

PERCEIVED RISK, STIGMA, AND POTENTIAL ECONOMIC IMPACTS OF A HIGH-LEVEL NUCLEAR WASTE REPOSITORY IN NEVADA

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ABSTRACT

What is the potential for the proposed Yucca Mountain repository to have serious adverse economic impacts on the city of Las Vegas and the State of Nevada? Adverse economic impacts may be expected to result from two related social processes. One has to do with perceptions of risk and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The second process that may trigger significant adverse impacts is that of stigmatization. The conceptual underpinnings of risk perception, social amplification, and stigma will be discussed in this paper and empirical data will be presented to demonstrate how nuclear images associated with Las Vegas and the State of Nevada might trigger adverse effects on tourism, migration, and business development.

In December, 1987, the U.S. Congress amended the Nuclear Waste Policy Act and authorized the Department of Energy to determine whether Yucca Mountain, Nevada, is a geologically sound and technically feasible site for storing high-level nuclear waste. If the site passes a set of prescribed technical criteria, a repository will be constructed there to store nuclear waste from the nation's commercial power plants.

Much effort has been, and will continue to be, devoted to characterizing the physical and biological risks associated with construction and operation of such a facility. Socioeconomic risks, though less studied, are also important. This paper addresses the following question pertaining to social impacts: What is the potential for a high-level nuclear waste repository at Yucca Mountain to have adverse economic effects on the city of Las Vegas and the State of Nevada?

The economic impacts of concern to us here include reduction in short-term visits to the city and state by vacationers or conventioners, effects on long-term residents (emigration, reduced immigration of retirees), and reduced ability to attract new businesses.

Assessment of these impacts is obviously important to citizens and officials of Nevada, who need to know what adverse economic consequences to expect if Yucca Mountain is developed as the repository. Indeed, selection of Yucca Mountain as the prime candidate and attempts to evaluate its qualifications over the next few years may trigger some of these impacts in advance of the final decision. Information about possible economic impacts may be relevant to the final decision itself. Moreover, such information is essential for decisions about compensation and mitigation.

Empirical research on this topic faces several major obstacles, however. Foremost among these is the fact that people may not really know how the repository will affect their future preferences and decisions. For example, asking people to project the repository's impacts on vacation decisions to be made many years hence may, in effect, be asking them to "tell more than they can know" (1). Surveys by Baker, Moss, West and Weyant (2) and West and Baker (3) have demonstrated that answers to questions about the impact of nuclear facilities on future behavior may not be

trustworthy. Despite this difficulty, there are theoretical reasons to expect that the repository will produce adverse economic impacts and, as will be shown later, there are methods for assessing impacts that are not dependent on direct questioning of people who have not thought hard about the decisions of concern here.

BACKGROUND AND THEORY

Adverse impacts from the proposed Yucca Mountain repository may be expected to result from two related social processes. One has to do with perceptions of risk and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The second process that may trigger significant adverse impacts is that of stigmatization.

Studies of risk perception have examined the judgments people make when they are asked to characterize and evaluate hazardous activities and technologies (4). One objective of this research has been to develop hazard taxonomies that can be used to understand and predict responses to risk. Nuclear power stands out in these studies as uniquely unknown, uncontrollable, and dreaded, with the perceived potential to produce immense numbers of fatalities, even in future generations (5). Nuclear waste tends to be perceived in a similarly negative way (6). Research has shown that lay people's perceptions of risk and their desire to see strict regulations employed to reduce risks are closely related to these perceived characteristics of nuclear power and other hazards.

Perceptions of risk play a key role in a process labeled "social amplification of risk" (7). Risk amplification reflects the fact that the adverse impacts of a risk event sometimes extend far beyond the direct damages to victims and property and may result in massive indirect impacts such as litigation against a company or loss of sales, increased regulation of an industry, etc.

It appears likely that multiple mechanisms contribute to the social amplification of risk. First, extensive media coverage of an event can contribute to heightened perceptions of risk, particularly if the information reported is exaggerated or distorted. Second, a particular risk or risk event may enter into the agenda of social groups, or what

Mazur (8) terms the *partisans*, within the community or nation. This may occur either because a particular group has goals which include this risk issue or simply because political advantage is to be had by keeping it in the public eye.

