural health products, waiting lists for healthcare services, blood transfusions, and medical X-rays.

In line with the population health model, exploratory and confirmatory factor analyses were expected to yield five factors as indicated in Table 1.

Table 1 Expected health risk perception factors and constituent health hazards

Health risk perception factor	*Constituent health hazards*
Physical environment	Tap water
	High voltage power lines
	Air pollution
	Nuclear power plants
	Genetically modified foods
	Pesticides
Biology	Vaccines
	Breast implants
	Flu epidemics
	West Nile virus
	Genetic makeup
	Obesity
Lifestyle	Cigarette smoking
	Drinking alcoholic beverages
	Unprotected sex
	Fast food
	Physical inactivity
	Sun tanning
Social environment	Street crime
	Family violence
	Unemployment
	Homelessness
	Poverty
	Stress
Healthcare	Prescription drugs
	Laser eye surgery
	Natural health products
	Waiting lists for healthcare services
	Blood transfusions
	X-rays

4.2.2 Locus of control over health risks

Similar to the multi-dimensional conceptualisation of health locus of control put forward by Wallston, Wallston and DeVellis (1978), three items assessed:

1. Internal locus of control over health risks ("The main thing that determines my exposure to health risks is what I myself do.").
2. Governmental locus of control over health risks ("Government agencies are responsible for controlling my exposure to health risks.").
3. Chance locus of control over health risks ("My exposure to most health risks is accidental.").

Respondents rated their level of agreement with these items using a four-point Likert-type scale (1 = disagree strongly, 2 = disagree somewhat, 3 = agree somewhat, 4 = agree strongly).

4.2.3 Demographics

Information was also collected on respondents' age (18–24 years; 25–34 years; 35–44 years; 45–54 years; 55–64 years; 65 years and up), education (some/completed elementary school; some/completed high school; some/completed community college or CEGEP; some/completed university; some/completed graduate), gender and self-rated health ("How would your rate your personal health?"). Respondents used a four-point Likert-type scale to rate their personal health (1 = excellent; 2 = good; 3 = fair; 4 = poor).

5 Procedure

The study protocol was reviewed and approved by the Research Ethics Board of the University of Ottawa. Respondents were recruited between February and March of 2004 using a random digit dialling procedure, stratified by province of residence, and by age and gender within province based on 2001 Canadian Census data. A maximum of five call-backs were made in an attempt to reach potential respondents identified by this procedure. Upon first household contact, the resident whose birthday was closest to the date of the call was selected to complete the survey. Phone interviews lasted for approximately 30 minutes. Of the 26,223 total numbers dialled, 5,604 were not valid and 4,944 were unanswered calls. Of the remaining 15,675 valid answered calls, 74.3% were refusals, 9.0% required a call back and 7.1% elicited ineligible respondents due to demographic quotas having already been met. Completed interviews represented the remaining 9.6% of valid answered calls.

5.1 Data analyses

Design effects due to the stratified sampling procedure were examined in a random sub-sample of variables and found to be close to one (ranging from 0.93 to 1.00). This permitted the use of simplified analytic procedures based on a simple random sample design, although resulting in slightly conservative inferences.

5.1.1 Exploratory Factor Analysis (EFA)

An EFA was first conducted using SPSS 14.0 for Windows (2005) on data from a randomly derived sub-sample of approximately 50% of cases ($n = 743$). This analysis was performed in order to determine whether a five-factor model would best describe the underlying structure of respondents' health risk perceptions, or whether an alternative factor solution might better fit the data. The number of factors to extract was chosen on the basis of eigenvalues and breaks in the scree plot. Principal axis factoring extraction technique was used with oblique rotation since health risk perceptions of different hazards have been found to correlate with one another.

