



Food and Nutrition Hazards Related to Public Health, Food Technology and Ecology: Perceptions of Experts and Non-experts in the United Kingdom

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Authors' contributions

This work was carried out in collaboration between both authors. Authors HB and AM designed the study. Author HB completed the data collection and data analysis. Author AM compiled the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2015/11161

Original Research Article

Received 29th April 2014
Accepted 24th February 2015
Published 17th April 2015

ABSTRACT

Aim: This study investigated perceptions of risk to self, risk to society, risk denial, control, responsibility, trust and knowledge of food and nutrition-related hazards among expert and non-expert groups with an aim of better understanding barriers to effective communication between experts and the public.

Design: Participants completed a questionnaire housed on an online platform.

Methodology: Experts were recruited from nutritionists in the food industry in the UK. Non-experts were recruited from a voluntary public panel with access to the online platform. Questions documented demographic variables and scores for the risk that food and nutrition-related hazards pose to self and society. Participants scored perceptions of expert and personal control of hazards, personal responsibility for averting the hazards, trust in experts for managing the hazards and personal knowledge of the hazards. The hazards were categorised for analysis into public nutrition, food technology and food ecology to reflect degrees of citizen participation in risk management.

Results: Experts scored perception of risk to self and risk to society from food technology hazards significantly lower than non-experts. Both groups had greatest risk denial, scores of personal control, personal responsibility and personal knowledge, and lowest scores for expert control, for public nutrition hazards. Trust in experts was higher among experts than it was among non-experts. Gender, personal responsibility and knowledge, but not trust in experts, were significant predictors of risk perception.

Conclusions: There were similarities in perception of risk of public nutrition and food ecology

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hazards between experts and non-experts, but differences in the perception of risk and trust in experts relating to food technology. Both groups perceived higher personal control of and personal responsibility for, and lower expert control for, public nutrition hazards.

Keywords: Public health nutrition; food technology; food ecology; risk perception; expert; non-expert.

1. INTRODUCTION

Effective communication in public health relies on a lateral appreciation of risk perception between the 'expert' and 'non-expert'. Early studies in the field of risk perception focused on hazardous environmental activities and novel technologies, in nuclear power and commercial transport for example [1]. Comment and study on risk perception relating to food and nutrition hazards have emerged in recent times in reaction to high-profile, acute food safety events including the BSE crisis in the UK, dioxins in animal feed in Belgium, bacterial contamination of infant formula in France and polychlorinated biphenyls in Scottish salmon [2].

Despite efforts in communication and mitigation of food and nutrition hazards, many such concerns in the United Kingdom (UK) remain chronic and persistent. The Health Survey for England in 1991 reported 53% of men and 44% of women were overweight or obese; data published two decades later, in 2011, shows 65% of men and 58% of women were overweight or obese. Similarly, prevalence of overweight and obesity among boys and girls aged 2 to 15 years has increased from 24% and 26%, respectively, in 1995 to 31% and 28%, respectively, in 2011 [3]. Recent National Diet and Nutrition Survey data shows total fat intake is 34-36% food energy among adults and children, which was similar to previous studies, although saturated fat intakes ranged from 13 to 15% food energy, which was lower to previous surveys, but still above the dietary reference value [4]. Trends in alcohol consumption in the UK show increases among women, middle and older age groups and very young adolescents [5]. Data from 2009 indicates that 37% of men and 29% of women in the UK were reported to consume greater the recommended limit of alcohol per day, with 20% of men and 13% of women exceeding twice the recommended limit [6].

As well as these persistent challenges in public health, The Giessen Declaration identifies additional areas of concern for food and nutrition experts to address in the 21st century [7]. Food waste, the carbon footprint of the food supply

and depletion of natural reserves are of present concern in public nutrition [8,9], although there has been some positive changes reported in recent years. Food wastage in the UK is reported to have fallen from 8.3 million tonnes to 7.2 million tonnes per year between 2006/7 and 2010 [10]. Indications that stocks of exploited fish in the EU have improved have recently been reported [11]. The complexity of food supply in the EU was drawn into sharp focus following the European investigation into authenticity of beef products; it is proposed that genetic technologies may be used more widely in the future to authenticate the origin of food ingredients [12]. Other developments in the use of genetic technologies for food and nutrition include harnessing it to address food shortage. The planet's population is expected to increase by 2 to 4 billion people over the next 3 to 4 decades, and food shortages are compounded by slowed development of arable land, energy costs, climate change and economic depression [13]. By 2008, 10% of cropland globally was planted with genetically modified crops, and 90% of the 13 million producers engaged were small-holder, resource poor farmers [13]. Genetic technology is seen by many as a viable approach to improving food security, particularly in developing countries [14], although dialogue in the public relating to genetic technologies remains contentious [15-17].

