# LOW LEVEL RADIATION EFFECTS

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## 1. Introduction

The objectives of this paper are to set forth some of the questions and problems created by the recent epidemiological study of congenital malformations in New York State [1]. This study uncovered the existence of differences in congenital malformation rates in various areas of Upstate New York. The higher malformation rates were found to be primarily associated with geographical areas containing natural materials with relatively high concentrations of radioactive elements. The potential significance of these preliminary findings has set in motion a series of efforts to attempt to confirm and refine these data and to permit an appropriate interpretation. Interested readers are referred to the published material for additional details and illustrations.

## 2. New York State study

2.1. *Study design.* The epidemiological study in New York State was initiated to attempt to obtain an answer to why congenital malformation rates are relatively higher in some parts of the state than others. Early leads suggested that there might be an association between an increase in congenital malformations and the presence of increased quantities of natural materials with relatively high levels of natural radioactivity. This knowledge resulted in the setting forth of four basic study objectives:

(a) Determination of the incidence of congenital malformations reported on birth and death certificates by county, city, township and village,

(b) Determination of the type, amount and distribution of natural materials with relatively high concentrations of the radioactive elements,

(c) Determination of the association, if any, between the incidence of congenital malformations and the distribution of such materials, and

(d) Evaluation of the role which known teratogenics, including radiation, may have had in producing congenital malformations within relatively high and low malformation rate areas.

2.2. *Findings.* A tabulation was made of all congenital malformations recorded for children born during 1948–1955 in New York State, exclusive of New York City. There were 16,369 malformations among 1,242,744 live births, an incidence of 13.2 per 1,000 live births. For the rural area the rate was 13.5. Rates of 20.0 or higher occurred in 186 out of a total of 942 townships. Contiguous

groupings of these high rate townships occurred primarily in the Adirondack Mountains, Hudson Highlands and Allegheny Plateau portions of the State.

An independent compilation was made of all available geological data pertaining to deposits of materials with relatively high levels of radioactivity. These data were used to classify all townships as to the probable or unlikely presence of extensive quantities of natural materials with relatively high levels of radioactivity. The malformation rate for all rural areas classified as "probable" was 15.8 per 1,000 live births. For "unlikely" rural areas the rate was 12.9. The most highly radioactive materials in New York State are found in areas with outcrops of igneous rocks. These areas had the highest malformation rate, 17.5. Areas with extensive deposits of glacial materials had a rate of 15.4. These included river valleys in the Allegheny Plateau and glacial moraine areas. Areas with less extensive glacial deposits had a lower rate.

Birth record data pertaining to occupation of father were used to evaluate the relationship between malformation rates, presence of radioactive materials and socio-economic status. The neonatal mortality rate from malformations was inversely related to socio-economic status as indicated by occupation of father. However, there was no relationship between socio-economic status and the presence of radioactive materials. In "probable" radioactive material areas, malformation rates were higher than in "unlikely" areas for all but one occupational group.

Data pertaining to source of public water supply were used to evaluate the relationship between malformation rates, presence of radioactive materials, and drinking water from wells and springs as contrasted with large surface supplies (lakes and rivers). In areas of "probable" radioactive materials, the malformation rate was highest, 16.9, in communities deriving their water supplies from wells and springs, and lowest, 12.4, in those utilizing surface waters. In the "unlikely" areas, the corresponding rates were 12.9 and 11.9.

Groups of contiguous townships with relatively high and relatively low malformation rates were selected for special epidemiological field study. There were no differences between the high and low rate areas in the distribution of births by age of mother, age of father, number of previous children born to mother, or occupation of father. There were also no differences in infant mortality after the first month, or in the stillbirth rate. Possible biases associated with different reporting practices by hospitals, sampling variation in the selection of field study areas, and general under-reporting of malformations were investigated and could not account for the difference in rates between the high and low rate townships. There was no association between the incidence of rubella and malformations in any of the townships. Extensive family interview data revealed that medical radiation, infectious diseases during the first trimester of pregnancy and other potential etiological factors were not responsible for the malformation rate differences noted.

Field measurements of external environmental radiation levels were found to lie mainly in the interval of 8 to 12 microroentgens per hour with appreciable

departures from this range at points adjacent to exposed minerals having an elevated radioactive content. These levels represent a range of from 2.1 to 3.2 roentgens per thirty-year period. Preliminary screening measurements of radium 226 for a limited number of water supplies revealed one highly radioactive supply, from an igneous rock outcrop area, which contained $29.0 \times 10^{-16}$ grams per ml. This level is in contrast to a general range of from 0.0 to $1.7 \times 10^{-16}$ grams of radium per ml found in public water supplies [2].

The geographical distribution of leukemia and bone tumor cases was reviewed with no significant correlation with geology being found. The number of reported cases of bone tumors, however, was small in the igneous bedrock areas. Possible changes in sex ratios were also investigated. Changes were considered to be too small to be of significance. Efforts to evaluate possible differences in longevity had to be postponed pending receipt of 1960 census data to permit computation of age specific death rates for the smaller political jurisdictions. Data pertaining to geographical differences in malformations among animals were either unavailable or unreliable.

2.3. *Interpretations.* The N.Y. State study represents an epidemiological fact finding effort. The associations noted are statistical in nature and represent a first step in establishing possible cause-effect relationships. It should be stressed that the associations relate to total malformation rates and the location of geographical areas containing materials with relatively high concentrations of radioactive elements. This is not equivalent to a direct relationship with external environmental radiation levels or "background" radiation.

