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# The Health Effects of Ionizing Radiation: A Survey of Local Health Officials in New England and New York

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## Synopsis.....

*The purpose of the study is to determine the educational needs of public health officials concerning their knowledge, attitude, beliefs, and practices with specific reference to ionizing radiation. The public health directors or designates, working in health departments whose jurisdictions fall within a 60-mile radius of the 14 operating nuclear power plants in*

*the New York-New England region, were studied. A review of the literature indicates that historically there appears to have been a limited effort to conduct such a needs assessment in the United States.*

*A questionnaire was developed to measure the public health directors' knowledge, attitudes, and practice. The instrument was mailed in the summer of 1992 to all public officials listed in the National Directory of Local Health Departments. Knowledge, attitude, and practice questions were analyzed in terms of frequency of correct, incorrect, and don't know responses. The data presented convey the message that there should be public input into the risk assessment of nuclear plants and that local health departments should inform the public about the health risks posed by nuclear plants in their locality.*

*The authors recommend that an appropriate Federal agency sponsor a national survey and that States should establish a training program on the health effects of ionizing radiation for local public health officials.*

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**T**HE POSSIBILITY of widespread health effects from the release of radioisotopes resulting from nuclear accidents or incidents raises a number of concerns for public health officials. The data obtained to date suggest that ionizing radiation may be a contributing cause of childhood cancer and that background radiation has an effect upon the development of childhood cancers (1,2). There is, however, increasing evidence of significant health effects associated with the Chernobyl accident. Furthermore, a number of studies have been done in Britain and the United States on the health effects of people living in close proximity to nuclear installations (3-7). While these reports currently do not all agree that significant health effects have been demonstrated, they do raise questions and suggest the need for further studies.

Since Hiroshima, we have learned the following about the effects of persistent low level of radiation on health:

- Background radiation plays a part in the etiology of childhood cancers.
- Estimates of risk from low level radiation for the general population have been set too low and are in need of correction.
- Public health officials must have access to the current information about the effects of low level radiation on the public's health.

This study addresses the third issue, namely, the level of knowledge, attitudes, and beliefs, and the planning and actions taken by public health officials. To obtain this information, we have developed and mailed a survey to all directors of public health in the New England region and New York State whose departments are located within a radius of 60 miles of a working nuclear plant. The survey was composed of nine categories.

The survey was designed to determine how

Table 1. Percentage distance of public health departments from a nuclear plant and of the population in their jurisdiction

Category	Percentage of departments
Distance in miles:	
1-14 .....	11.5
15-29 .....	17.9
30-44 .....	25.0
45-59 .....	23.1
60 or more .....	14.7
Population size:	
0-14,900 .....	32.0
15,000-29,999 .....	23.0
30,000-44,999 .....	10.3
45,000-59,999 .....	7.7
60,000 or more .....	22.4

Table 2. Percentage of correct answers on the knowledge scale of 156 public health officials

Knowledge score	Number of officials	Percent
1.....	1	0.6
2.....	6	3.8
3.....	8	5.1
4.....	7	4.5
5.....	16	10.3
6.....	12	7.7
7.....	19	12.2
8.....	19	12.2
9.....	21	13.5
10.....	18	11.5
11.....	10	6.4
12.....	9	5.8
13.....	7	4.5
14.....	1	0.6
15.....	2	1.3

NOTE: Mean score = 7.85; standard deviation = 3.03

knowledgeable health officials are about the risks to their populations of ionizing radiation emitted from nuclear power plants in their vicinity. The survey was also designed to determine what public health officials' attitudes and beliefs are about the potential health effects of these emissions, as well as what actions or plans for action they may have already taken in regard to the health threats posed by the emissions. Additionally, several demographic questions were asked. This paper presents both the survey results and an analysis of the responses.

## Method

**The conceptual framework and survey design.** The conceptual framework for the survey design is based upon two models. The first is the Knowledge, Attitude, and Practice Model (KAP). The KAP is a

widely used model in the field of health, and it indicates the likelihood of a person's engaging in risk reducing behavior. This model provided for the conceptual framework of the development of the questions on the survey instrument. These questions are constructed to test the health officials' knowledge about a given health risk, their attitudes towards that risk, and their practices or actions designed to reduce the risk.

