AMERICAN JOURNAL OF EPIDEMIOLOGY Vol. 126, No. 1

Printed in U.S.A.

Letters to the Editor

RE: "CANCER INCIDENCE PATTERNS IN THE DENVER METROPOLITAN AREA IN RELATION TO THE ROCKY FLATS PLANT"

Crump et al. (1) present several approaches to area-based studies of cancer incidence in the Denver area downwind of Rocky Flats, a US Department of Energy nuclear weapons facility. One corroborates my study (2) of populations in the period 1969–1971 in census tracts within plutonium isopleths that found a significant excess of cancer in a suburban area (Area I) nearest Rocky Flats (16 per cent higher than expected, and 8.5 per cent higher than in the Denver urban center) and a greater proportion of cancer of radiosensitive organs (12.2 per cent). Other conclusions in the study by Crump et al. are based on approaches that rely on arbitrary sectors and distances from the urban center, and these are not valid. The sector (or quadrant) that contains Rocky Flats also includes a large unexposed university city population (Boulder) upwind of the plant (3). In addition, there are major errors and oversights in these other approaches which also invalidate their conclusion that the pattern of cancer incidence downwind of Rocky Flats is due only to urban effect.

Crump et al. (1) assert that the period after exposure was too short to permit radiation-induced cancers to appear, and they did not consider population mobility, although these studies are area-based. Yet, exposures to radionuclides released from Rocky Flats began in 1953 and reached highest levels in 1957 (2), when an explosion (perhaps a fission reaction) blew out all 600+ industrial filters in the main stack, releasing a four-year accumulation of fine plutonium and uranium dust trapped in the filter system (2, 4). The same filters had been in use over four years of reprocessing and refining operations, and a heavy black plume of smoke from the plant passed over the Denver area for about 12 hours. A then secret survey by the Atomic Energy Commission (now Department of Energy) after this incident found heavy contamination of soil with plutonium and weapons-grade uranium offsite, including private land and two elementary school grounds six and 12 miles (9.6 and 19.3 km) distant (2). The period 1969–1971 in my study (2) was chosen to utilize cancer incidence data for the Denver Standard Metropolitan Statistical Area from a National Cancer Institute survey (5). This provided an adequate latency period of 12–16 years. Our evaluation of cancer incidence in the same study area (6) 10 years later, 1979–1981, was corroborated by Crump et al. (1), who noted significant positive trends. However, the excess incidence of cancer in Area I was now smaller (10 per cent) than in Area II (15.5 per cent). Area I lies in Jefferson County which had an in-migration of 113,700 people (+48 per cent) between 1970 and 1980, substantially diluting the population (denominator) with unexposed people, while in Areas II and III together there was an out-migration of 51,700 people and a net loss (−10 per cent), i.e., much less dilution of the exposed population by in-migration of unexposed people (6). More specifically, the population of Area I within 10 miles (16 km) of Rocky Flats considered by Crump et al. increased from 84,080 in 1970 to 155,696 in 1980, an increase of 85.2 per cent by in-migration of unexposed people, in contrast to a loss of population in Areas II and III. Of 29 census tracts in Area I selected by Crump et al. (3), 23 did not exist in 1970, but were created for the 1980 Census because of housing development and remarkable population growth in this area. The part of Area I 10 to 13 miles (16–20.9 km) from Rocky Flats was developed earlier; more people there would have been exposed in 1957, and this could explain a higher cancer incidence there in 1979–1981.

