The Utility of Mortality Surveillance: The Solutia Mortality Experience 1980-1994

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Abstract

Background: Several investigators argue that company wide mortality rates for recent workers allow early identification of potential health problems. We compare our mortality rates for recent workers with published studies of several plants in our company to determine the efficacy of mortality surveillance for identifying previously unknown health effects.

Methods: We examine the percentage of workers in the surveillance reports which appear in the published studies and compare relative risk estimates for relevant causes of death in the studies with the relative risk in the mortality surveillance.

Results: As reported by other companies, we find low mortality rates among workers in surveillance. Life expectancy at age 20 for White hourly males were 1.7 years greater and for non-White hourly males 4.6 years greater than the comparable U.S. population life expectancies. We did not find disease specific relative risk for our workers in surveillance predictive of relative risk in the studies.

Conclusion: Mortality surveillance provides an indication of the health status of current workers. However, mortality surveillance is of limited use for identifying health effects from past workplace exposures to specific materials. The healthy worker and survivor effects, the failure to identify

subsets of workers exposed to potentially toxic substances, and the inability of recent mortality levels to reflect historical conditions all may make it difficult to use mortality surveillance to identify workplace hazards. We recommend combining mortality surveillance with studies of workers with suspected toxic exposures to help identify previously unknown occupational hazards.

Keywords: mortality surveillance, occupational cancer, chemical industry, life expectancy, bladder cancer, leukemia

Introduction

Several investigators report mortality rates for recent workers for an entire company (Pell et al., 1978; Divine et al., 1985; Hanis et al. 1985; Pifer et al., 1986; Teta et al., 1987; Bond et al., 1987; Teta et al., 1990; Shallenberger et al., 1992; Olsen et al., 1994; Tsai et al., 1996; Divine et al., 1999a; Divine et al., 1999b). We refer to these reports as mortality surveillance. Mortality surveillance provides an evaluation of recent mortality levels without examining specific exposures as is done in a formal study. These reports uniformly show low rates of total mortality and total cancer mortality for the workers studied, although occasionally rates of some causes of death are greater than expected. Among other benefits, mortality surveillance may facilitate early identification of potential health problems (Pell et al., 1978; Teta et al., 1987; Teta et al., 1990; Tsai et al.,1991; Olsen et al., 1994; Tsai et al., 1996; Devine et al., 1999a). However, the utility of routine mortality surveillance for identifying disease occurrences which are the result of workplace exposure has not been demonstrated. The healthy worker and survivor effects, the failure to identify subsets of workers exposed to potentially toxic substances, the failure to trace workers who leave employment for reasons other than retirement, and the inability of recent mortality levels to reflect

historical conditions all may make it difficult to use mortality surveillance to identify workplace hazards. We present the results of mortality surveillance for a company and compare results to past published studies of several plants in this company to determine the efficacy of mortality surveillance for identifying previously unknown health effects from workplace exposure.

Methods and Materials

The population for our mortality surveillance is the 43,339 workers who worked one or more days at any Solutia U.S. location between January 1, 1980 and December 31, 1994. Solutia was formally the chemical businesses of the Monsanto Company. An extensive number and variety of chemicals have been produced at these locations. Studies have been done examining some of these chemicals (Melick et al., 1955; Melick et al., 1971; Zack and Suskind, 1980; Marsh, 1983; Zack and Gaffey, 1983; Suskind and Hertzberg, 1984; Blair et al., 1986; Wong, 1987; Fingerhut et al., 1991a; Wong et al., 1991; Collins et al., 1993; Strauss et al., 1993; Ireland et al., 1997; Blair et al., 1998; Collins et al., 1999).

Company personnel and payroll records provided demographic and work history data. For all eligible workers sex, race, birth date, hire date, employment termination date, and wage status were recorded. The completeness of study population ascertainment was evaluated by comparison

with the employer's quarterly report on earnings, Internal Revenue Service Form 941-Schedule A (Marsh and Enterline, 1979). A sample of the study population was verified as being 99% complete. We followed guidelines for study conduct given by the Chemical Manufacturers Association (Chemical Manufacturers' Association, 1991).

Vital Status Follow-up

Vital status was determined through company records and the National Death Index. Employees receiving wages or retirees receiving benefits on the last day of 1994 were assumed alive through the end of 1994. Vital status was complete for 98% (42,459 of 43,339) of the study population. 2,406 deaths were recorded.

