PUBLIC COMMENT DRAFT REPORT
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The La Salle Electrical Utilities Company Cohort Mortality Study La Salle, Illinois

The Illinois Department of Public Health
and
The University of Illinois at Chicago, School of Public Health

May 2000

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Public Comment Draft Report Provided by

Illinois Department of Public Health

The La Salle Electrical Utilities Company Cohort Mortality Study La Salle, Illinois

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May 2000

This report was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund provided to the Illinois Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document, presented in its entirety as submitted by the grantee, has not been revised or edited to conform with agency editorial guidance

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ACKNOWLEDGEMENTS

The authors would like to thank Dr. Daniel Hryhorczuk, of the University of Illinois at Chicago School of Public Health, for his comments and assistance in this study. Lin Kaatz-Chary, also of the University of Illinois School of Public Health, assisted in study management and data management. Adrienne Jacobs assisted with local tracking efforts, and the La Salle EUC Community Assistance Panel (CAP) provided invaluable assistance with all study activities.

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ABSTRACT

The Illinois Department of Public Health (IDPH), in conjunction with the University of Illinois at Chicago, School of Public Health, conducted a multi-year Polychlorinated Biphenyl (PCB) exposure/health study of former workers of the La Salle Electrical Utilities Company (EUC) Superfund site in La Salle, Illinois. This study was conducted with funding from the Agency for Toxic Substances and Disease Registry (ATSDR). Workers at this plant were exposed to PCBs, chlorinated naphthalenes, and trichloroethylene. The two-part study consisted of a retrospective cohort mortality study of the entire EUC cohort and a cross-sectional biomarker study of 191 former employees and 26 community controls. The mortality study is the subject of this report.

The entire EUC cohort of 3,305 persons who worked at the plant from 1944 to 1977 was identified, and 76% were traced to the end of the study period, December 31, 1997. Since most of the plant records had been lost or destroyed, the ability to do complete follow up was hampered, particularly for females, many of whom had changed their names since they were employed at EUC. Workers who worked three months or less (n=782) were least likely to be traced (66%), due to the more limited information available for these workers, so they were excluded from the mortality analysis resulting in 2,523 cohort members. A total of 1,976 of these workers were traced (78% of the cohort) and were included in the mortality analysis including 768 males and 1208 females. Standardized mortality ratios (SMRs) and 95% confidence intervals (CI) were calculated using the U.S. race, sex, and calendar year adjusted standardized mortality rates for whites.

There were 304 total deaths in males, and 464 deaths in females. Results show no statistically significant healthy worker effect, or deficit of deaths, in either males or females, whose SMRs for all causes of death were 1.07 (CI=0.95-1.20) and 0.93 (CI=0.84-1.01), respectively. The SMR for all cancer deaths combined was 1.20 (CI=0.95-1.49) in males and 1.12 (CI=0.94-1.31) in females, neither of which reached statistical significance.

The SMRs for cancer of the thyroid in males (SMR=16.91, CI=2.05-61.06) and non-Hodgkin's lymphoma in females (SMR=2.19, CI=1.05-4.02) were significantly elevated. Non-significantly elevated SMRs were observed for cancers of the liver and biliary tract (male SMR=2.67, CI=0.55-7.82, female SMR=1.92, CI=0.62-4.48), breast (females only, SMR=1.37, CI=0.96-1.89), stomach (male SMR=2.29, CI=0.84-4.99, female SMR=1.72, CI=0.63-3.74), kidney (male SMR=2.38, CI=0.65-6.08, female SMR=1.81, CI=0.49-4.63), leukemias (male only, SMR=1.57, CI=0.43-4.02), and bone (females only, SMR=6.09, CI=0.74-21.99). For non-cancer deaths, significantly elevated SMRs were found for non-pernicious anemias (SMR=4.72, CI=1.28-12.06) and acute/chronic renal disease in females (SMR=5.27, CI=1.44-13.49). A non-significantly elevated SMR for chronic liver disease and liver cirrhosis was found in males (SMR=1.84, CI=0.95-3.21). There were significant deficits of deaths due to diabetes in males (no deaths), and diseases of the heart (SMR=0.80, CI=0.67-0.95) and respiratory system in females (SMR=0.60, CI=0.37-0.91).

Mortality data were further analyzed according to length of employment and for a latency of 20 or more years since first employment. For workers with ten or more years of EUC employment, and 20 or more years latency, SMRs for stomach (SMR=6.03, CI=1.14-14.78) and thyroid cancer (SMR=86.53, CI=8.16-248.15) in males, and liver/biliary cancer in females (SMR=9.11, CI=2.37-20.23), were significantly elevated.

PCBs were not introduced at EUC until 1952. Prior to this time, chlorinated naphthalenes were used as a dielectric, and continued to be used in small assembly from 1952 until the plant's closing. Workers who only worked prior to 1952 would not have been exposed to PCBs. SMRs were, therefore, calculated separately for workers who worked before and after 1952 only, or who worked in both time periods. The SMR for non-Hodgkin's lymphoma was significantly elevated in women who worked prior to 1952 only (SMR=3.00, CI=1.10-6.54) and with a latency of 20 or more years. Four of these six non-Hodgkin's lymphoma deaths, however, occurred in women with only two to three quarters of employment.

Prior studies have detected associations between PCB exposure and liver/biliary cancer and non-Hodgkins' lymphomas, as well as between solvent exposure and non-Hodgkin's lymphoma. The lack of precise work histories in the EUC cohort precludes more in depth analyses of SMRs according to exposures. Additional follow up of this cohort will improve our ability to detect associations for small subgroups according to calendar year and length of employment, which may clarify some of the elevated mortality detected in this study.

Despite these limitations, this study is a unique opportunity to examine the mortality experience of a cohort which was exposed to an unusual mixture of contaminants. Our data suggests that these exposures, either alone or in combination, may have been associated with selected previously hypothesized cancers. Further studies of this cohort should help in the delineation of associations between specific exposure effects and health outcomes.

SITE BACKGROUND

The La Salle Electrical Utilities Company (EUC) manufactured electrical equipment in the city of La Salle, La Salle County, Illinois (106,913 population[1]), on a 9.6-acre tract of land (Figures 1 and 2). The EUC manufactured electrical capacitors at the plant from July 1943 until May 28, 1981. By the early 1950s, EUC had begun utilizing polychlorinated biphenyls (PCBs) and various volatile organic compounds (VOCs), including trichloroethylene (TCE), in manufacturing processes. PCBs were used as a dielectric (does not conduct electricity) material and TCE as a degreasing/cleaning agent. In addition, chlorinated naphthalenes were used as dielectrics prior to the use of PCBs, as well as in the manufacture of smaller capacitors after PCBs were introduced in 1952. Oils containing PCBs were reportedly used for dust control on and off the site property until 1969. PCBs and VOCs were also spilled at various on-site locations, roadways, and in nearby residential areas. Although over 3,000 persons were employed at the plant between 1944 and the time of its closing in 1981, at any given time, no more than 410 persons worked at the plant.

The original facility was comprised of a two-story brick building used for offices and employee lockers and a one story production area extending west from the two-story structure. The production area had a cat-walk running the length of the building with areas used for document storage. The production area housed a separate room used for making the internal components of the capacitors or windings. The winding room needed to be separated to reduce dust contamination of the windings (layers of foil and paper) in order to prevent short circuiting of the capacitors. This room was located in the northeast corner of the original production building. The southeast corner of the production building was comprised of offices and laboratory space used for engineering, production planning, purchasing, and quality assurance/quality control (QA/QC) laboratories. The main portion of the production area was used for the assembly of the capacitors and the southwest corner of the production area was used for adding the Halowax (chlorinated naphthalenes), a dielectric material which was used at the plant from its inception.

In 1950, a Quonset hut building was added to the southwest corner of the production building. The Halowax and maintenance operations were moved into this new building. In 1952, PCB use as a dielectric began in addition to the Halowax. This was determined through interviews with a former purchasing agent and the former foreman of the Cook department, the department where the PCBs and Halowax were used. In the cooking process, the assembled capacitors were placed into heated ovens where a vacuum was drawn to remove air from the capacitors and the oil or wax was impregnated into them. This area of the plant is thought to have the highest exposures to PCBs and Halowax. Soldering of the capacitors was performed in this area to seal the lids to the cans of the capacitors. Lead exposures were also prominent in this area according to an interview with an OSHA Compliance Officer who performed investigations at EUC.

In 1962 or 1963, a metal building was added to the north side of the brick production building. This new building housed an assembly area, the larger kilovolt capacitor manufacturing area, a

Figure 1 - Site Location

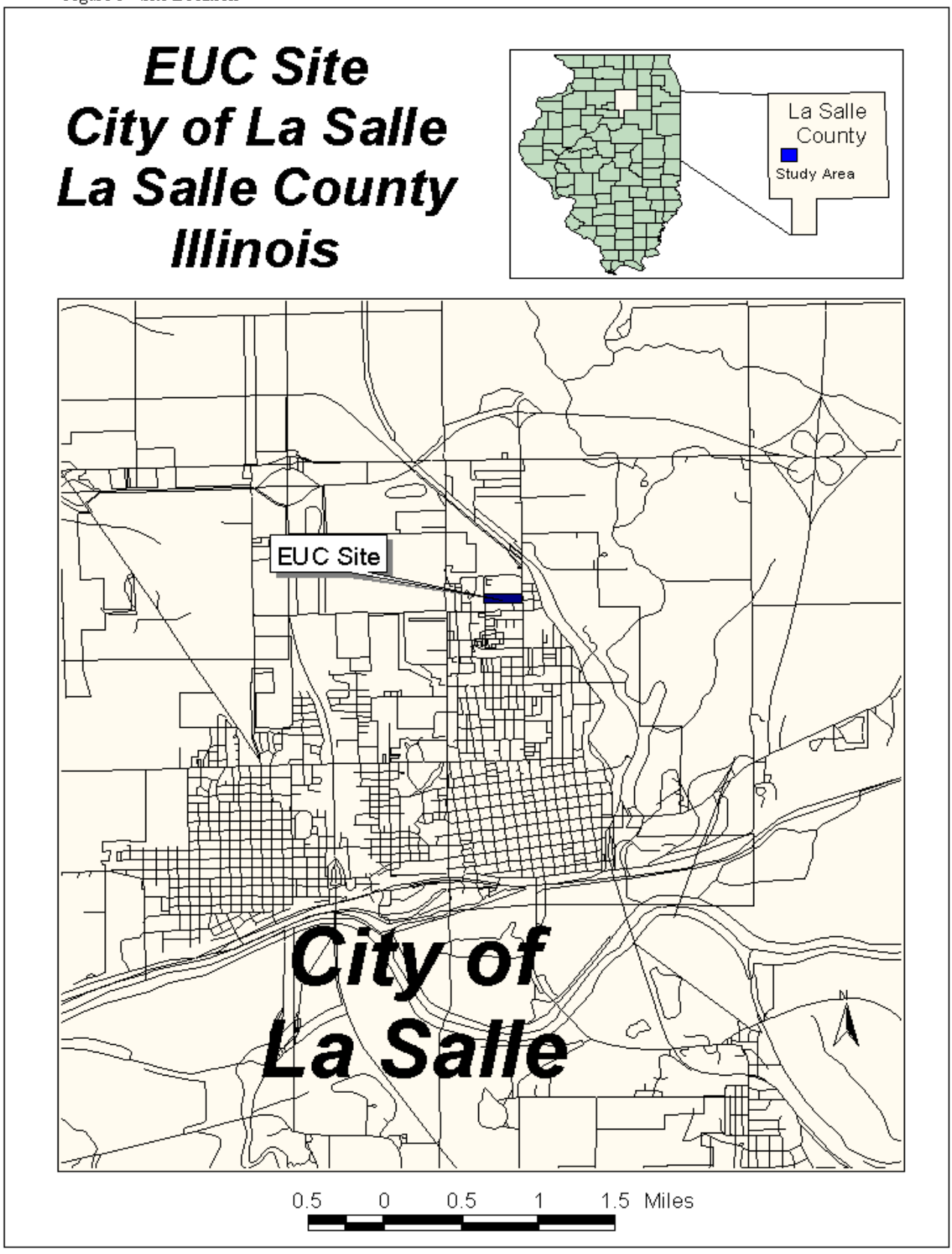


Figure 2 - Aerial Photo of Site

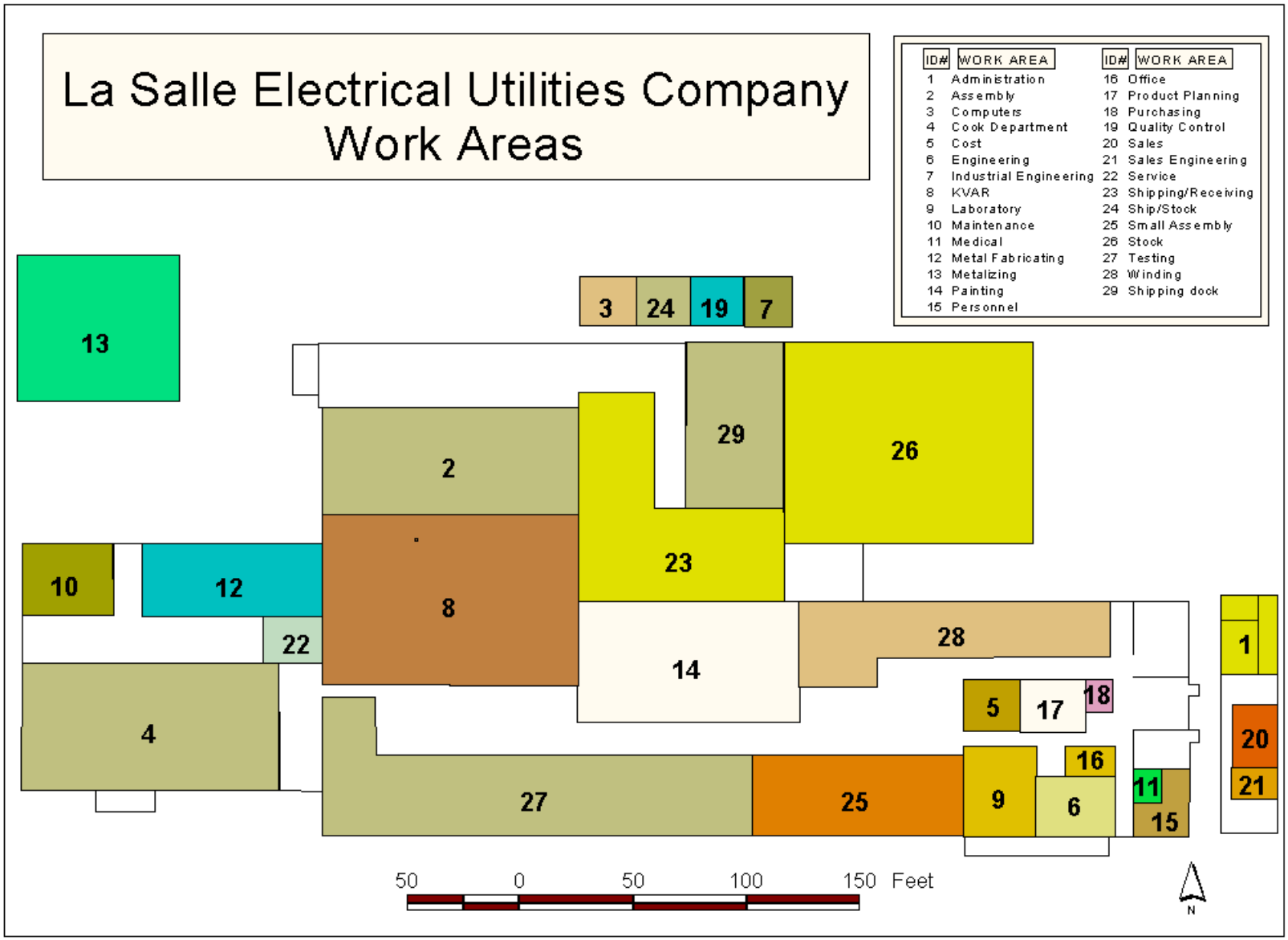
stock room, and a loading dock. In addition, there was a second story to the metal building in the dock area which housed offices for industrial engineering, computing, shipping and stocking, and quality control. In 1971, an addition was made to the metal building to accommodate manufacturing needs. North and west of the new metal building was the metalizing shed where a zinc coating was applied to the metal cans of the capacitors to prevent rusting. Production continued at the facility until 1981, when the plant was relocated to North Carolina. The United States Environmental Protection Agency (US EPA) had declared the site a Superfund site and the building was dismantled and destroyed. Most company records were lost in the move or destroyed in a fire. All information regarding process flow and chemical use were obtained from interviews with former employees of the company, both labor and management.

EUC used Halowax as a dielectric in the manufacturing of capacitors from its inception at La Salle in 1943 until the plant closed in 1981. In 1952, the use of PCB oil began with Aroclor 1254 being used until 1956. Aroclor 1242 use began in 1954 and continued until 1970. At that time, EUC began using Aroclor 1016. PCB oil was delivered to the plant in a tank car and consumption was estimated at 45,000 pounds per month. This continued until 1979 when EUC switched to di-(2)-ethylhexyl phthalate (DEHP) as the dielectric to replace PCBs. In addition, the TCE was used as a degreasing solvent to clean the outside of the capacitors after filling with dielectric, or after fabricating the cans to remove any oil. Another VOC, 1,1,1-trichloroethane, was used for only a short period of time at the facility (the exact dates, unknown). Mineral oil, lacquer paint, paint thinner and epoxies were also used throughout the plant's history. Methyl ethyl ketone was used for limited cleaning purposes and was ordered as one fifty-five gallon drum when needed.

Through interviews with project personnel from US EPA, it was established that there was PCB contamination throughout the facility. Reports from these personnel and from workers, indicated that PCB oil was literally everywhere, including soaked into the rafters and structural members. Little or no personal hygiene measures were followed to reduce skin contact/absorption and no personal protective clothing were used to prevent contact. The plant had no separate lunch room area, so employees would eat at their work station or in the bathrooms. Although the main exposure to PCBs was from skin contact, airborne exposures occurred in the Cook department, where the heat volatilized the oil. All workers in the area of the Quonset hut, where the Cook department was located, had potential airborne exposures. A 1958 memo, for example, obtained from plant records, discusses the fumes in the Cook department that "permeate the entire area" in the winter when the windows and doors are closed.

In addition, employee interviews stated that all employees of the company entered into production areas of the plant and at times of a strike or high production, office staff often worked in the production areas. Some administrative jobs, such as field sales and technical positions, required ready contact with PCB oil. For these reasons, it was assumed that there was no unexposed population within the plant. Since there are no records of exposure, or any other records to indicate potential exposure, areas of the plant were delineated based on job title and activity performed in those areas (Figure 3).

Figure 3 - EUC Work Areas



COMMUNITY HEALTH CONCERNS AND HEALTH ASSESSMENTS

Former employees of the EUC have voiced concern about possible adverse health effects, particularly a possible increased risk of cancer, and adverse reproductive effects, resulting from their exposure to PCBs and other toxic substances while employed by EUC. In addition, area residents have expressed similar concerns about possible adverse health effects resulting from exposure to PCBs, dioxins, and other toxic substances present in contaminated residential soils, well water, and from the clean-up incineration activities.

The Illinois Department of Public Health (IDPH), in cooperation with the Division of Health Assessment and Consultation, Agency for Toxic Substances and Disease Registry (ATSDR), completed a Public Health Assessment of the EUC Superfund Site (CERCLIS NO. ILD98074333) in October 1993.[2] This document reviews data pertaining to the extent and toxicity of the environmental contamination caused by EUC, as well as a summary and interpretation of results of three preliminary health outcome studies conducted by IDPH.

Measurements of on-site contamination were made during a 1985 remedial investigation. On-site PCB contamination of the top 12 inches of soil ranged from 0.22 to 17,000 micrograms per gram (ug/g). Below the 12 inch level, PCB concentrations dropped off below the 0.2 ug/g detection limit. Immediate off-site residential soil PCB concentrations ranged from 0.2 to 2,600 ug/g. Polychlorinated dioxins and furans were also detected in both on- and off-site soil samples. On-site total soil dioxin concentrations based on toxicity equivalency factors or TEFs ranged from 0.001 to 3.4 micrograms per kilogram (ug/kg) and total furan concentrations ranged from 3.80 to 31.70 ug/kg. Dioxin concentrations in off-site residential soil samples ranged from 0.0002 to 0.0033 ug/kg with furan concentrations ranging from 0.0095 to 0.1138 ug/kg. No 2,3,7,8-tetrachlorodibenzo-p-dioxin was detected in any on- or off-site soil samples. PCB contamination was detected in 18 of 20 monitoring wells on-site, with levels ranging from 0.13 to 440,000 micrograms per liter (ug/l). Groundwater contamination with VOCs was less wide spread but also detected in both on- and off-site monitoring wells.

