STRESS AND RADIOACTIVE WASTE MANAGEMENT

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ABSTRACT

In the Supreme Court case "People Against Nuclear Energy (PANE) vs. Metropolitan Edison," one of the conclusions was that the Nuclear Regulatory Commission did not have to consider psychological distress, community cohesiveness and sense of well-being in the supplement to the Environmental Impact Statement (EIS) covering the restart of Three Mile Island (TMI). This decision was based on the assumption that the intention of the National Environmental Policy Act (NEPA) is to focus on the physical environment, and the causal chain between psychological distress and adverse health effects is tenuous. Also, the risk of psychological distress is not considered a relevant issue under NEPA, and stress from the TMI accident could not be differentiated from general dissatisfaction or unpopularity associated with the existence of the nuclear power plant. As a result of this decision, little attention has been paid to the potential relationship between nuclear power, nuclear waste, and social psychological variables in subsequent EISs.

In this paper, we first summarize the literature on the relationship between environmentally-induced stress and its effects on health. Next, we present the results of a new survey research project in which levels of stress were evaluated in West Chicago, Illinois, a community in which radioactive wastes have been present for many years. Explanatory social variables are brought into the evaluation in which stress is evaluated as a function of proximity to the radioactive waste site. In addition, stress is discussed in the context of attitudes on nuclear power, environmental group participation, and knowledge about the health effects associated with radioactive waste. The paper ends with a discussion of the portion of the Supreme Court decision in which psychological distress, community stability, cohesiveness and sense of well being are excluded as variables to address in EISs.

INTRODUCTION

The relationship between environmentally-induced stress and the effects of such stress on the health of individuals and populations has not been well established. In fact, prior to the accidental release of radiation at the Three Mile Island (TMI) nuclear power plant in Harrisburg, Pennsylvania in 1979, there were few attempts to draw a causal link between stress that was caused by natural or man-made disasters, and public health. Since the TMI accident there have been numerous studies that have focused exclusively on this issue (1-3), primarily in response to lawsuits claiming that restarting the damaged TMI reactor would create severe psychological damage to persons living in the vicinity (4).

The accident at Three Mile Island led the Nuclear Regulatory Commission to evaluate closely, the kinds of short-term and long-term actions that were viewed as necessary to ensure that the restart of the damaged reactor would not adversely affect public health and safety. In particular, the issue was raised as to whether psychological distress (that was unrelated to exposure to radiation but associated with the accident), could be legally relevant in the proceedings to determine whether the damaged reactor should be restarted. Responding to this NRC concern, an association of residents in the Harrisburg area (People Against Nuclear Energy--PANE) contended that the accident had already impaired the health and sense of well-being of nearby residents, and that the physical symptoms they were experiencing were consistent with previous research indicating that similar problems occurred after other natural disasters (5-6). For this reason, they argued that the operation of the damaged reactor would be a constant reminder of the stress they experienced previously with the accident, and therefore the damaged reactor should not be restarted. Additionally, they argued that restarting the reactor would cause severe harm to the stability, cohesiveness and well being of the communities in the vicinity of the site.

Since the accident at TMI several studies have addressed the issue of public health in relation to both natural and man-made environmental stressors. For example, several studies have examined the relationship between the rapid boom-town growth of rural communities that was associated with energy development, and public health (7-10). More recently, there has been some concern raised about the potential health effects of living in proximity to hazardous waste facilities (11-14). With the rapid increase in the number of radioactive and toxic waste facilities across the U.S., it is anticipated that the public will continue to raise concerns about the potential health effects associated with living in proximity to such facilities.

In this paper we assess the level of stress in the city of West Chicago, Illinois, in relation to a low-level radioactive waste facility that has been located in the area for the past 50 years. In this study stress is evaluated in the context of how other social variables may influence the relationship between levels of stress and proximity to the radioactive waste site. In addition, stress is discussed in the context of attitudes on nuclear power, environmental group participation, and knowledge about the health effects associated with radioactive waste.

