Cancer Clusters:

Latest Studies Do Not Support Link Between Cancer Mortality and Radiation Discharges

The perceived connection between radiation discharges and increased cancer mortality received a major blow with the release of the recent National Cancer Institute (NCI) study that revealed *no* increased risk of death from cancer for people living in proximity to nuclear installations in the United States. On September 14, 1990, Health and Human Services Secretary Louis W. Sullivan, MD, announced the results of the two-year investigation that was conducted by members of the NCI's division of cancer etiology: Seymour Jablon and Zdenec Hrubec, ScD, both experts at the division's radiation epidemiology branch, John D. Boice, ScD, chief of the radiation epidemiology branch, and B.J. Stone, PhD, a staff member with NCI's biostatistics program.

The NCI analysis, entitled "Study of Cancer in Populations Living Near Nuclear Facilities," was initiated in 1987 largely in response to British epidemiologic studies that showed a slight excess of childhood leukemia near some nuclear installations in the United Kingdom, particularly a nuclear fuel reprocessing plant in Seascale, England.

Cancer cluster studies performed in Europe, Canada, and the US over the last ten years have uniformly failed to establish a link between reports of apparent increased cancer incidence and local discharges of radiation. The recent findings of the NCI represent the latest in a long line of scientific investigations that have failed to uncover any connection between radiation emissions from nuclear power plants and the increased risk of cancer among the local populace. Researchers have maintained, however, that further studies need to be done with meticulous detail given to all possible causes of cancer.

Landmark NCI Study

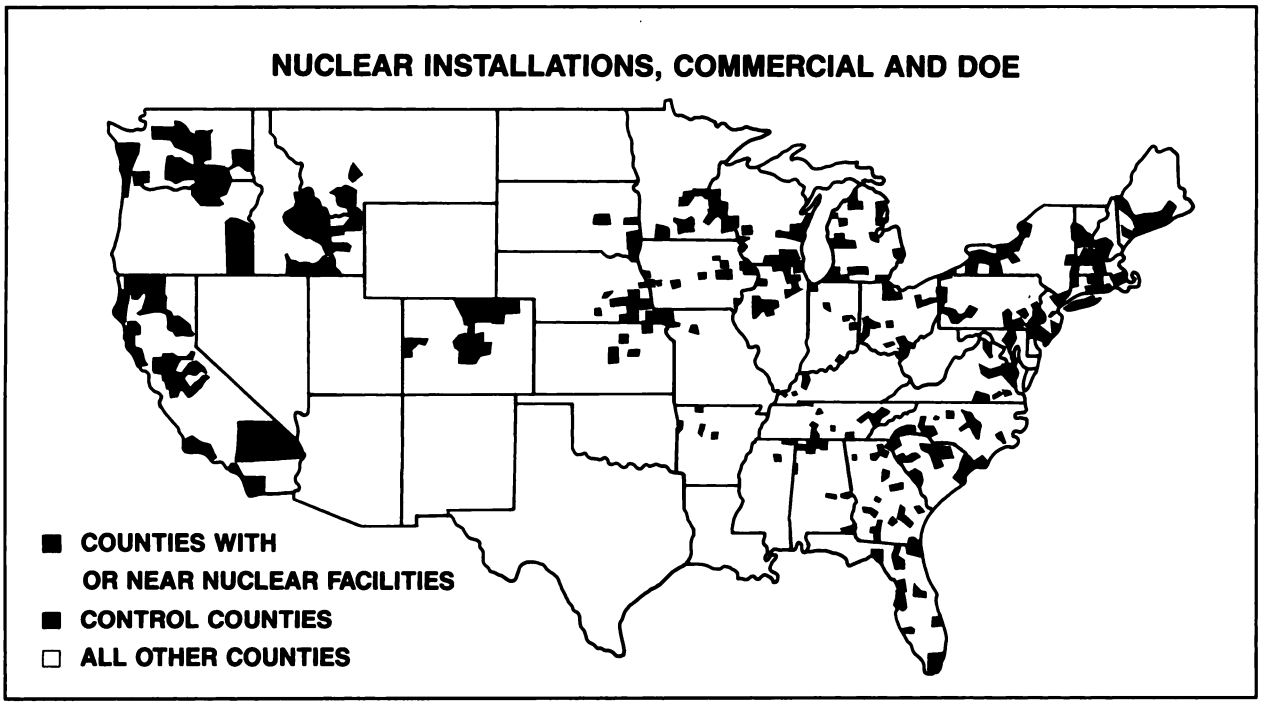
The NCI survey examined cancer mortality data in 107 US counties that contained or were situated next to one of 62 nuclear facilities — 52 commercial nuclear power plants, 9 Department of Energy research and weapons plants, and 1 commercial fuel reprocessing plant (see Figure 1). All the facilities in the survey had begun operation prior to 1982.