The EUC became a National Priorities List site (NPL or Superfund) in 1982. Since then, more than $50,000,000 has been spent remediating the site. The entire complex of EUC offices and various storage and industrial buildings occupied approximately 67,000 square feet of floor space. All on-site buildings have been destroyed, and PCB contaminated soils from both on- and off-site were incinerated on-site from 1988-1992 under supervision of USEPA and the Illinois Environmental Protection Agency (IEPA). All remedial activities are now complete with the exception of an on-site groundwater treatment facility.

1. In 1985, the IDPH conducted a questionnaire survey of 262 former EUC employees.[2] PCB exposure for each participant was estimated based on self-reported job activities and duration and job exposure ratings derived from interviews with workers and a review of the literature. Health outcome data were based upon study participant self-reporting.

Non-specific health conditions of persistent or severe headache, cough, and runny nose were significantly associated with high exposure to PCBs. Among women, high levels of exposure were significantly associated with elevated risk of gallbladder disease/stones compared with low levels of exposure. Uncertainty about the dates of these self-reported conditions in relation to the dates of exposure limits interpretation of these associations. Other similar non-specific conditions were not significantly associated with exposure in this study.

2. In 1985, the IDPH also examined cancer mortality data for La Salle County residents during 1969-1983.[2] La Salle County site-specific cancer mortality rates for each year were compared with rates obtained from other non-metropolitan counties. Malignant melanoma, pancreatic cancer, liver cancer, and soft tissue sarcoma were studied. The rate of pancreatic cancer in white males, but not females, was found to be significantly elevated, with an SMR of 1.45.

3. In 1991, the IDPH used Illinois State Cancer Registry data to assess the incidence of site-specific cancer in La Salle (defined by zip code) from 1985 through 1988.[3] Cases of cancer diagnosed in the study period were identified. This included cases diagnosed or treated in the neighboring states of Missouri, Iowa, Michigan, and Wisconsin. Ascertainment of cancer cases for the Illinois Cancer Registry is estimated to be 94 percent complete. Overall, there were fewer cancers reported for La Salle residents than would have been expected based upon registry rates for all cancers. The only statistically significant difference observed was a deficit of prostate cancer deaths. Twenty-five cases of prostate cancer were expected in La Salle for the period, but only ten cases were observed.

In 1994, a pilot study was conducted to determine serum PCB concentrations in former workers and residents who lived near the site. In addition, exposure and health information was collected to identify other sources of PCB exposure and potential health implications that should be investigated during future study activities. Serum samples were collected from 60 former EUC workers and 36 area residents. PCB serum concentrations in former EUC workers (mean=14.3 parts per billion (ppb)) were significantly elevated compared with area residents (mean=3.6 ppb). Lipid-corrected PCB concentrations maintained the same statistically significant relationship as serum PCB concentrations. Former EUC workers' levels were significantly elevated (mean=1,883 ppb) compared with those of residents (mean = 491 ppb). Self-reported length of employment was significantly correlated with PCB serum concentrations ($r=0.53$ $p < 0.001$, $n=60$). Because the majority of workers at this facility routinely rotated between jobs, and recall regarding length of time at each position was low, we were unable to relate job classification with PCB exposure. The average length of employment in pilot study participants was 12.25 years and total years worked ranged from 0.5 to 36.3 years. There was a positive correlation between length of residence near the site and serum PCB concentrations ($r=0.51$, $p<0.05$, $n=41$). Included in this analysis were 5 former EUC workers who also lived near the site. The average length of residence near the site

was 20.7 years. Serum PCBs were also significantly correlated with triglycerides and age. Lipid adjusted PCBs were significantly correlated with age, length of employment, and length of residence.

While these studies provide a mixed picture of possible health effects in La Salle residents, the interpretation of these data is far from certain. Reliance on self selection of study subjects and a lack of objective exposure and outcome data in the survey study raise the possibility that observed associations may be due to selection and recall bias. Many former EUC workers no longer live in La Salle County and almost 1/3 of the cohort is deceased. The observation that cancer incidence rates were not found to be elevated in La Salle residents for the period 1985-1988 is not very persuasive either. This is a rather short time period, with relatively few cancers expected in the small population of La Salle (population= 9,717 in the 1990 census[1]). These studies lack objective PCB exposure data, and consequently they do not provide a strong test of possible exposure related health effects. The current study was undertaken in response to community concerns. It included a retrospective cohort mortality study as well as a cross-sectional morbidity study examining the relationship of PCB exposure to serum lipids, liver function tests, hormonal balance and immune function. The retrospective cohort mortality study is the subject of this report. The morbidity study results are included in a separate report.

LITERATURE REVIEW

PCBs and Related Compounds

Despite a large amount of animal data suggesting that PCBs and related compounds are carcinogens, effects in humans are not as clear, in part because of the relatively small numbers of exposed individuals who are often not followed for more than 20 years. Animal studies of PCBs have shown effects which differ by gender and Aroclor mixture.[4] Liver cancer has been noted more frequently in female than male rats and, for females, more frequently after exposure to Aroclor 1254 compared to 1260, and 1242 compared to 1016. Thyroid cancer was noted more in males for Aroclor 1242, 1254, and 1260.[4] Some animal studies suggest PCB may also act as a tumor promoter.[5]

Most human studies of exposure to PCBs have been cohort studies of persons exposed in transformer and capacitor manufacturing plants. These exposures have been to mixtures: not only to mixtures of dioxin and non-dioxin like PCBs, but also to other chemicals such as chlorinated solvents which are also thought to be carcinogens. Previous studies include six cohort studies of workers exposed to PCBs in capacitor or transformer manufacturing plants. Brown[6] reported on cancer mortality among 2,588 workers at two capacitor manufacturing plants and noted increased risk of liver, gallbladder and biliary cancer, with most of the excess in women at one of the plants. Sinks et al,[7] however, also reporting cancer mortality among 3,588 persons (2,742 men and 846 women), noted increased risk of melanoma with a suggestion of increased risk of brain cancer and no increased risk of liver/biliary cancer. In a much smaller study of capacitor manufacturing workers in Sweden, a suggested increase in risk of cancer of the liver/bile ducts was found.[8] A study of 544 males and 1,556 females in a capacitor manufacturing plant in Italy found significantly increased deaths from total cancers and gastro-intestinal cancers among male workers and significantly increased deaths from total cancers and hematologic cancers in women.[9,10] In a capacitor manufacturing plant in Canada, a significant increase in pancreatic cancer deaths was detected in a cohort of 2,222 men.[11] Kimbrough et al[12] recently published results from a cohort of 7,075 male and female capacitor manufacturing workers who worked between 1946 and 1977. Length of employment and latency were not associated with elevated site specific mortality for any cause of death, except for an increased SMR for intestinal cancer in female hourly workers with 20 or more years latency.

In probably the largest cohort study to date of 138,905 electric utility workers exposed to PCBs, Loomis et al[13] noted a statistically significant association of PCB exposure with melanoma after control for solvent exposure. The association was particularly pronounced in those with high exposure after a 20 year lag. An association with liver cancer was no longer significant after control for solvents, while associations with brain cancer were inconsistent.

Two studies have followed the Yucheng and Yusho cohorts which had mixed PCB/furan exposure from ingestion of contaminated rice oil. Hsieh et al, in a study of acute mixed PCB/furan exposure in Taiwan, found an increased risk of death from liver disease in both males and females, after 12 years of exposure.[14] Kuratsune et al[15] followed the Yusho cohort and noted significant increased

risk for lung and liver cancer in males, a non-significant risk of liver cancer in females, as well as non-significant risks of liver cirrhosis in both males and females.

Case control studies of PCB exposure and specific diseases are less numerous, due to problems assessing PCB exposure in the general population. Results from three case control studies of breast cancer and PCB exposure showed mixed results, with only one[16] of three[16-18] studies suggesting a possible association between PCB exposure and risk of breast cancer. A case control study of transformer manufacturing workers found that the association of liver cancer with PCBs was no longer significant after control for exposure to solvents.[19] In a nested case-control study of non-Hodgkin's lymphomas in Maryland, Rothman et al[20] found a strong dose-response relation between quartiles of total lipid-corrected PCB levels and the incidence of non-Hodgkins lymphoma, with evidence suggesting an interactive effect with seropositivity for Epstein-Barr virus.

Trichloroethylene

Occupational exposures to TCE can affect some of the same target organs as PCBs and must be considered as an exposure which could interact with PCBs on health outcomes. Since TCE is rapidly metabolized there is no biomarker which can measure it 15 years or more after exposure. There is some, but not consistent, evidence, however, that it may affect endpoints which require a long lag period before clinical manifestation.

High levels of TCE exposure have been associated with liver and lung tumors in mice and renal and testicular tumors in rats.[21] Historical cohort mortality studies of TCE exposed-workers, however, have yielded inconsistent results. One cohort study of 2,117 workers with a latency of only 6-13 years showed no increase in cancer deaths.[22] The only cancer associated with low TCE exposure in another cohort of 1,670 persons was nonmelanotic skin cancer.[23] A larger cohort of 2,050 male and 1,924 female workers in Finland exposed to TCE and other solvents, showed significant increases in stomach, liver, prostate and lympho-hematopoietic cancers in persons followed more than 20 years.[24] An additional study of 4,733 aerospace workers found a significantly elevated risk for ovarian cancer in women with high cumulative exposure (RR=7.09).[25] Slightly elevated risks were noted for kidney, bladder and prostate cancers. Another cohort of 14,457 aircraft maintenance workers found increased risk for multiple myeloma in white women (SMR=236), non-Hodgkin's lymphoma in white women (SMR=212), and cancer of the biliary tract and liver in white men (SMR=358).[26] Reanalysis of the cohort with extended follow-up, however, showed non-significantly increased risk for non-Hodgkin's lymphoma, esophagus, colon, liver, breast, cervix, kidney and bone cancers, with no dose response.[27] There were no elevated risks for respiratory cancer, liver cancer or leukemia. Examination of rates of renal cell cancer in the Danish Cancer Registry found a significantly increased odds ratio of 10.8 for exposure to TCE,[28] while environmental exposure to TCE-contaminated drinking water has been associated with leukemia in two other studies.[29,30]

Chlorinated Naphthalenes

Chlorinated naphthalenes have been associated with acute and chronic liver disease, and share similar toxicities with PCBs.[31] These effects have been well recognized since 1937 when the first of several case reports describing deaths from acute liver toxicity was presented.[32] A retrospective mortality study of cable manufacturing workers exposed to chlorinated naphthalenes, as well as asbestos, during World War II, documented a significant excess of deaths from cirrhosis (both alcoholic and non-alcoholic) (SMR=1.84).[33] They noted an increase in deaths from all cancers, which was statistically significant for men (SMR=1.18). An excess of cancer of the connective tissue was suggested for workers with over one year of exposure and 25 years of latency (SMR=3.54).[34] Among other cancer sites increased risks were seen in both men and women for stomach, rectum and lung cancers, with associations diminished by the use of county, rather than the US population, as reference.

SPECIFIC AIMS

The retrospective mortality study of EUC workers will examine mortality among EUC workers employed between 1944 and 1977, and followed until December 31, 1997. Specific aims of the study are:

1. To determine subsequent mortality (total, total cancer, and cause specific cancer mortality) among persons employed at EUC, using Standardized Mortality Ratios (SMR) to assess any excess deaths in the cohort.

2. To calculate SMRs for specific causes of death among EUC employees according to latency, and length and calendar year of employment.

3. To assess mortality from selected causes of death that have been associated with PCBs, TCE, and chlorinated naphthalene exposure in previous studies. These include cancer of the breast, liver/biliary/gallbladder, kidney, melanoma, hematopoietic cancers, non-Hodgkin's lymphoma, and liver disease.

METHODS

Establishment of Cohort

Complete personnel records from the EUC plant were not available, since the plant was torn down in 1981 and most of the records were either lost or moved to North Carolina when the plant relocated. A few boxes of miscellaneous plant records were obtained by the IEPA but these records were incomplete. Therefore, a variety of methods were used to reconstruct the employee cohort as described below.

Social Security Administration Records

The EUC cohort was identified using microfiche copies of records from the Social Security Administration (SSA) that were based on reports filed by the EUC. In the Fall of 1995, quarterly lists of workers for each year were obtained for calendar years 1944 through 1977 (except the first quarter of 1955 which was missing). The plant first opened in July of 1943, but records for this year were not available. The plant closed in 1981, but SSA records for 1978-1981 were also not available. Since PCBs were not used after 1978, these missing records should have a minimal effect on the results. Each quarterly report included social security numbers, workers' names, and wages for any person who worked in that quarter. However, no information was available from these records regarding the number of days or weeks worked in that quarter for any person, nor was there any gender, birth date or race information.

The information obtained from the SSA, including social security number, worker name, and quarter and year worked, were entered into a data base in February of 1996. There are 43,397 records in this data base, as each worker has a record for every quarter they worked at EUC. Some of the social security numbers were not always legible on the microfiche copies. Therefore, once all of the data was entered, it required cleaning in order to match social security numbers and names for every quarter worked. Since in many cases, female workers had changed their last names due to marriage, careful matching of last names and social security numbers for these women was required.

For workers with long work histories, it was relatively simple to insure that the social security number was correct. For workers who only worked one or two quarters, and who had no other records available, an illegible social security number rendered follow up difficult, since social security number and name were the only information available to trace these individuals. A small number of individuals were found to have invalid or inaccurate social security numbers, and hence could not be traced. For the most part, these were people with only one or two quarters of employment. More detailed tracing results are presented below.

After cleaning the data, and matching social security numbers and names, a total of 3,307 different workers were identified who had worked at least one quarter at EUC, and for whom a social security number was identified. Three workers with no social security number were not included in the cohort (these were workers with only one quarter of employment at EUC). Two workers

who contacted us said they only put in applications at EUC and never worked there. These two were also excluded, resulting in 3,305 workers to be traced.

The number of employees in the plant averaged 321 per **quarter** between 1944 and 1977, with a range of 154 to 474 workers per quarter. The average number of employees per **year** ranged between 222 and 410. The highest years of employment occurred in 1950-1953 with approximately 400 employees per year. The last three years of the follow-up study, 1975-1977, had the lowest number of employees with approximately 240 employees per year.

As shown in Table 1 below, fifty-three percent of the cohort worked less than one year, including 782 workers, or 24 percent of the cohort, having worked in only one quarter (which could range from one day to three months employment). These 782 workers include 112 workers who worked in the first quarter of 1944, the first year and quarter that records were available from the SSA. However, since the EUC plant opened in La Salle in July of 1943, it is possible that some of these 112 workers may have also worked in 1943.

The large majority of the EUC cohort were first employed there prior to 1955 (53%), with 29 percent first employed before 1950 (Table 2). As previously described, PCBs were not used at EUC prior to 1952, but chlorinated naphthalenes were. The more highly chlorinated PCBs were used in the early to mid-1950s. Thus, a majority of EUC workers were either exposed to chlorinated naphthalenes and/or highly chlorinated PCBs.

In order to approximate workers' exposure to chlorinated naphthalenes and PCBs, calendar years of employment were also categorized according to whether they worked only prior to 1952, between 1952 and 1977 only, or in both time periods (Table 3). Thirty one percent of the cohort worked only in 1944-1951, and so would probably not have been exposed to PCBs. Fifty-six percent of the cohort only worked after 1952, and 13% worked both before and after 1952.

Table 1. Length of employment of EUC cohort

Length of Employment	Number	Percent
1 quarter	782	23.7
2-3 quarters	969	29.3
1-4 years	1013	30.6
5-9 years	207	6.3
10 + years	334	10.1
Total	3305	

Table 2. Calendar year first worked at EUC

Year first employed	Percent (number)	
1944-49	29.3	(967)
1950-54	23.5	(776)
1955-59	11.7	(388)
1960-64	5.3	(176)
1965-69	15.5	(514)
1970-77	14.6	(484)
Total[1]	99.9	3305

1. Percent doesn't add to 100 due to rounding.

Table 3. EUC employees by calendar year of employment

Years worked	Percent (number)
1944-1951 only	30.9 (1021)
1952-1977 only	55.9 (1847)
Before and after 1951	13.2 (437)
Total	100.0 (3305)

Miscellaneous EUC Records

IEPA obtained several boxes of records from the EUC plant before it was torn down. These boxes contained a variety of different records, none of which was complete, but could be used to ascertain birth date, race, sex and address information for some cohort members. These records are described below.

Personnel records (PR1) with name, social security number, birth date, sex, marital status, and payroll information were available for 15 different years, including 1957-1968, and 1971-1973. A total of 1,249 workers were found in these records, or 38 percent of the total cohort.

A second set of personnel records (PR2) include name, social security number, address, gender, and a list of jobs held in the plant, but do not include birthdate. However, these records only have information starting in the early 1970s. Therefore, workers who left EUC by this time are not included in these records. A total of 430 workers were found in these records, including 255 workers who were also in the PR1 file.

A variety of other records, consisting primarily of first aid and insurance claim records were also found. These records for the most part, do not have any information for workers after the late 1950s, and so are of limited usefulness. However, some birth date and death information was obtained from these files that was otherwise unavailable, including birth dates for 34 workers.

Follow up Procedures

In order to ascertain the vital status for the 3,305 workers in the EUC cohort, a variety of procedures were used. In the spring of 1995, to locate workers for the cross-sectional interview study, letters and questionnaires were sent to all known former EUC workers in the La Salle County area, using addresses obtained from the 430 workers in the personnel file, lists from IDPH, the United Steel Workers Union, mailing lists from previous community meetings, and information from the EUC Community Assistance Panel (CAP). There were 1,030 individuals identified from these lists, to whom questionnaires were mailed. The questionnaire asked for a brief work history, as well as information about any relatives (deceased or living) who worked at EUC. This mailing and subsequent telephone calls resulted in 188 interviews in workers employed at EUC between 1944 and 1977 (five workers were excluded from the cohort study who were interviewed but who worked at EUC only after 1977). Vital status of the remaining workers was determined by the following procedures.

Death Certificate Searches

Death searches were done prior to address searching, as several sources are readily available to identify deaths using social security numbers, names and birth dates. The National Death Index, (NDI) of the National Institutes of Health, provides death matches for deaths occurring in the U.S. beginning in 1979 until the most recent data available. This index was used for deaths between 1979 and 1997. Four requests for NDI data were sent starting in 1996 through 1999, and all requests through 1997 deaths have been received.

The NDI returns lists of deaths with possible matches, with the place and date of death listed for each possible match. Death certificates for these matches were then requested from the state of death, and the information on the death certificate was compared to the EUC worker information to insure that a correct match was found.

In order to locate deaths in EUC workers prior to 1979, the Social Security Death Index (SSDI) was used. The SSDI includes any deaths reported to the Social Security Administration for individuals with social security numbers. Those whose retirement was covered by the Railroad Retirement Board are also included in the SSDI, but only if they received RRB numbers before 1963.

About 98 percent of the deaths in the SSDI include persons who died after 1962, the year in which the SSA data was computerized.[35] This index can be searched either using social security number or name, and provides date of death, birth date, last known residence state and zip code, and the zip code of the last known lump sum payment. Unlike the NDI, it does not provide the state of death, although the last known residence state is often the state of death as well.

In order to match a large number of names with the SSDI, private search firms were used that have purchased the SSDI, and then match clients' data to their data base. Death matches were first obtained from Epidemiology Resources Incorporated in the spring of 1997. The remaining cohort with no death matches were then sent to Choice Point for matching, since this firm uses sources other than SSDI to locate deaths.

Once possible matches were obtained from these companies, death certificates were requested from the state of death if known, or from the last known residence. If a death certificate was received, it was reviewed to insure that the correct individual was found.

In some instances, a death certificate could not be located from the state where it was requested. In others, a social security number was matched but the name on the death certificate was incorrect (after taking into account possible name changes in females). These latter mismatches for the most part were cases where the social security number we had recorded for that person was probably incorrect, the individual worked only one or two quarters, and, we had no other information for that person. There are currently 25 known individuals with a probable incorrect social security number.

There were also 58 individuals for whom a death certificate could not be found, but who were reported as deceased by the SSDI. In the spring of 1998, Choice Point was employed to search for a possible state of death for these persons. A variety of techniques were used to locate the state of death, such as telephoning funeral directors in the town of last residence. The state of death was found for 20 of the 58 individuals.

In the summer of 1998, the names of the remaining individuals were sent to a resident of La Salle, Illinois, who searched for death information in local sources, such as newspaper obituaries. She also used local city directories and telephone books to find a last known date of residence in the La Salle area, to search for addresses and last date. She was able to locate the state of death for 12 additional workers using these methods.

Deaths were also identified from questionnaires sent to former EUC workers known to be alive. These questionnaires solicited information on the worker's own work history, as well as information on other relatives who worked at EUC, including any deaths in these relatives. A small number of deaths (less than 20) were identified this way.

As of February 1999, a total of 1000 death certificates were obtained for former EUC employees, including 594 deaths in females, and 406 deaths in males. The majority of deaths occurred among residents of Illinois (81%), followed by California (3.5%), Florida (2.7%), and 26 other states. Most deaths occurred in 1970 or later (89%), with 67% of deaths occurring in 1980 or later. There were 13 known deaths in 1998, but since follow up is not complete for that year, these deaths are not included in the analysis. These individuals are counted as last known alive on December 31, 1997.