Food and nutrition experts must effectively communicate about persistent public health concerns, but also for moving forward with strategies for addressing global issues on climate change and food supply. Reconciling the perception of risk that hazards pose between experts and the public they communicate to is, therefore, of importance. It is reported that technical, quantitative and objective risk measurement is taken as the key informant of risk perception among experts [18]; non-experts incorporate broader issues including dread, catastrophic potential, controllability, equity and risk to future generations [19], as well as ethics [15] in their perception of risk. The expert-lay discrepancy in the perception of risk has been established in a variety of fields, including toxicology, biotechnology [20,21] and nutrition

[22,23], and may impact risk communication between expert and non-expert. This survey hopes to inform the communication of nutrition and health messages between experts and the public. As a reconciled perception of risk is key to effective communication, the main aim of this survey is to investigate the perception of risk to self and society of food and nutrition hazards among expert and non-expert groups. Perceptions of control, responsibility trust and knowledge of the food and nutrition related hazards were also investigated, as these can offer insights into what influences how risk is perceived.

2. METHODOLOGY

The survey was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Biomedical Sciences, Dentistry, Medicine, Natural and Mathematical Sciences Research Ethics Sub-Committee of King's College London (BDM/11/12-18).

A questionnaire investigating perceptions of risk to self and society, control, trust in experts, responsibility for and knowledge of nine food and nutrition related hazards was developed in line with those used in previous studies [21,22]. Hazards were chosen subjectively by the researchers to reflect Arnstein's three levels on the citizen 'ladder of participation' [24]: degrees of citizen participation (obesity, alcohol consumption, high fat diet), tokenism (carbon footprint of food supply, depletion of fish stocks, food shortage) and non-participation (salt in manufactured foods, genetically modified food, *E. coli* contamination of food) in their mitigation. The hazards were subsequently categorised for analysis as relating to 'public nutrition' (obesity, alcohol, high fat diet), 'food technology' (genetically modified food, salt in manufactured food, *E. coli* contamination) and 'food ecology' (food shortage, carbon footprint from food supply and fish stock depletion). The hazards were randomly presented, and not categorised, on the questionnaire. Participants were asked to score on a scale from 1 to 10 (low to high) their perceptions of risk, control, trust in experts, responsibility for and knowledge of each food and nutrition related hazard. Scores for perceived risk to self and risk to society were used determine risk denial. Questions on demography were administered. The questionnaire was housed on an online

survey platform (SurveyShack, <http://live.surveystack.com/>).

Experts were recruited from the Nutritionists in Industry (NII) group representing nutritionists working in the food industry in the United Kingdom. There are 100 members of this group. The response rate was 20%. A non-expert population was recruited from panellists pre-recruited to the online survey platform. There were no inclusion criteria for participant through SurveyShack. A small fee was paid to SurveyShack for the survey to be opened and promoted on the platform until 200 responses were retrieved. This response rate was achieved in under one week. Both the NII and SurveyShack distributed information sheets including the link to the online survey to their members by email.

Data was analysed using SPSS 20.0. Categorical data defining the subject characteristics of the expert and non-expert group was analysed by Chi-squared test. Scores of perception of risk, control, personal responsibility, trust in experts and knowledge of hazards and categorised hazards were compared between the expert and non-expert groups using Mann-Whitney U tests. Variance in scores for categorised hazards within expert and non-expert groups was compared using Friedman's two way analysis of variance by rank. Linear regression was used to investigate potential predictors of risk perception. Data is presented as median and 95% confidence interval (CI) of the median. A *P* value of ≤ 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

The characteristics of the expert and non-expert groups are presented (Table 1). Twenty experts and 200 non-experts responded to the survey.

3.1 Expert and Non-expert Perceived Risk to Self and Risk to Society

Expert and non-expert scores of perceived risk to self and risk to society for each hazard are presented (Table 2). The expert group scores of perceived risk to self and risk to society of genetically modified foods ($P=0.008$ and $P=0.000$, respectively) and salt in manufactured foods ($P=0.006$ and $P=0.023$, respectively) were significantly lower than non-expert scores. The expert group score of perceived risk to self from fish stock depletion was significantly higher than

the non-expert score ($P=0.012$). For all other hazards, there were no significant differences between expert and non-expert scores of perceived risk to self and risk to society.

Expert and non-expert scores of perceived risk to self and risk to society of categorised hazards (ie: public nutrition, food technology and food ecology) are presented (Fig. 1). As indicated in Table 2, the expert group scored perceived risk to self and risk to society of food technology hazards significantly lower than non-experts ($P=0.024$ and $P=0.014$, Fig. 1a and Fig. 1b respectively). Experts did not attribute significantly different scores for perceived risk to self from public nutrition, food technology and food ecology hazards. Non-experts attributed decreasing scores of perceived risk to self from public nutrition, food technology and food ecology hazards ($P=0.000$; Fig. 1a). Experts and

non-experts attributed significantly higher scores of perceived risk to society from public nutrition hazards than food technology or food ecology ($P=0.000$ for both; Fig. 1b).

