

Mortality among US employees of a large computer manufacturing company — 1969-2001

Richard W. Clapp, DSc, MPH

Professor, Department of Environmental Health, School of Public Health, Boston University

Corresponding author:

Richard W. Clapp, DSc, MPH

Department of Environmental Health

School of Public Health

Boston University

715 Albany St., T-2 East

Boston, MA 02218

617-638-4731

617-638-4857 (fax)

rclapp@bu.edu (email)

ABSTRACT

Background: Previous studies suggested increased cancer incidence and mortality in workers exposed to solvents and other chemicals in computer manufacturing jobs. Most previous studies were of small cohorts and findings were inconsistent. A lawsuit involving a large U.S. company produced a data file for analysis. This study sought to elucidate patterns of mortality in workers who were engaged manufacturing computers and related electronic components in the largest database available to date.

Methods: A proportionate mortality and proportionate cancer mortality analysis of deaths in eligible workers between 1969 and 2001 was carried out, with U.S. population and California mortality data as the standard for comparison. Mortality and work history data was from corporate mortality and work history files produced during litigation and standard U.S. and state mortality files. The study base comprised 31,941 decedents who died between 1969 and 2001, who had worked for at least five years and whose death information was collected in the corporate mortality file. Proportionate mortality ratios (PMRs) and Proportionate Cancer Mortality Ratios (PCMRs) and their 95% confidence intervals were computed for 66 causes of death in males and females.

Results: PMRs for all cancers combined were elevated in males (PMR=107; 95% C.I.=105-109) and females (PMR=115; 95% C.I.=110-119); several specific cancers and other causes of death were also significantly elevated in both males and females. There were reduced deaths due to non-malignant respiratory disease in males and females and heart disease in females; several specific cancers and other causes of death were significantly reduced in both males and females. Proportional cancer mortality ratios (PCMRs) for brain and central nervous system cancer were elevated (PCMR=166; 95% C.I.=129-213), kidney cancer (PCMR=162; 95% C.I.=124-212),

melanoma of skin (PCMR=179; 95% C.I.=131-244) and pancreatic cancer (PCMR=126; 95% C.I.=101-157) were significantly elevated in male manufacturing workers. Kidney cancer (PCMR=212; 95% C.I.=116-387) and cancer of all lymphatic and hematopoietic tissue (PCMR=162; 95% C.I.=121-218) were significantly elevated in female manufacturing workers.

Conclusions: Mortality was elevated due to specific cancers and among workers more likely to be exposed to solvents and other chemical exposures.

INTRODUCTION

In 2002, plaintiffs' attorneys in a lawsuit obtained computerized files of deaths and work histories for US employees of a large company which manufactured electronic office equipment; mainframe and personal computers; computer parts, components, and accessories; and software products. The files contained data on employees who had qualified for pension and death benefits and died in the US between the years 1969 and 2001. A unique identifier was included in both files so that death and work history data for individual decedents could be linked.

Few studies of workers in computer manufacturing and semiconductor fabrication are available in the published literature. A study of workers at a Scottish semiconductor plant was released by the government occupational health authority in 2001.^{1,2} This study showed statistically significant excesses of lung, stomach, and breast cancers among females and an excess of brain cancer among males; however, the number of employees in this plant was relatively small and the number of cases of cancer was limited. Recently, an update of a UK semiconductor workers study was released which was also small and had few significant findings with regard to cancer.³ Two studies were published of workers in an electronics company in Taiwan.^{4,5} An analysis of mortality in three semiconductor and storage device-manufacturing plants identified significant excess central nervous system cancer in one plant and excess prostate cancer in workers in another plant.⁶ In a cancer incidence analysis, there was a significant excess of breast cancer in female electronics company workers when compared to cancer incidence in two other groups of industrial workers.⁷

There are numerous studies of workers exposed in other industries to individual chemicals used in computer and semiconductor manufacturing. For example, trichloroethylene is used in many industries and there is a large literature on its health effects.⁷ Similarly, the health effects of methylene chloride, isopropyl alcohol, methyl ethyl ketone, Freon, and several other solvents and feedstocks have been studied in other groups of workers⁸ and in experimental animals. Furthermore, various US and international agencies have classified several of these chemicals as to their carcinogenicity.^{9, 10}

Based upon the available literature, workers exposed to the chemicals used in computer and semiconductor manufacturing would be expected to have elevated mortality from non-Hodgkin's lymphoma, brain cancer, kidney cancer, lung cancer, and breast cancer. Additionally, exposures in the computer and semiconductor manufacturing industries are complex and have changed as new processes and materials were introduced. Thus, the mortality experience of computer and semiconductor manufacturing workers would be expected to vary over time due to changing exposures.