WEST CHICAGO, ILLINOIS

In 1931, the Lindsay Light and Chemical Company moved its gas lamp mantel factory site to West Chicago, Illinois, about 30 miles west of Chicago. They produced thorium at the West Chicago site until 1936, and subsequently provided thorium ore to the Manhattan Engineer District in the 1940s. In 1954, Lindsay Light and Chemical expanded their plant in order to produce thorium nitrate, and they continued production until 1963. American Potash and Chemical Corporation purchased Lindsay Light and Chemical in 1958, and through a merger, the Kerr-McGee Corporation acquired the West Chicago facility in 1967. Due to adverse economic conditions, the Kerr-McGee corporation terminated all manufacturing operations of the West Chicago facility in December of 1973.

The disposal of radioactive thorium wastes at the West Chicago site began in the early 1930s. While most of the wastes were buried on site, there have been occasions over the past 50 years when some of the contaminated soils were used for landfill by local residents. In July of 1976, the U.S. Environmental Protection Agency found relatively high levels of radiation at the site and at nearby properties, and subsequently blocked off and closed sections of a nearby park. Through media coverage of these events, the public became aware of the existence of the radioactive wastes at the site, and discovered for the first time that some of their properties contained soils that were previously contaminated by wastes from the facility.

In 1984, Kerr-McGee initiated a survey program with the city of West Chicago to determine the level of contamination at nearby properties, including residences, and a nearby Park and sanitary treatment plant. Surveys were subsequently completed on 2,726 properties, and close to 35 thousand cubic yards of contaminated soils were excavated from 115 properties. These contaminated soils are now stored at the West Chicago site. The site is within the city limits of West Chicago and surrounded on three sides by residential areas. There is also a school approximately one block away from the site. The site is currently fenced and the industrial portion of the site, the part nearest the residential areas, has been reduced to a large rubble pile. There are currently several lawsuits ongoing involving the site, and an Environmental Impact Statement (EIS) was completed in 1984. An addendum to the EIS was prepared in 1986 to include reasonable on-site and off-site alternatives for disposal of the wastes. Social psychological variables were not considered in the EIS.

The West Chicago site is located in the middle of a densely populated urban area, and only within the last 10 years has the public been aware of the nature and extent of the contamination. Many of the local residents have personal ties to the site in the form of previous employment of some family member, and the facility and its various operations have contributed significantly to the local economy in the past. However, due to periodic media exposure over the past 10 years, concerns have been raised by residents of West Chicago with respect to the potential health effects of living in proximity to the site. In this paper we address one specific aspect of that concern -- that is, whether there is a quantifiable relationship between level of stress, perceived health effects of radioactive waste, perceived knowledge of nuclear waste, attitudes about nuclear power, and proximity to the site.

METHODS

A five page questionnaire was developed using standard indicators for stress, a global measure of community satisfaction, open ended questions about satisfaction and dissatisfaction, and questions on environmental group participation and the perceived health risks of nuclear technology. Baseline data on general demographic characteristics of the population were also collected.

Several interviews were initially conducted over the telephone to pretest the questionnaire and the respondent's willingness to answer five pages of questions over the telephone. It was decided for better cooperation and sampling in proximity to the site the interviews would be conducted in person. The pretested telephone interviews were included in the sample.

The sampling frame for the personal interviewing was defined as a three-block radius around the perimeter of the site (approximately one-half mile radius). The telephone interviews included people living as far away as 10 blocks. Seventy people were interviewed over a period of five days in July 1986. Local residents were cooperative and very interested in the research, with only two people refusing to be interviewed. Interviews lasted 15 minutes on the average.

Because there is a large Mexican-American sector in the community, two separate questionnaires were developed. The first was the five-page instrument (in English) discussed above, the second was a one-page questionnaire written in Spanish for interviews with respondents that spoke no English. The second questionnaire represents a condensed version of the English language questionnaire. Four Spanish-only interviews were conducted and are included in the data set.

The data were analyzed using SPSS PC+. Two statistical procedures were used in analyzing the data: cross-tabulations and regression analysis. The primary technique was regression analysis. This approach analyzes the effects of selected independent variables on the variance in the dependent variable. Significance is based on F values with .05 used as the level of significance. One dependent variable, stress, was used in the regression equations. A 14-item scale for measuring stress was also used (15).

