

Product Quality Risk Perceptions and Decisions: Contaminated Pet Food and Lead-Painted Toys

Tianjun Feng,¹ L. Robin Keller,² Liangyan Wang,^{3,*} and Yitong Wang²

In the context of the recent recalls of contaminated pet food and lead-painted toys in the United States, we examine patterns of risk perceptions and decisions when facing consumer product-caused quality risks. Two approaches were used to explore risk perceptions of the product recalls. In the first approach, we elicited judged probabilities and found that people appear to have greatly overestimated the actual risks for both product scenarios. In the second approach, we applied the psychometric paradigm to examine risk perception dimensions concerning these two specific products through factor analysis. There was a similar risk perception pattern for both products: they are seen as unknown risks and are relatively not dread risks. This pattern was also similar to what prior research found for lead paint. Further, we studied people's potential actions to deal with the recalls of these two products. Several factors were found to be significant predictors of respondents' cautious actions for both product scenarios. Policy considerations regarding product quality risks are discussed. For example, risk communicators could reframe information messages to prompt people to consider total risks packed together from different causes, even when the risk message has been initiated due to a specific recall event.

KEY WORDS: Decisions; lead-painted toys; pet food; product quality risks; risk perception

1. INTRODUCTION

The year 2007 was called “the Year of the Recall” due to the recalls of pet food and children's toys in the United States.⁽¹⁾ In particular, the 2007 pet food contamination crisis led to the widespread recall of more than 5,300 pet food products, mainly from Menu Foods, beginning in March 2007.⁽²⁾ According to the U.S. Food and Drug Administration (FDA) newsletter,⁽³⁾ as of April 26, 2007, the FDA had received consumer reports of approximately 2,200

deaths of dogs and 1,950 deaths of cats with 14 cases confirmed. Further investigation revealed that, though not yet proven, the presence of melamine and melamine-related compounds, such as cyanuric acid, in the ingredients of the affected food appears to be the cause of kidney failure that killed thousands and sickened tens of thousands of pets. Meanwhile, on August 2, 2007, the toy-making giant Mattel recalled 967,000 toys, including Dora the Explorer and Sesame Street toys, due to violations of lead paint standards,⁽⁴⁾ which was followed by a rash of toy recalls in August and September 2007.⁽⁴⁾ Children who

¹ School of Management, Fudan University, Shanghai, P.R. China.

² The Paul Merage School of Business, University of California Irvine, Irvine, CA, USA.

³ Antai College of Economics and Management, Shanghai Jiaotong University, Shanghai, P.R. China.

*Address correspondence to Liangyan Wang, Antai College of Economics and Management, Shanghai Jiaotong University, Shanghai, China, 200052; tel: 0086-21-52301003; wly@sjtu.edu.cn.

⁴ According to the U.S. Consumer Product Safety Commission (CPSC), the amount of lead in toys and other consumer products that are expected to be used by infants is limited to 0.06% (or 600 parts per million) by law. However, among the toys Mattel recalled in August and September 2007, lead in the paint on some of them was 180 times the limit.

suck on or ingest toys with high lead content may have elevated blood lead levels and may get lead poisoning. This can lead to learning and behavior problems, and at very high levels, seizures, coma, and even death (U.S. Centers for Disease Control and Prevention (CDC)).⁵

We are interested in how consumers perceive the quality risk of a product under threat of recall and how they make a decision about actions to take upon hearing news of an actual or threatened product recall. Here, product quality risk refers to the risk of a product (e.g., health, financial, safety risk, etc.) caused to customers and generated by its inherent quality problems (e.g., in raw materials, ingredients, production, logistics, or packaging). We examine risk perceptions and decisions using the contaminated pet food and lead-painted toys as examples in the same study for a number of reasons. First, pets and children are vulnerable members of a household that adults have a responsibility to protect.⁶ Second, both involved potentially serious health threats. Third, the recalls occurred in the same time span. Finally, both products originated in China and were destined for the U.S. market. For these two recalls, there was a great deal of media attention, including anecdotal stories of relatively extreme actions by consumers. For instance, in response to the recall of lead-painted toys, some parents were so concerned and scared that they tested all of their children's toys for lead and threw away the toys on the recall list.⁷ For regulators, consumers, and the companies in the supply chain for these products, it will be valuable to understand the components of people's reactions to such events. This line of work should be helpful in future recalls of other products to gain a quick understanding of likely patterns of consumer reactions.

To explore risk perceptions of these two product recalls, we used two approaches that have been widely adopted in the risk perception literature. The first approach was to elicit judged probabilities of the adverse quality risk with respect to these two product recalls.^(8,9) Specifically, we elicited judged

probabilities that (1) a dog will die from eating contaminated dog food within the next month (in the case of the dog food recall) and (2) an under-six-year-old child will have elevated blood lead levels from playing with lead-painted toys within the next couple of months (in the case of the children's toys recall). We then examined biases in judged probabilities of quality risks of these two products due to using a packed frame (lumping together multiple items) or unpacked frame (listing items separately). We chose to investigate this since companies or regulators in future recall crises would have the ability to frame probability information and other messages using packed or unpacked probability frames. People tend to have an overall higher judged probability for a focal event's occurrence when the description of an event is unpacked into its individual components.^(10–16) Also Tversky and Kahneman⁽¹⁷⁾ showed that when a described specific case seems very representative of a general category, this “representativeness” may lead to higher judged probabilities. In this study, an adverse health effect from the recalled product may be incorrectly seen as more likely to occur than that same health effect from any cause.

In the second approach, we applied the well-known psychometric paradigm^(18–20) developed by Slovic and his colleagues to further examine risk perceptions of the two product recalls. This approach has been widely adopted to understand and predict people's responses to various risks by identifying similarities and differences among those risks. Analyzing newly arising risks and comparing them with existing ones along a number of dimensions will help policymakers understand each new risk and potentially help the general public accurately perceive the risks. Accordingly, we considered eight hazardous products and risky situations, including the two recalled products and six additional risks spanning sickness risks from food⁷ and nonfood consumer products,⁸ on seven qualitative rating scales. The six comparison risks include avian flu (because it poses severe health risks to both birds and humans),^(42–44) mad cow disease (bovine spongiform

⁵ More information about children's risks and opportunities to manage them can be found at <http://www.kidsrisk.harvard.edu/>, a project created and directed by Professor Kimberly Thompson at the Harvard School of Public Health.

⁶ The public tends to have different perceptions and attitudes toward risks faced by children and adults, respectively,⁽⁵⁾ and probably the same is true for humans and pets. In addition, while our study focused on making decisions on behalf of a child or a pet, similar decisions might also apply when made for adults (e.g., Johnson *et al.*).⁽⁶⁾

⁷ Studies of perceived health risks of various human food products have been done on modified food,^(21–23) organic food and conventional food,^(24–26) Salmonella food poisoning,⁽²⁷⁾ and general food safety issues.^(28–33) Little or no attention in this stream of work has been on pet food.

⁸ Perceived health and safety risks of technologies have been done on gene technology,⁽³⁴⁾ biotechnology,⁽³⁵⁾ nuclear power,⁽³⁶⁾ environmental risk and technology,^(37–40) and other technologies.⁽⁴¹⁾

Table I. Questions on Subjective Probability Judgments for Contaminated Dog Food and Lead-Painted Toys

Suppose 10,000 dogs ate the same contaminated dog food. What do you expect to happen among these dogs within the next month?	
Contaminated dog food	
Version A	_____ No. of dogs dying from the dog food
Version B	_____ No. of dogs dying
Version C	_____ No. of dogs dying from the dog food
	_____ No. of dogs dying from other causes
Suppose 10,000 under-six-year-old children played with the same lead-painted toys. What do you expect to happen among these children within the next couple of months?	
Lead-painted children's toys	
Version A	_____ No. of children having higher blood lead levels from lead-painted toys
Version B	_____ No. of children having higher blood lead levels
Version C	_____ No. of children having higher blood lead levels from lead-painted toys
	_____ No. of children having higher blood lead levels from other causes

encephalopathy (BSE), which has raised consumer anxiety about beef consumption,^(45–47) severe acute respiratory syndrome (SARS), contaminated spinach, smoking cigarettes,^(48–54) and cell phone radiation. This allows us to establish the risk perception map, which helps investigate how these newly recalled products score on factors shown in the past to influence risk perception and how they compare with the six comparison risks.

As discussed before, both recalled products originated in China. The well-documented country-of-origin literature emphasizes that a product's origin plays an important role in consumers' perceptions of the product.⁽⁵⁵⁾ Thus, we conjecture that the country of origin may influence risk perceptions of the two contaminated products. In this study, we examined this issue for four original sources of products (the United States, China, Japan, and Mexico).

Finally, it has been shown that risk perceptions influence people's decisions in risky situations.^(9,46) Accordingly, we examined people's actions in response to the product recalls. For example, a pet owner may choose to gain more information about the recalls before taking further actions, or a child's parents may decide to throw away all toys at home when they hear about the recall announcements. Further, we identified the factors most predictive of their cautious actions.