For each county which contained or was adjacent to a county that contained a nuclear facility — the "study counties" — cancer death rates from before *and* after the start-up of the facilities were compared to cancer death rates in three non-nuclear test "control" counties with similar demographics and topography but which had no nuclear facilities.

The NCI scientists examined over 900,000 cancer deaths in the study counties using county mortality records collected from 1950-1984. The researchers evaluated changes in mortality rates for 16 types of cancer in these counties from 1950 until the facility began and from the start-up of the operation until 1984. The data revealed that the operation of nuclear facilities had no influence whatsoever over the regional cancer mortality rates. Some study counties had slightly higher risks, some had lower, and all the vacillations fell within the standard normal variation of natural events (see Table 1).

The NCI researchers analyzed and compared the numbers of cancer deaths in the study and control counties, using the concept of relative risk (RR) of dying from cancer for persons living near a nuclear facility. An RR equal to 1.00 meant that the risk of dying from cancer was the same in the study and control counties. Any number below 1.00 meant that the overall risk was lower in the study county than the control county, and any number greater than 1.00 indicated a higher risk in the study county. For example, an RR of 1.03 would indicate that there was a 3% higher risk of cancer death in the study county. Conversely, an RR of 0.93 would indicate a 7% lower risk of dying from cancer in the study county.

Since childhood leukemia had been a special focus of the British studies, the NCI investigators paid particular attention to this form of cancer. For childhood leukemia in children aged 0-9 years, the overall RR before start-up was 1.08, and after start-up it was 1.03. These data indicated that the risk of dying from childhood leukemia was slightly greater in the study counties *before* start-up of the nuclear facilities than after. The risk of dying from childhood cancers other than leukemia changed slightly from an RR of 0.94 before the plant began operation to an RR of 0.99 after start-up. For leukemia at all ages, the RR values were 1.02 before start-up and 0.98 after. For



(Figure 1; Courtesy of the National Cancer Institute)

other cancer at all ages, the RR numbers were 1.00 before start-up and 1.01 afterwards.

"From the data at hand," concluded Dr. Boice in a NCI press release, "there is no convincing evidence of any increased risk of death from any of the cancers we surveyed due to living near nuclear facilities."

The data gathered by the NCI investigators featured a few outlying numbers. For example, New London County, Connecticut, which contains the Millstone nuclear power plant, showed a significant excess of cases of childhood leukemia, relative to its control counties. The RR was 3.04 after start-up of the facility. Upon review, according to Mr. Jablon, it was discovered that a previously unpublished survey by the Centers for Disease Control (CDC), Atlanta, Georgia, had found that an unusual high rate of childhood leukemia had existed in the town of Waterford (near the Millstone plant) *prior* to the start-up of the nuclear facility. "Despite the limitations of our study," says Mr. Jablon, "we were pleased that we were able to detect a high cancer incidence such as this, although we uncovered that it was not related to radiation." Mr. Jablon added that no excess of childhood leukemia was found close to any other nuclear facility in the nation.

In its review of the NCI study, a panel from the US Council of Energy Awareness (USCEA) commented on some of the outlying figures: "When you have small numbers, the variability is great. . . .You would expect the RRs for some of the sites to be larger than the average and a number of the sites to be lower than average, and that is, in fact, what is reported in the study. This is simply based on [the] random nature of natural events." In fact, three facilities (San Onofre in Orange County, California; Quad Cities in Rock Island County and Whiteside County, Illinois; and Vermont Yankee in Windham County, Vermont) showed significant *deficits* in relative risk for leukemia deaths among children. The RRs near these nuclear plants were 0.75, 0.24, and 0.09, respectively.

The NCI selected an ad hoc advisory committee composed of independent experts in the fields of cancer epidemiology and biostatistics to review the study and outline its strengths and limitations. The committee largely endorsed the report and the methodology behind it, citing "the large numbers of facilities studied, the selection of control counties for comparison purposes, the evaluation of risks before and after reactor start-up, and the availability of 35 years of mortality data for each county." The committee further noted that the method of using correlation analyses from county mortality data had previously been successful in uncovering such carcinogenic hazards as arsenic pollution from metal smelters and asbestos exposure in shipyard workers. However, the committee determined that using county mortality presented some limitations.

