INVESTIGATION 6

WHAT ARE OUR RISKS FROM RADON?

INTRODUCTION

It has been estimated by the U.S. Environmental Protection Agency (EPA) that between 15,000 and 22,000 Americans die each year from lung cancer caused by exposure to radon in indoor air. In New Jersey, the State Department of Environmental Protection estimates about 500 cancer deaths annually because of exposure to radon. What do these numbers mean? How do the health risks from radon compare to other environmental and safety risks? How do you make sense of perceived risks, statistical probabilities, and the combined threat of lung cancer from smoking and exposure to radon? What are the trade-offs between the economic costs of reducing your radon risk versus the benefits of a lowered probability of developing lung cancer?

There are about 200,000 deaths each year in the United States from lung cancer. It is believed that about 150,000 of those deaths are attributable to smoking. There is also strong evidence linking lung cancer to radon inhalation. This evidence comes mainly from studies of underground miners who have been exposed to *very high* radon levels and from laboratory animal experiments and some studies of radon concentrations in homes. Lung cancer deaths among miners have been studied since the 1950's, and clearly show increased incidence of lung cancer among groups of miners exposed to the highest radon concentrations (Figure 1).

Cancer mortality rates for males are about three times higher than for females, probably because men have historically smoked much more than women. The number of lung cancer deaths attributable to radon are somewhere around one tenth of the lung cancers attributable to smoking, making radon the second leading cause of lung cancer in this country. You can choose to smoke or not to smoke. You may or may not be able to choose where you live. But even if you live in a home with very high concentrations of radon, there are many ways to reduce those concentrations and thereby reduce your health risk. You don't have to live in a highly radioactive household! The first step is to learn what your risks are. Only then can you make an informed decision regarding whether or not you choose to reduce those risks.

There are four basic problems in attempting to quantify the cancer risks associated with exposure to radon in homes:

a) The underground miners who have been studied were exposed to *a lot* of radon and radon decay products in the mines. We don't know exactly how the cancer rates among those individuals compare with the risks associated with exposure to much lower levels in the home.
b) Animal studies provide useful information, but applying those data to the human population and human health risks is difficult.
c) There is generally a latency period (delay) between exposure to a cancer-causing agent and development of the cancer. This latency period may vary from 5 to 50 years and seems to be related to the age of the individual.
d) Carefully controlled studies of groups of people are difficult to obtain. People move; spend only part of their time at home; choose to smoke or not smoke; and have genetically determined predispositions to a variety of ailments.

Uncertainties resulting from these problems, among others, cause the disparity we see in different estimates of health risk. For example, typical estimates of lung cancer incidence attributable to radon exposure vary by about a factor of four-fold or more. Basically, however, all methods of estimating the risks from long-term exposure to household radon involve calculating a risk factor based on data from a small group of people (for example, miners) and then projecting this risk factor to a larger population that receives a lower dosage. **In this exercise you will examine different mathematical models to predict or describe health effects from radiation exposure.**

OBJECTIVES

To apply statistics and probability to the problem of exposure to radon in indoor air, to develop a working knowledge of human health risks and risk assessment, and to develop the skills needed to make informed decisions regarding the acceptance of health risks and appropriate needs for risk reduction.

PROCEDURE

1. Review the graph in Figure 1.

2. Interpret what the graph in Figure 1 means.

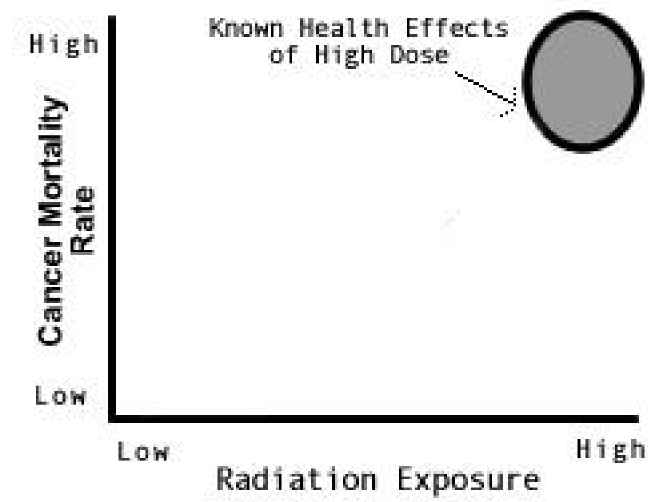

Figure 1. Relationship between radon dose and effect (lung cancer) based on studies of underground miners.

3. What does the graph in Figure 1 tell you about the relationship between dose (radiation exposure) and health effect (lung cancer) at the lower levels of radon exposure?

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4. Scientists often use mathematical models to describe or predict effects at doses that have not been well studied. Review the three mathematical models illustrated in Figures 2, 3, and 4.

DATA

Three common methods (models) used for projecting the relationship between the dose of a cancer-causing substance and the effect (development of cancer) are shown in Figures 2, 3, and 4. The linear model (Figure 2) assumes that as you increase the dose, you will see a linear increase in the effect. The threshold model (Figure 3) assumes that there is no effect at all with a very low dosage, but as the dosage increases you reach a certain threshold at which an effect is seen. The quadratic model (Figure 4) assumes that as you go to lower doses the risk decreases faster than the dose. In the quadratic model, the risk increases approximately as a square of the dose. All three models assume that there is no effect at a zero dose and all three show the same health risk at high doses because they are all based on the available data such as the underground miner studies.