Address Searches

Names and social security numbers for the remaining workers with no vital status information were sent to a private firm, Pension Benefits Incorporated (PBI), in order to find and verify addresses for these workers. PBI searches several data bases to find an address, matching on social security number. If an address is found, PBI sends a verification letter to the individual to make sure that the person still lives at that address. Data bases are searched sequentially. If an address in one data base is not confirmed, other data bases are searched until another address is found, and a letter is then sent to this address.

Once an address was confirmed by PBI it was sent to the study investigators so that a letter and questionnaire could be mailed. The letter and questionnaire are included in Appendix A. The questionnaire asks for information on birth date, gender, race, years worked at EUC, as well as information on other relatives that worked at EUC. Current addresses, or date and place of death were requested for these relatives.

The PBI search began in the Spring of 1998. As of February 1999, a total of 1005 addresses were confirmed by PBI. Letters and questionnaires were sent to these addresses. If questionnaires were not returned in 2-3 months, a second questionnaire was mailed.

If the respondent identified an address for an EUC worker that we had no information for, these individuals were also sent a letter and questionnaire. Telephone calls and Internet searches using name and address locators yielded additional address information. A previous pilot study by IDPH also yielded an additional 43 addresses. As of February 1999, a total of 769 questionnaires had been returned, for a response rate of 72 percent. Only 752 of these questionnaires had complete data however, including birth date, race and sex, and only these were used in the analysis.

Health Care Financing Administration Search

The Health Care Financing Administration (HCFA) administers the Medicare program and has a database of eligible participants, which includes the 65 and over population, and those deemed eligible for disability benefits, who can be of any age. These data can be accessed for research purposes, and include social security number, name, current address, race, sex and birth date. For deceased participants, it also includes date of death and last known address, but not state of death.

A protocol was sent to HCFA in March of 1998, to request information on EUC workers whose vital status had not yet been determined. In order to contact HCFA participants for any research study, a letter from HCFA describing the study must be mailed to the participants before any other letters or questionnaires are sent. The protocol was approved by HCFA in October of 1998 and the matching data received in December 1998.

The data had to be cleaned and edited due to HCFA data processing problems and mismatched social security numbers. After the file was cleaned, there were a total of 555 additional names with vital status information. These 555 names included death information for 14 workers who died in 1997 or earlier, and 18 workers who died in 1998, resulting in 541 additional names of workers known to be alive as of December 1998. Questionnaires were sent to these 541 individuals in April of 1999 to confirm vital status and birth date information.

For purposes of the mortality analysis, it is assumed that the HCFA vital status information is correct as of December 1997, the current ending date for the study. The HCFA death dates are also assumed to be correct for the mortality analysis. Death certificates not yet obtained for these HCFA deaths have the causes of death are recorded as "unknown." Since 18 of the 32 deaths occurred in 1998, after the end of the study period, only 14 deaths will have cause of death as unknown. In the total cohort to be analyzed, there are 1001 total deaths as of December 31, 1997, including the 14 HCFA identified deaths with no death certificate as of this date.

Comparison of Traced and Non-Traced Cohort

To assess any potential bias in the cohort traced to this date, work histories were compared for the untraced and traced cohort, as shown in Tables 4-6. Birth year, gender, and race of the traced and non-traced cohort cannot be compared because race was not coded on any of the available SSA or personnel records. Birth date and gender were only available for 46 percent and 31 percent of the untraced cohort, respectively.

As of February 1999, 76 percent of the total cohort had been traced. However, those who worked less than one quarter were significantly less likely to be traced (66%) than those who worked at least two quarters (78%) (Table 4). The percentage of workers traced increases with quarters worked, with 92 percent of workers with 10 or more years employment having been traced (Table 5). Workers who were employed only after 1951 were less likely to be traced than workers who worked at any time prior to 1952 (Table 6). Workers who worked before 1952 were generally older than the rest of the cohort, and more likely to be deceased than workers who started after 1951.

Less information is available for workers with short term employment, and particularly for those with only one quarter of employment, and so are more difficult to trace. Often only a social security number and name is available for these workers, and if the only quarter with social security information is not clearly legible, these workers will be difficult to trace.

Standardized Mortality Ratios may be biased for these short term workers if person years are under represented due to missing information for workers lost to follow up. Short term workers who are deceased may be more easily traced than workers who are alive, since there are many data bases available for death searching. Since no information is available for number of days worked in a quarter, employees with only one quarter of employment could have worked between one day and 3 months. For these reasons, workers with only one quarter of EUC employment are excluded from the mortality analysis in this report. Assuming follow up of these workers continues, all workers will continue to be traced. If there is a sufficient increase in follow up for workers with one or more quarter of employment, they will be included in the final mortality analysis.

Table 4. Number of quarters worked by follow up status

	Number of Quarters Worked		
	One Quarter	**Two or more quarters**	**Total**

Follow up Status	Percent (Number)	Percent (Number)	Percent (Number)
Not found	34.0 (266)	21.6 (545)	24.5 (782)
Found*	66.0 (516)	78.4 (1978)	75.5 (2523)
Total	23.7 (782)	76.3 (2523)	100 (3305)

*Includes workers found by HCFA but not yet contacted.
$X^2 = 439.7$, p=.001

Table 5. Vital status percentage distribution of all EUC workers by quarters worked

	Vital Status			
Quarters worked	**Deceased** % (number)	**Alive** % (number)	**Unknown** % (number)	**Total** % (number)
1	29.8 (233)	37.2 (291)	33.0 (258)	23.7 (782)
2-3	25.3 (245)	47.9 (464)	26.8 (260)	29.3 (969)
4-19	28.9 (293)	49.0 (496)	22.1 (224)	30.6 (1013)
20-39	32.8 (68)	54.1 (112)	13.0 (27)	6.3 (207)
40 or more	48.5 (162)	43.4 (145)	8.1 (27)	10.1 (334)
	1001	1508	796	3305

Table 6. Vital status percentage distribution of all EUC workers by calendar years worked

	Vital Status			
Calendar year worked	**Deceased** Percent	**Alive** Percent	**Unknown** Percent	Total
1944-1951 only	41.3	40.1	18.6	1021
1952-1977 only	19.9	49.5	30.6	1847
Both time periods	48.3	42.3	9.4	437

Race Distribution

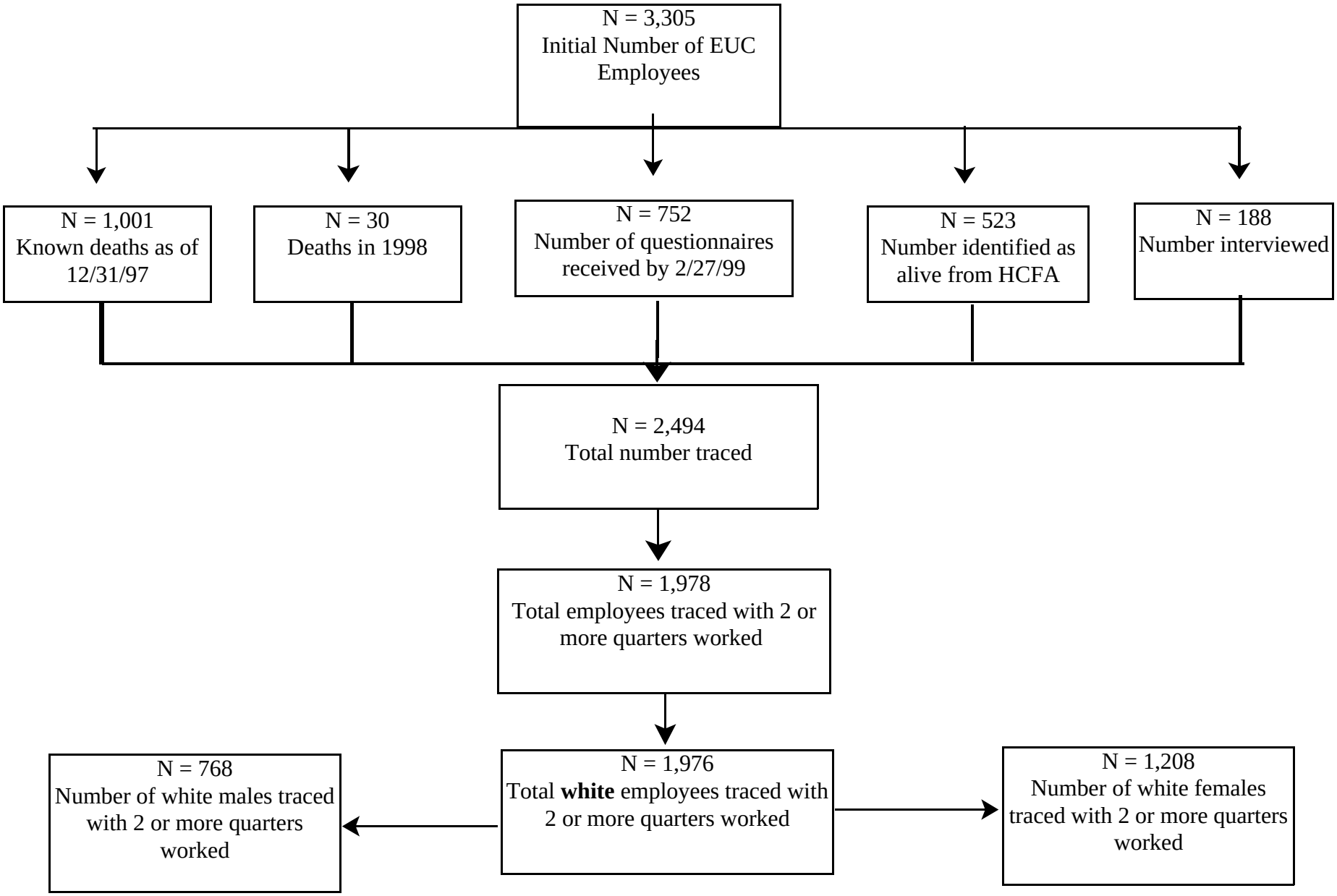
Since race is not specified in the SSA files or any of the EUC personnel files, race can only be determined from death certificates, returned questionnaires, or HCFA data. However, since the La Salle County area is more than 97 percent white[1], cohort members are assumed to be white unless additional data obtained shows otherwise. The mailed questionnaires include codes for white, black, Asian and other races. The HCFA race codes include white, black, other, and unknown. Death certificate race codes vary somewhat by state, but usually include white, black, Asian, and other races, with Hispanic origin coded as white. Based on these questionnaires, HCFA and death certificate data, 19 blacks were identified in the cohort, including 12 deaths, but 18 of these blacks worked only one quarter. There was also one Asian identified. Due to these small numbers, the 20 blacks and Asians were excluded from the mortality analysis. Figure 4 details the process of identification of the cohort used in the mortality analysis.

Description of Cohort Used in Mortality Analysis

A description of the 1,976 workers included in the mortality analysis is included in Tables 7-11. There are 768 males and 1208 females in the cohort to be analyzed. Table 7 includes mean descriptive values for males and females. Mean quarters worked is similar in males (mean=20.2) and females (mean=18.2). Latency, defined as the number of years between first employment and death or the end of the study period for alive workers, is somewhat higher for females (mean=38.6) then males (mean=33.1). Mean ages of deceased (69 years) and alive (70 years) females are higher than those of males (64 years in deceased, 61 years in alive).

The majority of the cohort (51%) worked only after 1951, with males more likely to have worked in this time period (65%) than females (42%) (Table 8). Only twenty percent of the cohort worked both before and after 1951. However, 58 percent of females worked sometime before 1952 compared to only 35 percent of males.

Figure 4. Chart of Electrical Utility Company (EUC) Employees According to Follow Up Status and Selection Criteria



Since the Aroclors used at EUC varied by calendar years, starting in 1952 when PCBs were first used in the plant, the number of workers who worked when specific Aroclors were used (1944-51,1952-56, 1957-70, 1971-77) was determined. Thirty-five percent of the workers worked in more than one of these time periods, and 29 percent worked only before 1952, when PCBs were not used (Table 9). The number of workers who **only** worked in one of the calendar time periods was too small to analyze as subgroups in the mortality analysis, particularly when stratified by gender.

There are 307 workers with 10 or more years of EUC employment, and 180 workers with 5-9 years of employment (Table 10). Seventy five percent of the cohort worked less than five years, including 36 percent with two to three quarters of employment. Length of employment is similar for males and females.

Table 7. Mean ages, quarters worked, and latency [1] by gender, in traced EUC employees with two or more quarters worked, whites only

	Means (number)	
Variable	Males	Females
Quarters worked	20.2 (768)	18.2 (1208)
Latency	33.1 (768)	38.6 (1208)
Age at death	63.6 (304)	69.4 (464)
Age of those alive on 12-31-97	60.7 (464)	69.9 (744)

1. Latency= Date of death or end of study period minus year first employed.

Table 8. Calendar year of employment for traced EUC workers who worked two or more quarters by gender, whites only

	Males	**Females**	**Total**
Calendar Years Worked	Percent (Number)	Percent (Number)	Percent (Number)
1944-1951 only	16.7 (128)	37.0 (447)	29.1 (575)
1952-1977 only	65.2 (501)	41.7 (504)	50.9 (1005)
Both time periods	18.1 (139)	21.3 (257)	20.0 (396)
Total	100 (768)	100 (1208)	100 (1976)

Table 9. Percent and number of workers who only worked in specified calendar years, or in mixed[1] calendar years at EUC, for traced workers with two or more quarters of employment, by gender, whites only

Calendar Years Worked	**Males** Percent (Number)	**Females** Percent (Number)	**Total** Percent (Number)
1944-1951 only[1]	16.7 (128)	37.0 (447)	29.1 (575)
1952-56 only[2]	9.9 (76)	8.8 (106)	9.2 (182)
1957-1970 only[3]	28.4 (218)	11.2 (135)	17.9 (353)
1971-1977 only[4]	9.2 (71)	7.8 (94)	8.4 (165)
Mixed[5]	35.8 (275)	35.3 (426)	35.5 (701)
Total[6]	100.0 (768)	100.1 (1208)	100.1 (1976)

1. Chlorinated naphthalenes used 1944-1977.
2. Aroclor 1254 used (estimated).
3. Aroclor 1242 used 1954-1970 (estimated).
4. Aroclor 1016 used (estimated).
5. Worked in more than one calendar time period.
6. Percents don't add to 100 due to rounding.

Table 10. Quarters worked by gender for traced EUC workers with two or more quarters of employment, white race only

Quarters worked	**Males** Percent (number)	**Females** Percent (number)	**Total** Percent (number)
2-3	35.8 (275)	35.5 (429)	35.6 (704)
4-19	37.0 (284)	41.5 (501)	39.7 (785)
20-39	10.3 (79)	8.4 (101)	9.1 (180)
40 or more	16.9 (130)	14.6 (177)	15.5 (307)
Total[1]	100.0 (768)	100.0 (1208)	99.9 (1976)

1. Percents don't add to 100 due to rounding.

Deceased workers

Death certificates were located for 1000 former workers, including 13 deaths that occurred in 1998, after the end of the study period. Excluding these 13 deaths, and with the addition of the 14 known HCFA deaths as of December 31, 1997 (for which death certificates are pending), there were a total of 1001 known deaths in the entire EUC cohort through the end of 1997. These include 403 deaths in white males, 586 in white females, and 12 deaths in African-Americans. All of the 12 deaths in blacks occurred in workers with less than one year of EUC employment.

Excluding all workers with only one quarter of employment and excluding blacks, results in 768 deaths available for analysis, including 304 deaths in white males, and 464 deaths in white females.

Standardized Mortality Ratio Analysis

The Standardized Mortality Ratio analysis was conducted using PC LTAS, Life Table Analysis System for Use on the PC, a National Institute for Occupational Safety and Health software program in the public domain.[36] This program provides U.S. age, race, sex, and calendar year adjusted Standardized Mortality Ratios. Calendar years and age groups are categorized in five year intervals (age groups begin with 15-19 and end with 85 years and over). Mortality rates for 1990-1994 are assumed for 1995-1999 mortality rates. Race is categorized as white (including white, Hispanic, and unknown) and non-white (including black, Asian, Native American, and other).

Person years are calculated beginning with the workers' first employment, and end with the date of death, or end of the study period (12-31-97). Only white workers who have known vital status and worked two or more quarters are included in the analysis. Subgroups of workers were also created according to calendar years worked and length of employment for separate analyses. Observed and expected deaths are calculated based on person years of exposure by calendar year, age and race. Standardized Mortality Ratios (SMRs) are the ratios of the observed to expected deaths. SMRs are also calculated according to latency, defined for this study as number of years since first employment until death or the end of the study period.

Confidence intervals and p-values for the SMRs (observed to expected deaths) are calculated on the assumption that the observed deaths follow a Poisson distribution. When the number of deaths is less than or equal to five, exact confidence intervals and p-values are calculated for the SMRs. When the number of observed deaths is greater than five, the Byar approximation is used.[37] In these analyses, two-sided ninety-five percent confidence intervals are used.

The mortality rate files include 92 underlying cause of death groupings for the years 1940 to 1995, and 99 underlying cause of death groupings for the years 1960 to 1995. The expanded rate files with 99 causes of death include causes that were split apart starting in 1960, and adds categories for HIV related disease in 1987, and for cardiomyopathy in 1968. In addition, "Other neoplasms of the lymphatic and hematopoietic tissue" was changed to "myeloma," and a new category of non-Hodgkin's lymphoma was created in 1960. Since the EUC cohort encompasses the 1940-1997 time period, the 92 causes of death categories are primarily used in this analysis. The 99 expanded causes of death are used to calculate SMRs for non-Hodgkin's lymphoma, which cannot be assessed using the 92 causes of death. Person years accumulated before 1960 are not used in the calculation of the non-Hodgkin's lymphomas, and this limitation is addressed in the analysis section.

Underlying cause of death for each deceased employee was coded by a nosologist using the International Classification of Disease (ICD-9) coding procedures. The NIOSH software used to

analyze mortality data converts ICD-9 codes to the codes that were used at the time of death, so that expected deaths by calendar year are based on the same codes used in the standard mortality rates for that calendar year.

It would be preferable to use Illinois or Illinois county standard mortality rates to generate expected deaths in the EUC cohort, in order to reduce any bias caused by any differences in state and national rates. State and local rates are not provided with the NIOSH software but have been requested from the CDC Wonder System and will be applied after they are obtained.

Standardized Mortality Ratios were analyzed for workers with at least 2 quarters of EUC employment. For selected causes of death, SMRs were also calculated according to length of EUC employment, in the following categories: 2-3 quarters, 1-4 years, 5-9 years and 10 years or more. SMRs were also calculated according to calendar year of employment, to represent workers exposed to chlorinated naphthalenes but not PCBs (only worked between 1944-1951), workers exposed primarily to PCBs and on a limited basis to chlorinated naphthalenes (worked between 1952-1977 only), and workers who would have been exposed to both chlorinated naphthalenes and PCBs (worked any time before and after 1951).

As previously described, all workers in the plant, including administrative employees, supervisors and executives, were exposed to PCBs and other chemicals, due to the nature of the plant setting. The amount of PCB and other exposures did vary according to department worked in. However, given that work histories are only available for a small number of workers, SMRs cannot be calculated according to type of job. However, where information is available for selected outcomes, job titles will be listed for those employees.

White collar workers are included in the analyses since they were also exposed to PCBs, because plant offices were situated in the plant itself, and not in a separate building. The exact number of white collar workers is unknown, but based on limited plant records, it is estimated to be less than 20 at any one time. These would include the President, Vice-President, Treasurer, Engineers, Nurse, Payroll Clerk, and a few other assorted administrative employees.

Person Years

A total of 73,495 person years were accumulated for the traced cohort with two or more quarters of employment between January 1, 1944, and December 31, 1997. As shown in Table 11 below, the number of person years accumulated varies somewhat by sex, with white females accumulating 1.8 times more person years than males. Female person years outnumber male person years regardless of length of employment, but with the smallest ratio in those with ten or more years of employment. Overall, employees with one to four years employment have the largest accumulated person years, followed by those who worked two to three quarters only.

Table 11. Person years accumulated 1944-1997, by time worked, in white males and females

Time worked	White Males	White Females
2-3 quarters	9,224	16,547
1-4 years	9,491	20,036
5-9 years	2,401	3,908
10 or more years	4,857	7,031
TOTAL[1]	25,974	47,521

1. Numbers may not add exactly due to rounding.

SMR RESULTS

Results for EUC workers with two or more quarters of EUC employment are presented in Tables 12-13, for the 92 cause of death categories included in the 1944-1997 time period. The International Classification of Disease (ICD) codes corresponding to the category codes in these tables are included in Appendix B.