The study, the committee members wrote, "is based on data from counties, some of which are very large, and it is possible that any effects in the immediate vicinity of the facilities escaped detection because they were diluted by the larger populations more remote from the facilities." To remedy

this limitation in future studies, the committee suggested that "surveys of cancer occurrence around certain facilities using smaller population groupings, such as census tract data, might be useful." Although Dr. Boice acknowledged that the size of the counties might have been too large to detect risks that may be present in only very limited areas around the plants, he added that "no study can prove the absence of an effect. But if any excess cancer risk due to radiation pollution is present in counties with nuclear facilities, the risk is too small to be detected by the methods used." While noting that a study using county data took two years to do, Dr. Boice asserted that a study using smaller data sets would take considerably longer to complete.

The advisory committee listed some other limitations of the report. The committee noted that it might be too early to properly evaluate the health risks associated with living near nuclear facilities since "many of the nuclear. . . plants have come into service only in the past few years and not enough time may have passed for possible radiogenic effects to have appeared." The group recommended that cancer mortality rates in areas around nuclear facilities should continue to be monitored.

Furthermore, leukemia is only one of the major cancers that has been associated with exposure to radiation. While leukemia generally may occur within two years following exposure, the committee pointed out, other cancers associated with radiation do not develop for more than 10 years after exposure. "Solid tumors, for example of the lung and stomach, are known to have a latency period of 10-15 years following exposure to radiation," says Donald A. Pierce, PhD, professor of statistics at Oregon State University, Corvallis, Oregon, a member of the Biological Effects of Ionizing Radiation (BEIR) IV Committee and a member of the NCI's ad hoc advisory committee.

TABLE 1.
Relative Risk of Dying from Cancer in Countries with Nuclear Facilities Compared to Risk in Non-Nuclear Test Counties

Type of Cancer	Relative Risk (RR)	
	Before start-up of local nuclear site	After start-up of local nuclear site
Childhood leukemia (ages 0-9 years)	1.08	1.03
Childhood cancers* (ages 0-9 years, other than leukemia)	0.94	0.99
Leukemia (all ages)	1.02	0.98
Other Cancers* (all ages)	1.00	1.01

* Other cancers included Hodgkin's disease, lymphoma, multiple myeloma, cancers of the digestive organs, cancer of the trachea, bronchus, and lungs, female breast cancer, thyroid cancer, cancer of the bone and joints, bladder cancer, brain and other central nervous system cancers (Courtesy of the National Cancer Institute).

The committee suggested that data on cancer incidence rather than mortality would permit a more accurate assessment of possible increases in cancer. "This is particularly true for cancers that are not highly fatal, like cancers of the thyroid and the breast," comments Dr. Pierce. "While it is true that cancer incidence data would provide a more sensitive indicator of health risk," says Bertrand Brill, MD, professor of nuclear medicine, director of research, department of nuclear medicine, University of Massachusetts Medical School, Worcester, "such data is very difficult to get. Cancer mortality data should serve as a good indicator of the health risk involved, if any."

The committee recommended that future studies should concentrate on other possible causes of apparent increased risk of cancer death: excessive but undetected radioactive emissions from the plant, chance observation, and exposures to chemical effluents or other carcinogens.

The committee concluded that "overall, the relative risks of leukemia and other cancers appeared to be slightly higher before reactor start-up than after, providing no evidence that environmental pollution attributable to the facilities might be causing a substantial increase in cancer risk in the study counties."

"This is the best study of this type ever done," says Stanley J. Goldsmith, MD, director of the department of physics-nuclear medicine at Mount Sinai Medical Center, in New York City. "[The study] is compatible with the. . . BEIR V Report, which hypothesized that the low levels of radiation associated with nuclear energy plant operation would not be expected to produce a demonstrable increase in cancer or leukemia." Dr. Goldsmith added that critics of the NCI study, especially anti-nuclear activists, will probably not be satisfied with its results. "The study could not identify any significant increase in cancer whatsoever, but critics will contend that something was missed in the survey anyway," he says. "But, basically, the findings of the NCI report are squarely at odds with the unsubstantiated claims of anti-nuclear activists who maintain that living near nuclear sites causes enormous increases in cancer. That's simply not true." Dr. Brill comments, "the public should be reassured by the fact that this exhaustive study found no detectable hazards of living near a nuclear plant. Furthermore, nuclear plants operating normally are closely monitored and emit far less radiation than, say, a coal-

burning plant."