Additionally, the Health Belief Model (HBM) has been used to provide a conceptual basis for the construction of the attitude and belief questions. The theory that underlies the HBM is that a belief system provides a framework (of beliefs) to define health and make judgements (8). The HBM postulates that the initiation of health action is a function of a person's belief system along four subjective variables:

- the perceived level of personal susceptibility,
- the perceived degree of severity of the consequences that might result from the condition occurring,
- the estimation of the recommended health actions potential benefit,
- the perceived cost barriers that a proposed action might create.

**The survey instrument.** The development of the survey instrument proceeded along the following lines. A questionnaire was constructed using both open ended and fixed alternative questions to measure the independent variables, that is, knowledge, attitude and beliefs, and planning and practices. A system of scoring, coding, and scaling was developed to enable data analysis.

The questionnaire contained 56 questions. For purposes of analysis these 56 items were subsumed under 15 knowledge variables, 24 attitude and belief variables, and 4 demographic variables. Some individual questions were constructed with both *a* and *b* and occasionally *c* parts. If a question had more than one part, it would still be subsumed under the same variable number.

**Validity of the questionnaire.** To ensure that the study is measuring the appropriate constructs under question, the completed questionnaire has been put through a formal test for consensual validity. It was submitted to a number of persons knowledgeable about the health effects of ionizing radiation. To prevent unforeseen problems with content, length of questions, and phrasing of questions, the questionnaire was pretested on graduate students in the University of Massachusetts School of Public Health

who have had some experience working in the health field.

*Sample selection and description.* The names and addresses of all the working nuclear power plants in New York State and in New England were obtained. Officials from the 267 public health departments located within a 60-mile radius of the nuclear plants formed the survey population.

**Data gathering.** The data were gathered from the mass-mailed questionnaires. Data collection proceeded on the basis of a modified form of the Dillman Method (9). This method as modified follows: Each questionnaire was addressed to the director of the department of public health and was accompanied by a cover letter, which requested the local health official to fill out the survey. The respondents were provided with a self-addressed and stamped envelope to return the answered questionnaire.

The rationale was presented as follows: There is controversy over the health effects of adverse exposure to low level radiation, indicating a need for further study. Confidentiality was assured, and the principal author's address and telephone number were listed. If the questionnaire was not returned within 2 weeks, a reminder postcard was sent. If another 2 weeks went by without a return, a second questionnaire with a newly composed cover letter was mailed. Received were 162 returns. Of those, 156 were useful, a return rate of 58.4 percent.

### Data Entry and Analysis

Fifteen knowledge variables, 6 practice and planning variables, 24 attitude and belief, and 4 demographic variables were identified for purposes of data entry. All knowledge variables were scored on a three-point scale—don't know = 0, yes = 1, no = 2. Attitude and belief variables were also scored on a three-point scale—disagree = 0, uncertain = 1, and agree = 2. Practice and planning variables were scored from 0 for an inactive or negative response and 1 for an active or positive response.

The SPSS computer package (10) was used to analyze these data into a knowledge (K) scale and a practice and planning (P) scale, as well as a frequency and percent count of the responses to the knowledge, attitude, and belief, practice and planning, and demographic variables. The K scale refers to the number of knowledge variables that received a correct answer from each respondent. The scores could range from 0 (none right) to 16 (all correct).

*'Approximately four-fifths of our respondents were located less than 60 miles from a plant with 11.5 percent of the departments at a distance of 14 miles or less.'*

The P scale represents the number of respondents who gave positive responses to each of the four planning and practice questions. These scores ranged from 0 to 4. The attitude and belief questions were designed in part upon conclusions in the current literature concerning the health effects of nuclear emissions.

### Results

**Demographics.** Who were the 156 respondents? Table 1 groups them according to the distance of their health departments from a working nuclear plant. Approximately four-fifths of our respondents were located less than 60 miles from a plant with 11.5 percent of the departments at a distance of 14 miles or less. Table 1 data also indicate that 32 percent of the departments are responsible for populations of less than 15,000 people. Respondents responsible for 15,000 to 30,000 people constituted 23 percent of our respondents. The next largest group were the health departments responsible for 60,000 or more (22.4 percent). Those between 30,000 and 60,000 accounted for only 18 percent of the respondents.

**Responses to the knowledge questions.** Table 2 provides the percent of health officials with correct scores. The mean score for the knowledge questions was 7.85, and the standard deviation was 3.03. These health officials were able to answer slightly less than half the questions correctly, on average. The variance measure, however, points to a large variability with some respondents appearing to be quite knowledgeable, while others seem to know very little about ionizing radiation and its health effects.

