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Present Risk, Future Risk Or No Risk - Measuring and Predicting Perceptions of Health Risks of a Hazardous Waste Landfill

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Introduction: Measuring Perceived Risk

Over the past several decades, social scientists have helped to illuminate dozens of social, psychological, demographic and contextual factors that influence perceptions of risk. Several attempts have been made to catalogue these factors.[1] These factors have become familiar to risk managers and risk communicators and are often expressed as, "Risks are perceived as more acceptable if they are seen as: voluntary, natural, familiar, chronic, controllable, fair, having delayed consequences, moral...."

While knowing about these basic factors is important, it is not always clear which are most important (or relevant) in specific situations involving hazardous technologies or facilities. Moreover, in situations involving existing facilities or technologies, many factors that might influence perceived risk are difficult or impossible to change. This often leaves risk communicators wondering about which of the factors they should give priority.

Part of the problem lies in the fact that studies of risk perception have generally fallen into three categories, varying both as to the nature and specificity of the hazards studied, and the relevance of the hazard to the respondents. For example, several studies have examined perceived

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1 *See, e.g.,* Vincent T. Covello, Peter M. Sandman & Paul Slovic, Risk Communication, Risk Statistics, and Risk Comparisons: A Manual for Plant Managers (1988); William K. Hallman & Abraham H. Wandersman, *Perception of Risk and Toxic Hazards,* in Psychosocial Effects of Hazardous Toxic Waste Disposal on Communities, 31 (Dennis L. Peck, ed. 1989); Billie Jo Hance, Caron Chess & Peter M. Sandman, Improving Dialogue with Communities: A Risk Communication Manual for Government (1989); Peter M. Sandman, Responding to Community Outrage: Strategies for Effective Risk Commuincation (1993); and Charles Vlek & Pieter-Jan Stallen, *Rational and Personal Aspects of Risk,* 45 ACTA Psych. 273 (1980).

risk using groups of respondents in laboratory settings using a psychometric approach.[2] In those investigations, subjects were typically asked to estimate the risks "to society" associated with broad categories of hazardous activities, such as nuclear power or skiing. While these studies were seminal in understanding risk perception, the hazards they examined had no special relevance to the respondents. In addition, they asked subjects to consider hazards without being given any particular ecological context for those hazards.[3] Thus, the respondents were comparing hazards in the abstract, rather than feeling particularly threatened by them.

In the second approach, studies have typically examined potential hazards of specific relevance to the subject population, often within the context of a siting controversy. For example, several studies have examined perceived risks associated with proposed hazardous waste facilities.[4] Because these studies involved populations engaged in real risk controversies, they have provided useful information concerning social and psychological

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[2] *See, e.g.,* Baruch Fischhoff et al., *How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits,* 9 Policy Sci. 127 (1978); Eric J. Johnson & Amos Tversky, Representations of perceptions of risks, 113 J. Exp. Psych.: Gen. 55 (1984); Paul Slovic, Baruch Fischhoff & Sarah Lichtenstein, Facts and Fears: Understanding Perceived Risk, in Societal Risk Assessment: How Safe is Safe Enough? 18 (Richard C. Schwing & W. A. Albers, eds. 1980).

[3] Vincent T. Covello, *The Perception of Technological Risks: A Literature Review,* 23 Tech. Forecast. & Soc Change 285 (1983).

[4] *See, e.g.,* Kenneth M. Bachrach & Alex J. Zautra, *Coping with a Community Stressor: The Threat of a Hazardous Waste Facility,* 26 J. Health & Soc. Behav. 127 (1985) and *Assessing the Impact of Hazardous Waste Facilities: Psychology, Politics, and Environmental Impact Statements,* in Advances in Environmental Psychology, Vol.6, Exposure to Hazardous Substances: Psychological Parameters, at 109 (Allen H. Lebovits, Andrew Baum & Jerome E. Singer, eds. 1986); Howard Kunreuther, William H. Desvousges & Paul Slovic, *Nevada's Predicament: Public Perceptions of Risk from the Proposed Nuclear Waste Repository,* 30(8) Environment 16, 30 (1988); Gary H. McClelland, William D. Schulze & Brian Hurd, The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site, 10 Risk Anal. 485 (1990); Jerry V. Mitchell, Perception of Risk and Credibility at Toxic Sites, 12 Risk Anal. 19 (1992); Kent E. Portney, Citizen Attitudes Toward Hazardous Waste Facility Siting: Public Opinion in Five Massachusetts Communities (1983) and *The Potential of the Theory of Compensation for Mitigating Public Opposition to Hazardous Waste Treatment Facility Siting: Some Evidence from Five Massachusetts Communities,* 14 Policy Stud. J. 81 (1985); Paul Slovic et al., *Perceived Risk, Stigma, and Potential Economic Impacts of a High-level Nuclear Waste Repository in Nevada,* 11 Risk Anal. 683 (1991); Alex J. Zautra, Kenneth M. Bachrach & Ana Cofresi, Assessment of Two Communities Adjacent to the Planned Hazardous Waste Treatment Facility (Final report to AZ Dept. Environmental Quality & Dept. of Health Services) (1987); and Alex J. Zautra, Ana Cofresi & Kenneth M. Bachrach, Stability and Caprice in Resident Perceptions of Environmental Hazards, (Community Responses to Environmental Hazards Symposium, Ann. Meeting, Am. Psych. Assn., New York) (1987).

influences on perceived risk. Yet these studies have been mainly prospective, eliciting residents' perceptions of risks that would be associated with a facility built near their homes. While the hazard was relevant, it posed no threat, because it had not yet been built. Therefore, any risk judgments had to be made in the abstract.