Death certificates were requested from the respective states when not available in company records. All but two of the death certificates were obtained. Death certificates were coded independently by two nosologists according to the International Classification of Diseases in use at the time of death. Differences were resolved through discussion between the two nosologists.

Statistical Methods

Person-years for study subjects were accumulated across 5-year age- and calendar year-specific intervals beginning with the date of hire or January 1, 1980, whichever was later. Subjects continued to contribute person-years at risk

until the earliest of the date lost to follow-up, the date of death, or December 31, 1994. We limited the racial breakdown to White and non-White workers because of the small number of workers in some racial groups. We calculated standardized mortality ratios (SMRs) to compare mortality rates with those of the U.S. population (Marsh and Preininger, 1980). We present common causes of death and causes of death which have been associated with occupational exposures (Doll and Peto, 1981).

We constructed lifetables using the Greville method on the age, race, and salary specific rates to estimate life expectancy (U.S. Bureau of the Census, 1975). Life expectancy provide an overall summary of total mortality levels and, unlike the SMR, allows direct comparison among all sub-groups in the study and U.S. population. The life expectancy also provides an easily understandable summary of death rates expressed in individual terms, or average years of life remaining for an individual at a specific age. Life expectancy at ages 20, 40, 60 and working life (age 20 to 65) are presented as summaries.

We selected all published studies which examined the mortality rates of workers at any of our plants to compare to the findings of the mortality surveillance. When multiple studies reported on the same study population, we used only the most recent study (Melick et al., 1971; Marsh, 1983;

Blair et al., 1986; Wong et al., 1991; Fingerhut et al., 1991a; Collins et al., 1993; Ireland et al., 1997; Blair et al., 1998; Collins et al., 1999). We used weighted and non-weighted linear regression to compare the relative risks of hypothesized diseases among workers in the study plant with relative risks of workers in the mortality surveillance at that plant(SAS, 1995). We limited the comparison in the surveillance data to workers with 20 or more years since first hire to exclude recently hired workers. The weights used in the regression are the percentage of workers in the study which are included in the surveillance.

Results

Table I presents the distribution of the 43,389 workers by selected characteristics. The study population is mostly White (85.6%) and male (72.7%). The Whites and Hispanics from Table I are combined to form the "White" percentage noted. Most workers are salaried (64.5%) which included administrative, technical and professional staff, clerks and secretaries, all workers at the General Offices, and all workers at two plants after 1993 which reclassified all hourly workers to salaried. 43.5% of the workers left the company before retirement and 24.2% are retired. More than 40% of the workers are hired before 1970. Almost 70% of the workers are in production facilities.

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The 43,339 workers contributed a total of 525,764 person years of observation for a mean followup of 12.1 years. Table II presents the observed and expected deaths by cause for hourly and salaried workers by sex for the entire follow-up period and 20 years since first hired. Male hourly workers have an SMR of 0.8 (95%CI 0.8-0.9) for all causes of death. Death rates for all cancer (SMR 0.9, 95%CI 0.8-1.0) and heart disease (SMR 0.9 95%CI 0.8-1.0) are also below expected levels. Most individual cancer sites for hourly males are at or below expected levels with the exception of leukemia (SMR 1.8, 95%CI 1.1-2.6), large intestine (SMR 1.2, 95%CI 0.9-1.6), bone (SMR 1.2, 95%CI 0.0-6.6), and prostate (SMR 1.1, 95%CI 0.7-1.6). SMRs for non-malignant respiratory disease (SMR 0.5, 95%CI 0.3-0.6) and accidents are also at or below expected levels. The workers who were hired 20 or more years before the end of the study period have SMRs similar to all workers.

Male salaried workers have an SMR for all causes of death of 0.5 (95%CI 0.5-0.5). Observed deaths for all cancer (SMR 0.6 95%CI 0.6-0.7) and all heart disease (SMR 0.6 95%CI 0.5-0.6) are also less than expected. All individual sites of cancer and other causes of death are at or below expected levels. The SMRs for workers who were hired 20 or more years before the end of the study period are similar to all workers.