2. STUDY DESIGN

Our survey had three versions depending on the information format of the focal events. Table I shows the main difference between these three versions of the survey. First, we asked all participants to think

about dogs that had eaten the contaminated dog food. In version A, one group of participants reported their estimate of the probability of one of those dogs dying due to eating the contaminated dog food. The version B group was asked what the probability is of one of those dogs dying (with no cause mentioned). In contrast, the version C group received an unpacked framing of the question in version B, in which they judged the probability of one of those dogs dying from eating contaminated food and then judged the probability of one of them dying from other causes. The question design of these three versions was similar for the scenario of lead-painted children's toys, except that we asked respondents to estimate the probability of one of those under-six-year-old children having elevated blood lead levels (from playing with lead-painted toys, from unspecified causes, or from other causes).⁹ Each participant received the same version of the questions for both the food and toy scenarios.

All the other questions in the survey were the same across all participants, including questions on the characterization of perceived quality risks on various dimensions and on trust in the original sources of products. Several other short questions were designed to measure participants' knowledge and actions toward the recalls of contaminated pet food and lead-painted children's toys. To identify

⁹ There are several other causes that could lead to elevated blood lead levels for young children. According to the case studies from the U.S. Center for Disease Control (CDC), the primary source of lead exposure to children in the United States is lead-contaminated household dust. Landrigan⁽⁵⁶⁾ claimed that childhood lead poisoning is the major factor that contributes to the costs of all pediatric environmental disease in the United States, which amount to approximately \$43.4 billion every year.

determinants that are significant predictors of respondents' potential actions, we also asked for information about demographic characteristics, such as gender and personal experience with dogs or cats.

3. DATA AND METHODS

3.1. Data Collection and Analysis Methods

Two hundred and five survey participants, ranging in age from 18 to 45, were recruited from the human subject pool at the University of California, Irvine. (In total, 210 respondents, all enrolled in undergraduate classes, participated in our study. Among them, five participants did not complete their survey and thus were removed from the data analysis.) They were randomly assigned to three groups of 67, 69, and 69 participants for versions A, B, and C. Note that college student samples have been used in several prior risk perception papers.^(57–62) Participants received one hour of course extra credit. Table II provides the demographic data. Eighty-eight

percent of the participants were female.¹⁰ Approximately 41% of the respondents and their families have had 1–2 dogs and 18% of them have had more than two dogs. Nearly 86% of the respondents do not have siblings under six years old, but 68% of them had been a babysitter.

Survey data were collected through SurveyMonkey.com, recorded in a Microsoft Excel spreadsheet and analyzed using the SPSS statistical software. Participants took about 40 to 50 minutes to complete this online survey. Statistical analyses included tests of differences in means, factor analysis, ANOVA, multiple regression, and logistic regression. For comparability, a common set of independent variables was used to estimate all regression models.

3.2. Descriptive Statistics

After reading a short description of both the food and toys recalls, respondents gave an estimate of how many dogs died in the United States from contaminated dog food in 2007 and how many under-six-year-old children got elevated levels of lead in their blood in the United States from playing with lead-painted toys in 2007. The median responses on these two questions were 5,000 dogs (mean: 61,600, *SD*: 303,622) and 6,000 children (mean: 202,871, *SD*: 1,146,795), respectively. Note that for pet food, approximately 2,200 dog deaths were attributed to the contaminated food, according to the FDA. The large standard deviations indicated that respondents held varied opinions about impact of the recalled products.

Trust in institutions is closely related to subjective risk judgments regarding human food quality risks.^(26,27,33) An individual who trusts less in institutions for food quality information tends to perceive a higher probability of risk. Using three 7-point rating scales, we also asked questions related to participants' trust in institutions, information

Table II. Demographic Characteristics of Survey Respondents

Characteristics	% Survey Respondents
Gender	
Male	12.1%
Female	87.9%
Age (years old)	
< 20	59.5%
20–22	34.6%
≥ 23	5.9%
Race	
African American	0.5%
Pacific Islander	7.8%
White	20.9%
Hispanic/Latino	11.7%
Asian American	48.5%
None of the above	10.7%
Number of dogs you and your family have had	
0	41%
1–2	41%
≥ 3	18%
Number of cats you and your family have had	
0	79.1%
1–2	14.6%
≥ 3	9.3%
Number of brothers or sisters who are under six years old	
0	85.9%
1	8.8%
≥ 2	5.4%
Having babysitting experience	68.3%

¹⁰ While this uneven gender distribution was partly due to the fact that female students account for a majority of the university's human subject pool, we believe that such a distribution would also hold for pet food and children's toy shoppers. Participants self-selected the experiments they would participate in. Those selecting our study were told: "We are conducting a study on how people react to product quality related crises, with a focus on the recent recalls of contaminated pet food and lead-painted children's toys." We further analyzed the relationship between participants' gender and their subjective probability judgment for all three versions, and we did not find significant differences. Therefore, we conducted the analyses based on the pooled data from both male and female respondents.

Table III. Questions on Trust, Information, and Concern

	Ratings	
	Pet Food	Toys
Do you trust the information that the authorities have provided on dog food/toys? (1 = do not trust; 7 = fully trust)	4.85	4.75
Are you provided enough information to judge properly whether dog food/toys is/are safe or not? (1 = not enough info.; 7 = enough info.)	3.57	3.75
Overall, how concerned are you about dog food/toy safety? (1 = not concerned; 7 = very concerned)	4.86*	5.82*

*Significantly different at $p < 0.0001$.

sufficiency, and overall concerns about these product quality risks, as shown in Table III. Respondents had a fairly good level of trust in the information that the authorities provided on both food (mean = 4.85 out of 7, where 7 is full trust) and toys (mean = 4.75), but did not think that they had fully received enough information for either recall (mean = 3.57 for food, and mean = 3.75 for toys). Participants were highly concerned about the safety of dog food (mean = 4.86) and had significantly more concern about toys

(mean = 5.82, $p < 0.0001$). Since respondents had a relatively high level of trust in the authorities and concern about these products' safety, but felt they did not have enough information, government agencies and companies could provide people with more information to aid them in making more informed decisions.

4. RESULTS ON RISK PERCEPTIONS

4.1. Judged Probabilities

We first elicited judged probabilities in response to the two product recalls, which are shown in Table IV. In survey version A, participants gave an estimate of the number of dogs dying from eating the food within the next month. For instance, if an estimate was 2,000, this participant's judged probability of dogs dying from eating the contaminated food was 20% = 2,000/10,000 (i.e., participants were told in the survey to suppose that 10,000 dogs ate the same contaminated dog food). A similar structure was used for toys. Thus, using version A, we elicited participants' subjective probabilities for the two scenarios and found that the mean judged probability of dogs dying from eating the contaminated food was 46.9% and the mean judged probability of children having higher blood lead levels from lead-painted toys

Table IV. Means of Subjective Probability Judgments Associated with the Contaminated Pet Food and Lead-Painted Toys Scenarios^a

		Frame of Question	Mean
Contaminated dog food			
Version A	Judged probability of dogs dying from eating the contaminated food	Recall event only	46.9%
Version B	Judged probability of dogs dying from eating the contaminated food	General event	38.5%
Version C	Judged probability of dogs dying from eating the contaminated food plus judged probability of dogs dying from other causes	Separate recall and nonrecall event, then sum	56.8% (=36% + 20.8%)
Lead-painted toys			
Version A	Judged probability of children having higher blood lead levels from lead-painted toys	Recall event only	51.7%
Version B	Judged probability of children having higher blood lead levels	General event	40.6%
Version C	Judged probability of children having higher blood lead levels from lead-painted toys plus judged probability of children having higher blood lead levels from other causes	Separate recall and nonrecall event, then sum	56.8% (=43.8% + 13%)

^aVersion C (unpacked condition) had a significantly higher mean judged probability than version B (packed condition) at the 1% level using a *t*-test ($p = 0.0002$ for contaminated dog food and $p = 0.0018$ for lead-painted toys).

was 51.7%. We believe that our participants tended to overestimate their probability judgments for the potential adverse reactions with these two recalls.¹¹ This is very likely due to the availability heuristic,⁽¹⁷⁾ which states that people predict the frequency and probability of an event by the extent to which occurrences of that event are easily “available” in memory.¹² Clearly, there was extensive media coverage on the two product recalls during the recall crisis and thus adverse examples could be readily brought to mind for respondents. Note that a similar pattern has also been observed in the prior literature on risk perception. For example, by using a large-scale national survey, Viscusi⁽⁴⁸⁾ found that both smokers and non-smokers significantly overestimated the lung cancer risk of cigarette smoking.

Interestingly, when participants focused on the adverse effects due to the recall event (version A), their answers were higher than when they considered all adverse effects from any cause (version B). This may be seen as falling prey to the representativeness

heuristic of Tversky and Kahneman.⁽¹⁷⁾ More specifically, since the vivid and recent stories about product recalls seem to represent well the category of dog deaths or sources of lead paint for children, when people were asked just about adverse effects of the recall event in version A, the high representativeness of the recall to the category may have led to higher probability estimates. In contrast, in version B, the general set of causes of the adverse event may not have been very available in people’s imagination, and thus their estimates for the probability of the larger category of adverse events from all causes may have been lower, since it might have been harder to bring to mind other instances of the adverse event not from the recalls.