We evaluated these expectations and examined the mortality among US employees of the large computer manufacturing company by calculating overall and sex-, age-, and time-specific proportional mortality ratios (PMRs) and proportional cancer mortality ratios (PCMRs). We performed analyses for all eligible decedents and subgroups of decedents who were ever employed in manufacturing and, more specifically, ever employed in manufacturing at selected locations.

METHODS

The context of this analysis is unusual because the data were obtained as part of litigation and the company's attorneys resisted making the files available. A court order forced the production of the files, and minimal documentation was provided about the content and coding of the files. Due to the context in which we received these data, we were not able to obtain additional documentation, access the original or complementary data, or contact company personnel knowledgeable about the data. Since we could not resolve problems in the data, we spent considerable time developing logical rules for handling incomplete and apparently erroneous information. These constraints limited the data available for subgroup analyses.

Corporate Mortality File

At the time it was provided to plaintiffs' attorneys, the Corporate Mortality File (CMF) maintained by the large computer manufacturing company had 33,730 records. These records were for decedents who had been employed for five years or more, who were actively employed or receiving retirement or disability benefits at time of death, and whose families had filed a claim for death benefits. CMF data required for analysis were the identifier, sex, birth date, death date, and underlying cause of death.

We reviewed the numbers of deaths by year of death. Based on the apparent degree of completeness of the CMF by year of death, we defined the study period as 1969-2001. We excluded duplicate records and records for which the sex, birth date, and/or death date remained unknown or discrepant. Of the 33,730 records in the CMF, 1,456 records were excluded for

these reasons. Processing of the work history data (see below) identified 20 additional CMF records with discrepant birth and/or death dates and these also were excluded. We then excluded 313 CMF records for which the year of death was before 1969 or after 2001.

The final number of CMF records used for analysis was 31,941 and comprised 27,272 males and 4,669 females.

Work History Data

The work history data set had a total of 586,258 records representing 18,928 decedents. Work history data required for analysis were the identifier, effective date, position code, location code, and text notes indicating a key employment event such as leave of absence, return from leave of absence, separation, retirement, or death.

We added the birth and death dates from the CMF to the work history data set. We then identified irrelevant, missing, invalid, and inconsistent work history data to the extent feasible. We deleted all work history records for decedents that were excluded from the CMF (see above). Likewise, we deleted all work history records with irrelevant, missing, invalid or inconsistent data. Upon completion of these steps, the work history data set included a total of 375,563 records representing 10,219 decedents.

Cause of Death Coding

The underlying causes of death were coded to the Ninth Revision of the International Classifications of Diseases (ICD 9).

Comparison Population

We selected the US as the most appropriate comparison population for the overall CMF analyses and we used it as the comparison population for the exposure subgroup analyses for consistency. We obtained cause-, sex-, age-, and time-specific mortality data, adjusted to ICD 9, for the US comparison population from the Mortality and Population Data System (MPDS) at the University of Pittsburgh.¹⁰ We used default categories for sex, age, and time, and default and “custom” categories for cause of death. The mortality data were not categorized by race because race was not known for the decedents included in the CMF.

Analysis

We analyzed the data with the Occupational Cohort Mortality Analysis Program (i.e., OCMAP-PLUS version 3.10) software package from the University of Pittsburgh.¹¹ In addition to the 63 OCMAP-PLUS default cause of death categories, we defined the following six “custom” cause of death categories: non-Hodgkin's lymphoma, multiple myeloma, diseases of the nervous system, multiple sclerosis, Parkinson's disease, and amyotrophic lateral sclerosis.

Standardized proportional mortality ratios (PMRs) were calculated from the ratio of the observed number of deaths due to a particular cause among the workers to the expected number of deaths based on the age-, sex-, time-, and cause-specific proportional mortalities of the US population. The expected number of deaths was computed by multiplying the proportional mortalities of the US population by the total number of deaths for the workers. The PMRs were standardized on age, sex, and time. Standardized proportional cancer mortality ratios (PCMRs) also were

calculated. For the PCMRs, site-specific cancer proportional mortality was computed as a proportion of all cancer mortality. The underlying cause of death was used for calculation of the PMRs and PCMRs. Workers with an unknown cause of death were included in the “all causes of death” and “unknown causes” categories. The associated 95% confidence intervals (95% CIs) for the PMRs and PCMRs were calculated as well.

Exposure Subgroups

We defined the following exposure subgroups for both men and women:

- ever worked in manufacturing for 30 days or more;
- ever worked at a selected CA location in manufacturing for 30 days or more; and
- ever worked at a selected MN location in manufacturing for 30 days or more.