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Female hourly workers have death rates (SMR=0.7, 95%CI 0.6-0.8), cancer rates (SMR=0.7 95%CI 0.5-0.9), and heart disease rates (SMR=0.5 95%CI 0.3-0.5) which are less than the U.S. population. Death rates for motor vehicle accidents are greater than the U.S. population, although there was a deficit among women 20 or more years after hire. SMRs for individual cancer sites for hourly females are at or below expected levels with the exception of leukemia (SMR 1.7, 95%CI 0.3-4.9), and large intestine (SMR 1.1, 95%CI 0.3-2.5). The SMRs for female hourly workers with 20 or more years since being hired are similar to the SMRs for all female hourly workers with the exception of stomach cancer (SMR = 1.3, 95%CI0.0-7.5).

The SMRs for female salary workers are very similar to female hourly workers with low death rates (SMR=0.6 95%CI 0.5-0.7), cancer rates (SMR=0.9 95%CI 0.7-1.0), and heart disease rates (SMR=0.7 95%CI 0.4-1.0) relative to the U.S. population. Cancer SMRs are at or below expected levels with the exception of leukemia (SMR=1.5 95%CI 0.5-3.5), esophagus (SMR 1.1, 95%CI 0.0-6.2), and stomach (SMR 1.1, 95%CI 0.1-3.9). The SMRs for female salary workers 20 or more years since hire are generally similar to the SMRs for all female salary workers with the exceptions of stomach cancer (SMR=2.0, 95%CI 0.2-7.1) and malignant melanoma of the skin (SMR=1.4, 95%CI 0.0-7.6).

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We compare the life expectancies for Solutia workers for the year 1980-94 with the U.S. population for the years 1985-89 in Table III. Solutia males and females of both racial groupings have life expectancies at all ages which exceed life expectancies for U.S. population. At age 20, Solutia White male salary workers are estimated to live 5.3 years longer (58.9 years for Solutia White salary males minus 53.6 years for U.S. White males) and White male hourly workers 1.7 years longer than White males in the U.S. population. Solutia non-White males enjoy a larger advantage over their counterparts in the U.S. population. Salary non-White males live 8.3 years longer and hourly non-white males live 4.6 years longer than their counterparts in the U.S. population. There are also large differences between salaried and hourly Solutia workers. Non-White male hourly workers have a life expectancy at age 20 of 53.6 compared to 57.3 years for non-White salary workers, or a 3.7 year difference. There are smaller differences between the racial groupings among Solutia workers. For example, White male hourly workers have a life expectancy at age 20 of 55.3 years compared to 53.6 for non-White hourly workers.

Life expectancies for Solutia women are much higher than Solutia men but show less variance across groups. Life expectancy at age 20 is 60.1 years for the U.S. White female. Solutia hourly women have a life expectancy at age 20 of

61.6, and Solutia salary women a life expectancy at age 20 of 62.8.

We identified nine studies at six different plants included in the mortality surveillance (Melick et al., 1971; Marsh, 1983; Blair et al., 1986; Fingerhut et al., 1991b; Wong et al., 1991; Collins et al., 1993; Ireland et al., 1997; Blair et al., 1998; Collins et al., 1999). Figure 1 shows the years of employment inclusion criteria for workers in these nine studies and our mortality surveillance. Only a recent study by Blair et al. (1998) which includes workers employed between 1952 and 1983 overlaps with the employment inclusion criterion of surveillance, or employed between 1980 and 1994. The remaining eight studies have study employment inclusion criterion which are several years earlier than the employment criterion for surveillance. The percentage of workers in surveillance which appear in the studies ranges from 72% for the Blair et al.(1998) study to 7% for the study of Fingerhut et al.(1991b).

We compare the study relative risks for causes of death which are causally evaluated in the studies with the relative risk in the surveillance population in Figure 2 (Marsh, 1983; Fingerhut et al. 1991b, Collins et al., 1993; Ireland et al., 1997; Blair et al., 1998; Collins et al., 1999). Three studies could not be included in this analysis because either there were no relative risks presented (Melick et al., 1971),

or the relative risks were not presented by plant (Blair et al., 1986; Wong et al., 1991). There were 21 causes of death evaluated in the 6 studies included. There is little correlation when either the unweighted (R^2=0.01) or the weighted (R^2=0.01) regression is used to evaluate the relationship between the relative risks in the studies and the mortality surveillance.