5.1.2 Confirmatory Factor Analysis (CFA)

A CFA on the remaining 760 cases was conducted as a second step to test the validity of the model derived from population health theory and results of the EFA described above. This CFA analysis was based on covariance matrices using maximum likelihood estimation procedures and was carried out with EQS 6.1 software (Bentler, 2001). Model fit was evaluated using multiple criteria; namely, the χ^2 likelihood ratio statistic, the comparative fit index (CFI; Bentler, 1990) and the Residual Mean-Square Error of Approximation (RMSEA). Given the sensitivity of these statistics to violations of the assumption of multivariate normality, the Satorra–Bentler χ^2 scaled statistic (S–Bχ^2; Satorra and Bentler, 1988) as well as the robust CFI and RMSEA (*CFI and *RMSEA), which are based on the S–Bχ^2 scaled statistic, were used to evaluate model fit if evidence of multivariate non-normality was found (Byrne, 1994).[1] In addition, the Lagrange Multiplier (LM) was examined to identify mis-specified parameters that might, if allowed to covary, substantially improve model fit.

5.1.3 Sequential regression analyses

As a final step, a series of sequential regression analyses were performed to compare the relative degrees to which the different types of health risk perceptions emerging from factor analyses are predicted by beliefs regarding internal, governmental and chance locus of control over health risks. To adjust for their likely contribution to health risk perceptions, self-rated personal health and demographic variables (age, education and gender) were sequentially entered as covariates into the regression in Steps 1 and 2.

6 Results

6.1 Results of the exploratory factor analysis

Numerous correlations >0.30 were observed in the correlation matrix among the 30 health hazards, indicating that data were suitable for factor analysis. An EFA was thus performed on health risk perception ratings using principal axis factoring extraction and oblimin rotation with list wise deletion of cases.[2] Prior to analyses, data were screened for violations of assumptions inherent to EFA. With use of a Mahalanobis distance criterion of $p < 0.001$, 28 multivariate outliers were identified and deleted from the analysis, for a final sub-sample of $n = 490$ (65.9% of the original sub-sample).

With eigenvalues of at least one as a criterion, an initial freely estimated solution produced six factors. Yet, an examination of breaks in the scree plot indicated that a three-factor solution be retained. A second EFA was conducted constraining the data to a three-factor solution. This second solution showed some factor loadings to be < 0.30 (e.g. natural health products, drinking alcoholic beverages and unprotected sex). As suggested by Floyd and Widaman (1995), when items fail to load substantially onto the factors, the analysis may be recomputed with omission of these items. These items were, therefore, omitted in a third three-factor analysis. Again, one item in this analysis (waiting lists for healthcare services) did not produce a factor loading > 0.30. A final three-factor analysis was performed, which yielded adequate communalities (all > 0.20) and significant factor loadings (all > 0.30). The three factors accounted for 33.2% of the total variance, and were labelled 'biochemical', 'lifestyle' and 'social' health risk perceptions. Table 2 displays all factor loadings and communalities obtained in the final analysis.

Biochemical health risk perceptions accounted for roughly 25.9% of the total variance. Health hazards loading onto this factor were those that had been selected to reflect the three health determinants of physical environment, biology and healthcare. It is worth noting that a common feature of these items is their involvement in health-related biochemical processes either as environmental agents that can lead to biological changes (e.g. nuclear power plants, pesticides and air pollution) or as a biological substance (e.g. West Nile virus, vaccines and flu epidemics). Lifestyle health risk perceptions accounted for 4.6% of the total variance and mostly consisted of items related to lifestyle. Exceptions were noted with obesity and stress, which were considered to reflect biology and the social environment *a priori*. Nevertheless, obesity and stress are also related to lifestyle. Finally, social health risk perceptions accounted for 2.8% of the total variance and included items associated with the social environment.

6.2 Results of the CFA

To test the model based on the EFA findings, a CFA was performed on data from the remaining cases with complete data using structural equation modelling. The model is shown in Figure 1, where circles represent the latent variables (factors) and rectangles represent the measured variables (scale items). Absence of an arrow connecting two variables indicates that no direct relationship is hypothesised between them. It was hypothesised that the three latent variables would correlate with one another, since individuals display consistency in their health risk perception attitudes (Weber, Blais and Betz, 2002).