RESULTS

The number of decedents and the percent of decedents with available and usable work history information are shown in Table 1 by year of death and sex. Of the 27,272 male decedents, 9,219 (33.8%) had work histories. For the 4,669 female decedents, 1,000 (21.4%) had work histories. In general, work history information was most complete for the years 1985 – 1999 and was more complete for men than women. The resulting numbers of male and female decedents included in exposure subgroups are shown in Table 2.

The distributions of age at death by sex for all causes and all cancers are shown in Tables 3.

The all cause average age at death was 64.5 years for male decedents and 63.4 for female decedents. For both men and women, the number and percent of deaths increased with age until the mid 70s. The all cancer average age at death was 63.9 years for male decedents and 59.5 for female decedents. For all cancers, the number and percent of deaths increased with age until the mid 70s for men, but the number and percent of deaths increased until the mid 60s for women.

Cause-specific PMRs and 95% CIs for male decedents in the CMF were calculated and the results for major causes of death are summarized in Table 4. There were 27,272 deaths from all causes. The PMR for all cancers was significantly greater than 100. There were 7,697 cancer deaths and 7,206 were expected (PMR=107; 95% CI=105, 109). This excess was due to statistically significant excesses for cancer of the digestive organs and peritoneum, testicular and other male genital cancer, kidney cancer, malignant melanoma of the skin, brain and central nervous system cancer, thyroid and other endocrine cancer, and lymphatic and hematopoietic cancer.

In addition, statistically significant excesses were observed for benign neoplasms, nervous system diseases, ischemic heart disease, and all other causes of death, although the excess for ischemic heart disease was quite small. Statistically increased PMRs for multiple sclerosis, Parkinson's disease, and amyotrophic lateral sclerosis contributed to the excess for diseases of the nervous system. There also were deficits of several causes of death as estimated by the PMR method.

In Table 5, we present the cause-specific PCMRs and 95% CIs for males in the CMF. There were 7,697 deaths from all cancers in this group. Except for testicular and other male genital organ cancer, all of the significantly increased PMRs for specific cancers also had significantly increased PCMRs, but the magnitudes of the PCMRs were less than those for the PMRs. The testicular cancer PMR was statistically significantly increased, whereas the PCMR was not (PCMR=91; 95% CI=63, 130).

The cause-specific PMRs and 95% CIs for the 4,669 female decedents in the CMF also were calculated and the results for major causes of death are summarized in Table 6. The PMR for all cancers was significantly greater than 100 for women as well. There were 1,667 cancer deaths and 1,454 were expected (PMR=115; 95% CI=110, 119). This excess was due to statistically significant excesses for respiratory system cancer, breast cancer, cancer of other female genital organs, brain and central nervous system cancer, and lymphatic and hematopoietic cancer. A statistically significant excess also was observed for all other causes of death. As in males, there were statistically significant deficits for several causes as estimated by the PMR method.

In Table 7, the cause-specific PCMRs and 95% CIs for females in the CMF are shown. There were 1,667 deaths from all cancers in this group. The PCMR for breast cancer (PCMR=115; 95% CI=106, 125) remained significantly elevated, while the PCMRs for several other cancers were no longer elevated compared to their respective PMRs. These cancers included the following: respiratory system cancer; cancer of the trachea, bronchus, and lung; cancer of other female genital organs; brain and central nervous system cancer; lymphatic and hematopoietic cancer; leukemia and aleukemia; non-Hodgkin's lymphoma; and all other lymphatic and

hematopoietic cancer. Furthermore, the PCMRs for cancer of the buccal cavity and pharynx, and cancer of the digestive organs and peritoneum were significantly decreased compared to the corresponding PMRs.

In Table 8, PCMRs are presented for males in the CMF who worked in manufacturing for 30 days or more. There were 1,180 deaths from all cancers in this group. In comparison to the PMRs, only the PCMRs for pancreatic cancer (PCMR=126; 95% CI=101, 157), kidney cancer (PCMR=162; 95% CI=124, 212), malignant melanoma of the skin (PCMR=179; 95% CI=131, 244), and brain and central nervous system cancer (PCMR=166; 95% CI=129, 213) remained statistically significant.

In Table 9, PCMRs are presented for female manufacturing workers. All cancers accounted for 302 deaths in this group. The PCMRs for kidney cancer and the other lymphatic and hematopoietic cancers (i.e., leukemia and aleukemia and all other lymphatic and hematopoietic cancer) were significantly increased in this subgroup.

DISCUSSION

We found an overall excess mortality for all cancer in males and females in the entire corporate mortality data. The PMRs for all sites were significantly elevated when comparing the computer company workers to the US population experience during the time period 1969-2001. In addition, there was excess mortality in both males and females due to several types of cancer .