Models

A model is a description, or representation, of how a system or process works. A model often uses mathematical equations to describe, as thoroughly as is practical, the workings of the system or process. For example, an atmospheric scientist studying the possibility of global warming might use models that attempt to describe global air flow patterns or the interactions between air temperature and ocean temperature. These models might be enormously complex and the calculations might require many hours of computing by the fastest and most powerful computers in the world.

Risk assessment is an area of study that attempts to quantify your health risk from various things like accidents, toxic materials, or radioactive substances. One might try to measure the health risk associated with smoking, eating large amounts of fatty foods, or exposure to radiation. Health scientists never ***know*** what the health risk is for these factors. But they can assemble all of the pertinent data available and ***assess*** what they think the health risk is. This assessment generally involves the use of one or more mathematical models. Such models start with what is known, or strongly suspected, and then predict the likely effects associated with different kinds or levels of exposure to the risk factor.

ANALYSIS

5. These three mathematical models[1] are used to estimate health risks from exposure to radon. All three use the same data for quantifying risk from high exposure (miner studies). The dose-effect relationships for the high doses are reasonably well established. The problem is to make a connection between these data and lower dose levels. Most people are exposed to much lower concentrations than the miners. What assumptions did the scientists make regarding the relationship between dose (radiation exposure) and effect (lung cancer) at the low levels of exposure for each of the three models?

Linear model ____________________

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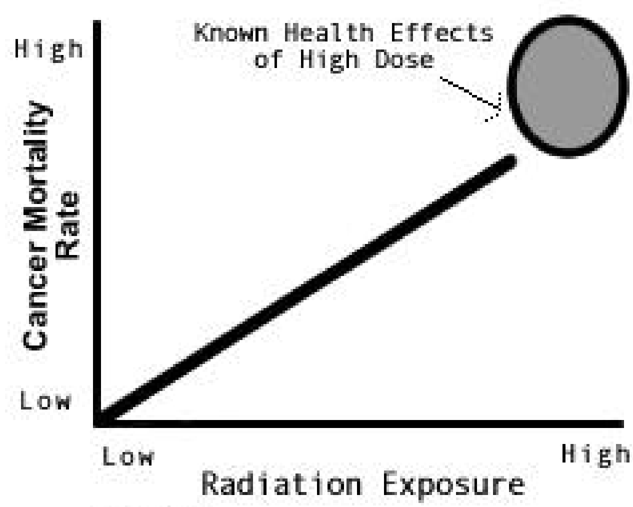

Figure 2

[1]Modified from the National Academy of Sciences (1988).

Threshold model ______________________

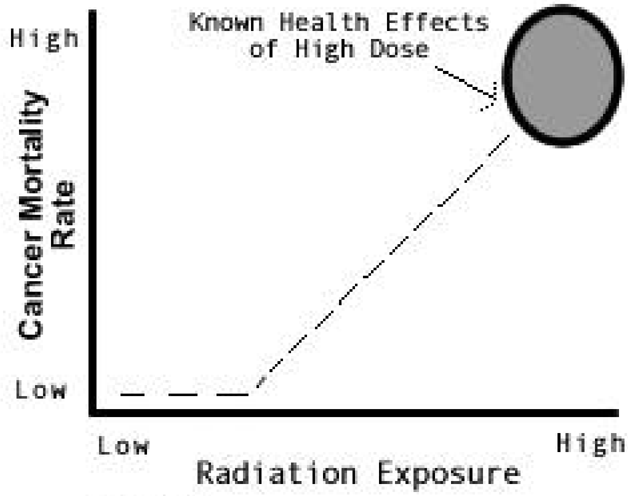

Figure 3

Quadratic model ______________________

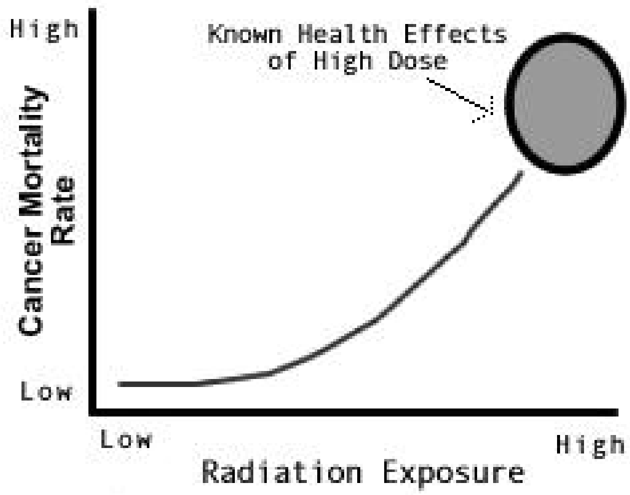

Figure 4

6. Under what level of radiation exposure is there the greatest difference in the risk estimates for the three models?

7. Assuming that your dose at home is equivalent to about half-way between zero dose and the dose received by the miners shown in Figures 1-4, which of the three models would you hope to be the real situation? Why?

8. Assuming that it is your job to communicate information to the public in New Jersey regarding the public health risk of radon, which of the three models shown in Figures 2-4 will you use? Why?

CONCLUSIONS

People seem to have a *need* to be given health *standards*. They want to know what levels of a particular toxic or cancer-causing substance are “safe” and what levels will cause health problems.

9. Why is it so difficult to provide people with definite answers about health risks?

10. The U.S. Environmental Protection Agency recommends that people take action to reduce household radon levels if they are higher than 4 pCi/L on average. What would you do if your house was measured at 3.9 pCi/L?

NOTES