White Males

The number of total deaths from all causes in white males was not significantly different than that expected (SMR=1.07). Given the long follow-up period and the aging of the EUC cohort, the lack of a healthy worker effect, or deficit of deaths, in this population is not surprising. The healthy worker effect accounts for the assumption that workers are healthier than the general population. This effect declines as the age of the cohort increases and worker's health becomes more similar to nonworkers. The SMR for all cancers was slightly elevated at 1.20, but was not significant, based on 80 total deaths from cancer.

Within the digestive cancer group, non-significantly elevated SMRs of two or more were found for stomach cancer (SMR=2.29), and biliary passages, liver and gallbladder (SMR=2.67). No excess of deaths from pancreatic cancer were found.

A non-significantly elevated SMR was found for cancer of the kidney (SMR=2.38). No excess of skin (SMR=.69) or brain cancer (SMR=.52) was found. There were no deaths in males from non-Hodgkin's lymphoma, but a non-significantly elevated SMR was found for leukemias (SMR=1.57). The SMR for thyroid cancer was significantly elevated based on two cases (SMR=16.91). No other cancer sites had significantly elevated SMRS.

Among non-cancer causes of death, there were no significantly elevated SMRs, and none of the SMRs based on 3 or more cases were above two. A non-significant SMR of 1.84 was found for the category cirrhosis of the liver, which includes chronic liver disease and cirrhosis. There was a significant deficit of deaths due to diabetes, with no deaths having occurred from this cause.

White Females

The SMR for all causes of death in white females was .93, and was not significant. The SMR for all cancers was 1.12, also not significant. The healthy worker effect, as in males, was not a factor among these female workers, likely due to the long follow-up period and aging of the cohort.

Among digestive cancers, non-significantly elevated SMRs were found for cancer of the stomach (SMR=1.72) and biliary passages, liver and gallbladder (SMR=1.92). Of note is the non-significant excess found in these two cancer sites for males as well. Deaths from cancer of the pancreas were below expectation (SMR=.73). A non-significant excess of cancer of the peritoneum and other, unspecified digestive sites was found, based on only two deaths (SMR=2.99).

A small excess of breast cancer mortality was found, but was not significant (SMR=1.37). A non-significant excess of kidney cancer based on four deaths, was also found (SMR=1.81). Deaths from skin and brain cancer were not elevated. A non-significant SMR of 6.09 was found for bone cancer, based on two deaths.

The SMR for all neoplasms of lymphatic and hematopoietic tissue was non-significantly elevated (SMR=1.51). The SMR for leukemias was not elevated (SMR=1.14). Non-significantly elevated SMRs were found for the two categories, "lymphosarcoma and reticulosarcoma" (SMR=2.05), and "other neoplasms of lymphatic-hematopoietic tissue" (SMR=1.85). The SMR for non-Hodgkin's lymphomas (NHL) was calculated using the 99 cause of death categories from 1960-1997, in order to exclude the multiple myelomas from this category, as previously discussed.

The 10,385 person years in white females accumulated prior to 1960 are not included in the calculation of expected numbers of deaths in the NHL analysis. In order to assess the extent of underestimation of risk by excluding these person years, expected deaths and SMRs were compared for the combined groups of non-Hodgkin's lymphomas and multiple myelomas, using the 92 death categories and the 99 death categories. Results for the two comparisons are very similar: an SMR of 1.89 using 1944-1997 person years (full cohort), and an SMR of 1.95 using the 1960-1997 person years (reduced cohort), based on 6.88 and 6.67 expected deaths respectively, and 13 observed deaths in both cohorts. Thus, minimal bias is introduced in the exclusion of the pre-1960 person years.

There were ten non-Hodgkin's lymphomas deaths in white females, all of which occurred after 1960, so all of these deaths are included in the expanded cause of death analysis. Results from this analysis (not included in Table 13) show a significantly elevated SMR of 2.19 for white females based on 10 deaths (95% CI: 1.05-4.02). The three multiple myeloma deaths, all of which occurred after 1960, had a non-significant SMR of 1.43 (95% CI: .29-4.18).

Among non-cancer deaths, a significantly elevated SMR of 4.72 was found for "anemias of other and unspecified type" based on four deaths. A significantly elevated SMR of 5.27 was found for deaths from "acute glomerulonephritis nephrotic syndrome, and acute renal failure" also based on 4 deaths.

A significant deficit for all heart diseases combined was found (SMR=.80). Within the overall heart disease group, SMRs were low for each type of heart disease, but a significant deficit was found only for death from hypertension with heart disease (SMR=.15). Deaths from all respiratory diseases were also significantly low (SMR=.60), and within this grouping, a significant deficit was found for deaths from pneumoconiosis and other respiratory diseases (SMR=.38).

Table 12. Summary of observed deaths, expected deaths, and age and calendar adjusted Standardized Mortality Ratios (SMR), in Electrical Utility Company workers with two or more quarters employment, using standard U.S. death rates, 1944-1997, for 92 causes of death

Race = WHITE Gender = MALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
1	TUBERCULOSIS	0	1.0596	0.00	0.0000	3.4823
1	RESPIRATORY TUBERCULOSIS	0	0.9735	0.00	0.0000	3.7903
2	OTHER TUBERCULOSIS	0	0.0861	0.00	0.0000	42.8595
2	MN OF BUCCAL CAVITY AND PHARYNX	2	1.7249	1.16	0.1404	4.1860
3	MN OF LIP	0	0.0386	0.00	0.0000	95.6877
4	MN OF TONGUE	0	0.3986	0.00	0.0000	9.2570
5	MN OF OTHER PARTS OF BUCCAL CAVITY	0	0.4638	0.00	0.0000	7.9559
6	MN OF PHARYNX	2	0.8239	2.43	0.2939	8.7637
3	MN OF DIGESTIVE ORGANS AND PERITONEUM	23	17.0210	1.35	0.8562	2.0277
7	MN OF ESOPHAGUS	3	1.6896	1.78	0.3661	5.1916
8	MN OF STOMACH	6	2.6176	2.29	0.8370	4.9892
9	MN OF INTESTINE EXCEPT RECTUM	5	6.0107	0.83	0.2692	1.9436
10	MN OF RECTUM	3	1.5072	1.99	0.4104	5.8201
11	MN OF BILIARY PASSAGES, LIVER, AND GALL BLADDER	3	1.1216	2.67	0.5515	7.8210
12	MN OF LIVER NOT SPECIFIED	0	0.4676	0.00	0.0000	7.8914
13	MN OF PANCREAS	3	3.3354	0.90	0.1855	2.6299
14	MN OF PERITONEUM AND OTHER AND UNSPECIFIED OF DIGESTIVE ORGANS	0	0.2712	0.00	0.0000	13.6042
4	MN OF RESPIRATORY SYSTEM	33	24.2095	1.36	0.9381	1.9144
15	MN OF LARYNX	1	0.8722	1.15	0.0290	6.3697
16	MN OF TRACHEA, BRONCHUS, AND LUNG	32	23.0825	1.39	0.9481	1.9572
17	MN OF OTHER PARTS OF RESPIRATORY SYSTEM	0	0.2548	0.00	0.0000	14.4846
5	MN OF BREAST	0	0.0833	0.00	0.0000	44.3061
18	MN OF BREAST	0	0.0833	0.00	0.0000	44.3061
6	MN OF FEMALE GENITAL ORGANS	0	0.0000	0.00	0.0000	0.0000
19	MN OF CERVIX UTERI	0	0.0000	0.00	0.0000	0.0000
20	MN OF OTHER AND UNSPECIFIED PARTS OF UTERUS	0	0.0000	0.00	0.0000	0.0000
21	MN OF OVARY, FALLOPIAN TUBE, AND BROAD LIGAMENT	0	0.0000	0.00	0.0000	0.0000
22	MN OF OTHER FEMALE GENITAL ORGANS	0	0.0000	0.00	0.0000	0.0000
7	MN OF MALE GENITAL ORGANS	5	5.5180	0.91	0.2932	2.1171
23	MN OF PROSTATE	5	5.2168	0.96	0.3102	2.2394
24	MN OF OTHER MALE GENITAL ORGANS	0	0.3012	0.00	0.0000	12.2523

Table 12. Summary of observed deaths, expected deaths, and age and calendar adjusted Standardized Mortality Ratios (SMR), in Electrical Utility Company workers with two or more quarters employment, using standard U.S. death rates, 1944-1997, for 92 causes of death (continued)

Race = WHITE Gender = MALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
8	MN OF URINARY ORGANS	4	3.4438	1.16	0.3165	2.9706
25	MN OF KIDNEY	4	1.6827	2.38	0.6477	6.0794
26	MN OF BLADDER AND OTHER URINARY ORGANS	0	1.7611	0.00	0.0000	2.0953
9	MN OF OTHER AND UNSPECIFIED SITES	9	8.4520	1.06	0.4859	2.0215
27	MN OF SKIN	1	1.4481	0.69	0.0175	3.8365
28	MN OF EYE	0	0.0461	0.00	0.0000	80.1281
29	MN OF BRAIN AND OTHER PARTS OF NERVOUS SYSTEM	1	1.9120	0.52	0.0132	2.9056
30	MN OF THYROID GLAND	2	0.1182	16.91*	2.0477	61.0626
31	MN OF BONE	0	0.2153	0.00	0.0000	17.1413
32	MN OF CONNECTIVE TISSUE AND SOFT TISSUE	1	0.3371	2.97	0.0751	16.4822
33	MN OF OTHER AND UNSPECIFIED SITES (MINOR)	4	4.3753	0.91	0.2491	2.3382
10	NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE	4	6.3393	0.63	0.1719	1.6138
34	LYMPHOSARCOMA AND RETICULOSARCOMA	0	0.7908	0.00	0.0000	4.6661
35	HODGKIN'S DISEASE	0	0.5275	0.00	0.0000	6.9957
36	LEUKEMIA AND ALEUKEMIA	4	2.5425	1.57	0.4287	4.0236
37	OTHER NEOPLASMS OF LYMPHATIC HEMATOPOIETIC TISSUE	0	2.4785	0.00	0.0000	1.4888
11	BENIGN AND UNSPECIFIED NEOPLASMS	1	0.8322	1.20	0.0304	6.6757
38	BENIGN NEOPLASMS OF THE EYE, BRAIN, AND OTHER PARTS OF NERVOUS SYSTEM	0	0.1096	0.00	0.0000	33.6594
39	NEOPLASMS OF EYE, BRAIN, & OTHER PARTS OF NERV SYSTEM UNSPECIFIED	0	0.3643	0.00	0.0000	10.1295
40	OTHER BENIGN AND UNSPECIFIED NATURE NEOPLASMS	1	0.3583	2.79	0.0706	15.5055
12	DIABETES MELLITUS	0	4.6089	0.00*	0.0000	0.8006
41	DIABETES MELLITUS	0	4.6089	0.00*	0.0000	0.8006
13	DISEASES OF THE BLOOD AND BLOOD FORMING ORGANS	0	0.8268	0.00	0.0000	4.4627
42	PERNICIOUS ANEMIAS	0	0.0288	0.00	0.0000	128.0419
43	ANEMIAS OF OTHER AND UNSPECIFIED TYPE	0	0.2939	0.00	0.0000	12.5543
44	COAGULATION DEFECTS, PURPURA, AND OTHER HEMORRHAGIC CONDITIONS	0	0.1862	0.00	0.0000	19.8176
45	ALL OTHER DISEASES OF BLOOD FORMING ORGANS	0	0.3179	0.00	0.0000	11.6072
14	MENTAL, PSYCHONEUROTIC, AND PERSONALITY DISORDERS	1	2.1406	0.47	0.0118	2.5953
46	ALCOHOLISM	0	1.0811	0.00	0.0000	3.4132
47	OTHER MENTAL DISORDERS	1	1.0595	0.94	0.0239	5.2435

Table 12. Summary of observed, expected deaths, and age and calendar adjusted Standardized Mortality Ratios (SMR),in Electrical Utility Company workers with two or more quarters employment, using standard U.S. death rates, 1944-1997, for 92 causes of death (continued)

Race = WHITE Gender = MALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
15	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	3	3.4252	0.88	0.1806	2.5610
48	MULTIPLE SCLEROSIS	0	0.2735	0.00	0.0000	13.4930
49	OTHER DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	3	3.1518	0.95	0.1963	2.7832
16	DISEASES OF THE HEART	120	107.4022	1.12	0.9263	1.3360
50	RHEUMATIC HEART DISEASE, INCLUDING FEVER	0	1.7113	0.00	0.0000	2.1563
51	ISCHEMIC HEART DISEASE	101	86.1023	1.17	0.9554	1.4253
52	CHRONIC DISEASE OF ENDOCARDIUM	0	0.9804	0.00	0.0000	3.7639
53	OTHER MYOCARDIAL DEGENERATION	2	1.3084	1.53	0.1851	5.5183
54	HYPERTENSION WITH HEART DISEASE	3	2.8856	1.04	0.2144	3.0399
55	OTHER DISEASES OF THE HEART	14	14.4143	0.97	0.5305	1.6297
17	OTHER DISEASES OF CIRCULATORY SYSTEM	28	24.3489	1.15	0.7640	1.6621
56	HYPERTENSION WITHOUT HEART DISEASE	0	0.8804	0.00	0.0000	4.1913
57	CEREBROVASCULAR DISEASE	18	16.0474	1.12	0.6644	1.7728
58	DISEASES OF THE ARTERIES, VEINS, AND PULMONARY CIRCULATION	10	7.4212	1.35	0.6451	2.4783
18	DISEASES OF THE RESPIRATORY SYSTEM	15	19.7985	0.76	0.4237	1.2497
59	ACUTE RESPIRATORY INFECTIONS EXCEPT INFLUENZA AND PNEUMONIA	0	0.0991	0.00	0.0000	37.2283
60	INFLUENZA	1	0.2514	3.98	0.1006	22.1004
61	PNEUMONIA (EXCEPT NEWBORN)	4	6.4963	0.62	0.1678	1.5748
62	CHRONIC AND UNSPECIFIED BRONCHITIS	1	0.6566	1.52	0.0385	8.4606
63	EMPHYSEMA	3	3.1913	0.94	0.1938	2.7487
64	ASTHMA	0	0.4743	0.00	0.0000	7.7805
65	PNEUMOCONIOSES AND OTHER RESPIRATORY DISEASES	6	8.6295	0.70	0.2539	1.5134
19	DISEASES OF THE DIGESTIVE SYSTEM	18	12.6885	1.42	0.8403	2.2421
66	DISEASES OF THE STOMACH AND DUODENUM	2	1.5079	1.33	0.1606	4.7882
67	HERNIA AND INTESTINAL OBSTRUCTION	0	0.6132	0.00	0.0000	6.0175
68	CIRRHOSIS OF THE LIVER	12	6.5354	1.84	0.9477	3.2076
69	OTHER DISEASES OF DIGESTIVE SYSTEM	4	4.0319	0.99	0.2703	2.5373
20	DISEASES OF THE GENITO-URINARY SYSTEM	1	3.7511	0.27	0.0067	1.4810
70	ACUTE GLOMERULONEPHRITIS, NEPHROTIC SYNDROME, & ACUTE RENAL FAILURE	0	0.3290	0.00	0.0000	11.2159
71	CHRONIC & UNSPEC. NEPHRITIS, RENAL FAILURE, & OTHER RENAL SCLEROSIS	1	1.7289	0.58	0.0146	3.2133
72	INFECTION OF KIDNEY	0	0.3541	0.00	0.0000	10.4212
73	CALCULI OF URINARY SYSTEM	0	0.0864	0.00	0.0000	42.7292
74	HYPERPLASIA OF PROSTATE	0	0.2820	0.00	0.0000	13.0864
75	OTHER DISEASES OF MALE GENITAL ORGANS	0	0.0779	0.00	0.0000	47.3546
76	DISEASES OF THE BREAST	0	0.0002	0.00	0.0000	15793.0977
77	DISEASES OF THE FEMALE GENITAL ORGANS	0	0.0000	0.00	0.0000	1290856.1250
78	OTHER GENITO-URINARY SYSTEM DISEASES	0	0.8926	0.00	0.0000	4.1339

Table 12. Summary of observed, expected deaths, and age and calendar adjusted Standardized Mortality Ratios (SMR),in Electrical Utility Company workers with two or more quarters employment, using standard U.S. death rates, 1944-1997, for 92 causes of death (continued)

Race = WHITE Gender = MALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
21	DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE	1	0.2146	4.66	0.1179	25.8922
79	INFECTIONS OF THE SKIN AND SUBCUTANEOUS TISSUE	0	0.0700	0.00	0.0000	52.7420
80	OTHER DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE	1	0.1446	6.92	0.1749	38.4196
22	DISEASES OF THE MUSCULOSKELETAL SYSTEM AND CONNECTIVE TISSUE	1	0.5212	1.92	0.0485	10.6584
81	ARTHRITIS AND SPONDYLITIS	0	0.2142	0.00	0.0000	17.2288
82	OSTEOMYELITIS AND PERIOSTITIS	0	0.0397	0.00	0.0000	93.0500
83	OTHER DISEASES OF MS SYSTEM	1	0.2674	3.74	0.0946	20.7757
23	SYMPTOMS AND ILL-DEFINED CONDITIONS	0	2.7984	0.00	0.0000	1.3186
84	SYMPTOMS AND ILL-DEFINED CONDITIONS	0	2.7984	0.00	0.0000	1.3186
24	ACCIDENTS	16	17.9356	0.89	0.5096	1.4488
85	TRANSPORTATION ACCIDENTS	9	10.2295	0.88	0.4015	1.6703
86	ACCIDENTAL POISONING	0	0.8441	0.00	0.0000	4.3716
87	ACCIDENTAL FALLS	2	1.9086	1.05	0.1269	3.7830
88	OTHER ACCIDENTS	5	4.6147	1.08	0.3506	2.5315
89	MEDICAL COMPLICATIONS AND MISADVENTURE	0	0.3387	0.00	0.0000	10.8952
25	VIOLENCE	12	8.6355	1.39	0.7172	2.4275
90	SUICIDE	10	6.4595	1.55	0.7411	2.8472
91	HOMICIDE	2	2.1760	0.92	0.1113	3.3181
26	OTHER CAUSES	7	5.6127	1.25	0.4996	2.5698
92	OTHER CAUSES	7	5.6127	1.25	0.4996	2.5698
	All Cancers	80	66.7917	1.20	0.9497	1.4907
	All Deaths	304	283.3922	1.07	0.9555	1.2003

+ ICD codes corresponding to category numbers are in Appendix B
----- Value too large
* Two-Sided P < 0.05
** Two-Sided P < 0.01

Table 13. Summary of observed, expected deaths, and age and calendar year adjusted Standardized Mortality Ratios (SMR), in Electrical Utility Company workers with two or more quarters employment, using standard U.S. death rates, 1944-1997, for 92 causes of death

Race = WHITE Gender = FEMALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
1	TUBERCULOSIS	0	1.4378	0.00	0.0000	2.5664
1	RESPIRATORY TUBERCULOSIS	0	1.2851	0.00	0.0000	2.8714
2	OTHER TUBERCULOSIS	0	0.1527	0.00	0.0000	24.1620
2	MN OF BUCCAL CAVITY AND PHARYNX	0	1.7323	0.00	0.0000	2.1301
3	MN OF LIP	0	0.0116	0.00	0.0000	317.2580
4	MN OF TONGUE	0	0.4052	0.00	0.0000	9.1074
5	MN OF OTHER PARTS OF BUCCAL CAVITY	0	0.5808	0.00	0.0000	6.3538
6	MN OF PHARYNX	0	0.7348	0.00	0.0000	5.0220
3	MN OF DIGESTIVE ORGANS AND PERITONEUM	42	32.8351	1.28	0.9218	1.7291
7	MN OF ESOPHAGUS	1	1.2580	0.79	0.0201	4.4162
8	MN OF STOMACH	6	3.4897	1.72	0.6278	3.7424
9	MN OF INTESTINE EXCEPT RECTUM	20	14.4860	1.38	0.8430	2.1324
10	MN OF RECTUM	3	2.6702	1.12	0.2317	3.2851
11	MN OF BILIARY PASSAGES, LIVER, AND GALL BLADDER	5	2.6045	1.92	0.6213	4.4854
12	MN OF LIVER NOT SPECIFIED	0	0.8551	0.00	0.0000	4.3155
13	MN OF PANCREAS	5	6.8033	0.73	0.2378	1.7171
14	MN OF PERITONEUM AND OTHER AND UNSPECIFIED OF DIGESTIVE ORGANS	2	0.6683	2.99	0.3623	10.8039
4	MN OF RESPIRATORY SYSTEM	21	25.0424	0.84	0.5189	1.2819
15	MN OF LARYNX	0	0.4384	0.00	0.0000	8.4166
16	MN OF TRACHEA, BRONCHUS, AND LUNG	19	24.3073	0.78	0.4704	1.2207
17	MN OF OTHER PARTS OF RESPIRATORY SYSTEM	2	0.2967	6.74	0.8161	24.3366
5	MN OF BREAST	37	27.0183	1.37	0.9641	1.8877
18	MN OF BREAST	37	27.0183	1.37	0.9641	1.8877
6	MN OF FEMALE GENITAL ORGANS	12	17.8153	0.67	0.3476	1.1767
19	MN OF CERVIX UTERI	5	3.9499	1.27	0.4097	2.9576
20	MN OF OTHER AND UNSPECIFIED PARTS OF UTERUS	3	4.3449	0.69	0.1424	2.0189
21	MN OF OVARY, FALLOPIAN TUBE, AND BROAD LIGAMENT	4	8.9277	0.45	0.1221	1.1459
22	MN OF OTHER FEMALE GENITAL ORGANS	0	0.5928	0.00	0.0000	6.2243
7	MN OF MALE GENITAL ORGANS	0	0.0000	0.00	0.0000	149944.4375
23	MN OF PROSTATE	0	0.0000	0.00	0.0000	0.0000
24	MN OF OTHER MALE GENITAL ORGANS	0	0.0000	0.00	0.0000	149944.4375