Because of the potential for lowered mortality due to major causes such as ischemic heart disease or respiratory disease, we calculated PCMRs, which focused specifically on cancer mortality. The PCMR is less susceptible to distortion by the “healthy worker effect,” and focuses on the health outcome of most interest in these analyses. The results of the PCMR analyses in males were for the most part quite similar to the PMR results for the same cancers. For cancer of the testis, however, the PCMR was 91 (95% C.I. 63,130) as compared to a PMR of 146. In females, the PCMR for breast cancer was significantly elevated, while the PCMRs for several other cancers were not, compared to their respective PMRs. A recent SMR analysis of workers at three of the plants over an earlier time period in this large company⁶ indicated that there was a substantial “healthy worker effect” although the data to do an evaluation of this in our dataset was not available to us. A graphic comparison of the SMRs from one table in this analysis with our nearest equivalent PCMR results is provided in an appendix. From this, it appears that the overall pattern is very similar in the two mortality analyses.

Cancer mortality patterns in the general population over the time period 1969-2001 changed somewhat. For example, lung cancer mortality increased dramatically in US females during this time period while cervical cancer mortality decreased. In males, lung cancer mortality increased in the early part of the time period, but began to decline in the 1990s. Accordingly, we examined the workers’ mortality experience in five-year time intervals, and we looked at patterns by five-year age groups during these intervals. The excesses of some cancers were greater in the younger age groups and in the 1970s and 1980s rather than the latter years of the study period. These patterns are consistent with a work-related cancer mortality effect that has diminished in recent years.

Additional analyses of specific subgroups of decedents were carried out, primarily because of concerns that toxic chemicals used in manufacturing, such as solvents and the components of photoresist, might be associated with increased cancer mortality. For example, numerous halogenated solvents are used in computer manufacturing^{1,2,9} and some of these are associated with increased risk of kidney cancer and cancer of the lymphatic and hematopoietic tissue in workers^{7,9}. We examined the mortality patterns among decedents for whom work histories were available and grouped them into manufacturing jobs in the overall database and for selected company locations where “clean room” manufacturing was concentrated.

The overall PMR and PCMR analyses for manufacturing workers revealed a pattern that was similar to the pattern in all workers combined. In most instances, the PMRs and PCMRs that were elevated in the total CMF were somewhat more elevated in the manufacturing workers. The decreased mortality due to respiratory system cancer in males in the CMF was similar in the manufacturing subgroup. However, all the manufacturing subgroup analyses were based on fewer deaths and were therefore statistically less stable. In males employed in manufacturing, there was consistent increased mortality from cancer of digestive organs, kidney cancer, melanoma of skin and cancer of the brain and central nervous system. The PCMRs for several of these cancers were significantly elevated and there was also excess mortality due to non-Hodgkin’s lymphoma within the broader category of lymphatic and hematopoietic malignancies. Among female manufacturing workers, we found the breast cancer PMR to be slightly elevated, while the PMRs for kidney cancer and lymphatic and hematopoietic tissue malignancies were

significantly elevated but based on few deaths. The female manufacturing workers PCMRs were based on very few deaths and followed a similar pattern.

The analyses of mortality among manufacturing workers at particular locations were based on small numbers of deaths and results were also limited (data not shown). In San Jose, CA manufacturing workers, there were significant excess deaths in males due to brain and central nervous system cancer and in females due to breast cancer. In Rochester, MN manufacturing workers, there were excess deaths in males due to melanoma of skin and non-Hodgkin's lymphoma and in females due to multiple myeloma. The patterns of deaths in workers at these specific locations generally reflect the patterns seen in manufacturing workers because these locations were among those where such occupations were concentrated.

Proportional mortality analyses are always limited by the availability of information on death certificates, and typically this does not permit controlling for confounding factors such as prior occupational exposures, non-occupational exposures, or cigarette smoking.¹² Similarly, the cause of death information is often limited and may be incomplete for certain types of cancer. These limitations are well-documented and apply to these CMF analyses, as well. Work history information available for grouping manufacturing workers or locations was also incomplete. We examined the overall patterns of mortality among those for whom work history information was available and they appeared to be similar to those for whom this information was not available. Consequently, we do not consider the manufacturing analyses to be distorted in any important way; the lack of information reduces the number of deaths available for inclusion in these analyses and therefore reduces the power to detect some associations.

As noted above, this study was conducted in the context of litigation, so we were unable to communicate with the record providers to clarify inconsistencies or fill gaps in the information provided. Here again, we do not consider this to be a significant source of bias, but it limits the power of the sub-group analyses. If additional work is carried out on this database, it would be desirable to do this in an atmosphere of open communication.