Table 3 provides the percent of the public health officials who answered the knowledge questions correctly. Less than one-third of the respondents answered questions 3,6,7,15, and 18b correctly. For questions 6,7, and 15, the majority of respondents checked "don't know." Four of these questions, numbers 3,6,7, and 15, required specific answers such as the legal allowable yearly dose for the general

Table 3. Distribution of 156 public health officials' responses to knowledge questions (percentages)

Question	Correct	Incorrect	Don't know
1. Does ionizing radiation cause cell damages.....	74.0	1.3	21.2
2. Which groups are more susceptible.....	45.5	52.6	1.9
3. Is there a threshold where ionizing radiation is harmless.....	25.0	26.3	46.8
4a. Controversy over effects of ionizing radiation.....	87.3	3.8	7.1
5. Are alpha, beta, and gamma particles examples of ionizing radiation....	75.6	6.4	16.0
6. Legal dose for general population.....	23.1	6.4	69.2
7. Legal dose for workers.....	25.6	3.8	69.2
11. Have U.S. reactors experienced partial meltdown.....	53.2	29.5	14.7
15. Insure home against nuclear accident.....	2.6	16.7	79.5
16a. Does weather lead to unequal distribution of radioisotopes.....	73.7	1.3	23.7
16b. Downwind means more exposure.....	65.4	8.3	24.4
17. Routine operations can lead to emissions.....	30.1	16.7	51.9
18b. Accumulation in food chain of radioisotopes.....	30.8	25.6	42.3
27. Environmental protection zone equals a 10 mile zone.....	41.7	19.2	35.9
34. How much nuclear generation of electricity in the United States.....	44.9	45.5	3.8
35. Are safe disposal sites for radioactive waste available.....	10.3	68.6	19.2

Table 4. Distribution of 156 public health officials' responses to attitude-belief questions (percentages)

Question	Agree	Disagree	Don't know
4b. Low dose equals fewer cancers.....	53.2	12.2	34.6
4c. Low dose greater risk over years.....	22.4	18.6	41.0
8. Legal dose protects public.....	30.8	21.2	48.0
9. Legal dose protects worker.....	23.7	21.2	55.1
10. Public input into risk assessment.....	78.2	12.2	9.6
14a. Nuclear Regulatory Commission regulations are adequate protection....	26.3	42.9	30.8
14b. State regulations are adequate protection.....	21.2	37.8	41.0
18a. Routine emissions no threat to public.....	29.5	25.6	44.9
19a. Routine emissions pose threat to public.....	23.1	33.3	43.9
23. Departments should inform public about health risks.....	77.6	9.6	12.8
29. In case of severe accident, are emergency measures adequate.....	14.7	48.7	36.6
30. In case of severe accident, are there adequate medical measures.....	15.4	41.7	42.9
36. Burial adequate means to dispose of low level wastes.....	32.1	41.7	26.2
38. Reject reliance on nuclear power.....	29.5	44.2	26.3
39a. Can your department influence State level policies regarding nuclear issues.....	43.6	39.1	17.3
40. Would your more active role benefit public.....	55.8	16.7	27.5
41. Are there pressures on your department to enhance public awareness..	6.4	85.9	7.7
42. Pressures to avoid enhancing public awareness.....	6.4	81.4	12.2
44. Do economic consequences of plant closing outweigh health consequences of operation.....	16.7	44.2	39.1

population and for nuclear workers. Question 3, 17, and 18b are concerned with the effects of ionizing radiation on health. More than two-thirds of the respondents knew the answers to questions 1,5,16a, and 16b. These answers require a recognition that radiation may have negative health effects, that downwind of a nuclear plant is a potentially dangerous location, and that the safety of disposal sites is an unsolved issue.

Finally, the majority of responses to questions 2 and 35 were incorrect. These two responses reflect a misconception of who is most susceptible to the health effects of ionizing radiation and an assumption, also incorrect, that there is a permanent site for safe disposal of high-level radioactive waste.

**Responses to the attitude and belief questions.** Tables 4 and 5 present a response analysis to each of the attitude and belief questions.

Table 5 presents responses about possible health risk from an accident or emissions. Sixty-two percent of the respondents believed that a Chernobyl type accident could occur in the United States. There is no consensus on the adequate size of the emergency planning zone (EPZ); more than one-half the respondents did not know the desirable size. Additionally three-fourths of the respondents said the health risk from routine emissions are not applicable to their concerns.