Discussion

Mortality surveillance by design focuses on the mortality rates of recent workers. Thus, mortality surveillance provides a better overall assessment of mortality risk for current workers than does a formal study which typically focuses on workers who have long since left employment. We found low rates of total mortality, heart disease, accidents, and cancer among our workers in surveillance. These low mortality rates are probably the result of relatively short follow-up since workers were hired, a low prevalence of smoking and alcohol abuse, and no major impact of recent plant operations on workers' mortality rates. However, mortality rates of recent workers may not be useful for evaluating safety of the workplace in the past.

The mortality rates of long term hourly workers are the most useful in mortality surveillance for detecting possible work related effects in the past. The rates observed in our surveillance report do not indicate widespread cancer

increases among workers in these production facilities. With the exception of increased rates of leukemia, mortality from cancer, non-malignant respiratory disease, heart disease, and accidents were comparable to or lower than mortality rates for the U.S. population at each plant examined. This is similar to findings in other industrial groups with the exception of high rates of leukemia in our surveillance. The high rates of leukemia in our surveillance occur at a single plant. The workers at this plant have been subject of two benzene studies (Wong, 1987; Ireland et al., 1997).

The low mortality rates in our surveillance particularly for non-cancer causes of death probably reflect in part the "healthy worker" and the "healthy survivor" effects. The healthy worker effect refers in part to the initial selection of relatively healthy persons at the time of hire (Checkoway et al., 1989). The healthy survivor effect is attributed to the tendency of the least healthy workers to leave the active workforce (Arrighi and Hertz-Picciotto, 1994). Both of these effects may impact the mortality rates of the surveillance populations. In our study, 15,367 workers were hired in the last fifteen years of follow-up and the remaining 27,972 workers are a censured population since they had to be in the active Solutia workforce in 1980 to be included. The potential biases associated with the healthy worker effect diminish with time since employment and are

less important for interpreting cancer mortality rates (Checkoway et al., 1989). In our surveillance report, long term and recently hired workers had similar mortality patterns indicating the healthy worker effect has not had a major impact on our results. The potential impact of the healthy survivor effect is impossible to evaluate since our surveillance report has no information on workers who left employment before 1980.

We determined that our surveillance results are not predictive of the causal findings from our studies. This is not surprising since the studies mostly examined workers not included in the mortality surveillance. The workers in the studies were employed during periods of generally higher exposures to different substances and processes than the population in the mortality surveillance.

We find it difficult to justify using surveillance results to do further study unless the relative risk values are large and very precise. Teta et al. (1990) mention that large increases in mortality, especially for rare diseases in plant sub-populations can often be observed in surveillance data. Thus Teta et al. are able to detect a liver cancer excess in their surveillance data at a plant with vinyl chloride exposures. However, while we were successful in identifying from our plant specific surveillance high rates of leukemia at our plant in a benzene study (Ireland et al.,

1997), we were unable to detect high rates of bladder cancer in a plant with past exposure to 4-aminobiphenyl a potent bladder carcinogen (Collins et al., 1993). The difference in these cases appears to be in the timing of the exposure, the induction-latency period of the cancers, and the percentage of workers exposed to toxic agent in the surveillance report. In the case of 4-aminobiphenyl, exposure ceased in 1955 and only 17% of the workers employed in 1980 worked at the time when 4-aminobiphenyl exposure occurred. With the possible exception of the leukemia findings, it is unlikely that any of the findings in our surveillance reports would of themselves had caused additional study.

Conclusion

Mortality surveillance reports which focus on recent workers provide important information on mortality risk to current workers. However, our plant surveillance reports are of limited value in discovering occupational hazards in the past. While there have been examples where these reports have been useful in identifying hazards, we did not find our surveillance reports to be predictive of substance specific studies which identified potential occupational hazards. Mortality surveillance reports as they become longer running and cover more of the worker population with each year of update could become more useful in identifying unknown hazards. Mortality surveillance also has other uses including

giving a quick response to health related inquires, providing data for other studies, and setting priorities for programs and studies (Tsai et al., 1991). At present, however, it seems prudent to combine mortality surveillance with long running substance studies on suspect toxic exposures to help identify previously unknown occupational hazards.

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Table I. Distribution of Solutia workers 1980-1994 by selected characteristics.