The third group of studies examined specific identifiable physical hazards of particular relevance to the subject population, such as exposure to radiation at Three Mile Island[5] and toxic chemicals at Love Canal.[6] Such studies illuminate social and psychological influences on perceived risk and psychosocial effects resulting from trying to cope with perceived threats. Yet, most studies in this group were conducted after discovery of the release of hazardous materials or other disaster, in the wake of extensive media coverage, and often with members of citizen action groups or litigants. As such, most respondents were confronted with evidence that community members might have been exposed to hazardous materials.

While the insights gained from these three kinds of studies have been important in understanding how people perceive risks, the contexts in which the studies have been conducted are atypical. Most risk decisions about technologies do not take place in the laboratory, and few as the result of a disaster or a siting controversy. As such, an important category of risks has gone relatively unstudied. There are thousands of existing and operating landfills, nuclear installations, factories, manufacturing plants and other facilities, that local residents may perceive as risks, though no conclusive evidence exists that the facilities have exposed people to hazardous materials. What factors influence perceptions of risks in these sites? With a few exceptions focusing mostly on property values,[7] few studies have examined this issue.

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5 *See, e.g.,* Laura M. Davidson, Andrew Baum& Daniel L. Collins, *Stress and control-related problems at Three Mile Island,* 12 J Appl. Soc. Psych. 349 (1982 andMary A. Dew, Evelyn J. Bromet & Herbert C. Schulberg, *Application of a Temporal Persistence Model to Community Residents' Long-term Beliefs about the Three Mile Island Nuclear Accident,* 17 J. Appl. Soc. Psych. 1071 (1987).

6 *See, e.g.,* Adeline G.Levine & Russell A. Stone, *Threats to People and What They Value: Residents' Perceptions of the Hazards of Love Canal,* in Advances in Environmental Psychology, Vol. 6, Exposure to Hazardous Substances: Psychological Parameter, 109 (Allen H. Lebovits, Andrew Baum & Jerome E. Singer, eds. 1986) and Russell A. Stone & Adeline G. Levine, *Reactions to Collective Stress: Correlates of Active Citizen Participation at Love Canal,* in Beyond the Individual: Environmental Approaches and Prevention, 153 (Abraham H. Wandersman & Robert Hess, eds. 1985).

7 Leslie A. Nieves, *Economic Impacts of Noxious Facilities: Incorporating the Effects of Risk Aversion,* 4 Risk 35 (1993).

This study examines perceptions of risks associated with a hazardous waste landfill in the southeastern U.S. that had been operating for more than ten years. However, unlike the sudden release of radiation at Three Mile Island or the discovery of a leaking waste dump at Love Canal, there has yet to be evidence of the release of hazardous materials at the waste facility.

Yet, several disturbing events have taken place that some residents link to the landfill. Several fish kills in an adjoining lake have occurred. Small amounts of chemicals were found in an aquifer below the facility (officially attributed to lubricants used to drill groundwater monitoring wells). In addition, blood tests revealed elevated levels of industrial solvents in a small sample of residents who live near the landfill. Yet, no single catastrophic incident has attracted widespread media attention nor any that most residents point to as the probable cause of harm.

Some residents believe that the landfill has already caused harm despite any clear physical evidence. Other residents do not believe that the landfill has caused current problems but do believe that the landfill has the potential for causing future problems. They argue that there is no such thing as a secure landfill and that all landfills eventually leak. Because of the temporal nature of these perceptions, we hypothesize that the standard approach in risk perception studies, to ask, "How risky is the facility?" is inadequate to capture the concerns of residents.

People commonly incorporate temporal information in many kinds of risk decisions. Personal experience in an age of planned obsolescence, repeatedly confirms that with age, most complex mechanical and electronic systems eventually fail and must be replaced. Excepting their grandfather's pocket-watch, few people have any experience with complex technologies that they might reasonably expect to pass onto their own grandchildren. We understand and have come to expect that "things wear out." Good maintenance may only delay the inevitable. That is one reason the trade-in value of a car does not equal what one originally paid for it, and the principal reason many people avoid buying a used car.

Thus, it should not be surprising that people apply this experience when considering other kinds of technologies. For example, if an aircraft is well-maintained, it may be safe to fly indefinitely. However, most people would probably feel safer in a two year old airplane than one that was twenty years old. They may also feel more comfortable living near a modern industrial facility than one built during the 1920's. Similarly,

given personal experience with an old house with a leaky roof and a cracked foundation, people may lack confidence that a hazardous waste landfill will not leak within the next one hundred years.

Asking "how risky is the facility" is inadequate for other reasons as well. Perceptions of risk implicitly involve personal and societal value judgments. To define how risky something is, one must identify its adverse effects on those things that one considers to be valuable. Fischhoff, Watson and Hope suggest that no definition of risk is suitable for all problems.[8] They suggest that definitions of risk must be generated that are relevant to specific circumstances.

When considering the risks posed by the hazardous waste landfill, community members in our study talked about various negative events or outcomes.[9] Some of these were specific, distinct events such as the probability of a leak or other accident. Others were less distinct ongoing processes, such as the probabilities of air or water pollution. Residents also talked about specific outcomes such as crop damage, damages to fish, pets or livestock, property damage or devaluation and human illness and mortality. In addition, they talked about risks related to the landfill, such as increased traffic hazards created by huge trucks carrying hazardous wastes exceeding the speed limit on their way to the facility.