**Responses to planning and action questions.** Table

6 presents the percent of public health officials who gave correct answers on the planning and action scale. The majority of respondents (65.4 percent) were not in favor of their local health departments' taking any steps to plan or to act to protect the public's health from the potential dangers from the local nuclear plants. However, 25.6 percent did respond positively to one question, and 9.5 percent responded positively to more than one of the questions.

Table 7 presents the data on the responses to the four questions that are concerned with local health departments' planning and actions taken in the event of a threat to public health from a local nuclear plant. The responses to questions 20a, 21, 24 and 37 reveal that more than three-fourths of the local public health departments have neither planned to take nor taken any action. Two additional questions, 20b and 31, are also responses to practice and planning. In response to the question 20b, 44.2 percent of the respondents said no while 17.3 percent said yes and 29.5 percent were uncertain. In response to the question 31, 25 percent said yes while 73.7 percent said no.

## Discussion

**Demographics.** The researchers, based upon geographic data, tried to restrict the sample to health departments that were located 60 miles or less from a working nuclear plant. However, 22 percent of the respondents say their departments are more than 60 miles from a plant. The researchers had no data on exact distances and may have erred by 10 to 20 miles. It is also possible that the respondents, who may not have known the exact distance, have themselves erred by placing their offices at a greater distance than is actually the case.

The greatest percentage of returns came from departments from small towns (32.1) and from the larger cities of 60,000 and more (22.4). The intermediate size cities returned only 18 percent of the surveys. The principal author, A.E.W., has interviewed a few of the health directors from this group. They all remembered receiving the questionnaire; none remembered returning it. They offered two kinds of responses. First, that the big city departments could delegate while they suffered from the press of work and shortage of staff. Second, that this was, for large departments, a low priority health issue.

**Knowledge.** The knowledge questions were reviewed by a professor of radiology at the University of Massachusetts Medical School for both clarity and

Table 5. Public health officials' responses to attitude-belief questions

Responses	Responses	
	Chance of occurrence	Percent
12. Chernobyl type accident in the United States is possible	1-25	12.8
	26-50	62.2
	51-75	4.5
13. Level of public's concern about health effects of local plant	none	10.3
	mild	40.4
	moderate	35.9
	severe	7.7
19b. Magnitude of threat of routine emissions	NA	76.9
	mild	10.9
	moderate	9.0
	severe	1.3
28. Adequacy of current Environmental Protection Zone	adequate	19.2
	too large	0.6
	too small	25.6
	not know	54.5
39b. Your department's influence on State policy	little	23.7
	somewhat	19.2
	large	2.6
	NA	51.3
43. Rate your community's economic dependence on nuclear power	none	38.5
	slight	30.8
	somewhat	21.2
	much	2.6

NOTE: NA = not applicable.

Table 6. Correct answers on the planning-action scale of 156 public health officials

Planning score	Number of officials	Percent
0.....	102	65.4
1.....	40	25.6
2.....	8	5.1
3.....	3	1.9
4.....	3	1.9

NOTE: Mean score = .49; standard deviation = .84.

the exclusion of questions that were technically difficult. Nevertheless, the mean score of 7.85 of 16 questions, a score of less than 50 percent on the knowledge part of the survey, indicated a significant lack of knowledge by a majority of the respondents. The standard deviation of 3.03, however, points to a wide variation among respondents' answers.

Responses for specific questions have been grouped for purposes of discussion. On the three questions that dealt specifically on the potential effects of ionizing radiation on the public's health, 40-50 percent of the respondents were uncertain or didn't know. This suggests that neither a reading of the report of the Committee on the Biological Effects

Table 7. Responses of 156 public health officials to the planning-action questions

Question and responses	Percent
20a. Does your department monitor levels of radiation?	
Yes .....	3.8
No .....	92.3
Don't know .....	3.2
20b. Should your department monitor levels?	
Yes .....	17.3
No .....	44.2
Don't know .....	29.5
21. Initiate studies of health impact?	
Yes .....	5.1
No .....	88.5
Don't know .....	5.8
24. Initiate health education programs?	
Yes .....	4.5
No .....	92.9
Don't know .....	1.9
31. Develop a plan to deal with nuclear emergency?	
Yes .....	25.0
No .....	73.7
Don't know .....	1.3
37. Is department involved in State's disposing of low level radioactive waste	
Yes .....	10.9
No .....	84.0
Don't know .....	3.8

of Ionizing Radiation, Number Five (11) nor information about health risks from this environmental area was read by the departments.