The indicators included:

1. Trouble getting to sleep or staying asleep.
2. Nervousness, feeling fidgety or tense.
3. Can't take care of things because you can't get going in the morning.
4. Restlessness, unable to sit still for long.
5. Personal problems that get you down physically.
6. Feel alone, isolated even from friends.
7. Nothing ever turns out the way you want.
8. Thinking nothing is worthwhile anymore.
9. Anxious about something or someone.

10. Feel people are saying all kinds of things behind your back.

11. Blue or depressed to the point it interferes with your daily activities.

12. Times when you can't stop thinking about things that are bothering you.

13. Tendency to make little troubles into big ones.

14. Bothered by nightmares.

The overall stress score was produced by summing the scores across indicators and dividing by the number of indicators marked. This variable was assumed to be continuous for purposes of analysis. Three predictor variables were continuous parameters (perceived health risk of nuclear waste, distance from site, perceived knowledge of nuclear waste). Two predictor variables were dichotomous (in favor or not of nuclear power and environmental group participation).

RESULTS

The stress scale had a potential range from 1 to 4 with 1 being low stress and 4 being high stress. The scale midpoint is 2.5. Responses to the summated stress scale produced a range from 1 to 2.93 with a median score of 2.

Stress was used as the dependent variable in five separate regression equations. It was hypothesized that the variables: perceived health risk of nuclear waste, distance from the site, perceived knowledge of nuclear waste, attitude toward nuclear power, and environmental group participation, would explain most of the variance in stress. The following diagram represents a conceptual model of the hypothesized relationships and results of the analysis (see Fig. 1).

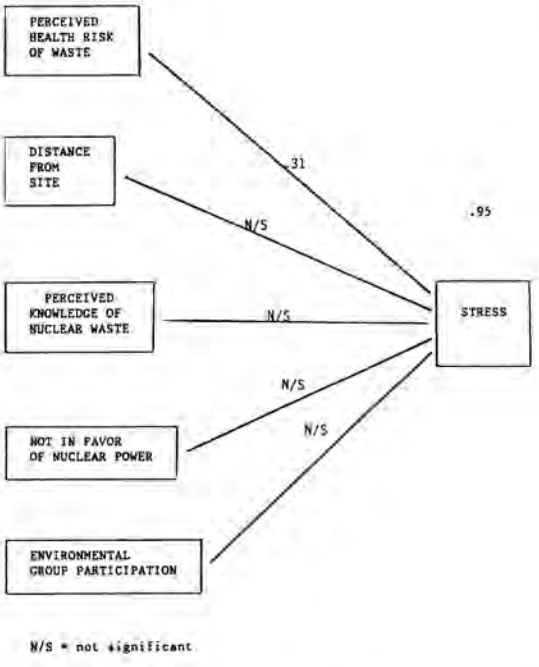

Fig. 1. Conceptual Model of Nuclear Waste and Stress.

According to the diagram, only perceived health risk of nuclear waste was statistically significant in accounting for variance in stress (10 percent of the variance is explained). The relationship is one in which the higher the perceived health risk, the higher the stress. Two other health risk questions were also asked on the questionnaire. These included perceived health risk associated with nuclear power and perceived health risk associated with radon. The responses to these questions were significantly correlated with perceived health risk of nuclear waste as indicated in Table I.

TABLE I

Correlation Matrix of Perceived Health Risk

	Perceived Health Effects of Radon	Perceived Health Effects of Nuclear Waste	Perceived Health Effects of Nuclear Power
Perceived Health Effects of Radon	1.00		
Perceived Health Effects of Nuclear Waste	.52*	1.00	
Perceived Health Effect of Nuclear Power	.47*	.46*	1.00

*Level of significance .001

Because of the high intercorrelation among these health risk variables only the perceived health risk of nuclear waste was entered in the regression equation.

According to Table II, 71 percent of the respondents were either very satisfied (30.4%) or somewhat satisfied (40.6%) with their community. Less than 20 percent of the respondents were dissatisfied with their community, and of those who were dissatisfied, less than 10 percent listed the radioactive waste site as the reason.

