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# Evaluating Chemical Risks: Results of a Survey of the British Toxicology Society

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## Summary

- 1 Members of the British Toxicology Society participated in a survey to determine their attitudes, beliefs, and perceptions regarding risks from chemicals. Similar surveys had previously been conducted with toxicologists and members of the general public in the United States and Canada. Data from 312 completed questionnaires were analyzed.
- 2 In general, the British toxicologists judged risks to be quite low for most hazards, with the exception of cigarette smoking and asbestos. They tended to have quite favorable attitudes toward the use of chemicals and were confident about the adequacy of chemical regulations.
- 3 As in previous studies of toxicologists, women expressed higher perceptions of risk than did men and had consistently stronger anti-chemical attitudes.
- 4 Toxicologists working in industry had more favorable attitudes towards chemicals and their use than did those working in academic settings.
- 5 When asked to evaluate technical summaries of various animal studies there was considerable disagreement among the respondents about the toxicity of the chemicals involved.
- 6 In general, British toxicologists were equivocal about the reliability of animal studies in predicting human effects (particularly carcinogenicity) but were rather confident that human risks could be assessed accurately.

**Key words:** risk assessment; risk attitudes; risk perception; British Toxicology Society

## Introduction

Judgments of chemical risks have been the subject of systemic examination in a series of studies dating back to 1988. Kraus, Malmfors, and Slovic<sup>1</sup> surveyed members of the U.S. Society of Toxicology and members of the general public to determine their attitudes, beliefs, and perceptions regarding risks from chemicals. That survey was replicated and extended in Canada in 1993, with members of the Canadian Society of Toxicology and a large representative sample of the Canadian public. A similar survey was sent to the entire membership of the British Toxicology Society in 1994 and the results are reported in this paper.

The original study by Kraus et al. was motivated by the premise that different assumptions, conceptions, and values underlie much of the discrepancy between expert and lay views of chemical risks. They attempted to address this issue by exploring the cognitive models, assumptions, and inference methods that comprise laypeople's 'intuitive toxicological theories' and by comparing these theories with the cognitive models, assumptions, and inference methods of scientists working in the field of toxicology.

Toxicologists and laypeople were found to differ greatly, documenting some common assumptions (e.g., that the public believes natural chemicals to be safer than synthetic ones) and verifying many of the other hypotheses that motivated the questionnaire. Of particular importance was the finding that the members of the public were much less sensitive than the toxicologists to considerations of dose and exposure. Lay respondents generally tended to view chemicals as either safe or dangerous, and they appeared to equate even small exposures to toxic or carcinogenic chemicals with almost certain harm. This tendency was found to be associated with high levels of concern about very small residues of chemicals on food and with a desire to reduce chemical risks regardless of cost. Although Kraus et al. were not able to develop a precise

description of the lay mental models of how a chemical carcinogen works, their results were consistent with a contagion or contamination model,<sup>2</sup> which is very different from the kinds of models that toxicologists hold.

One of the major surprises in the data was the lack of difference between the public and toxicologists with regard to their confidence in extrapolation from animal studies. Both groups were divided in their opinions, and the high percentage of toxicologists who lacked confidence in animal studies is particularly noteworthy in light of the extensive reliance on such studies in risk management. Also, whereas the public's trust in extrapolation from animal studies increased greatly when these studies were found to produce evidence of carcinogenicity, toxicologists were much less confident that such evidence could be used to predict cancer risk in humans. Kraus et al. also found an affiliation effect; toxicologists working for industry saw chemicals as more benign than did their counterparts in academia and government.

The studies of toxicologists and laypeople in Canada,<sup>3-5</sup> replicated and extended the results obtained in the United States. Canadian toxicologists had far lower perceptions of risk for all hazards and more favorable attitudes toward chemicals than did the Canadian public. The public's attitudes toward chemicals were quite negative and showed the same lack of dose-response sensitivity found in the U.S. study. Both the public and the toxicologists exhibited a lack of confidence in the value of animal studies for predicting human health risks. An important result, also found in the U.S. survey, was that a study showing evidence that a chemical caused cancer in animals led to high confidence within the public that the chemical would cause cancer in humans but did not elicit much confidence among the toxicologists. Affiliation effects found in the U.S. survey were also replicated in the Canadian survey of toxicologists.

A special feature of the Canadian research was the inclusion of technical material for the toxicologists to evaluate and the inclusion of questions pertaining to general philosophical attitudes known as worldviews.<sup>6</sup> The range of disagreement among toxicologists on some of the technical questions was significant as was the correlation between technical judgments and some 'nonscientific' factors such as gender and worldviews. Also important was the lack of agreement that animal studies of the type done in the National Toxicology Program in the U.S. will permit reliable judgments of a chemical's carcinogenic potential in humans.

## Methods

### Survey content

The present survey was designed to assess many different aspects of health-risk assessment. Accordingly, a variety of question types and formats were used, including ratings of perceived risk, attitude and opinion questions, and questions pertaining to the technical evaluation of several chemicals. The survey design was similar but not identical to the previous survey conducted by the authors with the Canadian Society of Toxicologists in 1993.<sup>5</sup> The main components of the survey are outlined below.

**Risk perception.** In the first segment of the survey, respondents were asked to indicate the degree of health risk they associated with each of 29 items covering a wide range of hazards, including risks from technology (e.g., nuclear power, electric and magnetic fields), lifestyle (e.g., cigarette smoking, alcoholic beverages), pollution (e.g., waste incinerators, indoor air pollution), common substances (e.g., food additives, tap water), and crime and violent behavior. The array of items was selected to include many of the hazards that have recently been of concern to the public, the medical community, or government agencies.

Each of these items was rated in terms of the health risk posed to 'the average exposed citizen of your country.' The possible responses were 'almost no health risk,' 'slight health risk,' 'moderate health risk,' and 'high health risk.' These responses were coded 1, 2, 3, and 4, respectively, and were then averaged across the 29 items to create a 'risk-perception index' for each respondent.

**Attitudes and opinions.** The next segment of the survey contained 40 items designed to elicit the respondents' attitudes and opinions regarding a variety of health-risk perception issues.

These items were presented as statements with which the respondent was asked to agree or disagree. The content of these items included statements about:

- One's local environment (e.g., 'There are serious environmental health problems where I live')
- Government regulation (e.g., 'Chemical risks are sufficiently regulated in this country.')
- Risk/benefit tradeoffs (e.g., 'People should be prepared to accept some risks to their health in order to strengthen the economy.')
- The objectivity of scientific inquiry (e.g., 'When emotions influence scientific judgments, rationality suffers.')
- Health risks from chemicals (e.g., 'In general, the use of chemicals has improved our health more than it has harmed it.')
- Risks from chemicals and radiation

The questions about the risks from chemicals and radiation were designed to assess (a) sensitivity to dose or amount of exposure as a determiner of risk, and (b) opinions about the value of animal tests as predictors of the effects of chemicals on humans.

**Worldviews.** Over the past decade, evidence has been accumulating regarding the importance of general dispositions or 'worldviews' in determining an individual's perceptions of risk.<sup>6-7</sup> Most of this evidence comes from studies of the general population. To determine whether worldviews influence the judgments of our toxicologist respondents, the survey contained a small number of statements designed to determine agreement or disagreement with the following worldviews:



- Fatalism (e.g., 'I feel that I have very little control over risks to my health.')
- Hierarchy (e.g., 'Decisions about health risks should be left to the experts.')
- Individualism (e.g., 'In a fair system, people with more ability should earn more.')
- Egalitarianism (e.g., 'If people in this country were treated more equally, we would have fewer problems.')
- Technological enthusiasm (e.g., 'A high technology society is important for improving our health and social well-being.')
- Economic growth ('Continued economic growth is necessary to improve our quality of life.')
- Consent ('When a risk is very small, it is okay for society to impose that risk on individuals without their consent.')

**Toxicological evaluations.** Two series of questions were directed toward technical judgments of specific chemicals. In the first series, a table was presented summarizing the 2-year study of Bromoethane done in the U.S. within the National Toxicology Program (NTP). The standard NTP protocol had been used, in which four separate studies were conducted, one each with male mice, female mice, male rats, and female rats. The summary of results from these four studies was presented in the survey in the format shown in Table 1. Bromoethane is an alkylating agent used primarily as a chemical intermediate in various organic syntheses. The chemical was identified only as 'Chemical B' in the survey. Respondents were asked to study the summary table and to judge the level of carcinogenic activity of Chemical B for male rats, female rats, and so on according to the NTP criteria, which were also defined and displayed in the survey. The NTP categories were: clear evidence of carcinogenic activity, some evidence, equivocal

evidence, no evidence, and inadequate evidence. Respondents were also asked whether they agreed or disagreed that 'In general animal studies of the type done with Chemical B will permit one to make reliable judgments of the likelihood that the chemical is carcinogenic in humans' and 'Based on the data presented above (in the table), a concentration of 1 ppb of Chemical B in indoor air is acceptable.' Finally, they were asked to indicate whether Chemical B is:

- a probable carcinogen in humans,
- a possible carcinogen in humans,
- probably not carcinogen in humans,
- definitely not carcinogenic in humans, or
- the data are not adequate to make this type of judgment.