Data were first screened for violations of assumptions inherent to CFA. With use of a Mahalanobis distance criterion of $p < 0.001$, 25 multivariate outliers were detected and deleted from the analysis, leaving 524 cases (68.9% of the original sub-sample). Preliminary analyses determined that few items were skewed or kurtotic; skewness values ranged from −2.12 to 0.22, and kurtosis values ranged from −1.03 to 3.74. A normalised Mardia's coefficient of multivariate kurtosis of 13.85 was observed. Although this value is not excessively high, it departs from 0 – a value indicating multivariate normality of data. Given some evidence of non-normality, the possibility that maximum likelihood estimates might be affected was recognised. In particular, non-normality can lead to an underestimation of standard errors and thereby result in an inflated number of statistically significant parameters (Muthén and Kaplan, 1985). Thus, the final assessment of model fit was based on the S–Bχ^2.

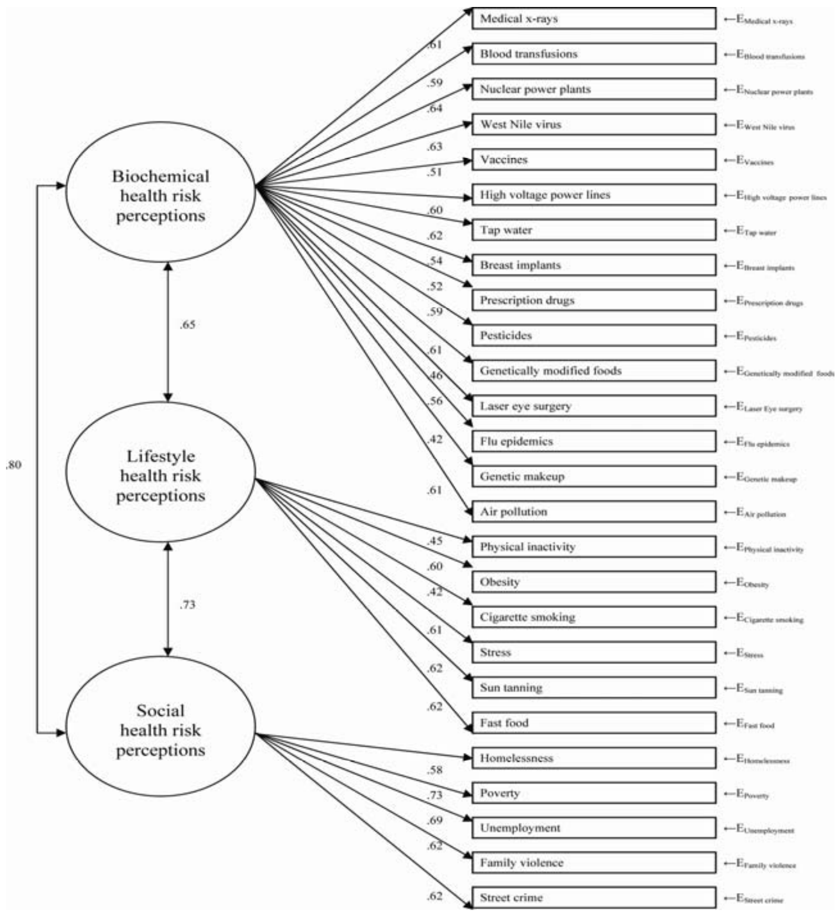
The proposed model converged in eight iterations. The majority of the off-diagonal values in the standardised residual covariance matrix were small (< 0.10) and evenly distributed – an indication of good model fit. Examination of goodness-of-fit indices revealed some evidence of lack-of-fit of the proposed model; S–Bχ^2 (296) = 661.65, $p < 0.001$. Given the sensitivity of this index to sample size, the *CFI was employed as a practical index of fit (Byrne, 1994). A value of 0.91 was observed, indicating that the model adequately represented the raw data. This was corroborated with a low observed *RMSEA of 0.05. Furthermore, examination of robust parameter estimates indicated that all parameters were significant. While LM statistics suggested that additional paths be included between air pollution and both lifestyle and social health risk perceptions, re-specification of the model as such yielded little improvement. It was also believed that the theoretical rationale for re-specification was insufficient (Byrne, 1994). The model was, therefore, retained as presented in Figure 1.