Next, we examined biases in judged probabilities of quality risks of these two products due to using a packed frame or unpacked frame. In version B, participants estimated the number of those dogs dying within the next month. Since those dogs might die from other possible causes in addition to the contaminated food in the next month (e.g., natural death from aging, dying from a car accident, etc.), version B is a packed frame of the focal event of death. In contrast, version C is an unpacked frame, in which participants explicitly provided an estimate of the number of those dogs dying from eating contaminated food and the number of those dogs dying from other causes. By comparing responses between versions B and C, we examine biases in probabilities due to packing or unpacking of the focal event. For children’s toys, we asked respondents to think about those under-six-year-old children who played with the lead-painted toys. Hence the focal event in the scenario of lead-painted toys is that an under-six-year-old child has a higher blood lead level from any cause within the next couple of months.

Shown in Table IV, in the packed condition (B) of the contaminated dog food scenario, the mean probability of dogs dying (from any cause) was 38.5%, while the mean probability of dogs dying from any cause calculated by summing the responses for food-caused and other deaths in the unpacked condition (C) was significantly higher (56.8%, $t = 3.648$, $d.f. = 136$, $p = 0.0002$). The pattern also held in the lead-painted toys scenario ($t = 2.959$, $d.f. = 136$, $p = 0.0018$). Specifically, the mean probability in the packed condition and unpacked condition was 40.6% and 56.8%, respectively. So our result is consistent with support theory⁽¹⁵⁾ in that people tend to judge an overall higher probability when the description of the focal event is unpacked.

¹¹ According to the U.S. *Pet Ownership & Demographics Sourcebook*,⁽⁶³⁾ there are approximately 72,114,000 pet dogs in the United States, so roughly every fourth person owns a pet dog (the total population of the United States by July 1, 2007 was around 301,621,157 based on the 2007 population estimates from the U.S. Census Bureau). The FDA received reports that about 2,200 dogs died from eating contaminated food with 14 cases confirmed, including the confirmed deaths of cats. Assume that only 0.1% of the dogs in the United States had eaten the contaminated dog food during the recall crisis in 2007, which is a relatively low estimate since several major pet food manufacturers recalled more than 5,300 products, with most of the recalls coming from Menu Foods, the largest maker of wet dog and cat food in North America. Then the “actual” probability of a dog dying from eating the contaminated food would be as low as 3.1% (i.e., $2,200/72,114 = 3.1\%$). As a result, respondents apparently generally overestimated the probability of a dog dying from eating the contaminated food. In the case of children’s toys, although the real data about the number of under-six-year-old children who had elevated blood lead levels from playing with lead-painted toys during the recall were not available, we suspect that respondents’ judged probabilities were higher than the actual probabilities. In 2007, Mattel Inc., the world’s largest toy company, recalled over 19 million Chinese-made toys, including dolls, cars, and action figures. From this, one might expect that at least several millions of children could have played with the lead-painted toys. On the other hand, there was very little news coverage on the reports of children’s lead poisoning cases due to playing with the lead-painted toys in 2007. Consequently, we are led to believe that the actual probability of an under-six-year-old child having elevated blood lead levels from playing with lead-painted toys would be much lower than 51.7%.

¹² We are grateful to an anonymous referee for this suggestion. It is possible that participants tend to err on the high side since pets and children are vulnerable in general and there is no cost to overestimating.

This suggests that extensive recall publicity that may focus people's attention on the focal recall event, and thus lead them to mentally unpack adverse health effects into different causes, could lead to overestimating the actual probability.

4.2. Risk Perception Dimensions

Using the psychometric paradigm, we now examine the ratings on seven risk perception dimensions of eight hazardous products or risky situations, including contaminated dog food, lead-painted toys, contaminated spinach, avian flu, mad cow disease, SARS, cell phone radiation, and cigarette smoking. We chose to examine contaminated spinach, since it is a contaminated food, like the dog food. We chose to examine SARS, avian flu, and mad cow disease since they are health risks beginning in outbreaks outside of the United States with the potential to spread to the United States, like both the dog food and toys. (Contaminated beef from mad cow disease could be seen as contaminated food or as a disease without the focus on food.) We chose to examine cell phones and smoking since they involve nonfood consumer products with ear/mouth/nose contact leading to possible adverse health effects, like the toys. For some items, we provided participants with a one-sentence description.¹³

The seven 7-point psychometric scales reflecting risk characteristics have been used to characterize perception of risk in previous research.^(18,68) The potential influence of these dimensions was suggested in early risk research,^(69,70) verified by Fischhoff *et al.*⁽⁶⁸⁾ and applied widely in further work, such as Slovic *et al.*⁽¹⁸⁾ and McDaniels *et al.*⁽⁷¹⁾ Table V describes the seven rating scales of controllability, dread, severity of consequences, voluntariness, known to the exposed, immediacy of effect, and risk newness.

The mean ratings on the risk dimensions for the eight risks are shown in Table VI. Among the eight risks, contaminated dog food had the highest mean ratings on the 1–7 scale on the dimensions of unknown to the exposed (mean = 4.90, where 1 = precisely known to the dog owners) and newness (mean = 4.93 where 1 = old), but the lowest mean ratings in terms of dread (mean = 3.22, where 1 = not dreaded). Compared to other contaminated food for human consumption (i.e., spinach and beef), respondents viewed the risk of contaminated dog food to be the least dread. The lead-painted toys were the third most unknown (mean = 4.74), third most new (mean = 4.32), and second least dread (mean = 3.66).

Meanwhile, SARS was rated to be the most uncontrollable risk (mean = 4.67), the most dread risk (mean = 4.48), the risk with the most fatal consequence (mean = 5.64), the most involuntary risk (mean = 5.66), and the risk of the most immediate effect (mean = 3.44). This was likely because of the extensive media coverage on the rapidly increasing number of infected cases and death during the outbreak of SARS between November 2002 and July 2003. In contrast, perhaps due to its prevalence in the general population, cigarette smoking received the lowest ratings on four scales, including controllability (mean = 3.14), voluntariness (mean = 2.96), known to the exposed (mean = 2.47), and newness (mean = 1.94). Cell phone radiation was seen to be the least fatal (mean = 3.81) and to have its negative effect delayed the most (mean = 5.48).

Table VII provides the intercorrelations among the mean ratings of the seven risk characteristics. There were high associations between many scales and no association between a few others (e.g., dread and known to the exposed, $r = 0.02$). Given that there were sufficiently high intercorrelations for several pairs of the seven risk characteristics, we conducted a principal component factor analysis with a Varimax rotation to seek any key factors underlying the seven risk characteristics. The seven characteristics loaded onto the two factors displayed in Table VIII. The two orthogonal factors explained almost 94% of the variance, which was sufficiently high to account for the observed intercorrelations. Factor 1 was highly correlated with all risk characteristics except risk dread and severity of consequence. Factor 2 was highly correlated with both the risk's severity of consequence and risk dread, and moderately highly associated with risk controllability, though a little bit lower than the two risk characteristics mentioned above. Thus, as used in the previous literature,

¹³ Four items were described. The contaminated spinach outbreak occurred in September 2006 and people faced a risk of getting sick or even dying due to infection from eating uncooked spinach with *E. coli* bacteria.⁽⁶⁴⁾ Avian flu refers to an illness mainly caused by the influenza subtype H5N1 virus adapted to birds and it could lead to clinically severe and fatal human infections through bird-to-human transmissions.⁽⁶⁵⁾ Mad cow disease, also known as BSE, is a degenerative neurologic disease of cattle that affects the central nervous system and humans could have degeneration of physical and mental abilities, and ultimately die from eating contaminated beef.⁽⁶⁶⁾ Severe acute respiratory syndrome (SARS) is a viral respiratory disease in humans caused by the SARS coronavirus and this highly contagious virus could cause substantial illness and death among the general population.⁽⁶⁷⁾

Table V. Descriptions of Risk Rating Scales

	Description of Scale	Scale End Points	
		Low (1)	High (7)
Controllability	Please rate to what extent you can, by personal skill or diligence, avoid death for the exposed dog or person, if exposed to the risk	Controllable	Uncontrollable
Dread	Please rate to what extent this is a risk that you have learned to live with and can think about reasonably calmly, or it is the one that you have great dread for—on the level of a gut reaction	Not dread	Dread
Severity of consequences	Please rate how likely it is that the consequence will be fatal when the risk is realized in the form of a mishap or illness	Consequences not fatal	Consequences fatal
Voluntariness	Please rate to what extent this risk is faced voluntarily	Voluntarily	Involuntarily
Known to exposed	Please rate to what extent the risks are known precisely by the dog owners (for dog food)/child's parents (for toys)/persons (for other risks) who face those risks	Known precisely	Not known
Immediacy of effect	Please rate to what extent the risk of death is immediate—or sickness or death is likely to occur at some later time	Effect immediate	Effect delayed
Newness	Please rate to what extent this risk is old and familiar or new and novel	Old	New