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Insert Table 1 about here

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Next respondents were shown the following paragraph describing results of studies done on the chemical 2-mercaptobenzothiazole, labeled in the survey as 'Compound E.'

E is used as a rubber accelerant and a preservative. The annual production is several million kilograms. It is a solid material with a disagreeable odor. It is insoluble in water but soluble in different solvents. It occurs as a contamination in medicinal products and in rubber baby bottle nipples. It inhibits dopamine-B-hydroxylase.

E has a low acute toxicity (LD<sub>50</sub> in rats is 2-3 g/kg given orally). At repeated oral administration hepatomegaly and forestomach lesions are found in rats at doses around 500 mg/kg. A reproductive toxicity study did not show any toxic effects at 200 mg/kg given intraperitoneal day 1-15 gestation including embryotoxicity, which was indicated in another study. Genotoxic effects were found in mammalian cells but not in bacteria.

Carcinogenicity studies were evaluated as showing some evidence of carcinogenic activity in rats—mononuclear cell leukemia, pancreatic acinar cell adenomas, adrenal gland pheochromocytomas, and pituitary gland adenomas in females. In mice there was no evidence in males and equivocal evidence in females—hepatocellular adenomas or carcinomas—at 750 mg/kg given by gavage.

E has been shown to be a very strong allergen in guinea pigs but is judged a moderate contact sensitizer in humans.

Respondents were asked to judge the relative toxicity of Chemical E, the risk of using it as a rubber accelerant and preservative, the factors they took into account in assessing its toxicity, and the acceptability of using it in rubber nipples for baby bottles.

Chemical B and Compound E were selected because the animal data raised a number of questions that made the interpretations and evaluations 'nonobvious.'

**Personal characteristics and professional experience.** The final section of the survey elicited information pertaining to the personal and professional background of the respondent. In addition to standard demographic information (gender, age, and education), respondents were asked detailed questions pertaining to their organizational affiliation, their experience with various types of chemicals, and the nature of their work, including experience with various specified aspects of risk assessment.

### **Administration of the survey**

The survey was mailed to all 857 members of the British Society of Toxicology in January, 1994. There were 312 completed surveys returned for a response rate of 36.4%.

## Results

### Background characteristics

Sixty percent of the toxicologists who completed the survey were age 44 or younger; 66.7% were male; 53.2% had a Ph.D. or M.D. degree; toxicology or pharmacology was the most common academic background (45.0%) followed by biochemistry/chemistry (23.0%) and biology (17.1%); 37.1% were primarily affiliated with private industry; 26.4% were primarily with academic institutions; and 17.0% were primarily with a government agency. Their main current position varied among active scientific research (44.1%), administrative and/or managerial (32.3%) and teaching (8.9%). Nearly half (47.7%) indicated that general toxicology was their primary field. In terms of primary experience, 51.6% had worked frequently with drugs; 37.5% had worked frequently with experimental toxicants; 35.3% had worked frequently with chemical products such as industrial or household chemicals, food additives and/or cosmetics; and 19.2% had worked frequently with naturally occurring chemicals. Whereas 60.9% engaged frequently in toxicological evaluation, 54.8% frequently engaged in research, and 30.8% and 30.1% frequently did testing and risk assessment, respectively. The major test system for these people was animal studies (65.4% frequently worked with these systems) compared to 33.7% who worked frequently with in vitro systems and 13.5% who worked frequently with humans. The survey respondents were highly experienced; 51.3% had more than 10 years' experience in experimental work and 44.9% had similar length of experience in evaluation of chemicals, including risk assessment.

### Ratings of risk

Figure 1 presents the response distributions for the toxicologists' judgments of health risks to the average exposed citizen of their country. Cigarette smoking and asbestos had by far the highest ratings of risk with 79.8% and 50.3% high-risk responses, respectively. Dioxins and nuclear waste were rated next highest with 20.2% and 15.7% high-risk responses. Other risks that had over 10% high-risk responses were motor vehicle traffic, suntanning, and crime and violence, all lifestyle or behavioral risks. The remaining items, including most of the chemical hazards, were rated rather low in risk. Three items, mercury in dental fillings, food additives, and tap water, received no high-risk ratings.

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Insert Figure 1 about here

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Figure 2 presents the difference in proportion of moderate and high risk ratings between men and women toxicologists. For 27 of the 29 items, women were more likely than men to label an item moderate or high in risk. There was only one item (burning fossil fuels) for which men had slightly more moderate or high-risk responses than women. There were no gender differences for chemical pollution in the workplace. The 'gender gap' was particularly large for nuclear waste and nuclear power reactors, followed by outdoor air pollution, alcoholic beverages, suntanning, and environmental tobacco smoke.

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Insert Figure 2 about here

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### Attitudes and opinions

Tables 2 to 10 present the response distributions for the 49 attitude and opinion statements. These statements are grouped together by content category for easier interpretation.

Category 1 (Table 2) includes general statements about risks from chemicals. An overwhelming majority of toxicologists (93.2%) agreed that the use of chemicals has improved our health more than it has harmed it (Statement 1a). A strong majority disagreed (78.8%) that they try hard to avoid contact with chemicals and chemical products in their daily life. One third of the toxicologists agreed that our society has perceived only the tip of the iceberg with regard to the risks associated with chemicals (Statement 1c). However, only 22.4% agreed that it can never be too expensive to reduce the risks associated with chemicals (Statement 1d).

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Insert Table 2 about here

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Category 2 (Table 3) included 11 questions designed to gauge one's trust in the use of animal and epidemiological studies to determine a chemical's risk to humans. Only about half of the toxicologists agreed with the general Statement 2a, 'The way that an animal reacts to a chemical is a reliable predictor of how a human would react to it.' Moreover, when an animal study was said to provide 'evidence that a chemical causes cancer in animals' (Statement 2b), agreement that it 'will cause cancer in humans' decreased to 34.9%. When asked whether 'laboratory studies of a chemical's harmful effects on animals allow scientists to accurately determine how much of the chemical it takes to cause similar harm in humans,' agreement decreased to 29.8% (Statement 2c).

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Insert Table 3 about here

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A series of five statements (Statements 2d to 2h) explored attitudes about the accuracy of risk assessment in carcinogenicity studies in animals. A strong majority of toxicologists (85.5%) agreed that carcinogenicity studies in animals 'overestimate risks to humans because some

animal studies produce carcinogenic effects due to cytotoxic or other effects that occur only at high doses.' Over three-quarters (77.9%) also agreed that such studies 'overestimate risks to humans because human exposures are quite small compared to the levels of exposures to animals in these studies' (Statement 2f). However, the respondents were divided over whether risks to humans were overestimated 'due to the use of animals that are extremely sensitive (cancer prone)'; 49.7% agreed, 42.3% disagreed and 8.0% were undecided. Half (51.6%) of the toxicologists disagreed that animal studies underestimated risks to humans 'because there is greater genetic diversity in the human population than there is in laboratory animals' (Statement 2g); 15.1% were undecided. Respondents were divided about whether animal studies 'underestimate risks to humans due to synergistic effects among the many substances that humans are exposed to' (Statement 2h); 40.7% agreed, 38.5% disagreed, and 20.8% were undecided.

Three additional questions examined opinions about cancer risk-assessment models and epidemiological studies (Statements 2i to 2k). A strong majority (71.2%) indicated that risk-assessment models tend to overestimate risk when extrapolating laboratory data from high to low doses. Seventy percent also indicated that such models overestimate risks when extrapolating data from animals to humans. About 60% thought that epidemiological studies tended to overestimate cancer risks from chemicals. In general, toxicologists tended to believe that animal and epidemiological studies overestimate the risks that chemicals pose to humans.

Attitudes toward regulation of chemical hazards are indicated by responses to two statements in Category 3 (Table 4). Fairly strong confidence in the regulatory system is shown by 63.5% of respondents who agreed that 'Chemical risks are sufficiently regulated in this

country' (Statement 3a). However, less support for regulatory intervention into individual behaviors was shown by the tendency to agree (57.4%) with Statement 3b that the government has no right to regulate people's personal risk-taking.

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Insert Table 4 about here

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Statements 4a and 4b (Table 5) assessed the respondents' sensitivity to the relationship between dose or amount of exposure to a chemical and the degree of health risk. Whereas the public tends to equate any degree of exposure with harm,<sup>1</sup> toxicologists tend to view things quite differently; 90.7% of the toxicologists disagreed that exposure to a chemical that can cause cancer implies that the exposed person will probably get cancer some day (Statement 4a). A high proportion (63.4%) also disagreed with Statement 4b asserting that 'if a carcinogen were found in my tap water at levels below regulatory concern, I wouldn't drink the water.' Interestingly, 27.5% agreed with this statement.