3.2 Expert and Non-expert Risk Denial

Expert and non-expert risk denial, calculated as the difference between scores of perceived risk to self and perceived risk to society, is presented (Fig. 2). The expert group had significantly greater risk denial regarding obesity and food shortage than the non-expert group ($P=0.016$ and $P=0.015$, respectively) and significantly lower risk denial regarding genetically modified foods than the non-expert group ($P=0.027$; Fig. 2a). Both expert and non-expert risk had significantly greater risk denial for public nutrition hazards than for food technology and food ecology hazards ($P=0.000$ for both; Fig. 2b).

Table 1. Subject characteristics (column %) of expert and non-expert groups

Variable	Expert (n 20)	Non-expert (n 200)	P
Gender			0.001
Male	0	36.0	
Female	100.0	64.0	
Ethnicity			NSD
White	95.0	90.5	
Mixed	0	1.5	
Asian or Asian British	5.0	4.5	
Black or Black British	0	1.0	
Chinese or other ethnicity	0	2.5	
Age			NSD
18-24 years	0	4.0	
25-34 years	45.0	23.0	
35-44 years	25.0	26.0	
45-54 years	25.0	23.5	
55+ years	0	23.5	
Unanswered	5.0	0	
Education			0.000
No formal/primary/secondary	0	58.5	
Third level	95.0	41.5	
Unanswered	5.0	0	
Employment			0.000
Manual/skilled labour	0	10.0	
Non-science/non-health/admin/business	26.3	44.0	
Science/healthcare	73.7	9.0	
Student/unemployed	0	37.0	

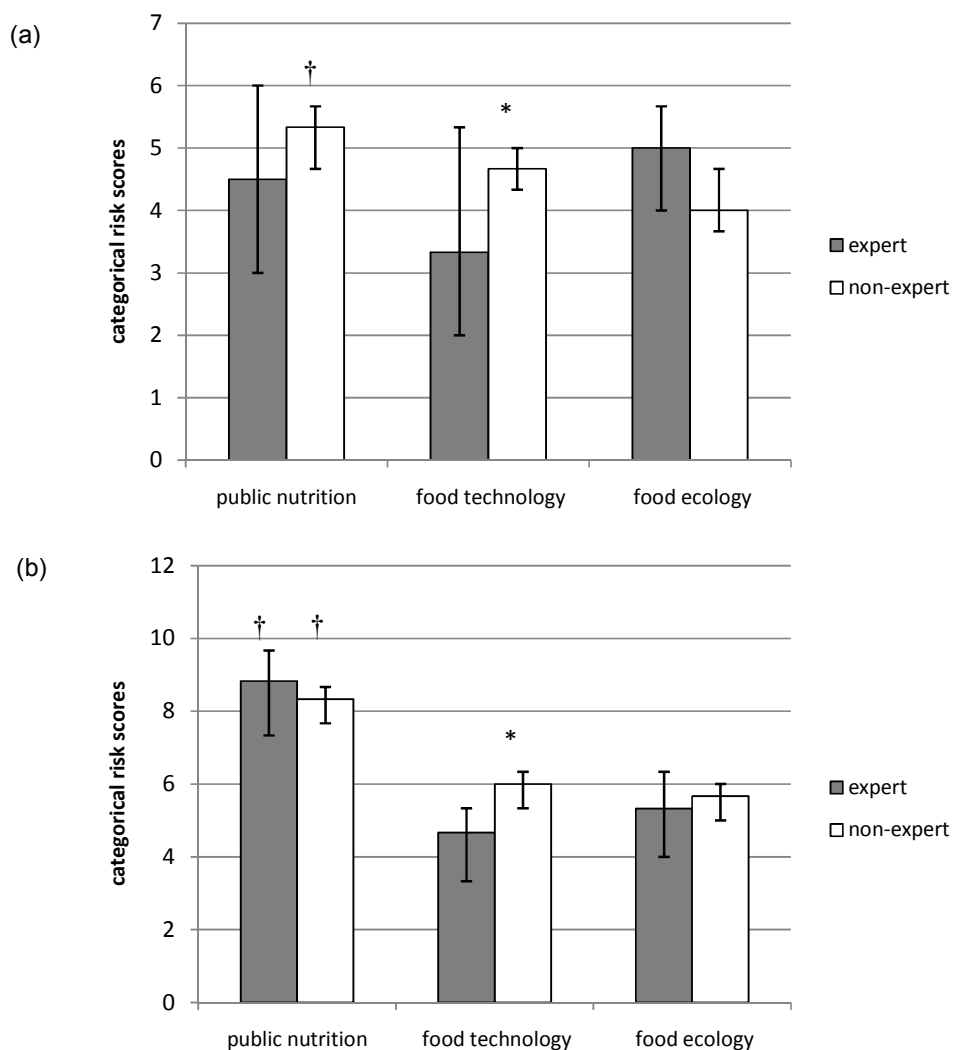


Fig. 1. Categorical risk scores of food and nutrition related hazards to (a) self and (b) society among expert and non-expert groups; Data represents median and 95% CI median; * $P < 0.05$ within category between expert and non-expert groups; † $P < 0.05$ across categories within expert or non-expert group

