NATIONAL CANCER INSTITUTE

Executive Summary

"NCI 1997"

Estimating Exposure

Historical measurements of the amounts of radioactivity deposited and of a daily rainfall were used as the basis for the dose calculations whenever feasible. These historical measurements consisted of a simple collection of daily fallout on sticky paper (i.e., gummed film) made at the time of and during several days following most of the

tests. The number and location of the monitoring stations across the United States varied with time but never exceeded 100. The collected fallout was measured daily for the amount of gross beta radioactivity present. The monitoring system was intended to determine where and when fallout occurred, but did not measure specific radionuclides. In other words, the system did not measure individually the amounts of different kinds of radioactivity, such as iodine-131, strontium-90, and cesium-137.

Reanalyses of these data together with the use of mathematical modeling, and the incorporation of precipitation data for each county during the time fallout clouds were over the United States, permitted estimates of iodine-131 deposition in each county for each day following each test. This reanalysis included: 1) the assessment of the collection efficiency of the gummed film for fallout collection; 2) the assessment of the efficiency of the radioactivity counting equipment, which varied from test series to test series; 3) accounting for the loss of volatile radionuclides during sample processing at the time of the original measurements; and 4) the use of more recently declassified and published characterization of the distribution and quantity of radionuclides in the fallout cloud produced by each test.

Measurements of the amount of radioactivity deposited were not available for 3 tests conducted in 1951, and for 6 tests conducted between 1962 and 1970. The latter six tests are thought to have led possibly to significant depositions of iodine-131 in the U.S. For these nine tests, atmospheric dispersion and deposition models were used to estimate the amount of iodine-131 deposited by county.

Regional data on consumption of pasture grasses by cows and on the transfer to milk of iodine-131 deposited on pasture grasses were used to estimate concentrations of iodine-131 in milk fresh from cows. These concentrations, together with milk distribution patterns in the 1950s, were used to estimate local concentrations of iodine-131 in the cows' milk available for human consumption throughout the country. (Milk consumed immediately after milking a family cow would have a higher concentration if iodine-131 than does milk processed and then consumed days after a cow was milked.) Finally, milk consumption rates, based upon diet surveys, were used to estimate the amounts of iodine-131 ingested by age group and by gender. The transfer of iodine-131 to people through the other exposure routes was similarly analyzed.

The overall average thyroid dose to the approximately 160 million people in the country during the 1950s was 2 rads. The uncertainty in this per capita dose is estimated to be a factor of 2, that is, the per capita dose may have been as small as 1 rad or as large as 4 rads, but 2 rads is the best estimate. The study also demonstrated that there were large variations in the thyroid dose received by subcategories of individuals. The primary factors contributing to this variation are

county of residence, age at the time of exposure, and milk consumption patterns.

Estimating Individual Exposures

Geography

The importance of geographical location can be seen in Figure 1, which shows the overall per capita doses by county. In general, the highest per capita thyroid doses, in the range of 9 to 16 rads, were obtained in counties of western states located east and north of the NTS, such as Colorado, Idaho, Montana, South Dakota, and Utah. In many counties on or near the west coast, the border with Mexico, and parts of Texas and Florida, the per capita thyroid doses were lowest, in the range of less than 0.1 to 0.5 rad. By comparison, the average individual in the United States receives a thyroid dose of about 0.1 rad each year from exposure to cosmic rays and naturally occurring radioactivity, with relatively large variations from one location to another.

The counties with the highest estimated average doses are listed in Table 1. Individuals living in these five western counties were estimated to have a cumulative average dose of 12 to 16 rads. These were Meagher County, Montana, and Custer, Gem, Blaine, and Lemhi Counties in Idaho. The table lists another 20 counties, mostly in Montana, where cumulative individual doses were estimated to be in the range of 9 to 12 rads.

Diet, Particularly Milk Consumption

For most people, the major exposure route was the ingestion of cows' milk contaminated as the result of iodine-131 deposited on pasture grasses; other exposure routes such as the inhalation of contaminated air and the ingestion of contaminated leafy vegetables, goats' milk, cottage cheese, and eggs also were considered. For individuals within a particular age range, milk consumption can vary substantially. For example, surveys have shown that 10% to 20% of children between ages 1 and 5 do not consume cows' milk. Their doses were only about one tenth of those received by children who consumed fresh cows' milk at average rates for their age. Conversely, the milk consumption of 5% to 10% of individuals in the same age range was

two to three times greater than the average and their thyroid doses were therefore proportionally larger. The type of milk consumed also is important. It is estimated that at that time about 20,000 individuals in the U.S. population consumed goats' milk. Thyroid doses to those individuals could have been 10 to 20 times greater than those to other residents of the same county who were the same age and sex and drank the same amount of cows' milk. Goats' milk concentrates iodine-131 more than cows' milk.

The foregoing examples illustrate that the thyroid dose received by any particular individual depends on his/her source of milk and dietary habits and thus may differ considerably from the group dose estimates. Furthermore, the person's total thyroid dose from all tests depends upon place of residence and age at the time of each test. Because of the very large number of variations in residence location, age, and dietary habits, it is not feasible to provide estimates of cumulative doses for individuals. However, detailed information is provided in the full report so that individual cumulative doses can be estimated based upon personal residence and dietary history.