Table VI. Mean Ratings for Seven Characteristics of Risk for Eight Health Risks

	Controllability 1 = Controlled	Dread 1 = Not Dread	Fatal 1 = Not Fatal	Voluntariness 1 = Voluntary	Known to the Exposed 1 = Precisely	Immediacy 1 = Immediate	Newness 1 = Old
Contaminated dog food	3.47	3.22	4.33	4.58	4.90	3.86	4.93
Lead-painted toys	3.50	3.66	4.21	4.46	4.74	4.57	4.32
Contaminated spinach	3.82	3.86	4.33	4.44	4.66	3.78	4.36
Avian flu	4.31	4.33	5.20	5.50	4.73	3.63	4.15
Mad cow disease	4.24	4.44	5.42	5.00	4.62	3.75	3.61
SARS	4.67	4.48	5.64	5.66	4.78	3.44	3.86
Cell phone radiation	3.51	3.73	3.81	3.55	3.97	5.48	4.29
Cigarette smoking	3.14	3.95	5.20	2.96	2.47	5.26	1.94

Table VII. Intercorrelations of the Seven Rating Scales

Scale	Controllability	Dread	Fatal	Voluntariness	Known to the Exposed	Immediacy	Newness
Controllability 1 = Controlled	—	0.79*	0.63	0.90**	0.58	−0.78*	0.21
Dread 1 = Not Dread	—	—	0.81*	0.50	0.02	−0.39	−0.39
Fatal 1 = Not Fatal	—	—	—	0.47	−0.09	−0.50	−0.53
Voluntariness 1 = Voluntary	—	—	—	—	0.82**	−0.91**	0.48
Known to the Exposed 1 = Precisely	—	—	—	—	—	−0.74*	0.87**
Immediacy 1 = Immediate	—	—	—	—	—	—	−0.40
Newness 1 = Old	—	—	—	—	—	—	—

* $p < 0.05$; ** $p < 0.01$.

Table VIII. Factor Loadings Across Seven Risk Characteristics^a

Scale	Controllability	Dread	Fatal	Voluntariness	Known to the Exposed	Immediacy	Newness	λ	Percentage of Variance Accounted for
Factor 1 “Unknown Risk”	<u>0.649</u>	0.073	−0.010	<u>0.864</u>	<u>0.988</u>	<u>−0.803</u>	<u>0.844</u>	4.109	58.7
Factor 2 “Dread Risk”	<u>0.718</u>	<u>0.938</u>	<u>0.962</u>	0.482	−0.073	−0.461	<u>−0.517</u>	2.437	34.8
Communality	0.936	0.885	0.926	0.979	0.982	0.857	0.980	–	–

^aPrincipal components analysis with loadings from Varimax rotation.

we refer to Factor 1 as the “unknown risk factor” and Factor 2 as the factor of “dread risk.”^(18,72)

Following the procedures of Slovic *et al.*,⁽¹⁸⁾ we computed two factor scores for each risk item by weighting the ratings on each risk scale proportionally to the scale’s importance in determining each factor and then summing across all scales. Note that respondents’ ratings on each risk dimension were recoded from the 1–7 scale into a scale with endpoints −3 and 3, with a midpoint 0, to highlight the relationship between responses and the scale midpoints. Fig. 1 depicts the relative position of each of the eight risks within the two-factor space, with Factor 1 on the vertical axis (i.e., “unknown risk”) and Factor 2 on the horizontal axis (i.e., “dread risk”). This figure is also known as a risk perception map in the literature.^(19,71) The upper extreme of Factor 1 is associated with risk being unknown, new, involuntary, uncontrollable, and having delayed consequences. Items at the far right of Factor 2 are construed as dread, having fatal consequences, new, and uncontrollable.

From Fig. 1, we observe that contaminated dog food and lead-painted toys almost overlapped in the upper left quadrant, with both being perceived as moderately unknown and relatively neutral on the scale of dread to not dread risks. Their location is similar to that found in prior work for lead paint.^(19,72) Cell phone radiation was also in this quadrant. The most extreme item in the upper right quadrant was SARS, which was perceived as highly unknown and dread. In that quadrant, Avian flu had a pattern similar to SARS, except that it was seen as slightly less dread. One possible explanation is that both of them were contagious diseases and had recently broken out primarily in Asia. The two contaminated human food items, mad cow disease (i.e., contaminated beef) and contaminated spinach, were also located in this upper right quadrant. Respondents perceived nearly the same level of un-

known risks for both contaminated human food and pet food and they considered contaminated human food to be more dread than contaminated dog food. Cigarette smoking was located at the lower left quadrant, seen as rather known and slightly not dread. This is consistent with the pattern of smoking found previously.^(19,72) Finally, note that none of the eight items considered in this study was included in the lower right quadrant, in which risks were perceived to be known but dread (e.g., handguns were found to be located in this quadrant in prior research).^(19,72)

4.3. Country-of-Origin Effects

In this section, we examine country-of-origin effects on risk perceptions of the two contaminated products. Specifically, using a 7-point scale, we asked participants to rate how much they trust products made in the United States, China, Japan, and Mexico in terms of health and safety risks, how much they are satisfied with those products in terms of a good affordable price with decent product quality, and how much they are satisfied with those products in terms of product quality.

As shown in Table IX, there were significant differences in the respondents’ evaluations between the four countries for each of the three ratings scales above based on an ANOVA. This is consistent with the literature that country of origin has a strong influence on perceived quality or product evaluation.^(73,74) Moreover, through Tukey’s tests, we found that for each of the three scales, the United States and Japan on average received significantly higher ratings than both China and Mexico. However, for each of the three scales, there was no significant difference between the two developed countries, the United States and Japan.

Similarly, between the two developing countries, China and Mexico, we might have found insignificant differences since China and Mexico were the second

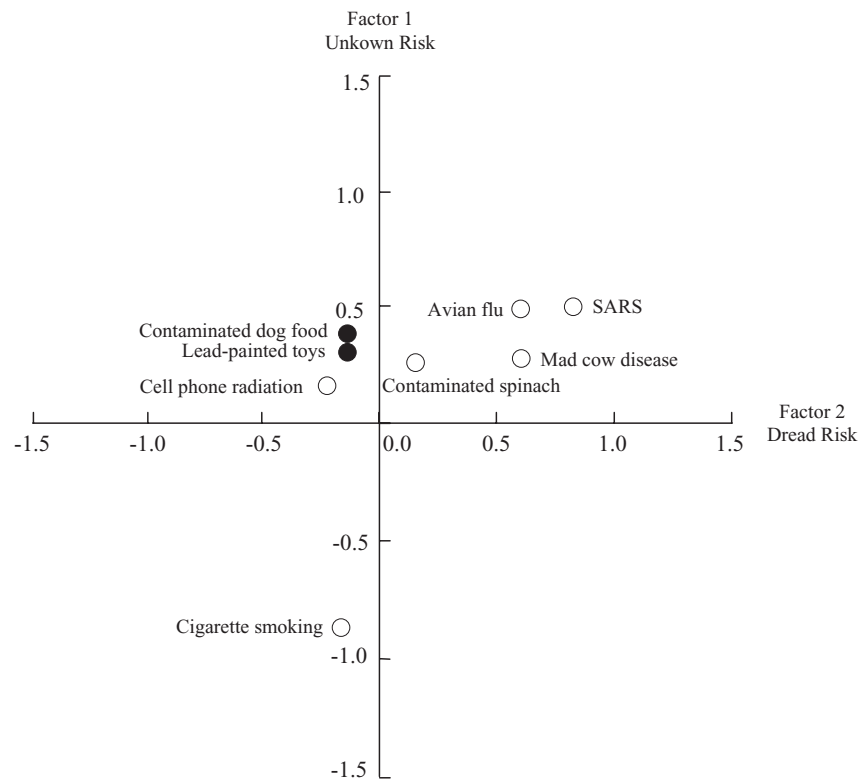


Fig. 1. Location of eight risks within the two-factor space.

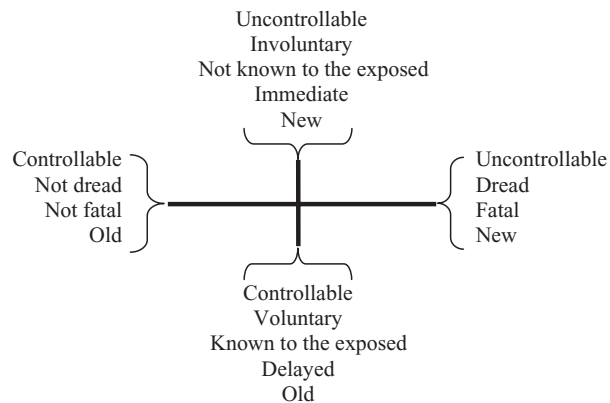


Table IX. Cross-Country Differences in Trust and Satisfaction with Products^a

	United States	China	Japan	Mexico
For health and safety risks, do you trust products made in each of the four countries? (1 = do not trust; 7 = fully trust) ($p < 0.0001$)	5.28	3.70	4.94	3.05
For a good affordable price with decent product quality, how satisfied are you with products made in each of the four countries? (1 = not satisfied; 7 = fully satisfied) ($p < 0.0001$)	5.16	4.75	5.33	4.05
For product quality (e.g., a product works for the purpose, does not break, made of high quality materials, etc.), how satisfied are you with products made in each of the four countries? (1 = not satisfied; 7 = fully satisfied) ($p < 0.0001$)	5.48	4.34	5.54	3.80

^aThe hypothesis that the means of these three scales between the four countries are equal was rejected at the 1% level using ANOVA.

and third largest countries that the United States imported products from in 2007, with each country accounting for 16.5% and 10.8% of the U.S. annual total imports, respectively (according to the U.S. Census Bureau, the year report of 2007). But, interestingly, we found that respondents had significantly higher (more favorable) ratings of products made in China than those of products made in Mexico for all three rating scales despite the fact that the focus of our study was on recalled pet food and children's toys that were made in China. We provide an alternative explanation as follows. Prior literature suggested that differences in economic development or industrialization levels are an important factor in accounting for the country-of-origin effect, that is, the higher the level of economic development or industrialization, the more favorable is the perception of the quality of its workers, as well as the perceived quality of its products.^(73–77) Despite the privileged tariff status set by the North American Free Trade Agreement, Mexico appears to be losing its U.S. export marketing shares; whereas with its accession to the World Trade Organization, China has played a very important role in today's world economy, that is, China has become the world's third largest economy since 2007, behind only Japan and the United States (CNN News, January 15, 2009). This might lead to a difference in people's perceived quality between products made in China and products made in Mexico.

