University of Lowell
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A REPORT TO THE GENERAL ELECTRIC COMPANY CONCERNING A CASE-CONTROL STUDY OF CANCER MORTALITY AT THE GENERAL ELECTRIC PITTSFIELD FACILITY

Executive Summary

(January 2, 1990)

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BACKGROUND

This study of mortality in General Electric workers grew out of a preliminary, unpublished study which was part of a series of worker mortality studies undertaken in the late 1970's. The preliminary study focussed on General Electric Company in Pittsfield and found an excess of mortality from leukemia and cancer of the large intestine among those persons where General Electric's name was entered on the death record filed from the town of Pittsfield. The findings from the preliminary study were described in 1978 to the General Electric Company, which cooperated in the further investigation of the problem.

Initially General Electric provided a list of insurance pension records for all employee deaths from 1969 to 1977 which had resulted in death benefit claims. Study of these data, which included last job at General Electric, did not change earlier findings. No specific last job type or exposure was associated with the proportional mortality excesses noted.

In January 1981, it was decided to obtain complete work histories for all pension eligible workers who had died. Subsequently it was decided to undertake a detailed and in depth historical reconstruction of worker exposures to groups of substances considered to be most commonly in use.

This reconstruction of exposures for each former employee in the study was attempted for Pyranol (a mixture of polychlorinated biphenyls and trichlorobenzene), trichloroethylene, benzene, other solvents, asbestos, machining fluids and miscellaneous resin systems. Individual work histories were matched to the exposure data base to generate individual estimates of exposure histories to each group of chemicals.

Since not all subject work history records were still available, the total number of subjects available for study was less than the total number of deaths recorded. In order to maximize the study's statistical power, therefore, the mortality data base was extended twice until finally deaths were included from 1969 through 1984.

The final study population, therefore, includes those pension-eligible workers who died at some time between 1969 and 1984 for whom work history records could be recovered. The protocol for the current study was modified and adopted in its final form in 1985.

The objective of the study was to determine, to the extent possible, if there was evidence for work related cancer risks. A case-control approach was followed: exposure histories of cancer cases were compared with those of a control group consisting of workers who died of causes not thought to be related to the exposure under study.

OVERVIEW OF THE STUDY

Study Subjects

The initial study size was 2,914 white male employees who met "vesting requirements" and whose last place of work was at the GE Pittsfield plant and who died between January 1, 1969 and December 31, 1984. Those included may have died either while actively employed or after retiring. For all individuals included in the study, official death certificates were obtained. Extensive efforts were made to collect complete information on all subjects. After exclusions were made for inadequate or absent work history records and appropriate exclusions made for selection of control subjects, a total of 1,714 subjects were included in the study.

Work History Records

Work history records were sought for all deceased subjects enrolled in the study but turned out to be unavailable for a substantial number largely due to elimination of these records according to standard company policy on record retention. Although there was no evidence that the losses were biased there was no way to evaluate the losses.

Occupational Exposures

The following exposures thought to be of primary importance were rated (primarily by systemetic overlapping interviews with long-term employees):

Pyranol: a transformer oil composed of polychlorinated biphenyls (PCBs) (a mixture of isomers but mostly hexachlorobiphenyl), trichlorobenzene (or a mixture of tri- and tetrachloro-benzene), less than 0.25% phenoxypropene oxides and trace amounts of dibenzofurans. The PCB content in Pyranol could vary from 45 to 80%.

Benzene: a solvent used in various departments for general cleaning during machining and assembly operations.

Trichloroethylene (TCE): a solvent used as a degreaser

Other solvents: this group includes Varsol (petroleum spirits), CPE 1000 (petroleum spirits and methylene chloride), methylene chloride, kerosene, paint thinners (primarily xylene or toluene based), solvent based paints, xylene, toluene, and naphtha. Some type of solvent exposure occurred in the majority of plant operations.

Machining fluids: used for machining and fabrication operations. Straight mineral oils were first used, then soluble oils and finally synthetic oils. There was a very minimal usage of straight cutting oils.

Asbestos: Used as wet insulation blankets during brazing and welding. Some insulation pieces were made from asbestos.

Resin systems: primarily phenol formaldehyde and polyvinyl formal resin systems.

Exposures known to be present but not specifically rated were:

Mineral oil: (10C oil) used as transformer oil. Pyranol was used as a transformer fluid only in 15-25% of the transformers built and mineral oil was used in the remainder. A review of the exposure to Pyranol was conducted in March 1988, and the following changes were made to the existing exposure ratings, in order to improve separation between the exposures to Pyranol and to mineral oil: a rating of no exposure was assigned to all jobs in which there was no dielectric fluid used or in which the dielectric fluid used was certainly mineral oil and not Pyranol. As a result, all jobs in buildings 4, 5, 19, 100, 41 and 44 were assigned a rating of 0 for Pyranol.

Metal fumes and dust: exposure occurred during welding, brazing and painting with metal based pigments.

Sawdust: in woodworking shops.

Adhesives: water, solvent based and epoxy (those using petroleum solvents are rated with group 4)

Electromagnetic fields: exposure occurred during testing and development of transformers.

DESIGN AND ANALYSIS

Basic Design

The study was designed as a case control study of cancer mortality risks. Distribution of demographic characteristics was used to obtain a preliminary description of differences between cases and controls. The characteristics of those with and without work histories were compared to examine bias due to excluding those without work histories. The data were then divided into various subcategories (stratified analysis) to examine combinations of exposure and other variables (for example, age, year of death, etc.). This analysis sought to separate exposure effects from effects attributable to other variables.

