Mortality Update for the Pantex Weapons Facility:

Final Report

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

MORTALITY UPDATE FOR THE PANTEX WEAPONS FACILITY: FINAL REPORT

HEALTH-RELATED ENERGY RESEARCH BRANCH

National Institute for Occupational Safety and Health

January 2005

DISCLAIMER

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites.

Ordering Information

To receive documents or other information about occupational safety and health topics, contact NIOSH at

NIOSH—Publications Dissemination
4676 Columbia Parkway
Cincinnati, Ohio 45226–1998
Telephone: **1–800–35–NIOSH** (1–800–356–4675)
Fax: 513–533–8573
E-mail: pubstaft@cdc.gov

or visit the NIOSH Web site at **www.cdc.gov/niosh**

HHS (NIOSH) Publication No. 2005-124

AUTHORS

Silver, Sharon R, National Institute for Occupational Safety and Health, Division of Surveillance, Hazard Evaluations, and Field Studies, Cincinnati, Ohio

Anderson-Mahoney, Pamela[1], Health Research Association, Los Angeles, California

Burphy, Jenneh, Associated Schools of Public Health, Public Health Graduate Training Program, Atlanta, Georgia

Hiratzka, Shannon, Constella Group Inc., Durham, North Carolina

Schubauer-Berigan, Mary K, National Institute for Occupational Safety and Health, Division of Surveillance, Hazard Evaluations, and Field Studies, Cincinnati, Ohio

Waters, Kathy M, National Institute for Occupational Safety and Health, Division of Surveillance, Hazard Evaluations, and Field Studies, Cincinnati, Ohio

[1] Formerly with NIOSH

ABSTRACT

In 1985, Acquavella, et al. [1985] reported the results of a cohort mortality study of white male workers ever employed at the Pantex Plant between 1951 and the end of study date, December 31, 1978. Compared to U.S. death rates, the mortality experience of these workers suggested a strong healthy worker effect overall, but non-significant elevations were observed for leukemia and brain cancer. For the current analyses, the National Institute for Occupational Safety and Health (NIOSH) expanded the study population to include workers of both genders and all races ever employed between 1951 and 1978 and extended vital status follow-up through 1995. Summary Standardized Mortality Ratios (SMRs) were generated for these workers (the *full NIOSH cohort*).

Workers terminating or deceased by December 31, 1978, for whom complete employment records were available (the *early-term subcohort*), were included in SMR and Standardized Rate Ratio (SRR) duration of employment analyses. The all-cause SMR for the early-term subcohort (0.98, 95% confidence interval (CI) = 0.92-1.05) was higher than that seen in the full NIOSH cohort (SMR=0.81, 95% CI=0.76-0.86) and by Acquavella et al. [1985] (SMR=0.72, 95% CI=0.64-0.81) and was close to that expected from U.S. population rates. Brain cancer was no longer elevated in the full NIOSH cohort (SMR=0.51, 95% CI=0.17-1.19) in the updated analysis, although the confidence intervals span unity. The leukemia SMR was elevated (early-term subcohort SMR=1.47, 95% CI = 0.73–2.63) but SRRs showed no evidence of a positive exposure-response relation with increasing duration of employment. Lung cancer SMRs with 10- and 15-year lags were just below expectation. Breast cancer was elevated only in workers with employment durations of 5 to 10 years. The SMR for prostate cancer was as expected, but this outcome showed a statistically significant positive exposure-response [slope: $1.36 \cdot 10^{-5}$ per person-year (PY)·year of employment (YOE), standard error: $4.31 \cdot 10^{-6}$ per PY·YOE], with a very high, though imprecise, point estimate (SRR=7.57, 95% CI=1.03–55.72) for workers employed at least 20 years with a 10-year lag imposed. Multiple myeloma also exhibited a statistically significant positive exposure-response. Due to the potential for positive bias in the early-term subcohort, caution should be exercised in generalizing the exposure-response results. These findings suggest the need for collection of full employment information about workers employed beyond 1978, as well as the estimation of occupational exposure for Pantex workers.

ABBREVIATIONS

ATSDR	Agency for Toxic Substance and Disease Registry
CI	confidence interval
DOE	U.S. Department of Energy
ICD	international classification of disease
LTAS	Life Table Analysis System
mSv	millisievert
NDI	national death index
NIOSH	National Institute for Occupational Safety and Health
PC-LTAS	personal computer Life Table Analysis System
PY	person-year
REM	Roentgen Equivalent Man
SE	standard error
SMR	standardized mortality ratio
SRR	standardized rate ratio
SSA	Social Security Administration
YOE	years of employment

INTRODUCTION

The U.S. Department of Energy (DOE) Pantex Plant, located near Amarillo, Texas, originated as a conventional ammunitions loading facility but became involved with assembly and disassembly of nuclear weapons in 1951. The facility's functions include assembling conventional high explosive and nuclear materials into new nuclear weapons, maintaining and testing existing nuclear weapons, disassembling these weapons, and performing related research and development [DOE 1999]. Employees have been potentially exposed to components of both nuclear weapons and high explosives during these procedures.

As described by Acquavella et al. [1985], potential exposures at the site include low-level external radiation from nuclear weapons components and from industrial radiographic equipment, as well as a number of solvents and other chemicals involved in high-explosives processing. Unfortunately, complete dosimetry information was readily available only for workers first hired after 1962 and industrial hygiene sampling was limited prior to 1973, limiting the feasibility of evaluating the health outcomes of specific on-site exposures.

In 1985, Acquavella reported the results of a cohort mortality study of workers at the Pantex Plant. The study compared total and cause-specific mortality for 3,564 white male workers ever employed between the start of plant operations in 1951 and the end of study date, December 31, 1978, with U.S. death rates. Females and nonwhite males were excluded because the relatively small numbers of such persons did not allow meaningful analyses. No exposure data were used except for identification of a subcohort of workers known to have cumulative recorded radiation exposure of at least 1 rem (10 mSv).

The small number of white male deaths (269) and relatively short length of follow-up of the workforce (average=14.6 years) limited the power of the study to detect statistically significant excesses or deficits in mortality rates, compared to expected rates. Overall mortality was below expectation, with a Standardized Mortality Ratio (SMR) of 0.72 (95% confidence interval [CI]=0.64–0.81), a finding Acquavella and colleagues attributed to a strong healthy worker effect and short follow-up time. However, the authors did report non-statistically significant elevations for leukemia (SMR=1.28, 95% CI=0.35–3.27, 4 deaths) and for brain cancer (SMR=1.36, 95% CI= 0.37–3.47, 4 deaths). The all-cause mortality rate was even lower among the 1-rem subcohort than in the general cohort. Lung cancer and cerebrovascular SMRs were higher in this subcohort, but these results were based on very small numbers (2 cases and 1 case, respectively) and CIs were quite wide.

Because the findings for leukemia and brain cancer warranted additional follow-up, the National Institute for Occupational Safety and Health (NIOSH) initiated a limited analysis to update the cohort's mortality experience and to examine mortality trends with increasing duration of employment. Resources to identify, collect, and code additional employment and exposure records were not available at the time the current study was conducted, so duration of employment was used as a nonspecific measure of cumulative workplace exposures.

NIOSH STUDY POPULATION

The current study population includes all males and females, regardless of race, ever employed at the Pantex facility between the start of operations in 1951 and December 31, 1978. Vital status follow-up was extended through December 31, 1995. This *full NIOSH cohort* comprises 4,668 workers. Because complete work history information was not collected for workers who continued employment after December 31, 1978, analyses involving duration of employment were limited to an *early-term subcohort* of 2,721 workers who had died or terminated employment before 1979. Analytic files included workers' sex and race, as well as dates of birth, hire, and termination (where available). Date and cause of death were included for workers known to be deceased. Vital status follow-up was conducted through December 31, 1995 using Social Security Administration (SSA) death tapes and the National Death Index (NDI). An attempt was made to obtain all death certificates for SSA- or NDI-confirmed deaths. A qualified nosologist coded all deaths according to the International Classification of Diseases (ICD) revision in effect at the time of each death. No cause of death was available for 44 people from the full NIOSH cohort, including 38 from the *early-term subcohort*. These deaths were retained in the all-cause SMR analyses and were included in the *other unspecified* cause of death category. Only underlying cause of death was considered in the analyses.

NIOSH STUDY ANALYSIS

The NIOSH personal computer Life Table Analysis System (PC-LTAS, version 1.0d) was used to generate expected numbers for all deaths, all cancer deaths, and cause-specific deaths for each race and sex within 5-year age and 5-year calendar time periods [NIOSH 2001]. Workers of unknown race (24.2%) were assumed to be white. Hispanic workers were included in this category as well.

Expected and observed deaths were enumerated for each of these age and calendar time periods from January 1, 1951 through December 31, 1995. Expected numbers of deaths were based on U.S. population death rates specific for the race, gender, and 5-year age and calendar time periods, applied to the number of person-years at risk of dying. Numbers of deaths observed for each cause were divided by the expected number of deaths to obtain cause-specific SMRs.

Outcomes of *a priori* interest based on a site summary report of the Pantex Plant by the Agency for Toxic Substance and Disease Registry (ATSDR) describing community health concerns about a number of malignancies were as follows: lung, bone, prostate, brain, breast, thyroid, all cancers combined, leukemia, and malignant pleural mesothelioma [ATSDR 1996]. SMRs were calculated with no lag period for all LTAS causes of death. The statistical significance of each SMR was assessed assuming a Poisson distribution, with two-sided 95% CIs.

