

Proportionate Mortality Among Construction Laborers

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This report presents the results of proportionate mortality ratio (PMR) analyses and proportionate cancer mortality ratio (PCMR) analyses among the 11,685 members of the Laborers' International Union of North America (LIUNA), who died between 1985-1988, using U.S. proportionate mortality rates as the comparison population. Statistically significant elevated mortality risks were observed for all malignant neoplasms (N = 3285, PMR = 1.13, CI = 1.09-1.17), as well as for site-specific neoplasms of the lung (N = 1208, PCMR = 1.06, CI = 1.00-1.12), stomach (N = 170, PCMR = 1.44, CI = 1.23-1.68), and thyroid gland (N = 10, PCMR = 2.24, CI = 1.07-4.12). The PCMRs for these malignant neoplasms were elevated among both white and non-white males, regardless of length of union membership, in most 10-year categories of age at death above 40 and for the three largest LIUNA regions examined. The study also observed 20 mesothelioma deaths, which indicated that some LIUNA members had been previously exposed to asbestos. Statistically significant elevated risks were also observed for deaths from transportation injuries (N = 448, PMR = 1.37, CI = 1.25-1.51), falls (N = 85, PMR = 1.34, CI = 1.07-1.66), and other types of injuries (N = 245, PMR = 1.61, CI = 1.42-1.83). The deaths due to injuries were most often observed among those members who had the shortest amount of time within the union, were younger, and first entered the union after 1955. This is the first study that has examined the general mortality experience limited to construction laborers only (Bureau of Census code 869). © 1995 Wiley-Liss, Inc.*

Key words: laborer, construction, proportionate mortality, injuries, asbestos, construction trades

INTRODUCTION

Construction workers can be broadly grouped into "skilled" trades such as painters, carpenters, plumbers, electricians, roofers, and ironworkers, as well as those who perform a variety of job tasks in conjunction with the other skilled trades, usually working in a utility capacity and often transferring from one task to another

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TABLE I. Job Subclassifications of Construction Laborers*

Aggregate weighman	Flagmen	Rubbing of concrete
Asbestos removal	Flaremen	Salamander heat
Asphalt kettlemen	Form liners and tampers	Sandblaster pot tender
Asphalt saw operators	Form oilers	Sandblaster, nozzlemen
Asphalt takers	Form setters	Sandblasting
Asphalt tampers	Gas service men	Sawmen and trimmers
Batch dumpmen on levers	Gravel box men	Scaffold men
Blade grade operators	Gunnite nozzlemen	Scaffold work
Bottom men sewer	Gypsum handlers	Servicing of all vibrators
Brick setters	Handing/conveying creosote	Shoring and bracing
Carpenter tender	Handling creosote	Signal man
Carrying reinforcement rods	Hod carriers	Skip men
Caulkers and yarners	Hoopermen	Slip form men on elevator
Cement dumpers	Hot tar and kettlemen	Small boat motorized man
Cement handlers	Housemovers	String off concrete
Center steel men	Jackhammer man	String men
Chain saw operator	Laying of steel mesh	Swampers, crane, tractor
Chip spreaders	Lead and leadite burners	Tending all types heaters
Compressed air workers	Machine cleaners	Tile and pipe layers
Concrete chippers and grinders	Mason tender	Tool room man
Concrete form strippers	Mat weaver	Top man
Concrete puddlers	Mixing asphalt emulsion	Track layers, railroad
Concrete saw operator	Monorail track layer	Tree trimmers/toppers
Cutters and burners	Mortar men	Trick helpers
Debris cleaning and cleaning	Motorized concrete buggyman	Tunnel and shaft miners
Deck hands on boats	Muckers	Unskilled laborers
Din spotters	Pile driver tender	Watchmen, guards
Dismantlers	Pipe wrapping machine man	Water distributors
Drain and tile layers	Plasterers senders	Windlass man
Drillers	Power tool operator	Woods men
Dynamite shooters	Rip rap stone layer	Wreckers-torch men
Expansion joints	River underwater work	
Explosive handlers	Rock dust handlers	
Fiber optics	Rod and chain man	

*Job subclassifications used by the Laborers' International Union of North America. Construction laborers were identified using code 869 [BOC, 1982], Published with permission of co-author, Greg Burkhardt.

when demands require (U.S. DOL, 1977). These latter workers are known as construction "laborers." During an average year, a construction laborer works ~1,500 hours and for 3–5 different employers [Moran, 1993]. Indicative of the many activities that laborers perform, 286 jobs were listed in the 1970 Bureau of the Census Index of Occupations under the heading "construction laborer" (U. S. DOC, 1971). This is substantiated by the list of job classifications used by the Laborers' International Union of North America (LIUNA) to dispatch workers to various construction sites (Table I).