Table 13. Summary of observed, expected deaths, and age and calendar year adjusted Standardized Mortality Ratios (SMR),in Electrical Utility Company workers with two or more quarters employment, using standard U.S death rates, 1944-1997, for 92 causes of death (continued)

Race = WHITE Gender = FEMALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
8	MN OF URINARY ORGANS	5	3.9656	1.26	0.4080	2.9459
25	MN OF KIDNEY	4	2.2083	1.81	0.4936	4.6327
26	MN OF BLADDER AND OTHER URINARY ORGANS	1	1.7574	0.57	0.0144	3.1613
9	MN OF OTHER AND UNSPECIFIED SITES	17	15.7937	1.08	0.6267	1.7235
27	MN OF SKIN	2	1.7707	1.13	0.1367	4.0776
28	MN OF EYE	0	0.1002	0.00	0.0000	36.8309
29	MN OF BRAIN AND OTHER PARTS OF NERVOUS SYSTEM	3	3.2495	0.92	0.1904	2.6994
30	MN OF THYROID GLAND	0	0.4120	0.00	0.0000	8.9558
31	MN OF BONE	2	0.3283	6.09	0.7375	21.9917
32	MN OF CONNECTIVE TISSUE AND SOFT TISSUE	1	0.7124	1.40	0.0355	7.7987
33	MN OF OTHER AND UNSPECIFIED SITES (MINOR)	9	9.2206	0.98	0.4454	1.8530
10	NEOPLASMS OF LYMPHATIC AND HEMATOPOIETIC TISSUE	18	11.9296	1.51	0.8938	2.3848
34	LYMPHOSARCOMA AND RETICULOSARCOMA	3	1.4632	2.05	0.4227	5.9950
35	HODGKIN'S DISEASE	0	0.6611	0.00	0.0000	5.5816
36	LEUKEMIA AND ALEUKEMIA	5	4.3916	1.14	0.3685	2.6601
37	OTHER NEOPLASMS OF LYMPHATIC HEMATOPOIETIC TISSUE	10	5.4137	1.85	0.8843	3.3972
11	BENIGN AND UNSPECIFIED NEOPLASMS	0	2.2771	0.00	0.0000	1.6205
38	BENIGN NEOPLASMS OF THE EYE, BRAIN, AND OTHER PARTS OF NERVOUS SY	0	0.4336	0.00	0.0000	8.5104
39	NEOPLASMS OF EYE, BRAIN, & OTHER PARTS OF NERV SYSTEM UNSPECIF. N	0	0.8239	0.00	0.0000	4.4787
40	OTHER BENIGN AND UNSPECIFIED NATURE NEOPLASMS	0	1.0196	0.00	0.0000	3.6190
12	DIABETES MELLITUS	13	12.6884	1.02	0.5450	1.7521
41	DIABETES MELLITUS	13	12.6884	1.02	0.5450	1.7521
13	DISEASES OF THE BLOOD AND BLOOD FORMING ORGANS	5	1.9964	2.50	0.8105	5.8516
42	PERNICIOUS ANEMIAS	1	0.0733	13.65	0.3453	75.8350
43	ANEMIAS OF OTHER AND UNSPECIFIED TYPE	4	0.8481	4.72*	1.2851	12.0622
44	COAGULATION DEFECTS, PURPURA, AND OTHER HEMORRHAGIC CONDITIONS	0	0.4627	0.00	0.0000	7.9752
45	ALL OTHER DISEASES OF BLOOD FORMING ORGANS	0	0.6123	0.00	0.0000	6.0261
14	MENTAL, PSYCHONEUROTIC, AND PERSONALITY DISORDERS	4	4.3682	0.92	0.2495	2.3420
46	ALCOHOLISM	0	0.6079	0.00	0.0000	6.0704
47	OTHER MENTAL DISORDERS	4	3.7603	1.06	0.2898	2.7206

Table 13. Summary of observed, expected deaths, and age and calendar year adjusted Standardized Mortality Ratios (SMR),in Electrical Utility Company workers with two or more quarters employment, using standard U.S death rates, 1944-1997, for 92 causes of death (continued)

Race = WHITE Gender = FEMALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
15	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	9	8.4053	1.07	0.4886	2.0328
48	MULTIPLE SCLEROSIS	1	0.8728	1.15	0.0290	6.3652
49	OTHER DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	8	7.5325	1.06	0.4573	2.0928
16	DISEASES OF THE HEART	136	169.3096	0.80*	0.6739	0.9502
50	RHEUMATIC HEART DISEASE, INCLUDING FEVER	3	5.3908	0.56	0.1147	1.6272
51	ISCHEMIC HEART DISEASE	110	122.2371	0.90	0.7396	1.0846
52	CHRONIC DISEASE OF ENDOCARDIUM	1	2.6135	0.38	0.0097	2.1258
53	OTHER MYOCARDIAL DEGENERATION	0	1.4147	0.00	0.0000	2.6084
54	HYPERTENSION WITH HEART DISEASE	1	6.6367	0.15*	0.0038	0.8371
55	OTHER DISEASES OF THE HEART	21	31.0168	0.68	0.4189	1.0350
17	OTHER DISEASES OF CIRCULATORY SYSTEM	55	59.8751	0.92	0.6920	1.1957
56	HYPERTENSION WITHOUT HEART DISEASE	2	2.1812	0.92	0.1110	3.3101
57	CEREBROVASCULAR DISEASE	34	43.5919	0.78	0.5401	1.0900
58	DISEASES OF THE ARTERIES, VEINS, AND PULMONARY CIRCULATION	19	14.1020	1.35	0.8108	2.1041
18	DISEASES OF THE RESPIRATORY SYSTEM	22	36.7269	0.60*	0.3753	0.9070
59	ACUTE RESPIRATORY INFECTIONS EXCEPT INFLUENZA AND PNEUMONIA	1	0.2190	4.57	0.1155	25.3664
60	INFLUENZA	1	0.6092	1.64	0.0415	9.1200
61	PNEUMONIA (EXCEPT NEWBORN)	9	14.3305	0.63	0.2866	1.1923
62	CHRONIC AND UNSPECIFIED BRONCHITIS	1	0.9753	1.03	0.0259	5.6964
63	EMPHYSEMA	4	3.5923	1.11	0.3034	2.8478
64	ASTHMA	0	1.3418	0.00	0.0000	2.7500
65	PNEUMOCONIOSES AND OTHER RESPIRATORY DISEASES	6	15.6590	0.38*	0.1399	0.8340
19	DISEASES OF THE DIGESTIVE SYSTEM	21	21.3545	0.98	0.6085	1.5033
66	DISEASES OF THE STOMACH AND DUODENUM	2	2.0884	0.96	0.1159	3.4572
67	HERNIA AND INTESTINAL OBSTRUCTION	1	1.9408	0.52	0.0130	2.8625
68	CIRRHOSIS OF THE LIVER	6	7.6228	0.79	0.2874	1.7133
69	OTHER DISEASES OF DIGESTIVE SYSTEM	12	9.7024	1.24	0.6383	2.1606
20	DISEASES OF THE GENITO-URINARY SYSTEM	10	9.0106	1.11	0.5313	2.0411
70	ACUTE GLOMERULONEPHRITIS, NEPHROTIC SYNDROME, & ACUTE RENAL FAILURE	4	0.7583	5.27*	1.4373	13.4908
71	CHRONIC & UNSPEC. NEPHRITIS, RENAL FAILURE, & OTHER RENAL SCLEROSIS	2	3.7622	0.53	0.0644	1.9192
72	INFECTION OF KIDNEY	0	1.0359	0.00	0.0000	3.5622
73	CALCULI OF URINARY SYSTEM	0	0.1995	0.00	0.0000	18.4958
74	HYPERPLASIA OF PROSTATE	0	0.0000	0.00	0.0000	0.0000
75	OTHER DISEASES OF MALE GENITAL ORGANS	0	0.0000	0.00	0.0000	0.0000
76	DISEASES OF THE BREAST	0	0.0161	0.00	0.0000	228.5880
77	DISEASES OF THE FEMALE GENITAL ORGANS	0	0.3136	0.00	0.0000	11.7682
78	OTHER GENITO-URINARY SYSTEM DISEASES	4	2.9251	1.37	0.3726	3.4974

Table 13. Summary of observed, expected deaths, and age and calendar year adjusted Standardized Mortality Ratios (SMR),in Electrical Utility Company workers with two or more quarters employment, using standard U.S death rates, 1944-1997, for 92 causes of death

(continued)

Race = WHITE Gender = FEMALE

Category Number+	Cause	Observed Deaths	Expected Deaths	Ratio	95% Confidence Limits Lower	Upper
21	DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE	0	0.8128	0.00	0.0000	4.5397
79	INFECTIONS OF THE SKIN AND SUBCUTANEOUS TISSUE	0	0.1829	0.00	0.0000	20.1759
80	OTHER DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE	0	0.6299	0.00	0.0000	5.8576
22	DISEASES OF THE MUSCULOSKELETAL SYSTEM AND CONNECTIVE TISSUE	2	2.3818	0.84	0.1017	3.0314
81	ARTHRITIS AND SPONDYLITIS	1	1.0060	0.99	0.0251	5.5224
82	OSTEOMYELITIS AND PERIOSTITIS	0	0.0880	0.00	0.0000	41.9099
83	OTHER DISEASES OF MS SYSTEM	1	1.2877	0.78	0.0196	4.3142
23	SYMPTOMS AND ILL-DEFINED CONDITIONS	4	3.9492	1.01	0.2760	2.5905
84	SYMPTOMS AND ILL-DEFINED CONDITIONS	4	3.9492	1.01	0.2760	2.5905
24	ACCIDENTS	14	13.4323	1.04	0.5693	1.7489
85	TRANSPORTATION ACCIDENTS	8	6.1011	1.31	0.5646	2.5838
86	ACCIDENTAL POISONING	0	0.7667	0.00	0.0000	4.8126
87	ACCIDENTAL FALLS	1	3.0112	0.33	0.0084	1.8450
88	OTHER ACCIDENTS	5	2.7833	1.80	0.5814	4.1973
89	MEDICAL COMPLICATIONS AND MISADVENTURE	0	0.7700	0.00	0.0000	4.7924
25	VIOLENCE	3	5.3764	0.56	0.1151	1.6316
90	SUICIDE	3	4.2679	0.70	0.1449	2.0553
91	HOMICIDE	0	1.1085	0.00	0.0000	3.3289
26	OTHER CAUSES	14	11.0356	1.27	0.6930	2.1287
92	OTHER CAUSES	14	11.0356	1.27	0.6930	2.1287
	All Cancers	152	136.1324	1.12	0.9461	1.3089
	All Deaths	464	500.5706	0.93	0.8445	1.0153

+ ICD codes corresponding to category numbers are in Appendix B
----- Value too large
* Two-Sided P < 0.05
** Two-Sided P < 0.01

Results By Length and Calendar Years of Employment and Latency

The causes of death included in these analyses include those with elevated SMRs in the overall analysis, or who had elevated SMRs in the subgroup analyses by calendar years worked and length of employment, based on two or more total deaths.

Stomach Cancer

In white males, the highest SMRs were found in men with ten or more years of employment (SMR=3.91) and 1-4 years of employment (SMR=2.57), neither significantly elevated (Table 14). In women, all of the stomach cancer deaths occurred in those with one to four years employment, with a significant SMR in this group of 4.29. When 20 or more years latency was taken into account, males had significantly elevated SMRs regardless of employment, but the highest SMR of 6.03 was found in men with 10 or more years employment and 20 or more years latency (Table 15). In women, a non-significant SMR of 2.20 was found in women with one or more years employment and 20 or more years latency (95% CI: 1.0-12.9).

In males, no pattern emerged according to calendar year of employment (Table 16). SMRs for men who worked before 1951 had the highest SMRs, but none were significant. The number of deaths in each of the calendar year groups is small, however. In females, three of four deaths from stomach cancer occurred in women who only worked after 1951, with a significant fivefold SMR in this period for women with one or more years of employment. A separate analysis was done for women who worked only after 1951, and with a 20 year latency period. Results from this analysis show a significant SMR of 5.26 based on 3 deaths (95% CI: .99-12.91). Thus, in men, the highest SMRs were found in those with 10 or more years of EUC employment, regardless of calendar year worked, while women who worked after 1951 had the highest SMRs, none of whom worked more than 5 years.

Table 14. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for stomach cancer for white males and white females, according to years worked at EUC

	White Males			White Females		
Years Worked	Observed	SMR	95% Confidence Interval	Observed	SMR	95% Confidence Interval
2-3 quarters	1	1.52	.04-8.46	0	0	0-3.54
1-4 years	2	2.57	.31-9.27	6	4.29[1]	1.57-9.35
5-9 years	0	0	0-8.91	0	0	0-13.89
>= 10 years	3	3.91	.81-11.42	0	0	0-4.70
Total[2]	6	2.29	.84-4.99	6	1.72	.63-3.74

1. $p < .01$
2. Total includes workers with two or more quarters worked.

Table 15. Stomach cancer observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for workers with 20 or more years latency[1], by years worked

	White Males			White Females		
Years Worked	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Two quarters or more	6	3.70[2]	1.33-7.25	4	1.52	.40-3.38
One year or more	5	4.31[3]	1.36-8.92	4	2.20	.57-4.87
10 years or more	3	6.03[3]	1.14-14.78	0	0	0-1.22

1.Latency defined as year of death or end of study period minus year first employed.
2. $p < .01$
3. $p < .05$

Table 16. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95 percent confidence intervals for stomach cancer in white males and females by length and calendar year of employment

	White Males			White Females		
	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Only worked 1951 and earlier	3	4.41	.91-12.90	1	.62	.02-3.44
Number of years worked						
2-3 quarters	1	3.06	.08-16.97	0	0	0-4.99
One year or more	2	5.67	.69-20.47	1	1.14	.03-6.34
Employed before and after 1951	1	1.11	.03-6.17	2	1.98	.24-7.14
Number of years worked[1]						
One year or more	1	1.13	.03-6.27	2	2.00	.24-7.23
Only employed 1952 and later	2	1.93	.23-6.97	3	3.48	.72-10.16
Number of years worked						
2-3 quarters	0	0	0-11.76	0	0	0-12.74
One year or more	2	2.77	.33-9.99	3	5.23[2]	1.08-15.29

1. Only ten workers employed in this time period who worked only 2-3 quarters.
2.$p< .05$

Liver, Gallbladder, Biliary Tract Cancers

The standard mortality rates used to generate the expected deaths do not separate primary liver cancer from cancer of the biliary tract and gallbladder. The grouped code includes primary liver cancer, and cancer of the biliary tract and gallbladder (hereafter referred to as liver/biliary).

In white males, a non-significant SMR of 2.67 was found in all workers (Table 17). Non-significant SMRs were found for males with 1-4 and with 5-9 years of employment. In women, four of the five deaths occurred in those with ten or more years employment. Females in this subgroup had a significantly elevated SMR of 7.16. These four deaths included two gallbladder cancers, one primary liver cancer, and one cholangiocarcinoma. A further breakdown of the females with ten or more years employment shows an elevated SMR of 6.47 for the 10-19 years employment group (95% CI .78-23.36), and an SMR of 8.02 in the group with 20 or more years EUC employment (95% CI=.97-28.96), based on two deaths in each group.

The three male liver cancer deaths all occurred 20 or more years after first EUC employment. When 20 years or more latency was taken into account, white males had a significantly elevated five-fold SMR in those with one or more years of EUC employment (Table 18). Each of the three deaths occurred in different calendar years of employment, and limits any further analysis of this variable (Table 19).

The four female deaths in the ten or more years employment group all occurred after 20 years latency. The female SMR for 20 years latency and ten or more years employment is significant at 9.11 (Table 18). These four deaths also occurred in women who worked both before and after 1951, with a significant SMR of 5.6 (Table 19). Each of these four deaths occurred in females who were initially employed in 1944, and so were potentially exposed to chlorinated naphthalenes for eight years or more. A separate analyses was conducted of workers with five or more years of employment between 1944 and 1951. The liver/biliary SMR in this subgroup of females (based on four deaths) was 10.8 (95% CI: 2.9-27.6, $p<.01$). A detailed description of the liver/biliary/gallbladder deaths is included in Table 20.

Table 17. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for primary liver, gallbladder, and biliary tract cancer for white males and white females, according to years worked at EUC

	White Males			White Females		
Years Worked	Observed	SMR	95% Confidence Interval	Observed	SMR	95% Confidence Interval
2-3 quarters	0	0	0-12.11	1	1.26	.03-6.98
1-4 years	2	5.73	.69-20.69	0	0	0-3.53
5-9 years	1	6.41	.16-35.61	0	0	0-18.05
>= 10 years	0	0	0-11.83	4	7.16[1]	1.95-18.32
Total[2]	3	2.67	.55-7.82	5	1.92	.62-4.49

1. p< .01
2. Total includes workers with two or more quarters worked

Table 18. Primary liver, gallbladder, and biliary tract cancer observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for workers with 20 or more years latency[1], by years worked

	White Males			White Females		
Years Worked	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Two quarters or more	3	3.62	.68-8.87	4	1.89	.49-4.19
One year or more	3	5.13[2]	.97-12.58	4	2.75	.72-6.12
10 years or more	0	0	0-11.83	4	9.11[3]	2.37-20.23

1.Latency defined as year of death or end of study period minus year first employed.
2. p < .05
3. p < .01

Table 19. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for primary liver, gallbladder, and biliary tract cancer, according to length and calendar year of employment for white males and females

	White Males			White Females		
	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Only worked 1951 and earlier	1	3.65	.09-20.27	1	.85	.02-4.70
Number of years worked						
2-3 quarters	0	0	0-26.00	1	1.81	.05-10.03
One year or more	1	7.57	.19-42.03	0	0	0-5.87
Employed before and after 1951	1	2.95	.07-16.39	4	5.49[1]	1.50-14.05
Number of years worked[2]						
One year or more	1	3.00	.08-16.65	4	5.56[1]	1.52-14.23
Only employed 1952 and later	1	1.97	.05-10.92	0	0	0-5.32
Number of years worked						
2-3 quarters	0	0	0-23.41	0	0	0-15.85
One year or more	1	2.85	.07-15.83	0	0	0-8.01

1. P< .05
2. Only ten workers employed in this time period who worked only 2-3 quarters.

Table 20. Work history, gender and cause of death for primary liver, gall bladder, and biliary tract cancer deaths

				Cause of Death	
Gender	Year first Employed	Length of Employment	Year of Death	Ninth ICD Revision Code	Death Certificate Description
Male	1944	5 years	1976	155.0	Primary carcinoma of liver
Male	1969	1 ½ years	1992	155.1	Cholangiocarcinoma
Male	1944	1 3/4 years	1991	156.2	Ampullary carcinoma
Female	1944	23 years	1988	155.0	Liver cancer
Female	1944	25 years	1995	155.1	Metastatic cholangiocarcinoma
Female	1946	2 quarters	1952	156.0	Carcinoma of gallbladder with liver metastasis
Female	1944	13 years	1968	156.0	Cancer of gallbladder
Female	1944	20 years	1980	156.0	Metastatic cancer from gallbladder

Female Breast Cancer

The overall SMR for breast cancer was not significantly elevated in females, but a significant SMR of 1.8 was found in women who worked 2-3 quarters only (Table 21). Among women with ten or more years employment, the SMR was less than one. When 20 or more years latency were taken into account, the SMR for women with two or more quarters employment was significantly elevated, but in women with more than one year employment, the SMR was no longer significant. (Table 22).

Results according to calendar years worked show elevated SMRs for women only employed before 1952, with a non-significant SMR of 1.82 for women with one or more year of employment in this time period (Table 23). A separate analysis of 20 years latency was conducted in these women. Results show a significant SMR of 2.04 in women with two or more quarters worked, and a non-significant SMR of 1.80 in women with one or more years of employment (Table 24).