3.3 Personal and Expert Control

Expert and non-expert perceptions of personal and expert control of each food and nutrition related hazard (Table 3) and categorised hazards (Fig. 3) were investigated. The expert group scores of personal control of obesity and high fat diet were significantly higher than non-expert scores ($P=0.014$ and $P=0.002$, respectively). For all other hazards there were no significant differences between scores of personal control and expert control between expert and non-expert groups. Experts attributed significantly higher scores for personal control of

public nutrition hazards than non-experts ($P=0.024$; Fig. 3a). Both expert and non-expert risk had significantly higher scores for personal control of public nutrition hazards than for food technology and food ecology hazards ($P=0.000$ for both; Fig. 3a). There were no differences between scores attributed by experts and non-experts to expert control of each category of hazard, but both expert and non-expert groups scored expert control of public nutrition hazards significantly lower than food technology and food ecology ($P=0.002$ and $P=0.000$, respectively; Fig. 3b).

Table 2. Risk scores of food and nutrition related hazards to self and to society among expert and non-expert groups; data represents median and 95% CI median

	Risk to self				P	Risk to society				P
	Expert		Non-expert			Expert		Non-expert		
	Median	95% CI	Median	95% CI		Median	95% CI	Median	95% CI	
Public Health										
Obesity	3.5	2.0-7.0	6.0	5.0-6.0	NSD	9.0	8.0-10.0	9.0	8.0-9.0	NSD
Alcohol	4.5	2.0-5.0	4.0	3.0-5.0	NSD	9.0	7.0-10.0	8.0	8.0-8.0	NSD
High fat diet	6.0	2.0-8.0	6.0	6.0-7.0	NSD	8.5	8.0-9.0	8.0	8.0-9.0	NSD
Food technology										
Genetically modified food	2.0	1.0-3.0	4.0	3.0-5.0	0.008	2.0	1.0-3.0	5.0	5.0-6.0	0.000
Salt in manufactured food	4.5	2.0-5.0	6.0	6.0-7.0	0.006	5.0	3.0-7.0	7.0	7.0-8.0	0.023
<i>E. coli</i> contamination	5.0	3.0-5.0	5.0	4.0-5.0	NSD	6.5	5.0-7.0	6.0	5.0-6.0	NSD
Food ecology										
Food shortage	2.5	1.0-4.0	3.0	2.0-4.0	NSD	4.0	3.0-7.0	5.0	3.0-5.0	NSD
Carbon footprint of food supply	4.5	3.0-6.0	4.0	3.0-5.0	NSD	3.0	2.0-6.0	6.0	6.0-6.0	NSD
Fish stock depletion	7.5	5.0-8.0	5.0	4.0-6.0	0.012	7.0	6.0-9.0	6.0	6.0-7.0	NSD