In opening the door for additional research into cancer cluster studies in the US, the NCI surveyors concluded that their study is "the initial step in evaluating the possible hazards of living near nuclear facilities. Information gained from this survey and other ongoing projects will guide future research efforts. The study provides background information that will complement other studies being conducted or being planned by the CDC and various state health departments." According to Mr. Jablon, the NCI will consider doing a follow-up study in five years.

Three Mile Island

The findings of the NCI report support and complement a recent cancer study of the residents of Three Mile Island (TMI) near Harrisburg, Pennsylvania, which was directed by Maureen C. Hatch, PhD, associate professor, division of epidemiology, School of Public Health, Columbia University, New York City. The study, which appeared in the September 1990 issue of the *American Journal of Epidemiology*, stated that there was no conclusive association between TMI's accidental plant emissions in 1979 and the incidence of cancer among children or the incidence of leukemia among adults. According to Dr. Hatch's survey, the TMI investigators "failed to find definite effects of exposure on the cancer types and population subgroups thought to be most susceptible to radiation."

Dr. Hatch's study concentrated on residents living within a 16 km radius of the plant and estimated the radiation emissions based upon a mathematical dispersion model that takes into account the modifying factors of wind and terrain. According to the Hatch study, using the dispersion model and a knowledge of the climatic conditions present during the accident, scientists can predict, to a great degree of certainty, the pattern of radiation exposure upon a small geographic region.

"Overall, the pattern of results does not provide convincing evidence that radiation releases from the [TMI] nuclear facility influenced cancer risk during the limited period of follow-up," the Columbia study concluded.

> "From the data at hand, there is no convincing evidence of any increased risk of death from any of the cancers we surveyed due to living near nuclear facilities."

Dr. Hatch's results support an earlier extensive study conducted by George K. Tokuhata, PhD, MD, director of the division of epidemiological research, Pennsylvania Department of Health, in 1988, which observed very little effect on pregnancy outcomes since the accident at TMI. Aside from a slightly increased risk of low birth weight, Dr. Tokuhata's survey identified no changes in spontaneous abortions, fetal mortality, infant mortality, congenital hypothyroidism, or cancer mortality for data assessed through 1985.

A State Investigation: West Valley, New York

Alleged reports of increased cancer in a locality are often investigated by universities and state health agencies, often at the behest of citizen groups. These local efforts, by and large, have also failed to find any substantive proof that connects low-level radioactivity with apparent increases in cancer.

In 1986, Tim Byers, MD, and John E. Vena, MD, of the department of social and preventive medicine, University of Buffalo Medical School, conducted a study of cancer incidence in the vicinity of a former nuclear fuel reprocessing plant at West Valley in western New York State. They responded to a request by state health agencies and the Coalition on West Valley Nuclear Wastes, an anti-nuclear activist group that had expressed concern over an apparent excess of leukemia cases in the area.

The study, covering the years 1973-1983, found no increase in cancer cases in any of the seven towns surrounding the former nuclear site, which had been operated by Nuclear Fuel Services, Inc., a subsidiary of Getty Oil, from 1966-1972. In fact, the study showed that the total number of cancer cases recorded in the area was *lower* than expected. For two years, the Coalition, which according to the New York State Department of Health had tried to rally the public against low-level waste sites, kept the study's results concealed. The findings were finally released by the health department in 1989.

The Buffalo investigators used census data and cancer incidence data from New York State Cancer Registry records to determine the number of observed and expected cases of cancer for each of the seven towns in the region around the West Valley nuclear site. *No* excess cases were observed in any of the seven towns. In fact, a slight *reduction* of cancer incidence was detected. When the investigators inspected the data according to classifications of cancer types, they observed a slight but statistically insignificant

excess in lung cancer and leukemia. The researchers discovered, however, that the leukemia excess was attributable to acute lymphocytic leukemia, which has been shown not to be caused by radiation. Admitting that their study was not designed to detect long-term health effects following exposure to radiation, Dr. Byers and Dr. Vena concluded that no data existed that would "support the impression that there is an excess of cancer in this region due to West Valley radiation."

An ordinary member of the public living a few kilometers away from a typical nuclear power station would receive a maximum annual dosage of less than 2% of naturally occurring background radiation.