My finding of an excess cancer incidence in Area I in 1969–1971 is supported by other data (6) which Crump et al. (1) do not cite. The infant mortality rate for Jefferson County (including Area I) was below the US rate in 1950, rising above the US rate after Rocky Flats began releasing radionuclides in 1953, and peaking between 1955 and 1958 (around the time of the 1957 explosion and fire) (6). Furthermore, fetal death rates rose sharply after 1953 (6). Leukemia death rates in children in Jefferson County were below the US rate in the five-year period before 1953, but increased to about twice the US rate after 1957 (6). An increase was also noted for other major childhood cancer deaths (6). Similar trends were observed in Denver County (Areas II and III). Children born after 1957 (age groups 0–14 years in 1970) had a smaller incidence of cancer (6). A strong upward trend in cancer incidence for the entire Denver metropolitan area from 1969–1971 to 1979–1981 was not noted by Crump et al. Cancer incidence in exposure Areas I–III, adjusted for age, race, sex, and ethnicity, rose from an excess of 491 cases in 1969–1971 to 1,123 in 1979–1981 (6). A study by Berg (7) for the AMC Cancer Research Center in Denver compared the cancer incidence in 1969–1971 in the Denver metropolitan area (including my Areas I–III and the control population in Area IV) with that in 1979–1981 and found an excess of about 2,000 cases of cancer after adjusting for changes in the population. Denver area residents in 1980 had a 30 per cent risk of contracting a nonskin cancer, or a greater than 40 per cent risk of all cancer (7). This was an increase in age-adjusted cancer incidence over a 10-year period of 15 per cent (7) in a largely nonindustrial metropolitan area once known for its healthful environment. This can be compared with an increase of only 9.3 per cent between 1973 and 1983 in a National Cancer Institute study of cancer incidence including about 13 per cent of the US population (8, 9).

Crump et al. (1) incorrectly assert that plutonium

has not been observed to cause cancer in man, but causes cancers of lung, liver, and bone in animals. Yet my own study of plutonium workers found an eightfold excess of brain tumors, a threefold excess of malignant melanoma, and an excess of respiratory cancer (10, 11). Plutonium has also been found in animal studies to cause leukemia, mesothelioma, reticulum cell sarcoma, fibrosarcoma, liposarcoma, rhabdomyosarcoma, leiomyosarcoma, mammary adenocarcinoma and adenoma of the kidney (12, 13). One study (13, p. 80) noted, "After injection of Pu 239, myeloid and lymphatic leukemias were diagnosed in most animals dying without osteosarcoma," and that the leukemias were as great a risk as osteosarcoma, which appeared on the average later at increasing incidence with age. In another study (12), plutonium induced 10 types of tumors after an average latency of about one year in 114.5 per cent of the animals (many developed two types of cancer) (12). Plutonium induces chromosome injury in man at extremely small doses (14). Rocky Flats workers had a 30 per cent increase in the rate of chromosome aberrations with body burdens of only 0.4 to 4 nanocuries (billionths of a curie) (14).

Crump et al. (1) imply that plutonium has an internal deposition pattern limited to lung, liver, and bone. Yet an autopsy study of Department of Energy workers found plutonium in all organs measured, including brain, omentum and skin (15). Analyses by the Los Alamos Laboratory of tissues of workers suing Rocky Flats for injury (cancer) found important concentrations of americium and other radionuclides in addition to plutonium (23).

Crump et al. note an excess of prostate cancer in Area I in both time periods but deny this organ is radiosensitive or significantly radiated by plutonium. In my study of the 1969–1971 data, there was a 9 per cent excess incidence of cancer of prostate and other organs not considered radiosensitive in Area I. In Areas I–III, there were 42 cases of cancer of testes (18 cases expected), and this cancer was also found in excess in 1979–1981 (2, 6). Both prostate and testes had greater concentrations of plutonium in a study of Department of Energy workers than in muscle, fat, and kidney (15).

