Mortality among Workers Exposed to Coal Tar Pitch Volatiles and Welding Emissions: An Exercise in Epidemiologic Triage

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Abstract: The United Automobile Workers International Union has established a system of epidemiologic triage to evaluate patterns of mortality among groups of union members. In response to worker concerns, the Union examined mortality at a metal stamping plant, using a method which linked pension records with the State of Michigan computerized death registry. The observed proportion of malignant neoplasms was nearly twice that expected (95% Confidence Limits 1.36, 2.62). Two- to five-fold excess proportional mortality from cancer of the digestive organs, lung cancer, and leukemia accounted for most of the overall excess. Strong associations were found between lung and digestive organ cancer and employment as maintenance welders or millwrights in the plant (odds ratios > 10). High levels of six polycyclic aromatic hydrocarbons with mutagenic and carcinogenic properties were found during hot coal tar application to wood block floors, work conducted by the high-risk groups. These levels were substantially reduced following the purchase of new tar pots. The example demonstrates that epidemiologic tools can play a valuable role in occupational health decision making, but care must be taken to avoid mechanical reliance on quantitative testing and to acknowledge the important role of social and political value judgments in the establishment of responsible public policy. (*Am J Public Health* 1985; 75:1283–1287.)

Introduction

This paper describes recent union-based efforts to develop and use epidemiologic surveillance techniques as routine, accessible tools in the day-to-day conduct of a health and safety program.

The United Automobile Workers International Union (UAW) represents 1.2 million workers in more than 2,500 workplaces throughout the United States and Canada. These workers face an enormous range of potential health hazards on jobs ranging from paint formulation to salt mining. Automobile manufacture, employing one-half of UAW members, is itself a collection of many distinctly different types of work.

The UAW has had an active health and safety program for many years, utilizing occupational health professionals and local union health and safety representatives to identify workplace hazards and to develop technical and political strategies for their control. Stimulated by recent intense membership concern with apparent excess cancer mortality in various workplaces, it became apparent that the health and safety program needed a new dimension—one which could evaluate patterns of illness, injury, and death that might not be apparent to even a skilled observer with the training to recognize known hazardous materials and conditions.

A practical system of epidemiologic triage was required so that threshold decisions about health and safety strategy could be made on firm grounds. For example, with several workplaces reporting apparent clusters of cancer deaths, a prompt choice among three courses of action is necessary: 1) a priority program to reduce worker exposures to known or likely hazards through engineering or other controls; 2) systematic research to explore suspected health effects supplemented with modest, interim protective measures; 3) reassurance to workers that work-related health problems have not been demonstrated and are unlikely to have occurred and that little additional action is needed. It is not reasonable to expect that any epidemiologic method can determine unequivocally which of these activities is correct for a given workplace. Moreover, many epidemiologic techniques are too slow and cumbersome to have short-term decision-making value in the workplace. However, it has been possible to adapt standard epidemiologic methods to serve as public health tools in the workplace, so that quantitative data can be used in choosing among alternatives at a given workplace and in determining priorities among different locations according to relative urgency. One such method, addressing mortality, has been established in Michigan by making use of the State's computerized death registry. Three steps are involved:

- First, when a potential problem is identified, Local Union and International Union records are searched to produce a listing of persons at risk, or known to have died, with names and social security numbers. The full cohort of interest, all those who worked in the plant over a defined period, is usually not accessible or cannot be generated quickly. However, an inventory of available records (e.g., seniority lists, dues cards, application records, and sometimes death records) usually provides a fairly complete specification of those at risk. The fact that such a list might have gaps and sampling inconsistencies is not a deterrent in this triage process, as long as there is reasonable certainty that major confounding and selection bias have been avoided. This can often be assured by using a subgroup for which nearly complete and unbiased ascertainment is possible, such as all those hourly employees with at least 10 years of credited pension service.
- Second, names and social security numbers on the list of deceased or at-risk persons are matched against computerized mortality files such as those obtained from the State of Michigan Department of Public Health. The Michigan files contain all in-state deaths since 1970 with underlying cause coded by the International Classification of Disease (ICD) classification revision in effect at the year of death. As a useful but not essential adjunct, out-of-state deaths are identified by searches of Social Security Administration (SSA) records.
- Third, the resulting deaths identified, with underlying cause and demographic data, are used as input to the Monson program (with revisions) to generate standardized proportional mortality ratios (SPMR).[1]

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As an example, we describe the course of a mortality investigation at a metal stamping plant where maintenance welders and millwrights were exposed to coal tar and welding emissions.