Pioneer Cluster Studies in Britain

Cancer cluster investigations have also progressed at full steam in foreign countries with extensive nuclear programs. During the past ten years a flurry of cancer clusters have been reported in the vicinity of British nuclear installations, fueling debate among nuclear power advocates, public health officials, and anti-nuclear activists, while engendering fear and suspicion among the public.

Reports of apparent increased incidence of cancer — notably childhood leukemia — have surfaced in Britain both near *and* far from existing nuclear plants. According to David Wilkie, ScD, senior scientist and statistician with the United Kingdom Atomic Energy Association (UKAEA), British studies of cancer clusters have failed to point to nuclear radiation as the cause. Dr. Wilkie specifies that scientific measurements have determined that an ordinary member of the public living a few kilometers away from a typical nuclear power station would receive a maximum annual dosage of less than 2% of naturally occurring background radiation. Furthermore, cites Dr. Wilkie, using current UKAEA-recommended figures on radiation risk assessment and supposing that everyone in a given town of 10,000 people receives the maximum dosage every year, only one excess case of leukemia might be expected to arise in 1,000 years. "This estimation is based on a linear extrapolation from the Hiroshima-Nagasaki data," says Dr. Wilkie.

In support of these figures, in 1987 the UK Office of Population Censuses and Surveys released a highly detailed and exhaustive study on cancer incidence in the vicinity of British nuclear sites and found no evidence linking nuclear power stations to excess childhood leukemia deaths. The Office researchers gathered data from cancer registries and mortality reports around nuclear sites and analyzed 8,000,000 separate occurrences of cancer for the years 1959-1980, taking into account the distances from nuclear installations. The following year, scientific teams from Oxford University's Imperial Cancer Research Fund (ICRF) and the Medical Research Council (MRC) analyzed the data again and confirmed the original findings.

The ICRF study, under the direction of Sir Richard Doll of the Cancer Epidemiology and Clinical Trials Unit, Gibson Laboratories, Radcliffe Infirmary, Oxford, yielded two results similar to the NCI findings: there appeared to be a significant *deficit* in the number of deaths arising from *all* cancers around nuclear sites, and, although there was concrete evidence of a small but statistically significant excess of childhood leukemia and Hodgkin's disease near older nuclear sites, these apparent excesses appeared to suffer from an unfavorable comparison with control areas that had particularly low numbers of cancer deaths. The Oxford researchers analyzed mortality and census data for 400 districts in England and Wales for the years 1969-1978 and failed to find evidence to connect radiation with the excess childhood leukemia incidence. The group advised that because of the statistically apparent increased cancer incidence, *all* possible causes should be investigated and none should be ruled out.

Controversy Over Sellafield

The most publicized cancer cluster study in Great Britain centers around the small town of Seascale, West Cumbria on England's northwestern coast. A 1983 television broadcast by Yorkshire Television triggered a national sensation by revealing an apparent cancer cluster in Seascale, adjacent to a nuclear fuel reprocessing installation at Sellafield. Broadcasters recounted that between 1945 and 1980, 5 children had died of leukemia in Seascale, compared to an expected number of only 0.5 for the 35-year period.

Following the report, a wave of investigations took place, most notably a government-funded survey conducted by British physician Sir Douglas Black in 1983, and a 1987 study by the UK Committee on the Medical Aspects of Radiation in the Environment (COMARE). Both investigations

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agreed that a real excess of childhood leukemia occurred in Seascale, but neither attributed the increase to Sellafield's discharge of radioactivity. The Black Committee discredited the possibility that radiation could account for the excess deaths, asserting that the radiation discharged by Sellafield was insufficiently low. Assuming that *all* cases of leukemia in Britain are caused by naturally occurring background radiation, the Black Committee submitted, the estimated discharges from Sellafield over the 35-year period would have caused only an additional 0.1 deaths.

COMARE's subsequent study confirmed the Black Committee's judgments. No other leukemia cases were found in any of the other towns in the vicinity of the Sellafield plant. Furthermore, noted COMARE, no excess cases of leukemia occurred following higher-than-average discharges from Sellafield, taking into account the normal two-year latency period between radioactive emissions and manifestation of the disease. "If radioactive discharges are to explain the Seascale cluster," concluded COMARE's report, "either the magnitude of discharges from Sellafield or our understanding of the risk of radiation-induced leukemia, or both, must be in error by a factor of hundreds or thousands."