More interestingly, we found that there was a significant difference in perception of products from Asian countries between the Asian-American and non-Asian-American subjects.¹⁴ The general quality index of products from each country was considered by averaging respondents' ratings of products made in that country on the three scales above, where 1 represents "do not trust/not satisfied," and 7 represents "fully trust/satisfied." Specifically, Asian-

American respondents had significantly lower general quality ratings of products made in China (mean = 3.99) than non-Asian-American respondents (mean = 4.53) ($p < 0.01$). On the contrary, products made in Japan received significantly higher ratings from Asian-American respondents (mean = 5.57) relative to non-Asian-American respondents (mean = 5.00) ($p < 0.01$). We did not find a significant difference in perceived quality of products made in the United States or Mexico between these two groups. This finding makes a contribution to the country-of-origin literature and complements results from public opinion surveys.¹⁵

5. RESULTS ON ACTIONS

5.1. Actions

Respondents' possible actions to deal with the product recalls are in Table X. Participants said they would take a variety of actions when they were asked what they would do with the pet food or the toys at home when they heard about recalls of contaminated pet food and lead-painted children's toys. The pattern was similar for food and toys in that the top three options for both scenarios included "Check websites for more information," "Read/Listen to news coverage," and "Throw away all dog food/toys," each of which had more than 60% of the respondents selecting it. (Some participants provided other alternatives, such as "Take dogs to the vet for checkup," "Purchase dog food without contaminated ingredients," "Test child for lead poisoning," "Return item and ask for refund," "Put them away for a period of time until I have more information about the topic," "Sue toy makers if my child has been poisoned," etc.) This suggested that when faced with a product recall event, people may collect more information about the product itself before taking any further actions or simply proceed to take cautious actions (i.e.,

¹⁴ Nearly half of the respondents were Asian Americans in our study (note that according to the undergraduate profile of University of California, Irvine, in fall 2007, our sample was quite representative in terms of distribution by race). Although we did not ask our subjects how long their family had been in the United States, one may expect a difference in risk perception based on how many years their family has been in the United States, or even a difference in risk perception among different generations of family members. Wong-Kim *et al.*⁽⁷⁸⁾ suggested that length of stay in the United States and fluency with the English language affected people's beliefs. Bonin *et al.*⁽⁷⁹⁾ found that there was a difference in risk preference between first-generation immigrants (born abroad) and the second generation (born in the immigrated country). Future studies could investigate this.

¹⁵ Our results on perceptions of country sources are fairly consistent with other surveys of adult consumers in the United States. In the context of imported food, deWaal⁽⁸⁰⁾ found 616 of the survey respondents who answered a question to place countries/regions in order of concern from greatest to least concern, on average gave the order of China (greatest concern), Mexico, European Union, Australia, Canada (least concern). Similarly, Weise⁽⁸¹⁾ reported on a USA TODAY/Gallup Poll of 921 adults (who shop for groceries) showing that products "from China rank highest on those shoppers' suspicion scale: 83% are concerned about food from China, compared with 61% concerned about foods from Mexico and 39% concerned about foods from the USA."

Table X. Respondents' Potential Actions to the Recalls of the Contaminated Pet Food and Lead-Painted Toys

		Ratings
What would you do with the dog food at your home when you heard that some dog food has recently been contaminated? Check all that apply.		
Contaminated	• <i>Check websites for more information*</i>	85%
	• <i>Throw away all dog food*</i>	75%
	• <i>Read/listen to news coverage*</i>	73%
Pet	• Talk with friends about what their experience is with this issue	47%
Food	• Cook dog food from fresh ingredients	28%
	• Trust store to remove recalled items	20%
	• Modify use (e.g., give food to bigger dogs, not puppies)	2%
	• Other	5%
What would you do with the toys at your home when you heard that some toys have recently been recalled due to lead-paint? Check all that apply.		
Lead	• <i>Check websites for more information*</i>	83%
	• <i>Read/listen to news coverage*</i>	78%
	• <i>Throw away all toys*</i>	62%
Painted	• Talk with friends about what their experience is with this issue	49%
	• Test toys for lead	38%
Toys	• Trust store to remove recalled items	24%
	• Wash toys	24%
	• Modify use (e.g., give toys to bigger kids, not infants/toddlers)	16%
	• Other	6%

*Actions in bold italic font were selected by more than 60% of respondents.

dispose of the products before complete information has been obtained).

5.2. Factors Predictive of Cautious Actions

We were interested in identifying the determinants of respondents' cautious actions to "Throw away all dog food/toys." Thus we developed two logistic regression models using maximum likelihood estimation to determine the factors most predictive of their cautious actions for both the contaminated dog food scenario and the lead-painted toys scenario based on the data in version A. Table XI shows the results from the two logistic regression models.

From this table, we can see that both models had moderate explanatory power in predicting respondents' actions to "Throw away all dog food/toys." Specifically, respondents' subjective probabilities were found to be a consistent predictor of their cautious actions to "Throw away all dog food/toys" at the 0.05 level for both product scenarios (Wald statistic = 4.45, $p = 0.035$ for dog food, and Wald statistic = 4.26, $p = 0.039$ for toys). For example, respondents who had higher subjective probabilities were more likely to choose cautious actions, that is, throwing away all dog food/toys.

Several other factors were found to be significant predictors in specific product scenarios. In the logistic regression model for the dog food scenario,

race was a significant predictor of throwing away all dog food at the 0.05 level (Wald statistic = 4.48, $p = 0.034$), that is, Asian-American respondents were more likely to choose to throw away all dog food than non-Asian-American participants. This is consistent with the previous country-of-origin finding that Asian-American respondents perceived significantly lower quality for products made in China (where the recalled dog food was from) than their non-Asian-American counterparts. Two of the seven risk dimensions were found to be significant predictors of throwing away all dog food at the 0.10 level. Dread was positively associated with throwing away all dog food (Wald statistic = 2.88, $p = 0.09$), which implies that respondents who perceived the risk of contaminated dog food to be more dread were more likely to take cautious actions. Conversely, newness was negatively associated with this cautious action (Wald statistic = 3.15, $p = 0.076$), since, for a new risk, respondents might need to know more about it before they decide to throw away all dog food. Respondents who more frequently wear a seatbelt when riding in a car were generally more cautious and more likely to choose to throw away all dog food (Wald statistic = 3, $p = 0.083$).

In the logistic regression model for the children's toys scenario, trust in authorities was positively associated with the cautious action of throwing away the toys (Wald statistic = 3.29, $p = 0.07$). This implies

Table XI. Logistic Regression Models for Respondents' Actions of "Throw Away All Dog Food/Toys"^a

	Dog Food		Toys	
	Coefficient	Wald Test	Coefficient	Wald Test
Judged probability	12.74	4.45**	2.83	4.26**
Trust in authorities (1 = do not trust; 7 = fully trust)	3.30	1.53	0.79	3.29*
Information sufficiency (1 = not enough; 7 = enough)	0.97	0.60	-0.21	0.35
Overall concern (1 = not concerned; 7 = very concerned)	-1.83	2.54	0.09	0.10
Controllability (1 = controllable; 7 = uncontrollable)	-0.91	1.12	0.44	2.37
Dread (1 = not dread; 7 = dread)	3.08	2.88*	0.29	1.53
Severity (1 = consequences not fatal; 7 = consequences fatal)	-0.49	0.27	-0.45	1.29
Voluntariness (1 = voluntarily; 7 = involuntarily)	0.39	0.46	0.12	0.28
Known to exposed (1 = known precisely; 7 = not known)	-0.13	0.06	-0.42	2.82*
Immediacy of effect (1 = effect immediate; 7 = effect delayed)	0.99	1.30	0.00	0.00
Newness (1 = old; 7 = new)	-1.27	3.15*	0.19	0.57
U.S. index ^b	-2.03	1.20	-0.24	0.22
China index ^b	2.18	2.10	-0.14	0.10
Japan index ^b	-4.31	3.70*	-0.47	0.71
Mexico index ^b	-0.63	0.22	-0.18	0.20
Gender (1 = male; 2 = female)	-0.20	0.01	-2.73	2.63
Age (years)	0.69	1.07	-0.11	0.27
Race (1 = Asian American; 0 = non-Asian American)	10.11	4.48**	0.18	0.04
Dogs (no.)	0.80	0.90	-	-
Cats (no.)	6.77	2.58	-	-
Wear seatbelt when riding in a car (1 = never; 7 = always)	1.14	3.00*	-0.10	0.10
Young siblings (no.)	-	-	0.38	0.71
Babysitting experience (1 = yes; 0 = no.)	-	-	0.76	0.86
Constant	-14.23	0.87	8.38	1.70
R^2 (Cox and Snell)	0.47		0.32	

^aIn the contaminated dog food scenario, the dependent variable is the action of "Throw away all dog food." In the lead-painted toys scenario, the dependent variable is the action of "Throw away all toys."