Methods

Development of Study

The study site was a metal stamping plant located near Kalamazoo, Michigan. The plant, which began operations in 1966, has employed on average approximately 3,000 UAW members. The plant operations have included metal stamping, spot welding, tool and die making, metal machining, and pattern making.

The Local Union became concerned in 1980 about a possible high number of cancer deaths among its members. The Local Union Health and Safety Representative began to compile a list of deceased members along with information about their causes of death and jobs, which he was able to abstract from information available at the plant. The UAW had not yet developed most of the epidemiologic tools described in this paper. However, manual calculations of proportional mortality were done and did not reveal excesses of cause-specific mortality or associations between mortality and specific work assignments.

By 1982, the number of known decedents was 58 and the Union had developed the computerized capacity for PMR analysis.[1] Twenty-two cancer deaths among White men were observed, compared with eight expected based upon national rates. The Union decided to continue the investigation on a high priority basis.

A site visit was conducted by International Union staff to gain insight into the nature of chemical exposures potentially associated with various jobs. It was observed that the floors in this plant consist of wood blocks which are set and protected with hot coal tar in an operation that closely resembles roof tarring. Further, employees reported that: 1) millwrights have been responsible for laying the floor tar and have been exposed to smoke and vapors from this work; 2) the millwrights at this plant also work closely with the maintenance welders who weld or flame cut floor-bolts at floor level where tar and wood blocks sometimes ignite and generate smoky emissions; and 3) the wood blocks have been treated with wood preservatives, and have absorbed solvent and oil spills.

Historically, maintenance welding and floor tarring work had been done with a minimum of local exhaust ventilation or respiratory protection. Routine quantitative measurements of these exposures had not been made, but in 1979 personal and area air samples taken by the employer during floor tarring revealed coal tar pitch volatile concentrations in excess of 200 ug/cubic meter TWA (8-hour time weighted average) with peak exposures much higher.

This additional information about the chemical environment prompted a decision to expand the mortality evaluation and, simultaneously, to press for reduced exposure to tar emissions. The outcome of this more thorough review is presented below.

Study Group

The target population for the investigation was all deceased local union members ever-employed at the stamping plant with a date of death between January 1, 1966 and December 31, 1982. Sources of data included local union lists of deceased workers, union pension records, and employer life insurance records. These sources routinely received reports of deaths or copies of death certificates of active workers and retirees. Additionally, the local union newsletter circulation file was used to identify those who left employment before vesting or left employment with vested pension rights but might have died before retirement. This file was matched to SSA records of deceased persons using Social Security number as the match key.

Ninety-eight (98) deaths were reported from all sources, including eight uniquely ascertained from SSA records. Our judgment is that the group of 98 decedents is a virtually complete ascertainment of hourly workers who died while active or retired; a small number of deaths among workers on deferred vested status, or those terminated with less than 10 years seniority may have been missed.

Death certificates (or, in two cases, abstracted records) were obtained for 94 of the 98 deaths (96 per cent). For 62 of the Michigan deaths, underlying cause of death was determined by record-linkage of the death file to the computerized Michigan death certificate registry using Social Security numbers for matching. The remaining deaths, which included out-of-state deaths and those which occurred before the State computerized its files in 1970, were coded according to the 8th Revision of the ICD by the investigators.

The final study group included 91 White males, 2 Black males, and 1 White female.

Work Histories

Personnel records were obtained from the employer for 83 of the study group. Following site visits, discussions with the plant management and the Local Union, and a review of the available industrial hygiene reports, decedents were grouped into two exposure categories: 1) maintenance welders and millwrights; and 2) all other job classifications. This classification scheme was based on the judgment that maintenance welders and millwrights are most likely to be exposed to coal tar pitch volatiles.

Pre-plant employment as a welder or millwright was coded on an ever-never basis.