Thus, perceived risk encompasses a very wide range of risks. A person's perception of risks may include a combination of many negative or undesired events, processes or outcomes.[10] As a result, how perceived risk is measured is important; different measures can lead to different conclusions about perceived risk.[11]

Perceived health risk was selected as a specific dependent measure because our preliminary interviews suggested that health risks were of greatest concern to the residents. This is consistent with Edelstein, who suggests that a primary impact of toxic exposures are perceptions that personal health or the health of one's family has been endangered.[12] Past

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8 Baruch Fischhoff, Stephen R. Watson & Chris Hope, *Defining Risk,* 17 Policy Sci. 123 (1984).

9 William K. Hallman, Coping with an Environmental Stressor: Perception of Risk, Attribution of Responsibility, and Psychological Distress in a Community Living Near a Hazardous Waste Facility (Doctoral Dissertation) (1989).

10 William K. Hallman & Abraham H. Wandersman, *Attribution of Responsibility and Coping with Exposure to Toxic Substances,* 48(4) J. Soc. Issues 101 (1992)

11 George Cvetkovich & Timothy C. Earle, Classifying Hazardous Events. 5 J. Env'l Psych. 5 (1985).

and current symptoms are often attributed to exposure, and concerns about future effects of exposure often result in anxiety about future illnesses, a shortened lifespan and genetic damage. One of the most robust findings in the literature on communities affected by hazardous wastes is an overriding concern with health.[13]

Here, we propose that it is important to recognize the multidimensional nature of perceived risk, paying particular attention to temporality. By narrowing the focus to perceived health risks, and by specifying temporality, measurement error can be reduced, resulting in improved theoretical precision. In better specifying the construct, creating more meaningful measures of perceived risk may be possible, providing greater insight into the social and psychological influences on risk perception.

Method

Respondents

Respondents were 268 residents over the age of eighteen from communities within a 25-mile radius of the hazardous waste facility mentioned previously. A total of 196 subjects were selected to be interviewed from the membership rolls of churches from four denominations in surrounding communities. Male and female respondents were selected in an alternating manner from as many different households as could be identified from the lists. Residents who lived within two miles of the landfill were oversampled, resulting in interviews with an additional 42 respondents. Finally, 21 members of a community action group opposed to the landfill and nine other community leaders were also interviewed. These additional samples were combined with the random sample to cover the broad range of opinions about the facility within the surrounding communities. The total sample was 55% female, the median age was 41 years and 80% had completed high school.

Materials

All of the measures were part of a much larger questionnaire designed to assess perceptions of risk, attributions of responsibility and coping

[12] Michael R. Edelstein, Contaminated Communities: The Social and Psychological Impacts of Residential Toxic Exposure (1988).

[13] *See, e.g.*, Michael R. Edelstein, The Social and Psychological Impacts of Groundwater Contamination in the Legler Section of Jackson, New Jersey (Report to a law firm) (1982); Martha Fowlkes & Patricia Miller, Love Canal: The Social Construction of Disaster (Report to the Federal Emergency Management Agency) (1982); Adeline Levine, Love Canal: Science, Politics and People (1982) and Levine & Stone, *supra* note 4.

behaviors in communities close to a hazardous waste landfill.[14] Dependent measures were created to try to capture residents' concerns about the landfill, based on open-ended discussions with key informants conducted prior to the interviews. Respondents were asked how much they were concerned, if at all, that they had been exposed to hazardous wastes from the landfill. They were also asked how much, if at all, they were concerned that hazardous wastes from the facility: had harmed their health; would cause health problems in their community in the future; would affect children born in the future; would cause cancer in adults; and would cause cancer in children. Each response was measured on a five-point scale, where 1 = "not at all concerned," and 5 = "concerned enough to be terrified." The respondents were also asked whether they agreed or disagreed that it was safe to: drink water from their taps at home; eat fish caught locally; and raise children in the community. These were measured on a five-point scale, where 1= "strongly agree" and 5 = "strongly disagree."

Independent variables were based on Vlek and Stallen's personal decision-making model of risk acceptability.[15] Proposed within that model are 32 "aspects of risk," grouped under eleven categories, hypothesized to influence perceptions of risk. They suggest that the acceptability of risky activity varies with: voluntariness of exposure; controllability of the consequences; distribution of consequences in time; distribution of consequences in space; context of probability assessment; context of accident evaluation; combination of accident-probability and "seriousness"; knowledge about the risky activity; condition of the respondent; social considerations; and confidence in experts/regulators. These aspects of risk were operationalized into 42 questions relevant to the context of the hazardous waste landfill.[16]

Procedure

Each interview was conducted face-to-face using a structured survey instrument. Interviewers were graduate students specifically trained to administer the survey. Complete interviews lasted between one and two hours. Confidentiality was assured and respondents were paid ten dollars for completing the interview.

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14 Hallman, *supra* note 9.

15 Vlek and Stallen, *supra* note 1.

16 *See* Appendix *infra.*

Results

Measures of Risk Perception

Two temporal measures of perceived risk were hypothesized as necessary to cover adequately residents' concerns about the health risks posed by the hazardous waste facility. To test this hypothesis and to create measures of perceived present and future health risk to be used in further analyses, the nine items representing various facets of perceived health risk were subjected to factor analysis. Principal components analysis extracted two factors for further analyses. The first factor had an eigen value of 4.46 and accounted for 49.6% of the total variance. The second factor had an eigen value of 1.13 and accounted for an additional 12.5% of the variance. A varimax rotation was performed to aid in the interpretation of the factors (Table 1). Factor one (Future) appeared to represent future health risks. Items loading most heavily on this factor referred to perceptions of the probability of health problems occurring in the future, the probability that children born in the future would be affected by hazardous wastes, and the probability that adults — as well as the probability that children — in the community would get cancer due to the facility. Factor two (Present) appeared to represent perceptions of present health risks. Variables that loaded most heavily on this factor were perceptions of: current exposure to hazardous wastes; the extent of current damage to health; the safety of local drinking water; the safety of eating fish caught locally; and the safety of raising children in the community.

