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Cancer in the Semiconductor Industry

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Cancer in the Semiconductor Industry

THE POSSIBLE ASSOCIATION between chemical exposures and brain cancer is receiving renewed interest in light of the recently published results of the United Kingdom's Health and Safety Executive (HSE) investigation of cancer among current and former workers of the National Semiconductor, Ltd., Facility (NSUK) in Greenock, Scotland.¹ The HSE investigators found not only a higher than expected incidence of breast, lung, and stomach cancers among female workers, but approximately 4 times as many brain cancer deaths in males as expected, on the basis of comparisons with age and sex-specific mortality rates for Scotland. Although recognizing the need for additional, broader cancer studies among workers in the semiconductor industry, the HSE investigators took a questionable stance on the brain cancer findings: "In view of the fact that brain cancer was not of specific interest at the outset of the investigation and the short latency for 3 of the 4 cases, it is most probably not work-related," the authors wrote.²

The statement is worrisome, suggesting that if the HSE does not initially suspect a particular type of cancer as being work related, then indications to the contrary may be dismissed. It is especially worrisome when the cancer in question has been associated with exposure to toxic chemicals since the mid-1970s³ and when several of the associated chemicals and agents—including the organic solvents trichloroethane and trichloroethylene, and both ionizing and nonionizing radiation—are found in Table 1 of the HSE report, in which the known or suspected carcinogens are listed that had been used or had been present at the NSUK Greenock plant since operations began in 1970.⁴

In fact, a review of the epidemiological literature over the past 2 decades—which, as the HSE investigators note, is generally based on electronics manufacturing industries—gives reason for one to suspect that the increased risk of brain cancer among NSUK workers *is* work related. The HSE investigators argue that because exposures in electronics assembly work are not identical to those in semiconductor manufacturing, "It would be unwise to draw any conclusions about the semiconductor industry from more broadly based studies." However, as was noted earlier, several of the suspected

carcinogens associated with brain cancer in these broader studies are as common, if not more so, in the semiconductor industry. At the very least, the studies should caution against concluding that the excess of brain cancer at NSUK *is not* work related.

In 1983, the first (and only) evaluation of the general cancer incidence pattern in the electronics industry—as opposed to a study of a particular cancer or of a sub-population, such as workers of a particular company or gender—was conducted in Sweden by linking the Swedish Cancer Registry with Swedish census records for the period 1961–1973.⁵ Of more than 75,000 subjects, the investigators found an increased risk of cancer of 1.15 times for men and 1.08 for women who were employed in the electronics manufacturing industry. That may not sound profound, but keep in mind the size of the study. More than 75,000 subjects were included and were taken from all sectors of the industry—from manufacturing to administrative to sales. Listen to the authors' own cautionary statement: "An estimated slight excess risk [of cancer], referring to the electronics industry as a whole, could reflect some hazardous practice of a more severe type in some sectors of the industry. Since the registry does not include any specific exposure data, risk estimates should be taken as starting points for further inquiry, focusing on particular features of the work environment."⁶

Two years later, Milham⁷ looked for links between cancer and exposure to electromagnetic fields (EMFs) by linking the death records with occupational codes of males in Washington State. He found an increased risk of death from lung, pancreas, kidney, and brain cancer "usually greatest in those occupations which have [chemical] inhalation exposures in addition to EMF [electromagnetic field] exposures."⁷ In that same year, Lin et al.⁸ conducted a study and looked specifically at brain tumors among electrical workers. They found an excess death rate from brain cancers in their data set. "It is not known," the authors concluded, "whether the increased risk of brain tumors observed among electrical workers is due to the magnetic or electric fields themselves or possibly to a common chemical exposure, for example polychlorinated biphenyls, organic solvents, or metal fumes."⁸

That same year—1985—Gary Adams, a chemist who was working in the Material Analysis Department in Building 13 of IBM's disk drive manufacturing facility in San Jose, California, wrote a memo to Corporate Headquarters in which he described a cluster of cancers among his colleagues. Brain cancer had killed Gary Adams's colleagues John Wong and Al Smith, and a variety of other cancers, many of them terminal, were eventually diagnosed in 8 of 14 employees in a single work area of Building 13. This building was where disk drive coatings—which contained various epoxy resins and organic solvents, including acetone and xylene—were tested and refined.

"All of a sudden we began to worry," Adams told Dateline NBC in 1998. "And then when another one [was diagnosed] and another one, it really began to hit home." Adams said the response of a staff doctor to his request that the company monitor its workers' health, particularly in Building 13, was to say such a program would be a waste of time, because "workers did not get cancer from their jobs."