Because SMRs are affected by the age structure of different exposure categories within the study population, comparison of SMRs for exposure groups can be misleading. Standardized Rate Ratios (SRRs) allow for comparison among populations by weighting observed stratum-specific rates according to a common (internal) standard [Rothman 1986]. For the early-term subcohort, SMRs and SRRs were calculated for leukemia using 0-, 2-, and 5-year lag periods and for solid tumors using 10-, 15-, and 20-year lag periods. LTAS generates Taylor-series-based CIs for each

SRR. For exposure-response analyses based on duration of employment, a linear trend is calculated in a regression of directly standardized rates. Statistical significance of each trend was determined using a two-tailed z-test with an alpha of 0.05 [Cassinelli et al. 1998].

RESULTS

Demographics

The demographics of the early- and late-term subcohorts and the full NIOSH cohort are shown in Table 1. The early- and late-term subcohorts were quite similar in sex and race, although the percentages of nonwhite males and females were somewhat higher, and the percentage of white females was slightly lower in the late-term subcohort. Mean age at hire and attained age (at death or end of study) were virtually identical. Both the full cohort and the subcohorts were still fairly young at end of follow-up, with 75% of workers aged 70 or younger (Table 2).

Vital status of the subcohorts at end of follow-up differed substantially (Table 3). While 1,032 members (22.1%) of the full NIOSH cohort were deceased by the study end date, the early-term subcohort was 29.4% deceased, while only 11.9% of the late-term subcohort had died. A total of 175 workers were of unknown vital status, with 173 of these from the early-term subcohort. The latter were considered alive for all analyses.

The other major difference between the early- and late-term subcohorts was the average duration of employment. Average duration of employment for the early-term subcohort was 4.4 years. Although duration from date of hire to termination date could not be determined for late-term workers due to lack of work history data (truncating employment for this subset of workers at the end of 1978), the last date of known employment for the group as a whole gave an average duration of 11 years. This figure underestimates the late-term workers' average duration of employment, but it is still more than double the average duration for the early-term subcohort. Finally, members of the late-term cohort were hired, on average, 6 years later than their early-term counterparts.

Summary SMR Analyses, Full NIOSH Cohort and Early-Term Subcohort

To evaluate the effects of restricting some analyses to workers who terminated employment as of 1978 (the early-term subcohort), we generated summary SMR figures (Table 4 and Appendix A) for both the early-term subcohort and for the full NIOSH cohort. The SMR for all-cause mortality still exhibited a healthy-worker effect in the full NIOSH cohort, at 0.81 (95% CI=0.76–0.86), but was very close to expectation in the early-term subcohort at 0.98 (95% CI=0.92–1.05). Similarly, all-cancer mortality was further below expectation in the full NIOSH cohort (SMR=0.78, 95% CI=0.69–0.88) than in the early-term subcohort (SMR=0.86, 95% CI=0.74–1.00). No deaths from bone or thyroid cancer, two outcomes of *a priori* interest, occurred in the subcohort. A number of other causes of death were below expectation, with no cases of tuberculosis or of malignant neoplasms of the tongue, peritoneum, cervix, uterus, eye, or connective tissue (Appendix A). Ischemic heart disease was also lower than expected, with CIs below 1.00 for both the full NIOSH cohort (SMR=0.70, 95% CI=0.62–0.79) and the early-term subcohort (SMR=0.81, 95% CI=0.70–0.94).

Brain cancer was elevated in the original report, but in the current analysis, the SMR for this cause of death was below expectation in the full NIOSH cohort (SMR=0.51, 95% CI=0.17–1.19, 5 deaths) and the early-term subcohort (SMR=0.67, 95% CI=0.18–1.71, 4 deaths). However, deaths from neoplasms of the eye, brain, and other parts of the nervous system, unspecified as to benign or malignant, were elevated, though with very few cases, in both the full NIOSH cohort (SMR=1.66, 95% CI=0.34–4.84, 3 deaths) and early-term subcohorts (SMR=1.76, 95% CI= (0.21–6.34, 2 deaths). These poorly-classified deaths hinder definitive comparison of brain cancer deaths observed in these cohorts with the expectation from U.S. population rates.

For most causes of death, mortality rates in relation to the general U.S. population were lower, though confidence intervals are very wide, for the full NIOSH cohort than for the early-term subcohort. An exception was prostate cancer, which had very similar SMR results for the early-term subcohort (SMR=1.03, 95% CI=0.55–1.76) and the full NIOSH cohort (SMR=1.05, 95% CI=0.64–1.62) with 10-year lags; results were similar with a 15-year lag imposed.

SMR and SRR Duration of Employment Analyses, Early-Term Subcohort

SMR duration runs and duration-based SRR analyses were limited to the early-term subcohort (Table 5). This group exhibited a leukemia SMR of 1.47 (95% CI=0.73–2.63) with no lag and an SMR of 1.50 (95% CI=0.75–2.75) with a 2-year lag. However, in SRR analyses, the exposure-response trends were negative with both 0- and 2-year lags, with the negative trend statistically significant with a 2-year lag (Figures 1 and 2). This negative trend is influenced by a deficit of cases among workers in the highest duration of employment category, >=20 years, with an SRR of 0.43 (95% CI=0.05–3.63) with a 2-year lag. For multiple myeloma, the SMR was elevated at 2.09 (95% CI= 0.76–4.55, 6 deaths) with a 10-year lag and the exposure-responses were positive and statistically significant with 10- and 15-year lags (Figures 3 and 4). Prostate cancer had only a slightly elevated SMR, but the SRRs showed statistically significant positive exposure responses with 10- and 15-year lags, with very high, though imprecise, point estimates for workers employed for at least 20 years (Figures 5 and 6).

Several malignancies which had SMR results below expectation (1.00) did show risk differences by duration of employment in the SRR analyses (Table 4). Lung cancer was elevated in the two intermediate duration categories with a 10-year lag and in the 5 to <10 year category with a 15-year lag. However, the SRR was well below expectation for workers employed for at least 20 years, yielding a negative slope that was statistically significant with the 15-year lag (Figures 7 and 8). The SMR for breast cancer in white females was also lower than expected at 0.85 (95% CI =0.28–2.00, 5 deaths). This outcome was elevated in the category 5 to <10 years in both SMR and SRR analyses with no lag, but there were no deaths at any longer duration, so analyses with longer lags could not be performed. Similarly, while the SMR for pancreatic cancer was below expectation at 0.49 (95% CI=0.16–1.15, 5 deaths), the unlagged SRRs were elevated in the 5 to <10 year and 10 to <20 year duration categories, with no deaths from this cause observed in workers employed for at least 20 years. The positive exposure-response was not statistically significant, and all cases shifted into duration categories below 10 years when lags of 10- or 15-years were applied.

DISCUSSION, LIMITATIONS, AND RECOMMENDATIONS

Attenuation of the healthy worker selection effect with additional follow-up has been noted before in occupational studies [Baillargeon et al. 1998]. Acquavella et al. [1985] observed a strong healthy worker effect among white male Pantex workers followed through 1978. Results for the full NIOSH cohort of all workers employed between 1951 and 1978, followed through 1995, show a weaker healthy worker effect.

A related phenomenon, the healthy worker survivor effect, has been observed in a number of occupational studies which found that workers who remain employed tend to be healthier than those who terminate [Siebert et al. 2001; Baillargeon and Wilkinson 1999]. The healthy worker survivor effect tends to attenuate exposure-related risk estimates in a cohort that includes long-term workers. As the early-term cohort by definition excludes long-term workers who were healthy enough to continue employment beyond 1978, the healthy worker survivor effect is likely attenuated, leading to an upward bias of the SMR results, compared to mortality expectation for the full cohort. Members of the early-term subcohort had shorter average employment durations than their late-term counterparts. Because of the 1978 employment cutoff, a worker in the early-term cohort first employed in 1960 could have worked at most 18 years, while a member of the late-term cohort first employed in 1960 would have worked anywhere between 18 and 35 years at Pantex. The shorter-term workers in the early-term cohort may have been more likely than their late-term counterparts to terminate employment due to ill health, have had poorer access to health care, or have had lifestyle factors detrimental to health, all suspected components of the healthy worker survivor effect [Kolstad and Olsen 1999]. Comparison of summary SMR results for the full NIOSH cohort and the early-term subcohort is consistent with this possibility, as SMRs for most outcomes are lower for the full cohort. Excluding healthy, long-term workers could also lead to a positive bias in the SRR results for the longer employment duration categories, and hence could be responsible in part for positive trends observed in the SRR analyses. These factors limit the generalizability of duration analyses beyond the early-term subcohort. In the current analyses, the differences between the SMR and SRR results suggest that there are indeed differences in age structures of workers in the different duration categories and in the ages of cases at time of death; this suggestion was confirmed by examination of person-year distributions by age at accrual and final employment duration categories for leukemia and prostate cancer (Tables 6 and 7). These findings weigh in favor of preferential focus on the SRR results.

In addition to biases introduced by exclusion of workers with late termination dates, it is possible that truncation of early employment histories could affect the duration analyses. Employment dates for the NIOSH cohort came from the Acquavella files, where plant operation was considered to start in 1951. Non-nuclear work at Pantex began as early as 1942. It is possible that a subset of workers were first employed at Pantex before 1951 but that these early employment periods were discounted. However, the hire dates for the full cohort do not show a disproportionate number starting in 1951, so the number of workers affected and any resulting bias is probably limited.

The elevated SMR for leukemia observed by Acquavella was again seen in this study, but the CIs include 1.0, and SRR analyses showed the risk decreasing with increasing duration of employment. It is important to note that these results are based on a total of only 11 cases, with only 1 case in workers employed at least 20 years. On the other hand, mortality from both prostate cancer and multiple myeloma showed statistically significant increases with duration of employment, suggesting the need to explore whether these causes of death may be related to some exposure at the site. The excess of prostate cancer was similar in the early-term subcohort and full NIOSH cohort, evidence that the overall excess is not due to selection bias operating in the early-term subcohort and warrants further follow-up.