Crump et al. question my adaptation of Krey's figure representing a 1970 Atomic Energy Commission soil survey (16). In my study, while the plutonium isopleths are adapted from Krey's published figure (16), they are not consistent with a later, unpublished figure drawn by Krey in 1979 and widely circulated by the Department of Energy, which appeared to reduce the implied exposures in Denver. An earlier survey, in 1969, by the National Center for Atmospheric Research found much higher concentrations in soil than did Krey, from 250 times fallout 3.2 km east of Rocky Flats to 10 times fallout 14.4 km east, decreasing to several times fallout in the eastern suburbs of Denver 35 km distant (17). Krey (16) reported Rocky Flats plutonium to be 74 per cent as much as fallout 100 km from Rocky Flats at about 90 degrees from the direction of prevailing winds. My own survey of plutonium in surface dust to 32 km around Rocky Flats (in collaboration with the US Geological Survey) also found much higher concentrations than did Krey (16), to 3,390 times fallout levels on private land planned for housing near Rocky Flats (18). I chose the original Krey isopleth map as a guide because it reflected the pattern of distribution of Rocky Flats plutonium offsite. Although not precise, the isopleths establish the pattern of contamination from an industrial point source over the years, reflecting the usual direction of winds and exhaust plumes. This method is clearly superior to the older method of drawing circles of arbitrary radii around an industrial point source, an approach still favored by Crump et al. (1) and the US Environmental Protection Agency (19).

Crump et al. (1) fail to note that Krey's map of plutonium contamination drawn in 1970 (16) may have less relevance for the 1979–1981 study period in view of the strong winds in the area and contamination of Denver area water supplies with plutonium, uranium and other radionuclides (2, 20, 21). The concentration of Rocky Flats plutonium in Denver area treated drinking water ranged from 7,000 to 40,000 times that of "background from nuclear fallout" concentrations in New York City water, as recently as 1972 (20). The treated water in one water district has had more than 400 picocuries (1 picocurie of a radionuclide produces 2.2 nuclear disintegrations per minute, or dpm) per liter of alpha radiation, chiefly from the Schwarzwalder uranium mine (21) (uranium is also released in water by Rocky Flats). Contamination of Denver area soil and water is reflected in air concentrations. A Department of Energy Environmental Measurements Laboratory air monitoring station near Rocky Flats recorded the highest air concentrations of plutonium reported in the world for every month measured, ranging from 68 times higher than in New York City in 1970 (average for the year) to 745 times higher for the month of November 1976 (2, 22). Air concentrations were much higher at times in earlier years.

Crump et al. (1) without qualification accept a joint study by the Environmental Protection Agency, the University of Colorado, and the Department of Defense of plutonium in autopsy specimens of persons who lived around Rocky Flats (19). However, this joint study concludes "we cannot rule out the possible conclusion that people who had lived southeast of Rocky Flats and lived near the plant for the last five years of life may have a larger proportion of weapons grade plutonium in their lungs than did people who had lived further away" (19, p. 198), and "It should be borne in mind that the reported results are to some extent selected from among a great many analyses performed, and this could have an effect on the true probabilities associated with putatively significant relationships" (19, p. 202). That Crump et al. (1) rely on a study (19) with "selected" results is illustrated by a scattergram in the latter study of lung plutonium by distance from Rocky Flats, which shows *no* analyses within 11 km of Rocky Flats, although elsewhere stating that there were three persons within 10 km included in the study.

Although Crump et al. (1) concluded that future studies must be based on more specific measures of plutonium exposure, it has been extremely difficult to get accurate information concerning releases of radionuclides from nuclear installations (2, 4). Until such information is obtained in a timely manner, public health authorities must rely on empirical studies, such

as my study of cancer incidence in census tracts within radionuclide soil concentration isopleths around a nuclear point source (2).

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Editor's note: In acccordance with Journal *policy, an exchange of views by the respective authors of a paper in the Original Contributions section and a letter in the same issue constitutes a complete debate. Therefore, Dr. Crump and coauthors were not invited to respond to Dr. Johnson's letter.*