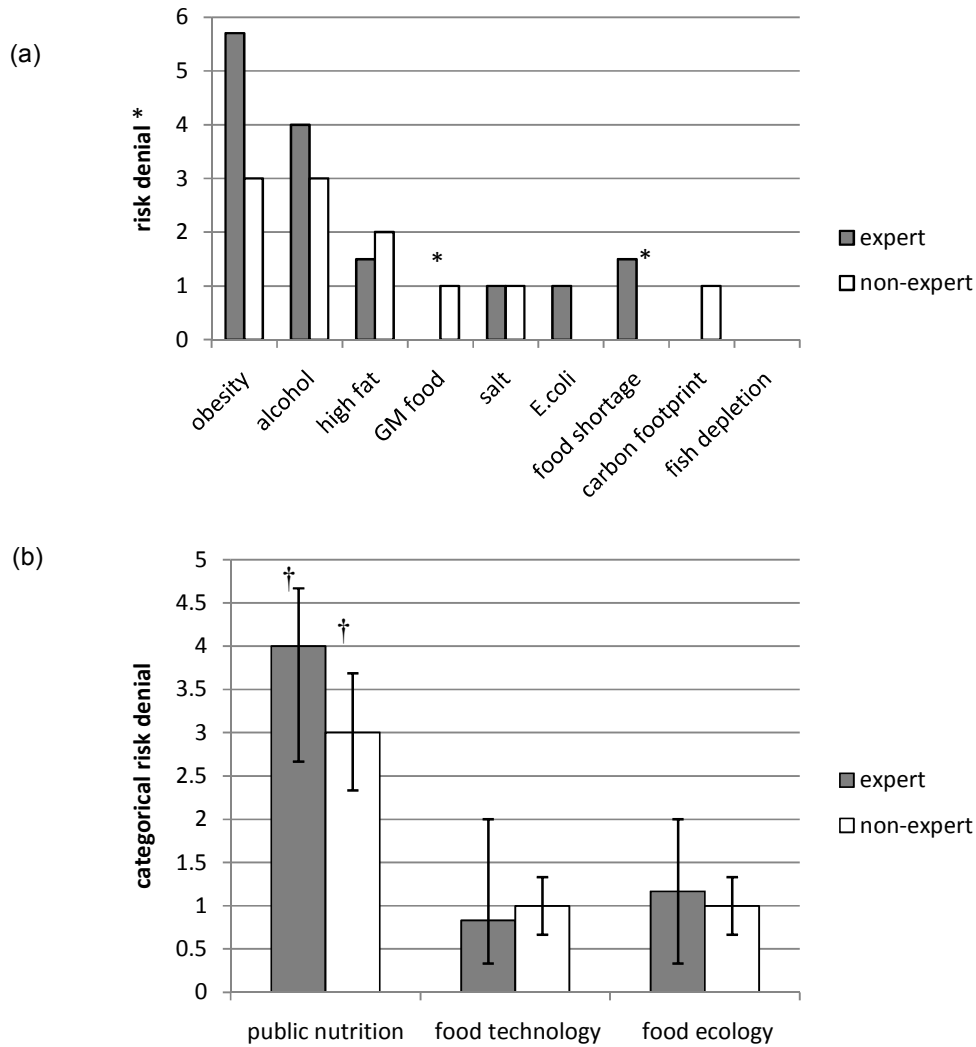


Fig. 2. Risk denial among expert and non-expert groups for (a) food and nutrition related hazard and (b) categorical hazards. Data represents median values in Fig. 2a and median and 95% CI of median in Fig. 2b. * $p < 0.05$ between expert and non-expert groups; † $p < 0.05$ across categories within expert or non-expert group

3.4 Personal Responsibility, Trust in Experts and Personal Knowledge

Expert and non-expert perceptions of personal responsibility for each food and nutrition related hazard (Table 4) and category of hazard (data not shown) were investigated. Experts had a significantly lower personal responsibility score than non-experts for carbon footprint of food ($P=0.014$). For all other hazards there were no significant differences between expert and non-expert scores of personal responsibility. There were no significant differences in scores of personal responsibility for categorised hazards

between expert and non-expert groups. Both expert and non-expert groups attributed scores in descending order for personal responsibility of public nutrition, food technology and food ecology hazards ($P=0.000$, for both; data not shown).

Expert and non-expert perceptions of trust in experts for each food and nutrition related hazard (Table 4) and category of hazard (data not shown) were investigated. Experts had a significantly higher trust in expert score than non-experts for high fat diet and salt in manufactured food ($P=0.039$ and $P=0.001$). For all other

hazards there were no significant differences between expert and non-expert scores of trust in experts. Experts attributed significantly higher scores for trust in experts for food technology hazards than non-experts ($P=0.034$; data not shown). For all other comparisons there were no significant differences in scores for trust in experts attributed by experts and non-experts.

Expert and non-expert personal knowledge for each food and nutrition related hazard (Table 4) and category of hazard (data not shown) were investigated. Experts reported significantly higher personal knowledge than non-experts for high fat diet ($P=0.001$), genetic modification

($P=0.034$) and salt in manufactured foods ($P=0.000$; Table 4). For all other hazards there were no significant differences between expert and non-expert reported personal knowledge. Experts attributed significantly higher scores for personal knowledge for public nutrition and food technology hazards than non-experts ($P=0.013$ and $P=0.026$, respectively; data not shown), and there were no significant difference between the experts and non-experts for personal knowledge of food ecology hazards. Both expert and non-expert groups attributed scores in descending order for personal knowledge of public nutrition, food technology and food ecology hazards ($P=0.000$ for both; data not shown).