ACKNOWLEDGMENTS

The author would like to acknowledge the major contribution to these analyses by Dr. Rebecca Johnson. The graph was prepared by Ms. Courtney Ledger. This work was supported in part by paid consultancy to Drs. Clapp and Johnson by the law firm of Alexander, Hawes & Audet, LLP in San Jose, CA. The funders obtained the raw data from the company but played no role in the design or conduct of the study nor in the management, analysis or interpretation of the results. The funders did not prepare, review or approve the manuscript.

REFERENCES

1. McElvenny DM, Darnton AJ, Hodgson JT, Clarke SD, Elliot RC, Osman J. Cancer among current and former workers at National Semiconductor (UK), Ltd., Greenock. Results of an investigation by the Health and Safety Executive, 2001.
2. McElvenny DM, Darnton AJ, Hodgson JT, Clarke SD, Elliot RC, Osman J. Investigation of cancer incidence and mortality at a Scottish semiconductor manufacturing facility. *Occup Med (Lond)*. 2003;53(7):419-430.
3. Nichols L, Sorahan T. Further update of cancer incidence and cancer mortality in a cohort of semiconductor workers. Research Report 265. HSE Books ISBN 0 7176 2891 4, 2004.
4. Chang YM, Tai CF, Yang SC, Chen CJ, Shih TS, Lin RS, et al. A cohort mortality study of workers exposed to chlorinated organic solvents in Taiwan. *Ann Epidemiol*. 2003;13(9):652-660.
5. Chang YM, Tai CF, Lin RS, Yang SC, Chen CJ, Shih TS, et al. A proportionate cancer morbidity ratio study of workers exposed to chlorinated organic solvents in Taiwan. *Ind Health*. 2003;41(2):77-87.
6. Beall C, Bender TJ, Cheng H, Herrick R, Kahn A, Matthews R, et al. Mortality among semiconductor and storage-device manufacturing workers. 2005;47:996-1014.
7. Wartenberg D, Reyner D, Scott CS. Trichloroethylene and cancer: epidemiologic evidence. *Environ Health Perspectives*. 2000;108Suppl2:161-176.
8. Park RM, Silverstein MA, Green MA, Mirer FE. Brain cancer mortality at a manufacturer of aerospace electromechanical systems. *Am J Ind Med*. 1990;17(5): 537-552.
9. Garabrant DH, Olin R. Carcinogens and cancer risks in the microelectronics industry. *State of the Art Reviews: Occup Med*. 1986;1(1):119-134.
10. IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. V. 63. Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals. Lyon: International Agency for Research on Cancer, 1995.
11. Marsh GM, Youk AO, Stone RA, Sefcik S, Alcorn C. OCMAP-PLUS: a program for the comprehensive analysis of occupational cohort data. *J Occup Environ Med*. 1998;40(4):351-362.
12. Monson R. Occupational Epidemiology. CRC Press: Boca Raton. 1980.

TABLES

Table 1. Number of Decedents and Number and Percent of Decedents with Work History Information in the Corporate Mortality File by Year of Death and Sex —						
1969 - 2001						
	MALES			FEMALES		
YEAR	NUMBER OF DEATHS	NUMBER WITH WORK HISTORY	PERCENT WITH WORK HISTORY	NUMBER OF DEATHS	NUMBER WITH WORK HISTORY	PERCENT WITH WORK HISTORY
1969	241	1	0.4	28	0	0.0
1970-1974	1,758	6	0.3	169	0	0.0
1975-1979	2,246	135	6.0	329	11	3.3
1980-1984	3,135	1,100	35.1	520	108	20.8
1985-1989	4,325	2,089	48.3	754	252	33.4
1990-1994	5,370	2,520	46.9	909	255	28.1
1995-1999	7,386	3,097	41.9	1,377	343	24.9
2000-2001	2,811	271	9.6	583	31	5.3
TOTAL	27,272	9,219	33.8	4,669	1,000	21.4

Table 2. Number of Decedents in the Corporate Mortality File Included in Exposure Subgroups by Sex — 1969 - 2001

EXPOSURE SUBGROUP	NUMBER	
	MALES	FEMALES
Ever worked in manufacturing for ≥ 30 days	3,652	723
Ever worked at selected CA location in manufacturing for ≥ 30 days	176	68
Ever worked at selected MN location in manufacturing for ≥ 30 days	149	18

Table 3. Distribution of Age at Death for All Causes in the Corporate Mortality File by Sex — 1969 - 2001