The most prominent and controversial study concerning Sellafield was conducted by Martin J. Gardner, PhD, an epidemiologist and medical statistician with MRC's environmental epidemiology unit at the University of Southampton, England. Since all the fatalities were children exclusively *born* in Seascale, Dr. Gardner sought to investigate a familial connection. In his five-year study, Dr. Gardner examined over 100 cases of leukemia, lymphoma, and Hodgkin's disease in West Cumbria and determined that a possible link between childhood leukemia and paternal occupation might exist. He discovered that for West Cumbrian male workers who received a dose of more than 100 mSv over their working lives, the risk of their children contracting leukemia might increase by as much as sevenfold. Furthermore, Dr. Gardner's report indicated that the risk might be even higher if significant doses were received just prior to conception.

"On face value, Dr. Gardner would have appeared to have found a link between infant cancer and paternal exposure to radiation prior to conception," says Stan Rodliffe, a physicist with Britain's Central Electricity Generating Board. "However, the statistical uncertainty behind such a finding is extremely high. Nevertheless, it is a correlation that had not previously been thought of. His tentative finding has not been supported or validated by other studies, however." Meanwhile, Dr. Gardner plans further studies that will comprehensively survey the children of all workers at the Sellafield plant to further examine the possible genetic effects of paternal radiation exposure.

Dr. Gardner's findings have come under fire and skepticism from the British government and epidemiologists worldwide. Critics point out that the total number of leukemia cases investigated in the West Cumbrian area over the 35-year period was only 74, and only 10 of these had parents who worked at Sellafield. "The data and the study lack statistical power," comments Dr. Wilkie. Critics also indicate that many of the children who contracted leukemia had fathers who worked in non-nuclear steel and iron factories in the area. Additionally, the suggestion that radiation-induced genetic damage to a father's sperm might be responsible for the occurrence of childhood leukemia directly contradicts the results of the 40-year study of the Japanese atomic bomb survivors who were exposed to much higher doses of radiation at a considerably higher dose rate.

Clark W. Heath, MD, vice president for epidemiology and statistics for the American Cancer Society, in Atlanta, a member of the ad hoc committee that reviewed the NCI study, cautions that "while Dr. Gardner's angle is interesting, it is hardly a conclusion of evidence. Even he would admit to that. His hypothesis would have to be rigorously reviewed and replicated by other investigators in order to gain credibility." Adds Dr. Brill, "Dr. Gardner's findings do not seem to make any biological sense. If his results are not replicated elsewhere, they will have to be judged to be a statistical fluke." Dr. Heath added that

the CDC is currently conducting such a "paternal occupation and exposure" thyroid cancer study at the Hanford nuclear reservation in Washington State, the results of which are expected to be released next year.

Other prominent cancer cluster investigations in Britain concerned reports of apparent excesses of childhood leukemia near a nuclear installation in Dounreay, Scotland, and near two nuclear weapons sites in Aldermaston and Burghfield in County Berkshire, England. In both cases, COMARE discounted the allegation that radiation could account for the leukemia increase since the reported radioactive discharges at both sites contributed to a negligible percentage of the total radiation dosage received from naturally occurring background radiation. COMARE — in independent agreement with the ICRF researchers — concluded that broad studies of all cancer incidence reports should be done in greater detail, specifically studies examining other possible factors, such as chemical carcinogens, viruses, and demographic phenomena.

Cancer cluster studies are also underway on the European continent. According to a study published in the March 3, 1990 issue of the *British Medical Journal*, there has been no increased incidence of childhood leukemia fatalities in the region surrounding the La Hague nuclear fuel reprocessing plant in Normandy, France. For the period 1968-1986, the examiners found one death from leukemia within 10 km from the plant. This figure was below the expected number of cancer deaths for the region.

A Study from Canada

Prompted by the results of Britain's Sellafield/Seascale studies, Canada's Atomic Energy Control Board commissioned the Ontario Cancer Treatment and Research Foundation, Toronto, to conduct an independent study on childhood leukemia incidence and mortality in the vicinity of Canadian nuclear facilities.

Aileen Clarke, MB, BS, MSc, and John McLaughlin, MSc, of the division of epidemiology and statistics at the Foundation, in collaboration with Terry W. Anderson, MD, PhD, of the University of British Columbia, Vancouver, examined leukemia-related incidence and mortality data for children aged 0-4 yrs, born to mothers living near nuclear installations in Ontario Province. Ontario was selected as a data region because it contained a variety of different types of nuclear sites.

The investigators studied 795 children who died of leukemia between 1950-1986 and 951 children who were diagnosed with leukemia between 1964-1985. The researchers cited the advantage of using incidence data. "If advances in treatment occurred during the study period then mortality would become a less sensitive outcome, whereas incidence would be unaffected," they noted.