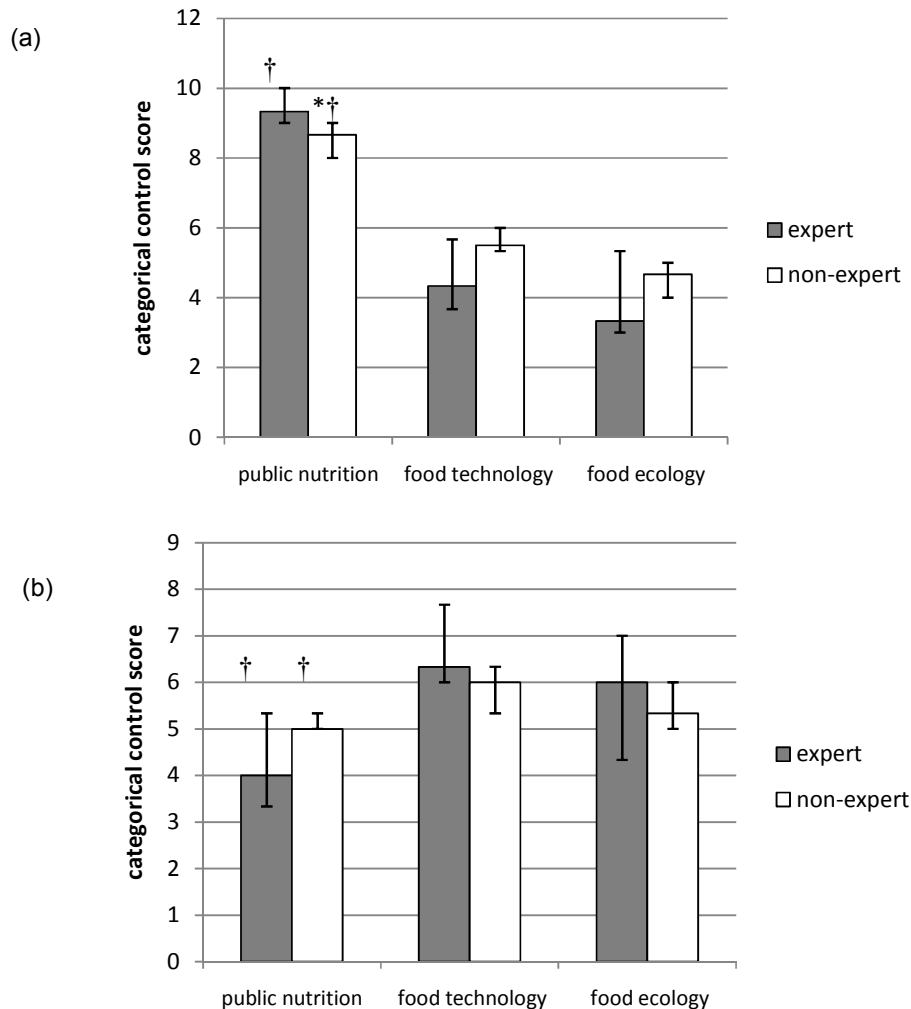


Fig. 3. Categorical scores of control food and nutrition related hazards by(a) the person and (b) experts among expert and non-expert groups; Data represents median and 95% CI of median; * $p<0.05$ within category between expert and non-expert groups; † $p<0.05$ across categories within expert or non-expert group

Table 3. Personal control and expert control scores of food and nutrition related hazards to self and to society among expert and non-expert groups; data represents median and 95% CI median

	Personal control				P	Expert control				P	
	Expert		Non-expert			Expert		Non-expert			
	Median	95% CI	Median	95% CI		Median	95% CI	Median	95% CI		
Public Health											
Obesity	9.0	9.0-10.0	9.0	8.0-9.0	0.014	5.0	4.0-6.0	5.0	5.0-5.0	NSD	
Alcohol	9.0	7.0-10.0	10.0	9.0-10.0	NSD	5.0	2.0-6.0	5.0	5.0-5.0	NSD	
High fat diet	10.0	7.0-10.0	9.0	8.0-9.0	0.002	4.5	3.0-5.0	5.0	5.0-6.0	NSD	
Food technology											
Genetically modified food	3.0	3.0-5.0	5.0	5.0-6.0	NSD	6.0	5.0-8.0	6.0	5.0-7.0	NSD	
Salt in manufactured food	6.0	4.0-7.0	6.0	6.0-7.0	NSD	7.0	6.0-8.0	6.0	5.0-7.0	NSD	
<i>E. coli</i> contamination	5.0	3.0-5.0	6.0	5.0-6.0	NSD	7.0	6.0-8.0	6.0	5.0-6.0	NSD	
Food ecology											
Food shortage	5.0	2.0-6.0	5.0	4.0-5.0	NSD	6.0	5.0-7.0	5.0	5.0-6.0	NSD	
Carbon footprint of food supply	3.0	2.0-6.0	5.0	5.0-6.0	NSD	6.0	5.0-8.0	5.0	5.0-6.0	NSD	
Fish stock depletion	2.0	2.0-5.0	4.0	3.0-5.0	NSD	6.0	5.0-8.0	6.0	5.0-6.0	NSD	

Table 4. Personal responsibility, trust in experts and personal knowledge of food and nutrition related hazards among expert and non-expert groups

	Personal responsibility				P	Trust in experts				P	Personal knowledge				P
	Expert		Non-expert			Expert		Non-expert			Expert		Non-expert		
	Median	95% CI	Median	95% CI		Median	95% CI	Median	95% CI		Median	95% CI	Median	95% CI	
Public health															
Obesity	8.0	7.0-9.0	9.0	8.0-9.0	NSD	6.0	3.0-8.0	5.0	4.0-5.0	NSD	9.0	8.0-9.0	8.0	8.0-8.0	NSD
Alcohol	9.0	9.0-9.0	9.0	9.0-9.0	NSD	5.0	3.0-8.0	5.0	4.0-5.0	NSD	8.0	8.0-9.0	8.0	8.0-8.0	NSD
High fat diet	8.0	7.0-9.0	8.0	8.0-9.0	NSD	6.0	4.0-7.0	5.0	4.0-5.0	0.039	9.0	9.0-10.0	8.0	7.0-8.0	0.001
Food technology															
Genetically modified food	4.0	1.0-7.0	5.0	4.0-5.0	NSD	6.0	4.0-8.0	5.0	5.0-5.0	NSD	7.0	5.0-7.0	5.0	5.0-6.0	0.034
Salt in manufactured food	6.5	5.0-7.0	6.0	5.0-7.0	NSD	7.0	6.0-8.0	5.0	4.0-5.0	0.001	9.0	9.0-9.0	6.5	6.0-7.0	0.000
<i>E. coli</i> contamination	4.0	2.0-5.0	5.0	4.0-5.0	NSD	6.0	4.0-7.0	5.0	5.0-5.0	NSD	5.0	4.0-6.0	5.0	5.0-6.0	NSD
Food ecology															
Food shortage	2.0	1.0-4.0	3.0	2.0-4.0	NSD	6.0	4.0-7.0	5.0	5.0-5.0	NSD	5.0	4.0-6.0	5.0	4.0-5.0	NSD
Carbon footprint of food supply	2.0	2.0-4.0	5.0	4.0-5.0	0.014	6.0	4.0-7.0	5.0	4.0-5.0	NSD	5.0	4.0-6.0	5.0	5.0-5.0	NSD
Fish stock depletion	3.0	1.0-5.0	4.0	3.0-5.0	NSD	6.0	4.0-6.0	5.0	4.0-5.0	NSD	6.0	4.0-6.0	5.0	5.0-6.0	NSD