TABLE II

Community Satisfaction in Proximity to Radioactive Waste

	Frequency	Percent	Cu. Percent
Very Satisfied	21	30.4	30.4
Somewhat Satisfied	28	40.6	71.0
Neutral	7	10.1	81.1
Somewhat Dissatisfied	11	15.9	97.0
Very Dissatisfied	2	2.9	99.9

(How satisfied are you overall with your community?)

When asked what residents liked least about their community, 26 percent responded the radioactive waste site, followed closely by 23 percent indicating problems with various community services. Other areas least liked included social aspects of the community (such as changing ethnic composition) and politics. It is interesting to note, however, that of those listing the radioactive waste site as the least liked aspect of their community, approximately 67 percent were either somewhat satisfied or very satisfied overall with their community.

The open ended question listed in Table III was used as the measure of unpopularity of the facility. According to our analysis, there was no statistically significant relationship between stress and dissatisfaction/unpopularity.

TABLE III

Responses to Dissatisfaction Question

	Frequency	Percent
Hazardous Waste	18	26.1
Services	16	23.2
Social	12	17.4
Other	12	17.4
Politics	5	7.2
No Response	7	8.7

What do you like least about your community?
(fill in the blank question)

The relationship between community satisfaction and stress was also explored. A simple regression analysis was used to see if stress was affecting ones evaluation of community. No statistically significant relationship between community satisfaction and stress was observed.

DISCUSSION

Waste managers have maintained that the major constraints to solving the nations radioactive waste problems are social-political in nature. These perceived social-political problems have typically been addressed with public education programs and attempts to facilitate public participation in the decision-making process. The rationale for using these educational programs is the underlying belief that if one could just educate the public as to the "real" risks involved there would be no opposition to waste sites. To date most of the public education/public participation associated with radioactive waste management has been through the National Environmental Policy Act (NEPA) process. The NEPA process encourages early participation of the public in defining the "scope" of the analysis to be performed, and in the subsequent review of the Draft Environmental Impact Statement (EIS). The techniques most often used to inform the public include the distribution of information packets and project schedules, as well as public presentations by project sponsors. Organized, educated and resourceful groups often use these meetings to highlight uncertainty involved with risk estimation, fear of nuclear material, concerns over community well being, and future prospects for economic development. The concerns can be divided and summarized into two main areas--fear for health and safety at the individual/family level, and fear that negative public perceptions associated with the project will create community-level adverse impacts such as lower property values, slower economic growth and development, etc.

While the NEPA process encourages early public participation and public assistance in defining the "scope" of the EIS, the PANE vs. Metropolitan Edison Supreme Court Decision limited the scope of the NEPA investigation. The Supreme Court decision basically stated that the supplemental EIS did not have to include in their analysis psychological distress, and community stability and cohesiveness. This decision was based on the following conclusions.

1. The **risk** of an accident is not an issue in the physical environment.

2. The element of risk lengthens the casual chain beyond the scope of that which should be addressed during the NEPA process.

3. Psychological distress is not easily separated from the general unpopularity of a facility.

4. The political process, not the NEPA process, provides the appropriate forum in which to air political disagreements.

As a result of the PANE decision many scientists and policy makers have adopted the position that one need not examine psychological distress, community stability, community cohesion, sense of well-being, and public perception in EISs related to nuclear waste disposal. It is argued here that to restrict the scope of EIS investigations *a priori* based on the PANE decision may be imprudent, and indeed such restrictions may inhibit informed decision-making with respect to siting decisions.

While it is generally agreed that risk does not constitute a physical impact, it is used as a basis for deciding how to judge physical impacts. Different combinations of engineering designs and siting locations yield different calculated risks. These calculated risks are often used as a basis for decision-making in the NEPA process, and they are perceived by decision makers as "real", with decisions often being made based on these calculated risks.

Transportation risk is another area where decisions are often made based on the assumed relationship between calculated risk and observable environmental consequences. It would thus appear that the concept of risk is used elsewhere in the NEPA process with decisions being based on these real calculated risks. It is also apparent that the general public performs their own informal risk assessments. Risks perceived as real can become real in their social and social-psychological consequences. It would thus appear inappropriate to dismiss risks in some areas and include it selectively in other areas.