As of 1992, there were ~654,000 construction laborers in the United States, of whom 3.1% were women, 12.5% black, and 16.7% Hispanic [BLS, 1993]. LIUNA is the largest and oldest national union of construction laborers in the United States.

As of 1989, there were ~423,000 members in this union (excluding 40,000 mail handlers), of whom 250,000 were employed directly as laborers in the construction industry, representing over one-third of all construction laborers in the United States.

Because laborers perform many varied duties, they have potential for exposure to numerous physical and chemical agents. Often these exposures can be episodic in nature. In addition, laborers may be also exposed to hazardous materials from working in close proximity to activities of other trades. Potential exposures among construction laborers at the job site include, among many others, asbestos, inorganic lead, solvents, carbon monoxide, and noise. Table II lists the potential exposures and estimated number of construction laborers who are exposed to each physical and chemical agent as derived from the National Occupational Exposure Survey (NOES) conducted by the National Institute for Occupational Safety and Health (NIOSH) (1988, 1992).

Little research has been done to characterize either the general health or the occupational risks of construction laborers. Because of this lack of research and in response to concerns from various organizations, a study was initiated to evaluate the proportionate patterns of mortality among deceased members of LIUNA who died in the years 1985–1988 and who had worked in the construction industry. This is the first known study to examine the mortality risks of a group of workers known to consist entirely of construction laborers.

METHODS AND MATERIALS

Study Population

Our study population consisted of all deceased laborers from local unions classified as largely construction by LIUNA, who were active dues paying members at the time of death (currently employed, unemployed, or retired), who had died between January 1, 1985 and December 31, 1988, and who had achieved at least 1 year of active continuous service within the union.

LIUNA learned of a member's death in two ways: from the local union to which the member belonged and from the beneficiary. The LIUNA death beneficiary file has been computerized since 1985 and was provided to us by the international headquarters of LIUNA. Only deaths in the LIUNA death beneficiary file were included in this study.

The study population included all eligible members for whom a death benefit claim had been filed as well as those known to be deceased by LIUNA through the local (and included on the death file), but for whom a death benefit claim had not been filed by the beneficiary. Members who died outside the United States were excluded from the analyses because death rates for countries other than the United States were unavailable to use as a comparison for the analyses and because of their relatively small numbers in the study ($N = 124$). The following information was utilized from the death claim and membership files: name, Social Security number, date of birth, years of active paying status, year of entry into the union, and local unions worked in.

All death certificates were coded by an experienced nosologist according to the Ninth Revision of the International Classification of Diseases [ICD, 1977]. Information coded from death certificates included underlying cause of death, up to three

TABLE II. Potential Exposures of Construction Laborers*

Potential exposures	Estimated number of employees exposed
Products of combustion-diesel fuels	128,399
Segmental vibration	110,711
Calcium carbonate	109,721
Potential continuous noise	107,881
Sand	91,887
Titanium oxide (TiO ₂)	84,443
Products of combustion-gasoline (leaded)	83,408
Concrete	82,445
Silica	75,237
Cement-Portland	72,663
Toluene	72,439
Limestone	67,357
Woods	65,964
Diesel fuel No. 2	54,766
Xylene	52,870
Iron oxide Fe ₂ O ₃	52,541
Asphalt	51,370
Butanone, 2-	49,042
Gasoline-leaded	48,538
Petroleum distillates, hydrotreated heavy naphthenic	41,009
Calcium sulfate	39,882
Oil, motor	39,468
Gypsum	36,038
Adhesive, synthetic resin	36,343
Calcium oxide	34,599
Products of combustion-jet fuel and unleaded gasoline	34,539
Calcium chloride	34,499
Sealants	33,375
Hydrochloric acid	33,242
Calcium hydroxide	32,953
Curing agent	32,315
Carbon dioxide	28,483
Oil, NEC	27,759
Kaolin	26,641
Caulking compound	25,567
Waterless hand cleaner	23,973
Inorganic-lead	23,121
Nitrilotriethanol, 2,2', 250305	20,825
Propylene glycol	20,630
Acetone	20,215
Vermiculite	19,194
Abrasive, grinding	19,172
Lubricants	18,889
Aluminum silicate	18,022
Ethylene glycol	17,798
Oleic acid	17,266
Plaster of paris	15,840
Grease	14,792
Asbestos	14,457
White mineral oil	14,221
Cleaning compound	14,086
Paint	12,795