Table 2 Factor loadings, communalities (h^2), and percents of explained variance of the three-factor analysis with principal axis factoring extraction and oblimin rotation of health hazards rated by Canadians on perceived health risk

Item	*F1*	*F2*	*F3*	h^2
Medical X-rays	0.71			0.42
Blood transfusions	0.67			0.37
Nuclear power plants	0.64			0.44
West Nile virus	0.58			0.36
Vaccines	0.57			0.29
High voltage power lines	0.56			0.31
Tap water	0.53			0.36
Breast implants	0.48			0.35
Prescription drugs	0.46			0.28
Pesticides	0.44			0.43
Genetically modified foods	0.44			0.36
Laser eye surgery	0.44			0.20
Flu epidemics	0.39			0.24
Genetic makeup	0.36			0.20
Air pollution	0.34			0.31
Physical inactivity		0.57		0.30
Obesity		0.57		0.38
Cigarette smoking		0.50		0.23
Stress		0.39		0.39
Sun tanning		0.35		0.28
Fast food		0.32		0.20
Homelessness			–0.73	0.46
Poverty			–0.72	0.52
Unemployment			–0.53	0.29
Family violence			–0.50	0.39
Street crime			–0.39	0.28
Percent of variance	25.9	4.6	2.8	

Note: Factor labels were *F*1 = biochemical health risk perceptions, *F*2 = lifestyle health risk perceptions and *F*3 = social health risk perceptions.

Figure 1 Diagram of the three-factor model of health risk perception with estimated parameter loadings



Note: *E* = error term for that item.

6.3 Results of sequential regression analyses

Aggregate variables for biochemical, lifestyle and social health risk perceptions were computed by summing across appropriate items (i.e. those that loaded onto the respective factors) to be used as dependent variables in subsequent analyses among all cases with complete data from the full sample. Scales for biochemical, lifestyle and social health risk perceptions yielded adequate Cronbach's reliability coefficients of 0.87, 0.70 and 0.77, respectively. Prior to analyses, the data were checked for violations of assumptions inherent to multiple regression analyses. Table 3 displays the correlation matrix between all covariates, predictors and health risk perception factors. The un-standardised regression coefficients (*B*) and standardised regression coefficients (β) observed in analyses for biochemical, lifestyle and social health risk perceptions are presented in Tables 4–6.

Table 3 Pearson's correlations among demographic variables, internal, governmental, and chance locus of control over health risks, and health risk perception factors

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1 Self-rated health	–	0.10***	–0.19***	<0.01	–0.09***	0.03	–0.02	0.10***	0.02	0.12***
2 Age		–	–0.09***	0.02	<0.01	0.01	0.10***	0.14****	0.08***	0.11***
3 Education			–	–0.05	–0.01	–0.03	–0.05*	–0.23***	0.01	–0.15***
4 Gender				–	–0.02	<–0.01	–0.03	0.23***	0.22***	0.26***
5 Internal LCHR					–	–0.02	0.01	–0.03	0.08**	0.02
6 Govern-mental LCHR						–	0.09***	0.15***	0.05*	0.11***
7 Chance LCHR							–	0.01	–0.06*	–0.04
8 Biochemical HRP								–	0.49***	0.61***
9 Lifestyle HRP									–	0.50***
10 Social HRP										–

Note: LCHR = locus of control over health risks; HRP = health risk perceptions. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