Initially, the less certain cause of death diagnoses were validated by clinical records. Then case and control status was assigned as follows:

a) Cases are all types of cancer.
b) Controls were the non-cancer deaths excluding diseases of the digestive system, genitourinary diseases, diseases of the blood and the blood forming organs, mental disorders and ill defined conditions.

While the stratified analysis provided an essential description and summary of the data, it was limited when attempting to look at several variables at once. Because of sparse data, special methods were used to examine several variables simultaneously. Careful attention was paid to following a predefined strategy so that the selection of the models would not be inappropriately affected by the results. Finally special attention was directed at the impact of time on risk.

Each exposure was considered first separately and then two or more exposures were placed in the same models in order to obtain estimates of relative risk adjusted for other exposures. Interactions between variables were also considered.

Of greatest concern is the lack of information on the smoking history of study subjects. Smoking is a risk factor for several of the cancer sites under study. Therefore it was necessary to assess its potential confounding effect. This was done by hypothesizing several possible distributions of smoking in the study population.

Statistical Power

Statistical power is a measure of the probability (given a specified magnitude of association) of obtaining a set of data such that level of an effect being sought is likely. A conventional power analysis showed that this study was generally characterized by low power, unless the effects were very strong or the causes of death common (e.g. lung cancer).

RESULTS

The results of the study are summarized in the attached Chapter III that also serves as the summary chapter of the detailed report. The detailed report includes extensive tabular material in support of the epidemiologic conclusions.

In brief, the epidemiologic analysis did not identify any unequivocal or definitive association of the General Electric-Pittsfield work environment with excess cancer risk. With limited power the study failed to find an association between pyranol (containing PCBs) and excess cancer risk among employees. In addition cancer of the large intestine, one of the two cancer sites which was in excess in the exploratory proportional mortality studies, was not found associated with the exposures included in the study.

Several findings, however, suggest further study which may clarify certain of the apparent associations. In particular, the association of lung cancer with operations coded as "resins" needs to be further evaluated. To do so requires new coding of asbestos exposures in these locations to determine whether the associations noted are attributable to unestimated asbestos exposure. Other associations deserving further study include: trichloroethylene and leukemia; benzene and cancer of the esophagus, bladder, kidney, and brain; other solvents and cancers of the kidney and the lymphatic system (especially reticulosarcoma); resin components and cancers of the esophagus, large intestine and lung; and machining fluids and kidney cancer.

COMMENT AND RECOMMENDATIONS

This study was carried out using state of the art epidemiologic and exposure assessment attribution methods. In some instances new methods were developed to address some of the more difficult data problems or analytical dilemmas. Nonetheless, findings from this study must be tempered by the fact that a number of important problems existed which limited the ability of the study to examine fully the question of cancer-

related risks from exposure to toxic agents in this work environment.

The problems of greatest importance include:

1. Records of personnel activity had not been maintained in a manner which serves the needs of an epidemiologic study. There was no effective way to document employment at the Pittsfield plant at a time sufficiently far in the past to undertake a population-based study using an historical cohort approach;

2. Information on previous employees was limited to pension-eligible employees, a designation which changes many times over the study interval. This fact made interpretation of the findings much more difficult. Furthermore, the record of pensioners was reliably available only beginning in 1969; this limited the total number of subjects who could be included in the study;

3. The need to rely on death records limited the efficiency of the study to those cancers which are likely to cause death (a high case-fatality ratio). Hence a cancer with relatively good survival (for example, cancer of the urinary bladder) is not as well studied as for work-related causes since the number of cases will far exceed the number of deaths attributed to this cause;

4. Evidence of cancer had to be based on information listed on the death certificate. Although a major effort was made to verify cases with clinical records, it was only feasible to attempt this for those cancers reported to be less well documented.

5. Very limited data were available on historical work-place exposures to the toxic materials of interest. For most of the exposures of interest there was no information for the vast majority of the study interval. As a result, exposure ratings had to be based predominantly on subjective assessment using only a few categories, which limits the power to distinguish between exposure levels. Furthermore, the exposure ratings do not reflect individual exposure variation. There is a high probability, therefore, that even if elevated cancer risks exist in this environment they might not be found.

6. Work history records, like the general personnel records, were incompletely maintained. Standard policy on record elimination to reduce volume of stored paper resulted in loss of a third of the work history records of potential interest;

7. There had been multiple changes in the work organization, so that operations of interest were carried out in different

plant buildings at different times. The historical record of these changes was very incomplete.

8. Healthy-worker selection effects could not be corrected for. This effect, although less important in studies of cancer mortality, results from the fact that workers at increased risk (e.g. disabled employees) will have a tendency to leave employment early and therefore are more likely not to be included in the study. Methods to correct for this effect require knowledge of the exposure history and date of termination for workers who left employment. This information is not available for this study.

9. Of some concern is the lack of information on the smoking history of study subjects. Therefore, it was necessary to assess its potential confounding effect. It was shown, however, that smoking was unlikely to be a strong confounder in our study.

10. The variety of problems invariably limit the statistical power of the study to find relatively small effects, even if they are present. Conventional statistical power analyses showed that this study is generally characterized by low power, except for very strong effects or for outcomes with a large number of cases (lung cancer).

* * * * *

Based on the associations noted in the epidemiologic study, and on the absence of any definitive findings, the following are recommended:

1. <u>Further study is indicated to attempt to clarify the findings for lung cancer and work in resin systems.</u>

   Because the predominant plastic product manufactured in the resin systems category involved the use of asbestos and phenol-formaldehyde, this finding cannot be clearly interpreted. Asbestos is widely accepted as a human carcinogen and OSHA has recently recognized formaldehyde as a carcinogen. The jobs in this exposure grouping were not characterized for exposure to asbestos nor specifically for formaldehyde and the process has not been operated in the Pittsfield facility for some time. The possibility for further elucidation of work risks for this area should be evaluated to determine whether the source of risk can be better specified. The feasibility of further study will depend upon the estimate of possible statistical power (based on the number of persons who worked in the area and whose work records are available) and the determination that reasonable job specific exposure assignments can be made for asbestos and formaldehyde.