The group did considerably better on the more general questions on health and ionizing radiation; they knew that ionizing radiation does have negative health effects and that rainstorms and prevailing winds can create conditions for greater public exposure. Only one-third of the respondents knew the acceptable radiation levels for either the public or occupational workers. Again, the very relevant but more technical questions were missed. This poor showing points to the need for providing basic information to health department personnel on the basic facts of radiation and its effect on health.

**The attitude and belief questions.** The data presented in table 4 reflect two beliefs that are held by more than three-fourths of the respondents, namely, that there should be public input into the risk assessment of nuclear plants and that the health department should inform the public about the health risks posed by the plant in their locality. A further finding is that only a quarter of the respondents believe that either the Nuclear Regulatory Commission or the State regulations offer adequate protection

to the public. Furthermore, only 14.7 percent believe emergency measures would be adequate in case of severe accident, and only 15.4 percent believe that in the same situation that medical measures would be adequate. Only 43.6 percent respondents believe that their department could influence State policy regarding nuclear issues. While more than half the respondents believe that a more active role by their department would benefit the public, the great majority do not perceive any pressure either to enhance or avoid enhancing awareness of nuclear plant risks.

### Limitations of the Study

There are limitations in every stage of the study. The following is a discussion of the recognized limitations.

**Limitations of the survey design.** The sample design used for the needs assessment precludes making causal analyses. Since the study surveyed only public health officials within a 60-mile radius of nuclear power plants and did not include any controls, no comparisons can be drawn between public health officials within a 60-mile limit and those outside of this limit. Therefore the findings cannot establish whether there are significant differences in knowledge, attitudes, beliefs, and practices attributable to working in proximity to a nuclear power plant.

**Limitations of the survey instrument.** Mailed questionnaires have their own limitations. Of most relevance are a low response rate and biases resulting from self-selection (that is, more responses come from those respondents most interested in the subject). However, use of the Dillman Method may overcome the problem of low response rates and, furthermore, Dillman suggests that specialized populations such as public health officials suffer less from self-selection.

**Limitation of questionnaire implementation.** Due to financial constraints, there were limitations when the survey was implemented. Because there were no funds to pretest the questionnaire on the actual target population, the researchers used a population that, while not comparable, has some similarity to the public health officials. Thus, the researchers may not have eliminated all the problems that could arise from the questionnaire.

The researchers were also unable to carry out "practice mail-outs" and were, therefore, unable to predict or anticipate all the problems that could arise

when the final questionnaires were mailed (for example, handling of returns and so forth). Finally, financial constraints did preclude sending the third followup via certified mail. Dillman suggests that this final reminder results in a large number of responses, and we are uncertain about the consequences of not sending the third followup mailing.

**Limitations from the procedure of sample selection.** The method used to select the sample may also have had its limitations. The departments were identified in the National Directory of Local Health Departments of September 1991. This listing may not be complete and may include departments that no longer existed by the time that the questionnaires were mailed. Another limitation may be attributed to personnel changes in the health departments (the questionnaire was addressed to a person who might no longer work there, which resulted in indecision about forwarding the envelope). Another limitation of the sampling procedure results from excluding those health departments within a 60-mile radius of a nuclear power plant but in another State.

Finally, these limitations and the possibility suggested by several public health officials, in a later interview, that answering surveys had a low priority, placed limits on the response rate. We do not know if the knowledge, attitudes, and practices of the nonrespondents differed significantly from those of the public health officials who did respond.

## Recommendations

1. Communicate with the State departments of public health asking them to develop and disseminate information of the health effects of ionizing radiation to the local public health boards.

2. Communicate with the appropriate agencies of the Federal Government asking them first to address and then mandate actions to be taken by the local boards of health to ensure public safety in case of excessive emissions from nuclear plants.

3. Develop a health education curriculum and training program for local board directors or their designates. This should include the development of fact sheets and information guides. This training might take the form of day-long workshops sponsored by the State or Federal Government at various localities and various times.

4. Mandate that the local boards provide their publics with an objective fact sheet on the benefits and health risks of nuclear plants.

5. The appropriate Federal agency should sponsor a national survey to obtain the knowledge, attitudes,

and practices of local boards throughout the United States about the health effects of ionizing radiation stemming from generation of nuclear power.

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