The second major Supreme Court finding in the PANE decision addressed the length of the causal relationship between stress and health effects. According to NEPA regulations, it is appropriate to address "higher order" effects in EISs (eg. variables

that are causally related to one another in a vertical hierarchy). Again, in practice, it is often the case that primary and secondary effects of a given project are considered during an EIS. This often occurs when project consequences are positive. For example, the primary effect of a large project might be an increase in the local workforce. A secondary consequence of increased employment that is appropriate to consider in an EIS is the effects of such employment on secondary variables such as the local sales tax, property taxes, etc. Increased consumer demand (secondary effects) created by new jobs and higher project wages are often translated into tertiary effects of increased employment in the service sector. This increased service sector employment is then translated into increased labor force participation and inmigration (third and fourth order effects). The analysis can go on from this point to include the tax benefits of the fourth order effect. The causal chain, although long, can be easily documented. Statistical methods in economics and public finance are sufficiently advanced to handle the mathematical relationships between these variables.

In the case of psychological distress, the perception of risk (primary effect) results in stress (secondary effect) which could in turn effect health (tertiary effect) and/or community satisfaction, sense of well-being, migration, etc. (also tertiary effect). Thus, it appears that the length of the causal chain may not be the critical variable defining what is and is not to be included in an EIS. The critical issue may be how one controls for extraneous variables in the causal chain such that it can be demonstrated that A leads to C. Social and social-psychological analyses suffer from the plethora of extraneous variables that must be controlled in such analyses. In addition, it might be perceived by non-social scientists that social science methods are not sufficiently advanced to quantify such variables and prove such relationships.

The third point on which the Supreme Court decision rests is that psychological distress could not be easily separated from the unpopularity of a facility. This is an empirical questions that is subject to scientific verification. The scientific work in this area of stress is sufficiently advanced to measure and quantify levels of stress and changes. The data in this study showed no statistical relationship between stress and dissatisfaction with the community as a whole and dissatisfaction with the waste site in particular. At least in this case stress and unpopularity were not statistically associated.

The fourth point considered by the Supreme Court was that the political process, not NEPA, is the appropriate forum in which to air grievances. This finding defies the very intention of NEPA which is to include the social meaning of projects and related social change by including social values as an appropriate issue under NEPA. The act specifically states that one should "Identify and develop methods and procedures...which will ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making..." (NEPA, Section 102).

In addition, the Council on Environmental Quality in the Regulation for Implementing the National Environmental Policy Act specifically indicates that public controversy should be taken into account in determining if an EIS is necessary.

In fact, there are a number of statements in NEPA that seem to contradict the Supreme Court decision excluding social and social psychological variables in the TMI case. Quoting from NEPA (Sec. 10), the act is intended to "Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings". In the process of assuring the above, scientists are to "Utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and **social sciences** and environmental design arts in planning and in decision-making which may have an impact on man's environment". (Section 102, emphasis added). In addition, if the methods do not exist, the Act directs one to develop such methods such that "unquantified environmental amentities and values may be given appropriate consideration....".

Under Title II of the Act, the Council on Environmental Quality is charged "to be conscious of and responsive to the scientific, economic, social, aesthetic, and cultural needs and interests of the nation" and "To develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, **social**, economic, health, and other requirements and goals of the Nation".

Thus, it appears the intention of NEPA is to consider social factors and cultural meaning attached to change. The PANE vs. Metropolitan Edison Decision dealt originally with the need to provide a supplemental EIS for inclusion of social psychological variables in the decision-making process. It would seem imprudent, at best, to generalize this decision to waste management EISs, especially where "public controversy" is present. One gets into legal trouble under NEPA by not considering significant areas of impacts in the decision-making process. Decision-makers need not make the best environmental decision on any given project, they need only demonstrate that they considered all significant environmental impacts in the process. To exclude one set of factors, such as social and social psychological variables, on the basis of the PANE decision, would make one vulnerable to future legal challenges.

The research reported in this paper shows that social and social psychological variables may be useful for decision makers in the decision-making process. In addition, this research does not support the Supreme Court finding that the unpopularity of a facility is not easily separable from stress caused by the facility. Future empirical work on this point alone could serve to challenge this portion of the Supreme Court decision.

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