3.5 Predictors of Perceived Risk to Self and Risk to Society

From the variables investigated (gender, ethnicity, age, education level, being an expert/non-expert, perceptions of risk to society, personal control, expert control, personal responsibility, trust in experts and personal knowledge), none were significant predictors of perceived risk to self from public nutrition hazards (adjusted $r^2=0.045$; data not shown); gender, perceptions of risk to society and expert control were predictors of perceived risk to self from food technology hazards ($P=0.010$, $P=0.000$ and $P=0.013$, respectively; adjusted $r^2=0.588$; data not shown); perceived risk to society was the only predictor of perceived risk to self from food ecology hazards ($P=0.000$; adjusted $r^2=0.507$; data not shown). From the variables investigated (gender, ethnicity, age, education level, being an expert/non-expert, perceptions of risk to self, personal control, expert control, personal responsibility, trust in experts and personal knowledge), perceptions of personal knowledge, expert control and personal control were predictors of perceived risk to society from public nutrition hazards ($P=0.000$, $P=0.025$ and $P=0.000$, respectively; adjusted $r^2=0.296$; data not shown); gender, being an expert/non-expert, perceptions of personal responsibility, personal knowledge and risk to self were predictors of perceived risk to society from food technology hazards ($P=0.000$, $P=0.001$, $P=0.023$, $P=0.002$ and $P=0.000$, respectively; adjusted $r^2=0.662$; data not shown); gender, perceptions of risk to self and personal knowledge were predictors of perceived risk to society from food ecology hazards ($P=0.003$, $P=0.000$ and $P=0.004$, respectively; adjusted $r^2=0.607$; data not shown).

4. CONCLUSION

Non-experts had significantly higher scores of risk to self and society from food technology hazards than experts, with genetically modified food and salt in manufactured food being significant. Non-experts had significantly lower scores of risk to self from food ecology hazards than experts. Both groups gave higher scores for risk to society to public nutrition hazards than to food technology or food ecology hazards. Non-experts had higher risk denial for genetically modified foods than experts, but experts had significantly higher risk denial for obesity and food shortage than non-experts. Risk denial for public health hazards was higher among both expert and non-expert groups than for food

technology or food ecology hazards. These results indicate that non-experts have a higher perception of risk to self and society from technological hazards, and that both groups have high risk denial for public nutrition hazards, with obesity a significant example for experts. Savadori et al. [20] investigated risk judgements relating to food biotechnology applications among 58 expert and 58 non-experts. For 7 applications of genetic modification relating to food, plants and animals (non-medical), the public had significantly higher risk judgements than experts. The group studied the influence of four factors relating to risk from food biotechnology applications (harmful and dreadful application, useful application, science knowledge and new application). The four factor model accounted for 44% of the variance of risk judgement among experts and 30% of the variance among non-experts. Non-experts scored more highly on scales measuring 'harmful and dreadful application' and lower on scales measuring 'useful application' for biotechnology applied to food. Just 2 of the factors (harmful and dreadful application, and useful application) were significantly associated with expert risk judgement, whereas all 4 factors were for the non-expert. The authors concluded that non-experts have a wider perception of risk associated with food biotechnology than experts. Our survey supports the work of Savadori et al. [20] showing a disparity in the perception of risk to self and society among experts and non-experts relating to genetic modification. There have been a number of discursive publications concerning the 'democratisation of risk' in areas where policy is driven largely by scientific expertise, such as the genetic modification of food [15-17]. The expert-lay discrepancy in risk perception of food technology may highlight the need for such an approach to interpretation and communication of risk.