Table 21. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for female breast cancer, by length of employment

Length employment	Observed Deaths	SMR	95% Confidence Interval
2-3 quarters	16	1.81[1]	1.03-2.94
1-4 years	17	1.53	.89-2.45
5-10 years	0	0	0-1.70
10 + years	4	.82	.22-2.09
Total[2]	37	1.37	.96-1.89

1.p < .05
2.Total includes workers with two more quarters worked.

Table 22. Cancer of the breast observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals in white females with 20 or more years latency, by years worked

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Two or more quarters	31	1.52[2]	1.03-2.11
One year or more	17	1.25	.73-1.91
10 years or more	3	.85	.16-2.08

1.Latency defined as year of death or end of study period minus year first employed.
2. p < .05

Table 23. Observed deaths, SMRs, 95 percent confidence intervals for cancer of the breast in white females by length and calendar year of employment

	Observed	SMR	95% Confidence Interval
Only worked 1951 and earlier	22	1.86[1]	1.17-2.82
Number of years worked			
2-3 quarters	11	1.91	.95-3.41
One year or more	11	1.82	.91-3.26
Employed before and after 1951	5	.73	.24-1.71
Number of years worked[2]			
One year or more	5	.74	.24-1.74
Only employed 1952 and later	10	1.20	.57-2.20
Number of years worked			
2-3 quarters one year	5	1.70	.55-3.96
One year or more	5	92	.30-2.16

1. p< .05.
2. Only ten workers employed in this time period who worked only 2-3 quarters.

Table 24. Cancer of the breast observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals in white females with 20 or more years latency[1], and EUC employment restricted to calendar years 1944-1951, by years worked

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Two or more quarters	20	2.04[2]	1.25-3.03
One year or more	9	1.80	.81-3.16

1. Latency defined as year of death or end of study period minus year first employed.
2. p < .05

Cancer of the Kidney

A non-significant excess of kidney cancer was found in both males (SMR=2.38) and females (SMR=1.81), based on 4 deaths in each sex (Table 25). Although based on small numbers, the SMRs in males increase with length of employment. Three of the four female deaths occurred in women with only two to three quarters of employment.

All of the kidney cancer deaths occurred 20 or more years after first employment, and SMRs were non-significantly elevated in males and females in this latency group (Table 26). Since half of the deaths occurred in workers employed only before 1952, SMRs were calculated for 20 or more years latency in workers only employed in this time period (Table 26). Results show elevated but not significant SMRs in males (SMR=5.88) and females (SMR=2.28), based on two deaths in each group.

A significantly elevated SMR of 10.99 was found for males employed before 1952 and who worked one or more years (Table 27). Females who worked before 1952 had a non-significantly elevated SMR of 4.21 in those who worked 2-3 quarters. Only one death each in males and females occurred in each of the other two time periods.

Due to the similarity in SMRs for males and females, an SMR was calculated for males and females combined (adjusted for gender), by latency, calendar year of employment and years worked. A significantly elevated SMR of 2.56 was found for the 20 years latency group with two or more quarters of employment (Table 28). In workers employed before 1952 only, the SMR for this subgroup was 3.28 (not significant), based on 4 deaths.

Table 25. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for kidney cancer for white males and white females, according to years worked at EUC

	White Males			**White Females**		
Years Worked	Observed	SMR	95% Confidence Interval	Observed	SMR	95% Confidence Interval
2-3 quarters	1	2.07	.05-11.48	3	4.24	.87-12.41
1-4 years	2	3.72	.45-13.44	0	0	0-4.11
5-9 years	1	4.63	.12-25.74	1	5.60	.14-31.12
>= 10 years	0	0	0-8.28	0	0	0-8.67
Total[1]	4	2.38	.65-6.08	4	1.81	.49-4.63

1. Total includes workers with two or more quarters worked

Table 26. Cancer of the kidney observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for workers with 20 or more years latency[1], by years worked

	White Males			White Females		
Years Worked[2]	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Two quarters or more	4	3.17	.82-7.03	4	2.15	.56-4.77
One year or more	3	3.43	.65-8.41	1	.79	0-3.12
Worked before 1952 only						
Two quarters or more	2	5.88	.55-16.85	2	2.28	.21-6.52

1. Latency defined as year of death or end of study period minus year first employed.
2. No deaths from this cause in workers with ten or more years employment and 20 or more years latency.

Table 27. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for cancer of the kidney, according to length and calendar year of employment for white males and females

	White Males			White Females		
	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Only worked 1951 and earlier	2	5.06	.61-18.28	2	2.05	.25-7.40
Number of years worked						
2-3 quarters	0	0	0-17.33	2	4.21	.51-15.20
One year or more	2	10.99[1]	1.33-39.68	0	0	
Employed before and after 1951	1	2.11	.05-11.73	1	1.73	.04-9.60
Number of years worked[2]						
One year or more	1	2.14	.05-11.91	0	0	0-6.48
Only employed 1952 and later	1	1.23	.03-6.82	1	1.53	.04-8.49
Number of years worked						
2-3 quarters	1	3.80	.10-21.08	0	0	0-16.58
One year or more	0	0	0-6.70	1	2.32	.06-12.86

1.p< .05
2. Only ten workers employed in this time period who worked only 2-3 quarters.

Table 28. Cancer of the kidney observed deaths, males and females combined, gender, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for workers with 20 or more years latency[1,] by years worked and calendar years worked

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Two quarters or more	8	2.56[2]	1.09-4.64
One year or more	4	1.87	.49-4.16
Worked before 1952 only			
Two quarters or more	4	3.28	.85-7.29

1. Latency defined as year of death or end of study period minus year first employed.
2. p<.05

Non-Hodgkin's Lymphoma

The SMR analysis of non-Hodgkin's lymphomas (NHL) analysis only includes person years accumulated since 1960, as previously discussed. However, the subgroups created according to length of employment, calendar year of employment, and latency, were based on the actual work history since 1944. Thus, the work history subgroups are defined by complete work histories, but the SMRs are only based on person years accumulated since 1960.

There were ten non-Hodgkin's lymphoma deaths in women, all of which occurred after 1960. Five of the NHL deaths occurred in females with 2-3 quarters of employment (Table 29). A significantly elevated SMR of 3.37 was found in these short term workers. In women with one to four years employment, a non-significantly elevated SMR of 2.16 was found. When 20 or more years latency was taken into account, a non-significant SMR of 1.8 was found in women with two or more quarters worked (Table 30). In women with one or more years employment and 20 or more years latency, the SMR was .98.

Six of the ten NHL deaths occurred in women who worked only before 1952. A significantly elevated SMR of 3.00 was found in this subgroup (Table 31). Only two deaths in this subgroup occurred in women with one or more years employment, who had a non-significant SMR of 2.0. Among women who only worked after 1951, a non-significant SMR of 2.2 was found in women with one or more years employment.

SMRs were also calculated for women who only worked prior to 1952, and who had 20 or more years latency (Table 30). In this subgroup, a significantly elevated SMR of 3.00 was found in women with two or more quarters of EUC employment, and a non-significantly elevated SMR of 1.99 was found in women with one or more year of EUC employment.

Table 29. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for non-Hodgkin's lymphomas in white females, using 1960-1999 ICD categories

Length of employment	Observed Deaths	SMR	95 % Confidence Interval
2-3 quarters	5	3.37[1]	1.09-7.89
1-4 years	4	2.16	.59-5.52
5-10 years	0	0	0-9.85
10 + years	1	1.16	.03-6.42
Total[2]	10	2.19[1]	1.05-4.02

1. $p < .05$
2. Total includes workers with two or more quarters worked.

Table 30. Non-Hodgkin's lymphoma observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals in white females with 20 or more years latency[1], by years worked[2] and calendar year worked

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Worked any calendar year			
Two quarters or more	8	1.76	.76-3.47
One year or more	3	.98	.20-2.85
Worked prior to 1952 only			
Two quarters or more	6	3.00[3]	1.10-6.54
One year or more	2	1.99	.24-7.17

1. Latency defined as year of death or end of study period minus year first employed.
2. No deaths in ten or more years employment group.
3. $p < .05$.

Table 31. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for non-Hodgkin's lymphoma in white females by length and calendar year of employment

	Observed	SMR	95% Confidence Interval
Only worked 1951 and earlier	6	3.00[1]	1.10-6.53
Number of years worked			
2-3 quarters	4	4.03[1]	1.10-10.31
One year or more	2	1.99	.24-7.17
Employed before and after 1951	1	.85	.02-4.72
Number of years worked[2]			
One year or more	1	.86	.02-4.79
Only employed 1952 and later	3	2.15	.44-6.29
Number of years worked			
2-3 quarters	1	2.13	.05-11.82
One year or more	2	2.16	.26-7.80

1. $p < .05$
2. Only ten workers employed in this time period who worked only 2-3 quarters

Leukemias

The overall SMRs for leukemia were slightly elevated in both males and females, but were not significant (Table 32). Analyses according to length of employment revealed that the excess was primarily due to an excess in workers with two to three quarters employment, with non-significant SMRs in males and females. Only two leukemia deaths occurred in workers with ten or more years employment. When 20 or more years latency was taken into account, the SMRs increased slightly (Table 33).

Eight of the nine leukemia deaths occurred in workers employed only after 1951, with four deaths each in males and females (Table 34). Males and females in this subgroup had three fold non-significantly elevated SMRs. SMRs were highest in workers with only 2-3 quarters employment in this time period, however. Only three deaths occurred in those with one or more years employment.

SMRs were also calculated for workers employed after 1951, and with 20 or more years latency. SMRs were 4.32 in males and 3.56 in females in this analysis, but were not significant (Table 33). SMRs were highest in workers with ten or more years employment, based on only one death each in males and females. Given the similarity in SMRs by gender in this analysis, a combined SMR was calculated for males and females who only worked in 1952 or later, with two or more

quarters worked, and 20 or more years latency. A significant SMR of 3.91 was found in this subgroup based on six deaths (95% CI: 1.41-7.66).

Table 32. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for leukemias in white males and white females, according to years worked at EUC

	White Males			White Females		
Years Worked	Observed	SMR	95% Confidence Interval	Observed	SMR	95% Confidence Interval
2-3 quarters	2	2.81	.34-10.14	3	2.16	.45-6.30
1-4 years	1	1.25	.03-6.93	1	.56	.01-3.14
5-9 years	0	0	0-10.95	0	0	0-10.50
>= 10 years	1	1.45	.04-8.04	1	1.14	.03-6.33
Total[1]	4	1.57	.43-4.02	5	1.14	.37-2.66

1.Total includes workers with two or more quarters worked.

Table 33. Observed deaths from leukemias, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% Confidence Intervals for workers with 20 or more years latency[1], by years worked and calendar year

	White Males			White Females		
Years Worked	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Worked any calendar time period						
Two quarters or more	3	1.73	.33-4.24	4	1.15	.30-2.56
One year or more	1	.81	.00-3.18	2	.84	.01-2.42
10 years or more	1	1.92	.08-7.51	1	1.42	.00-5.58
Only worked 1952 or later						
Two quarters or more	3	4.32	.08-10.60	3	3.56	.07-8.73
One year or more	1	2.18	.00-8.54	1	1.78	.00-6.9
Ten years or more	1	8.77	.00-34.39	1	6.59	.00-25.84

1. Latency defined as year of death or end of study period minus year first employed.

Table 34. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95 percent confidence intervals for leukemias in white males and females employed 1952 and later only[1]

	White Males			White Females		
	Observed Deaths	SMR	95% Confidence Interval	Observed Deaths	SMR	95% Confidence Interval
Only employed 1952 and later	4	3.35	.91-8.58	4	3.21	.88-8.22
Number of years worked						
2-3 quarters	2	5.22	.63-18.86	3	7.04[2]	1.45-20.59
One year or more	2	2.47	.30-8.92	1	1.22	.03-6.78

1. No leukemia deaths in workers employed in both time periods, one death in workers employed prior to 1952 only..
2. $p < .05$

Bone and Thyroid Cancers

A significant excess of thyroid cancers, based on two cases, was found in white males. Both cases had worked ten or more years, and the SMR of 62.32 was significantly elevated in males with ten or more years of employment (95% CI: 7.54-224.98). Among males with ten or more years employment and 20 or more years latency, the thyroid cancer SMR remained significant at 86.53 (95% CI: 8.16-248.15).

There were two female deaths from bone cancer, with a significant SMR of 8.88 in females with one or more years of employment (95% CI: 1.08-32.06). The SMR for females with 20 or more years latency and one or more years employment remained significant at 13.46 (95% CI: 1.27-38.58). Table 35 describes the bone and thyroid cancer deaths in more detail.

Table 35. Death information and employment history, thyroid and bone cancer deaths

Gender	**Cancer Cause of death**	**Date first employed**	**Length of Employment**	**Death year**	**Latency**	Job **Titles**
Male	Thyroid	1950	27 years	1988	38 years	Winder, maintenance
Male	Thyroid	1960	17 years	1987	27 years	Executive employee
Female	Bone	1944	15 months	1977	33 years	Unknown
Female	Bone	1946	28 years	1995	49 years	Winder

Non-Cancer Causes of Death

Anemias of Other - Unspecified Type

White females had a significant excess of non-pernicious anemias (SMR=4.72) based on four cases (Table 36). These include two deaths due to aplastic anemia, one anemia, and one marked hemolytic anemia. Two of the deaths occurred in women with two to three quarters employment. Analysis by latency reveals similar results (Table 37). All of the four deaths occurred 20 or more years after employment, with a significant SMR of 5.60 in this subgroup with two or more quarters worked. Three of these deaths occurred in women who only worked before 1952. For these calendar years, the SMR was significantly elevated at 7.66 (Table 38). A description of these deaths is included in Table 39.

Table 36. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for non-pernicious anemias[1] in white females, by length of employment

Length of employment	Observed Deaths	SMR	95 % Confidence Interval
2-3 quarters	2	4.76	.58-17.20
1-4 years	1	3.05	.08-16.96
5-9 years	0	0	0-54.47
10 + years	1	5.04	.13-27.99
Total[2]	4	4.72[3]	1.29-12.06

1. ICD-9 codes 280, 281.1-281.8, 282-285
2.Total includes worker with two or more quarters worked.
3. P< .05;

Table 37. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for non-pernicious anemias[1] in white females with 20 or more years latency[2], by years worked

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Two or more quarters	4	5.60[3]	1.46-12.43
One year or more	2	3.99	.38-11.44
10 years or more	1	5.82	.00-22.83

1. ICD-9 codes 280, 281.1-281.8, 282-285
2. Latency defined as year of death or end of study period minus year first employed.
3. p< .05

Table 38. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for non-pernicious anemias[1] in white females by length and employed prior to 1952 only[2]

	Observed	SMR	95% Confidence Interval
Only worked 1951 and earlier	3	7.66[3]	1.58-22.39
Number of years worked			
2-3 quarters	2	10.65[3]	1.29-38.44
One year or more	1	4.90	.12-27.23

1. ICD-9 codes 280, 281.1-281.8, 282-285
2. No deaths from this cause in workers only employed 1952 and later, one death in workers employed in both time periods..
3. $p < .05$

Table 39. Description of female deaths from non-pernicious anemias

Cause of death	Year first employed	Total time Worked	Year of death	Age at death	Latency
Marked hemolytic anemia	1944	3 years	1971	62	27 years
Aplastic anemia	1944	3 quarters	1981	73	37 years
Aplastic anemia	1945	3 quarters	1983	79	38 years
Anemia	1944	12 years	1980	90	36 years

Chronic Liver Disease and Cirrhosis

The grouped category, chronic liver disease and cirrhosis, includes cirrhosis as well as alcoholic fatty liver and hepatitis. The standard mortality rates do not include separate categories for liver cirrhosis only, so SMRs cannot be calculated for this cause of death alone. The causes of death for these 12 employees as listed on the death certificate include: five liver cirrhosis without mention of alcohol, three alcoholic liver cirrhosis, three acute alcoholic hepatitis, and one alcoholic fatty liver.

A non-significant SMR of 1.84 was found in all males based on 12 deaths (Table 40). However, the largest SMR of 3.49 was found in males with two to three quarters worked. Only one liver disease death occurred in males with five or more years of employment. SMRs were elevated in males who worked before and after 1951, but the largest SMRs were found in workers employed after 1951 (SMR=2.70) (Table 42). Within this subgroup, SMRs were significantly elevated in workers with 2-3 quarters worked (SMR=4.29), and non-significantly elevated in workers with one year or more of employment (SMR=1.85). A detailed description of these deaths is included in Table 43.

Table 40. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for liver disease in white males, by length of employment

Length of employment	Observed Deaths	SMR	95 % Confidence Interval
2-3 quarters	7	3.49[1]	1.40-7.20
1-4 years	4	1.83	.50-4.68
5-10 years	1	1.34	.03-7.42
10 + years	0	0	0-2.31
Total[2]	12	1.84	.95-3.21

1. p< .01
2. Total includes workers with two or more quarters worked.

Table 41. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for liver cirrhosis and other liver diseases in white males with 20 or more years latency[1], by years worked[2]

Years Worked	Observed Deaths	SMR	95% Confidence Interval
Two more quarters	8	1.90	.81-3.45
One year or more	3	1.07	.02-2.61

1. Latency defined as year of death or end of study period minus year first employed.
2. No deaths from this cause in workers with ten or more years employment and 20 or more years latency.

Table 42. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for cirrhosis and other liver disease in white males by length and calendar year of employment[1]

	Observed	SMR	95% Confidence Interval
Only worked 1951 and earlier	3	2.01	.41-5.88
Number of years worked			
2-3 quarters	2	2.46	.30-8.89
One year or more	1	1.47	.04-8.16
Only employed 1952 and later	9	2.70[2]	1.23-5.13
Number of years worked			
2-3 quarters	5	4.29[2]	1.39-10.03
One year or more	4	1.85	.50-4.73

1 No deaths from this cause in workers employed before and after 1952.
2. $p<.05$

Table 43. Description of male deaths from liver cirrhosis

Cause of death	Year first employed	Total time Worked	Year of death	Age at death	Latency
Alcoholic fatty liver	1972	2 quarters	1996	45	14 years
Acute alcoholic hepatitis	1972	5.7 years	1985	63	13 years
Acute alcoholic hepatitis	1948	1.5 years	1991	63	43 years
Acute alcoholic hepatitis	1969	1 year	1989	61	20 years
Alcoholic cirrhosis of liver	1966	2 quarters	1984	49	18 years
Alcoholic cirrhosis of liver	1950	2 quarters	1975	44	25 years
Alcoholic cirrhosis of liver	1950	2 quarters	1991	57	41 years
Non-alcoholic cirrhosis of liver	1969	3 quarters	1972	62	3 years
Non-alcoholic cirrhosis of liver	1952	5 quarters	1975	45	13 years
Non-alcoholic cirrhosis of liver	1952	1 year	1983	49	31 years
Non-alcoholic cirrhosis of liver	1969	2 quarters	1995	43	26 years
Non-alcoholic cirrhosis of liver	1952	2 quarters	1977	49	15 years

Acute Glomerulonephritis, Nephrotic Syndrome, and Acute Renal Failure

The four deaths among white females in this category include two acute renal failures, one acute renal failure with probable acute tubular necrosis, and one chronic renal insufficiency. Three of the four deaths occurred in females with 2-3 quarters worked, with a significant SMR of 12.92 (Table 44). No pattern emerged for calendar year worked, with significantly elevated SMRs in women who worked before and after 1951 (Table 45). A detailed description of these deaths is included in Table 46.

Table 44. Observed deaths, age and calendar year adjusted Standardized Mortality Ratios (SMR), and 95% confidence intervals for acute glomerulonephritis, nephrotic syndrome, and acute renal failure[1] in white females, by length of employment

Length of employment	Observed Deaths	SMR	95 % Confidence Interval
2-3 quarters	3	12.92[2]	2.66-37.77
1-4 years	1	3.41	.09-18.92
5-10 years	0	0	0-60.66
10 + years	0	0	0-21.50
Total[3]	4	5.27[2]	1.44-13.49

1. Includes ICD-9 codes 580, 581, 584.
2. p<.05;
3. Total includes workers with two or more quarters worked.

Table 45. Observed deaths, age and calendar adjusted Standardized Mortality Ratios (SMR), 95 percent confidence intervals for acute glomerulonephritis, nephrotic syndrome, and acute renal failure[1] in white females by length and calendar year of employment[2]

	Observed	SMR	95% Confidence Interval
Only worked 1951 and earlier	2	5.67[3]	.69-20.46
Number of years worked			
2-3 quarters one year	2	11.59[3]	1.40-41.83
One year or more	0	0	0-20.46
Only employed 1952 and later	2	10.94[3]	1.32-39.50
Number of years worked			
2-3 quarters	1	17.43	.44-96.84
One year or more	1	7.97	.20-44.30

1. Includes ICD-9 codes 580, 581 584.
2. No deaths from this cause in workers employed before and after 1952.
3. p<.05

Table 46. Description of female deaths from acute glomerulonephritis, nephrotic syndrome, and acute renal failure

Cause of death	Year first employed	Total time Worked	Year of death	Age at death	Latency
Chronic renal insufficiency	1950	2 quarters	1997	74	47 years
Acute renal failure	1944	3 quarters	1993	92	49 years
Acute renal failure	1953	3 quarters	1988	83	35 years
Acute renal failure	1956	9 quarters	1997	76	41 years

DISCUSSION

A healthy worker effect was not detected in this cohort in males or females. This could be due to incomplete follow-up, the long follow up period, and/or the aging of the cohort. The mean ages among those alive at the end of the follow up period were 61 years in males and 70 years in females. This contrasts sharply with the mean ages in a similar cohort of capacitor manufacturing workers, which, among hourly workers, were 53 years in males and 57 years in females who were alive at the end of the study period.[12] This latter study, in contrast to the EUC study, did detect a significant healthy worker effect in both males and females. This is not surprising since the healthy worker effect decreases as the age of the cohort increases.