A third mechanism of amplification arises out of the interpretation of unfortunate events as clues or signals regarding the magnitude of the risk and the adequacy of the risk-management process (4). The informativeness or *signal potential* of a mishap, and thus its potential social impact, appears to be systematically related to the perceived characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused to the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear waste repository or a recombinant DNA laboratory, may have immense social consequences if it is perceived as a harbinger of future and possibly catastrophic mishaps.

The concept of accidents as signals helps explain our society's strong response to mishaps involving nuclear power. Because nuclear power risks are seen as poorly understood and catastrophic, accidents anywhere may be seen as omens of disaster everywhere, thus producing large socioeconomic impacts.

Substantial socioeconomic impacts may also result from the stigma associated with a nuclear waste repository. The word *stigma* was used by the ancient Greeks to refer to bodily marks or brands that were designed to expose infamy or disgrace to show, for example, that the bearer was a slave or criminal. As used today, the word denotes someone "marked" as deviant, flawed, limited, spoiled, or generally undesirable in the view of some observer. When the stigmatizing characteristic is observed, the person is denigrated or avoided. Prime targets for stigmatization are members of minority groups, the aged, homosexuals, drug addicts, alcoholics, and persons afflicted with physical or mental disabilities and deformities.

Although the sociological and psychological treatment of stigma typically pertains to interpersonal contexts far removed from that of radioactive waste disposal, the concept of stigma can clearly be generalized from persons to environments (9). Times Beach, Missouri, and Love Canal, New York come quickly to mind as examples of stigmatized environments. A dramatic example of stigmatization involving radiation occurred in September, 1987, in Goiania, Brazil, where two men searching for scrap metal dismantled a cancer therapy device in an abandoned clinic. In doing so, they sawed open a capsule containing 100 grams of cesium 137. Children and workers nearby were attracted to the glowing material and began playing with it. Before the danger was realized, several hundred people became contaminated and four persons eventually died from acute radiation poisoning. Publicity about the incident led to stigmatization of the region and its residents (10). Hotels in other parts of the country refused to allow Goiania residents to register; airline pilots refused to fly with Goiania residents on board; automobiles driven by Goianians were stoned; hotel occupancy in the region dropped 60% for six

weeks following the incident and virtually all conventions were canceled during this period.

METHODS AND RATIONALE

Building on the theoretical concepts and research described above, we designed a series of studies to determine the potential impacts of the Yucca Mountain Repository on tourism, migration, and business location decisions.

Our first efforts (6) followed the traditional approach of simply asking people in a national survey to indicate whether a nuclear waste repository located 100 miles from a site would reduce the desirability of that site as a place to attend a convention, vacation, raise a family, retire, or locate a new business. Depending upon which of these activities was targeted in the question, between 41% (convention) and 73% (raise a family) said that a repository would reduce the desirability of the region. It appeared that the more time people think they will be spending in an area, the more likely they were to assert that the repository could make it a less desirable place in which to be.

The consistency of response to direct questions about the effects of a repository is impressive. However, in light of the aforementioned problems with projecting impacts far into the future on the basis of answers to hypothetical questions, one cannot rely heavily on such data. Therefore, the present studies employed an indirect strategy, based on the concept of environmental imagery. The importance of imagery is acknowledged in the Department of Energy (DOE) assessment of the potential impact of Yucca Mountain on Las Vegas tourism:

"Locating a repository at Yucca Mountain could damage the image or aesthetic appeal of the Las Vegas area. This could result from physical features of a repository (about 100 miles northwest of Las Vegas) or its associated transportation network (whose actual routes are presently unknown). Damage to the Las Vegas image could also be the result of events related to the repository, such as a highly visible debate in the national news media" (11).

We concur with DOE in this view. Studies of environmental imagery appear to have the potential to provide a sound and defensible theoretical framework from which to understand and project possible impacts of a nuclear-waste repository on tourism and other important behaviors. The present studies were designed to:

- 1) demonstrate the concept of environmental imagery and show how it can be measured;
- 2) assess the relationship between imagery and choice behavior; and
- 3) describe economic impacts that might occur as a result of altered images and choices.