2. The workforce should be notified of the findings of this study.

   A summary of the results should be prepared and distributed to all current employees and all retirees. In addition the results should be provided the union for publication in its newspaper, and to the local press for general publication.

3. A meeting should be held with the local physician organization.

   This meeting should explain the results and answer questions about the possible follow-up which might be indicated.

4. Follow-up medical examination should be offered in selected circumstances.

   There are no accepted screening tests for lung cancer which can be offered to the previous or current employees. It is, however, appropriate to provide for an organized response to requests for health risk appraisal from any who might express a concern regarding lung cancer or other health concerns related to this study. It is recommended that an outside contractor be hired to develop a program along the following lines:

   a) All current employees and retirees who can be contacted should be given the opportunity to attend a uniform cancer education and awareness program on company time on the plant's premises. The format should be small group session that address general cancer and cancer of the lung. The content of the program should include an overview and introduction on the study results, the interventions or actions which have taken place or are planned and the medical service program (MSP). The generic discussion of cancer should include what it is, how it develops, how it is treated, the causes of cancer, risk factors, occupation specific risks for the target group, early warning signs and symptoms, early detection and diagnosis, treatment and prognosis and prevention.

   b) A panel of physicians (internal medicine, occupational medicine specialties) be created to provide assessment and consultation to any employee who has further concerns about the health problems identified in the educational program, specifically lung cancer. Any participant in the educational program could request this consultation which should be an individual, private consultation with a uniform report submitted to the requestor.

c) A second panel should be created of physicians who are expert in the diagnosis and treatment of lung cancer and asbestos related disease. The first panel would refer any participant who requires additional diagnostic workup for cancer of the lung to this panel. Part of this work-up should be a targated examination for those judged to have had other than incidental asbestos exposure. (For example, chest X-ray screening for evidence of asbestos-like pleural reaction and/or sputum examination for asbestos fibers could, after further considaration and review, be deemed appropriate to offer workers who were employed in the resin systems areas). Advice on the importance of ceasing cigarette smoking should be provided and an organized program of smoking cessation should be sponsored for any cigarette smoker, but especially for any person with known prior exposure to asbestos.

d) Protocols should be developed to guide decision-making by the two panels to assure uniformity and consistency. these guidelines or protocols should be developed by the physicians and approved by a group which agrees jointly to represents the interests of the community and the company and who serve as an advisory group to any contractor selected to coordinate this overall effort.

BACKGROUND INFORMATION ON
THE CASE-CONTROL STUDY OF CANCER MORTALITY
AT THE GENERAL ELECTRIC PITTSFIELD FACILITY

January 24, 1990

Prepared by GE

BACKGROUND INFORMATION ON
THE CASE-CONTROL STUDY OF CANCER MORTALITY
AT THE GENERAL ELECTRIC PITTSFIELD FACILITY

January 24, 1990

This document provides background information on the Case-Control Study of Cancer Mortality at the General Electric plant in Pittsfield, Massachusetts (the Study) in a question/answer format. The document was prepared by GE scientists based, in part, on discussions with the principal investigators and the panel of technical advisers.

CONTENTS

I. BACKGROUND

A. Why was the Study initiated?

In the late 1970s, David H. Wegman, M.D., then occupational hygiene physician with the Massachusetts Division of Occupational Hygiene and also at Harvard, conducted a series of mortality studies which focused on selected New England towns. These studies were aimed at determining whether the proportion of deaths due to cancer for specific employees or occupational groups in these towns exceeded that of the U.S. general population. The purpose was to determine whether further in-depth definitive studies were needed.

"We chose towns in which the population was relatively stable and in which one or several plants or industries generally dominated employment," Dr. Wegman noted in a recent interview. "Pittsfield, Massachusetts -- site of GE's Transformer, Ordnance and Plastics operations -- was such a town."

"In Pittsfield, we found an excess of mortality from leukemia and cancer of the large intestine among people whose death records cited GE as the last employer," he added.

In 1978, Dr. Wegman communicated his findings to GE management in Pittsfield. The company then cooperated in an expanded Study by providing a list of insurance/pension records for all active and retired employee deaths between 1969 and 1977 (including out-of-state employee deaths) that had resulted in death benefit claims. The analysis was repeated and the results remained the same.

There was an issue whether these excesses were related to chemicals used at GE Pittsfield, including PCBs. In order to evaluate whether this was the case, a comprehensive cancer mortality Study was undertaken with Dr. Wegman as principal investigator.

B. What was the objective of the Study?

The objective of the Study was to determine if there was evidence of work-related cancer risks in the Pittsfield work force.

"A case-control approach was followed," Dr. Wegman wrote in his Summary of the Study. "Exposure histories of cancer cases were compared with those of a control group consisting of workers who had died of causes not thought to be related to the chemical exposure under Study."

The Study covered the following GE Pittsfield manufacturing divisions: Power Transformers and Distribution Transformers, Ordnance Systems and Plastics Division.

The study team identified seven substances commonly used in the Pittsfield plants. The aim was to examine every kind of link (or association) that might exist between exposure at work and the risk of cancer.