Table 1

Summary Table of Factor Analysis on Dependent Measures of Perceived Present and Future Risk

	Principal Components Solution		*Varimax Rotated Solution*		
	Loadings		*Loadings*		
Item	*Factor 1*	*Factor 2*	*Factor 1 Future*	*Factor 2 Present*	*Communality*
Affect Future Generations	.75	.50	*.89*	.16	.81
Cause Future Health Problems	.71	.53	*.87*	.11	.78
Cause Cancer in Children	.77	.13	*.64*	.44	.61
Cause Cancer in Adults	.74	.16	*.64*	.41	.58
Safe to Drink Water	–.59	.50	–.08	*–.77*	.60
Safe Place to Raise Kids	–.60	.41	-.14	*–.71*	.52
Perceived Exposure to Waste	.77	–.20	.41	*.68*	.63
Perceived Health Effect	.77	–.13	.46	*.63*	.61
Safe to Eat Fish	–.62	.28	–.24	*–.63*	.46

Two measures were created through linear combinations of the variables loading most heavily on each factor. Each variable was given a coefficient of one, creating additive measures of perceived health risk that could be adopted for future studies. Reliability analyses (Cronbach's Alpha) were performed for each scale. The present risk scale yielded an alpha of 0.77. The future risk scale yielded an alpha of 0.84, showing that each measure has good internal consistency. Not surprisingly, the two measures of risk perception are significantly correlated with each other ($p < 0.001$), but the correlations are moderate ($r = 0.59$).

Predictors of Perceived Health Risk

Based on a literature review, Vlek and Stallen arranged their 32 aspects of risk under eleven categories based on "psychological grounds."[17] A confirmatory factor analysis was performed to test this eleven-category arrangement empirically. A full correlation matrix was produced to examine the relationships among the 42 items chosen to operationalize the model. After examining the matrix, two items were eliminated from the subsequent analysis because of weak relationships with other matrix variables. These were Sellhouse, which asks respondents whether they think they could get a fair price if they tried to sell their house and Choices, which asks if respondents feel that they have a choice about living in their community.

Principal components factor analysis was employed to select factors from the remaining 40 variables. Rather than producing the eleven factors that would be expected from the categorization scheme developed by Vlek and Stallen, twelve factors with eigen values greater than 1.0 were selected. These twelve factors account for a cumulative total variance of 62.3%. The factors were rotated using a varimax (orthogonal) rotation for ease in interpretation (Table 2). As seen, the resulting factors are quite different from groupings of variables proposed by Vlek and Stallen.

The first factor, Confidence, appears to group variables that represent confidence in experts and workers, that is, those responsible for operating and making sure the facility does not leak. The second, Benefits, groups variables that describe perceived benefits of the facility to oneself, one's friends, one's community, and society. It also includes variables that measure how much one knows about the benefits of the facility, and perceptions of how long the benefits will last. The third factor, Seriousness (Serious), combines variables that concern the seriousness of an accident to property, physical and psychological health, and the environment.

17 Vlek and Stallen, *supra* note 1.

Table 2
Summary Table of Factor Analysis Of Independent Measures - Varimax Rotation