^b1 = do not trust/not satisfied; 7 = fully trust/satisfied. We averaged respondents' ratings of products made in China on the three scales to be the general quality index of China in both logistic regression models.

*Significant at 0.10 level; **significant at 0.05 level; ***significant at 0.01 level.

that respondents who had more trust in the product recall information provided by the government were more likely to adopt cautious actions against potentially contaminated products. The risk being known to those exposed was also found to be a significant predictor of the cautious action of throwing away all toys at the 0.10 level (Wald statistic = 2.82, $p = 0.093$). So, respondents who perceived the risk of lead-painted toys to be known precisely were more likely to throw away the toys.

6. DISCUSSION

We examined both the pet food and children's toys product recalls in a single study since we felt that both would have similar response patterns, being products for protected household members where their adverse effects come from ingestion via the mouth. When participants focused on the adverse ef-

fects due to just the recall event, their probability answers were higher than when they considered all adverse effects from any cause. So, when faced with a product recall event, extensive news coverage could make the public overestimate the actual probability for potential adverse outcomes. Thus, companies or regulators could provide information about future recall risks by putting the current risk in perspective by lumping it with other similar risks. A focus on all risks might lead consumers to display less bias in their probability judgments. However, we also found that when risks are unpacked, the probability judgment is higher than when they are packed together. The challenge for risk communication is to reframe information messages to get people to consider total risks from different causes in a lumped together way, even when the risk message has been prompted by a specific recall event.

Our results also suggest that there might be a paradox in the value of information when people

are faced with a product recall event. On one hand, we find that when a recall is publicized, it can lead to greater overestimation of the actual probability for potential adverse outcomes associated with the focal recall event. This implies that more information leads to an upward bias in people's subjective risk judgments. On the other hand, we found that "Check websites for more information" is the option that people choose the most during the outbreak of a product recall. That is, more information is desirable for the general public before they make their product use/disposal/repurchase decisions. More empirical research is needed to examine this possible paradox in the effect of added information when product quality risks are involved. Our results could also help policymakers frame additional information gathering efforts. Questions that could be investigated regarding pet food and toy safety include: At what level of perceived risk would individuals call the emergency (911) number or the poison control center? When would they use government resources to help mitigate risk? If the government or an agency recommended that they throw out the items, would they comply? Are the respondents concerned about the businesses that might suffer from the recall?¹⁶

Risk communication has also been examined from a sociological perspective.^(82,83) For instance, Mileti and Fitzpatrick⁽⁸⁴⁾ constructed a model to describe public perception and response to communication about natural hazards risks. They found that additional communications encouraged personal search for more information. More specifically, from the information processing perspective, people's response to hazard information can be divided into eight stages:^(85–88) (1) receiving the warning; (2) understanding the warning; (3) believing the warning; (4) confirming the threat; (5) personalizing the threat; (6) determining whether or not protective action is needed; (7) determining whether protective action is feasible; and (8) taking protective action. Note that although our work originated from a psychological perspective, our study does contribute to several stages in the above framework, such as stage 2 (how probabilistic information is understood in different formats), stage 3 (participants' trust in institutions), and stages 6, 7, and 8 (analysis of participants' actions).

Our results on perceptions of toys with lead paint risks are timely since the United States has recently

enacted higher safety standards for toys with lead paint risks via the Consumer Product Safety Improvement Act (CPSIA), which added certification and testing requirements for all products subject to CPSC standards or bans, including lead in paint on toys. This is consistent with consumers' opinions regarding lead paint in toys.¹⁷ However, the CPSC recently issued a one-year stay of enforcement until February 10, 2010 for certain testing and certification requirements of the CPSIA for manufacturers and importers of regulated products, including products intended for children 12 years old and younger. The stay of enforcement permitted toy providers to not have to prove they had tested their products, but they were still required to meet the lead standards.

Food safety also is a continuing public concern. At the National Center for Food Protection and Defense, founded in 2004 at the University of Minnesota, researchers are working on developing best practices for effective risk communications related to potentially catastrophic food bioterrorism incidents from a practice-oriented viewpoint. They have developed a Risk Communication Tool Kit and several case studies, including one on the Schwan's Salmonella crisis⁽⁸⁹⁾ and one on tainted strawberries.⁽⁹⁰⁾

Similarly, our findings on country of origin of products are timely, since the U.S. Department of Agriculture's mandatory country-of-origin labeling program's final regulation became effective on March 16, 2009, requiring labels for meat, fish, fruits, vegetables, and some nuts. This recent labeling policy is also consistent with consumers' opinions.¹⁸ In addition, the American Veterinary Medical

¹⁷ More specifically, lead paint in toys is of broad concern as demonstrated in the nationwide Pew Food Safety Survey (2008), where 1,002 U.S. adult interviewees were asked whether they considered "Toys for children being made with unsafe materials, such as lead-based paint" to be a serious problem. Fifty-seven percent said it was a "Serious problem that is fairly common," and 27% said it was a "Serious problem that rarely occurs." A larger percentage felt that toys were a fairly common serious problem than were prescription medications marketed prior to adequate testing (44%), fresh fruits and vegetables contaminated with bacteria that make them unsafe to eat (42%), or automobiles having flaws or faulty parts making them unsafe to drive (35%).

¹⁸ For example, among U.S. respondents (who described themselves as interested in food safety) in an August 2008 U.S. food safety survey by the Center for Science in the Public Interest, 51.6% were very concerned with the safety of domestically produced foods and 78.9% were very concerned with the safety of imported foods. Regarding U.S. food safety, 93% of the consumers in the deWaal⁽⁸⁰⁾ survey were very supportive of

¹⁶ We are grateful to an anonymous referee for suggesting these questions.

Association also approved policy changes on June 10, 2008 to use “pet food health claims” to replace the existing policy on “pet food therapeutic claims,” which indicated the increasing attention on health aspects of pet food.

During the summer of 2008, there was a new food contamination outbreak of the Salmonella Saint Paul strain in the United States, apparently from fresh vegetables.⁽⁹¹⁾ At first thought to be in tomatoes, later investigations pointed toward jalapeño or serrano peppers grown with contaminated water on a farm in the state of Nuevo Leon in northeastern Mexico as the potential source.⁽⁹²⁾ Our work can help shed light on such an evolving issue in the multinational food supply chain, both by providing a template for future surveys on evolving risks and by examining our results on the pattern of responses for products from different countries (in this case from Mexico) and where other contaminated food items fell in the factor analysis in Fig. 1. Contaminated spinach was near dog food on the vertical axis at moderately unknown risk and spinach was a bit more dread than dog food on the horizontal axis. Mad cow disease was even more dread. For future recall events, an examination of where the new risk falls on these dimensions could aid in understanding how the public might react.

7. CONCLUSIONS

Following the recent media focus on product quality risks in the contaminated pet food and lead-painted toy recalls, we examined risk perceptions and decisions related to these two recalls. Two approaches were used to explore risk perceptions of the product recalls. In the first approach, we elicited judged probabilities and found that people appear to have greatly overestimated the actual risks for both product scenarios. In the second approach, we applied the psychometric paradigm to examine risk perception dimensions among eight health risks. It was found that the contaminated dog food was most unknown, most new, but least dread. The lead-painted toys were the third most unknown, third most new, and second least dread. Examining these results via factor analysis, we found that both contaminated dog food and lead-painted toys were near each other and near contaminated spinach and cell phone radiation in the two-factor space of the risk perception map,

country-of-origin labeling. Eighty percent would support more detailed labeling, down to region, country, state, and farm.

and had similar patterns to what prior research found for lead paint.

Further, we found that the top three actions would be the same under the scenario of people hearing of pet and child risks: “Check websites for more information,” “Read/listen to news coverage,” and “Throw away all dog food/toys.” As could be expected, a higher subjective probability of quality risks was significantly associated with arguably more cautious actions, such as “Throwing away all dog food/toys.” Taken together, our results suggest that educating consumers about product quality risks can ultimately help them make better informed decisions, based upon more realistic assessments of actual risks.