C. What were the substances and cancer types included in the Study?

The seven substances as defined by the Study are:

- Pyranol: a transformer dielectric fluid composed of PCBs (a mixture of isomers but mostly hexachlorobiphenyl), trichlorobenzene (a mixture of tri- and tetrachloro- benzene), less than 0.25 percent phenoxypropene oxides and trace amounts of dibenzofurans. The PCB content in Pyranol could vary from 45 to 80 percent.

- Benzene: a solvent used in various departments for general cleaning during machining and assembly operations.

- Trichloroethylene (TCE): a solvent used as a degreaser.

- Other solvents: this group includes Varsol (petroleum spirits), CPE 100 (petroleum spirits and methylene chloride), methylene chloride, kerosene, paint thinners (primarily xylene or toluene based), solvent based paints, xylene, toluene and naphtha.

- Machining fluids: used for machining and fabricating operations. Straight mineral oils were first used, then soluble oils and finally synthetic oils.

- Asbestos: Used as wet insulation blankets during brazing and welding. Some insulation pieces were made from asbestos.

- Resin systems: primarily phenol-formaldehyde and polyvinyl-formal resin systems.

Initially all cancer types were considered. However, for in-depth analyses, cancer types with nine or more observed deaths (cases) were selected. These were orolaryngeal, esophagus, stomach, colon, rectum, pancreas, liver (liver, biliary and gall bladder), lung, prostate, urinary bladder, kidney, lymphomas, leukemias and brain.

D. Who are the members of the Study team?

David H. Wegman, M.D., Professor and Head of the Department of Work Environment, University of Lowell (Massachusetts), was the principal investigator for the project. As such, he is responsible for overall direction and supervision, as well as interpretation and communication of the Study findings. With former posts at Harvard and UCLA, Dr. Wegman is a well-recognized investigator in the field of occupational epidemiology (see following section on epidemiology). He has published numerous research papers in leading scientific journals.

Sander Greenland, Dr.P.H., Professor of Epidemiology at UCLA, was the co-principal investigator. He joined the Study team in 1984 and assumed major responsibility for developing and implementing analytical methodology. He is noted for his many contributions to theoretical epidemiology, and has published many research papers dealing with these aspects of epidemiology. Dr. Greenland was assisted on this project by Alberto Salvan, M.D., on this project.

Thomas Smith, Ph.D., Professor of Industrial Hygiene at the University of Massachusetts, assisted by Marilyn Hallock, Industrial Hygienist, also at the University of Massachusetts, created the comprehensive employee exposure profile. Dr. Smith is widely recognized as a leader in exposure assessment and exposure modeling.

E. What was the role of the Scientific Advisory Panel?

The Scientific Advisory Panel is an expert and distinguished group of scientists convened by GE to advise the study team and the managements. Panel members have expertise in the fields of epidemiology, biostatistics and industrial hygiene. Since its formation in 1988, the panel has met seven times and has also visited the Pittsfield plant. The Panel's charter included reviewing the Study methodology, participating in discussions and meetings, and providing technical advice to and interacting with the Study team.

Thomas Sinks, Ph.D., Supervisory Epidemiologist for NIOSH (the National Institute for Occupational Safety and Health), wrote the following to Massachusetts State Representative Sherwood Guernsey (D-Williamstown) on May 4, 1989 after attending a Scientific Advisory Panel meeting on April 28, 1989 in Baltimore: "I was struck by the peer review committee's concern for the workers and their benefits from the Study. The members seem to have been selected not only for their scientific objectivity, but also for their interest in public health. The workers are served well by their contribution."

Members of the Scientific Advisory Panel are:

- Leon Gordis, M.D., Dr. P.H. (Chair)
  Professor and Chairman
  Department of Epidemiology
  The Johns Hopkins University
  Baltimore, MD

- Genevieve Matanoski, M.D., Dr. P.H. (Assist. Chair)
  Professor of Epidemiology
  Department of Epidemiology
  The Johns Hopkins University
  Baltimore, MD

- Michael Gerin, Ph.D.
  Associate Professor
  Occupational and Environmental Health
  University of Montreal
  Montreal, Canada

- Jack Mandel, M.P.H., Ph.D.
  Associate Professor
  School of Public Health
  University of Minnesota
  Minneapolis, MN

- Howard Rockette, Ph.D.
  Professor of Biostatistics
  School of Public Health
  University of Pittsburgh
  Pittsburgh, PA

- James Schlesselman, Ph.D.
  Professor of Biostatistics
  Uniformed Services University of Health Sciences
  Bethesda, MD

F. What governmental review was provided?

Representatives from the National Institute for Occupational Safety and Health (NIOSH) did the following: reviewed and commented favorably on the research protocol in 1985; participated in a series of meetings in Pittsfield with Dr. Wegman, GE and Company retirees; met with Dr. Wegman, Dr. Greenland and GE at UCLA; and attended several Scientific Advisory Panel meetings in the role of observer.

In addition, Representative Guernsey monitored the progress of the Study.

G. What was the role of GE management?

GE management provided financial support in the form of research contracts to the universities represented by Drs. Wegman and Greenland, and reviewed progress periodically. It assisted the data collection process by providing work history records and death certificates. It set up a series of plant walk-throughs and interviews with plant personnel, by which the exposure assessment team observed and evaluated current work practices. These steps were critical to creating the exposure assessments that formed a primary data base for the Study. GE also established the Scientific Advisory Panel.

H. How long did it take to complete the Study?

The in-depth case-control Study began in 1981. Data were collected through an intensive interview process to recreate environmental conditions and exposures from memory. Assuring that the data were appropriate for in-depth statistical analysis turned out to be a long and complex process.

The Study began with worker deaths from 1969 to 1977; the number of deaths proved to be inadequate for in-depth statistical analysis. Ultimately, deaths from 1969 to 1984 were added in order to improve the reliability of the results. This extension necessitated additional interviews and exposure assessments.