AGE (YEARS)	MALES		FEMALES	
	NUMBER	PERCENT	NUMBER	PERCENT
< 20	22	0.1	3	0.1
20 - 24	156	0.6	53	1.1
25 - 29	343	1.3	89	1.9
30 - 34	507	1.9	140	3.0
35 - 39	622	2.3	165	3.5
40 - 44	949	3.5	244	5.2
45 - 49	1,510	5.5	296	6.3
50 - 54	2,191	8.0	377	8.1
55 - 59	3,004	11.0	476	10.2
60 - 64	3,684	13.5	500	10.7
65 - 69	4,130	15.1	535	11.5
70 - 74	3,710	13.6	546	11.7
75 - 79	2,941	10.8	531	11.4
80 - 84	1,946	7.1	335	7.2
85 +	1,557	5.7	379	8.1
TOTAL	27,272	100.0	4,669	100.0
AVERAGE AGE	64.5		63.4	

Table 4. Cause-Specific Proportional Mortality Ratios (PMRs) and 95 Percent Confidence Intervals (95% CIs) for Males in the Corporate Mortality File Using the U.S. Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PMR	95% CI	
All Causes of Death	27,272	27,272.00	100.0	---	---
All Malignant Neoplasms	7,697	7,206.21	106.8†	104.8	108.8
All Heart Disease	9,044	9,228.90	98.0†	96.4	99.6
Non-malignant Respiratory Disease	1636	2,131.06	76.8†	73.3	80.4
All External Causes of Death	1,809	2,440.60	74.1†	71.3	77.0

†=Significant at 5% level

Table 5. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Males in the Corporate Mortality File Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
All Malignant Neoplasms	7,697	7,697.00	100.0	---	---
Cancer of Buccal Cavity & Pharynx	126	189.63	66.4†	56.0	78.8
Cancer of Digestive Organs & Peritoneum	2,025	1,868.27	108.4†	104.4	112.6
Cancer of Esophagus	239	243.68	98.1	86.6	111.1
Cancer of Stomach	225	239.30	94.0	82.7	106.9
Cancer of Large Intestine	780	628.97	124.0†	116.0	132.6
Cancer of Rectum	135	130.29	103.6	87.7	122.5
Cancer of Biliary Passages & Liver	160	200.03	80.0†	68.7	93.2
Cancer of Pancreas	441	372.21	118.5†	108.2	129.8
Cancer of All Other Digestive Organs	45	47.42	94.9	70.9	127.0
Cancer of Respiratory System	2,220	2,837.10	78.2†	75.7	80.8
Cancer of Larynx	44	98.28	44.8†	33.6	59.6
Cancer of Trachea, Bronchus, & Lung	2,151	2,711.92	79.3†	76.7	82.0
Cancer of All Other Respiratory Organs	25	26.90	92.9	62.8	137.4
Cancer of Breast	12	9.51	126.1	71.8	221.8
Cancer of Prostate	648	603.95	107.3	99.9	115.3
Cancer of Testes & Other Male Genital Organs	28	30.85	90.8	63.2	130.3
Cancer of Kidney	265	194.74	136.1†	120.9	153.2
Cancer of Bladder & Other Urinary Organs	194	172.61	112.4	97.8	129.1
Malignant Melanoma of Skin	221	138.23	159.9†	140.6	181.8
Cancer of Eye	2	3.96	50.5	13.0	196.5
Cancer of Brain and Other Central Nervous System	355	219.24	161.9†	146.4	179.1
Cancer of Thyroid & Other Endocrine Glands	43	22.50	191.1†	142.5	256.2
Cancer of Bone	20	20.44	97.8	63.3	151.2
Cancer of All Lymphatic, Hematopoietic Tissue	938	761.22	123.2†	116.1	130.8
Lymphosarcoma & Reticulosarcoma	65	49.84	130.4†	102.6	165.8
Hodgkin's Disease	41	47.21	86.8	64.4	117.1
Leukemia & Aleukemia	327	288.48	113.4†	102.0	126.0

Table 5. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Males in the Corporate Mortality File Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
Cancer of All Other Lymphopoietic Tissue	505	375.72	134.4†	123.5	146.3
Non-Hodgkin's Lymphoma	395	291.46	135.5†	123.1	149.2
Multiple Myeloma	169	126.93	133.1†	114.7	154.5
All Other Malignant Neoplasms	598	631.10	94.8	87.8	102.3

†=Significant at 5% level

Table 6. Cause-Specific Proportional Mortality Ratios (PMRs) and 95 Percent Confidence Intervals (95% CIs) for Females in the Corporate Mortality File Using the U.S. Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PMR	95% CI	
All Causes of Death	4,669	4,669.00	100.0	---	---
All Malignant Neoplasms	1,667	1,454.39	114.6†	110.3	119.1
All Heart Disease	998	1,229.92	81.1†	77.1	85.5
Non-malignant Respiratory Disease	279	348.41	80.1†	71.6	89.6
All External Causes of Death	288	341.75	84.3†	76.2	93.2