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Insert Table 5 about here

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Views regarding threshold doses for genotoxic and nongenotoxic carcinogens were explored in Statements 4c and 4d (Table 5). About one-third (32.3%) of the toxicologists agreed that there was a threshold dose for genotoxic carcinogens, below which they do not induce neoplasms, whereas 76.0% agreed that there was a threshold dose for nongenotoxic carcinogens.

Four additional statements about cancer are grouped in Category 5 (Table 6). Most toxicologists (67.6%) share the view promoted by Ames<sup>8</sup> that fruits and vegetables contain natural substances that are carcinogenic (Statement 5a). Nearly three-quarters (73.7%) of the respondents also agreed that 'people worry more than necessary about getting cancer from



exposure to chemicals.’ Only one-third (32.4%) agreed with Statement 5c: ‘Even excluding lung cancer and taking age into account, there has been a trend toward more risk from cancer over the past several decades’; 45.8% disagreed, and 21.8% were undecided. About half of the toxicologists agreed that ‘children of fathers exposed to high doses of radiation are more likely to develop leukaemia’ (Statement 5d); however, a high number (34.6%) marked ‘don’t know/no opinion’ on this issue.

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Insert Table 6 about here

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The eight statements in Category 6 (Table 7) explored attitudes and opinions about local and national environmental health risks. A strong majority (87.5%) disagreed that there were serious environmental health problems where they lived (Statement 6a). There was also substantial disagreement that the air and water in Britain are more contaminated now than ever before (Statements 6b and 6c; 65.4% and 62.8% disagreement, respectively). A strong majority (86.6%) also disagreed that the quality of drinking water in the UK is unsatisfactory and poses a risk to health (Statement 6h). A moderate level of disagreement (54.8%) was indicated to Statement 6g, ‘Bathing beaches in the UK are so polluted that it is unsafe to swim in the sea.’

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Insert Table 7 about here

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Responses were more divided on the remaining three statements in Category 6 (Statements 6d, 6e, and 6f). In response to an assertion that the ‘fallout from the Chernobyl accident will increase the incidence of cancer among UK residents,’ 42.6% agreed, but 30.4% were undecided. Similarly, 41.3% agreed that ‘living near the nuclear reprocessing facility in Sellafield, Cumbria is likely to affect health adversely’; 38.1% disagreed and 20.5% were

undecided. In response to the statement 'municipal incinerators pollute the environment and cause adverse effects on the health of the local population,' 37.8% agreed, 35.0% disagreed, and 27.2% were undecided.

Category 7 (Table 8) includes five statements designed to assess the respondents' general attitudes about the objectivity of scientific inquiry and risk assessment. An overwhelming majority (91.0%) agreed with the view that 'when emotions influence scientific judgments, rationality suffers.' The strength of this opinion is demonstrated by the high number of strongly agree responses (42.9%). A strong majority (71.1%) also thought that when scientists deal with issues of high uncertainty, facts and values frequently merge (Statement 7c). However, 19.2% were undecided on this question. Nearly two-thirds (63.5%) agreed that 'risk is a subjective construct created through a mix of technical assumptions and personal and social values' (Statement 7e). When it came to risk assessment, the responses to Statement 7b indicated that most toxicologists (60.9%) thought it was an objective scientific process. However, 61.6% of the respondents agreed that risk assessment should be kept separate from risk management (Statement 7d).

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Insert Table 8 about here

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Three miscellaneous questions are contained in Category 8 (Table 9). A large majority (83.7%) disagreed with the assertion in Statement 8a that natural chemicals are less harmful than man-made chemicals, in contrast to the view forcefully proposed by Rachel Carson in Silent Spring. Three-quarters disagreed that people should be accept some risks to their health in order to strengthen the economy (Statement 8b). Most toxicologists (67.0%) agreed that 'experts are able to make reasonably accurate quantitative estimates of the health risks from chemicals in the

environment' (Statement 8c). The confidence expressed by responses to this statement stands in contrast to the equivocal response to inferences from animal studies, as expressed in responses to 2a, 2b, and 2c (see Table 3). The reason for this inconsistency is not understood.

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Insert Table 9 about here

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### **Worldviews**

Response distributions for questions pertaining to worldviews (also known as cultural biases or orienting positions) are shown as Category 9 in Table 10. A vast majority of respondents (82.1%) disagreed with the fatalistic view in Statement 9a to the effect that they had little control over risks to their health. Responses were mixed to the two statements reflecting adherence to hierarchical forms of social organization. In 9b, 57.1% agreed that decisions about health risks should be left to the experts. In 9c, 60.3% agreed that people in positions of authority tend to abuse their power. The individualistic statement that people with more ability should earn more (Statement 9d) was supported by 79.4% of the respondents. Egalitarianism, as expressed in Statement 9e, received mixed responses with 46.8% agreement and 39.4% disagreement that 'if people in this country were treated more equally, we would have fewer problems.' There was substantial agreement (73.1%) with the view that a high technological society is important for improving our health and social well being (Statement 9f). Thirty-nine percent agreed that when a risk is very small, it is okay for society to impose that risk on individuals without their consent (Statement 9g), and more than half (54.2%) agreed that continued economic growth is necessary to improve our quality of life (Statement 9h).

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Insert Table 10 about here

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### **Attitudes and opinions: Differences between men and women toxicologists**

Large gender differences were observed on several attitude and opinion items. Men were much more likely to agree that people worry more than necessary about getting cancer from exposure to chemicals and that when the risk is very small, it is OK for society to impose that risk on individuals without their consent (all differences in response frequency cited in this section were 10% or greater and were significant at  $p < .05$  or better). Women were more likely to agree that it can never be too expensive to reduce the risks associated with chemicals and that:

- Bathing beaches in the UK are so polluted that it is unsafe to swim in the sea
- Living near the nuclear reprocessing facility in Sellafield, Cumbria, is likely to affect health adversely
- There has been a trend toward more risk from cancer over the past several decades
- Municipal incinerators cause pollution and adverse effects on the health of local the population
- The children of fathers exposed to high doses of radiation are more likely to develop leukaemia

Women also tended to exhibit less sensitivity to dose and its relation to health risk, with more agreement that 'if a carcinogen were found in my tap water at levels below regulatory concern, I would not drink the water.' Men were more likely to agree that a threshold dose for both genotoxic and nongenotoxic carcinogens exists, below which they do not include neoplasms. Men also exhibited more agreement that a high technology society is important for improving our health and social well-being.

Men were more likely to agree that risk assessment should be kept separate from risk management. Men were also more likely to agree that how an animal reacts to a chemical is a reliable predictor of how a human would react to it; women, however, were more likely to agree that if a study produces evidence that a chemical causes cancer in animals, then it will cause cancer in humans. Men exhibited more trust that experts can make accurate estimates of the health risks from chemicals in the environment.

### **The risk-perception index**

A risk-perception index was created for each respondent by averaging his or her ratings across all 29 hazard items. For the purposes of averaging responses, "almost no risk" was coded as 1, "slight risk" as 2, "moderate risk" as 3, and "high risk" as 4. About 80% of these mean responses fell between 1.5 and 2.5. Only 2.9% of the respondents had a mean value greater than 3.0 (the 'moderate-risk' response). The median value was in the vicinity of the 'slight risk' category.

The risk-perception index was correlated with responses to the attitude, opinion, and worldview statements presented in tables 2 through 11. The correlation between the index and each statement is presented in parentheses after the statement in tables 2 through 11. The risk-perception index was significantly correlated with at least one statement from every category. In general, high correlations were found for items in Category 1 (Table 2; general opinions about health risks from chemicals), Category 5 (Table 6; other questions pertaining to cancer), and Category 6 (Table 7; local and national environmental health risks). Persons who had higher average ratings of risk across the 29 items tended to have generally negative attitudes toward chemicals, with less sensitivity to dose-response relationships, and with greater concern about the

environment. In Table 2, for example, the index correlated .42 with the view that 'our society has perceived only the tip of the iceberg with regard to the risks associated with chemicals' (Statement 1c). Toxicologists with higher average risk ratings tended to support the view that carcinogenicity studies in animals (Statements 2d through 2h) and cancer risk-assessment models (Statements 2i through 2k) tended to underestimate the risks to humans. They tended to disagree that chemical risks are sufficiently regulated (Statement 3a) and disagree that people worry more than necessary about getting cancer from exposure to chemicals (Statement 5b). They were also more likely to agree that natural chemicals are less harmful than man-made chemicals (Statement 8a) and to disagree that small risks should be imposed on people without their consent (Statement 9g).

### Technical evaluations

Another feature of this survey was the inclusion of two sets of technical evaluations for Chemical B and Compound E. The response distributions for questions about Chemical B are shown in Table 11. The percentage of respondents whose responses agreed with that of the majority of the National Toxicology Program panel ranged from 70.5% for female mice to 27.9% for male mice. Only eight persons (2.6%) matched the judgment of the NTP panel on all four studies. Except for female mice, there was considerable spread in the response distributions, reflecting differences of opinion among the respondents.