The statistical analysis process consumed several years as the team (headed by Dr. Greenland) developed new methodologies to evaluate a data base significantly more complex than that of most other studies and then subjected the data to an exhaustive series of statistical analyses. In addition, the Scientific Advisory Panel, while making constructive contributions in its role as advisor, suggested some additional analyses that consumed more time.

With respect to the time required, Dr. Wegman noted "If at any time during the Study I had evidence of an important finding revealed by the data analysis or new information of a current risk that could have been controlled, then I would have pushed for immediate, appropriate action."

I. What are PCBs?

PCBs are a class of compounds that do not conduct electricity, do not catch fire and do not evaporate or break down easily. For these reasons, PCBs were considered to be "wonder chemicals" that added to the safety of equipment where fire hazard was a concern. They were manufactured in the U.S. from 1929 until 1977, and sold as mixtures for use in a variety of applications, both electrical and non-electrical - for example, in transformers and as hydraulic fluids. GE was one of about 300 U.S. companies that used PCBs, which were banned in 1977.

II. EPIDEMIOLOGY

A. What is epidemiology?

Epidemiology is the science of the occurrence of disease in human populations. Historically, epidemiology evolved while studying great epidemic diseases such as cholera and typhoid. For example, in 1854, John Snow -- a practicing physician in London -- used simple observations to show that water supply was responsible for the cholera outbreak.

During the last few decades, epidemiologists began focusing on cancer with some remarkable success. For example, epidemiologic studies have contributed greatly to understanding the link between cigarette smoking and lung cancer. Many epidemiologic studies have demonstrated the association between workplace exposures to certain chemical substances and some kinds of adverse health effects.

B. What are the limitations of epidemiology?

Epidemiologists often face many practical problems in carrying out their studies. Foremost, the biological process involved in cancer is not well understood; this creates difficulty in selecting possible causal factors to study as well as in interpreting the results.

Furthermore, data available to the epidemiologist, such as on death certificates, is often incomplete. This is also true with exposure data when it needs to be reconstructed from memory due to the lack of historical workplace exposure data. Finally, statistical methodology is often not available for analyzing certain types of complex sets of data.

Epidemiologic results can be inconclusive (unable to establish either the presence or absence of a cause/effect relationship) for a variety of reasons. For example, the researcher may not have been able to identify and study all the potential causal factors for the disease. The results may not seem biologically plausible or consistent with other studies. Also, sample size may be too small to adequately investigate the relationship of exposures to a specific cancer site. Regardless of what the findings are in any single study, they need to be confirmed in multiple studies in different populations to be considered conclusive.

C. What types of epidemiologic studies were performed?

Initially, Dr. Wegman performed a proportional mortality study. In this study, the percentage of deceased employees dying from specific causes was compared to the percentage expected based on the U.S. general population. The primary purpose was to identify cause-specific deaths that might indicate the need for further in-depth evaluation through other types of studies. A proportional mortality study is generally considered as screening or exploratory in nature but is not conclusive.

Based upon the findings of the proportional mortality study and other interim analyses, Drs. Wegman and Greenland conducted a series of case-control studies. They began by identifying a group of deaths from cancer (cases) and a group of deaths from other causes (controls). Then for each individual in the two groups, they compared data on exposure, taking into consideration other factors. The purpose was to determine whether there is an association between exposure and disease. If cases seemed to have had a greater exposure history than the controls (more intense or lengthy exposure to the chemical being studied), one could conclude there to be an "association" between the exposure and the disease. However, such an association does not demonstrate causality.

III. DATA COLLECTION AND ANALYSIS

A. How was the Study population assembled?

For this Study, the GE insurance carrier provided death certificates on active and retired employees.

The following were the criteria for inclusion in the Study:

Died between January 1, 1969 and December 31, 1984
(no pension records were available for employees who had died before 1969).

- Met certain vesting requirements (these varied over time, but generally required 10 to 15 years employment with GE).

The final Study, therefore, totaled 1,714 subjects, which included 512 cases and 1,202 controls.

B. How were the cases and controls defined?

Cases are study subjects who died of all types of cancer.

Controls are study subjects who died of conditions other than cancer, excluding diseases of the digestive system, genito-urinary diseases, of the blood and blood-forming organs, mental disorders and ill-defined conditions.

C. How was the exposure data compiled?

The objectives of the exposure assessment were to: 1) Identify the significant exposures; 2) Choose an appropriate categorical rating scale; 3) Rate work history jobs for the selected exposures; 4) Check ratings to the extent possible.

The team made a series of week-long plant walk-throughs. During these walk-throughs, they reviewed current operations, and to the extent available, past records on production, chemical use and purchasing, industrial hygiene measurements, and building maps.

In addition, they interviewed 18 plant employees having average length of employment of 38 years. They were selected on the basis of their familiarity with a range of operations. Interviews were aimed at obtaining the following information: all major and minor chemical and metallurgical exposures within an operation and their control technology; history of location of the operation (many operations changed location over the years).

They also examined work histories for each subject in the Study to determine job histories and titles -- that is, the different assignments each person held in various buildings over the course of his employment. Ultimately, more than 7,000 separate job titles in various buildings were rated for chemical exposure.

Based on these data, the team then determined exposure levels (relative intensity of exposure) for each of the seven substances. These levels were used later to calculate person-years of exposure. For example, if an employee worked for 10 years at benzene exposure level 1 and 15 years at PCB exposure level 3, then he would have 10 level 1 benzene-years and 15 level 3 PCB-years of exposure.

"This was a difficult undertaking because of the large number of materials used in the plant, the many types of operations performed, and the limited number of past records," the authors wrote at the beginning of the Study's Chapter II, which details the exposure assessment process.