The study and the study data are also not comparable to the studies of the effects of atomic blast radiation in Japan [3] or to the majority of animal studies dealing with ionizing radiation. The latter studies have been related almost exclusively to high-dose, external radiation administered over short periods of time. In contrast, the environmental radiation factors described pertain to low dosage levels over long periods of time. With many families, the time factor has included several generations. The sources of radiation, in addition to external radiation, include internal emitters which may have been ingested with food or drinking water, or inhaled.

The data upon which the report is based relate to such a substantial number of births that most of the differences indicated would be statistically significant by whatever tests devised. However, the real significance lies in the overwhelming consistency of the pattern which is shown in the relationship of malformation rates to geology. The data are crude with factors other than chance variation operating. Some of the most convincing evidence may be found in a comparison of the relationships between bedrock, glacial material and malformation rates.

Special attention should be directed to the general range of external environmental radiation of 8 to 12 microroentgens per hour, and the fact that the higher readings are primarily associated with igneous bedrock areas. Although of undetermined significance, the 50 per cent increase in the level of the higher radiation figure over the lower is similar to the difference between the malformation rates

12.9 and 17.5 associated with different levels of natural radioactivity. These latter rates reflect the differences found between rural areas classified as probably not containing relatively large quantities of materials with elevated radioactivity versus those containing more highly radioactive igneous materials.

The general absence of unusually high external environmental radiation levels in river valley and morainal areas is offset by the potential radiation exposures to man via ground water used for drinking purposes. Epidemiological justification for this consideration is associated with the fact that higher rates in these areas are associated with consumers of ground water supplies in contrast to large surface supplies. These data suggest that an internal factor acquired through drinking water may play a more important role than an external agent.

The association of increased malformation rates with residence in areas containing materials with relatively high levels of radioactivity strongly suggests radiation as a primary etiological agent. However, a trace element or chemical compound which may be teratogenic for laboratory animals may also be associated with radioactive materials. Such an agent, however, is presently unknown and no known etiological factor other than radiation has the same statistical association with the malformation differences which are recorded. This applies to rubella, medical radiation, socio-economic status, consanguinity and the many other factors investigated in the study. Until such time as the existence of an alternate agent can be elicited, it would appear necessary to consider radiation as a possible causal agent. If such a causal association can be confirmed, it would serve as the basis for establishing more realistic and reliable information and standards pertaining to the long range effects on man of low level, environmental, radiation than those which have been extrapolated from laboratory experimentation with Drosophila and mice. Such information would be of special value in evaluating the hazards of environmental contamination by radioactive wastes and of fallout materials. Extensive additional radiological measurements will be required, however, before accurate estimates of these possible relationships can be made.

### 3. Collaborative studies

The possibility that detrimental biological effects may be produced in human populations from low levels of environmental radiation is currently under study elsewhere in the United States and abroad. Studies exploring possible relationships between environmental radiation and an increased incidence of cancer is under way in Illinois by the Atomic Energy Commission's Argonne National Laboratory, in Washington County, Maryland in cooperation with the Public Health Service, and in the New England States by personnel from the Harvard School of Public Health. Workers in these areas are currently planning to expand their studies to include a consideration of congenital malformations.

In view of the importance of ascertaining malformation hazards to man of low radiation exposure levels, a feasibility study was undertaken by Dr. Douglas

Grahn, geneticist for the Atomic Energy Commission in association with Jack Kratchman, geologist for the Commission's Division of Raw Materials [4]. Deaths from congenital malformations as a fraction of total deaths for the period 1952–56 were tabulated for the United States on a county basis. The data developed from this feasibility study suggests that the mortality incidence from congenital malformations may be higher in those geologic provinces in the United States which contain the major uranium ore deposits, uraniferous waters, or helium concentrations. The data thus suggests that variation in radiation exposure may underlie the observed differences in malformation death incidence. The crudeness of the data makes it impossible at this time to come to any conclusions concerning these preliminary findings. However, the data from this feasibility study have been considered sufficiently provocative to encourage more detailed investigations.

Following the publication of the New York State study, the Congress of the United States became sufficiently interested to provide funds for the United States Public Health Service to initiate pilot efforts in other states to evaluate the possible occurrence of similar associations between malformations and environmental radiation. A conference sponsored by the Public Health Service and the New York State Department of Health was held in Albany in November of 1959 for the purpose of acquainting representatives of various states with the details of the New York State study. Subsequent planning efforts for a collaborative study have taken place with involvement of workers from Illinois, Maryland and New England as well as staff from the University of Minnesota School of Public Health who will be working with representatives from the states of Michigan, Minnesota and Colorado. A special study group has also been established by the Public Health Service and the National Office of Vital Statistics on the development of recommendations for evaluation, improvement and utilization of data on congenital malformations from vital statistics.

### 4. Additional New York studies

A continuation of study efforts within New York State is under way with special emphasis on obtaining more adquate radiological measurement data concerning levels of environmental contamination. Information pertaining to quantity and distribution of trace elements and chemical compounds in drinking water is also being pursued.

Additional epidemiological studies are contemplated with particular interest being directed towards the question of a possible correlation between duration of residence in high malformation rate areas and malformation rate experience.

## REFERENCES

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