Characteristic	*N*	*% of Total*
Race		
White	36,415	84.0
Black	5,299	12.2
Hispanic	687	1.6
Asian	739	1.7
American Indian	164	0.4
Other and Unknown	35	0.1
Sex		
Male	31,494	72.7
Female	11,845	27.3
Pay Status		
Hourly	15,026	34.7
Salary	27,964	64.5
Hourly to salary	349	0.8
Working Status		
Currently employed	14020	32.3
Left company (not retired)	18834	43.5
Retired	10485	24.2

Characteristic	*N*	*% of Total*
Year of Hire		
<1970	17,955	41.4
1970 +	25,384	58.6
Location		
General Offices	13,386	30.1
Carondolet	541	1.3
Chocolate Bayou	1730	4.0
Columbia	714	1.6
Decatur	2986	6.9
Fovil	590	1.4
Greenwood	2650	6.1
Indian Orchard	3013	7.0
Nitro	1017	2.3
Pensacola	5566	12.8
Port Plastics	1316	3.0
Queeny	1657	3.8
Soda Springs	751	1.7
Texas City	2378	5.5
Trenton	1194	2.8
All other	3850	8.9

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Table II. Solutia mortality surveillance standardized mortality ratios (SMR) and 95% confidence intervals (CI) for hourly and salary workers for entire population and 20+ years induction-latency period.

Cause of Death (ICD9)	Hourly Workers		Salary Workers	
	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)
I. Males				
All Causes (001-999)	0.8(0.8-0.9)	0.8(0.8-0.9)	0.5(0.5-0.5)	0.5(0.5-0.6)
All Cancers (140-208)	0.9(0.8-1.0)	0.9(0.8-1.0)	0.6(0.6-0.7)	0.6(0.6-0.7)
Esophagus (150)	0.8(0.4-1.5)	1.0(0.5-1.7)	0.3(0.1-0.8)	0.3(0.0-0.8)
Stomach (151)	1.0(0.5-1.6)	1.0(0.5-1.7)	0.4(0.1-0.9)	0.3(0.0-0.8)
Large intestine(153)	1.2(0.9-1.6)	1.1(0.8-1.6)	0.8(0.6-1.2)	0.9(0.6-1.2)
Liver & biliary passages (155-156)	0.6(0.2-1.2)	0.7(0.2-1.5)	0.2(0.0-0.6)	0.1(0.0-0.6)
Larynx (161)	0.0(0.0-0.6)	0.0(0.0-0.7)	0.3(0.0-1.1)	0.2(0.0-1.0)
Bronchus, trachea, lung (162)	0.9(0.8-1.1)	0.9(0.8-1.1)	0.6(0.5-0.7)	0.6(0.5-0.7)
All other respiratory (160,163,164,165)	0.0(0.0-0.5)	0.0(0.0-5.8)	0.2(0.0-0.8)	0.1(0.0-0.8)
Prostate (185)	1.1(0.7-1.6)	1.0(0.7-1.5)	0.6(0.4-1.0)	0.6(0.3-0.9)
Bladder (188,189.3,189.4,189.8, 189.9)	0.8(0.3-1.6)	0.6(0.2-1.4)	0.5(0.2-1.3)	0.6(0.2-1.4)
Malignant melanoma of skin (172)	0.7(0.2-1.7)	0.6(0.1-1.7)	0.9(0.4-1.6)	0.8(0.3-1.7)

