

against such a cluster of affected children occurring in Seascale by chance are 4000 to 1. The problem is, no one has a clue what could have caused the cancers only in Seascale. An HSE official says: "We don't feel we are in a position to make any causal explanations on the basis of what we have found."

Whether the Seascale findings prove or disprove Gardner's hypothesis that radiation causes mutations in sperm is still very much in contention. "The cause must be some factor that is associated with radiation that applies particularly to the Seascale fathers," says Hazel Inskip, an epidemiologist and statistician who went to work with Gardner at the Medical Research Council's Environmental Epidemiology Unit in Southampton shortly before he died and has taken over his work. "It may be some associated exposure that we may not ever identify. There is some evidence from animal experiments that chemical exposures can cause tumors in later generations."

But the skeptics are also using the anomaly to support their case. The HSE discounts Gardner's explanation, the official says, and

instead points to a theory advanced by Leo Kinlen of Oxford University known as "population mixing." Kinlen recently published a study that found some of the excess cases of leukemia and non-Hodgkin's lymphoma in Seascale occurred in children who were not born there and whose fathers were not linked with the nuclear industry. He suggests that the cause may be some infective agent, and that the risk of childhood leukemia may be enhanced when there is an influx of people who come to live and work in a geographically isolated area, bringing the agent with them. This theory has one big drawback however: No one has so far been able to identify an infective cause for childhood leukemia.

James Neel, professor of human genetics at the University of Michigan, who has studied the Hiroshima and Nagasaki atomic bomb survivors and found no increase in leukemia among their children, says the Seascale finding "is either a statistical aberration or else factors which have not been identified are at work—but not radiation."

How this plays out could have important legal implications. An English court has al-

ready ruled, in a landmark case last month, that radiation was not to blame for the cancer that developed in the children of two men who had worked at Sellafield.

Gerald Draper, director of the Childhood Cancer Research Group at the University of Oxford, believes he will be able to resolve the confusion by attacking the problem from a different direction. Using a blanket approach, he has identified 30,000 children throughout Britain with leukemias and other cancers and is identifying their parents from birth records. He is then checking whether the parents appear in the National Registry of Radiation Exposure; if they do, records of their radiation doses can be obtained.

The results of his study are not due for another 15 months. Asked whether it will settle once and for all the question of whether parental radiation exposure is linked to childhood cancer, Draper says: "I devoutly hope so."

—Sharon Kingman

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EPIDEMIOLOGY

EMF-Cancer Links: Yes, No, and Maybe

The controversy over whether or not low-level electromagnetic fields (EMF) can cause cancer has been smoldering for 15 years. This month it got a little hotter—but there's still more smoke than fire. At the beginning of October, writer and EMF gadfly Paul Brodeur brought out his latest book exposing a purported EMF-cancer connection, entitled *The Great Power-line Cover-up*. Right on his heels, however, on 9 October, the *British Medical Journal* weighed in with two serious scientific assessments of the cancer risk. Unfortunately for those who long for a conclusive answer, one study found only a slight positive association between EMF and cancer, and the other found no link at all. Together the studies "artfully provide middle-of-the-road type of evidence," says Dimitrios Trichopoulos, chairman of the epidemiology department at the Harvard School of Public Health.

Even the positive study wasn't very positive. It was led by epidemiologist Jorgen Olsen of the National Cancer Registry of Denmark, and his team looked at all Danish children diagnosed over the past two decades with either leukemia, brain tumors, or malignant lymphomas, the three most common childhood cancers. After choosing controls from the general population, the researchers then established how close the cases and the controls lived to power lines and for how long a period of time. The Danes reported that the highest exposure level—children living within 25 to 50

meters of the most powerful transmitting stations—carried a slightly increased risk for all cancers. That conclusion is, however, based on "very small numbers," Olsen says: six cancer cases out of approximately 600 children who fit these criteria. The researchers also found an increased risk for lymphomas in this high-exposure category, although



Lines of debate. Positive and negative study results obscure any connection between cancer and power lines.

again adding a caveat that it was based only on three cases. But they found no elevated risk at all for brain tumors or leukemia.

In an accompanying editorial, Gerald Draper, director of the Childhood Cancer Research Group of the University of Oxford, pointed out that even the lymphoma effect was found only "in relation to a grouping of exposure categories chosen after examination of the data." Epidemiologists are traditionally suspicious of this kind of after-the-

fact data manipulation; Patricia Buffler, dean of the school of public health at the University of California, Berkeley, says that changing the exposure categories after gathering all the data is "just not the scientific method."

The second study was by Finnish researchers, led by Pia Verkesalo of the University of Helsinki and Markku Koskenvuo of the University of Turku, and no caveats were required. It was simply negative. The investigators located 135,000 children living within 500 meters of overhead powerlines in Finland. That group, the Finns reported, had only 140 cases of cancer versus an expected 145 cases in such a population, and "no statistically significant increases were observed in leukemia, lymphoma, and overall cancer in children at any exposure level."

So what is one to make of all this? Not much, according to Draper, who still agrees with the conclusions of major reviews of EMF published last year by the Oak Ridge Associated Universities and by Britain's National Radiological Protection Board (*Science*, 11 December 1992, p. 1724). Both panels concluded that no convincing evidence of an EMF-cancer link had yet been found. Yet Draper's editorial also noted that, because of studies such as the Danish investigation, the possibility that EMF may cause some cases of childhood cancer "cannot be dismissed." Of course, as Trichopoulos, one of the authors of the Oak Ridge review, observes, the inability to rule the connection out may be because "nobody can prove" the nonexistence of a phenomenon.

—Gary Taubes