D. What other types of data were collected?

The team collected data on a number of other factors to analyze statistically their effects since the results of epidemiologic studies can be compromised by other risk factors -- environmental or personal -- that might contribute to the disease under consideration. Other factors for which data were available included age and year of death, year of hire, duration of employment, foreign birth, and vesting and employment status five years before death.

Unfortunately, data were not available on life-style risk factors, in particular, smoking and alcohol consumption. These factors, therefore, could not be fully taken into account in the analysis.

E. How were data for the cases and controls analyzed?

After receiving death and exposure data, Drs. Sander Greenland and Alberto Salvan at UCLA set out to analyze the relative cancer risks of the seven substances.

"This was a formidable task, as the exposure assessments were somewhat involved," Dr. Greenland, noted. "There were 512 cases and 14 cancer types to deal with. And we were exploring multiple exposures and multiple disease outcomes. We didn't feel any adequate approach existed prior to our assignment to do justice to something of this complexity. So we tried out some new ideas."

The Greenland team's first challenge was to convert the job histories and exposure ratings into an exposure profile for each individual subject. From there, the team could compare cases and controls and make first-cut risk analyses for each chemical under study.

In essence, Dr. Greenland conducted 98 separate case-control studies, (14 cancer types times 7 exposures). The initial step was to create a series of two-by-two tables (exposed and unexposed) for each of the 14 cancers under study (those that had 9 or more individual cases). From these relatively simple tables, he was able to estimate the relative risk (odds ratio) of exposure to each substance for the cases versus the controls.

The results of a first cut of this kind, however, do not consider a range of factors that are the key to evaluating risk. These factors include level and duration of exposure, age, year of death, and exposure to more than one chemical. In order to take into consideration these variables Dr. Greenland then employed various types of sophisticated statistical analyses. The product of these procedures and analyses is three binders full of tables from which Drs. Wegman and Greenland drew their conclusions and wrote their final report.

GE SUMMARY OF KEY POINTS ON
THE CASE-CONTROL STUDY OF CANCER MORTALITY AT GE PITTSFIELD
January 24, 1990

STUDY SUMMARY

- The Study was designed to detect cancer risks -- during the period, 1969-1984 -- in the GE Pittsfield work force from workplace exposures to chemicals.

- The Study did not identify any definitive association of the GE Pittsfield work environment with excess cancer risk.

- Specifically, the Study did not establish that PCBs caused an increase in cancer at GE Pittsfield. The results are consistent with the seven other studies of PCB-exposed workers worldwide.

- The authors found several statistical associations between workplace exposures and cancer risks, but, as noted, none were concluded to cause cancer deaths. The authors further state: "Because we chose a liberal criterion to screen multiple associations, it is probable that most (and possibly all)...do not represent any real exposure effects." (Emphasis is the author's.)

- The strongest statistical association found was that of lung cancer and exposure to chemicals used in the production of GENAL (which has not been produced since 1983). There was no association between cancer risk and the use of GENAL. Several weaker statistical associations were investigated and interpreted as "highly inconclusive."

CURRENT CONDITIONS

- The results of the Study do not indicate any known risk of cancer related to current workplace exposures at GE Pittsfield.

- Of the seven groups of chemicals studied, only two -- solvents and machine fluids -- are currently used at GE Pittsfield. These chemicals are also commonly used throughout industry for the machining and cleaning of metal parts. Employees are protected with training regarding the identification of chemical hazards, including safe work practices and emergency procedures.

- Industrial hygiene programs, including monitoring of certain work areas and employees, are in place to protect the health and safety of the GE work force.

- Records of employee exposures to chemicals are maintained in accordance with guidelines of the U.S. Occupational Safety and Health Agency (OSHA).

HISTORY OF THE STUDY*

- Following preliminary analyses of mortality at GE Pittsfield by Dr. David H. Wegman, then with Harvard University, the Study was initiated in 1981 with GE as sponsor. Dr. Wegman, now with the University of Lowell, was retained as principal investigator.

- In the Study, exposure histories of workers who died of cancer (cases) were compared to exposure histories of workers who died of other causes (controls). If cases were found to have greater exposures to chemicals than the controls, then the statistical association was further investigated to determine its significance.

- Initially the Study period was 1969-1979, but this was extended through 1984 because the population was insufficient for in-depth analysis.

- The Study, in its final form, began in 1985 when Dr. Sander Greenland of UCLA joined the Study team as co-principal investigator.

- Independent review of the Study has been provided by a distinguished panel of academic epidemiological experts (see attached list).

GE RESPONSES

- GE will communicate the results of the Study to all GE Pittsfield employees, retirees, union representatives, and the local medical community.

- All GE Pittsfield employees and retirees will be given an opportunity to have their questions about the Study answered by a selected medical professional through a toll-free number: 1-800-4GE-3290.

- Appropriate medical consultations will be available to employees and retirees who have worked in the former GENAL operations.

- GE's actions -- both current programs and planned measures -- will adequately serve both past and present workers. Because of these GE actions and because no further significant data on past job-specific exposure are available, GE currently has no plan to conduct any further studies.