	Varimax Rotated Factors												
	Cnf[a]	Ben	Ser	Img	Csq	Prb	Cnd	DstPr	Knw	Bus	Sup	Prx	Cm
Best	*.79*	.14	–.09	–.06	–.05	–.11	–.01	–.08	–.01	.09	.18	–.04	.72
Methods	.72	.07	–.14	–.16	–.04	–.21	.01	–.03	–.12	.02	.06	.07	.64
Experts	*.68*	.28	–.06	–.11	.08	–.15	.06	–.05	–.13	.05	–.05	.05	.62
Workers	*.68*	.22	.06	–.05	–.18	–.07	–.06	.00	.16	.02	.07	.03	.59
Has leaked	*–.57*	–.03	.18	.04	.29	.11	–.09	.30	–.16	.21	.07	.05	.63
Will leak	*–.41*	–.13	.21	.23	.31	.16	–.20	.24	–.04	.15	.06	.06	.54
How often	*–.40*	.05	.25	.32	–.06	.20	.13	.33	–.02	.05	.11	.21	.55
Benefits-Town	.25	*.74*	–.02	.07	–.15	–.06	–.08	–.06	–.04	.03	–.08	.15	.68
Benefit-Personal	.08	*.73*	–.03	–.19	–.09	–.05	.18	.00	.17	.02	.18	.09	.69
Benefits-Society	.31	*.68*	–.11	.07	–.10	–.16	.06	–.04	–.27	.01	.05	.01	.69
Benefit-Friends	.07	*.67*	–.02	–.05	–.01	.06	.03	–.06	.48	.09	–.20	–.07	.75
Benefits-Last	.17	*.49*	–.21	–.31	–.20	.00	.10	–.04	.06	.18	–.04	–.12	.52
Know–Benefits	–.02	*.40*	.05	.10	.26	–.04	.05	.20	.38	–.27	.35	–.16	.65
Physical	–.18	.02	*.78*	.09	.04	.06	.01	.01	.04	.09	.08	.15	.69
Environmental	–.20	–.05	*.71*	.18	.09	.08	.04	–.09	–.03	–.03	.03	.12	.62
Property	.00	–.07	*.70*	–.05	.16	.01	.04	.17	.01	–.15	–.10	–.13	.61
Psycholoical	.06	–.11	*.66*	.08	–.07	.25	–.02	.04	.04	–.18	–.05	–.04	.56
Picture	–.07	.00	.08	*.81*	.12	.04	.11	.11	.02	–.05	–.05	–.01	.72
To occur	–.19	–.11	.10	*.75*	–.01	.05	.09	.02	.09	.11	.16	–.04	.69
Problems-Last	–.26	–.15	.36	*.45*	.16	–.02	–.13	–.08	–.04	.17	–.18	–.21	.57
Spread	–.02	–.16	.05	.18	*.64*	.29	–.05	.00	.01	–.22	–.03	.02	.61
Cleanup	–.18	–.11	.30	–.01	*.61*	.01	.06	.03	.02	.06	–.28	–.20	.63
Regulations	.27	.14	–.05	–.04	*–.60*	.03	–.05	.14	.08	–.17	–.21	–.25	.63
Control-Person	–.25	.17	.17	–.29	*–.37*	–.21	.34	.09	.03	–.08	.15	–.03	.54
Disaster	–.18	–.09	.16	.14	.03	*.67*	.03	–.10	.06	.04	.11	–.06	.57
Terrorist	–.18	.01	.13	–.08	–.10	*.66*	–.01	.03	.17	–.06	–.05	.24	.60
Reckless	–.24	–.03	.05	.01	.23	*.65*	.02	.16	–.17	.02	–.07	–.07	.60
Human Error	–.10	–.11	.07	.07	.45	*.57*	–.02	.10	–.14	.06	.03	–.14	.62
Happens	.14	.08	–.03	.14	.08	.07	*.78*	.09	.06	.01	–.13	–.04	.70
Control-Others	–.03	–.05	.06	.00	–.09	–.07	*.73*	–.23	.16	.05	–.06	–.03	.65
Continue	–.03	.11	.01	.06	.01	.04	*.69*	.17	–.14	–.11	.10	.00	.57
Accident	–.06	–.16	–.05	.10	.00	–.02	–.01	*.74*	.12	–.01	–.04	.07	.61
Problems-Friends	–.35	.07	.22	–.02	–.16	.17	.07	*.53*	.17	.13	–.04	–.01	.56
Know-Problems	–.17	.12	.15	.38	.22	.04	.14	*.40*	.13	–.17	.25	–.12	.56
Worker-Related	.01	.09	.04	.05	–.10	.04	.07	.15	*.68*	.22	–.08	.14	.59
Tour	–.05	–.03	–.01	.12	–.02	–.07	.00	.14	*.58*	.01	.45	.21	.63
Business-Person	.03	.16	–.20	.11	–.06	.02	–.07	–.13	.01	*.73*	.09	.05	.65
Business-Related	.00	–.02	–.01	–.04	.10	.00	.00	.29	.31	*.64*	.03	–.06	.61
Soldland	.14	–.01	–.04	.02	–.05	.04	–.06	–.05	–.01	.12	*.74*	–.04	.60
Worked for	.07	.07	.04	–.05	.05	–.03	–.09	.04	.15	–.01	–.01	*.83*	.74
Mileaway	.18	–.05	–.10	.20	.30	–.13	–.10	–.32	–.09	–.14	.30	*–.37*	.56

[a] The factors are, respectively: Confidence, benefits, seriousness, imaginability, consequences, probability, control, distribution of problems, knowledge, business, supplier, proximity and communality.

The fourth factor, Imaginability, seems to incorporate variables that ask residents to imagine or project the circumstances and outcomes of an accident. These variables included: what would cause an accident; what would happen if an accident did happen; and an estimate of how long any problems from the facility might last.

The fifth factor, Consequences, joins four variables associated with the controllability of the consequences of an accident at the facility. These are: how difficult it would be to keep any leak from spreading into the water; an estimate of the difficulty of cleaning up any leak; whether there are an appropriate number of written regulations that govern the activities of the landfill; and the perception of the amount of personal control one had over the creation of the facility in the first place.

The sixth factor, Probability, incorporates four variables that ask residents to estimate the probability of an accident due to a specific cause, including: natural disaster, terrorism, recklessness, and, human error. The seventh, Control, combines three variables that deal with control issues and voluntariness of exposure. These are: a measure of perceived control people have over what happens at the facility; a measure of perceived control people had over its creation; and, a measure of a respondent's perception of personal control over its continued operation.

The eighth factor, Distribution of problems, combines three variables concerned with the distribution of problems or negative consequences associated with the facility. These variables are: a measure of personal involvement with accidents related to the facility; an estimate of how many of the respondent's friends, family or neighbors have had problems as the result of the facility; and an estimate of how much the respondent knew about problems related to it.

The ninth factor, Knowledge, combines two variables related to knowledge about the benefits, problems and operations of the facility. These are: whether the respondent has toured it or personally seen what happens there, and whether the respondent is related to someone who has worked there.

The tenth factor, Business, combines two variables that identify the respondent as having worked for a company other than the owner of the facility whose business is the transportation or disposal of hazardous waste, or as having been married or related to someone who has worked for such a company. The eleventh factor, Supplier, identifies respondents who have sold land, equipment or supplies to the facility. Finally, Proximity, combines a variable that identifies respondents who have personally worked at the facility and an estimate of its distance to the respondent's home.