NIOSH findings suggest that a future, more comprehensive study might be informative. At the end of follow-up, only 29% of the early-term subcohort and only 12% of the late-term subcohort were deceased. Moreover, due to the small number of deaths and the short average duration of employment in the early-term subcohort, longer lag times (>1 years) could not be properly assessed for a number of solid tumor outcomes, and CIs were very wide for many duration of exposure categories. Procurement of work history data for workers still or first employed after 1978 would allow duration-based evaluation of the full NIOSH cohort, facilitate enhanced assessment of the full range of lag times for solid tumors, and reduce the problems of bias discussed above.

While several causes of death show positive trends with duration of employment at the site, exposure data must be used to assess the actual occupational risk factors behind this surrogate measure. Prostate cancer and multiple myeloma are outcomes of particular interest, although the number of cases of the latter probably precludes in-depth analysis. Records containing specific exposure information are reported by the Pantex staff to reside on site and at record repositories. While a large portion of these records would need to be computerized before they could be used in an in-depth analysis, this effort is key to elucidation of the findings of this preliminary report.

REFERENCES

Acquavella JF, Wiggs LD, Waxweiler RJ, Macdonell DG, Tietjen GL, Wilkinson GS [1985]. Mortality among workers at the Pantex weapons facility. Health Physics 48:735–46.

ASTDR [1996Site Summary Report on the Pantex Plant in Texas. Agency for Toxic Substances and Disease Registry. Atlanta, GA: Agency for Toxic Substances and Disease Registry.

Baillargeon J, Wilkinson G [1999]. Characteristics of the healthy survivor effect. Am J Ind Epidemiol 35:343–347.

Baillargeon J, Wilkinson G, Rudkin L, Baillargeon G, Ray L [1998]. Characteristics of the healthy worker effect: a comparison of male and female occupational cohorts. J Occ Env Med 40(4):368–373.

Cassinelli R II, Kock KJ, Steenland K, Spaeth S, Laber P [1998]. User documentation PC LTAS. Washington, DC: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

DOE [1999]. Comprehensive epidemiologic data resource. Washington, DC: U.S. Department of Energy, Office of Epidemiologic Studies, p. 48.

Kolstad H, Olsen J [1999]. Why do short term workers have high mortality? Am J Epidemiol 149(4): 347–351.

NIOSH [2001]. PC-Life Table Analysis System (Version 1.0 d). Cincinnati, OH: U.S. Department of Health and Human Services, Center for Disease Control and Prevention; National Institute for Occupational Safety and Health http://dshefs.niosh.cdc.gov/ltas/LT96MAST.html.

Rothman K [1986]. Modern epidemiology. Boston,MA:.Little, Brown, and Company, p. 47.

Siebert U, Rothenbacher D, Daniel U, Brenner H [2001]. Demonstration of the healthy worker survivor effect in a cohort of workers in the construction industry. Occ Environ Med 58(12):774–799.

Table 1. Demographics of full NIOSH cohort and early-term subcohort.

	Full NIOSH cohort*		Early-term subcohort†		Late-term subcohort‡	
White males‡	3,549	*(76.0%)*	2,077	*(76.3%)*	1,472	*(75.6%)*
White females	889	*(19.0%)*	569	*(20.9%)*	320	*(16.4%)*
Nonwhite males	152	*(3.3%)*	54	*(2.0%)*	98	*(5.0%)*
Nonwhite females	78	*(1.7%)*	21	*(0.8%)*	57	*(2.9%)*
Total	4,668		2,721		1,947	
Mean attained age§	60.0		60.7		59.0	
Mean age at hire	31.2		30.7		31.8	
Mean year of hire	1964		1961		1967	
Mean duration of employment**	7.2		4.4		11.0	

*All workers ever employed at Pantex between the start of operations in 1951 and December 31, 1978.
†Limited to those workers who died or terminated employment as of December 31, 1978.
‡Note that Hispanics are included in the white category. Workers of unknown race are assumed white and workers of unknown sex are assumed male.
§Age is calculated as age at death for deceased workers and age at end of study (12/31/1995) for all others.
**Duration of employment through later of termination date (early-term subcohort) or 12/31/1978 (late-term subcohort).

Table 2. Age distribution* of the full NIOSH cohort and early-term subcohort.

	Full NIOSH cohort†		Early-term subcohort‡	
Age category	**Number**	**Percent of total**	**Number**	**Percent of total**
20-29	12	*0.3*	11	*0.4*
30-39	90	*1.9*	40	*1.5*
40-49	974	*20.9*	511	*18.8*
50-59	1160	*24.9*	711	*26.1*
60-69	1331	*28.5*	765	*28.1*
70-79	868	*18.6*	501	*18.4*
80 and over	233	*5.0*	182	*6.7*

*Age is calculated as age at death for deceased workers and age at end of study (12/31/1995) for all others.
†All workers ever employed at Pantex between the start of operations in 1951 and December 31, 1978.
‡Limited to those workers who died or terminated employment as of December 31, 1978.

Table 3. Vital status of full NIOSH cohort and early- and late-term subcohorts as of December 31, 1995.

		Alive	Dead	Unknown*
Full NIOSH cohort†	Males	2,663 *(71.9%)*	947 *(25.6%)*	91 *(2.5%)*
	Females	798 *(82.5%)*	85 *(8.8%)*	84 *(8.7%)*
	Total	3,461 *(74.1%)*	1,032 *(22.1%)*	175 *(3.8%)*
Early-term subcohort‡	Males	1,308 *(61.4%)*	732 *(34.3%)*	91 *(4.3%)*
	Females	440 *(74.6%)*	68 *(11.5%)*	82 *(13.9%)*
	Total	1,748 *(64.2%)*	800 *(29.4%)*	173 *(6.4%)*
Late-term subcohort§	Males	1,355 *(86.3%)*	215 *(13.7%)*	0 *(0%)*
	Females	3 58 *(95.0%)*	17 *(4.5%)*	2 *(0.5%)*
	Total	1,713 *(88.0%)*	232 *(11.9%)*	2 *(0.1%)*

*Considered alive in all analyses.
†All workers ever employed at Pantex between the start of operations in 1951 and December 31, 1978.
‡Limited to members of the full NIOSH cohort who died or terminated employment as of December 31, 1978.
§ Limited to members of the full NIOSH cohort still employed after December 31, 1978.

Table 4. Summary SMR[*] results–full cohort and early-term subcohort.

		Full NIOSH cohort	Early-term subcohort
All causes, no lag	Observed	1,031	800
	Expected	1,273.21	814.23
	SMR (95% CI)	0.81 (0.76–0.86)[†]	0.98 (0.92–1.05)
All cancers, no lag	Observed	258	178
	Expected	331.78	206.31
	SMR (95% CI)	0.78 (0.69–0.88)[†]	0.86 (0.74–1.00)
Lung Cancer, 10-year lag	Observed	95	64
	Expected	106.71	65.13
	SMR (95% CI)	0.89 (0.72–1.09)	0.98 (0.76–1.25)
	SRR (95% CI)		Slope: -1.83e-05
			SE: 1.03e-05
Lung cancer, 15-year lag	Observed	85	58
	Expected	96.97	60.05
	SMR (95% CI)	0.88 (0.70–1.08)	0.97 (0.73–1.25)
	SRR (95% CI)		Slope: -2.18e-05[†]
			SE 6.74e-06
Leukemia, no lag	Observed	13	11
	Expected	11.88	7.49
	SMR (95% CI)	1.09 (0.58–1.87)	1.47 (0.73–2.63)
	SRR (95% CI)		Slope: -3e-06
			SE 1.63e-06
Leukemia, 2-year lag	Observed	13	11
	Expected	11.60	7.32
	SMR (95% CI)	1.12 (0.60–1.92)	1.50 (0.75–2.75)
	SRR (95% CI)		Slope:-3.32e-06[†]
			SE: 5.85e-07
Multiple myeloma, 10-year lag	Observed	8	6
	Expected	4.62	2.87
	SMR (95% CI)	1.73 (0.75–3.41)	2.09 (0.76–4.55)
	SRR (95% CI)		Slope: 2.81e-06[†]
			SE: 1.7e-07
Multiple myeloma, 15-year lag	Observed	8	6
	Expected	4.21	2.64
	SMR (95% CI)	1.90 (0.82–3.75)	2.27 (0.83–4.94)
	SRR (95% CI)		Slope: 2.04e-06[†]
			SE: 5.16e-08
Prostate cancer, white males, 10-year lag	Observed	20	13
	Expected	19.05	12.60
	SMR (95% CI)	1.05 (0.64–1.62)	1.03 (0.55–1.76)
	SRR (95% CI)		Slope: 1.36e-05[†]
			SE: 4.31e-06
Prostate cancer, white males, 15-year lag	Observed	20	13
	Expected	18.11	12.02
	SMR (95% CI)	1.10 (0.67–1.71)	1.08 (0.58–1.85)
	SRR (95% CI)		Slope: 3.12e-05[†]
			SE: 4.34e-06

[*] Abbreviations: CI = confidence interval; SMR = standardized mortality ratio; SRR = standardized rate ratio; SE = standard error.
[†] 2-sided p-value <0.05.
[‡] 2-sided p-value <0.01.

Table 5. SMR[*] and SRR results for early-term subcohort by duration of employment.