* See Background Information Document, January 24, 1990

SCIENTIFIC ADVISORY PANEL

for

THE CASE-CONTROL STUDY OF CANCER MORTALITY AT GE PITTSFIELD

Members of the Scientific Advisory Panel are:

- Leon Gordis, M.D., Dr. P.H. (Chair)
  Professor and Chairman
  Department of Epidemiology
  The Johns Hopkins University
  Baltimore, MD

- Genevieve Matanoski, M.D., Dr. P.H. (Assist. Chair)
  Professor of Epidemiology
  Department of Epidemiology
  The Johns Hopkins University
  Baltimore, MD

- Michael Gerin, Ph.D.
  Associate Professor
  Occupational and Environmental Health
  University of Montreal
  Montreal, Canada

- Jack Mandel, M.P.H., Ph.D.
  Associate Professor
  School of Public Health
  University of Minnesota
  Minneapolis, MN

- Howard Rockette, Ph.D.
  Professor of Biostatistics
  School of Public Health
  University of Pittsburgh
  Pittsburgh, PA

- James Schlesselman, Ph.D.
  Professor of Biostatistics
  Uniformed Services University of Health Sciences
  Bethesda, MD

David Howe Wegman, M.D.
Department of Work Environment
University of Lowell
Lowell, MA 01854

Education	Degree	Year	Field
Swarthmore College	BA	1963	History
Harvard Medical School	M.D.	1966	Medical
Harvard School of Public Health	MS	1972	Occupational Health

Professional Experience

1987-Present	Professor & Head	Department of Work Environment, College of Engineering, University of Lowell, Lowell, MA.
1983-87	Professor & Director	Division of Environmental and Occupational Health Services, UCLA School of Public Health.
1977-83	Assoc. Professor Occupational Health	Harvard School of Public Health, Boston.
1972-77	Assistant Professor of Occupational Health	Harvard School of Public Health, Boston.
1972-78	Occupational Hyg. Physician	Division of Occupational Hygiene, Mass. Dept. of Labor and Industries, Boston.
1969-71	Director	Urban Planning Aid, Inc., Industrial Health and Safety Project, Cambridge, MA.
1967-69	Medical Epidemiologist	National Communicable Disease Center, USPHS, New York City Health Department.
1966-67	Medical intern	Cleveland Metropolitan General Hospital.

Adjunct Appointments

1988-	Adjunct Professor	Department of Family and Community Medicine, University of Massachusetts Medical School, Worcester, MA.
1987-	Visiting Professor	UCLA School of Public Health
1984-	Visiting Professor	National Board of Occupational Safety and Health, Sweden (May).
1983-	Lecturer	Harvard School of Public Health, Boston.

Sander Greenland, Dr. P.H.
Division of Epidemiology
School of Public Health
UCLA
Los Angeles, CA 90024-1772

Education	Degree	Year	Field
U. of California, Berkeley	BA	1972	Math, Psychology
U. of California, Berkeley	MA	1973	Math
UCLA	MS	1976	Epidemiology
UCLA	Dr. P.H	1978	Epidemiology Math

Professional Experience

1989-Present	Professor of Epidemiology	UCLA School of Public Health
1984-89	Associate Professor of Epidemiology	UCLA School of Public Health
1985	Visiting Associate Professor of Biostatistics	School of Public Health University of Sydney
1980-84	Assistant Professor of Epidemiology	UCLA School of Public Health
1979	Assistant Research Epidemiologist	UCLA Public Health
1979	Assistant Professor of Biostatistics	Harvard School of Public Health
1978	Assistant Professor	California State University Northridge
1975-78	Statistician	School of Nursing & School of Public Health UCLA
1973-74	Research Assistant	Department of Biostatistics School of Public Health University of California, Berkeley

Leon Gordis, M.D.
Johns Hopkins University
Baltimore, MD 21205

Education	Degree	Year	Field
Columbia University	BA	1954	
Jewish Theological Seminary	BA	1954	Hebrew Literature
State University of NY, Downstate Medical Center	M.D.	1958	Medicine
Johns Hopkins University School of Hygiene and Public Health	M.A	1965	Public Health
Johns Hopkins University School of Hygiene and Public Health (Department of Chronic Diseases)	Ph.D.	1968	Public Health

Professional Experience

Current	Prof. & Chairman	Department of Epidemiology, Johns Hopkins School of Hygiene and Public Health, Joint Appointment in Pediatrics, Johns Hopkins School of Medicine; Director Clinical Epidemiology, Johns Hopkins School of Medicine
1971-73	Director	Epidemiology and Statistics Center, Maryland Regional Medical Program
1971	Member	Israel Government Commission on Mercury Hazards
1969-70	Visiting Professor	Department of Medical Ecology, Hebrew University Hadassah Medical School
1968-72	Assistant Professor	Pediatrics - John Hopkins School of Medicine
1968-79	Chief	Department of Community Medicine Sinai, Hospital of Baltimore
1966-69	Associate Director	Pediatric Family Clinic Sinai Hospital of Baltimore
1967-69	Director	Adolescent Center, Sinai Hospital of Baltimore
1966-67	Asst. Medical Dir.	Ambulatory Care, Sinai Hospital of Baltimore
1961-65	Field Officer	Heart Disease Control Program, Division of Chronic Diseases, U.S. Public Health Service

Genevieve M. Matanoski, M.D., Dr. P.H.
John Hopkins University
of Hygiene and Public Health
Department of Epidemiology
Baltimore, MD 21205

Education	Degree	Year	Field
Radcliffe College	BA	1951	Chemistry
John Hopkins School of Medicine	M.D.	1955	Medicine
John Hopkins School of Medicine	M.P.H.	1962	Epidemiology
John Hopkins School of Medicine	Dr. P.H.	1965	Epidemiology