Uncertainties and Model Validation

There are large uncertainties in the estimated thyroid doses given in the report because it is impossible to know all the information needed to determine exact doses. These uncertainties were assessed in two ways. First, calculated concentrations of iodine-131 were compared with the few historical measurements of iodine-131 in people and the environment that are available. Second, the uncertainties in the historical daily deposition data and in each of the factors used to estimate the transfer of iodine-131 to people's thyroids through the various exposure routes yielded an estimate of the total uncertainty. The uncertainty in the thyroid dose estimated for an individual is greater than the uncertainty in the overall average thyroid dose to the entire United States population. In general, the uncertainty of the thyroid dose from NTS iodine-131 for representative individuals is about a factor of 3, e.g., if the thyroid dose estimate for an individual is 3 rads, it will likely lie between 1 and 9 rads.

The results obtained from the mathematical models used in this study were compared with any data collected at the time of the tests in order to compare the findings of the modeling with those of the actual data collection. The comparisons also provide an estimate of the uncertainty attached to the calculated doses. As a result of these comparisons, a relatively good agreement was found between actual data and predictions made by the mathematical models. For example, independent analysis of urine samples volunteered by soldiers at Army bases throughout the United States following one of the test series showed iodine-131 dose levels consistent with doses predicted. However, it should be noted that the comparison between measured

and predicted values required the use of several assumptions, and there is no guarantee that the samples measured were representative of county averages.

Information To Be Included in the Full Report

Thyroid dose estimates are given for representative individuals in specified age groups residing in each county of the contiguous United States. The report also contains extensive tables of information organized by test and by county so that individual radiation doses to the thyroid from iodine-131 can be estimated based upon personal residence and dietary histories. Thyroid doses from iodine-131 were estimated for 13 age categories, including the fetus, with adults subdivided by gender, in 3,071 counties of the contiguous United States, and for all periods of exposure. There are four consumption scenarios calculated for each category. The report's maps, tables, and formulas will allow local governments and other organizations to calculate dose estimates for individuals falling in these categories in their geographic region.

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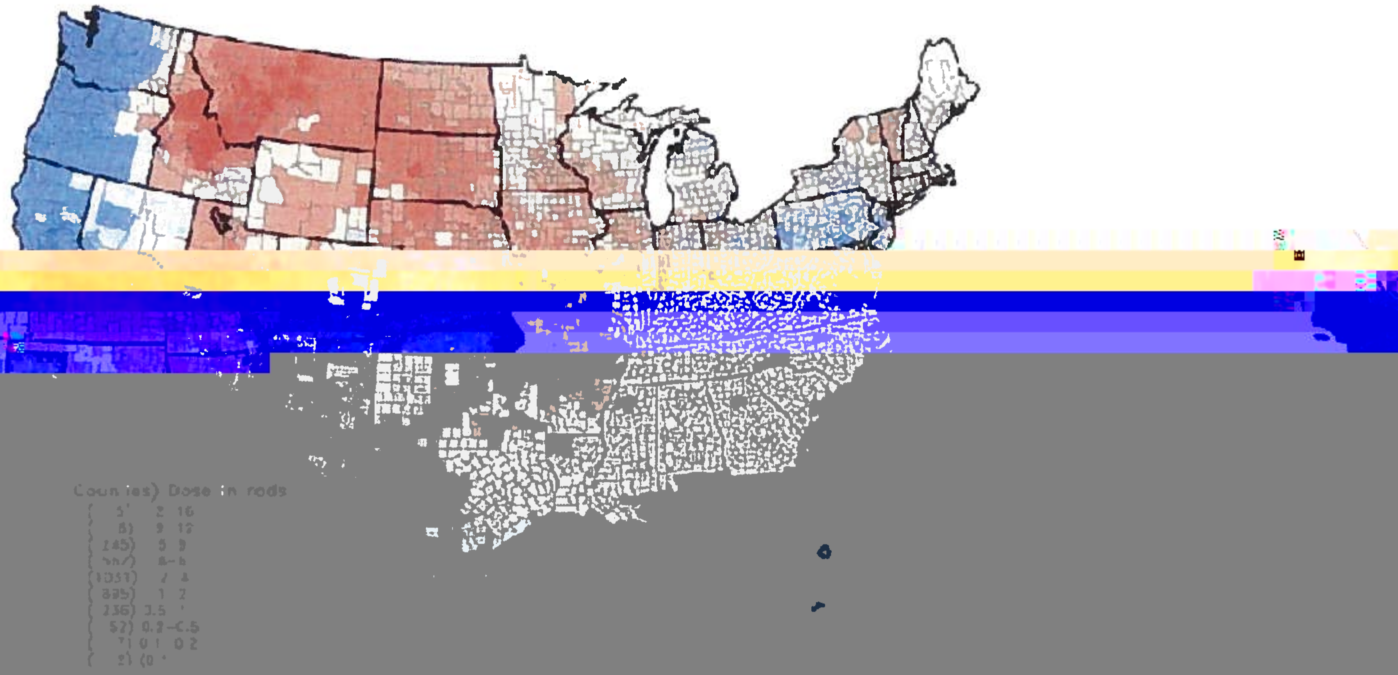
Dose in rads