(continued)

TABLE II. Potential Exposures of Construction Laborers* (continued)

Potential exposures	Estimated number of employees exposed
Petroleum resins	12,406
Coating, NEC	11,614
Welding rod ARW	11,044
Naphtha	10,502
Tall oil	9,615
Carbon monoxide	7,151
Elevated temperature	5,860
Mold release agents	5,732
Perlite	5,584
Chlorinated paraffin	4,461
Nitrogen oxide	3,337
Diesel fuel No. 1	3,064
Hardener	2,225
Calcium peroxide	2,193
Oil, lube	1,707
Steel	1,616
Calcium aluminum ferrite	862
Gasoline, lead content unknown	592
Polysulfide polymer	467

*Derived from the Job Exposure Matrix utilizing data from the National Occupational Exposure Survey conducted by NIOSH between 1981 and 1983. [NIOSH, 1988, 1990a,b]. Construction laborers were identified using code 869 [BOC, 1982].

contributory causes of death, and gender and race (which were not maintained by LIUNA).

Statistical Analyses

We conducted two types of proportionate mortality ratio (PMR) analyses [Hernberg, 1992] using NIOSH's Life Table Analysis System (LTAS) [Steenland et al., 1990], one that evaluated the overall proportionate mortality and a second that evaluated the proportionate cancer mortality. The number of deaths in the study population, by cause, was compared with the number of deaths expected based upon race, gender, and cause-specific proportionate mortality experience of the U.S. population by 5-year age groups for the 5-year calendar time period 1985–1989. The PMRs were then calculated by dividing the observed number of deaths by the number expected and multiplying the results by 100. Statistical significance of the results was determined using the Poisson distribution and 95% confidence intervals. If the observed number of deaths was greater than 6, the Byar approximation to the exact test was used; if the observed number of deaths was less than or equal to 6, exact confidence limits were used [Rothman and Boice, 1979]. PMRs were calculated for the effect of length of union membership (member paying dues whether employed, unemployed, or retired), year of entry, age at death, by LIUNA regions, and by race and gender. Proportionate cancer mortality ratios (PCMRs) were also calculated to correct for possible biases in cancer mortality due to excess elevations or deficits from other (nonmalignant) causes, particularly a possible deficit from heart disease due to the "healthy worker effect."

We analyzed separately those deaths for which death claims had been made and those deaths for which no claim had been filed. We anticipated the latter group would be both younger than the remaining group and have a higher proportion of deaths due to injuries. Chi-square trend tests for proportions were also used in some analysis to examine deviations from linearity [Rothman and Boice, 1979].

RESULTS

Characteristics of the Study Population

A total of 11,915 deaths among LIUNA members were identified between 1985 and 1988. From this total we excluded 124 deaths that occurred outside the United States (foreign deaths) and 106 deaths for whom a death certificate could not be obtained, for a total of 11,685 deaths included in this analysis.

To determine if the union records accurately reflected the amount of time a laborer worked in construction, we examined all death certificates in our study from the state of California, which is the only state that lists on the death certificates both the primary occupation or trade and the length of time the individual spent in such occupation or trade. Of the 1,793 death certificates reviewed from the state of California, all but 10 listed laborer or construction as the primary occupation or trade. The average time spent in the stated occupation was 26.4 years as listed on the death certificates. This result corresponded very closely to the average time "actively" in LIUNA as observed from the union records, which was 28 years.