Statistical Analyses

SPMRs, standardized for age, sex, race, and calendar year of death, and case-control studies within the decedent population were carried out. Standardized Proportional Mortality Ratios (SPMR) for 54 causes of death were calculated for the 91 White males with US White males as the reference population, updated to include National Center for Health Statistics (NCHS) mortality data through 1978. SPMRs were also calculated for restricted subgroups based on employment duration and prior occupational history as a welder or millwright.

Case-control analyses were designed to examine the relationship between cancer mortality and specific jobs which share, among other things, hot tar operations or welding and flame cutting near tarred surfaces. Cancer cases were defined by underlying cause of death and grouped according to specific ICD codes: lung, 162; digestive organs, 150–159; leukemia, 204–207; and all malignant neoplasms; 140–209. Controls were defined as all non-cancer deaths. Nonmalignant respiratory disease deaths were therefore included as controls in the case-control analysis of lung cancer, a decision made to conserve statistical power despite the possibility that shared etiologic factors might result in a reduced ability to demonstrate associations. "Exposed" was defined as ever-maintenance welder or ever-millwright and "non-exposed" were all other job classifications.

Cases and controls were drawn from the 83 decedents

TABLE 1—Standardized Proportional Mortality, White Males, 1966–82, by Cause of Death

Cause of Death	Observed	Expected	SPMR	95% C.L.
All Cancer	28	14.82	189	1.36, 2.62
CA of Lung	10	4.75	220	1.18, 3.76
CA Digestive Organs	7	3.10	226	1.12, 4.56
CA of Testis	2	0.41	485	—
Leukemia	4	0.94	428	1.75, 10.45
All Cardiovascular	22	26.79	82	0.59, 1.13
All Nonmalignant Lung	0	2.96	0	—
All Nonmalignant Digestive	2	5.22	25	—
All External Causes	37	33.28	111	0.90, 1.38
All Other	2	7.92	25	—
TOTAL	91	91		

TABLE 2—Characteristics of Cases and Controls

Characteristics	Cases n = 27	Controls n = 56
Age at Death, Mean (SD)	47 (11)	38 (12)
Age at Death, Range	22–66	20–68
Employment Duration, Mean (SD)	9 (5)	7 (4)
Former Welders/Millwrights, Number (%)	7 (26)	4 (7)

with complete work histories: 80 White males, 2 Black males, and 1 White female. Tobacco smoking patterns were not known. Stratification was used to control potential confounding by age and pre-plant occupation.

Results

The observed number of malignant neoplasms (Table 1) is nearly twice that expected (PMR = 28/14.82 = 189, 95% C.L.1.36, 2.62). Two-fold to five-fold excess proportional mortality from cancer of the digestive organs, lung cancer, and leukemia accounts for most of the overall cancer excess. Essentially the same excesses were found in the subgroups with five or more years seniority or with no pre-plant employment as a welder or millwright (data not shown).

Table 2 gives age and occupational characteristics of cases and controls. On average, both cancer cases and controls died at relatively young ages and short employment duration. Because cases tended to be older at death than controls and were overrepresented by former welders or millwrights, case-control analyses were stratified by age and pre-plant occupation.

Table 3 presents age-stratified odds ratios for the association between cancer mortality and employment as maintenance welders and millwrights. The mean age in the 40+ age stratum was 50.3 (49.4 among nine welder/millwrights and 50.6 among 34 non-welder/millwrights) and in the <40 age stratum was 30.9 (33.8 among four welder/millwrights and 30.6 among 36 non-welder/millwrights). Odds ratios of more than 10 were found overall and in the 40+ age strata. Similarly, the odds ratios for lung cancer and digestive organ cancers were highly elevated in the 40+ strata (Table 4).

Table 5 presents cancer mortality and welder or millwright classification stratifying on prior welding or millwright occupation. While odds ratios are elevated in both strata, the odds ratio was much greater and statistically more stable in the subgroup without prior welding or millwright occupations. Odds ratios for lung cancer or cancer of digestive organs followed a similar pattern.