†=Significant at 5% level

Table 7. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Females in the Corporate Mortality File Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
All Malignant Neoplasms	1,667	1,667.00	100.0	---	---
Cancer of Buccal Cavity & Pharynx	9	19.08	47.2†	25.0	88.9
Cancer of Digestive Organs & Peritoneum	289	323.00	89.5†	80.8	99.1
Cancer of Esophagus	13	16.13	80.6	47.0	138.3
Cancer of Stomach	34	32.53	104.5	74.9	145.7
Cancer of Large Intestine	120	133.00	90.2	76.1	107.0
Cancer of Rectum	18	22.61	79.6	50.4	125.8
Cancer of Biliary Passages & Liver	23	33.92	67.8	45.4	101.3
Cancer of Pancreas	71	72.74	97.6	77.8	122.5
Cancer of All Other Digestive Organs	10	11.11	90.0	48.6	166.9
Cancer of Respiratory System	376	365.12	103.0	94.3	112.4
Cancer of Larynx	1	5.77	17.3†	3.1	97.4
Cancer of Trachea, Bronchus, & Lung	373	355.71	104.9	96.0	114.6
Cancer of All Other Respiratory Organs	2	3.64	55.0	14.1	215.0
Cancer of Breast	418	362.40	115.3†	106.1	125.4
All Uterine Cancers	53	94.10	56.3†	43.6	72.8
Cancer of Cervix Uteri	23	55.35	41.6†	28.3	61.0
Cancer of Other Female Genital Organs	116	104.90	110.6	92.7	131.9
Cancer of Kidney	31	25.81	120.1	84.7	170.2
Cancer of Bladder & Other	13	15.55	83.6	48.8	143.4

Table 7. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Females in the Corporate Mortality File Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
Urinary Organs					
Malignant Melanoma of Skin	26	24.47	106.2	72.7	155.4
Cancer of Eye	0	.86	---	---	---
Cancer of Brain and Other Central Nervous System	51	46.92	108.7	83.0	142.3
Cancer of Thyroid & Other Endocrine Glands	10	6.64	150.6	81.5	278.3
Cancer of Bone	2	4.13	48.5	12.6	186.6
Cancer of All Lymphatic, Hematopoietic Tissue	167	149.40	111.8	96.9	129.0
Lymphosarcoma & Reticulosarcoma	8	8.70	92.0	46.2	183.0
Hodgkin's Disease	8	9.79	81.7	41.5	161.0
Leukemia & Aleukemia	64	56.27	113.7	89.6	144.4
Cancer of All Other Lymphopoietic Tissue	87	74.65	116.5	95.0	143.0
Non-Hodgkin's Lymphoma	70	57.18	122.4	97.3	154.0
Multiple Myeloma	25	25.20	99.2	67.3	146.3
All Other Malignant Neoplasms	106	125.53	84.4	70.3	101.4

†=Significant at 5% level

Table 8. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Males in the Corporate Mortality File Who Worked in Manufacturing \geq 30 Days Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
All Malignant Neoplasms	1,180	1,180.00	100.0	---	---
Cancer of Buccal Cavity & Pharynx	20	30.79	64.9†	42.3	99.7
Cancer of Digestive Organs & Peritoneum	303	287.11	105.5	95.7	116.4
Cancer of Esophagus	38	41.54	91.5	67.0	125.0
Cancer of Stomach	35	35.12	99.6	71.9	138.1
Cancer of Large Intestine	91	93.08	97.8	80.3	119.1
Cancer of Rectum	27	19.38	139.3	96.0	202.1
Cancer of Biliary Passages & Liver	29	32.90	88.1	61.6	126.1
Cancer of Pancreas	73	57.99	125.9†	100.7	157.4
Cancer of All Other Digestive Organs	10	6.99	143.1	77.4	264.7
Cancer of Respiratory System	389	464.42	83.8†	77.6	90.4
Cancer of Larynx	7	16.29	43.0†	21.0	87.8
Cancer of Trachea, Bronchus, & Lung	378	444.16	85.1†	78.6	92.1
Cancer of All Other Respiratory Organs	4	3.96	100.9	37.9	268.3
Cancer of Breast	2	1.42	140.9	35.5	559.2
Cancer of Prostate	77	68.98	111.6	90.1	138.3
Cancer of Testes & Other Male Genital Organs	2	2.99	66.8	17.1	260.9
Cancer of Kidney	51	31.49	162.0†	123.9	211.8
Cancer of Bladder & Other Urinary Organs	23	22.36	102.9	68.7	154.2
Malignant Melanoma of Skin	38	21.23	179.0†	131.4	243.9
Cancer of Eye	0	.58	---	---	---
Cancer of Brain and Other Central Nervous System	57	34.45	165.5†	128.6	212.9
Cancer of Thyroid & Other Endocrine Glands	4	3.34	119.9	45.1	318.6
Cancer of Bone	2	2.56	78.1	19.7	308.9
Cancer of All Lymphatic, Hematopoietic Tissue	115	109.46	105.1	88.4	124.9
Lymphosarcoma & Reticulosarcoma	8	5.14	155.7	78.6	308.4
Hodgkin's Disease	2	4.89	40.9	10.9	153.9
Leukemia & Aleukemia	35	39.94	87.6	63.4	121.2