6.3.1 Biochemical health risk perceptions

No outliers or multi-collinearity were observed among the cases, leaving 1,095 cases with complete data. Controlling for self-rated personal health and demographic variables in previous steps, the final model significantly predicted biochemical health risk perceptions, yielding an R of 0.38, $F(7, 1087) = 25.76$, $p < 0.001$. Predictors accounted for 14% of the adjusted variance in biochemical health risk perceptions. The change in R^2 after Step 2 was 0.02, $Finc(3, 1087) = 8.27$, $p < 0.01$, indicating that addition of the three types of locus of control into the equation added significantly to the prediction of biochemical health risk perceptions beyond the variance explained by background variables (Table 4). However, only governmental locus of control significantly, uniquely and positively predicted biochemical health risk perceptions.

Table 4 Results of sequential regression with internal, governmental and chance locus of control over health risks as predictors of biochemical health risk perceptions

Variable	*B*	*SEB*	*ß*
Step 1			
Self-rated personal health	1.0	0.31	0.10***
Step 2			
Self-rated personal health	0.54	0.30	0.05
Age	1.91	0.43	0.13***
Gender	3.49	0.43	0.23***
Education	–3.12	0.44	–0.21***

Table 4 Results of sequential regression with internal, governmental and chance locus of control over health risks as predictors of biochemical health risk perceptions (continued)

Variable	*B*	*SEB*	*ß*
Step 3			
Self-rated personal health	0.44	0.30	0.04
Age	1.93	0.43	0.13***
Gender	3.41	0.42	0.23***
Education	–3.12	0.44	–0.21***
Internal LCHR	–0.22	0.27	–0.02
Governmental LCHR	1.12	0.23	0.14***
Chance LCHR	–0.12	0.23	–0.02

Note: LCHR = locus of control over health risks; $R^2 = 0.01$ for Step 1 ($p < 0.001$), $\Delta R^2 = 0.09$ for Step 2 ($p < 0.001$), $\Delta R^2 = 0.02$ for Step 3 ($p < 0.001$). **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

6.3.2 *Lifestyle health risk perceptions*

Among the 1,438 cases with complete data, no outliers or multi-collinearity were observed. The final model significantly predicted lifestyle health risk perceptions, yielding an R of 0.27, $F(7, 1430) = 16.46$, $p < 0.001$. Predictors accounted for 7% of the adjusted variance in lifestyle health risk perceptions. Addition of three types of locus of control into the equation after Step 2 significantly enhanced predictability, with ΔR^2 at 0.02, $Finc(3, 1430) = 7.52$, $p < 0.001$ (Table 5). The strongest significant, unique predictor of lifestyle health risk perceptions was internal locus of control, followed by chance and governmental locus of control over health risks.

Table 5 Results of sequential regression with internal, governmental and chance locus of control over health risks as predictors of lifestyle health risk perceptions

Variable	*B*	*SEB*	*ß*
Step 1			
Self-rated personal health	0.05	0.09	0.14
Step 2			
Self-rated personal health	0.04	0.09	0.01
Age	0.42	0.13	0.08***
Gender	1.14	0.13	0.23***
Education	0.13	0.13	0.03
Step 3			
Self-rated personal health	0.05	0.09	0.01
Age	0.44	0.13	0.09***
Gender	1.14	0.13	0.23***
Education	0.12	0.13	0.02
Internal LCHR	0.27	0.08	0.09***
Governmental LCHR	0.16	0.07	0.06*
Chance LCHR	–0.17	0.07	–0.07**

Note: LCHR = locus of control over health risks; $R^2 = 0.01$ for Step 1 ($p < 0.001$), $\Delta R^2 = 0.11$ for Step 2 ($p < 0.001$), $\Delta R^2 = 0.02$ for Step 3 ($p < 0.001$). **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

6.3.3 Social health risk perceptions

Again, no outliers or multi-collinearity were observed among the 1,401 cases with complete data for the analysis. Social health risk perceptions were significantly predicted in the final model, which yielded an R of 0.35, $F(7, 1393) = 17.40$, $p < 0.001$. Predictors accounted for 12% of the adjusted variance. Together, the three types of locus of control significantly predicted social health risk perceptions beyond differences related to background variables, with ΔR^2 at 0.02, $Finc(3, 1393) = 8.71$, $p < 0.001$ (Table 6). Governmental locus of control was the strongest significant predictor, followed by chance locus of control over health risks. However, internal locus of control over health risks did not emerge as a significant unique predictor.