		Duration of Employment				
		0–<5 years	5–<10 years	10–<20 years	>=20 years	Totals, slope & SE for SRR
All causes, no lag	Observed	505	94	142	59	800
	Expected	526.20	117.23	122.28	48.45	814.23
	SMR (95% CI)	0.96 (0.88–1.05)	0.80 (0.65–0.98)	1.16 (0.98–1.37)	1.22 (0.93–1.57)	0.98 (0.92–1.05)
All cancers, no lag	Observed	107	29	28	14	178
	Expected	134.70	30.18	29.49	11.94	206.31
	SMR (95% CI)	0.79[†] (0.65–0.96)	0.96 (0.64–1.39)	0.95 (0.63–1.38)	1.17 (0.64–2.00)	0.86 (0.74–1.00)
Lung cancer, 10-year lag	Observed	38	13	10	3	64
	Expected	44.61	10.09	8.28	2.15	65.13
	SMR (95% CI)	0.85 (0.60–1.17)	1.29 (0.69–2.24)	1.21 (0.58–2.28)	1.40 (0.28–4.58)	0.98 (0.76–1.25)
	SRR (95% CI)	1.00	1.69 (0.88–3.25)	1.62 (0.76–3.45)	0.34 (0.10–1.10)	Slope: -1.83e-05 SE: 1.03e-05
Lung cancer, 15-year lag	Observed	37	13	6	2	58
	Expected	42.77	9.41	6.72	1.16	60.05
	SMR (95% CI)	0.87 (0.61–1.20)	1.38 (0.74–2.40)	0.89 (0.33–2.04)	1.73 (0.19–7.51)	0.97 (0.73–1.25)
	SRR (95% CI)	1.00	1.61 (0.83–3.14)	0.93 (0.32–2.71)	0.22 (0.05–0.93)	Slope: -2.18e-05[‡] SE 6.74e-06
Leukemia, no lag	Observed	5	3	2	1	11
	Expected	4.95	1.08	1.04	0.42	7.49
	SMR (95% CI)	1.01 (0.33–2.50)	2.78 (0.56–9.10)	1.93 (0.22–8.36)	2.39 (0.03–19.49)	1.47 (0.73–2.63)
	SRR (95% CI)	1.00	1.65 (0.38–7.17)	0.86 (0.14–5.10)	0.48 (0.06–4.19)	Slope: -3e-06 SE 1.63e-06
Leukemia, 2-year lag	Observed	6	2	2	1	11
	Expected	4.86	1.06	1.01	0.39	7.32
	SMR (95% CI)	1.23 (0.45–2.82)	1.88 (0.21–8.16)	1.99 (0.22–8.64)	2.55 (0.03–20.84)	1.50 (0.75–2.75)
	SRR (95% CI)	1.00	1.11 (0.22–5.62)	0.82 (0.14–4.66)	0.43 (0.05–3.63)	Slope:-3.32e-06[‡] SE: 5.85e-07
Multiple myeloma, 10-year lag	Observed	3	1	2	0	6
	Expected	1.93	0.43	0.38		2.87
	SMR (95% CI)	1.55 (0.31–5.08)	2.30 (0.03–18.80)	5.22 (0.59–22.65)	0	2.09 (0.76–4.55)
	SRR (95% CI)	1.00	1.16 (0.12–11.27)	1.49 (0.25–8.98)	0	Slope: 2.81e-06[‡] SE: 1.7e-07
Multiple myeloma, 15-year lag	Observed	3	1	2	0	6
	Expected	1.84	0.41	0.32		2.64
	SMR (95% CI)	1.63 (0.33–5.33)	2.46 (0.03–20.03)	6.17 (0.69–26.80)	0	2.27 (0.83–4.94)
	SRR (95% CI)	1.00	1.13 (0.12–10.96)	1.35 (0.22–8.17)	0	Slope: 2.04e-06[‡] SE: 5.16e-08
Prostate cancer, white males, 10-year lag	Observed	5	2	4	2	13
	Expected	7.79	1.81	2.18	0.82	12.60
	SMR (95% CI)	0.64 (0.21–1.59)	1.11 (0.12–4.80)	1.83 (0.49–5.09)	2.44 (0.27–10.59)	1.03 (0.55–1.76)
	SRR (95% CI)	1.00	1.60 (0.31–8.36)	2.14 (0.54–8.45)	7.57 (1.03–55.72)	Slope: 1.36e-05[‡] SE: 4.31e-06
Prostate cancer, white males, 15-year lag	Observed	5	3	4	1	13
	Expected	7.75	1.81	1.95	0.51	12.02
	SMR (95% CI)	0.65 (0.21–1.60)	1.66 (0.33–5.43)	2.05 (0.55–5.70)	1.95 (0.03–16.00)	1.08 (0.58–1.85)
	SRR (95% CI)	1.00	2.19 (0.51–9.38)	5.17 (1.07–24.91)	7.04 (0.82–60.37)	Slope: 3.12e-05[‡] SE: 4.34e-06

[*] Abbreviations: CI = confidence interval; SMR = standardized mortality ratio; SRR = standardized rate ratio; SE = standard error.
[†] 2-sided p-value <0.05.
[‡] 2-sided p-value<0.01.

Table 6. Percent of person-years contributed to employment duration categories by age, early-term cohort, no lag, leukemia SMR* and SRR results.

	Final employment duration			
Age at accrual	**<5 years**	**5–<10 years**	**10–<20 years**	**>=20 years**
<30	12.6%	11.4%	6.9%	1.4%
30–39	25%	24.3%	18.1%	9.1%
40–49	26.7%	27.6%	23.6%	23.6%
50–59	19.9%	20.9%	25.1%	27.3%
60–69	11.5%	11.6%	16.7%	22.7%
70+	4.3%	4.3%	9.6%	15.9%
Total	100%	100%	100%	100%
SMR	1.01	2.78	1.93	2.39
SRR	1	1.65	0.86	0.48
Number of deaths	5	3	2	1
Age of cases at death	50, 70, 75, 75, 80	30, 65, 65	40, 65	75

* Abbreviations: SMR = standardized mortality ratio; SRR = standardized rate ratio.

Table 7. Percent of person-years contributed to employment duration categories by age, early-term cohort, 10-year lag, prostate cancer SMR* and SRR results.

	Final employment duration			
Age at accrual	**<5 years**	**5–<10 years**	**10–<20 years**	**>=20 years**
<30	30.4%	0.1%	0.1%	0.1%
30–39	42.3%	13.9%	10.4%	7.0%
40–49	18.6%	33.0%	25.3%	19.3%
50–59	7.2%	28.9%	27.4%	25.7%
60–69	1.3%	16.9%	22.3%	27.2%
70+	0.2%	7.2%	14.5%	20.7%
Total	100%	100%	100%	100%
SMR	0.64	1.11	1.83	2.44
SRR	1.00	1.60	2.14	7.57
Number of Deaths	5	2	4	2
Age of Cases at Death	60, 65, 70, 75, 75	55, 75	50, 65, 80, 85	65, 75

* Abbreviations: SMR = standardized mortality ratio; SRR = standardized rate ratio.