The concept of imagery is not new to the study of environment and behavior. Geographers, environmental psychologists, marketing strategists, and consumer theorists have written at length about the importance of images in our

environmental consciousness and our behavior (see, e.g., 12, 13, 14). However, to our knowledge, no one has used a design such as ours to link imagery to the behaviors of concern here.

Our research design is predicated on four assumptions and a conclusion. The assumptions are:

1) There are consistent, often stereotypical images associated with environments.

2) These images have diverse positive and negative affective meanings which influence preferences for environments (e.g., in this case, preferences for sites in which to vacation, retire, find a job, or start a new business).

3) A nuclear-waste repository evokes a wide variety of strongly negative images, consistent with extreme perceptions of risk and stigmatization.

4) The repository at Yucca Mountain and the negative images it evokes will, over time, become increasingly salient in the images of Nevada and of Las Vegas.

If assumptions 1-4 hold true, it seems likely that, as the imagery of Las Vegas and of Nevada becomes increasingly associated with the repository and things nuclear, the attractiveness of these places to tourists, job seekers, retirees, and business developers will decrease and their choices of Las Vegas and Nevada within sets of competing sites will decrease.

Support for these four hypotheses, therefore, would validate the mechanism whereby the repository could adversely affect tourism and migration to Nevada and this validation would occur without having to ask people to make dubious introspective judgments about their future behaviors.

Survey Design

In order to test the hypotheses described above, we have designed and conducted three studies of imagery and preference. Studies 1 and 2 surveyed representative samples of residents in Phoenix, Arizona. Study 1 elicited images for four cities and asked people to indicate their preferences among these cities as places to vacation, take a new job, or retire. Study 2 did the same for four states. Study 3 surveyed a national sample of business executives, asking for their images of each of four cities and their preferences among these cities as places to open a new business or expand an existing business. All three surveys were conducted by telephone. Each survey had a sample size of about 400 persons.

The survey questions in Studies 1 and 2 were nearly identical. The cities questionnaire asked respondents to provide images for San Diego, Las Vegas, Denver, and Los Angeles. The states questionnaire elicited imagery for California, Nevada, Colorado, and New Mexico. These cities and states, in addition to Las Vegas and Nevada, were chosen for the study because they are important vacation destinations for residents of Phoenix.

The opening set of questions asked people for "the first six thoughts or images that come to mind when you hear the name of (city/state)." The order of the cities/states was

rotated across respondents. Next, respondents were asked to rate each image they gave on a scale ranging from very positive (+2), somewhat positive (+1), neutral, somewhat negative (-1), or very negative (-2).

Respondents were then asked to rank the cities/states according to their preference for a vacation site (long weekend vacation for cities; week or longer vacation for states). Subsequent questions asked for a preference ranking among these cities or states as retirement sites or places to move to assuming equally attractive job offers in each place, much in the same manner as vacation preferences were elicited. Additional questions assessed the extent of previous visits or living experiences in each of the cities or states, and the existence of family or close friends in each of those places.

Next, up to six images were elicited to the stimulus "underground nuclear waste storage facility" and the stimulus "nuclear test site."

The survey also asked "in which state has the federal government proposed to build an underground facility for storing radioactive wastes?" and "in which state is the Nuclear Test Site located?"

The survey of corporate decision makers first elicited images for each of four cities--Phoenix, Las Vegas, Denver, and Albuquerque--and then asked the respondents to evaluate these images on the 2 to +2 rating scale, as in the other surveys. These individuals were then asked to rank these cities in order of preference as a location for opening or expanding a business, assuming that market conditions and cost conditions were about equal.

Survey Samples

Adults 18 years of age and older were surveyed with the cities questionnaire during the period April 13 through May 4, 1988. The response rate was 73% of the households contacted by random digit dialing. The states telephone survey was conducted in metropolitan Phoenix between May 16 and June 8, 1988. The response rate was 71%. The survey of corporate decision makers took place between June 9 and July 29, 1988. The sample was selected randomly from the 1988 edition of *Who's Who in Corporate Real Estate* published by NACORE. The response rate was 70%.