Several of the cancers associated with exposure at the EUC plant, including liver/biliary,[6,8,14,24,26] non-Hodgkins lymphoma,[20,24,26,38,39] breast,[16] kidney,[25,27,28] and stomach[23] cancer, have been associated with exposure to PCBs, TCE or chlorinated naphthalenes in previous studies, although results have not been consistent.[6-8,12,13,17,18] Other cancers that were elevated in this study include bone (females only), and thyroid (males only), which have not been significantly associated with PCBs in other studies. Both thyroid cancer[41] and non-Hodgkin's lymphoma,[42,43] have been associated with dioxin exposure.

The significant excess of liver-biliary cancers found in females was highest for those with 10 or more years employment at EUC, all of which occurred 20 or more years after first employment. The four deaths in this subgroup occurred in women who were first employed at EUC in 1944, and could have been exposed to chlorinated naphthalenes for seven years, and to PCBs for 3-13 years. (Three of these deaths occurred in women with 20 or more years of employment). In males, the SMRs showed a slight increase with length of employment, but with no liver-biliary deaths occurring in those with ten more years employment. Each of the male deaths occurred after 20 or more years latency. No pattern appeared to emerge according to calendar year of employment in males or females.

Liver/biliary cancers have been associated with PCB exposure in epidemiologic as well as animal studies. Brown found a fourfold non-significantly elevated risk, primarily in women who worked with highly chlorinated PCBs,[6] while the Swedish cohort found a non-significantly elevated risk based on only two deaths.[8] Other cohort studies in Italy and the U.S. did not find any excess liver-biliary tract cancers.[7,9-13] A case control study of transformer manufacturing workers found a non-significant two fold excess of liver-biliary cancers after adjusting for solvents and other exposures.[19] In Japan, elevated liver cancer was found in a follow up study of those who ingested PCB contaminated rice-oil,[15] but in a similar Taiwanese cohort, only two liver cancer deaths were found.[14] The latter study had a relatively short follow up period of 12 years, however.

Results from rat studies show associations with PCB and primary liver cancers in females only.[4,44,45] In one of these studies, the incidence of hepatocellular neoplasms in female Sprague-Dawley rats increased with dose and with exposure to the more highly chlorinated Aroclors.[4] A significant excess in male rats was also found but only in those exposed to Aroclor 1260.

Liver cancer has also been associated with solvent exposure in some studies, particularly TCE,[24,26] and TCE was used at EUC for most of the plant's history. Since limited information is available on exposure history for these workers, it is not possible to determine which exposures might be associated with the liver cancer excess.

Although liver cancer could not be separated from biliary cancer in the referent population in the SMR analysis, review of the death certificates indicated that most of the biliary cancers were in women and most of the liver cancers were in men. This gender difference in biliary cancer has been seen previously[46] and suggests that hormones may affect the development of the disease.

Hepatitis B and C virus, along with cirrhosis, are major risk factors for primary liver cancer.[47] In areas of low incidence of liver cancer, however, such as the U.S., primary hepatocellular carcinoma is primarily associated with chronic alcoholic cirrhosis.[47] No information on these confounders is available, but there is no evidence to support a higher risk of infectious hepatitis in this cohort. An elevated risk of chronic liver disease/liver cirrhosis was found in males in this study, which was primarily concentrated in workers with short term employment. SMRs for alcoholic cirrhosis alone could not be determined due to the way the standard rates are grouped.

A major risk factor for gallbladder cancer is a history of gallstones.[46] In the earlier pilot study of EUC workers, a significant relative risk of 4.3 was found for a history of gallstones and work in high PCB exposure jobs.[2] Since the date of the disease occurrence was not included in this survey, it is not known if the gallstones first occurred during or after EUC employment. No information is available on a history of gallstones in the entire cohort, and the association between gallstones and PCBs is not known. It is possible however, that some of the elevated liver/biliary risk is due to direct hepatotoxic effects of PCBs.

The excess non-Hodgkin's lymphomas found in females in this study showed no consistent pattern by length of employment. The highest SMR was found in females who only worked before 1952 when no PCBs were used, with smaller SMRs found in women employed in 1952 or later. In females with 20 or more years latency however, the SMR was significantly elevated only for those who worked prior to 1952.

The strongest case for an association between NHL and PCBs is from a nested case control study of NHL incident cases and serum PCB levels collected pre-diagnostically.[20] A strong dose-response association was found with NHL incidence and quartiles of serum PCB, with a significant relative risk of 4.5 in the highest quartile of exposure. None of these cases were exposed occupationally to PCBs, and no information was reported by congener specific PCBs. Five occupational cohort studies did not find any association between PCBs and NHL mortality.[6-8,11,13] An Italian cohort study found a non-significant SMR of 1.77 in women for lymphomas based on four cases, but the types of lymphomas were not reported.[10] Hardell et al[39] measured PCBs in adipose tissue of NHL patients and non-cancer controls and found higher mean levels of the higher chlorinated congeners in cases compared to controls. A case control study found a non-significant excess of lymphomas in PCB exposed workers after controlling for solvent and other exposures, although the strongest association with NHL was with solvents.[19]

TCE and other solvents have been associated with NHL in some studies,[26,27,40,49,50] but the evidence is still inconclusive.[51]

Although immunosuppression is a risk factor for non-Hodgkin's lymphoma, it only accounts for a small percentage of NHL cases, and the reasons for the marked increase in non-Hodgkin's lymphoma incidence and mortality rates over the past three decades are still unknown.[51] Occupational associations with NHL and a variety of chemicals have been found in numerous studies, but evidence for specific chemical exposures is still ambiguous.[51]

Other cancers that were elevated in this study include stomach, female breast, kidney, thyroid, (males only), bone (females only) and leukemias. Except for female breast cancer, which has been inconsistently associated with serum PCB levels,[16-18] these cancers have not been associated with PCB exposure in other occupational cohorts. The Italian PCB cohort had a significantly elevated SMR for all gastro-intestinal cancers in males, based on six deaths, which included stomach, biliary tract, liver and pancreas[9] and a Canadian study found elevated mortality for pancreatic cancer only.[11] A cluster of kidney cancer in three utility workers was detected in one study,[52] and some studies have found associations between kidney cancer and exposure to trichloroethylene[25,27,28] and other solvents.[53,54]

Since the elevated bone and thyroid cancers are based on two female deaths and two male deaths, respectively, limited conclusions can be drawn from these data. The possible relationship of exposure with thyroid cancer was supported by the fact that in the biomarker study, two women who had worked prior to 1950 mentioned having had thyroid cancer which was diagnosed more than 35 years later. Additional follow up studies of this cohort could obtain information on any previous cancers found and continue to monitor the cohort for new cases of cancer.

The association of exposure at EUC with deaths from liver disease/cirrhosis is consistent with the known hepatotoxic effects of mixed furans and PCBs[14,15] and chlorinated naphthalenes.[32] PCBs and related compounds are hepatotoxic in animal studies, with abnormalities seen for hepatic enzymes, microsomal induction, and liver pathology in a wide variety of models.[55] Human studies have been less consistent, with acute hepatotoxic effects[32] as well as less severe changes in liver enzymes[56-62] noted. Several reports have noted positive associations of serum PCBs with serum GGT[56-61] and serum SGOT,[58,59,61,62] and negative associations with serum bilirubin[56] levels after occupational and environmental exposures. Most of these reports are in cohorts examined either during or shortly after exposure, with few reports including long term follow-up.[58,59]

Elevated mortality from liver cirrhosis was also found in the two PCB contaminated rice oil cohorts, with a significant SMR of 2.8 in the Taiwanese cohort[14] and 2.3 in the Japanese cohort.[15] The cohort of workers exposed to chlorinated naphthalenes also found elevated mortality from liver cirrhosis.[33]

Since the elevated mortality for liver cirrhosis in males occurred primarily in those with two to three quarters of employment, it may be unrelated to EUC employment. A recent study of short term workers in Denmark found that workers hospitalized before employment had a 20% higher

risk of terminating employment early compared to workers not hospitalized, and workers hospitalized two more times for alcohol abuse were 2.3 times more likely to have short term employment.[63] Prior illnesses and alcohol abuse may explain the elevated mortality found for these causes of death. Alternatively, PCBs may interact with alcohol in its effect on liver toxicity. The fact that short term workers also were somewhat more likely to be lost to follow up may also bias the SMRs upwards in short term workers, if we assume that deceased workers are more easily traced than workers who are alive. Person years may thus be underestimated in short term workers.

In this study there were also elevations in deaths from anemia and kidney disease in females. The four female deaths from non-pernicious anemia occurred in females who worked prior to 1952, with two working more than one year**.** Aplastic anemia has been associated with exposure to benzene[64] and other solvents,[65] but to our knowledge, benzene was not used at EUC. The morbidity study also noted inconsistent inverse associations with serum iron, but not with more direct measures of anemia, such as hemoglobin or hematocrit. Solvents have been associated with acute renal deaths, but these, in general, are at the time of acute exposure.[66] The long lag between time of exposure and death is not consistent with direct effects of exposure in this study.

Details of previous human studies of PCBs and health outcomes are summarized in Table 47. The inconsistency in the findings from these studies could be due to a number of factors, including the size and composition of the cohort, types of exposures, routes of exposures, and length of follow-up. Of the six cohort studies of workers in transformer/capacitor manufacturing plants, four included both males and females, two included only males, three had less than 200 total deaths, and the two non-U.S. studies had less than 100 total deaths. The largest cohort study (n=7,075) of transformer manufacturing workers recently published by Kimbrough et al[12] found a small elevated risk of intestinal cancer in a subgroup of females only, but found no other significantly elevated risks. The number of workers in the high exposure group in this study was small however, and the study may have had limited power to detect significant risks for less common cancers. Another large cohort study of PCB exposed workers was that of electric power workers, who had a significant excess of melanoma deaths only.[13]

STRENGTHS AND LIMITATIONS

One of the limitations of the data presented is the lack of follow up for 22 percent of the cohort. However, in workers with 10 or more years of EUC employment, follow up is 92 percent, lending credence to the results for long-term workers. Results for workers with short term employment should be viewed with these limitations in mind, as workers with two to three quarters employment had the lowest follow up rate of 73%.

One of the reasons for the incomplete follow-up is the difficulty in following a predominantly female cohort without work records dating from 54 years ago. Social security numbers are inaccurate and many women have subsequently changed their names. Our follow-up is comparable to that of Ward et al[33,34] following a similar cohort of women, but lower than that of other studies of men and women who worked in plants with more complete records.[12,13,68]

Since national death indices allow for fairly complete ascertainment of deaths, at least since 1979, and our follow-up is only 78%, our ascertainment of deaths may be more complete than our ascertainment of person years of follow-up. This would bias the mortality study towards positive associations. The effect could be particularly strong in short term workers, who have the lowest follow-up. The specificity of the findings, however, with associations with cancers previously noted in the literature, suggests that the associations may reflect coherent biologic phenomena.

Another limitation is the limited power to detect significant SMRs for some cancers and other causes of death, due to the small number of expected deaths these cause. Tables 48 and 49 show power analyses for selected causes of death, grouped according to how many deaths were expected. In males, there is a low probability of detecting significant SMRs of less than four for most cancers of interest, using a one sided 95% confidence interval. For chronic liver disease/cirrhosis, the probability of detecting an SMR of two or less is less than 80 percent. Among females, the probability of detecting SMRs of less than three is small for most cancers, except for breast cancer, for which an SMR of 1.5 is detectable with 76% power. For chronic liver disease/cirrhosis, the ability to detect an SMR below 3 is less than 80 percent.

Another limitation is the lack of information regarding job histories, and specific exposure histories. The amount of exposure to PCBs, chlorinated naphthalenes, TCE and other solvents in these workers is not known, except for the 193 interviewed former employees. Workers throughout the plant were exposed to PCBs starting in 1952, with minimal workplace controls in place. The excess deaths reported may be due to exposure to PCBs, chlorinated naphthalenes, TCE or joint exposure to all three substances. However, workers who left EUC before 1952 would not have been exposed to PCBs and so were analyzed separately.

Table 47. Description of studies of PCB exposed workers or communities

Location, Type of Study, Reference	Setting	Number in study by gender	Time Period	Number of deaths and/or incident cases	Type of PCBs or Aroclors Used	Other Exposures	Results
U.S. Retrospective Cohort[12]	2 capacitor manufacturing plants	4,062 males 3,013 females	1946-1977	763 male, 432 female deaths	1254, 1242, 1016	Toluene, Trichloroethylene lead, aluminum, Iron	Intestinal cancer SMR=189 in females with 20 years latency, p<.05
U.S. Retrospective Cohort[6,67]	2 plants manufacturing electrical capacitors	1270 males 1318 females	1946-1976[1] 1938-1976[1] Follow up extended to 1982[2]	141 male, 154 female deaths	Aroclors: 1254, 1242, 1016 (Both plants)	Trichloroethylene Lead, zinc, aluminum, iron, toluene, methyl isobutyl ketone	Liver/biliary tract/ gallbladder SMR=4.4 in females, plant 2, p <.05, based on 4 deaths
U.S. Retrospective Cohort[7]	Electrical capacitor manufacturing plant	2,742 males 846 females	1957-1986	192 deaths, both sexes	Aroclors: 1242, 1016	1,1,1 trichloroethane, trichloroethylene, toluene, methyl ethyl ketone, xylene	Malignant melanoma SMR=4.1, p<.01, based on 8 deaths Brain/nervous system cancer SMR=1.8, N.S. based on 5 deaths
U.S. Retrospective Cohort[13]	Five electric power companies	138,905 males	1950-1988	20,733 males	Unknown	1,1,1 trichloroethane, acetone, carbon tetrachloride, petroleum spirits, wood preservatives, sunlight	Dose response for malignant melanoma deaths, PCB exposure. Brain cancer mortality excess only in medium PCB exposure category
Canada Retrospective Cohort[11]	Transformer manufacturing plant	2,222 males	1946-1989	171 males	Unknown	Mineral oils, solvents	Pancreatic cancer SMR=7.6, in workers employed 6 months or more, p <.05, based on 8 deaths

Table 47. Description of studies of PCB exposed workers or communities, continued.

Location, Type of Study, Reference	Setting	Number in study by gender	Time Period	Number of deaths and/or incident cases	Type of PCB or Aroclors Used	Other Exposures	Results
Italy Retrospective Cohort[9,10]	Small, large capacitor manufacturing plant	544 males 1556 females	1946-1987[9] 1946-1991[10]	45 male 47 female	Aroclor 1254, Pyralene 1476 Pyralene 3010, 3011	Trichloroethylene	Lymphatic neoplasms SMR=1.8 in females, p > .05, based on 4 cases
Sweden Retrospective Cohort[8]	Capacitor manufacturing plant	242 males in power capacitor department	1965-1991	56 deaths, 18 incident cancers	Unknown	Unknown	Liver /bile duct cancer SIR=2.6, p >.05, based on 2 incident cases; Lung cancer SMR=1.7, p > .05, based on 5 deaths; Cardiovascular disease SMR=3.3 in highly exposed group, p < .05, based on 5 cases
U.S. case control mortality study[19]	Transformer manufacturing plant	512 male cancer deaths; 1202 male non-cancer control deaths	Deaths 1969-1984, employed 1946-84	9 liver-biliary 15 lymphomas, 496 other cancers	Pyranol (includes 45-80% PCB)	Benzene, trichloroethylene, a variety of other solvents, machining fluids, asbestos, resin systems	Liver-biliary adjusted odds ratio=2.2 for high Pyranol exposure score, p=.15; Lymphoma adjusted odds ratio=1.5 for high Pyranol exposure score; p=.42
U.S. nested case control study of non-Hodgkin's lymphoma[20]	Washington County, Maryland population, 1974	25,802 adults with a 15 ml blood sample	1975-1989 incident cases	35 male, 39 female NHL cases 69 male, 78 female controls	Unknown (Background exposure)	DDT (Background exposure)	Dose-response between quartiles of PCB exposure and NHL risk in men and women

Table 47. Description of studies of PCB exposed workers or communities, continued.

Location, Type of Study, Reference	Setting	Number in study by gender	Time Period	Number of deaths and/or incident cases	Type of PCB or Aroclors Used	Other Exposures	Results
Japan, prospective cohort study[15]	Western Japan residents who ingested PCB contaminated rice oil "Yusho" (Food poisoning) in 1968	887 males 874 females	1968-1983	79 male, 41 female	Kanechlor 400 (48% chlorine content)	Polychlorinated dibenzofurans, Polychlorinated quaterphenyls	Liver cancer SMR=5.6 in males, $p < .01$ based on 9 deaths, liver cancer SMR=3.0 in females, $p > .05$, based on 2 deaths; Lung cancer SMR=2.45 in males, $p < .01$ based on 8 deaths; Liver cirrhosis SMR=2.3 in males, 2.7 in females based on 6, 2 deaths, $p > .05$ for both
Taiwan, prospective cohort study[14]	Central Taiwan residents who ingested PCB contaminated rice oil	976 males 1062 females	1980-1991	55 male, 47 female	Kanechlor 500 (52-54 % chlorine content)	Polychlorinated dibenzofurans, Polychlorinated quaterphenyls	Liver cirrhosis SMR=2.8, $p <.05$, males and females, based on 11 deaths; Other liver diseases SMR=5.4, $p < .05$; males and females, based on 4 deaths

Table 48. Range of probabilities[1] of obtaining a result at the 5 percent level (one sided) for varying detectable Standardized Mortality Ratios (SMR) and for given ranges of expected deaths among males in the EUC cohort

		SMR			
Cause of death	Range of Expected Deaths	1.5	2.00	3.00	4.00
Lymphosarcoma, reticulosarcoma	0-1	0-7	8-14	15-35	36-57
Liver/biliary, rectum, brain, skin cancers	1-2	7-8	14-21	35-55	57-81
Stomach, other lymphatic, hematopoietic cancers	2-3	8-17	21-39	55-79	81-95
Intestine, All lymphatic/ hematopoietic cancers, chronic liver disease/ cirrhosis	6-8	29-32	65-73	97-99	100

1. From Table 7.2 in Reference 69.

Table 49. Range of probabilities[1] of obtaining a result at the 5 percent level (one sided) for varying detectable Standardized Mortality Ratios (SMR) and for given ranges of expected deaths among females in the EUC cohort

		SMR			
Cause of Death	Range of Expected Deaths	1.5	2.00	3.00	4.00
Skin cancer, lymphosarcoma/ retulosarcoma	1-2	7-8	14-21	35-55	57-81
Liver/biliary, rectum cancer	2-3	8-17	21-39	55-79	81-95
Stomach, brain cancer	3-4	17	39-41	79-84	95-98
Other lymphatic/ hematopoietic cancer	5-6	22-29	54-65	93-97	100
Chronic liver disease/cirrhosis	7-8	26-32	64-73	98-99	100
Breast cancer	27	76	100		

1. From Table 7.2 in Reference 69.

This study is unique in the long follow-up and complex mixtures to which the population was exposed. The long lag period allows for more in depth examination of cancer risk than has been possible in cohorts of similar size. Several studies of capacitor manufacturing workers have examined cohorts similarly exposed to both PCBs and TCE. However, there is only one published study of a cohort which had substantial exposure to chlorinated naphthalenes over a prolonged period of time,[33,34] and this cohort was not simultaneously exposed to PCBs and solvents. Chlorinated naphthalenes, in general, were used prior to the widespread use of PCBs and were generally discontinued in the 1950s after the liver toxicity was widely recognized.[31] Some of the effects seen in this study, such as the high rates of liver/biliary cancer, could have, in part, been due to mixed PCB and chlorinated naphthalene exposure, or to chlorinated naphthalene/TCE exposure prior to 1952.

A major limitation to the study is the difficulty in measuring exposure and potential confounders in a plant which has not only been closed, but destroyed many years prior to the study. Exposure at the plant appears to have been widespread. Some jobs, such as cook, were probably associated with greater exposure, but this is difficult to quantify. Serum PCB levels allow for an approximation of PCB exposure. The Spearman correlation coefficient for PCB levels and total quarters worked was 0.7 ($p<0.001$) from the EUC morbidity study. This was based on 193 workers, who were self-selected. Another limitation is that different Aroclor mixtures were used at different times in the plant, and the toxicity of these varies. Since most workers were exposed to more than one Aroclor mixture, it is not possible to analyze mortality according to specific Aroclor mixtures.

