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I find myself in a slightly difficult situation here because I am talking about health issues in a policy implications panel. I don't know if that assumes that health has no scientific background for health issues or not, but I must clarify my topic. I am always having to clarify a semantic problem which hopefully has already been touched on by Doctors Roberts and Cowling.

If we talk about the health issues connected with acid rain we are talking about the potential health effect that might arise as a result of the leaching out of various water supplies of metals that could be toxic to man. I am referring of course to lead, aluminum, copper, and mercury. These are some of the materials that can be leached out and, if they reach high enough concentrations in the drinking supply, could be directly toxic.

There are some members of the population that are peculiarly susceptible to copper. Those who suffer from Wilson's disease if exposed to high concentrations would demonstrate a clinical manifestation of resulting exacerbation of this condition. But I am not aware of any real direct impact as a result of such exposure.

There is also concern that some of these metals will leach into the food chain. For example, any fish that survive the acidity could have absorbed increased concentrations of metals. In Scandinavia I am told most fish have ingested such quantities of material that human ingestation of their liver would prove harmful. Acid rain, however, is not to blame for this because the spread of such metals as cadmium in animals is such that I no longer eat steak and kidney pie in order to avoid toxic levels of cadmium. It's a great sacrifice for an Englishman.

Acid rain cannot exist without the precursors of acid rain. The precursors of acid rain have now been amply demonstrated. The possibilities include acid sulfates, the chemical transformation product of SO_2, the hydrogen ion, of the nitrogen oxides. In the last 25 years the major components responsible for the increase in hydrogen ion in acid rain have been identified as derived from the utility combustion of fossil fuel. Transportation doesn't generate any SO_2. It does contribute to a certain amount of nitrogen oxides, but this nitrous oxide is usually at ground level and doesn't travel the long distance we are concerned with on this panel.

The weight of the scientific evidence is that air pollution is bad for

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you. Nobody could avoid that conclusion. I can say with absolute certainty that air pollution is bad for you, and I am going to explore a few links in the chain of evidence that indicate that is the case.

Exactly what is in the air pollution that is hazardous is still debatable, but there is a reasonable working hypothesis that acid sulfates are the culprits. The same element which composes the acid accounts for two-thirds of the acidity of acid rain. It is a reasonable hypothesis that such material damages human beings. It is still a hypothesis and I hope to explain the level of certainty or uncertainty of that hypothesis as I proceed. I think, however, it is reasonable. It is this theory upon which we base our calculations, and upon which I feel, our policy implications must be based at the present time. Fossil fuel combustion gives rise to a number of pollutants: SO_2; nitrogen oxides; and carbon monoxide. Among the hydrocarbons are certain trace metals: mercury; iron; and cadmium. These pollutants are then converted into secondary materials in the atmosphere. There is substantial evidence that the particulates and the acid sulfates which we are concerned with can travel hundreds of miles, I believe it is fair to say they can travel thousands of miles, with other very fine particulates.

There is ample evidence within the multi-city studies indicating that air pollution is harmful. This research was conducted by economists, who rushed into epidemiology and thereby alarmed the public in early 1970 by correlating increased mortality rates in the standard metropolitan areas with increased particulates and increased sulfates in those areas.

Many studies have focused on air pollution and mortality in different parts of the same city and they have correlated increased mortality in males (this also applies to females in these days of sexual equality) with increased pollution. The daily mortality studies demonstrated a correlation between the daily changes in mortality and the daily changes in air pollution.

Similar morbidity studies, have shown a correlation between increased pollution levels and an increase in hospital admissions during these periods. Episodes, such as the famous London fog took the lives of many people and startled the United Kingdom. It took the English three years, however, after the London fog to write their version of the Clean Air Act and they solved *their* pollution problems by building tall stacks. That policy decision made by the United Kingdom no longer applies; it's not a realistic option for the United States anymore.

Occupational studies, animal studies and controlled human studies in which subjects have been exposed to various elements of urban air pollution have shown that all were irritated by acid sulfates. Now, when you are talking about these multi-city studies (and we recently expanded these to cover 3,141 counties throughout the United States and when you are correlating mortality with a single element in the atmosphere, you immediately appreciate the fact that some of the people whose increased mortality you are measuring have not been exposed to a single pollutant.