Figure-1 SRRs for Leukemia and Aleukemia by Duration of Employment, No Lag

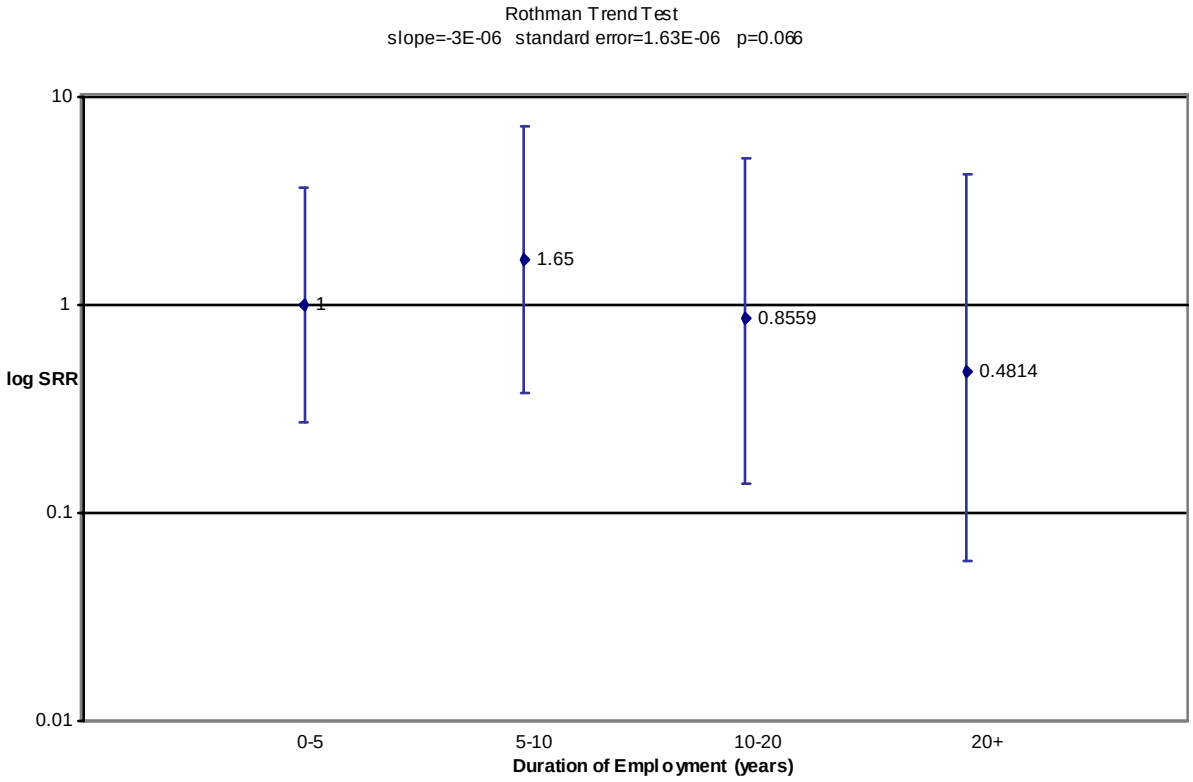


Figure-2 SRRs for Leukemia and Aleukemia by Duration of Employment, 2 Year Lag

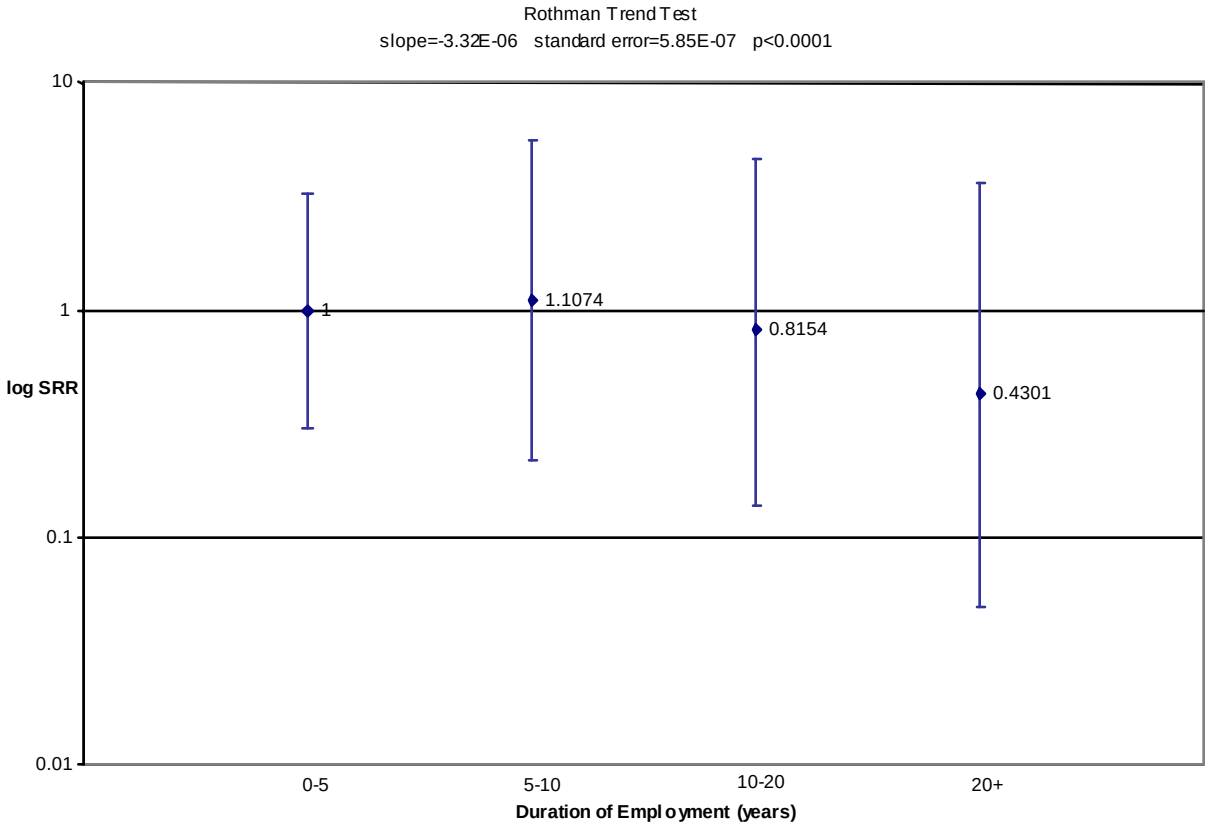


Figure 3- SRRs for Multiple Myeloma by Duration of Employment, 10 Year Lag

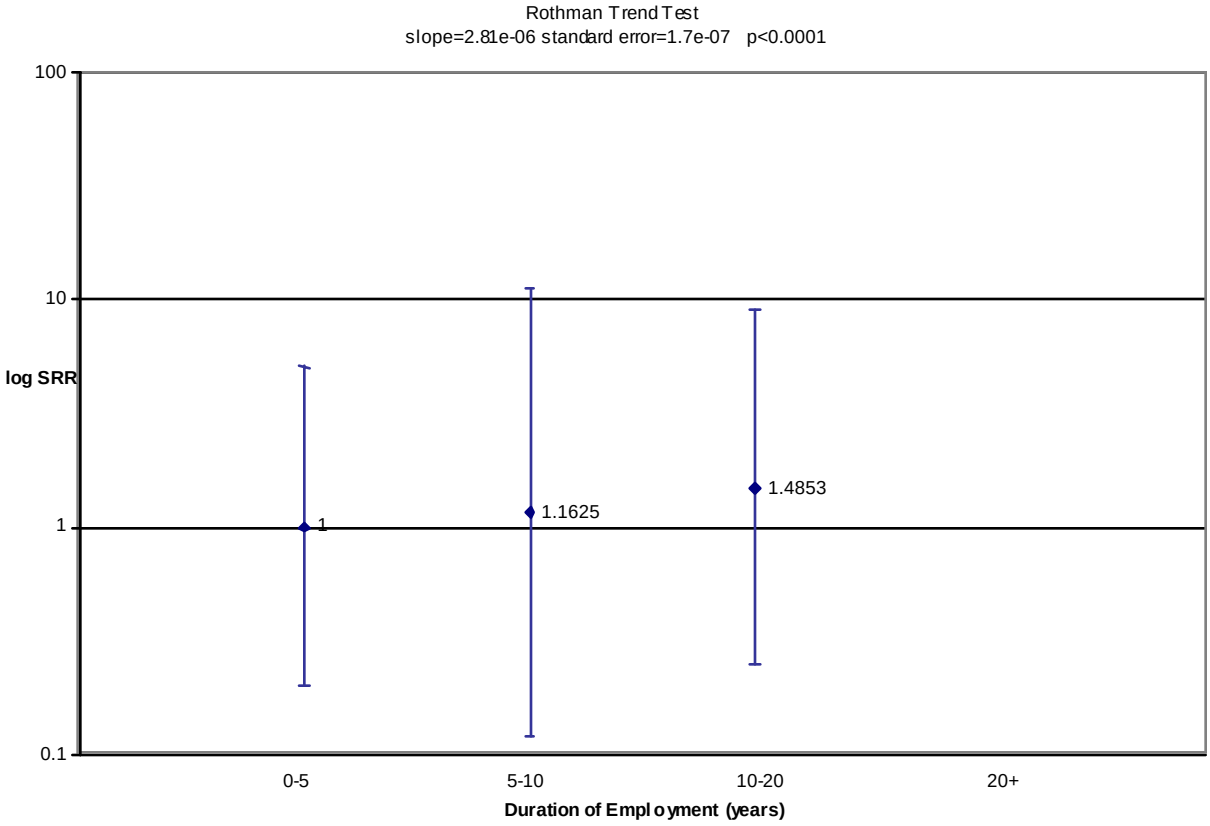


Figure 4- SRRs for Multiple Myeloma by Duration of Employment, 15 Year Lag

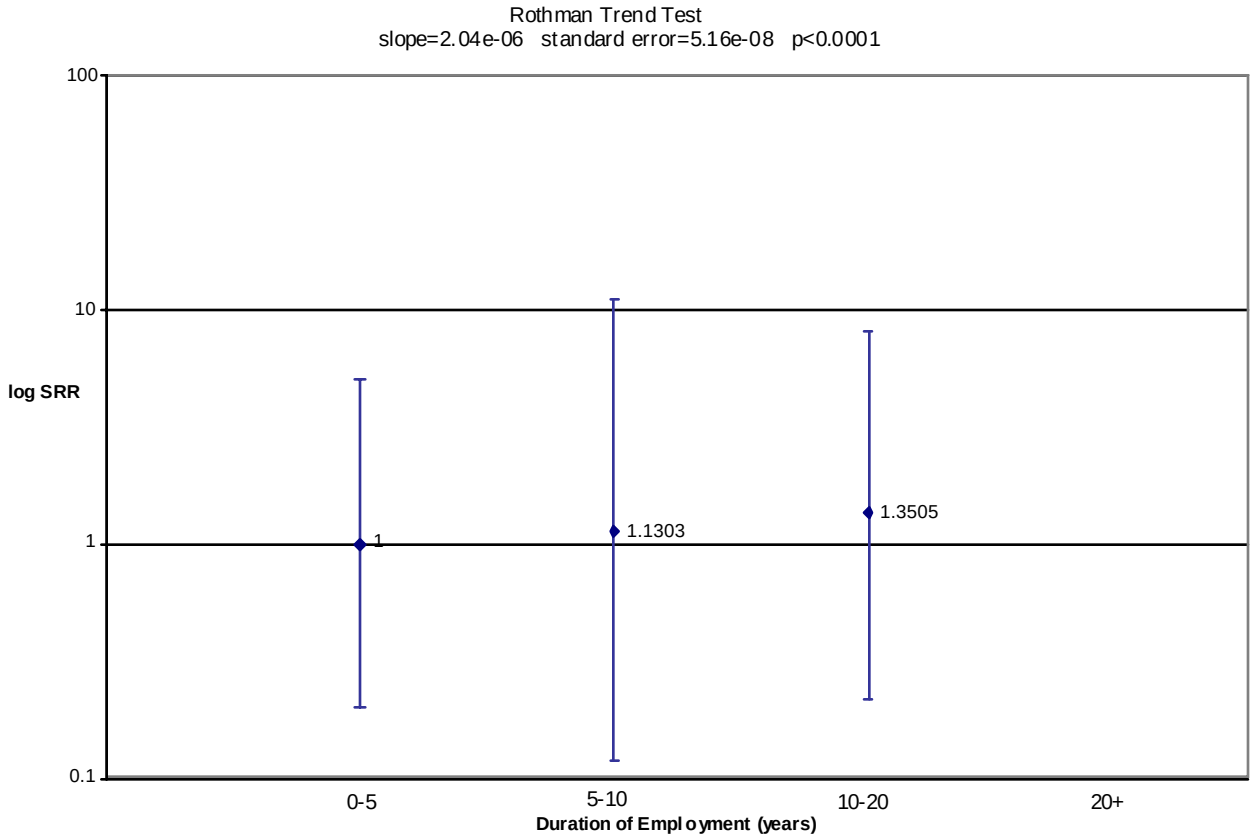


Figure 5- SRRs of Prostate Cancer by Duration of Employment, 10 Year Lag

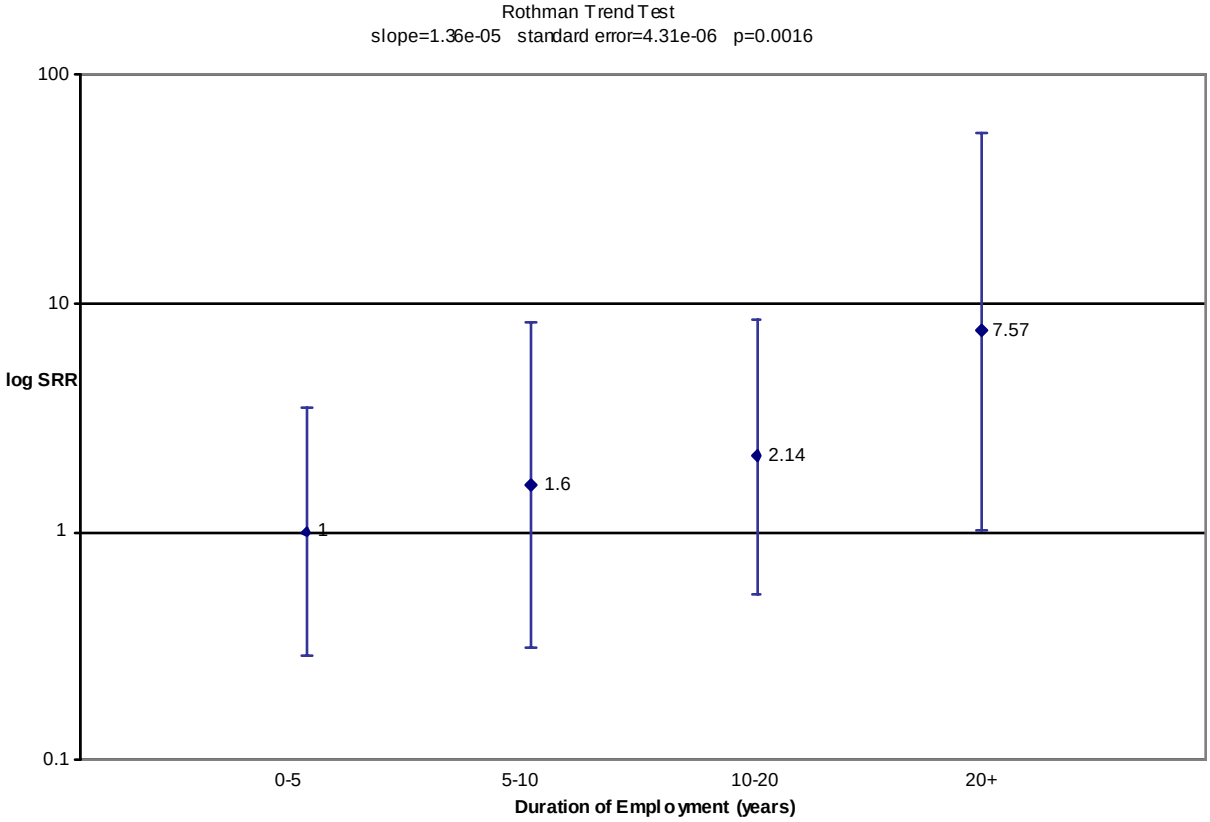


Figure 6- SRRs for Prostate Cancer by Duration of Employment, 15 Year Lag

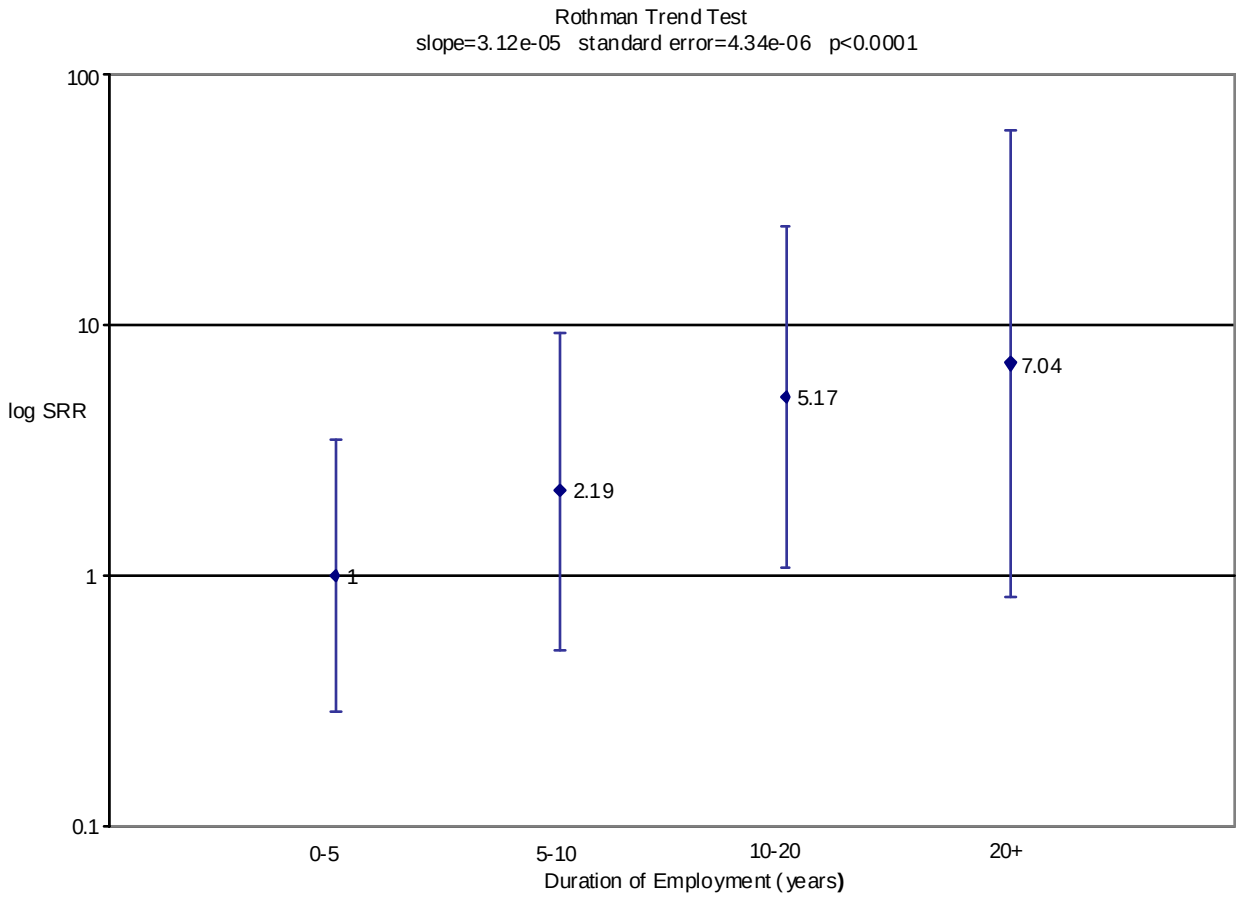


Figure 7- SRRs for Lung Cancer by Duration of Employment, 10 Year Lag

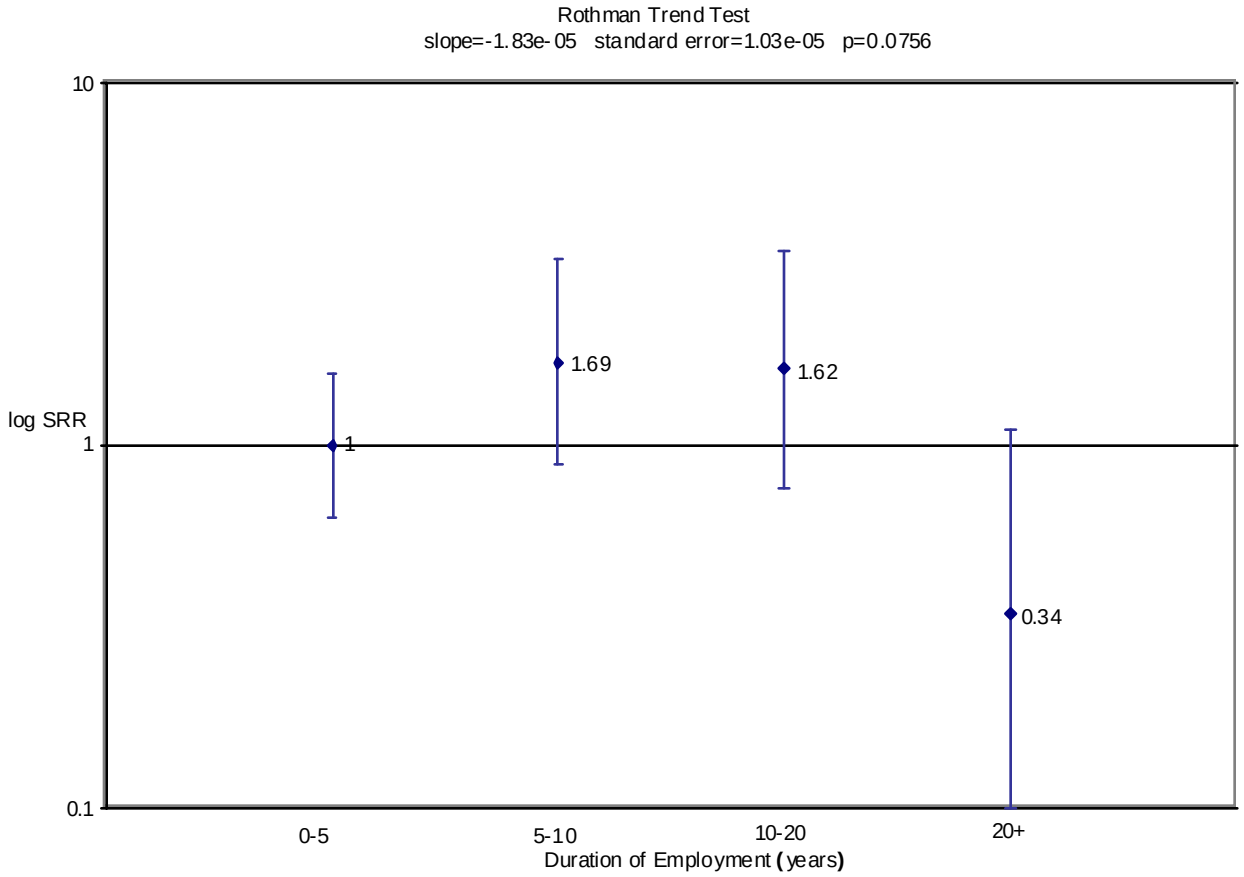
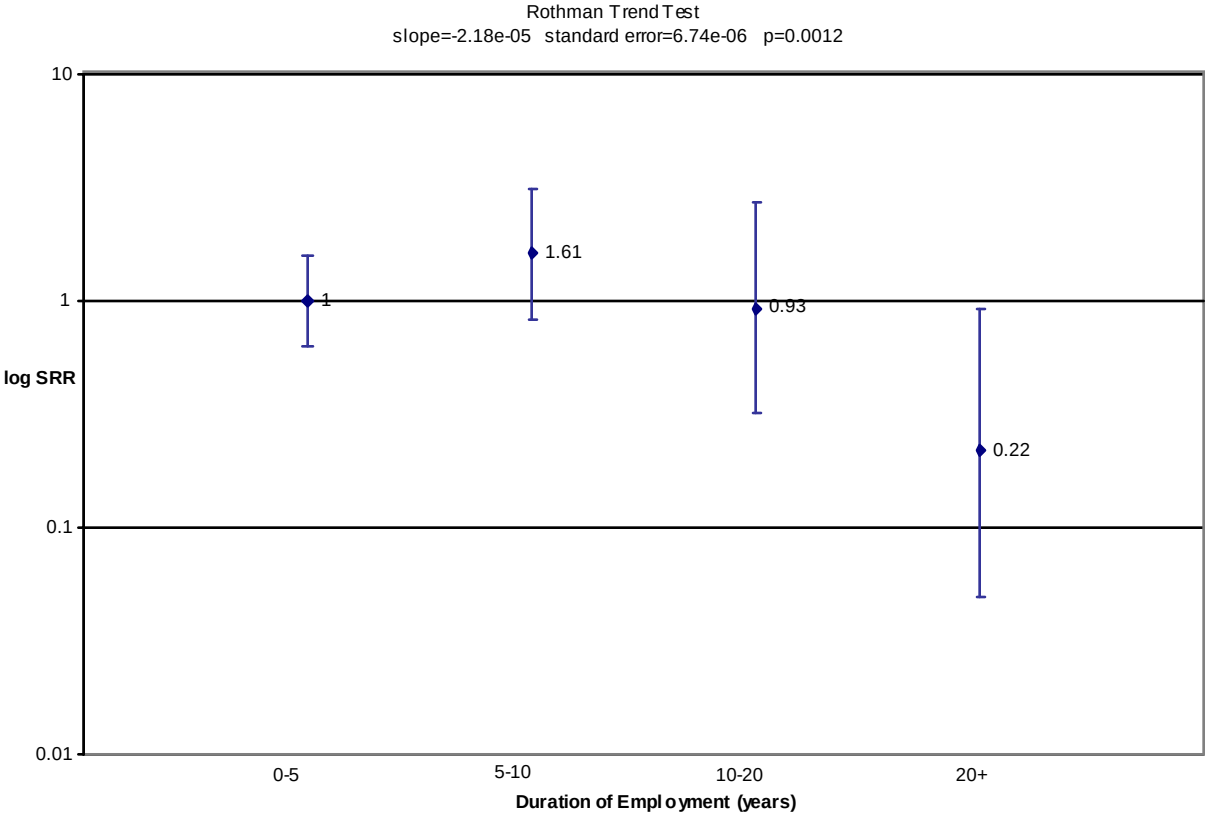


Figure 8- SRRs of Lung Cancer by Duration of Employment, 15 Year Lag



APPENDIX A

Summary SMR results–full cohort and early-term subcohort, men and women of all races, no lag.

Outcome	Full NIOSH Cohort			Early-term Subcohort		