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Insert Table 11 about here

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There was considerable disagreement about whether animal studies of the type performed by the NTP will permit reliable judgments of the likelihood that the chemical is carcinogenic in humans; only 53.2% agreed and 40.7% disagreed. Despite these concerns, 64.7% rated Chemical

B as a probable or possible carcinogen in humans (Statement B7) and 46.8% agreed that 1 ppb of the chemical in indoor air would be acceptable (Statement B6).

Evaluations of Compound E are shown in Table 12. Most respondents (78.5%) judged its toxicity to be in the low to moderate range. Most respondents (67.3%) also disagreed that the presence of Compound E in rubber baby bottle nipples is acceptable.

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Insert Table 12 about here

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The risk-perception index described earlier was found to correlate significantly ( $r = -.13$ , item B6) with the acceptability of Chemical B in indoor air (those with higher risk ratings were less likely to judge Chemical B as acceptable); with the evaluation of Chemical B as a probable human carcinogen ( $r = -.14$ , item B7), and with the judgments of toxicity of Compound E ( $r = .14$ , item E1).

Each respondent was given a score (called the pattern index) based on his or her evaluations of the four studies with Chemical B (items B1 to B4). A response of clear evidence or some evidence was coded as 1; equivocal evidence as 2; and no or inadequate evidence as 3. These values were summed over the four responses. A low score on the index indicated a tendency to see strong evidence for carcinogenicity in each of the four studies. This index was correlated with the individual item ratings of risk for the 29 hazards and with the attitudes and opinions expressed in the rest of the survey. Respondents with a tendency to see strong evidence of carcinogenicity in the four studies were more likely to:

- see high risk to society from depletion of the ozone ( $r = -.13$ )
- agree that the way an animal reacts to a chemical is a reliable predictor of how a human would react to it ( $r = -.14$ )

- agree that a scientific study producing evidence that a chemical causes cancer in animals it would probably cause cancer in humans ( $r = -.12$ )
- disagree that risk is a subjective construct created through a mix of technical assumptions and personal and social values ( $r = .15$ )
- agree that animal studies of the type done with Chemical B will permit one to make reliable judgments of the likelihood that the chemical is carcinogenic in humans ( $r = -.28$ )
- disagree that Compound E is acceptable in rubber baby bottle nipples ( $r = -.13$ )
- have spent more years conducting experimental work ( $r = -.19$ )
- have worked frequently with animal test systems ( $r = -.16$ )

### Affiliation effects

Previous research<sup>1,5</sup> found that toxicologists in industry were somewhat less inclined than other toxicologists to agree that a study producing evidence that a chemical causes cancer in animals indicates that we can be reasonably sure that the chemical will cause cancer in humans. Kraus et al. found that only 22% of toxicologists working in industry endorsed this view, compared to 48.9% and 52.7% endorsement among academics and government employees. This tendency was replicated with item 2b in the present study, though the discrepancy was much smaller. Whereas 29.7% of those in industry endorsed this statement, 39.3% and 35.2% of the academics and government employees endorsed it. Unlike the study by Kraus et al., differences were also found in response to the general statement (2a) about animal testing ('The way that an animal reacts to a chemical is a reliable predictor of how a human would react to it'), with 51.7% of industry employees, 50.0% of government employees, and 36.9% of academics agreeing.



Thus there was not much difference in the responses of the academics to these two statements (2a and 2b), whereas government and industry employees indicated much greater agreement with the general statement about animal testing (2a) than where the study was said to have found evidence for cancer (2b).

Examination of the responses to the 29 hazards showed that academics tended to have the highest perceptions of risk for most of the items. In particular, academics gave more than 15% more responses in the moderate and high-risk categories than government employees for nuclear power reactors, nuclear waste, outdoor air pollution, and pesticides in food. In comparison to industry employees, academics gave more than 15% more moderate and high-risk responses for alcoholic beverages, prescription drugs, chemical pollution in the workplace, suntanning, nuclear power reactors, and nonprescription drugs. There were three items (prescription drugs, chemical pollution in the workplace, and suntanning) for which government employees gave more than 15% more moderate and high-risk responses than did private industry employees. There were no items for which the private industry respondents had 15% or more moderate and high-risk responses in comparison with other groups.

Although there were other attitude and opinion statements that were correlated with affiliation, these differences will not be addressed in detail in this report. For example, academics spent more time doing research than did toxicologists in government and industry. Academics also worked more with in vitro systems, and were less experienced in doing risk assessment and toxicological work. Those in industry had more experience in toxicological and testing types of work whereas those in government were more experienced in risk assessment and risk characterization. Women were more likely to work in academia, with females representing

38.1% of the academic respondents, 33.3% of the government employees, and 22.9% of the industry employees. In summary, affiliation effects exist, but sorting out the underlying causes from the wealth of confounding factors will take further research focused specifically on this topic.

### **Risk perceptions, attitudes, opinions, and worldviews: Comparisons with Canadian and European toxicologists**

Two similar surveys of toxicologists were conducted in 1993 using samples from the European Society of Toxicologists ( $N = 125$ ) and the Canadian Society of Toxicologists ( $N = 150$ ). Figures 3 and 4 compare the moderate and high-risk responses for the British toxicologists with the European and Canadian toxicologists across the risk items given in each survey.

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Insert Figures 3 and 4 about here

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In general, British toxicologists tended to have lower risk perceptions for most items. The major exception was asbestos; British toxicologists had 25% or more moderate or high-risk responses to this hazard than either the European or Canadian toxicologists. They also tended to have higher risk perceptions for cigarette smoking than the other two groups. In addition, the British exhibited higher risk perceptions for dioxins compared to the European toxicologists. (Dioxins was not included as a hazard on the Canadian survey.) Items for which the British toxicologists had over 15% fewer moderate or high-risk responses than the European respondents were ozone depletion, motor vehicle accidents, alcoholic beverages, chemical pollution in the environment, and outdoor air pollution. Items for which the British respondents gave fewer moderate and high-risk responses than the Canadians were ozone depletion, motor vehicle

accidents, suntanning, chemical pollution in the environment, alcoholic beverages, medical X-rays, and food additives.

There were 18 attitudinal questions on the 1993 Canadian study that were included in the present survey. The differences in percent agreement between the British and Canadian responses on these items are displayed in Figure 5. There were several large differences. The British toxicologists were much more likely to feel that the government had no right to regulate personal risk-taking activities with 32.0% more agree responses than the Canadian toxicologists. However, the British were more likely to be willing to leave decisions about health risks to the experts with 57.1% agreement compared to only 31.3% of the Canadian toxicologists; a 25.7% difference. The British were also more likely to believe that the experts are able to make reasonably accurate quantitative estimates of the health risks from chemicals in the environment (with 23.7% more agree responses than the Canadian respondents). In addition, other items for which the British toxicologists recorded over 10% more agreement were:

- People in positions of authority tend to abuse their power.
- Chemical risks are sufficiently regulated in this country.
- If people in this country were treated more equally, we would have fewer problems.

Items for which the Canadian toxicologists recorded over 10% more agree responses than the British were:

- The way that an animal reacts to a chemical is a reliable predictor of how a human would react to it.
- If a scientific study produces evidence that a chemical causes cancer in animals, then we can be reasonably sure that the chemical will cause cancer in humans.

- I try hard to avoid contact with chemicals and chemical products in my daily life.

There are serious environmental health problems were I live.

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Insert Figure 5 about here

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## Discussion

In general, the British toxicologists judged risks to be quite low for most chemical hazards—their perceived risk responses were, in general, even lower than those of Canadian and European toxicologists. Exceptions to this were cigarette smoking and asbestos, hazards that the British toxicologists rated extremely high on risk. In keeping with their ratings of chemical risks as small, British toxicologists had quite favorable attitudes toward the use of chemicals, had confidence in the regulation of chemicals, and did not feel concerned about air and water contamination in the nation or in their local environment.

As with previous studies of toxicologists in the U.S., Canada, and Europe, British toxicologists showed strong effects of gender in their evaluations. For almost every hazard studied, women's risk ratings were considerably higher than men's ratings. Moreover, women had consistently stronger anti-chemical attitudes.

Affiliation effects found in British toxicologists were also similar to the results of previous studies. Toxicologists working for industry were much more likely than others to disagree that a chemical inducing cancer in animals was likely to induce cancer in humans. Academic toxicologists were more likely than others to perceive chemical risks as high and to have unfavorable attitudes toward chemicals and their use.

Confidence in the ability to extrapolate from animal studies to human health effects was rather low. Toxicologists disagreed about the reliability of animal tests and tended to discount the importance of studies that found a chemical to induce cancer in animals. This discounting appears related to the belief that animal studies overestimate risks to humans because of cytotoxic effects associated with high doses given to animals. Despite these problems, however,

about two-thirds of the respondents believed that experts could make reasonably accurate quantitative estimates of health risks from chemicals in the environment.