Relationships Between Predictive Factors and Perceived Risk

Twelve measures were created through combinations of the variables using the rotated factor scores for each item within each factor. As can be

seen in Table 3, nine of the twelve measures were significantly correlated with one or both of the temporal measures of perceived health risk. Only the measures corresponding to control over exposure (Control), controllability of consequences (Consequences), and suppliers of equipment and supplies (Supplier) were not significantly correlated with at least one measure of perceived risk. In part, this is because there was so little variability in these measures. Few people within the community sold equipment or supplies to the facility. Moreover, after operating for more than ten years with virtually no community oversight, no one in the community felt that they had much control over the landfill.

Table 3
Correlations Between Varimax Factors and Perceptions of Present and Future Risk

	Zero–order Correlations		*Partial Correlations*	
	Present	*Future*	*Present* (Controlling for Future)	*Future* (Controlling for Present)
Confidence	**–.411**	**–.404**	**–.232**	**–.218**
Benefits	.007	*–.134*	.062	*–.124*
Seriousness	.184	.414	–.085	.385
Imaginability	–.043	.167	–.073	.180
Consequences	–.121	.045	–.184	*.146*
Probability	.244	.255	.119	*.141*
Control	.020	.027	.004	.020
Distribution of problems	.334	.275	.220	.102
Knowledge	.176	.058	.176	–.060
Business	*.139*	.072	.119	–.012
Supplier	.004	–.013	.014	–.019
Proximity	.198	.067	.197	–.064

Bold: Significant at the .01 level (two-tailed); N = 268.
Italic: Significant at the .05 level.

Lack of confidence in experts and workers (Confidence), greater problems perceived as associated with the facility (Distribution of problems), greater perceived probability of an accident happening (Probability) and greater perceived seriousness of such an accident (Seriousness) were all associated with greater perceived present and future health risks.

However, although greater perceived benefits attributed to the facility (Benefits) was associated with the perception of less future risk, the ability to imagine what would happen in an accident (Imaginability) was associated with the perception of more future risk. Yet neither were associated with

perceptions of present risk. In contrast, greater knowledge about what happens at the facility (Knowledge), having a relative who works for a related industry (Business) and greater proximity to the facility (Proximity) were associated with the perception of greater present risk, but not future risk.

Because the two measures of perceived risk were moderately correlated, partial correlations were calculated to control for shared variance (Table 3). In doing so, the pattern of correlations shows even greater differences between the measures. Lack of confidence in experts and workers (Confidence) was associated with greater perceived present and future risks. However, a greater ability to imagine what would happen if an accident occurred, and greater perceived seriousness of such an accident (Seriousness), were both associated with greater perceived future risk but were unassociated with present risk. In addition, greater perceived benefits (Benefits) of the facility were associated with less perceived future risk, but were unassociated with present risk.

Similarly, greater problems perceived as associated with the facility (Disribution of problems), greater knowledge about what happens at the facility (Knowledge) and greater proximity to the facility (Proximity) were each significantly correlated with perceived present risk but not future risk.

Interestingly, controllability of consequences of an accident at the facility (Consequences) did not show significant zero order correlations with either measure of perceived risk. However, the partial correlations show that greater perceived controllability of consequences was associated with perceptions of greater future risk, but less perceived present risk.

To explain this, the individual correlations among the four factors that make up this factor and the two temporal measures of perceived health risk were examined. Results show that one item, perceived personal control over the facility's initial siting (Control) had no significant zero-order correlation with either measure of perceived health risk. However, two of the items that make up the factor were positively associated with perceived future risk, but unrelated to perceptions of present risk. The two items were those measuring the difficulty in keeping a leak from the facility from spreading (Spread) $r(268) = .17$, $p < 0.01$, and the difficulty in cleaning up such a leak (Cleanup) $r(268) = .24$, $p < 0.01$. In contrast, the remaining item, a measure of the perception of the adequacy of regulations covering what happens at the facility (Regulations) $r(268) =$

–.18, $p < 0.01$, was negatively associated with perceived present risk but unassociated with perceived future risk.

To learn the extent to which the factors created predict perceived health risks, two stepwise regression analyses were performed. In the first regression, the measure of perceived present health risk was used as the dependent measure (Table 4). The final reduced model, composed of the factors, Confidence, Seriousness, Consequences, Probability, Distribution of problems (Distprob), Knowledge, Business and Proximity, had a total R^2 of 0.44.

Table 4
Summary of Stepwise Regression Analysis
for Factors Predicting Perceived Present Health Risk

Step	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	.1559	49.111	.000	In:	Confidence	–.3948
2	.2586	46.219	.000	In:	Distprob	.3206
3	.3120	39.915	.000	In:	Probability	.2311
4	.3499	35.384	.000	In:	Proximity	.1945
5	.3783	31.886	.000	In:	Seriousness	.1686
6	.4062	29.759	.000	In:	Knowledge	.1670
7	.4236	27.292	.000	In:	Business	.1317
8	.4371	25.137	.000	In:	Consequences	–.1162

Note: p to enter = .05, p to remove = .10

Table 5
Summary of Stepwise Regression Analysis
for Factors Predicting Perceived Future Health Risk

Step	*Rsq*	*F(Eqn)*	*SigF*		*Variable*	*BetaIn*
1	.1676	53.570	.000	In:	Seriousness	.4094
2	.3301	65.287	.000	In:	Confidence	–.4031
3	.4047	59.831	.000	In:	Distprob	.2732
4	.4680	57.847	.000	In:	Probability	.2516
5	.4962	51.609	.000	In:	Imaginability	.1678

Note: p to enter = .05, p to remove = .10

The second regression used the measure of perceived future health risk as the dependent measure (Table 5). The final reduced regression model, composed of the factors, Confidence, Seriousness, Consequences, Imaginability, Probability and Distribution of problems (Distprob), had a total R^2 of 0.50.