	Observed	Expected	SMR* (95%CI)	Observed	Expected	SMR (95% CI)
Tuberculosis	0	2.93	0	0	2.10	0
Respiratory Tuberculosis	0	2.59	0	0	1.88	0
Other Tuberculosis	0	0.34	0	0	0.22	0
Malignant Neoplasms (MN) of Buccal Cavity and Pharynx	4	8.17	0.49 (0.13–1.25)	3	5.01	0.60 (0.1–1.75)
MN of Lip	1	0.12	8.03 (0.20–44.64)	1	0.09	11.75 (0.30–65.28)
MN of Tongue	0	1.87	0	0	1.15	0
MN of Other Buccal	2	2.18	0.92 (0.11– 3.32)	2	1.35	1.48 (0.18–5.34)
MN of Pharynx	1	4.00	0.25)	0	2.42	0
MN of Digestive Organs and Peritoneum	52	79.30	0.66‡	36	19.99	0.72 (0.50–1.00)
MN of Esophagus	7	8.26	0.85	4	4.86	0.82 (0.22–2.10)
MN of Stomach	8	10.77	0.74	6	6.94	0.86 (0.32–1.88)
MN of Intestine except Rectum	22	28.80	0.76	17	18.29	0.93 (0.54–1.49)
MN of Rectum	2	6.43	0.31	2	4.21	0.47 (0.06–1.71)
MN of Biliary Passages, Liver and Gallbladder	3	5.49	0.55 (0.11–1.60)	2	3.39	0.59 (0.07–2.13)
MN of Liver, not specified	0	2.13	0	0	1.36	0
MN of Pancreas	10	16.15	0.62	5	10.12	0.49 (0.16–1.15)
MN of Peritoneum and Other and Unspecified Digestive Organs	0	1.26		0	0.81	0