Results: Cities Survey

When respondents were asked to free associate to the stimulus words "Las Vegas," images pertaining to gambling, casino-hotels, bright lights and entertainment were dominant, followed by imagery pertaining to money and the climate and physical landscape. Prostitution and crime formed the seventh category of images. Imagery related to nuclear waste and the nuclear test site was very infrequent (only 2 images out of more than 1500).

The hierarchy of images elicited by the stimulus phrase "underground nuclear waste storage facility" was overwhelmingly negative. By far, the most frequent associations were dangerousness and death and their synonyms, followed by pollution, negative concepts, and radiation. Although we did not ask people to score these images, it seems likely that most of them would be judged "very negative," a

2 on our five-point scale. Although some images pertaining to "necessity" came at the 12th position, they were very few in number. "Nevada" was weakly associated with the repository, which is not surprising, given the fact that only 19.6% of the respondents knew where the repository site is proposed to be located.

Images of the nuclear test site were similarly negative. Major images included radiation, death, danger, cancer, destruction, and Nevada. More people associated Nevada with the test site than with the repository (46.8% knew that the test site is in Nevada). To predict preferences among cities from images, we developed a scoring rule, the summation model, which simply sums the ratings for all the images a respondent produced for each city.

The summation model does quite well, correctly predicting 55% of the number 1 ranked vacation cities and 56% of the fourth ranked cities, with somewhat less accuracy in predicting intermediate ranks (if the model had no validity, we would expect a 25% hit rate by chance). The exact rank order of four cities generated by the summation model matched the exact rank order of the respondent 26.4% of the time (perfect matching of ranks would be expected by chance only 4.2% of the time).

A second set of tests was conducted with the summation model. Each of the four cities was paired with every other city--making six pairs in all. For every respondent and every pair, the image score for city B was subtracted from the image score of city A. The resulting 2,346 A-B scores across all respondents were ordered from extreme negative to extreme positive and this distribution of difference scores was partitioned into five subsets, as equal in size as possible (range = 419 to 511 comparisons in each subset). Finally, within each subset, the percentage of respondents who ranked city A more favorably than city B as a vacation site was calculated. The plot of the mean A-B difference within each subset against the proportion of people preferring city A is shown for all respondents and all pairs combined in Fig. 1. Note the strong relationship between the mean image score difference (based on the summation model) in each subset and the proportion of respondents in that subset choosing city A over city B. Fig. 1 illustrates the performance of the summation model across all pairs of cities. The data for specific pairs of cities (e.g., Las Vegas vs. Denver) look essentially like the combined plot in Fig. 1 and are not shown here.

The summation model was equally accurate in predicting vacation preferences among states and predicting job and retirement preferences among both cities and states. The business location preferences of corporate decision makers were also strongly related to the quality of these persons' images (see Fig. 2). Additional analyses showed that image scores for Las Vegas and for Nevada were linearly related to the probability that a person had visited those places during the past two years.

Whereas few people expressed nuclear related imagery to the stimulus words "Las Vegas," about 10% of respondents in the states survey produced nuclear imagery in response to the stimulus "Nevada." Such images included

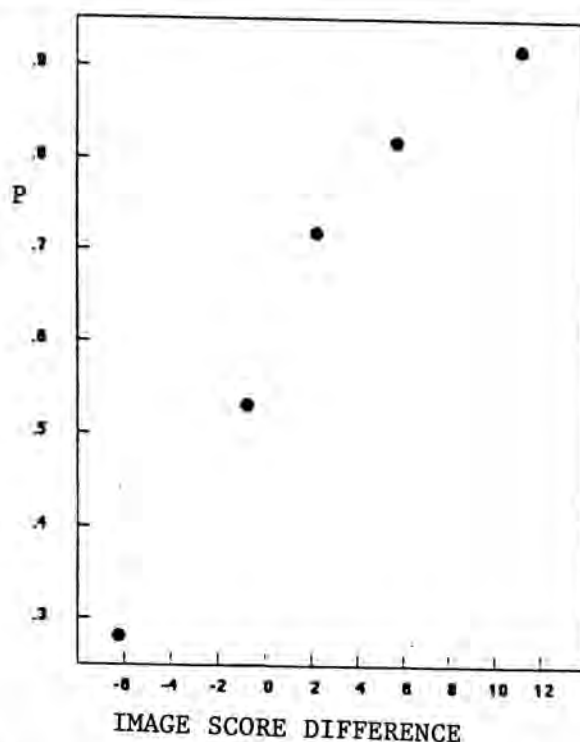


Fig. 1. Relationship between image score differences (City A-City B) and proportion of time (P) City A was ranked higher than City B in the respondent's preference rankings for vacation sites. All possible pairs of cities are included in this analysis.