Discussion

Measures of Risk Perception

While this study narrows the field of investigation from perceived risk overall to *perceived health risk* specifically, the results of the factor analysis suggest that two temporally related constructs, perceived present health risk and perceived future health risk, are necessary to cover even this restricted domain. This is important because it further refines the nomological network that defines perceived health risk.

The results of the factor analysis of the operationalized measures of the Vlek & Stallen personal decision-making model of risk acceptability are also important.[18] The analysis did not reproduce the eleven factors as proposed by Vlek & Stallen. This is not surprising, given the difficulty in operationalizing many of the constructs detailed in their model. However, the pattern of zero-order and partial correlations between the factors derived and perceived present and future risk have face validity and suggest that people do make such temporal distinctions. Moreover, the factors show good power in their ability to predict the two measures of perceived risk. This suggests that perceptions of health risk may be more predictable, and less irrational than many believe.[19]

Since perceived present health risk and perceived future health risk are related constructs, it is not surprising that several factors are correlated with both measures. Still, notable differences exist between the predictors of perceived present health risk and perceived future health risk. These are particularly apparent when examining the partial correlations.

The first of these corresponds to the ability to imagine what would happen if a leak took place (Imaginability) and the seriousness of such an accident (Seriousness). That these factors are significantly correlated with perceived future health risk and not with perceived present health risk can be explained by the future-oriented context of the individual items that make up the factors. Similarly, that the distribution of current problems caused by the facility (Distribution of problems) has the strongest association with present risk can be explained by the present-tense nature of the items that make up the factor.

Two factors, (Knowledge and Proximity), predict present risk, but not future health risk. Each of these suggests that the respondent has some special knowledge about the facility or its present operations. Such

[18] *Id.*

[19] *Cf.* Abraham H. Wandersman & William K. Hallman, *Are People Acting Irrationally? Understanding Public Concerns About Environmental Threats,* 48 Am. Psychologist 681 (1993).

knowledge might come through taking a tour of the facility, or being related to someone who works there, working for a company that transports or disposes of hazardous waste, working for the facility or (Proximity) living close to it. That these factors are significantly correlated with present risk (although rather modestly $r < .20$), but not future risk makes sense. People with more knowledge about the present operation of the facility were among those who perceived the greatest present risk, with scores quite far from the mean. While these people are also among the most concerned about future risks, there were members of the community, with no special knowledge about the operations of the facility who were equally concerned.

The last factor is different. This group of items measures the extent to which people feel that they, their neighbors and their community have benefited from the operation of the landfill. Each item is significantly negatively correlated with perceived future health risk but unrelated to perceived present health risk. What is particularly interesting about this from a practical perspective, is that while greater perceived problems associated with the facility are associated with greater perceived present risk, greater perceived benefits (Benefits) is unassociated with present risk. Other studies have suggested a robust inverse relationship between perceived risks and benefits.[20] Similarly, the theory of compensation in siting hazardous waste facilities assumes that opposition to such facilities stems from some imbalance in peoples' individual cost-benefit calculations.[21] Following these models, one might try to increase or make more salient the benefits of a facility that faces opposition. However, the results of this study suggest that such a strategy might lessen the perception of future risk, but would have little effect on the perception of present risk. Therefore, while perceived present risk is affected by the perceived extent of problems associated with a facility, there is no offsetting effect of perceived benefits. This is consistent with Portney, who argues that the potential for influencing public opposition to the siting of hazardous waste treatment facilities through compensation alone seems low.[22]

Similarly, the results suggest that stressing the adequacy of existing regulations, and how the facility meets those existing regulations may

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[20] Ali S. Alhakami & Paul Slovic, A Psychological Study of the Inverse Relationship Between Perceived Risk and Perceived Benefit (1994).

[21] *See* Susan G. Hadden & Jared Hazelton, Public Policies Toward Risk, 9 Policy Studies J. 109 (1980).

[22] Portney (1985), *supra* note 4.

affect perceptions of future risk but not perceptions of present risk. As a result, such strategies may be effective in addressing the concerns of the segment of the population that is relatively unconcerned about the present risks of a facility, but is worried about such risks in the long term.

The distinction made here between present and future risk is potentially important to policy makers and particularly to risk communicators. The kind of ambiguous threat represented by the hazardous waste facility in the present study is quite common and should be familiar to most risk-communication practitioners. Often in such cases, some people are convinced that such a facility or technology presents an immediate health risk. Others do not think that there is an immediate problem, but that ultimately there will be one. Still others do not believe that there is a threat at all. As such, perceived present health risk and perceived future health risk are necessary constructs in considerations of perceived health risk. Future research should include temporal dimensions of health risk and interpretations of past studies of perceived risk should take into consideration which dimension was actually measured. The specific measures used in this study, while useful for measuring these constructs within the current context, are just a start. Better research requires improved measures that can be normalized and standardized so that they can be used in a variety of contexts and for comparative purposes.