Further, case-control analysis simultaneously stratifying

TABLE 3—Association between All Cancer Mortality and Welder/Millwright Classification

Classification	All Ages Cases	Controls
Welder/Millwright	10	3
Other	17	53
OR = 10.4; 95% CL: 2.6–42.2		
	<40 Years	
Welder/Millwright	2	2
Other	5	31
OR = 6.2; 95% CL: 0.7–54.6		
	40+ Years	
Welder/Millwright	8	1
Other	12	22
OR = 14.7; 95% CL: 1.6–131.6		

TABLE 4—Association between Cancer Mortality, Two Sites, and Welder/Millwright Classification, Age 40+ Years at Death

Classification	Lung Cancer Cases	Controls
Welder/Millwright	3	1
Other	5	22
OR = 13.2; 95% CL: 1.1–154.9		
	All Digestive Cancers	
Welder/Millwright	3	1
Other	4	22
OR = 16.5; 95% CL: 1.1–162.2		

TABLE 5—Association between All Cancer Mortality and Job Classification by Prior Occupation

Classification	Former Welders or Millwrights Cases	Controls
Welder/Millwright	6	2
Other	1	2
OR = 6.0; 95% CL: 0.3–107.0		
	Not Former Welders or Millwrights	
Welder/Millwright	4	1
Other	16	51
OR = 12.8; 95% CL: 1.3–122.5		

on age, employment duration, and prior occupation also revealed similar associations between cancer mortality and millwright or maintenance welder classification, but statistical power was diminished, as expected with decreasing cell sizes.

Discussion

A union-based epidemiologic surveillance program proved to be an effective and efficient guide to occupational health action in a metal stamping plant. Use of a mortality surveillance system designed for routine use revealed excess proportional mortality from cancer of the lung, digestive organs, and leukemia. This lent credibility to local union concerns and led the union to assign this situation very high

TABLE 6—Stamping Plant Exposure Data* Before and After Installation of New Tar Pots

Chemical	Old Tar Pot: Vent	Old Tar Pot: Floor	New Tar Pot: Floor
Phenanthrene	500	50	0.88
Anthracene	200	20	0.55
Acridine	10	1	ND**
Pyrene	100	10	0.16
Chrysene	20	1	ND
Benz(a)pyrene	1	ND	ND

*All values in mg/cu.m.
Short-term Air samples.
**Non-Detectable.

priority for further investigation and to undertake interim efforts to control suspect chemical exposures. Subsequent case-control analysis documented associations between mortality from lung cancer and digestive cancers and work as maintenance welders and millwrights which involved probable exposure to coal tar pitch volatiles and welding emissions. This served as the basis for a further decision to seek more vigorous in-plant environmental intervention.

Following discussions of the findings the employer took short-term source and area samples during tarring which showed substantial levels of six specific polycyclic aromatic hydrocarbons with known carcinogenic or mutagenic properties (Table 6). Agreement was reached to take steps to reduce exposures of maintenance welders and millwrights to the suspect emissions. The employer purchased new, thermostatically controlled electric tar pots and agreed to obtain more than 20 portable ventilation units, construct several exhausted welding booths, purchase additional respirators, and initiate a search for non-coal tar floor coating substitutes. A series of educational meetings was held with more than 200 affected workers in the plant. At the urging of the union, the employer sent a bulletin to its other locations asking that floor tarring operations be evaluated and that steps be taken either to reduce emissions or find substitute materials. Follow-up area air sampling during tarring was conducted after the installation of the new tar pots and showed large reductions in airborne polycyclic aromatic hydrocarbons (Table 6).

We believe that these findings are sufficiently plausible to warrant an alert to the public health community of a probable, but previously unrecognized, hazard. The observed associations are large; feasible control measures are readily available; and the findings have considerable biologic plausibility.[2–4] Exposure of roofers and coke oven workers to coal tar pitch volatiles containing polycylic aromatic hydrocarbons has been associated with excess multiple-site cancer mortality.[5,6] The group experiencing excess mortality in this study uses similar materials under analogous conditions,[4] and exposures to specific mutagens and carcinogens have been documented (Table 6).