Control has been shown to be a determinant of risk perception [25] and the degree of control an individual has over their exposure to a hazard is a key predictor of risk denial [26]. Non-experts had significantly lower scores for personal control of public nutrition hazards than experts, particularly for obesity and high fat diet, but both groups had higher scores for personal control of public nutrition related hazards than for food technology and food ecology hazards. Information from untrusted sources amplifies risk perception [27]. Wynne cautions that trust should not be assumed to be a functional substitute for information in risky technologies [15], and

elsewhere it has been shown that trust is only weakly associated with risk perception [28]. In the present survey, non-experts had lower scores for trust in experts regarding high fat diet and salt in manufactured food than experts, and attributed significantly lower scores for trust in experts relating to food technology hazards than experts did. Autonomy and personal responsibility attenuate risk perception [27]. In this survey, there were no differences in how the groups perceived personal responsibility. Both experts and non-experts scored personal responsibility for public nutrition hazards higher than for food technology and food ecology hazards. Experts had significantly greater scores for personal knowledge of public nutrition and food technology hazards than non-experts, with high fat diet, salt in manufactured food and genetic modification being significant examples.

The perception of risk is attenuated by characteristics of familiarity, individual control, naturalness, statistical probability, clear benefits, fair distribution of exposure, voluntariness of exposure, information by trusted sources and coverage in the media, as well as freedom of choice, perception of autonomy and personal responsibility [27]. Risk perception may be amplified by characteristics of exoticness/novelty, control by others, manmade, catastrophic potential, little or no benefit, unfair distribution of exposure, imposition, information by untrusted sources and lack of coverage in the media [27]. Risk perception may also be shaped by gender, ethnicity and socio-economic distinctions [29]. Our model for investigation of risk perception among the entire cohort, incorporating factors such as gender, age, education, perceptions of control, responsibility, trust and knowledge, showed poor to moderate ability to predict variance in the scores of risk to self and risk to society. None of the predictors was associated with risk to self from public nutrition hazards. Gender, risk to society and expert control were associated with risk to self from food technology. Only risk to society was associated with risk to self from food ecology hazards. Personal knowledge, expert control and personal control were associated with perception of risk to society from public nutrition hazards. Gender, being an expert/non-expert, personal responsibility, knowledge and perception of risk to self were associated with perception of risk to society from food technology hazards. Gender, risk to self and personal knowledge were associated with risk to society from food ecology hazards variance. Our survey showed that control, personal

responsibility and knowledge, as well as gender, were significant predictors of risk perception. Trust in experts was not a predictor.

There are several limitations to the present study. Significant differences in the characteristics of the expert and non-expert groups were evidenced, and were anticipated: the experts were comprised exclusively of females, a higher proportion of the expert group had a third level education, and a higher proportion of the expert group was employed in the science-based/health care profession section. However, the response rate from the experts approached was poor, at 20%, and we recruited solely from experts in the food industry. A power calculation was not conducted; previous studies have detected significant difference between expert and non-expert group perceptions of risk, including 58 experts in biotechnology and 58 members of the public [20], 46 experts in nanotechnology and 375 members of the public [21], 40 experts in nutrition and 40 members of the public [22] and 21 experts in food safety and 29 members of the public [23]. We subjectively chose the hazards to investigate and the categorisation of the hazards as public health, food technology and food ecology. Furthermore, the terms 'hazard' and 'risk' were not defined on the questionnaire and were open to interpretation by the participant. The terms 'alcohol', 'genetic modification', 'salt in manufactured food' and 'carbon footprint of food' are evocative of, but not strictly, hazards; whereas 'obesity', 'high fat diet', '*E. coli* contamination', 'food shortage' and 'fish stock depletion' are more evidently hazardous. Additional factors in the psychometric paradigm for determining risk perception among non-experts [1,21] may have been incorporated into the study, including 'dread', 'unknown effects', 'voluntariness of risk' and 'ethics'. To build on the present work, we would suggest focus groups as a means of collecting richer, qualitative data on the perception of risk among expert and non-expert groups. Online health information searches have been used as a proxy for public health risk perception [30], and this may be a useful tool for understanding the perception of risk related to food and nutrition in the public.

The key message in this study is that disparity exists between expert and non-expert perceptions of risk to self and society, particularly with respect to food technology. Both experts and non-experts had more risk denial for public nutrition hazards than for food technology or food

ecology. Both groups had higher scores for personal control, personal responsibility and personal knowledge of public nutrition hazards, compared with food technology and food ecology hazards. Both groups gave higher scores to expert control for food technology and food ecology hazards than for public nutrition hazards. Trust in experts was not associated with risk perception, and did not vary depending on the nature of the hazard. This study, we believe, is the first to investigate risk perception of expert and non-expert groups on food and nutrition hazards relating to public nutrition, food technology and food ecology. The results signify the need for further research into reconciling, or levelling, the perception of risk between experts and the public they address, in an effort to optimise risk communication.

ETHICAL APPROVAL

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Biomedical Sciences, Dentistry, Medicine, Natural and Mathematical Sciences Research Ethics Subcommittee of King's College London (BDM/11/12-18).

ACKNOWLEDGEMENTS

We wish to thank all those who participated in this study.

COMPETING INTERESTS

The authors have no conflicts of interest to declare.

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