Table 6 Results of sequential regression with internal, governmental and chance locus of control over health risks as predictors of social health risk perceptions

Variable	*B*	*SEB*	*ß*
Step 1			
Self-rated personal health	0.44	0.11	0.11***
Step 2			
Self-rated personal health	0.33	0.10	0.08***
Age	0.51	0.15	0.09***
Gender	1.54	0.15	0.26***
Education	–0.71	–16	–0.12***
Step 3			
Self-rated personal health	0.32	0.10	0.08**
Age	0.55	0.15	0.09***
Gender	1.54	0.15	0.26***
Education	–0.70	0.16	–0.12***
Internal LCHR	0.13	0.09	0.04
Governmental LCHR	0.36	0.08	0.12***
Chance LCHR	–0.18	0.08	–0.06*

Note: LCHR = locus of control over health risks; $R^2 = 0.01$ for Step 1 ($p < 0.001$), $\Delta R^2 = 0.09$ for Step 2 ($p < 0.001$), $\Delta R^2 = 0.02$ for Step 3 ($p < 0.001$). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

7 Discussion

The aim of the present study was to uncover the underlying structure of Canadians' health risk perceptions and determine the extent to which it is reflective of a five-factor model based on the population health framework. A widespread notion in cognitive psychology is that individuals seek to organise information into simpler, cohesive patterns when faced with large volumes of information (Anderson, 1995). The present analyses reveal that individuals' health risk perceptions are no exception. Although the three-factor model emerging from the exploratory factor analysis slightly differed from the initial hypothesised model, it was supported in the confirmatory factor analysis. Specifically, respondents organised their health risk perceptions more succinctly according to broader categories of biochemical, lifestyle and social determinants of health.

Biochemical health risk perceptions consisted of hazards that had initially been hypothesised to reflect three separate health determinants: the physical environment, biology and healthcare. Careful examination of the hazards that loaded onto this factor nevertheless revealed some commonalities, as all were involved in health-related biochemical processes, either as environmental agents that lead to biological changes or as a biological substance. The finding that hazards chosen to reflect the physical environment did not emerge as a pure latent "environmental" factor clearly differs from results of the analysis by Lemyre et al. (2006). Although direct comparisons between the present findings and those emerging from this previous survey were difficult to carry out (Lemyre et al., 2006),[3] this finding may relate to a decreased salience of environmental hazards in 2004, relative to other issues. As much as the occurrence of high-profile environmental disasters (e.g. the Exxon Valdez oil spill disaster of 1989) and emphasis on environmental policy-making in Canada (VanNijnatten, 1999; Soroka, 2002) characterised the early 1990s, various human pathogens (e.g. West Nile virus and flu epidemics) and healthcare have been at the forefront of public health debates in recent years. This widened focus on biological, healthcare and environmental health determinants in public policy may have become part of the Canadian public's consciousness, perhaps making it easier for individuals to draw parallels between each of these determinants.

This finding aside, other aspects of the latent structure of health risk perceptions retained some features of the population health framework. As expected, lifestyle health risk perceptions emerged as a distinct factor, although two of the items that loaded onto it (obesity and stress) were originally hypothesised to reflect other health determinants (biology and the social environment, respectively). Having been linked with chronic diseases such as coronary heart disease and type 2 diabetes, obesity is recognised as a serious health problem in Canada. Indeed, a considerable proportion of Canadian healthcare funds are absorbed by the treatment of obesity-related conditions (Birmingham et al., 1999). Although primarily in research settings, the link between stress and health has also received considerable attention, with psychosocial stressors acknowledged as important factors in pervasive socioeconomic health disparities among Canadians (Raphael and Farrell, 2002; Orpana and Lemyre, 2004).