When asked to evaluate technical summaries of various animal studies, there was considerable disagreement among the toxicologists and disagreement with the judgments of NTP panels. About 40% of the respondents disagreed that animal studies of this type permit reliable extrapolation to humans.

The present survey shows considerable similarity between British toxicologists and their colleagues in other countries. However, the large sample size in this survey permits more reliable analysis of factors such as gender and affiliation and such effects were found to be large and statistically significant. Further research will be necessary to determine their scientific and political importance.

Perhaps the most intriguing finding in this and previous surveys is the disagreement about the value of animal studies and the skepticism about the ability to extrapolate from a positive finding of carcinogenicity in animals to human health effects. The skepticism shown in these surveys is consistent with numerous articles in the recent literature discussing scientists' concerns about the validity of animal tests (see, for example, ref. 9). Previous studies have shown that the public interprets positive findings in animal studies as strong evidence that a chemical will be carcinogenic in humans. These survey results suggest that animal studies do a good job of frightening the public without providing evidence that scientists see as convincing. Animal studies may thus be a contributing factor to the public's high perceived risk for chemicals and general anti-chemical attitudes.

## **Acknowledgments**

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**Table 1. Information Presented for the Evaluation of Chemical B**  
 Summary of the Two-Year Inhalation and Genetic Toxicology Studies of Chemical B

Male F344/N Rats	Female F344/N Rats	Male B6C3F <sub>1</sub> Mice	Female B6C3F <sub>1</sub> Mice
<b>Exposure concentrations</b> 0, 100, 200, or 400 ppm Chemical B, 6 h/d, 5 d/wk	0, 100, 200, or 400 ppm Chemical B, 6 h/d, 5 d/wk	0, 100, 200, or 400 ppm Chemical B, 6 h/d, 5 d/wk	0, 100, 200, or 400 ppm Chemical B, 6 h/d, 5 d/wk
<b>Body weights</b> Exposed and control similar	Exposed and control generally similar	Exposed and control generally similar	400-ppm group lower than controls (6-16%)
<b>Survival rates</b> 17/49; 26/50; 27/50; 21/50	19/50; 29/50; 24/49; 23/50	35/50; 37/50; 30/50; 34/50	36/50; 37/50; 37/49; 23/49
<b>Nonneoplastic effects</b> Alveolar and nasal epithelial hyperplasia, suppurative inflammation of nasal cavity	Alveolar and nasal epithelial hyperplasia	None	Inflammation of the lung
<b>Neoplastic effects</b> Adrenal gland: pheochromocytomas (8/40; 23/45; 18/46; 21/46); brain: granular cell tumors <sup>a</sup> (0/49; 3/50; 1/50; 1/50); glial cell tumors (0/49, 3/50, 0/50, 0/50); lung: alveolar/bronchiolar adenomas or carcinomas (combined) <sup>b</sup> (0/48; 0/49; 4/48; 1/48)	Brain: gliomas <sup>c</sup> (0/50; 1/50; 1/48; 3/50); lung: alveolar/bronchiolar adenomas <sup>d</sup> (0/50; 0/48; 0/47; 3/49); mammary gland: neoplasms (18/50; 15/50; 10/48; 7/50)	Lung: alveolar/bronchiolar adenomas or carcinomas (combined) (7/50; 6/50; 12/50; 15/50)	Uterus: adenomas, adenocarcinomas, or squamous cell carcinomas (combined) (0/50; 4/50; 5/47; 27/48)
<b>Genetic toxicology</b>		<b>CHO Cells In Vitro</b>	
	<b>Salmonella (gene mutation)</b>	<b>SCE</b>	<b>Aberration</b>
	Positive with and without S9 in vapor assay	Positive with and without S9	Negative with and without S9

<sup>a</sup> historical control 0/297

<sup>b</sup> historical control 6/299

<sup>c</sup> historical control: untreated 23/1,969; chamber 1/297

<sup>d</sup> historical control 4/297

**Table 2. Responses to Attitude and Opinion Statements: Category 1**  
**General Opinions About Health Risks From Chemicals**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q61	1a.	In general, use of chemicals has improved our health more than it has harmed it (-.22)	0.3	2.6	55.1	38.1	3.8
Q48	1b.	I try hard to avoid contact with chemicals and chemical products in my daily life (.28)	26.6	52.2	15.1	3.5	2.6
Q45	1c.	Our society has perceived only the tip of the iceberg with regard to the risks associated with chemicals (.42)	4.5	55.1	26.6	6.7	7.1
Q47	1d.	It can never be too expensive to reduce the risks associated with chemicals (.30)	16.3	59.3	14.1	8.3	1.9

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 3. Responses to Attitude and Opinion Statements: Category 2**  
**Trust in the Use of Animal and Epidemiological Studies to Determine**  
**Human Health Risk**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q32	2a.	The way that an animal reacts to a chemical is a reliable predictor of how a human would react to it (-.12)	5.4	43.3	44.6	3.5	3.2
Q34	2b.	If a scientific study produces evidence that a chemical causes cancer in animals, then we can be reasonably sure the chemical will cause cancer in humans (.20)	12.5	50.6	32.7	2.2	1.9
Q35	2c.	Laboratory studies of a chemical's harmful effects on animals allow scientists to accurately determine how much of the chemical it takes to cause similar harm in humans (-.01)	10.9	58.0	26.0	3.8	1.3
		<b>In general, carcinogenicity studies in animals . . .</b>					
Q56	2d.	. . . overestimate risks to humans because some animal studies produce carcinogenic effects due to cytotoxic or other effects that occur only at high doses (-.16)	1.0	9.6	61.5	24.0	3.8
Q57	2e.	. . . overestimate risks to humans due to use of animals that are extremely sensitive (cancer prone) (-.07)	1.0	41.3	42.3	7.4	8.0
Q58	2f.	. . . overestimate risks to humans because human exposures are quite small compared to the levels of exposures to animals in these studies (-.10)	1.0	17.0	66.0	11.9	4.2
Q59	2g.	. . . underestimate risks to humans because there is greater genetic diversity in the human population than there is in laboratory animals (.23)	2.6	49.0	30.8	2.6	15.1
Q60	2h.	. . . underestimate risks to humans due to synergistic effects among the many substances that humans are exposed to (.37)	2.6	35.9	36.9	3.8	20.8

(Table 3 continues)

(Table 3, continued)

			Much overest	Overest	Neither overest nor underest	Underest	Much underest	Don't know/no opinion
Q67	2i.	Do cancer risk-assessment models tend to <b>overestimate or underestimate</b> risk when extrapolating laboratory data from high to low doses? (.27)	7.7	63.5	6.7	3.8	—	18.3
Q68	2j.	Do cancer risk-assessment models tend to <b>overestimate or underestimate</b> risk when extrapolating data from animals to humans? (.28)	6.7	63.5	9.9	2.6	—	17.3
Q69	2k.	Do epidemiological studies tend to <b>overestimate or underestimate</b> cancer risks from chemicals? (.15)	11.9	48.1	20.5	0.3	—	19.2

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 4. Responses to Attitude and Opinion Statements: Category 3**  
**Attitudes Toward Regulation**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q43	3a.	Chemical risks are sufficiently regulated in this country (-.29)	3.5	27.6	55.8	7.7	5.4
Q98	3b.	Government has no right to regulate people's personal risk-taking activities such as drinking alcohol, mountain climbing, etc. (.00)	3.2	37.2	44.9	12.5	2.2

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 5. Responses to Attitude and Opinion Statements: Category 4**  
**Relationship Between Level of Exposure and Health Risk**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q38	4a.	If a person is exposed to a chemical that can cause cancer then that person will probably get cancer some day (.19)	26.3	64.4	6.7	1.0	1.6
Q49	4b.	If a carcinogen were found in my tap water at levels below regulatory concern, I wouldn't drink the water (.27)	16.0	47.4	22.4	5.1	9.0
Q36	4c.	There is a threshold dose for <b>genotoxic</b> carcinogens, below which they do not induce neoplasms (-.09)	14.4	44.6	30.4	1.9	8.7
Q37	4d.	There is a threshold dose for <b>nongenotoxic</b> carcinogens, below which they do not induce neoplasms (-.20)	3.5	12.5	51.0	25.0	8.0

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 6. Responses to Attitude and Opinion Statements: Category 5**  
**Other Questions Pertaining to Cancer**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q31	5a.	Fruits and vegetables contain natural substances that can cause cancer (-.03)	5.1	19.9	58.0	9.6	7.4
Q65	5b.	People worry more than necessary about getting cancer from exposure to chemicals (-.37)	1.3	17.3	53.8	19.9	7.7
Q66	5c.	Even excluding lung cancer and taking age into account, there has been a trend toward <b>more</b> risk from cancer over the past several decades (.31)	3.5	42.3	29.8	2.6	21.8
Q52	5d.	The children of fathers exposed to high doses of radiation are more likely to develop leukaemia (.27)	2.2	12.8	46.2	4.2	34.6

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .



**Table 7. Responses to Attitude and Opinion Statements: Category 6**  
**Local and National Environmental Health Risks**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q30	6a.	There are serious environmental health problems where I live (.42)	32.7	54.8	7.7	2.9	1.9
Q63	6b.	In general, the air in our country is <b>more contaminated</b> now than ever before (.29)	12.8	52.6	21.8	5.8	7.1
Q64	6c.	In general, the water in our country is <b>more contaminated</b> now than ever before (.30)	13.1	49.7	20.8	4.2	12.2
Q50	6d.	Fallout from the Chernobyl accident will increase the incidence of cancer among UK residents (.21)	2.9	24.0	40.7	1.9	30.4
Q51	6e.	Living near the nuclear reprocessing facility in Sellafield, Cumbria is likely to affect health adversely (.41)	3.2	34.9	35.9	5.4	20.5
Q53	6f.	Municipal incinerators pollute the environment and cause adverse effects on the health of the local population (.51)	2.9	32.1	34.0	3.8	27.2
Q54	6g.	Bathing beaches in the UK are so polluted that it is unsafe to swim in the sea (.35)	6.1	48.7	33.0	4.5	7.7
Q55	6h.	The quality of drinking water in the UK is unsatisfactory and poses a risk to health (.30)	24.7	61.9	7.4	1.0	5.1

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 8. Responses to Attitude and Opinion Statements: Category 7**  
**General Opinions About the Objectivity of Scientific Inquiry**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q33	7a.	When emotions influence scientific judgments, rationality suffers (-.10)	0.6	7.4	48.1	42.9	1.0
Q40	7b.	Risk assessment for chemicals is not an objective scientific process (.07)	9.0	51.9	30.4	4.8	3.8
Q42	7c.	Facts and values frequently merge when scientists deal with issues of high uncertainty (-.06)	1.0	8.7	61.5	9.6	19.2
Q44	7d.	Risk assessment (e.g., the identification and quantification of risk) should be kept separate from risk management (-.15)	2.9	26.3	51.3	10.3	9.3
Q46	7e.	Risk is a subjective construct created through a mix of technical assumptions and personal and social values (.03)	2.2	28.2	54.2	9.3	6.1

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 9. Responses to Attitude and Opinion Statements: Category 8**  
**Miscellaneous Questions**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q62	8a.	In general, natural chemicals are less harmful than man-made chemicals (.17)	29.2	54.5	9.6	3.2	3.5
Q103	8b.	People should be prepared to accept some risks to their health in order to strengthen the economy (-.04)	11.9	62.8	19.2	0.3	5.8
Q41	8c.	Experts are able to make reasonably accurate quantitative estimates of the health risks from chemicals in the environment (-.08)	2.9	25.3	62.5	4.5	4.8

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 10. Responses to Attitude and Opinion Statements: Category 9  
Worldviews**

			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q102	9a.	I feel that I have very little control over risks to my health (Fatalism; .18)	7.7	74.4	14.4	1.6	1.9
Q39	9b.	Decisions about health risks should be left to the experts (Hierarchy; -.05)	4.2	35.9	43.3	13.8	2.9
Q96	9c.	People in positions of authority tend to abuse their power (Hierarchy; .27)	1.0	30.1	44.6	15.7	8.7
Q97	9d.	In a fair system, people with more ability should earn more (Individualism; .14)	0.6	14.7	66.3	13.1	5.1
Q99	9e.	If people in this country were treated more equally, we would have fewer problems (Egalitarianism; .12)	2.9	36.5	38.1	8.7	13.8
Q95	9f.	A high technology society is important for improving our health and social well-being (Technological Enthusiasm; -.12)	1.6	19.6	56.1	17.0	5.8
Q100	9g.	When a risk is very small, it is okay for society to impose that risk on individuals without their consent (-.13)	9.0	44.2	38.1	1.0	7.7
Q101	9h.	Continued economic growth is necessary to improve our quality of life (-.05)	1.6	34.0	48.1	6.1	10.3

Note. Cell entries are percentages. Values in parentheses are correlations between responses to the statement and the risk-perception index. Correlations greater than .11 are significant at  $p < .05$ . Correlations greater than .16 are significant at  $p < .01$ .

**Table 11. Evaluations of Chemical B**

Q: Based on the information in the abstract you have read, what would you conclude about the level of evidence of carcinogenic activity of Chemical B for:

			Clear evidence	Some evidence	Equivocal evidence	No evidence	Inadequate evidence	
Q78	B1:	Male rats	16.0	46.8*	21.8	8.0	7.4	
Q79	B2:	Female rats	13.1	31.1	32.1*	17.6	6.1	
Q80	B3:	Male mice	23.7	40.1	27.9*	3.5	4.8	
Q81	B4:	Female mice	70.5*	18.9	4.8	0.3	5.4	
<b>Note.</b> Cell entries are percentages. The classification assigned by the panel of the National Toxicology Program is marked with an * for items B1 to B4.								
				Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion
Q82	B5:	In general, animal studies of the type done with Chemical B will permit one to make reliable judgments of the likelihood that the chemical is carcinogenic in humans		2.9	37.8	52.2	1.0	6.1
Q83	B6:	Based on the data presented above, a concentration of 1 ppb of Chemical B in indoor air is acceptable		5.4	22.1	38.5	8.3	25.6
			A probable carcinogen in humans	A possible carcinogen in humans	Probably not carcinogenic in humans	Definitely not carcinogenic in humans	The data are not adequate to make this judgment	
Q8.	B7:	Chemical B is...	8.3	56.4	6.7	0.3	25.3	(no answer = 2.9)

**Table 12. Evaluations of Compound E**

			Very low	Low	Moderate	High	Very high	Don't know/ no opinion
Q92	E1:	The overall relative toxicity of Compound E is:	1.0	29.8	48.7	8.0	0.0	12.5
			Strongly disagree	Disagree	Agree	Strongly agree	Don't know/ no opinion	
Q94	E2:	The presence of Compound E in rubber baby bottle nipples is acceptable	15.7	51.6	14.4	2.6	15.7	

Note. Cell entries are percentages.

## Figure Captions

**Figure 1.** Health risks to the average exposed citizen of your country.

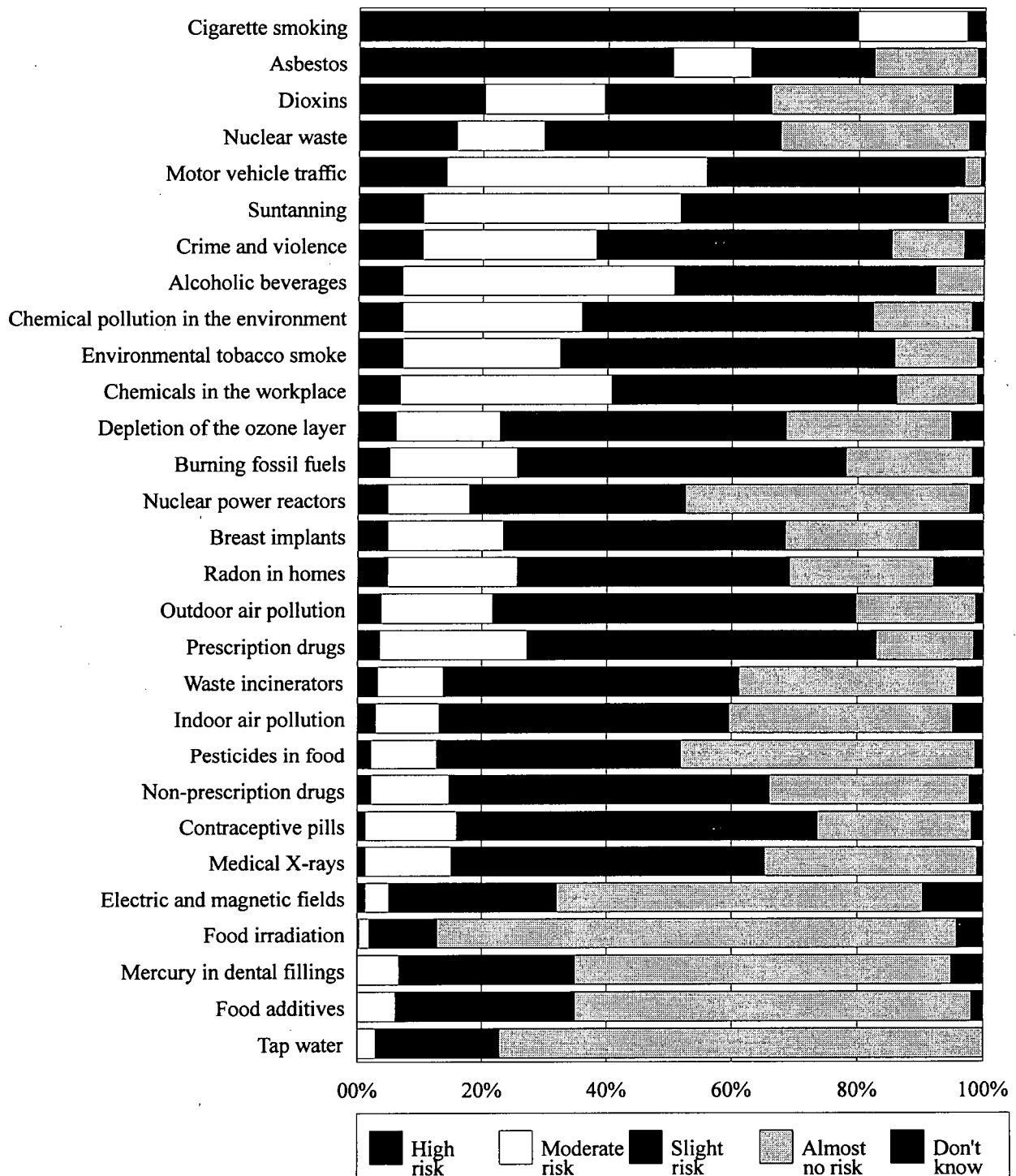
**Figure 2.** Health risk perceptions to average exposed citizen: Difference between males and females.