MN of Respiratory System	97	120.37	0.81	65	72.83	0.89 (0.69–1.14)
MN of Larynx	1	4.03	0.25	1	2.46	0.41 (0.01–2.25)
MN of Trachea, Bronchus and Lung	95	115.12	0.83 (0.67–1.01)	64	69.61	0.92 (0.71–1.17)
MN of Other Parts of Respiratory System	1	1.22	0.82 (0.02–4.56)	0	0.76	0
MN of Breast	5	8.98	0.56 (0.18–1.30)	5	6.17	0.81 (0.26–1.89)
MN of Female Genital Organs	1	4.84	0.21 (0.001–1.15)	1	3.42	0.29 (0.01–1.63)
MN of Cervix and Uteri	0	1.32	0	0	0.92	0
MN of Other and Unspecified Parts Of Uterus	0	0.91	0	0	0.66	0
MN of Ovary, Fallopian Tube, and Broad Ligament	1	2.48	0.40 (0.01–2.24)	1	1.75	0.57 (0.01–3.17)
MN of Other Female Genital Organs	0	0.13	0	0	0.09	0
MN of Male Genital Organs	21	21.53	0.98 (0.60–1.49)	13	14.01	0.93 (0.49–1.59)
MN of Prostate	21	20.41	1.03 (0.64-1.57)	13	13.31	0.98 (0.52–5.24)
MN of Other Male Genital Organs	0	1.12	0	0	0.70	0
MN of Urinary Organs	14	15.33	0.91 (0.50–1.53)	8	9.73	0.82 (0.35–1.62)
MN of Kidney	8	8.13	0.98 (0.42–1.94)	4	4.98	0.80 (0.22–2.05)
MN of Bladder and Other Urinary Organs	6	7.20	0.83 (0.30–1.82)	4	4.75	0.84 (0.23–2.16)

(Continued)