Cause-Specific Mortality Analysis

Table III shows the number of deaths, cause-specific PMRs, and 95% confidence levels for the 11,685 members in the study. There were significant elevations in deaths due to all malignant neoplasms (Proportionate Mortality Ratio (PMR) = 1.13, 95% Confidence Interval (CI) = 1.09–1.17) mainly due to significant elevations of cancers of the stomach, rectum, lung, and thyroid gland, and all categories of fatal injuries including transportation injuries (PMR = 1.37, CI = 1.25–1.51), falls (PMR = 1.34, CI = 1.07–1.66), and other injuries (PMR = 1.61, CI = 1.42–1.83). The latter category included injuries caused by falling objects, machinery, instruments, explosion, electrical current, fire or flames and overexertion, and other types of miscellaneous and unspecified injuries. Deaths from diseases of the blood, cerebrovascular diseases, pneumonia, diseases of the genito-urinary system, diseases of the skin, and ill-defined conditions were significantly lower than expected. The PMR for diseases most associated with smoking (other than lung cancer), heart disease, and diseases of the respiratory system, were similar to those found in the general population; PMR = 0.99, CI = 0.96–1.03 and PMR = 0.96, CI = 0.90–1.03, respectively.

The PCMR analyses were conducted to correct for possible distortions in the PMR due to significant increases or decreases in nonmalignant causes of death. In this study, the category "all malignant neoplasms" had a significantly elevated PMR of 1.13. The PCMR, by definition, reduces the "all malignant neoplasms" category to 100, which, consequently, reduces the site-specific cancer results. Even so, three of the four site-specific cancers that were significantly elevated in the PMR analyses were still significantly elevated in the PCMR analysis; cancers of the stomach (N = 170, PCMR = 1.44, CI = 1.23–1.68), cancers of the trachea, bronchus and lung (N = 1208, PCMR = 1.06, CI = 1.00–1.12), and cancers of the thyroid gland (N = 10,

TABLE III. Observed Number of Deaths, Proportionate Mortality Ratios (PMR), and 95% Confidence Intervals Among LIUNA Members Who Died 1985–1988

Cause of death (ICDA-9)	Observed no. of deaths	PMR	95% confidence interval
All causes (000–999)	11,685	1.00	0.98–1.02
Tuberculosis (010–018)	10	0.60	0.27–1.10
All malignant neoplasms (140–208)	3,285	1.13 ^a	1.09–1.17
Cancer of the stomach (151)	170	1.63 ^a	1.40–1.90
Cancer of rectum (154)	62	1.35 ^b	1.04–1.73
Cancer of lung (162)	1,208	1.20 ^a	1.14–1.27
Cancer of thyroid gland (193)	10	2.50 ^a	1.20–4.60
Benign neoplasms (210–239)	37	1.16	0.82–1.60
Diabetes mellitus (200)	183	0.92	0.79–1.06
Diseases of the blood (280–289)	25	0.64	0.41–0.94
Alcoholism (303)	37	0.79	0.56–1.09
Diseases of the heart (400–434)	4,017	0.99	0.96–1.03
Ischemic heart disease (410–414)	2,839	1.02	0.98–1.06
Cerebrovascular disease (430–438)	591	0.91	0.84–0.98
Diseases of the respiratory system (460–519)	926	0.96	0.90–1.03
Pneumonia (except newborn) (480–486)	296	0.87	0.78–0.98
Emphysema (492)	105	1.12	0.92–1.36
Asthma (493)	25	1.25	0.81–1.85
Other respiratory diseases (470–478, 494–519)	479	0.99	0.91–1.09
Diseases of the digestive system (520–579)	414	0.94	0.85–1.04
Diseases of the stomach (531–537)	40	0.98	0.70–1.34
Liver cirrhosis (571)	207	1.03	0.89–1.18
Diseases of the genito-urinary system (580–629)	169	0.83	0.71–0.97
Chronic nephritis (582, 583, 585–587)	86	0.85	0.68–1.05
Diseases of the skin (680–686)	10	0.53	0.25–0.97
Diseases of the musculoskeletal system (710–739)	19	0.90	0.54–1.40
Symptoms and ill-defined conditions (780–799)	73	0.50	0.40–0.63
Transportation injuries (E800–848)	448	1.37 ^a	1.25–1.51
Poisoning (E850–869)	50	1.13	0.84–1.49
Falls (E880–888)	85	1.34 ^b	1.07–1.66
Other injuries (E890–928)	245	1.61 ^a	1.42–1.83
Suicide (E950–959)	216	0.91	0.79–1.04
Homicide (E960–978)	162	1.10	0.94–1.29

^ap<0.01.^bp<0.05.

