SUMMARY OF PANEL DISCUSSION PLANNING A COMPREHENSIVE STUDY OF EFFECTS OF POLLUTION ON HEALTH

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1. Introduction

The invited panel, chaired by Professor Herbert A. David, consisted of 12 individuals: P. Armitage, C. L. Chiang, F. N. David, J. R. Goldsmith, B. G. Greenberg, R. J. Hickey, E. B. Hook, F. J. Massey, G. B. Morgan, J. Neyman, H. W. Patterson and C. A. Tobias. Also active in the discussion were S. W. Greenhouse, E. Landau, H. L. Rosenthal, E. J. Sternglass, W. Winkelstein, Jr., and B. E. Vaughan.

After opening the conference, Chairman David invited the authors of the four skeletal plans for a comprehensive statistical study of the health-pollution problem to outline their ideas briefly. Following the presentation of the plans by Goldsmith, Hexter, Neyman and Ury, the twelve panelists offered their remarks. Then there were comments from the floor.

The four skeletal plans differ considerably in their underlying ideas. One extreme contemplates what amounts to experimentation in hospitals on patients suffering from respiratory and heart diseases. A small number of patients, such as 15, can be divided into groups placed in separate rooms with different controlled degrees of air pollution. Frequent physiological observations could then provide information on the effects of each pollutant separately and of their combinations. Apparently experiments of this kind have been performed in Los Angeles. An intermediate point of view is represented by the recommendation of observational research typified by a study also performed in Los Angeles. Here, a measure of health conditions or a health parameter, such as number of deaths, is correlated with a variety of observational data, such as the cyclically varying temperatures and the concentration of selected air pollutants. Hope is expressed that, if such studies could be repeated in many urban areas in different countries, then the degree of agreement of the conclusions reached might be indicative of the real effects of the pollutants considered.

The other extreme proposal advocates a study involving simultaneously all the pollutants suspected to exercise major effects on health. The proposal is based on the observation that each particular locality is affected not by just one

pollutant but by a combination of several of them. Hence, in order to be able to assign to each of the pollutants its own effect on the health parameter chosen for investigation, it is unavoidable to include in the study a number of localities with different patterns of pollutants. According to this point of view, a really informative study must be both a multipollutant and a multilocality study. The proposal emphasizes the desirability that the suggested study be conducted by several independent statistical groups having access to the same data and enjoying the opportunity of frequent consultations.

The discussion that followed was as varied as the skeletal plans. It is summarized under the following headings: (1) subjects for study, (2) organizational difficulties, (3) availability of data and (4) statistical methodology.

2. Discussion of specific subjects for investigation

There seems to have been a general agreement that the effects of the various pollutants on health of small animals, such as *Drosophila*, are easier and perhaps preferable to study than the effects on human health. Because of the possibility of combining experiments with observational investigations, studies of animals might lead to a better understanding of the phenomenon in the large. Studies of this kind might reveal chains, particularly food chains leading to accumulation of noxious chemicals in the body of man. Also, studies of food chains might show the existence of important pathways from environment to man other than food chains. For example, according to a study of the Battelle Memorial Institute, over half of the body burden of DDT in man comes from other than food sources. Inferentially, this other half may come via inhalation of pesticide-laden soil particles or the like.

In spite of the greater ease of studying lower animals rather than humans, it is primarily human health that must be the ultimate subject of contemplated studies. While this general point of view was vigorously emphasized by several speakers, there was considerable variation in detail.

Some speakers felt it desirable to investigate health hazards from the use of thousands of new chemicals that appear on the market year after year, some as food additives, some others for use in commercial laundries, and so forth. The effects of these chemicals may be carcinogenic or teratogenic and they may be cocarcinogenic or coteratogenic. Also these effects may be long range. In order to be able to detect them, frequent and detailed observations of the exposed individuals are necessary. Even with generous financial support such observations could be made only on a limited number of individuals. But then, if the sample studied is small, there will be little hope of detecting the effects that one wishes to detect. On the other hand, if the study is to be based on a large sample, only a few health parameters could be included.

Two foreign studies were quoted as examples of what might be done in this country. One of them, performed in the United Kingdom, is a multilocality study on the general lines of the research by Hickey and co-workers (*IEEE*

Transactions on Geoscience Electronics, Vol. GE-8 (1970), pp. 186–202) but apparently less extensive. The other study, by V. L. Kapalin, at least in its part described at the panel discussion, gives tabulations of measurements on several groups of children, living in localities with different levels of air pollution and belonging to different income strata of Czechoslovakia. Among other things, it appears that the growth of children in polluted localities is slower than in localities with cleaner air.

With reference to possible health effects of radiation in the vicinity of nuclear power facilities, there seemed to be general agreement that, if this subject is studied, then the investigation should also indicate the localities with large plants using mineral fuels.

The culminating point of this part of discussion was an appeal for forming some kind of consensus on what is the question that has to be answered. If this question is settled then the discussion of the means of obtaining the answer could be fruitful.

3. Organizational difficulties

Several speakers expressed opposition to the idea that, if a comprehensive statistical study is attempted, it be conducted by several statistical groups working in parallel. The chief argument against a "multicenter" organization is the difficulty of reaching consensus on what should be done and how. Several speakers proposed that some kind of statistical consulting center be established where substantive research workers could request and receive authoritative advice.

4. Availability of reliable data

While results of monitoring various pollutants are published by appropriate agencies, concern was expressed as to the adequacy of monitoring stations to produce measurements to characterize substantial areas which these stations are supposed to represent. It was suggested that, in order to characterize the air pollution of an area like Los Angeles so that the measurements of pollution could be meaningfully correlated with health parameters relating to the same area, more stations than there are now would be needed. Also, it was suggested that these stations be randomly distributed over the area. The importance of expert design and surveillance of the monitoring equipment was emphasized.

There was extensive discussion of the desirability of using special surveys of health parameters and of the heavy cost and possible incompleteness of health data.

5. Statistical methodology

The following problems were discussed.

(i) *Problem of competing risks.* Ordinarily, an individual in a population is

exposed to the risk of death within a unit period of time not just from one particular cause C_1, but also from a number of other causes, say C_2. The probability of death from C_1 in the presence of "competition" from C_2 is labeled the crude rate of death from C_1. Clearly, the value of the crude rate of death from C_1 depends not only on C_1, but also on the severity of all other causes symbolized by C_2. The concept characterizing C_1 alone is labelled the net risk of C_1. This is the conditional probability of death from C_1 computed on the assumption that all other risks C_2 are inoperative.

The rates of death from various causes ordinarily published by various institutions are estimates of the crude rates. It was suggested that for pollution-health studies net rates of risks would be more relevant.

(ii) *Spurious correlations.* Several speakers warned against direct juxtaposition of morbidity data published for different geographical localities with the corresponding levels of pollutants. One possibility is that both the morbidity and the level of pollution are closely related to the socioeconomic status of the inhabitants in the different localities. Hence the unconditional correlation between pollution and morbidity may be very high even if the pollutants do not affect the health at all. In particular, a thorough statistical study may well reveal that the much discussed pollution with radioactive wastes is not really correlated with any damage to health.

Many present studies compute correlations between rates which have correlated (even identical) denominators. The researchers tend to infer that the observed correlation of rates implies correlation between the numerators. However, this inference may be entirely spurious, even in the wrong direction as has been illustrated by classical examples.

6. Recommendations

There was not complete unanimity on any plans for a comprehensive study of effects of pollution on health. However, there was general agreement that the results from this Symposium should be studied and that small working agencies should be set up to organize and recommend the details of the study.