Outcome	Full NIOSH Cohort			Early-term Subcohort		
	Observed	Expected	SMR* (95%CI)	Observed	Expected	SMR (95% CI)
MN Other Unspecified Sites	35	42.44	0.82	25	25.95	0.96 (0.62–1.42)
MN of Skin	5	7.08	0.71 (0.23–1.65)	2	4.26	0.47 (0.06–1.69)
MN of Eye	0	0.21	0	0	0.14	0
MN of Brain and Other Parts of Nervous System	5	9.78	0.51 (0.17–1.19)	4	5.97	0.67 (0.18–1.71)
MN of Thyroid	0	0.60	0	0	0.38	0
MN of Bone	0	0.90	0	0	0.59	0
MN of Connective Tissue and Soft Tissue	0	1.82	0	0	1.09	0
MN of Other and Unspecified Sites (Minor)	25	22.06	1.13 (0.73–1.67)	19	13.52	1.41 (0.85–2.20
Neoplasms of Lymphatic and Hematopoietic Tissue	29	30.82	0.94 (0.63–1.35)	22	19.22	1.14 (0.72–1.73)
Lymphosarcoma and Reticulosarcoma	3	3.56	0.84 (0.17–2.46)	3	2.40	1.25 (0.26–3.66)
Hodgkin's Disease	1	2.36	0.42 (0.01–2.35)	1	1.53	0.66 (0.02–3.64)
Leukemia and Aleukemia	13	11.88	1.09 (0.58–1.87)	11	7.49	1.47 (0.73–2.63)
Other Neoplasms of Lymphatic Hematopoietic Tissue	12	13.02	0.92 (0.48–1.61)	7	7.81	0.90 (0.36–1.85)
Benign and Unspecified Neoplasms	3	4.05	0.74 (0.15–2.17)	2	2.60	0.77 (0.09–2.78)
Benign Neoplasms of the Eye, Brain, and other parts of the Nervous System	0	0.54	0	0	0.36	0
Neoplasms of the Eye, Brain, and other parts of the Nervous System, Unspecified	3	1.81	1.66 (0.34–4.84)	2	1.14	1.76 (0.21–6.34)
Other Benign and Unspecified Nature Neoplasms	0	1.69	0	0	1.10	0
Diabetes Mellitus	14	22.45	0.62 (0.34–1.05)	11	14.07	0.78 (0.39–1.40)
Diseases of the Blood and Blood Forming Organs	2	3.89	0.51 (0.06–1.86)	2	2.48	0.81 (0.10–2.91)
Pernicious Anemias	1	0.06	16.94 (0.43–94.09)	1	0.05	21.70 (0.55–120.57)
Anemias of Other and Unspecified Type	0	1.35	0	0	0.89	0
Coagulation Defects, Purpura, and other Hemorrhagic Conditions	0	0.98	0	0	0.60	0
All other Diseases of Blood Forming Organs	1	1.50	0.67 (0.02–3.71)	1	0.95	1.05 (0.03–5.83)
Mental, Psychoneurotic, and Personality Disorders	7	11.00	0.64 (0.25–1.31)	6	6.65	0.90 (0.33–1.96)
Alcoholism	3	5.70	0.53 (0.11–1.53)	3	3.25	0.92 (0.19–2.70)
Other Mental Disorders	4	5.30	0.76 (0.21–1.93)	3	3.41	0.88 (0.18–2.58)
Diseases of the Nervous System and Sense Organs	19	16.75	1.13 (0.68–1.77)	14	10.63	1.32 (0.72–2.21)
Multiple Sclerosis	2	1.54	1.30 (0.16–4.69)	2	0.96	2.09 (0.25–7.55)
Other Diseases of the Nervous System and Sense Organs	17	15.21	1.12 (0.65–1.79)	12	9.67	1.24 (0.64–2.17)
Diseases of the Heart	348	456.90	0.76‡ (0.68–0.85)	266	299.39	0.89 (0.78–1.00)
Rheumatic Heart Disease	11	7.51	1.46 (0.73–2.62)	11	5.22	2.11† (1.05–3.77)
Ischemic Heart Disease	252	359.92	0.70‡ (0.62–0.79)	194	238.48	0.81‡ (0.70–0.94)
Chronic Disease of Endocardium	6	4.31	1.39 (0.51–3.03)	3	2.77	1.08 (0.22–3.65)
Other Myocardial Degeneration	2	2.50	0.80 (0.10–2.89)	2	1.98	1.01 (0.12–3.62)

(Continued)

Outcome	Full NIOSH Cohort			Early-term Subcohort		
	Observed	Expected	SMR* (95%CI)	Observed	Expected	SMR (95% CI)
Hypertension with Heart Disease	3	10.90	0.28† (0.06–0.81)	3	7.09	0.42 (0.09–1.24)
Other Diseases of the Heart	74	71.77	1.03 (0.81–1.29)	53	43.85	1.21 (0.91–1.58)
Other Diseases of the Circulatory System	82	97.24	0.84 (0.67–1.05)	72	66.10	1.09 (0.85–1.37)
Hypertension without Heart Disease	0	3.74	0†	0	2.44	0
Cerebrovascular Disease	44	62.32	0.71† (0.51–0.95)	39	43.06	0.91 (0.64–1.24)
Diseases of the Arteries, Veins, and Pulmonary Circulation	38	31.18	1.22 (0.86–1.67)	33	20.61	1.60† (1.10–2.25)
Diseases of the Respiratory System	81	87.60	0.92 (0.73–1.15)	68	57.49	1.18 (0.92–1.50)
Acute Respiratory Infections except Influenza and Pneumonia	1	0.41	2.42 (0.06–13.43)	1	0.28	3.58 (0.09–19.90)
Influenza	0	0.80	0	0	0.59	0
Pneumonia (except newborn)	24	26.33	0.91 (0.58–1.36)	21	17.86	1.18 (0.73–1.80)
Chronic and Unspecified Bronchitis	1	2.60	0.38 (0.01–2.14)	0	7.81	0
Emphysema	13	13.16	0.99 (0.53–1.69)	12	8.99	1.33 (0.69–2.33)
Asthma	4	2.20	1.82 (0.50–4.66)	3	1.42	2.12 (0.44–6.18)
Pneumoconioses and other Respiratory Diseases	38	42.10	0.90 (0.64–1.24)	31	26.53	1.17 (0.79–1.66)
Diseases of the Digestive System	36	60.83	0.59‡ (0.41–0.82)	28	38.02	0.74 (0.49–1.06)
Diseases of the Stomach and Duodenum	7	5.82	1.20 (0.48–2.48)	6	4.00	1.50 (0.55–3.27)
Hernia and Intestinal Obstruction	1	2.32	0.43 (0.01–2.39)	1	1.63	0.61 (0.02–3.40)
Cirrhosis of the Liver	17	33.64	0.51‡ (0.29–0.81)	13	20.26	0.64 (0.34–1.10)
Other Diseases of the Digestive System	11	19.04	0.58 (0.29-1.03)	8	12.13	0.66 (0.28-1.30)
Diseases of the Genito-Urinary System	8	15.26	0.52 (0.23-1.03)	6	10.25	0.59 (0.21-1.27)
Acute Glomerulonephritis, Nephrotic Syndrome, and Acute Renal Failure	0	1.48	0	0	0.97	0
Chronic and Unspecified Nephritis, Renal Failure, and other Renal Sclerosis	4	7.48	0.53 (0.15-1.37)	4	4.87	0.82 (0.22-2.10)
Infection of Kidney	1	1.15	0.87 (0.02-4.83)	1	0.88	1.14 (0.03-6.31)
Calculi of Urinary System	0	0.29	0	0	0.21	0
Hyperplasia of Prostate	1	0.42	2.36 (0.06-13.13)	0	0.35	0
Other Diseases of Male Genital Organs	1	0.24	4.10 (0.10-22.78)	1	0.17	5.80 (0.15-32.25)
Diseases of the Breast	0	0.01	0	0	0.004	0
Diseases of the Female Genital Organs	0	0.08	0	0	0.06	0
Other Genito-Urinary System Diseases	1	4.11	0.24 (0.01-1.35)	0	2.73	0
Diseases of the Skin and Subcutaneous Tissue	0	1.04	0	0	0.69	0
Infections of the Skin and Subcutaneous Tissue	0	0.34	0	0	0.21	0

(Continued)

Outcome	Full NIOSH Cohort			Early-term Subcohort		
	Observed	Expected	SMR* (95%CI)	Observed	Expected	SMR (95% CI)
Other Infections of the Skin and Subcutaneous Tissue	0	0.71	0	0	0.48	0
Other Diseases of the Musculoskeletal System	0	1.62	0	0	1.00	0
Symptoms and Ill-Defined Conditions	17	13.72	1.24 (0.72–1.98)	15	8.51	1.76 (0.99–2.91)
Accidents	58	74.05	0.78 (0.59–1.01)	47	45.59	1.03 (0.76–1.37)
Transportation Accidents	36	41.01	0.88 (0.61–1.22)	29	25.12	1.15 (0.77–1.66)
Accidental Poisoning	1	4.22	0.24 (0.01–1.32)	1	2.43	0.41 (0.01–2.28)
Accidental Falls	5	7.53	0.66 (0.21–1.55)	4	4.94	0.81 (0.22–2.07)
Other Accidents	12	19.54	0.61 (0.32–1.07)	9	11.99	0.75 (0.34–1.42)
Medical Complications and Misadventure	4	1.75	2.29 (0.62–5.86)	4	1.10	3.63 (0.99–9.28)
Violence	29	42.43	0.68† (0.46–0.98)	24	24.88	0.96 (0.62–1.44)
Suicide	23	29.87	0.77 (0.49–1.16)	19	18.11	1.05 (0.63–1.64)
Homocide	6	12.57	0.48 (0.17–1.04)	5	6.77	0.74 (0.24–1.73)
Other Causes	68	28.41	2.39‡ (1.86–3.03)	60	16.64	3.61‡ (2.75–4.64)
All Cancers	258	331.78	0.78‡ (0.69–0.88)	178	206.31	0.86 (0.74–1.00)
All Deaths	1031	1273.2	0.81‡ (0.76–0.86)	800	814.23	0.98 (0.92–1.05)

*Abbreviations: CI = confidence interval; SMR = standardized mortality ratio.

†2-sided p-value <0.05.

‡2-sided p-value <0.01.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226–1998

Delivering on the Nation's promise:
Safety and health at work for all people
through research and prevention

To receive NIOSH documents or more information about occupational safety and health topics, contact NIOSH at
1–800–35–NIOSH (1–800–356–4674)
Fax: 513–533–8573
E-mail: pubstaft@cdc.gov
or visit the NIOSH Web site at
www.cdc.gov/niosh

DHHS (NIOSH) Publication No. 2005-124

SAFER • HEALTHIER • PEOPLE