ACKNOWLEDGMENTS

The authors gratefully thank the editor Michael Greenberg, the area editor Ann Bostrom, and three anonymous reviewers for their extremely thoughtful and constructive reviews, which have significantly helped improve the article. Portions of this work were supported by grants to Professor Tianjun Feng from the National Natural Science Foundation of China (Grant 70901022), the Ph.D. Programs Foundation of Ministry of Education of China (Grant 20090071120082), and the Shanghai Science and Technology PuJiang Funds (Category C), and Professor Liangyan Wang from the Ministry of Education of China (Grant 09YJC630156 and Grant for Overseas-Returnees). Prior versions of this article were presented at the INFORMS 2008 Annual Meeting in Washington, DC, and as posters at the 2008 Judgment/Decision Making conference in Chicago and the 2008 Behavioral Decision Research in Management conference at UCSD.

REFERENCES

1. U.S. FEMA news release. The Year of the Recall, 2007. Available at: <http://www.fema.gov/news/newsrelease.fema?id=37850>, Accessed on July 18, 2008.
2. Weise E, Schmit J. FDA limits Chinese food additive imports. USA Today, April 30, 2007.
3. U.S. Food and Drug Administration (FDA) News Alert, 2008. Available at: http://www.fda.gov/ora/fiars/ora_import_ia9929.html, Accessed on January 7, 2008.
4. U.S. Consumer Product Safety Commission news. Mattel Recalls Various Barbie® Accessory Toys Due to Violation of Lead Paint Standard, 2007. Available at: <http://www.cpsc.gov/cpscpub/prerel/prhtml07/07301.html>, Accessed on September 4, 2008.
5. Dockins C, Jenkins RR, Owens N, Simon NB, Wiggins LB. Valuation of childhood risk reduction: The importance of

- age, risk preferences, and perspective. *Risk Analysis*, 2002; 22(2):335–346.
6. Johnson FR, Ozdemir S, Mansfield C, Hass S, Siegel CA, Sands BE. Are adult patients more tolerant of treatment risks than parents of juvenile patients? *Risk Analysis*, 2009; 29(1):121–136.
 7. Schaper D. Thomas Tank Engine Toy Recall Angers Parents, 2007. Available at: <http://www.npr.org/templates/story/story.php?storyId=11271805>, Accessed on June 22, 2008.
 8. Slovic P, Monahan J, MacGregor DG. Violence risk assessment and risk communication: The effects of using actual cases, providing instruction, and employing probability versus frequency formats. *Law and Human Behavior*, 2000; 24(3):271–296.
 9. Liao Q, Lam WWT, Jiang CQ, Ho EYY, Liu YM, Zhang WS, Richard F. Avian influenza risk perception and live poultry purchase in Guangzhou, China, 2006. *Risk Analysis*, 2009; 29(3):416–424.
 10. Fiedler K, Armbruster T. Two halves may be more than one whole: Category split effects on frequency illusions. *Journal of Personality and Social Psychology*, 1994; 66(4):633–645.
 11. Fischhoff B, Slovic P, Lichtenstein S. Fault trees: Sensitivity of estimated failure probabilities to problem representation. *Journal of Experimental Psychology: Human Perception Performance*, 1978; 4:330–344.
 12. Kahneman D, Slovic P, Tversky A. *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press, 1982.
 13. Rottenstreich Y, Tversky A. Unpacking, repacking, and anchoring: Advances in support theory. *Psychological Review*, 1997; 104:406–415.
 14. Teigen KH. Overestimation of subjective probabilities. *Scandinavian Journal of Psychology*, 1974; 15:56–62.
 15. Tversky A, Koehler DJ. Support theory: A nonextensional representation of subjective probability. *Psychological Review*, 1994; 101:547–567.
 16. Biswas D, Keller LR, Burman B. Making Probability Judgments of Future Product Failures: The Role of Mental Unpacking. Working paper, 2009. Bentley University, Waltham, MA.
 17. Tversky A, Kahneman D. Judgment under uncertainty: Heuristics and biases. *Science*, 1974; 185(4157):1124–1131.
 18. Slovic P, Fischhoff B, Lichtenstein S. Characterizing perceived risk. Pp. 91–125 in Kates RW, Hohenemser C, Kaspersen JX (eds). *Perilous Progress: Managing the Hazards of Technology*. Boulder, CO: Westview Press, 1985.
 19. Slovic P. Perception of risk. *Science*, 1987; 236(4799):280–285.
 20. Slovic P. Perception of risk: Reflections on the psychometric paradigm. Pp. 117–152 in Krinsky S, Golding D (eds). *Social Theories of Risk*. New York: Praeger, 1992.
 21. Frewer LJ, Miles S, Marsh R. The media and genetically modified foods: Evidence in support of social amplification of risk. *Risk Analysis*, 2002; 22:701–711.
 22. Laros FJM, Steenkamp JEM. Importance of fear in the case of genetically modified food. *Psychology and Marketing*, 2004; 21(11):889–908.
 23. Lang JT, Hallman WK. Who does the public trust? The case of genetically modified food in the United States. *Risk Analysis*, 2005; 25:1241–1252.
 24. Hammitt JK. Risk perceptions and food choice: An exploratory analysis of organic- versus conventional-produce buyers. *Risk Analysis*, 1990; 10(3):367–374.
 25. Williams PRD, Hammitt JK. A comparison of organic and conventional fresh produce buyers in the Boston area. *Risk Analysis*, 2000; 20:735–746.
 26. Williams PRD, Hammitt JK. Perceived risks of conventional and organic produce: Pesticides, pathogens, and natural toxins. *Risk Analysis*, 2001; 21:319–330.
 27. Parry SM, Miles S, Tridante A, Palmer SR, South and East Wales Infectious Disease Group. Differences in perception of risk between people who have and have not experienced Salmonella food poisoning. *Risk Analysis*, 2004; 24(1):289–299.
 28. Fife-Schaw C, Rowe G. Public perceptions of everyday food hazards: A psychometric study. *Risk Analysis*, 1996; 16:487–500.
 29. Frewer LJ, Howard C, Hedderley D, Shepherd R. What determines trust in information about food-related risks? Underlying psychological constructs. *Risk Analysis*, 1995; 16:473–485.
 30. Dosman DM, Adamowicz WL, Hrudef SE. Socioeconomic determinants of health- and food safety-related risk perceptions. *Risk Analysis*, 2001; 21:307–317.
 31. Fischer ARH, De Jong AEI, De Jonge R, Frewer LJ, Nauta MJ. Improving food safety in the domestic environment: The need for a transdisciplinary approach. *Risk Analysis*, 2005; 25(3):503–517.
 32. Fischer ARH, Frewer LJ, Nauta MJ. Towards improving food safety in the domestic environment: A multi-item Rasch scale for the measurement of the safety efficacy of domestic food handling practices. *Risk Analysis*, 2006; 26(5):1323–1338.
 33. de Jonge J, van Trijp H, Jan Renes R, Frewer L. Understanding consumer confidence in the safety of food: Its two-dimensional structure and determinants. *Risk Analysis*, 2007; 27(3):729–740.
 34. Siegrist M. The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. *Risk Analysis*, 2000; 20(2):195–204.
 35. Savadori L, Savio S, Nicotra E, Rumiati R, Finucane M, Slovic P. Expert and public perception of risk from biotechnology. *Risk Analysis*, 2004; 24(5):1289–1299.
 36. Liu J, Smith VK. Risk communication and attitude change: Taiwan's national debate over nuclear power. *Journal of Risk and Uncertainty*, 1990; 3:331–349.
 37. Hadden SG. Public perception of hazardous waste. *Risk Analysis*, 1991; 11:47–57.
 38. Border RJ, O'Connor RE. Determinants of risk perceptions of a hazardous waste site. *Risk Analysis*, 1992; 12(3):411–416.
 39. Peters RG, Covello VT, McCallum DB. The determinants of trust and credibility in environmental risk communication: An empirical study. *Risk Analysis*, 1997; 17(1):43–54.
 40. Parnell GS, Frimpon M, Barnes J, Kloeber JM Jr, Deckro RF, Jackson JA. Safety risk analysis of an innovative environmental technology. *Risk Analysis*, 2001; 21(1):143–155.
 41. Siegrist M, Cvetkovich G. Perception of hazards: The role of social trust and knowledge. *Risk Analysis*, 2000; 20(5):713–719.
 42. Basili M, Franzini M. Understanding the risk of an avian flu pandemic: Rational waiting or precautionary failure? *Risk Analysis*, 2006; 26(3):617–630.
 43. Fischhoff B, de Bruin WB, Guvenc U, Caruso D, Brilliant L. Analyzing disaster risks and plans: An avian flu example. *Journal of Risk and Uncertainty*, 2006; 33(1):131–149.
 44. Suder G, Inthavong S. New health risks and sociocultural contexts: Bird flu impacts on consumers and poultry businesses in Lao PDR. *Risk Analysis*, 2008; 28(1):1–12.
 45. Pennings JME, Wansink B, Meulenberg MTG. A note on modeling consumer reactions to a crisis: The case of the mad cow disease. *International Journal of Research in Marketing*, 2002; 19:91–100.
 46. Setbon M, Raude J, Fischler C, Flahault A. Risk perception of the “mad cow disease” in France: Determinants and consequences. *Risk Analysis*, 2005; 25:813–826.
 47. Adda J. Behavior towards health risks: An empirical study using the “mad cow” crisis as an experiment. *Journal of Risk and Uncertainty*, 2007; 35:285–305.