Meanwhile, reports of elevated rates of brain cancers among electronics workers continued to turn up in the scientific literature. A study published in the *Journal of the National Cancer Institute* in 1987 found that risk of a certain type of brain cancer—"astrocytic tumors"—among electronics manufacture and repair workers increased 10-fold among those employed to 20 or more years.⁹

Once again, although the study started out by looking at EMFs as a possible causal agent, Thomas et al.⁹ pointed out that any EMF exposure in electronics jobs "is probably intermittent and may be accompanied by exposures to lead, solder fluxes, solvents, and other chemicals." They continued: "Numerous solvents used throughout the electrical and electronics industry are known neurotoxins, causing peripheral neuropathy, central nervous system depression, and neurobehavioral dysfunction." The authors reminded scientists that a common effect of these solvents was anesthesia (i.e., an attack on the brain and nervous systems), and they cited evidence of liver tumors in rats¹⁰ and astrogliosis in gerbils¹¹ exposed to chlorinated chemicals by inhalation.

A cautionary editorial in a 1988 issue of the *American Journal of Industrial Medicine* reminded researchers that the environmental links to brain cancer were first reported in studies of chemical exposures, and that "the recent interest in occupational exposure to EMFs is but one example that mandates a general note of caution."¹²

One can see today that this editorial was exceptionally circumspect. "When you look back at the EMF literature," says toxicologist Dr. Michael McClain of the Robert Johnson Medical School, "you'll find papers and papers on EMFs and brain cancer, of which some were positive and some were negative. The National Research Council set up this big group to evaluate all this literature, and the bottom line, when all was said and done, is that if there's any relationship between EMFs and brain cancer, it's probably pretty small. EMFs are still being studied to some extent—the bigger issue is

people who live by electric power lines—but the concern there is primarily leukemia in children."¹³

So, if EMFs were not causing the excess brain cancer among electronics workers, what was? Unfortunately, if the agent was some type of chemical exposure, there is not much supporting data, despite the repeated warning in the literature. Few studies have managed to identify, much less quantify, specific and combined chemical exposures among subject employees. In fact, the authors of a 1996 study of brain cancer mortality among electronics workers, commissioned by IBM, acknowledge this limitation in findings published more than a decade after Gary Adams, the chemist, submitted his memo to IBM corporate headquarters.

"Information about specific exposures in the work environment, such as EMFs, ionizing radiation, or chemical agents, was not available," wrote Beall et al.¹⁴ "Some of the observed associations are difficult to interpret because exposure information pertaining to division and job groups is lacking."¹⁴

Among the IBM study's observed associations was an upward slope in brain cancer deaths among male electronics workers as duration of employment increased. As shown earlier, this is consistent with trends observed previously in the scientific literature: The risk of dying from brain cancer is highest among electrical and electronics workers with long-term work histories—specifically, of 10 yr or more—and with probable exposure to solders and organic solvents.^{15,16}

The primary data provided for the IBM-commissioned study consisted of a so-called Corporate Mortality File, developed from the death certificates of employees who died from 1975 to 1989. These records, like those used in the Swedish cancer study of 1983, represent the entire spectrum of workers at a microelectronics company, from sales to executives to the bunny-suited workers in clean rooms. Yet, it is the clean-room workers, who constitute only a fraction of the total workforce, who are at the highest risk of long-term chemical exposures.

Once again: If EMFs were not causing the excess brain cancers among electronics workers, what was? Dr. Bruce Fowler, director of toxicology at the University of Maryland in College Park, has an idea. "It isn't uncommon, with exposures to these kinds of solvents, to see brain tumors. Partly, I think, because this stuff is inhaled, and it can get access to the brain."

Many of the chlorinated solvents used in semiconductor manufacturing are fat soluble, and they are stored in organs that have a high fat content. Nerve cells, like those of the brain, are enmeshed in fatty tissue.

"Inhalation exposure to almost anything is one of the most effective means of getting something into the body," Fowler continued. "If [the workers] have inhalation exposure, they're going to take it in, it will get into the bloodstream, and it will go where it's going to go."

It is too early for the HSE investigators to characterize a 4-fold excess of brain cancer deaths at NSUK as "probably not work-related." It is critical that future cancer studies of the semiconductor industry investigate

possible associations between solvent exposure and brain cancer.

Editor's Statement: This assessment of associations between chemical exposures and brain cancer was written as part of an extensive investigative series on semiconductor manufacturing, "Poison Valley," published in the online magazine *Salon.com* in July 2001. Because of the assessment's length and relatively technical language, it was summarized for lay readers and its citations were omitted from the finished series, which readers of the *Archives of Environmental Health* are encouraged to read online.¹⁷ The commentary, which has been updated following the publication of the results of the United Kingdom's Health and Safety Executive's investigation into cancer among National Semiconductor workers in Scotland, is being presented to the more technical audience of *IJOEH*, with the disclaimer that it was reached and composed by an investigative journalist—that is, by a researcher without any formal medical training. It traces patterns in the scientific literature, which underscore the need for further study of chemical exposure and brain cancer among workers in the semiconductor industry.

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