Without overlooking their respective relations with biology and the social environment, it is undeniable that obesity and stress are also related to diet, smoking and exercise. However, a problem arises in that such lifestyle factors receive a disproportionate amount of attention (Raphael and Farrell, 2002). Compounded with the numerous recent health campaigns aimed at raising awareness of the importance of healthy living, this emphasis on lifestyle can obscure people's recognition of other equally important factors such as social influences (Evans and Stoddart, 1990). Perhaps a parallel phenomenon can account for the fact that obesity and stress were more strongly related to hazards that had been selected to reflect lifestyle rather than their respective hypothesised categories.

As did lifestyle, the social environment emerged as a prominent feature of respondents' health risk perceptions. Within the population health framework, social factors are recognised as powerful determinants of health. Yet, their contribution relies on indirect pathways, for instance through the type of physical environment or lifestyle that living in unfavourable social conditions entails (Evans et al., 1994). For the most part, hazards that loaded onto social health risk perceptions were consistent with this fundamental principle of population health. Along with that of lifestyle health risk perceptions, the prominence of this factor in this more recent data set is notable. While this finding may be an artefact of differences in the hazard constituency of the scales included in each survey, it may also in part reflect the abovementioned emphasis on lifestyle factors in health as well as the growing prominence of discourse on the social environment in public health (e.g. Frank, 2006; Judge, 2006).

An examination of relationships between health risk perceptions and beliefs about the locus of control over health risks revealed additional distinctions among the three categories of hazards. In accordance with the fact that the majority of hazards that fell within this category are primarily controlled by state regulation, biochemical health risk perceptions were solely significantly predicted by governmental locus of control (and more so than lifestyle or social health risk perceptions).

In contrast, lifestyle health risk perceptions were most strongly predicted by internal locus of control, perhaps reflecting the greater relative degree of control individuals can exert over lifestyle compared to other determinants of health. However, significant relationships were also observed with governmental and chance locus of control. Certainly, the government can play a role by providing information to the public about lifestyle risks or by making services available to at-risk populations (e.g. smokers or alcohol abusers). Nevertheless, lifestyle health risk perceptions were more strongly related to chance compared to governmental locus of control over health risks, suggesting that respondents may have been more likely to attribute exposure to lifestyle risks to chance.

Social health risk perceptions, on the other hand, were more strongly associated with governmental than with chance locus of control over health risks. As emphasised by some participants in Dallaire's (2005) qualitative interviews, the government can intervene by improving social conditions through the reduction of childhood poverty or the protection of underprivileged individuals. Moreover, the potential of strong social networks, in particular, has received an increased amount of interest from public policy researchers and practitioners as a means to improve the health of Canadians (Frank, 2006; Judge, 2006).

In spite of differences in the relative contributions of internal, governmental and chance locus of control to the prediction of biochemical, lifestyle and social health risk perceptions, the directions of these relationships were consistent. More specifically, elevated levels of internal and governmental locus of control over health risks predicted higher health risk perceptions, whereas elevated levels of chance locus of control over health risks predicted lower health risk perceptions. These findings may appear to go against the widely held view that hazards deemed as uncontrollable evoke the highest degree of concern (Fischhoff et al., 1978; Slovic, 1987). However, it should be stressed that the variables under study did not solely reflect beliefs surrounding the level of controllability of hazards. Instead, these items assessed beliefs about the responsibility of different entities for the control of health risks. Moreover, relationships were examined with health risk perceptions as opposed to concern over health risks. From this perspective, it can be understood how elevated health risk perceptions could lead to a greater perceived responsibility for the control of health risks. Similarly, it seems entirely plausible that lowered health risk perceptions could lead to increased fatalism regarding health risks. Unfortunately, interpretation of these findings is hindered by a cross-sectional design, which does not allow for conclusions to be made on the directions of relationships among variables.