Professional Experience

1978-Present	Program Director	Occupational and Environmental Epidemiology, John Hopkins School of Hygiene and Public Health, Baltimore, MD
1976-Present	Professor	Epidemiology, Johns Hopkins School of Hygiene and Public Health, Baltimore, MD
1970-Present	Associate Professor	University of Maryland Dental School, Baltimore, MD
1970-Present	Associate Professor	Preventive Medicine, University of Maryland, Baltimore, MD
1969-76	Associate Professor	Epidemiology, John Hopkins School of Hygiene & Public Health, Baltimore, MD
1964-69	Assistant Professor	Epidemiology, John Hopkins School of Hygiene & Public Health, Baltimore, MD
1959-64	Instructor	Epidemiology, John Hopkins School of Hygiene & Public Health, Baltimore, MD
1957-	Pediatrician	Out-Patient Department, Johns Hopkins Hospital, Baltimore, MD

Michel Gerin, Ph.D.
Dept. of Occupational & Environmental Health
Medical Faculty
University of Montreal
Montreal, Quebec

Education	Degree	Year	Field
Senior School of Chemistry & Industry of Lyon (France)	Engineering	1970	Chemistry
McGill University, Montreal	Ph.D.	1976	Chemistry

Professional Experience

Current	-Assoc. Professor	Dept. of Occupational & Environmental Health, University of Montreal.
1986-87	Visiting Scientist	International Agency for Research on Cancer, Lyon, France
1980-86	Asst. Professor	Dept. of Occupational & Environmental Health, University of Montreal.
1982-	Invited Professor	Research Center for Epidemiology & Preventive Medicine, Armand Frappier Institute, Laval, Quebec
1979-80	Research Asst.	Reserach Center for Epidemiology & Preventive Medicine, Armand Frappier Institute, Laval , Quebec.

Jack S. Mandel, Ph.D., M.P.H
Division of Environmental & Occupational Health
School of Public Health
University of Minnesota
Minneapolis, MN

Education	Degree	Year	Field
University of Minnesota	Ph.D	1981	Epidemiology
University of Minnesota	M.P.H.	1973	Epidemiology
University of Manitoba	B.Sc.	1966	Mathematics

Professional Experience

1989-	Professor	Division of Environmental & Occupational Health, School of Public Health, University of Minnesota
1989-	Director of Graduate Study	Division of Environmental & Occupational Health, School of Public Health, University of Minnesota
1983-88	Instructor	Midwest Occupational Health Institute , University of Minnesota
1984-89	Associate Professor	Division of Environmental Health, School of Public Health, University of Minnesota
1980-85	Instructor	Graduate Summer Session in Epidemiology, University of Minnesota
1979-83	Assistant Director	Division of Epidemiology, School of Public Health, University of Minnesota
1982-84	Director of Graduate Study	Division of Epidemiology, University of Minnesota
1981-84	Associate Professor	Division of Epidemiology, School of Public Health, University of Minnesota
1975-80	Instructor	Division of Epidemiology, School of Public Health, University of Minnesota
1974-75	Assistant Professor	Department of Epidemiology and Community Medicine, University of Ottawa

Howard E. Rockette, Ph.D.
Graduate School of Public Health
Department of Biostatistics
University of Pittsburgh
Pittsburgh, PA 15261

Education	Degree	Year	Field
Franklin & Marshall College	BA	1965	Mathematics & Physics
Pennsylvania State University	MA	1972	Mathematics
Pennsylvania State University	Ph.D.	1972	Statistics

Professional Experience

1987-88	Director	Data Center for the Institute for International Studies in Natural Family Planning
1983-	Professor	Graduate School of Public Health Department of Biostatistics, University of Pittsburgh
1983-	Co-Director	National Surgical Adjuvant Breast Protocol, Statistical Center, Pittsburgh
1981-	Director	Statistical Unit, Otitis Media Center, Children's Hospital, Pittsburgh
1986-Present	Sr. Research Scientist	Institute for International Studies in Natural Family Planning
1978-83	Associate Professor	University of Pittsburgh Graduate School of Public Health, Department of Biostatistics
1972-78	Research Assistant Professor	University of Pittsburgh Graduate School of Public Health

James J. Schlesselman, Ph.D.
F. Edward Hebert School of Medicine
Uniformed Services University of Health Sciences
Bethesda, MD 20814

Education	Degree	Year	Field
Michigan State	BS	1966	Psychology
Princeton	MA	1968	Psychology
Princeton	MA	1968	Statistics
Princeton	Ph.D.	1971	Statistics

Professional Experience

1985-Present	Professor	Department of Preventive Medicine & Biometrics, F. Edward Hebert School of Medicine, Uniformed Services University of the Health Sciences (USUHS).
1981-85	Associate Professor	Department of Preventive Medicine & Biometrics, F. Edward Herbert School of Medicine, (USUHS).
1976-81	Chief	Biometry Branch, National Institute of Child Health & Human Development (NICHD).
1973-76	Mathematical Statistican	Biometry Branch, NICHD.
1971-73	Senior Staff Fellow	Biometry Branch, NICHD.
1969-71	Commissioned Officer	U.S. Public Health Service, Epidemiology & Biometry Branch, NICHD.

GE STATEMENT ON CANCER MORTALITY STUDY

"Dr. Wegman's Study is completed, and the news is reassuring. Despite the large number of cancer types that were investigated, no definitive association between workplace chemical exposures at GE Pittsfield and excess cancer risk was established."

"Specifically, and importantly, the Study found that past worker exposure to PCBs did not increase the risk of cancer. This finding is consistent with seven other studies worldwide.

"GE will promptly communicate the Study results to all interested parties -- employees, retirees, union representatives and the local medical community. GE will also have medical professionals available to answer employee and retiree questions about the Study.

"We are grateful to Dr. Wegman, his co-investigator, Dr. Sander Greenland, and their team, as well as to the external Scientific Advisory Panel, for their tremendous effort in completing this complex Study."

Herb Coulter, GE Pittsfield,
At media briefing, January 24, 1990