Cause of Death (ICD9)	Hourly Workers		Salary Workers	
	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)
Bone (170)	1.2(0.0-6.6)	0.0(0.0-6.4)	0.0(0.0-3.2)	0.0(0.0-5.0)
Leukemia (204-208)	1.8(1.1-2.6)	1.5(0.8-2.4)	0.7(0.4-1.3)	0.7(0.4-1.4)
All heart disease (390-398,402,404,410-429)	0.9(0.8-1.0)	0.9(0.8-1.0)	0.6(0.5-0.6)	0.6(0.5-0.6)
Non-malignant respiratory disease (460-519)	0.5(0.3-0.6)	0.5(0.4-0.7)	0.3(0.2-0.5)	0.3(0.2-0.5)
Motor vehicle accidents (E810-825)	1.0(0.7-1.4)	1.1(0.6-1.7)	0.3(0.2-0.5)	0.6(0.3-1.0)
All other accidents (E800-807,E826-949)	0.6(0.4-0.9)	0.7(0.4-1.1)	0.3(0.2-0.5)	0.4(0.2-0.7)
II. Females				
All Causes (001-999)	0.7(0.6-0.8)	0.6(0.5-0.8)	0.6(0.5-0.7)	0.7(0.5-0.8)
All Cancers (140-208)	0.7(0.5-0.9)	0.6(0.4-0.9)	0.9(0.7-1.0)	0.8(0.6-1.1)
Esophagus (150)	0.0(0.0-5.8)	0.0(0.0-8.3)	1.1(0.0-6.2)	1.8(0.0-10.2)
Stomach (151)	0.9(0.0-5.0)	1.3(0.0-7.5)	1.1(0.1-3.9)	2.0(0.2-7.1)
Large intestine(153)	1.1(0.3-2.5)	0.9(0.2-2.5)	0.9(0.4-1.8)	0.9(0.2-2.1)

Cause of Death (ICD9)	Hourly Workers		Salary Workers	
	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)
Liver & biliary passages (155-156)	0.0(0.0-3.0)	0.0(0.0-4.2)	0.0(0.0-1.8)	0.0(0.0-3.1)
Larynx (161)	0.0(0.0-13.9)	0.0(0.0-19.2)	0.0(0.0-9.2)	0.0(0.0-15.1)
Bronchus, trachea, lung (162)	0.9(0.5-1.5)	0.8(0.4-1.5)	0.9(0.5-1.3)	1.0(0.6-1.6)
All other respiratory (160,163,164,165)	0.0(0.0-9.2)	0.0(0.0-13.2)	0.0(0.0-5.8)	0.0(0.0-10.3)
Breast (174,175)	0.5(0.2-1.0)	0.5(0.2-1.3)	0.7(0.4-1.1)	0.4(0.1-0.8)
Bladder (188,189.3,189.4,189.8, 189.9)	0.0(0.0-8.0)	0.0(0.0-10.5)	0.0(0.0-4.9)	0.0(0.0-7.6)
Malignant melanoma of skin (172)	0.0(0.0-4.7)	0.0(0.0-7.8)	0.6(0.0-3.4)	1.4(0.0-7.6)
Bone (170)	0.0(0.0-31.3)	0.0(0.0-58.6)	0.0(0.0-16.5)	0.0(0.0-42.2)
Leukemia (204-208)	1.7(0.3-4.9)	1.8(0.2-6.5)	1.5(0.5-3.5)	1.9(0.4-5.5)
All heart disease (390-398,402,404,410-429)	0.5(0.3-0.5)	0.5(0.3-0.9)	0.7(0.4-1.0)	0.7(0.4-1.0)
Non-malignant respiratory disease (460-519)	0.8(0.3-1.5)	0.8(0.3-1.7)	0.7(0.3-1.2)	0.8(0.4-1.6)

Cause of Death (ICD9)	Hourly Workers		Salary Workers	
	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)	Entire Population SMR(95%CI)	20+ Induction-Latency SMR(95%CI)
Motor vehicle accidents (E810-825)	1.7(0.7-3.5)	0.8(0.0-4.2)	0.5(0.2-1.2)	0.5(0.0-2.6)
All other accidents (E800-807,E826-949)	0.7(0.1-2.4)	0.0(0.0-2.8)	0.6(0.2-1.7)	0.5(0.0-2.8)
III. Persons, Person Years, and Deaths				
Persons at risk	15,026	6,853	27,964	13,354
Person years	189,658	70,377	336,106	130,526
Total deaths	1,325	1,063	1,079	845

Table III. Life expectancies for the U.S. Population and Solutia workers by race, sex, and wage status.