**Figure 3.** Health risk perceptions to average exposed citizen: Difference between British and European toxicologists.

**Figure 4.** Health risk perceptions to average exposed citizen: Difference between British and Canadian toxicologists.

**Figure 5.** Attitudes and opinions: Percent difference in agreement between British and Canadian toxicologists.

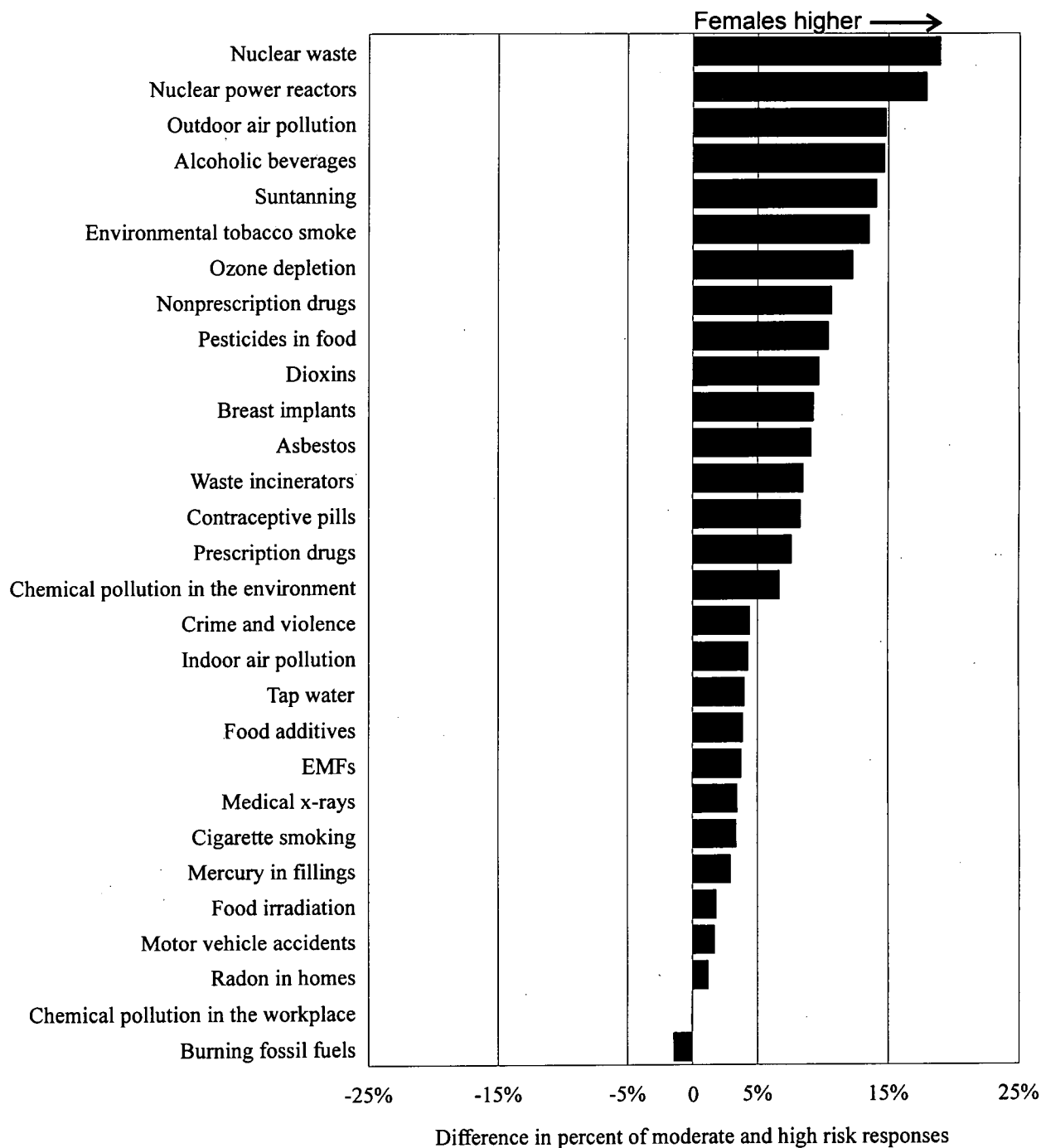
**Figure 1**  
**Health risks to the average exposed citizen of your country**





**Figure 2**  
**Health risk perceptions to average exposed citizen**

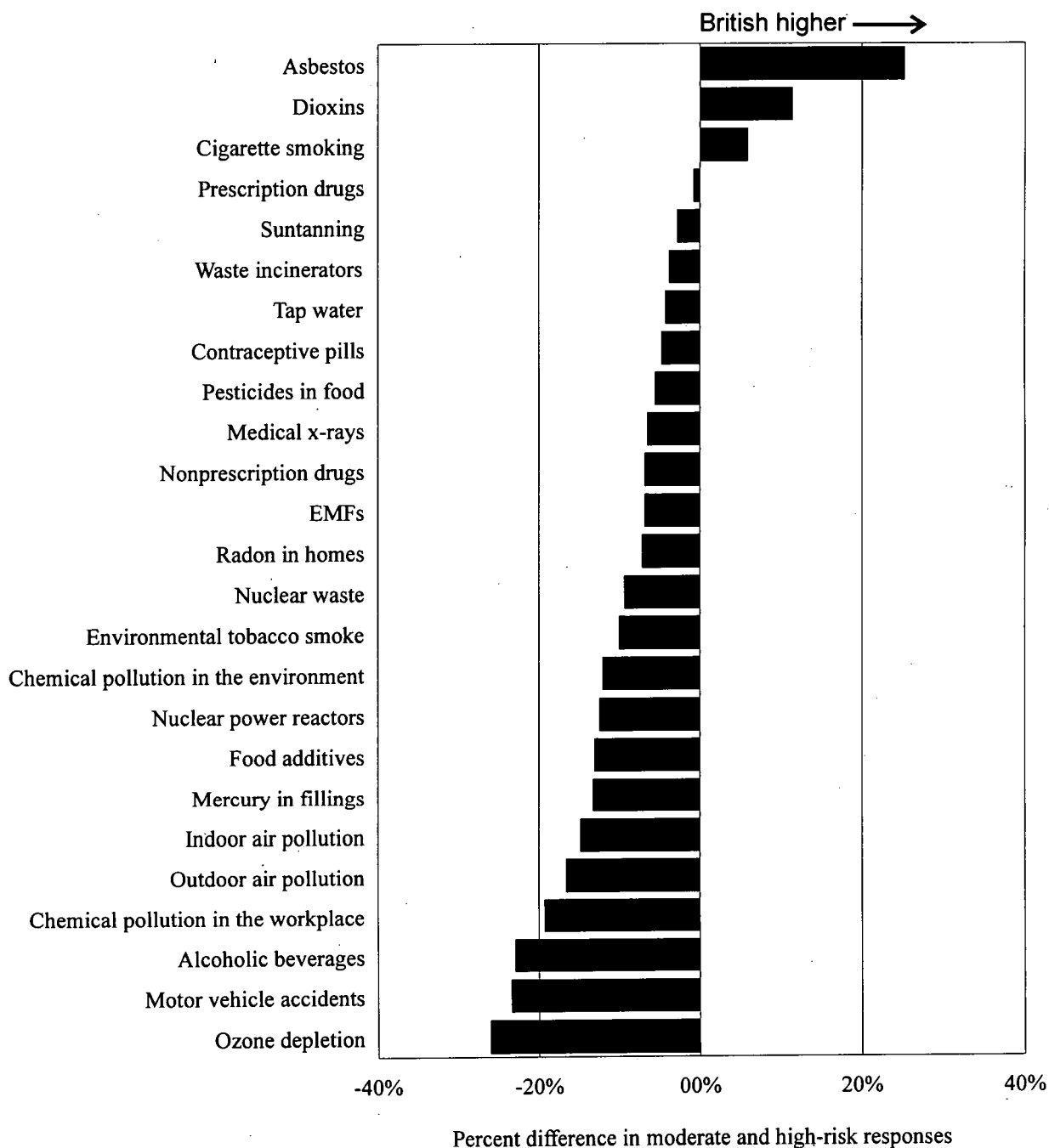
Difference between males and females



**Note:** Percent difference is percent female moderate and high risk responses minus percent male moderate and high risk responses.