Among those exposed, however, you will find the most solid correlations with acid sulfates currently. This finding does not preclude the fact that something else in the mix may be responsible for these harmful effects.

The reasons that we tend to focus on acid sulfates as the most likely candidate is, of course, because we have some controlled human observations and experimental laboratory evidence which implicates them. These are tentative conclusions. Nevertheless I want to emphasize that uncertainties remain. It could be that it is something very like acid sulfates that we still know nothing about.

The problem, I find, in talking about human risks and one of the reasons there is such uncertainty about health effects is, first of all, because governments don't like to talk about numbers of people dying. It is something they would rather avoid because it's very politically senstitive issue. It is easily misinterpreted by the media which publicizes the numbers and neglects the caveats.

Another policy problem concerns the limited resources available for investigating the environmental impact of acid rain. If the resources allocated to analyzing health effects were to receive proper emphasis in any particular program, it would have the deleterious effect of drawing away many of the resources needed for the environmental analyses. The point is that the health effects really should be studied by an entirely different group and should not be drawing resources from these environmental areas of analysis.

From our own research and review of the literature we have derived a dose-response function which, despite all of the uncertainty, one can use to measure the impact of air pollution. We use a damage function which compares the number of deaths we associate with certain levels of micrograms of acid sulfate per cubic meter in the affected population. We conclude that about three deaths per 100,000 people per microgram of sulfate occur each year. We feel confident that this is a reasonable damage estimate. We are much more uncertain when using this damage function in Pristine, Arizona or North Dakota, but in the Northeastern United States and Southeastern Canada we feel that it is a reliable damage function. We have also used it in a study of the National Energy Plan.

The National Energy Plan in the United States essentially proposes to greatly increase the combustion of fossil fuel by both utilities and industrial sources. This exercise involves plotting the placement of all of the utility plants and industrial plants operating in the United States in the year 1975 and then projecting where they are going to be in 1985 and 1990. The analysis concludes that we can double or more than double the amount of coal currently in use by the year 1990 with very little increase in harmful health effects providing that plants in existence conform to state-implementation plans and providing that new plants are built with the new source performance standards which are the law in the United States.

There has been no relaxation of the state-implementation plans. We

will be able to double the burning of coal output, but the crucial point of our analysis is that we have an existing health problem in the acid rain area which is effecting terrestial organisms and aquatic lakes.

Using our damage function we calculate that somewhere between 7,500 and 120,000 Americans are dying every year in the United States as a result of acid air pollution. That is our best estimate. When you bear in mind the fact that 2 million Americans overall die every year you can appreciate the severity of this problem. Roughly about 2.7 percent of these deaths are associated with existing air pollution which we believe is in turn associated with acid rain or the precursors of acid rain, the sulfates.

I performed a similar calculation for Canada. In the next six months I hope to use the same long range transport models and transfer matrices we have used for the United States and Canada. My preliminary calculation ran along these lines. I start with the proposition that every year roughly two percent of American deaths are attributed to air pollution. Let's assume the proportions are the same in Canada because the prevailing winds are the same and we have the same acid rain problem, and the population is distributed in a similar pattern. There are approximately 25 million Canadians. If one percent of them dies every year, that amounts to 250,000 deaths and if I say two percent are attributable to air pollution I get a figure of 5,000. It is a very crude calculation, but we are hoping to refine this by the end of September using exactly the same process we used in the United States.

I think that it would be wrong for me to leave you without some other perspectives. If I say 17 percent of deaths are associated with smoking, 2.5 percent of deaths every year are associated with automobile accidents, half of which are due to drunken driving, that sets the situation in a different light. Five percent of the people who go to a physician die as the result of the treatment which was prescribed. This does not provide a sound argument for not going to the doctor, however, because clearly 95 percent of the people who sought help from the physician benefited.

I believe the policy implications of these health issues are such that even bearing in mind all of the caveats I have mentioned, we clearly have to do something about the existing situation. It will become especially urgent and important to take action if we do go forward with the increased use of coal. I believe that accelerating and constructing new plants with new source performance standards would be one way of dealing with the existing problem. It is certainly one that we cannot affort to ignore considering the present situation. Good technology for washing coal and scrubbing the effluents is on hand, indeed is being widely applied. It therefore comes down to unswerving enforcement of existing regulations.