48. Viscusi WK. Do smokers underestimate risks? *Journal of Political Economy*, 1990; 98:1253–1269.
49. Viscusi WK. Age variations in risk perceptions and smoking decisions. *Review of Economics and Statistics*, 1991; 73:577–588.
50. Liu J, Hsieh C. Risk perception and smoking behavior: Empirical evidence from Taiwan. *Journal of Risk and Uncertainty*, 1995; 11:139–157.
51. Antoñanzas F, Viscusi WK, Rovira J, Braña FJ, Fabiola P, Carvalho I. Smoking risks in Spain: Part I—Perception of risks to the smoker. *Journal of Risk and Uncertainty*, 2000; 21(2/3):161–186.
52. Viscusi WK, Carvalho I, Antoñanzas F, Rovira J, Braña FJ, Portillo F. Smoking risks in Spain: Part III—Determinants of smoking behavior. *Journal of Risk and Uncertainty*, 2000; 21:213–234.
53. Viscusi WK, Hersch J. Cigarette smokers as job risk takers. *Review of Economics and Statistics*, 2001; 83(2):577–588.
54. Khwaja A, Sloan F, Chung S. The effects of spousal health on the decision to smoke: Evidence on consumption externalities, altruism and learning within the household. *Journal of Risk and Uncertainty*, 2006; 32(1):17–35.
55. Srinivasan N, Jain SC. Country of origin effect: Synthesis and future. Pp. 458–476 in Jain SC (ed). *Handbook of Research in International Marketing*. Cheltenham, UK: Edward Elgar, 2003.
56. Landrigan PJ. Forward. *Pest Control in Public Housing, Schools, and Parks: Urban Children at Risk*, 2002. Available at: <http://www.oag.state.ny.us/environment/pest-control/report.html>, Accessed on April 19, 2008.
57. Kleinhesselink RR, Rosa EA. Cognitive representation of risk perceptions: A comparison of Japan and the United States. *Journal of Cross-Cultural Psychology*, 1991; 22(1):11–28.
58. Brun W. Cognitive components in risk perception: Natural versus manmade risks. *Journal of Behavioral Decision Making*, 1992; 5(2):117–132.
59. Holtgrave DR, Weber EU. Dimensions of risk perception for financial and health risks. *Risk Analysis*, 1993; 13(5):553–558.
60. Karpowicz-Lazreg C, Mullet E. Societal risk as seen by the French public. *Risk Analysis*, 1993; 13(3):253–258.
61. Mullet E, Duquesnoy C, Raiff P, Fährasmane R, Namur E. The evaluative factor of risk perception. *Journal of Applied Social Psychology*, 1993; 23(19):1594–1605.
62. Johnson BB, Slovic P. Presenting uncertainty in health risk assessment: Initial studies of its effects on risk perception and trust. *Risk Analysis*, 1995; 15(4):485–494.
63. The American Veterinary Medical Association (AVMA). U.S. Pet Ownership & Demographics Sourcebook (2007 Edition) Available at: <http://www.avma.org/reference/marketstats/sourcebook.asp>, Accessed on June 16, 2008.
64. U.S. Centers for Disease Control and Prevention (CDC). Update on Multi-State Outbreak of E. coli O157:H7 Infections from Fresh Spinach, 2006. Available at: <http://www.cdc.gov/foodborne/ecolispinach/100606.htm>, Accessed on October 6, 2008.
65. Beigel JH, Farrar J, Han AM, Hayden FG, Hyer R, de Jong MD, Lochindarat S, Nguyen TK, Nguyen TH, Tran TH, Nicoll A, Touch S, Yuen KY. Avian influenza A (H5N1) infection in humans. *New England Journal of Medicine*, 2005; 353(13):1374–1385.
66. United States Department of Agriculture, Animal and Plant Health Inspection Service. Bovine Spongiform Encephalopathy: An Overview, 2006. Available at: http://www.aphis.usda.gov/publications/animal_health/content/printable_version/BSEbrochure12-2006.pdf, Accessed on December 12, 2008.
67. World Health Organization. WHO Guidelines for the Global Surveillance of Severe Acute Respiratory Syndrome (SARS), 2004. Available at: http://www.who.int/csr/resources/publications/WHO_CDS_CSR_ARO_2004_1/en/index.html, Accessed on October 15, 2008.
68. Fischhoff B, Slovic P, Lichtenstein S, Read S, Combs B. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Science*, 1978; 9:127–152.
69. Lowrance WW. *Of Acceptable Risk*. Los Altos, CA: Wm. Kaufman, 1976.
70. Starr C, Rudman R, Whipple C. Philosophical basis for risk analysis. *Annual Review of Energy*, 1976; 1:629–662.
71. McDaniel T, Axelrod LJ, Slovic P. Characterizing perception of ecological risk. *Risk Analysis*, 1995; 15(5):575–588.
72. Slovic P, Lichtenstein S, Fischhoff B. Modeling the societal impact of fatal accidents. *Management Science*, 1984; 30(4):464–474.
73. Peterson RA, Jolibert AJ. A meta-analysis of country-of-origin effects. *Journal of International Business Studies*, 1995; 26(4):883–900.
74. Verlegh PW, Steenkamp Jan-Benedict EM. A review and meta-analysis of country-of-origin research. *Journal of Economic Psychology*, 1999; 20(5):521–546.
75. Iyer GR, Kalita JK. The impact of country-of-origin and country-of-manufacture cues on consumer perceptions of quality and value. *Journal of Global Marketing*, 1997; 11(1):7–28.
76. Ahmed SA, d'Astous A. Antecedents, moderators and dimensions of country-of-origin evaluations. *International Marketing Review*, 2008; 25(1):75–106.
77. Mizrahi K. Americans' attitudes toward immigrants and immigration: The role of values, social identification, and attitudinal ambivalence. Dissertation Abstracts International: Section B: The Sciences and Engineering, 66(3-B), 2005.
78. Wong-Kim E, Sun A, DeMattos MC. Assessing cancer beliefs in a Chinese immigrant community. *Cancer Control*, 2003; 10(5):22–28.
79. Bonin H, Constant A, Tatsiramos K, Zimmermann KF. Native-migrant differences in risk attitudes. *Applied Economics Letters*, 2009; 16(15):1581–1586.
80. deWaal CS. Imported Food: USDA's Options for Change Limited by 1906 Statute and Consumer Confidence, Presentation at National Advisory Committee on Meat & Poultry Inspection Meeting, 2008. Available at: http://www.fsis.usda.gov/about_fsis/NACMPI_Meetings/index.asp#August, Accessed on August 27, 2008.
81. Weise E. Buying only U.S. food is a tall order. *USA TODAY*, July 10, 2007. Available at: http://www.usatoday.com/news/health/2007-07-10-american-goods_N.htm, Accessed on January 30, 2009.
82. Tierney KJ, Lindell MK, Perry RW. *Facing the Unexpected: Disaster Preparedness and Response in the United States*. Washington, DC: Joseph Henry Press, 2001.
83. Tierney KJ. From the margins to the mainstream? Disaster research at the crossroads. *Annual Review of Sociology*, 2007; 33:503–525.
84. Mileti D, Fitzpatrick C. The causal sequence of risk communication in the Parkfield earthquake prediction experiment. *Risk Analysis*, 1992; 12(3):393–400.
85. Donner W. *An Integrated Model of Risk Perception and Protective Action: Public Response to Tornado Warnings*. Newark, DE: PhD Dissertation, Department of Sociology and Criminal Justice, University of Delaware, 2007.
86. Lindell M, Perry R. *Behavioral Foundations of Community Emergency Planning*. Bristol, PA: Hemisphere, 1992.

87. Mileti D, Sorensen J. Communication of Emergency Public Warnings: A Social Science Perspective and State of the Art Assessment. Oak Ridge, TN: Oak Ridge National Laboratory, 1990.
88. Mileti D. Disasters by Design: A Reassessment of Natural Hazards in the United States. Washington, DC: John Henry Press, 1999.
89. McIntyre JJ. Social responsibility: Lessons learned from Schwan's salmonella crisis. Pp. 9–19 in Sellnow T, Littlefield R (eds). Lessons Learned About Protecting America's Food Supply, Case Studies in Crisis Communication. Fargo, ND: North Dakota Institute for Regional Studies, 2005.
90. Novak J. Crisis plans and interagency coordination: Lessons learned from tainted strawberries in the school lunch program. Pp. 47–56 in Sellnow T, Littlefield R (eds). Lessons Learned About Protecting America's Food Supply, Case Studies in Crisis Communication. Fargo, ND: North Dakota Institute for Regional Studies, 2005.
91. Hsu T. Salmonella “smoking gun” located. Los Angeles Times, July 31, 2008, C1–C2.
92. U.S. Food and Drug Administration (FDA). U.S. Grown Jalapeño and Serrano Peppers Not Connected to Salmonella Saintpaul Outbreak, 2008. Available at: <http://www.cdc.gov/foodborne/ecolispinach/100606.htm>, Accessed on July 25, 2008.