Appendix
Operationalizations of Vlek and Stallen's Personal Aspects of Risk

Voluntariness of exposure

• *Availability of options*

(Sellhouse)	If I tried to sell my house today, I think that I could get a fair price for it.
(Choices)	I feel as though I have other choices besides living in this community.

• *Personal influence on the decision*

(Control–Person)	How much control do you personally feel you had over the facility's coming to your community?

• *The possibility of radically changing and/or correcting the chosen action*

(Continue)	How much control do you personally feel you have over the continued operation of the facility in your community?

• *The importance of intended benefits*

(Benefit–Town)	How important do you think any benefits of the facility are to your community?
(Benefit–Society)	How important do you think any benefits of the facility are to society in general?

Controllability of consequences

• Accident probabilities may be more or less influenced by safety measures

(Regulations) Do you feel that there are too many, just the right number or too few written regulations that apply to what happens at the facility?

• Accident probabilities are dependent upon opportunities for human error, recklessness and sabotage

(Human-error) How likely do you think an accident at the facility could be caused by human error?

(Reckless) How likely do you think an accident at the facility could be caused by recklessness?

(Terrorist) How likely do you think an accident at the facility could be caused by terrorists?

(Disaster) How likely do you think an accident at the facility could be caused by natural disaster?

• Accident-effects may be more or less influenced by rescue operations

(Spread) If a leak took place at the facility how hard would it be to keep the leak from spreading into the water?

• Accident-effects may be more or less reversible

(Cleanup) If a leak took place and it did spread to the water supply, how hard would it be to clean up the water?

Distribution of consequences in time

• Intended benefits may be obtained sooner or later

(Benefit-last) How long do you think any benefits of the facility will last?

• Undesired consequences may have immediate or delayed effects

(Problems-last) How long do you think that any problems of the facility will last?

Distribution of consequences in (social-) geographical space

• Benefits may occur closer-by or farther away

(Benefit-person) How much do you feel you have personally benefited from the facility?

(Benefit-friends) How many of your friends, family or neighbors would you say have benefited from the facility?

• Undesired consequences may occur at a greater or shorter distance.

(Mileaway) About how many miles away do you live from the facility?

(Problem-Friends) How many of your friends, family or neighbors would you say have had problems because of the facility?

Context of probability assessment

• Personal probabilities depend upon judged (relative) accident frequencies

(How often) How often do you think accidents occur at similar waste facilities?

• Personal probabilities depend upon the imaginability of events causing an accident to occur

(To occur) How well can you picture in your mind the things that would cause an accident to occur at the facility?

• Probabilities may be assessed with greater or lesser ambiguity

(Will leak) Do you believe that the facility will leak hazardous waste in the future?

(Has Leaked) Do you believe that the facility has leaked hazardous waste?

Context of accident evaluation

• *An accident is more serious to the extent that it violates central values or frustrates basic needs*

(Psychological) If an accident were to occur at the facility how serious would the damage be to peoples' psychological health?

(Physical) If an accident were to occur at the facility how serious would the damage be to peoples' physical health?

(Environment) If an accident were to occur at the facility how serious would the damage be to the environment?

(Property) If an accident were to occur at the facility how serious would the damage be to property values?

• *Accident effects may be more or less imaginable*

(Picture) How well can you picture in your mind what would happen if the facility had an accident?

• *The seriousness of an accident may be assessed with greater or lesser ambiguity*

(No questions)

Combinations/interactions of accident probability and seriousness

• *Equivalent expected losses may be categorized as (relatively) high-probability/small-loss risks versus low-probability/large-loss risks*

(No questions)

Knowledge about the risky activity

• *One can be better informed about intended benefits derived from the risky activity*

(Know-Benefits) How much do you feel you know about any benefits of the facility?

• *One can hear, read, or see more or less about the risks associated with the risky activity.*

(Know-Problems) How much do you feel you know about any problems of the facility?

(Tour) Have you ever taken a tour of the facility or seen what happens there?

• *One can have relevant personal accident experience.*

(Accident) Have you had any personal experience with any accidents related to the facility?

Condition of the subject

• *One's personal permanent condition can favor risk acceptance*

(Worked for) I have worked for the facility in the past.

(In Business) I have worked for a company other than X whose business is the transportation or disposal of hazardous wastes.

(Worker-related) I have been married or related to someone who has worked for the facility.

(Business-related) I have been married or related to someone who worked for a company other than X whose business is the transportation or disposal of hazardous wastes.

• *One's personal temporary condition can favor risk acceptance*

(Soldland) Have you ever sold land, equipment or supplies to the facility?

One's accumulated 'risk-load' can be larger or smaller (or more optimal)

(No questions)

Social considerations

• *The benefit/loss ratio is can be relatively favorable or unfavorable to the subject*

(No questions)

Voluntariness of exposure can be equitably or inequitably distributed

(Control-others) How much control do you feel people in the community had over the facility's coming to your community.

• *Controllability of consequences can be equitably or inequitably distributed*

(Happens) How much control do you feel people in the community have in what happens at the facility?

Social traditions, norms and customs favor risk acceptance

(No questions)

Confidence in experts/regulators

• *Experts/regulators may or may not be thought of as competent*

(Workers) How well trained do you think the workers are at the facility?

(Experts) How well trained do you think the safety experts are who are supposed to make sure the facility is safe?

• *Experts/regulators may or may not be thought of as using optimal strategies*

(Methods) Do you think that the facility uses the right materials, methods and equipment to take care of hazardous waste?

• *Experts/regulators may or may not be thought of as serving the subject's (group) interests*

(Best) Do you think that the safety experts at the facility are doing what is best for the community?