Group	*Life Expectancy Age 20*	*Life Expectancy Age 40*	*Life Expectancy Age 60*	*Working Life Expectancy ages 20-65*
White Males				
Solutia Hourly	55.3	36.6	19.6	42.6
Solutia Salary	58.9	39.2	20.7	44.0
U.S. White Males*	53.6	35.1	18.3	42.1
Non-White Males#				
Solutia Hourly	53.6	35.3	19.4	41.7
Solutia Salary	57.3	38.2	20.6	43.2
U.S. non-White Males*	49.0	31.7	16.9	40.0
White Females#				
Solutia Hourly	61.6	42.5	23.9	43.8
Solutia Salary	62.8	43.4	24.7	44.0
U.S. White Females*	60.1	40.8	22.9	43.6
Non-White Females#				
Solutia Hourly	59.7	41.1	23.5	43.1
Solutia Salary	58.0	38.7	+	+
U.S. non-White Females*	57.0	38.2	21.6	42.6

* Rates for 1985-89

\# Rates for 1980-94. The rates of the U.S. population 1985-89 are used for ages 80-84 and 85+. For non-White females age 20-24, 25-29, U.S. rates 1985-89 are used because of few or zero deaths in these categories.

\+ Not calculated because of zero deaths in several age groups.

Figure 1. Employment criteria for workers in the study and the percentage of workers in the study who are in Solutia Surveillance

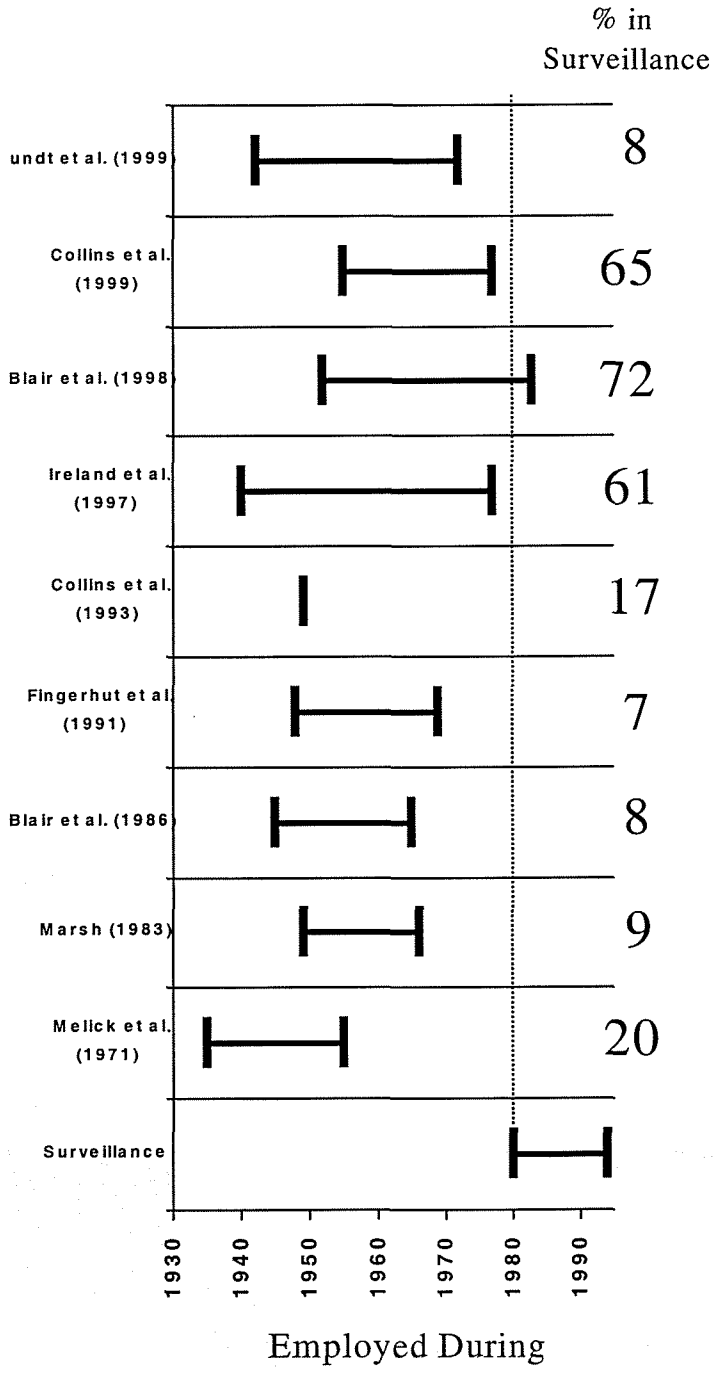

Figure 2. Scatterplot of the relative risks of causes of death featured in the studies with the relative risks in the surveillance report for workers 20+ years after hire.