Table 8. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Males in the Corporate Mortality File Who Worked in Manufacturing \geq 30 Days Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
Cancer of All Other Lymphopoietic Tissue	70	59.49	117.7	93.7	147.8
Non-Hodgkin's Lymphoma	56	44.42	126.1	97.6	162.8
Multiple Myeloma	21	19.55	107.4	70.3	164.1
All Other Malignant Neoplasms	97	98.93	98.1	81.1	118.6

†=Significant at 5% level

Table 9. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Females in the Corporate Mortality File Who Worked in Manufacturing \geq 30 Days Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
All Malignant Neoplasms	302	302.00	100.0	---	---
Cancer of Buccal Cavity & Pharynx	1	3.46	28.9	4.6	179.8
Cancer of Digestive Organs & Peritoneum	49	54.62	89.7	69.7	115.4
Cancer of Esophagus	3	3.01	99.7	32.4	307.3
Cancer of Stomach	9	5.26	171.0	90.2	324.2
Cancer of Large Intestine	17	22.06	77.1	48.9	121.6
Cancer of Rectum	3	3.77	79.6	25.9	244.6
Cancer of Biliary Passages & Liver	2	5.98	33.4	9.1	123.3
Cancer of Pancreas	14	12.69	110.3	66.1	183.9
Cancer of All Other Digestive Organs	1	1.84	54.4	7.9	372.2
Cancer of Respiratory System	65	73.66	88.2	71.6	108.7
Cancer of Larynx	1	1.17	85.3	12.1	601.6
Cancer of Trachea, Bronchus, & Lung	64	71.86	89.1	72.1	110.0
Cancer of All Other Respiratory Organs	0	.63	---	---	---
Cancer of Breast	65	67.00	97.0	78.5	119.9
All Uterine Cancers	8	16.05	49.9†	25.8	96.3
Cancer of Cervix Uteri	3	9.25	32.4†	11.4	92.4
Cancer of Other Female Genital Organs	25	19.00	131.6	90.1	192.0
Cancer of Kidney	10	4.71	212.2†	116.4	386.9
Cancer of Bladder & Other Urinary Organs	1	2.31	43.2	6.5	287.6
Malignant Melanoma of Skin	2	4.21	47.5	12.4	181.5
Cancer of Eye	0	.14	---	---	---
Cancer of Brain and Other Central Nervous System	10	8.40	119.1	64.8	219.0
Cancer of Thyroid & Other Endocrine Glands	0	1.10	---	---	---
Cancer of Bone	0	.60	---	---	---
Cancer of All Lymphatic, Hematopoietic Tissue	40	24.64	162.4†	121.2	217.5
Lymphosarcoma & Reticulosarcoma	0	1.12	---	---	---
Hodgkin's Disease	3	1.26	237.7	80.4	702.6

Table 9. Cause-Specific Proportional Cancer Mortality Ratios (PCMRs) and 95 Percent Confidence Intervals (95% CIs) for Females in the Corporate Mortality File Who Worked in Manufacturing \geq 30 Days Using the US Comparison Population — 1969 – 2001

CAUSE OF DEATH	OBSERVED	EXPECTED	PCMR	95% CI	
Leukemia & Aleukemia	15	9.05	165.8†	101.6	270.8
Cancer of All Other Lymphopoietic Tissue	22	13.21	166.5†	111.2	249.4
Non-Hodgkin's Lymphoma	14	9.74	143.8	86.2	240.0
Multiple Myeloma	8	4.50	177.8	90.3	350.2
All Other Malignant Neoplasms	26	22.10	117.6	81.3	170.2

†=Significant at 5% level

Additional files provided with this submission:

Additional file 1 : Latenc : 66Kb

<http://www.ehjournal.net/imedia/1908614960111178/sup1.XLS>