Efforts should be made to replicate the findings at other locations where similar work is done in such a manner that the combined and independent effects of coal tar and welding exposures can be evaluated. In our judgment, concurrent efforts should be made to notify representatives in potentially affected workplaces of the possible hazards and to encourage actions to reduce worker exposures to chemical emissions during floor tarring operations as the prudent response to the surveillance findings.

Mortality surveillance enabled the union to distinguish this plant situation from others which, on the surface, might have appeared equally urgent. For example, in another location there were 54 cancer deaths in 260 total deaths among White men. More than 60 malignancies were expected. There were slight excesses of brain and lymphopoietic cancers but a review of job histories revealed no clustering and did not direct attention to any specific chemical exposures. The mortality file has been updated yearly but no other intervention has been made.

Some advocates for an increased role for epidemiology in public health have argued that quantitative decision rules can be used by occupational and environmental health policy makers as virtually sufficient and complete guides to action. Dinman and Sussman, for example, have proposed, "a set of criteria for acceptance or rejection of any published study."[7] These criteria would be used to generate a summary score for studies in a given area of policy concern. The score would be used to ensure that "the public decision-making process optimally utilizes data in an organized, systematic fashion." Although they concede that "these scaled systems should not be considered as providing a mechanical method for arriving at judgment without thought," their single example seems to rely upon just such mechanical application. Dinman and Sussman calculate scores for five published studies of mortality among workers exposed to coal tar emissions in several industries. They average the scores for two studies of workers exposed to emissions in the early stages of coal tar production (i.e., coke oven workers) and for three studies of workers exposed to emissions after coal tar has been further distilled to produce coal tar pitch (i.e., roofers and aluminum reduction workers). They direct attention to an "information/option nonogram," a scale along which the epidemiologic scores correspond to public policy options. Use of this scale directs that strong action is necessary to "restrict manufacture" in coke ovens and that the appropriate measures for roofers and aluminum reduction workers fall somewhere between "no action" and "simple educational measures." Dinman and Sussman conclude that "the fumes of pitch are indeed less carcinogenic than tar if, indeed, they are carinogenic at all."

Lanes and Poole have critiqued the Dinman/Sussman scheme and conclude that, with respect to their coal tar/coal pitch assessment, "It is difficult to imagine a less secure evaluative foundation for such a strong and sweeping statement about causality."[8] We echo their critical judgment, sharing the belief that the fault lies not merely with the specific scoring system but with the very notion that public health policy decisions can be reduced to any set of epidemiologic rules and that the "formulation is best left to epidemiologists."[7]

Our concern with such reductionist systems is that even the most rigorous are essentially deceptive. Their apparent objectivity invariably masks a set of value judgments every bit as politically charged as those expressed by the most rhetorical of lay policy makers. The statistical concepts upon which scientific decision rules are based are inherently judgmental. For example, the choice of a statistically significant level expresses the willingness of an investigator to risk a conclusion which might be falsely positive. At a level of $p = .05$ the investigator is unwilling to conclude that a finding is significant unless there is less than a 5 per cent chance of being wrong. This embodies a value judgment about the level of certainty necessary for action, one which is more stringently conservative than we apply to most decisions of daily living.

While we advocate the increased input of quantitative epidemiologic science in workplace health and safety programs, we caution against the tendency to substitute numbers for balanced decision making which incorporates subjective judgments and openly acknowledges differences in values.

The UAW has articulated its approach in this regard as follows:

> "We must work with what we have before us, not what we hope to learn after five more years of studies. We face today the growing likelihood that substantial numbers of metalworkers have been exposed to cancer hazards on the job for years. If only a fraction of the reports are eventually substantiated, we still face a public health problem of major dimension. If we wait for the final reports before deciding to warn workers of the possible risks, and before taking protective actions, we will lose years of opportunity . . .
>
> "This means that in many situations we must take presumptive action. We have grown up believing that 'innocent until proven guilty' is the essence of justice. But the workplace is not a courtroom and chemicals have no constitutional rights. Giving a carcinogen freedom to roam through the plant during its lengthy trial is far more dangerous than letting an accused burglar free on bail."*

*Fraser D: Problems and challenges facing occupational medicine in the new decade from labor's viewpoint. Presented at American Occupational Health Conference, Detroit, MI, 4/22/80.

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