A related issue which must also be acknowledged is the fact that analyses only accounted for a modest portion of variance in health risk perceptions. This may reflect the nature of the items used to assess internal, governmental and chance locus of control over health risks. As no existing scales were available to measure these constructs, the items were developed on the basis of Wallston, Wallston and DeVellis' (1978) multi-dimensional conceptualisation of health locus of control. Further examination of how these items relate to scales assessing similar constructs would assist in establishing their construct validity. Conceptual clarification of the constructs under study (e.g. health risk locus of control) combined with the development of a more refined measure of these could benefit policy makers by facilitating the identification of risk domains in need of attention and by informing the type of interventions required (e.g. government action vs. public education on individual action).

8 Conclusion

Notwithstanding limitations, the present study reveals a number of important findings about the factors shaping the public's population health risk perceptions. While the model that best described Canadians' health risk perceptions was more parsimonious than expected, the utility of the population health framework to health risk perception research should not be discounted. Rather, the population health framework provides a good basis on which to distinguish public from expert models of health risk – an aim of risk perception research since its beginnings. Indeed, differences between the observed three-factor model and the population health framework have important implications for the design of population-based health education campaigns, for example, by emphasising the need to raise the public's awareness about the role of the social environment in psychological stress. Also, additional consideration of beliefs about the locus of control over health risks allowed for a more in-depth understanding of the processes influencing respondents' mental organisation of population health risks. More importantly, doing so helped to shed light on Canadians' expectations of government with regards to the control of biochemical and social health risks – the acknowledgement of which is an important dimension of effective risk management (Krewski et al., 2005). A natural direction for future research would be to perform similar analyses using data from non-Canadian populations. Comparing the structure of health risk perceptions among different populations or within sub-populations at different time periods would complement other approaches aimed at uncovering important socio-cultural influences.

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Notes

[1]The χ^2 likelihood ratio statistic measures the closeness of fit between the observed covariance matrix and the fitted covariance matrix. Small values that approximate the number of degrees of freedom are generally viewed as being indicative of a good fit (Byrne, 1994). Given the sensitivity of this statistic to violations of multivariate normality, use of the Satorra–Bentler χ^2 scaled statistic (S–Bχ^2; Satorra and Bentler, 1988) is recommended to assess model fit when non-normality is observed (Byrne, 1994). With its incorporation of a scaling correction for the χ^2 statistic when violations of normality are the case, the S–Bχ^2 has been shown to be the most reliable. While the χ^2 likelihood ratio statistic and S–Bχ^2 are useful as measures of fit, both are highly sensitive to sample size such that they are often significant even for well-fitting models (Byrne, 1994). Use of the CFI as a practical index of fit is therefore recommended (Byrne, 1994). Based on the χ^2 statistic, the CFI is derived from the comparison of the restricted model with that of the independence model to determine goodness-of-fit. Values range from 0 to 1.0, with values of at least 0.90 indicating an acceptable fit (Byrne, 1994). The robust CFI (*CFI) is based on the S–Bχ^2 statistic and as such, is best used for non-normal distributions. As an alternative index, the RMSEA estimates a model's lack of fit compared to a perfectly fitting model, where values lower than 0.06 are considered to indicate a good fit (Tabachnick and Fidell, 2001). Also based on the S–Bχ^2 statistic, the robust RMSEA (*RMSEA) can be used as an index in place of RMSEA for non-normal distributions.

[2]It was decided not to replace values of 5 = do not know/no opinion because respondents actively selected these values, rendering them non-equivalent to missing values.

[3]Scale items were not precisely the same in the 2004 survey as in the previous survey. Also, a different analysis was performed on data from the 2004 survey in congruence with the aim of testing the five population health determinants as a theoretical model of health risk perception in the general population rather than the aim of Lemyre and colleagues' study (2006) of reducing a high number of items into a smaller set of empirically derived groups.