The researchers analyzed five nuclear sites located throughout Ontario. They also did further analyses with separate geographic delineations: "county" — the political subdivision in which the site was located — and "nearby" — a circle of 25 km around each installation. The researchers chose such a large radius because due to Canada's relatively sparse population, radii below that level would have further diluted the statistical significance of the results. The data also distinguished between where the victims were born and where they died, in order to find a possible "birthplace pattern," as had been detected in the British study at Seascale.

The researchers cautioned at the outset of their investigations that, due to statistical insignificance (resulting from the small number of identified cases of leukemia), most of the findings might simply be the outgrowth of chance, and therefore, hardly conclusive. After producing their data, the examiners noted that the ranges of observed-to-expected (O/E) ratios fell within variations of natural occurrence of the disease.

The second phase of the study, which extended the program to include children aged 5 to 14 — to improve the statistical significance of the study — is expected to be released later this year. That study will concentrate only on residence-at-birth data, since the preliminary results of the first study suggested a slightly higher incidence among children born exclusively near nuclear sites.

The Viral Link?

Some epidemiologists have looked into causes other than radiation for the statistical variations in cancer incidence around nuclear sites. Leo Kinlen, MD, of the cancer epidemiological unit of Edinburgh University, Scotland, proposed a novel explanation to justify the high incidence of childhood leukemia near the Sellafield and Dounreay sites. At a London conference on medical responses to effects of ionizing radiation in June 1989, Dr. Kinlen postulated that an epidemic of childhood leukemia illustrated a reaction to some unidentified common infection generated by the mixing of populations in previously isolated communities. Dr. Kinlen pointed out that the severity of epidemics and infections in island or other isolated regions following the influx of outsiders has been documented since the time of the 18th century philosopher Samuel Johnson, who noted that the arrival of a stranger into a remote community was often followed by an epidemic of colds.

Thurso, the coastal town nearest to the Dounreay nuclear site, is such a community. Located 200 miles from the nearest population center greater than 100,000, Thurso remained isolated until a tremendous influx of people in the 1950s increased its population by 147%. To test his hypothesis, Dr. Kinlen selected a demographically similar area in Scotland, which experienced a comparable population

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boom in the 1950s following centuries of isolation but which had no nuclear facility. The town of Glenrothes in County Fife, whose population doubled in the 1950s, sufficed as a "test control." Dr. Kinlen discovered a significant excess of leukemia in Glenrothes (O/E ratio of 2.78) following the period of population growth. Glenrothes' O/E ratio jumped to 4.70 when confined to cases of childhood leukemia. Dr. Kinlen also found four other hitherto remote towns in England and Wales that experienced significant increases in the incidence of childhood leukemia following a large population influx in the 1950s. Dr. Kinlen tempered his argument by pointing out that the mixing of populations is a complex matter and that further studies need to be conducted to confirm the validity of a viral connection.

Inherent Problems in Methodology

Clusters might also be the product of reporting methods or an artifact of the inherent peculiarities of the statistical methodologies used in the various studies. According to Dr. Wilkie, apparently significant excesses of a disease can be "manufactured" by particular permutations and discretely selected subgroups of data. "The selection of tight, prejudicial boundaries around apparent clusters can create highly improbable incidences," says Dr. Wilkie. In preparing cancer cluster studies, explains Dr. Wilkie, researchers choose test "boundaries," some of which might influence the results themselves. A "boundary" can be space, population, time range, age range, disease type, etc. Furthermore, since leukemia does not define a single disease, particular types of the illnesses and combinations thereof might be examined as well. Thus, hundreds of permutations of the data, possibly influencing the final outcome, can be performed in any given cluster study.

Dr. Wilkie asserts that the British health service researchers who surveyed Dounreay and Sellafield the data drew "boundaries of space, time, and age" *after* some of the facts were already known. This tended to maximize the significance of the results, thus implying the existence of a local epidemic. Also, according to Dr. Wilkie, researchers for Yorkshire Television who studied the clusters near Sellafield drew tight geographical boundaries around the observed excess cases at Seascale, while virtually ignoring the negligible figures in other towns near the plant. "They also ignored the fact that the cancer rate among the 10,000 or so workers at Sellafield is below the national rate," adds Dr. Wilkie. "Negative findings are rarely published or publicized. However, in the science of statistics, negative findings are just as important as positive findings."