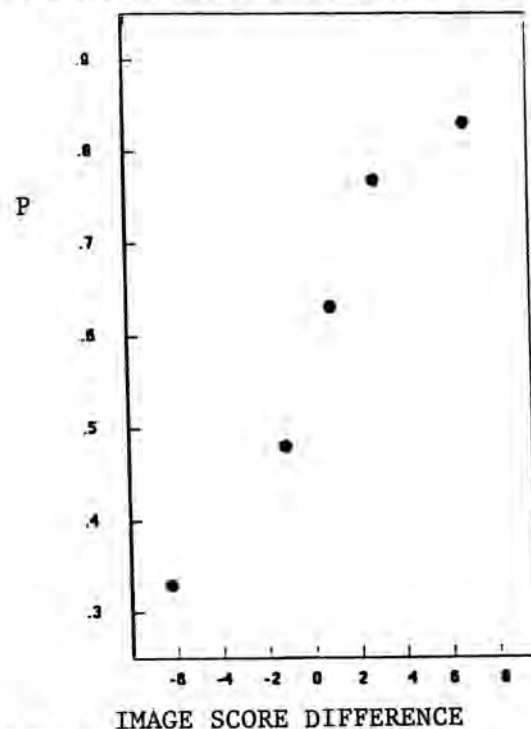


Fig. 2. Relationship between image score differences and business location preferences of corporate executives (all pairs of cities included).

the terms nuclear testing, nuclear bomb, nukes, explosions, and radiation. The mean image score for Nevada for these persons was 0.18. The mean image score for persons who did not associate Nevada with things nuclear was 2.56 (a statistically significant difference; $p < .001$). As expected, persons with nuclear imagery assigned much lower (poorer) preference rankings to Nevada than did persons without such images. Many additional analyses were done to validate the link between imagery and preference. These will be reported in subsequent publications.

CONCLUSIONS

The results reported above support the four assumptions that this research aimed to test: Images associated with cities and states were consistent across people (Assumption 1). These images had diverse positive and negative affective meanings which were highly predictive of expressed preferences for future vacations, retirement locations, etc. (Assumption 2). Imagery was also closely related to previous visitations to a place. The concept of a nuclear waste storage facility evoked consistent, extreme, negative imagery (Assumption 3). The nuclear test site, which has been around far longer than the Yucca Mountain project, has led to a modest amount of nuclear imagery associated with the state of Nevada. This provides indirect evidence for Assumption 4, which asserts that nuclear waste related images will also become associated with Nevada and Las Vegas. Nuclear imagery, when present, was associated with much lower preference rankings for Nevada.

The verification of these four assumptions implies that an increase in nuclear imagery will produce adverse impacts on tourism and other economically important activities in Nevada. Predicting the exact magnitude of those impacts, however, is currently impossible. Quantitative prediction requires knowledge of the event scenarios that will unfold during the history of the repository, as well as the likely effects that those scenarios will have upon people's images. Because choices are always determined within a context of competing alternatives, prediction also requires knowledge of the alternatives that people will have available to them in the future. Countermeasures, designed to mitigate adverse impacts (e.g. heavy promotional advertising to stimulate tourism) will undoubtedly be employed. The success of these measures is also difficult to predict.

In sum, the present study demonstrates the behavioral mechanisms whereby development of the Yucca Mountain repository may impose serious impacts on tourism, migration, and economic development in Las Vegas and the state of Nevada. These mechanisms of perceived risk, signal, social amplification, and stigma are so powerful that well-publicized problems associated with the repository have the potential to result in substantial losses to each of the various economic sectors at risk. Precise specification of the probability, magnitude and duration of such impacts is beyond the current state of the art in social-science prediction. What is clear, however, is that the possibility of these im-

pacts should no longer be ignored in repository-planning decisions.

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