We also have no measure of chlorinated naphthalene or TCE exposure to date. However, results from a pilot study of ten former EUC workers to examine the feasibility of measuring serum chlorinated naphthalenes are pending from CDC. These results will determine the feasibility of measuring chlorinated naphthalenes in future studies.

Except for the 193 workers who were interviewed, no information is available on potential confounders, such as smoking, and exposure to other substances at non-EUC jobs. Using local mortality rates would partially control for these potential confounders. These have been requested from CDC and will be used in future analysis of the data.

Confirmation of specific causes of death through review of pathology reports would also have added to the study. This could have been particularly important for cancers, such as primary liver cancer, for which the validity of death certificate diagnosis is less than optimal.[70]

Despite these limitations, this study is a unique opportunity to examine a wide variety of health effects in a cohort which was exposed to an unusual mixture of contaminants. Our data suggest that these exposures, either alone or in combination, may have been associated with several previously hypothesized cancers. Further studies should help in the delineation of associations between specific exposure effects and selected health outcomes.

CONCLUSIONS

Standardized Mortality Ratios for all causes of death and all cancer deaths combined showed no statistically significant elevations in this cohort. SMRs for selected cancers were significantly elevated compared with the US population. These include non-Hodgkin's lymphoma (females only) and thyroid (males only). Among workers with ten or more years of EUC employment and 20 years latency, significantly elevated SMRs were found for stomach and thyroid cancer in males and liver/biliary cancer in females. Cancers of the liver and biliary tract and non-Hodgkin's lymphoma have been associated with PCB exposure in previous studies. The significantly elevated SMRs were based on small numbers and must, therefore, be viewed with caution. Elevated risks of non-Hodgkin's lymphoma were observed in women employed before the use of PCBs at EUC, suggesting that exposures to other compounds such as chlorinated naphthalenes and trichloroethylene might have been associated with this increased risk. Elevated risks of liver/biliary cancer in women occurred primarily in those who worked both before and after 1951, and therefore were exposed to both chlorinated naphthalenes and PCBs. No previous studies have documented health effects of these joint exposures. Two non-cancer causes of death were also significantly elevated including non-pernicious anemia (females only) and kidney disease (females only). These occurred in short-term workers, however, and must be viewed with caution. There were significant deficits of deaths due to diabetes in males (no deaths), and diseases of the heart and respiratory system in females. Additional follow up of the EUC cohort may further delineate mortality differentials in workers with these joint exposures.

RECOMMENDATIONS

1. Extend the follow-up of the cohort through use of IRS records, drivers license records, and more extensive search procedures, including the use of private firms and local residents.

2. Provide verification of cancers for elevated SMRs with medical records, autopsy reports, tissue samples, or whatever means available.

3. Obtain cancer incidence data from the Illinois State Cancer Registry (ISCR) for any EUC workers diagnosed with cancer between 1985 (the year ISCR began) and the most current year available. Although these data will only reflect cancer incidence in workers still alive in 1985 and later, and still residing in Illinois, they may provide additional information regarding cancer incidence in this subgroup of workers that will not be reflected in the mortality data, particularly for cancers with high survival rates. It may also be used to confirm some of the cancer causes of death listed on Illinois death certificates starting with 1985 deaths.

4. Obtain more precise measures of work histories and exposures at the EUC through measurement of blood levels of PCBs and, if possible, chlorinated naphthalenes in former workers identified as still alive in the cohort study.

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Appendix A

Letter and Questionnaire for Cohort Mortality Study

Public Comment Draft

Date

Dear ,

The purpose of this letter is to request your help for a health study of former employees of the Electrical Utilities Company in LaSalle, Illinois, which is being conducted by the Illinois Department of Public Health, and the School of Public Health at the University of Illinois at Chicago. One of the studies we are conducting is a follow-up study of all former employees of the EUC to determine the rate and causes of death among these workers. This study includes all former EUC workers, including those who may have worked there for only a short period of time. We believe that you may be one of these former employees.

That is why we are asking you to complete the enclosed brief form, and return it to us in the enclosed stamped, pre-addressed business envelope, **even if you never worked at the EUC**. If you also have a relative who worked at the EUC, we would like you to provide information for them as well on the enclosed form.

All of the information you give us will be kept strictly confidential. No names, social security numbers, cause of death or any other personal information will be released. Only research staff associated with the project will have access to this information which will be kept in locked file cabinets. Results from this study will be presented in summary tables only, with no identifying information. If you are interested in the results of this study, we can send them to you when the study is completed.

Although the results of this study will have no direct benefit for you, they may help us to better understand the association between certain workplace exposures and particular causes of death. In order to have a valid study, we need to find as many former EUC employees as possible, so your response to this survey is important, even if you never worked at EUC yourself.

If you have any questions about this study, please contact Dr. Mallin toll free at 1-877-413-7466. We thank you in advance for your participation in this important study.

Sincerely,

Katherine Mallin, Ph.D.
University of Illinois at Chicago

Ken McCann
Illinois Department of Public Health

HEALTH STUDY OF EMPLOYEES OF THE 1ELECTRICAL UTILITIES COMPANY OF LASALLE ILLINOIS

Please fill in or circle the answers. Please print legibly.

1. What is YOUR full name?

_____ _____
LAST NAME FIRST NAME

_____ _____
MIDDLE NAME MAIDEN NAME (if applicable)

2. Did you ever work at the Electrical Utilities Company in LaSalle, Illinois?

YES 1

NO ..... 2 *(If No, skip to Q. 12, pg. 2)*

3. Please fill in your social security number. (This is to insure that we have matched employees correctly. This information will be kept strictly confidential)

Social Security Number ___ ___ ___ - ___ ___ - ___ ___ ___ ___

4. What is your current address?

_____ _____ _____ _____
STREET ADDRESS CITY STATE ZIP CODE

5. What is your telephone number including area code?

(___ ___ ___) - ___ ___ ___ - ___ ___ ___ ___
Area Code

6. What is your date of birth? ___ ___ / ___ ___/ ___ ___ ___ ___
MONTH DAY YEAR

7. Are you Male.....1 or Female.....2 ? (Circle appropriate response)

8. What is your race? White.....1

Black/African American.....2

Asian.....3

Other (specify)_____4

9. In which year did you **first** work at EUC? 1 9 ___ ___

10. In which year did you **last** work at EUC? 1 9 ___ ___

11. How many months or years in total did you work at EUC?

Months ___ ___ OR Years ___ ___

12. Did any of your relatives (including spouse) work at the Electrical Utilities Company in LaSalle, Illinois?

YES..... 1

NO..... 2

If NO, please skip to Question 20, page 3. Otherwise continue.

Please provide the following information about your SPOUSE or RELATIVE that worked at EUC.

13. _____ _____ _____
LAST NAME FIRST NAME MIDDLE NAME

_____
MAIDEN NAME (if applicable)

14. ___ ___ ___ - ___ ___ - ___ ___ ___ ___ SOCIAL SECURITY NUMBER

15. ___ ___ / ___ ___ / ___ ___ ___ ___ Month Day Year DATE OF BIRTH

Please provide their approximate starting and ending dates of employment at EUC.

16. First Year Employed at EUC 19 ___ ___

17. Last Year Employed at EUC 19 ___ ___

18. How is this person related to you? Spouse.....1

Parent.....2

Son/daughter.....3

Other relative (specify)_____4

19. Is this person still alive? YES 1

NO 2

If yes, please provide their address and telephone so that we may contact them.

_____
STREET ADDRESS

_____ _____ _____
CITY STATE ZIP CODE

TELEPHONE (___ ___ ___)- ___ ___ ___ - ___ ___ ___ ___
Area Code

(If deceased, please provide place and approximate date of death)

State or country where they died, for example, Illinois, Canada, etc.

_____
STATE OR COUNTRY OF DEATH

Date of death ___ ___ / ___ ___/ 1 9 ___ ___
MONTH DAY YEAR

(If you don't know the exact date of death, please provide the year of death if possible).

20. Would you like a copy of the study results (they will be available in 1-2 years). Yes...1

No...2

Thank you for your assistance in this study. Please mail in the enclosed self-addressed stamped envelope. (If you lost the envelope, contact Dr. Kathy Mallin for another at 312-413-3496, or mail to):

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Appendix B

NIOSH 92 Death Category Codes

Major	Minor	NIOSH 92 Death Categories TITLE	5th Revision 1940-1948	6th Revision 1949	6th, 7th Rev. 1950-1967	8th Revision 1968-1978	9th Revision 1979-
01		Tuberculosis					
	01	Respiratory Tuberculosis	013	001- 008	001- 008	010- 012	010- 012
	02	Other Tuberculosis	014- 022	010- 019	010- 019	013- 019	013- 018
02		Malignant Neoplasms (Mn) of Buccal Cavity and Pharynx					
	03	Mn of Lip	045A	140	140	140	140
	04	Mn of Tongue	045B	141	141	141	141
	05	Mn of Other Parts of Buccal Cavity	045C,E	142- 144	142- 144	142- 145	142- 145
	06	Mn of Pharynx	045F	145- 148	145- 148	146- 149	146- 149
03		Mn of Digestive Organs and Peritoneum					
	07	Mn of Esophagus	046A	150	150	150	150
	08	Mn of Stomach	046B	151	151	151	151
	09	Mn of Intestine Except Rectum	046C,E	152, 153	152, 153	152, 153	152, 153
	10	Mn of Rectum	046D	154	154	154	154
	11	Mn of Biliary Passages and Liver	046F	155, 156, 156A, 156.1	155	155, 156	155.0, 155.1, 156
	12	Mn of Liver Not Specified	No rates	No rates	156, 156A, 156.1	197.8	155.2
	13	Mn of Pancreas	046G	157	157	157	157
	14	Mn of Peritoneum and Unspecified of Digestive Organs	046H,M	158, 159	158, 159	158, 159	158, 159
04		Mn of Respiratory System					
	15	Mn of Larynx	047A	161	161	161	161
	16	Mn of Trachea, Bronchus, and Lung	047B- F	162, 163	162, 163	162	162
	17	Mn of Other Parts of Respiratory System	No rates	No rates	160, 164	160, 163	160, 163-165
05		Mn of Breast					
	18	Mn of Breast	050	170	170	174	174- 175
06		Mn of Female Genital Organs					
	19	Mn of Cervix Uteri	No rates	No rates	171	180	180
	20	Mn of Other Parts of Uterus	048	172- 174	172- 174	181, 182	179, 181, 182
	21	Mn of Ovary, Fallopian Tube, and Broad Ligament	049A,B	175	175	183	183
06		Mn of Female Genital Organs					
	22	Mn of Other Female Genital Organs	049C- E	176	176	184	184
07		Mn of Male Genital Organs					
	23	Mn of Prostate	051B	177	177	185	185
	24	Mn of Other Male Genital Organs	051A, 051C- E	178- 179	178- 179	172.5, 173.5, 186, 187	186, 187
08		Mn of Urinary Organs					
	25	Mn of Kidney	052A	180	180	189.0- 189.2	189.0- 189.2

Major	Minor	NIOSH 92 Death Categories TITLE	5th Revision 1940-1948	6th Revision 1949	6th, 7th Rev. 1950-1967	8th Revision 1968-1978	9th Revision 1979-
	26	Mn of Bladder and Other Urinary Organs	052B,C	181	181	188, 189.9	188, 189.3-189.9
09		Mn of Other and Unspecified Sites					
	27	Mn of Skin	053	190, 191	190, 191	172.0-172.4, 172.6-172.9, 173.0-173.4, 173.6-173.9,	172, 173
	28	Mn of Eye	No rates	No rates	192	190	190
	29	Mn of Brain and Other Parts of Nervous System	054	193	193	191, 192	191, 192
	30	Mn of Thyroid Gland	No rates	No rates	194	193	193
	31	Mn of Bone	No rates	No rates	196	170	170
	32	Mn of Connective Tissue	No rates	No rates	197	171	171
	33	Mn of Other and Unspecified Sites (Minor)	045D, 055	156B, 156.2, 160, 164, 165, 192, 194- 203, 205	156B, 156.2, 165, 195, 198, 199	194- 196, 197.0-197.7, 197.9, 198, 199	194- 199
10		Neoplasms of Lymphatic and Hematopoietic Tissue					
	34	Lymphosarcoma and Reticulosarcoma	No rates	No rates	200	200	200
	35	Hodgkin's Disease	No rates	No rates	201	201	201
	36	Leukemia and Aleukemia	074	204	204	204- 207	204- 208
	37	Other Neoplasms of Lymphatic and Hematopoietic Tissue	No Rates	No rates	202, 203, 205	202, 203	202, 203
11		Benign and Unspecified Neoplasms of the Brain					
	38	Benign Neoplasms of the Eye, Brain, and Other Parts of Nervous System	056D	223	223	224, 225	224, 225
11		Benign and Unspecified Neoplasms of the Brain					
	39	Neoplasms of Unspecified Nature of Eye, Brain, and Other Parts of Nervous System	057D	237	237	238, 743.4	237.5-237.9, 239.6-239.7
	40	Other Benign and Unspecified Nature Neoplasms	056A- C, 056, 057A- C, 057	210- 222, 224- 236, 238- 239	210- 222, 224- 236, 238- 239	208, 210-223, 226- 237, 239	210-223, 226-237.4, 238.0-239.5, 239.8-239.9
12		Diabetes Mellitus					
	41	Diabetes Mellitus	061	260	260	250	250
13		Diseases of the Blood and Blood Forming Organs					
	42	Pernicious Anemias	073A	290	290	281.0, 281.9	281.1, 281.9

Major	Minor	NIOSH 92 Death Categories TITLE	5th Revision 1940-1948	6th Revision 1949	6th, 7th Rev. 1950-1967	8th Revision 1968-1978	9th Revision 1979-
	43	Anemias of Other and Unspecified Type	073B- D	291- 293	291- 293	280, 281.1- 281.4, 282- 285	280, 281.1- 281.8, 282- 285
	44	Coagulation Defects, Purpura and Other Hemorrhagic Conditions	072	296	296	286, 287	286, 287
	45	All Other Diseases of Blood Forming Organs	075, 076	294, 295, 297- 299	294, 295, 297- 299	209, 288, 289	288, 289
14		Mental, Psychoneurotic, and Personality Disorders					
	46	Alcoholism	077	322	322	303	303
	47	Other Mental Disorders	079, 084	300- 321, 323- 326	300- 321, 323- 326	290- 302, 304- 315	290- 302, 304- 319
15		Disorders of the Nervous System and Sense Organs					
	48	Multiple Sclerosis	087	345	345	340	340
	49	Other Diseases of the Nervous System and Sense Organs	080- 082, 085- 086, 088, 089	340- 344, 350- 398	340- 344, 350- 398	320- 333, 341- 389	320- 337, 341- 389
16		Diseases of the Heart					
	50	Rheumatic Heart Disease, Including Fever	058, 090A, 092B- 092C, 093C, 095B	400- 402, 410- 416	400- 402, 410- 416	390- 398	390- 398
	51	Ischemic Heart Disease	093D, 094	420	420	410- 414	410- 414
	52	Chronic Disease of Endocardium	091C, 092A, 092D, 092E	421	421	424	424
	53	Other Myocardial Degeneration	093B, 093E	422	422	428	429.0, 429.1
	54	Hypertension with Heart Disease	131A	440- 443	440- 443	400.1, 400.9, 402, 404	402, 404
	55	Other Diseases of the Heart	090B, 091A, 091B, 093A, 095A,C	430- 434	430- 434	420- 423, 425- 427, 429	420- 423, 425- 428, 429.2- 424.9
17		Other Diseases of the Circulatory System					
	56	Hypertension without Heart Disease	102	444- 447	444- 447	400, 400.2,400 .3, 401, 403	401, 403, 405
	57	Cerebrovascular Disease	083	330- 334	330- 334	430- 438	430- 438
	58	Diseases of the Arteries, Veins, and Pulmonary Circulation	096- 101, 103	450- 468	450- 468	440- 444.1, 444.3- 458	415- 417, 440- 459
18		Diseases of the Respiratory System					
	59	Acute Respiratory Infections Except Influenza and Pneumonia	104, 105	470- 475, 500	470- 475, 500	460- 466	460- 466
	60	Influenza	033	480- 483	480- 483	470- 474	487

Major	Minor	NIOSH 92 Death Categories TITLE	5th Revision 1940-1948	6th Revision 1949	6th, 7th Rev. 1950-1967	8th Revision 1968-1978	9th Revision 1979-
	61	Pneumonia (except newborn)	107- 109	490- 493	490- 493	480- 486	480- 486
	62	Chronic and Unspecified Bronchitis	106	501, 502	501, 502	490, 491	490, 491
	63	Emphysema	113	527.1	527.1	492	492
	64	Asthma	112	241	241	493	493
	65	Pneumoconiosis and Other Respiratory Diseases	110, 111, 114A- E	510- 527.0, 527.2	510- 527.0, 527.2	500- 519	470- 478, 494- 519
19		Diseases of the Digestive System					
	66	Diseases of the Stomach and Duodenum	117, 118	540, 541, 543	540, 541, 543	531- 537	531- 537
	67	Hernia and Intestinal Obstruction	122	560, 561, 570	560, 561, 570	550- 553, 560	550- 553, 560
	68	Cirrhosis of the Liver	124	581	581	571	571
	69	Other Diseases of Digestive System	115, 116, 119- 121, 123, 125- 129	530- 539, 542, 544, 545, 550- 553, 571- 578, 580, 582- 587	530- 539, 542, 544, 545, 550- 553, 571- 578, 580, 582- 587	444.2, 520- 530, 540- 543, 561- 570, 572- 577	520- 530, 540- 543, 555- 558, 562- 570, 572- 579
20		Diseases of the Genito-urinary System					
	70	Acute Glomerulonephritis Nephrotic Syndrome and Acute Renal Failure	130	590	590, 591	580, 581	580, 581 584
	71	Chronic and Unspecified Nephritis and Renal Failure and Other Renal Sclerosis	131B, 132	592- 594	592- 594	582- 584	582, 583 585- 587
	72	Infection of Kidney	133	600	600	590	590
	73	Calculi of Urinary System	134	602, 604	602, 604	592, 594	592, 594
	74	Hyperplasia of Prostate	137	610	610	600	600
	75	Other Diseases of Male Genital Organs	138	611- 617	611- 617	601- 607	601- 608
	76	Diseases of the Breast	No rates	No rates	620, 621	610, 611	610, 611
	77	Diseases of the Female Genital Organs. (Contains breast disease prior to 1950)	139	620- 637	622- 637	612- 629	614- 629
	78	Other Genito- Urinary System Organs	135- 136	591, 601 603 605- 609	601, 603 605- 609	591, 593 595- 599	588, 589 591, 593 595- 599
21		Diseases of the Skin and Subcutaneous Tissue					
	79	Infections of the Skin and Subcutaneous Tissue	151- 152	690- 698	690- 698	680- 686	680- 686
	80	Other Diseases of the Skin and Subcutaneous Tissue	153	700- 716	700- 716	690- 708	690- 709
22		Disease of the Musculoskeletal System and Connective Tissue					

Major	Minor	NIOSH 92 Death Categories TITLE	5th Revision 1940-1948	6th Revision 1949	6th, 7th Rev. 1950-1967	8th Revision 1968-1978	9th Revision 1979-
	81	Arthritis and Spondylitis	59	720- 727	720- 725	710- 715	711- 716 720, 721
	82	Osteomyelitis and Periostitis	154	730	730	720	730
	83	Other Diseases of MS System	155, 156	731- 749	731- 749 726- 727	716- 718 721- 738	710, 717- 719 722- 729 731- 739
23		Symptoms and Ill- defined Conditions					
	84	Symptoms and Ill-Defined Conditions	162, 199 200	780- 793 795	780- 793 795	780- 793 795, 796	780- 796, 798 799
24		Accidents					
	85	Transportation Accidents	169- 173	E800- E866	E800- E866	E800- E845 E940- E941	E800- E848 E929.0- E929.1
	86	Accidental Poisoning	078, 178 179	E870- E895	E870- E895	E850- E877 E942	E850- E869 E929.2
	87	Accidental Falls	186A	E900- 904	E900- 904	E880- E887 E943	E880- E888 E929.3
	88	Other Accidents	174- 177 180- 185 186B- 194 195C- E	E910- E936 E960- E962	E910- E936 E960- E962	E890- E929 E944- E946	E890- E928 E929.4- E929.9
	89	Medical Complications and Misadventure	195A,B	E940- E959	E940- E959	E930- E936 E947- E949	E870- E879 E930- E949
25		Violence					
	90	Suicide	163, 164	E963 E970- E979	E963 E970- E979	E950- E959	E950- E959
	91	Homicide	165- 168 198	E964 E980- E985	E964 E980- E985	E960- E978	E960- E978
26		Other Causes					
	92	Other Causes	Residual and blank	Residual and blank	Residual and blank	Residual and blank	Residual and blan