Another crucial component of methodology is the quality and integrity of the data input into a cluster study. Dr. Wilkie claims that cancer registries miss a large portion, perhaps as much as 30%, of all leukemia cases in their records, while existing registries may be plagued with errors. "When dealing with rare diseases, especially," says Dr. Wilkie, "errors in reporting and documentation can dramatically alter results." Cancer registries have a policy of recording the address of the victim when the disease was reported instead of where the disease developed. For rare diseases, the effects of migration can be quite important, as in the case of a Seascale leukemia victim who emigrated out of England during childhood.

Dr. Wilkie adds that cancer mortality data provide a more accurate assessment of cancer risk than cancer incidence data because "in Britain, as in most countries, reporting deaths due to cancer is a legal requirement

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News Briefs

Radiation Doses for Nuclear Power Workers Decline

The Nuclear Regulatory Commission (NRC) reports that the average radiation dose to workers at United States nuclear power plants declined 14% to 340 mRem (3.4 mSv) in 1989 from 395 mRem (3.95 mSv) in 1988. The NRC compiled data from 108 nuclear power plants with light water reactors (LWR) to develop radiation dose statistics. In 1989, the LWRs were comprised of 72 pressurized water reactors (PWRs) and 36 boiling water reactors (BWRs). The average individual dose was 328 mRem (3.28 mSv) at the PWRs and 356 mRem (3.56 mSv) at the BWRs. There was one non-LWR commercial power plant in operation in 1989; it used a high temperature gas cooled reactor. Data from this plant, which is now closed, were not used when calculating average radiation doses. The average individual dose at this plant was 55 mRem (0.55 mSv).

Radiation doses to nuclear power plant workers peaked in the early 1980s. The NRC attributes the continued decline of radiation doses since then to the completion of a number of technical improvements that were implemented after the 1979 accident at the Three Mile Island II reactor in Middletown, Pennsylvania and to an increased vigilance in adhering to the ALARA (as low as reasonably achievable) principle. LeMoine Cunningham, chief, radiation protection branch, division of radiation protection and emergency preparedness, office of nuclear reactor regulation, NRC, says that the 14% drop in radiation dose is a fairly significant decline and is a good indication that utilities are paying attention to safeguards. Mr. Cunningham cites the introduction of robotics to perform tasks formerly done by personnel and improved planning for scheduled plant outages as a few of the factors leading to the dose decline.

Scheduled outages are the periods during which a plant shuts down for refueling, repairs, or routine maintenance. The NRC reports that currently 80% of the workers' radiation dose occurs during scheduled outages. Plants

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Clusters

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whereas cancer incidence is not. On the other hand, incidence data provides larger numbers." Dr. Wilkie has been working to develop a rigorous and standardized methodology for studying cluster investigations so that arbitrary and artifactual results can be eliminated.

Role of Chance

Some researchers of cancer clusters have presented the possibility that periodic outbreaks of high incidence are simply the result of chance and coincidence. In the theory of mathematical probability and random distribution, the phenomenon of clustering is not uncommon. Dr. Wilkie offered the following example: "If we discovered, as indeed is the case, that an unusually high number of American presidents had died on July 4th, would that necessarily mean that future presidents should be especially careful on Independence Day? And should we construe that to mean that there is some apparent connection between July 4th and former presidents?" Dr. Wilkie remarks that similar misguided logic is often applied to cancer cluster studies.

Future Outlook

Cancer cluster studies — the vast majority of which do not point to nuclear radiation as a leading culprit — are continuing throughout the industrialized world. Although cancer studies have shown that the amount of low-level radiation emitted by nuclear facilities cannot account for the apparent rise of cancer incidence in the vicinity, no resolute conclusions have yet been achieved.

In order to put the subject in perspective for the public, the NCI researchers admonished, "it is important to distinguish between a major release of radioactivity from a reactor accident, such as Chernobyl, and the small amounts of radiation that are likely to be emitted by nuclear facilities under normal operation." Says Dr. Heath, "As long as the public demands answers to its fears and questions, it is the responsibility of public health officials to examine cancer cluster reports that warrant investigation."

At a CDC-sponsored conference on cluster studies that convened last year in Atlanta, representatives from various US state health agencies discussed ways to prevent states from pursuing needless studies and to develop guidelines to establish protocols for cluster investigations. Many epidemiologists agree that cluster investigations are too often precipitated by pressure imposed upon an influential politician by irate voters. While they concede it is important to allay the fears and distrust of the general public, they argue that cluster studies should be conducted in a more circumspect and discriminatory fashion.

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