**Figure 3**  
**Health risk perceptions to average exposed citizen**

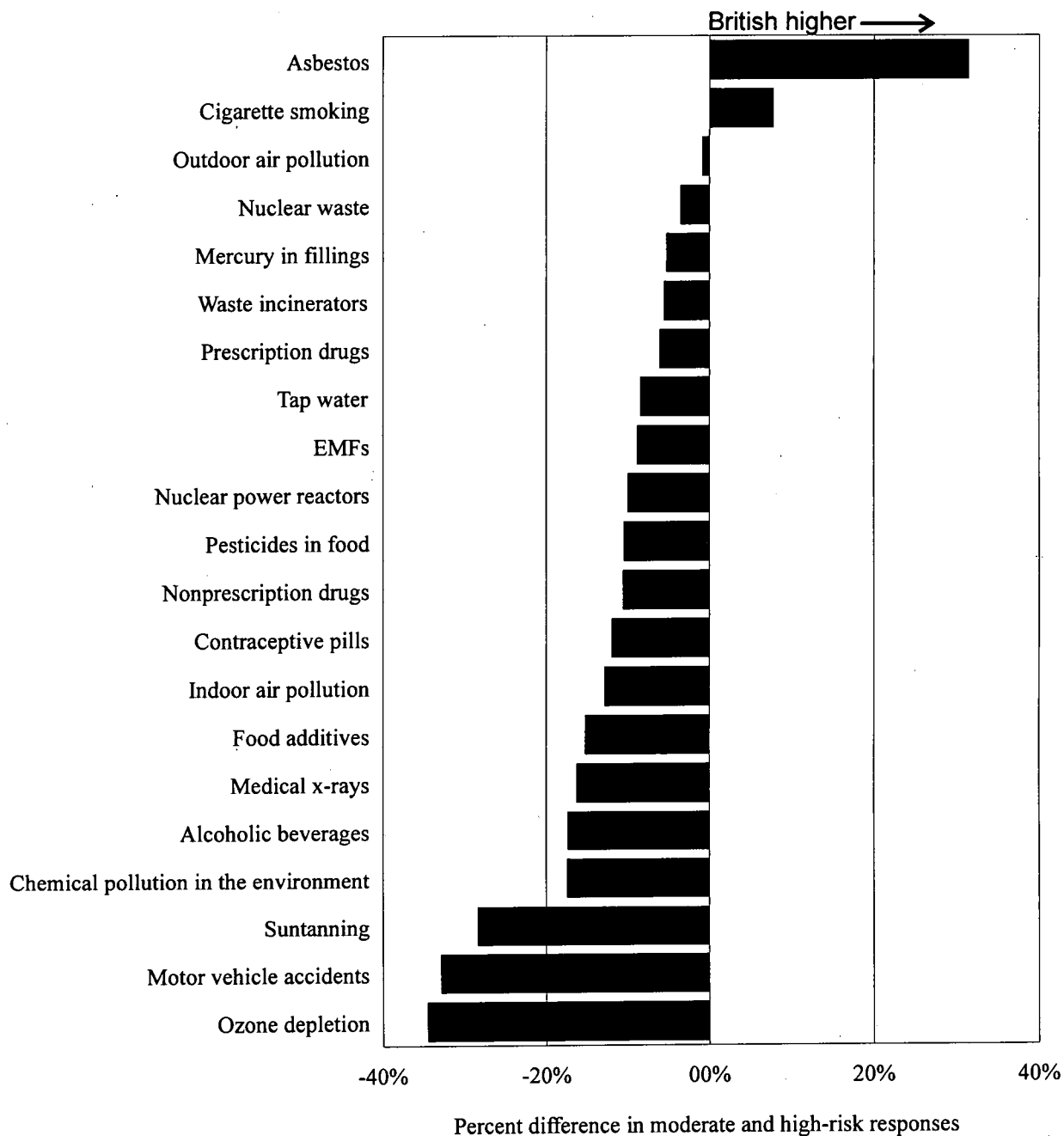
Difference between British and European toxicologists



**Note:** Percent difference is percent British toxicologists moderate and high-risk responses minus percent European toxicologists moderate and high-risk responses.

**Figure 4**  
**Health risk perceptions to average exposed citizen**

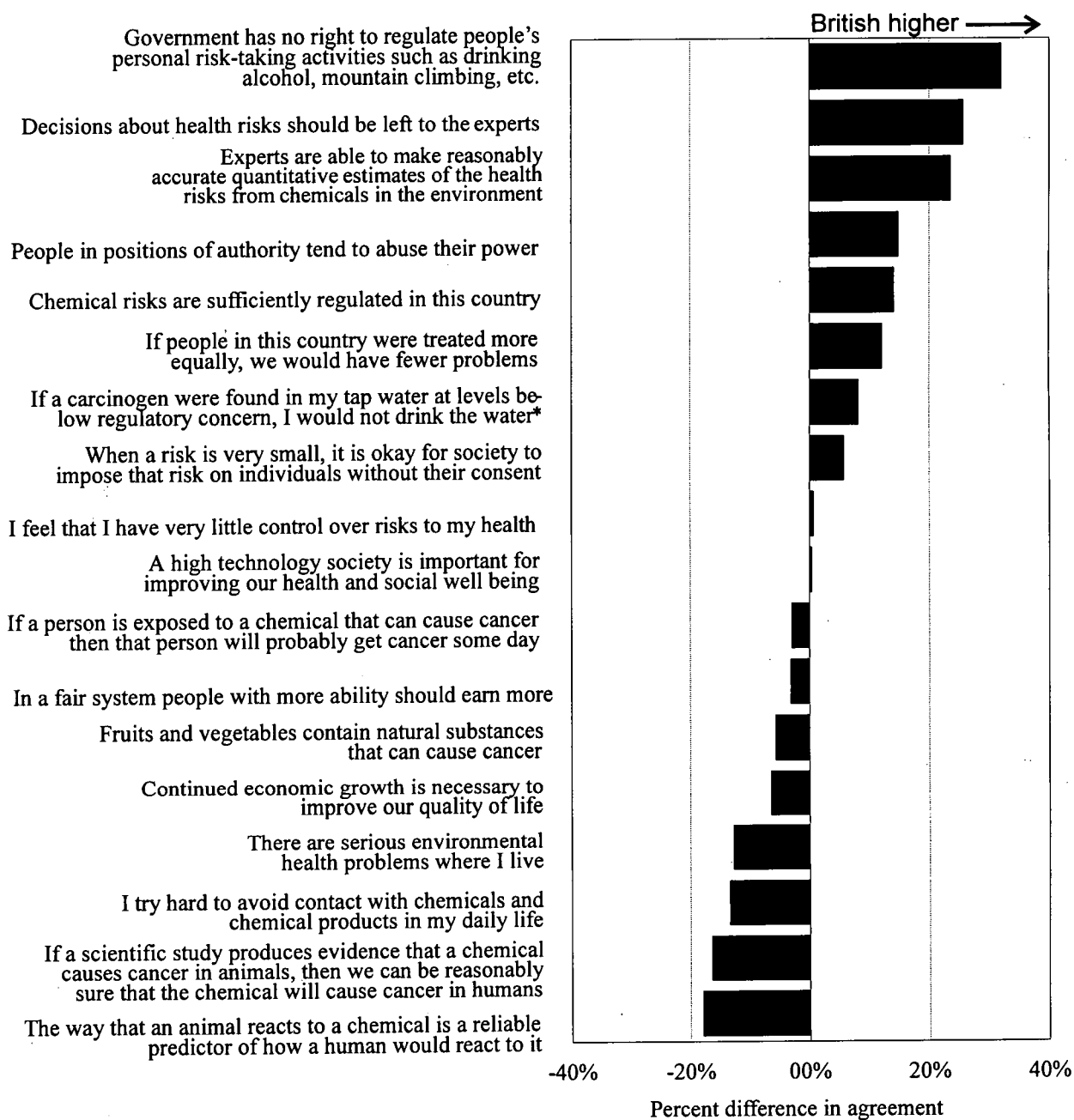
Difference between British and Canadian toxicologists



**Note:** Percent difference is percent British toxicologists moderate and high-risk responses minus percent Canadian toxicologists moderate and high-risk responses.

**Figure 5**  
**Attitudes and opinions**

Percent difference in agreement between British and Canadian toxicologists



\*This text is from the British survey. The Canadian version of this question differed slightly.

**Note:** Percent difference is percent of British toxicologists agree and strongly agree responses minus percent of Canadian toxicologists agree and strongly agree responses.