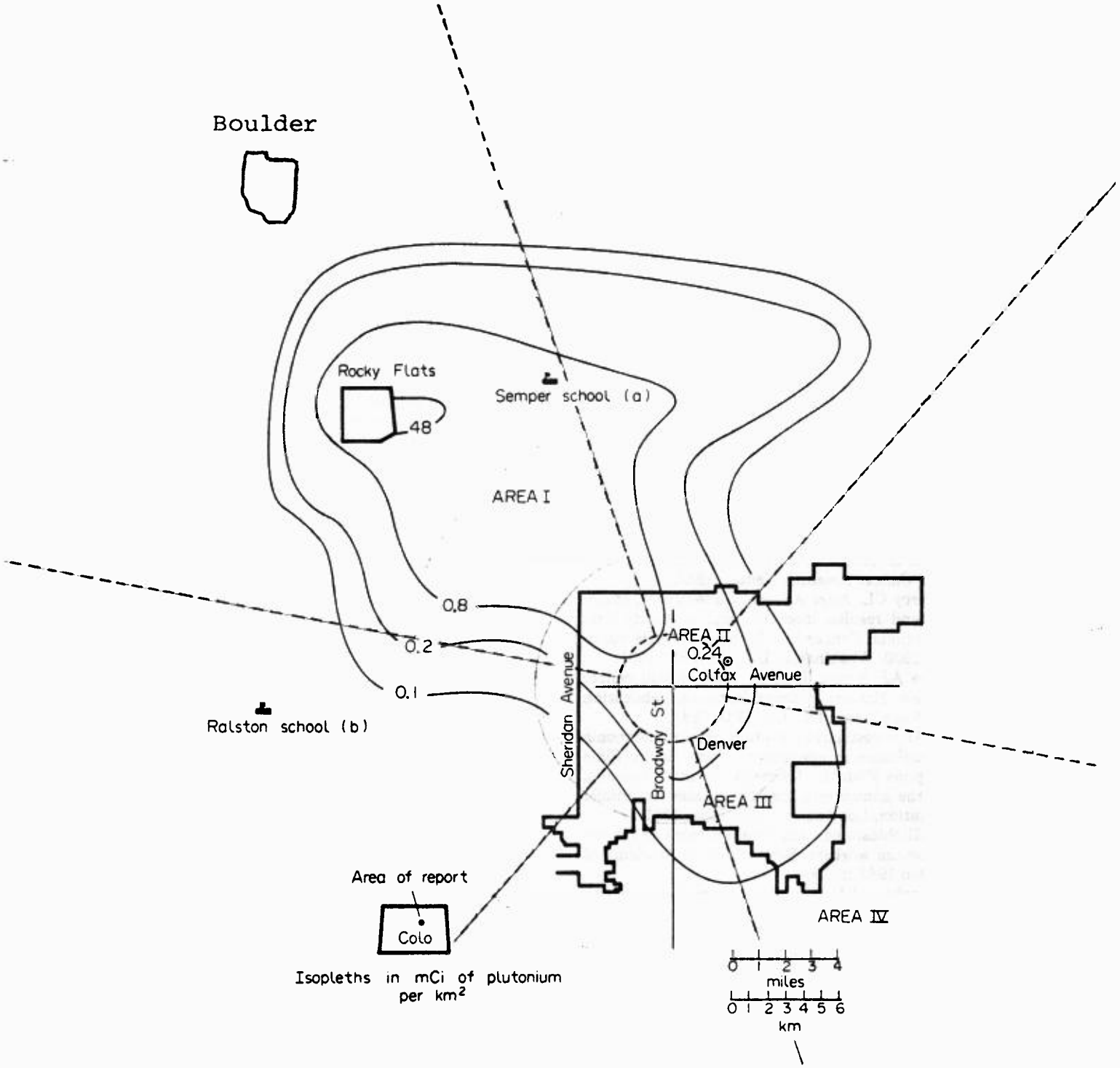

Fig. 1. (a) Soil contamination at the Semper School (13 March 1958) was 16,000 dpm/kg of 'possible enriched uranium' [19]. (b) Soil contamination at the Ralston School (13 March 1958) was 12,000 dpm/kg of 'possible enriched uranium'. (c) Soil contamination on private property east of Rocky Flats was 18,000 dpm/kg of plutonium. (Plutonium contamination was not reported for the schools.)