PCMR = 2.24, CI = 1.07–4.12). The PCMR for cancers of the rectum, which was significantly elevated in the PMR analysis, was also elevated (N = 62, PCMR = 1.20, CI = 0.92–1.54) (Table IV).

Years of Union Membership

Analyses were also conducted by years of union membership using the PMR and PCMR methodologies (Table V). For cancer of all sites, and for stomach, lung, and thyroid gland, there was an increased risk of death for each 10-year period of union membership. However, no statistically significant trend was observed.

For fatal injuries prior to 20 years of union membership there were significantly increased risks for transportation injuries, falls, and other types of injuries, the trend

TABLE IV. Observed Number of Deaths, Proportionate Cancer Mortality Ratios (PCMR), and 95% Confidence Intervals Among LIUNA Members Who Died 1985–1988

Causes of death (ICDA-9)	Observed no. of deaths	PCMR	95% confidence interval
All malignant neoplasms (140–208)	3,285	1.00	0.97–1.04
Buccal cavity and pharynx (140–149)	49	0.64	0.47–0.84
Digestive system (150–159)	857	1.06	0.99–1.13
Esophagus (150)	96	0.91	0.74–1.11
Stomach (151)	170	1.44 ^a	1.23–1.68
Peritoneum and other digestive (158–159)	17	1.35	0.78–2.16
Large intestine (152–153)	264	0.90	0.80–1.02
Rectum (154)	62	1.20	0.92–1.54
Liver (155–156)	23	1.02	0.65–1.53
Pancreas (157)	163	1.07	0.92–1.25
Respiratory system (160–165)	1,255	1.05	0.99–1.11
Pleura and other parts of respiratory system (160, 163–165)	12	1.13	0.58–1.98
Trachea, bronchus, and lung (162)	1,208	1.06 ^b	1.00–1.12
Larynx (161)	35	0.83	0.58–1.58
Prostate (185)	334	0.91	0.82–1.02
Kidney (189)	67	0.96	0.74–1.21
Bladder (188)	70	0.94	0.73–1.19
Skin (172, 173)	53	0.93	0.70–1.22
Brain and other central nervous system (191, 192)	57	0.88	0.66–1.14
Thyroid gland (193)	10	2.24 ^b	1.07–4.12
Other and unspecified sites (194–199)	239	0.99	0.87–1.12
All lymphopietic cancer (200–208)	262	0.97	0.86–1.10
Lymphosarcoma/reticulosarcoma (200)	21	1.22	0.76–1.87
Hodgkin's disease (201)	6	0.56	0.20–1.22
Other lymphatic neoplasms (202–203)	149	1.08	0.92–1.27
Leukemia and aleukemia (204–208)	86	0.83	0.66–1.02

^a $p < 0.01$.^b $p < 0.05$.

being statistically significant. After 20 years of union membership, the risks for all fatal injuries declines dramatically.

Results for diseases of the respiratory system seemed to increase slightly with greater time within the union. No pattern was observed for ischemic heart disease.

Year of Entry into the Union

Analyses were conducted by year of entry into the union prior to and after 1955 (Table VI). These results could be helpful in evaluating possible increased or decreased risks due to newly introduced or eliminated toxic substances at the worksite. The year 1955 was chosen to allow persons employed after that date sufficient time to develop most cancers (30 years). The PMRs for all cancers combined and the PCMR for cancers of the stomach were significantly elevated in both time periods. For all cancers combined, the PMR = 1.11, C.I. = 1.05–1.17, ($p < 0.01$) prior to 1955; and PMR = 1.15, C.I. = 1.10–1.20, ($p < 0.01$) after 1955. For cancers of the stomach, the PCMR was 1.33, C.I. = 1.03–1.70 ($p < 0.01$) before 1955 and PCMR = 1.52, C.I. = 1.24–1.84 ($p < 0.01$) after 1955. Lung cancer was elevated during both periods, but not significantly. The PCMRs for cancer of the thyroid gland were

TABLE V. Observed Selected Causes of Death (OBS), Proportionate Cancer Mortality Ratios (PCMR), or Proportionate Mortality Ratios (PMR) by Years of Union Membership Among LIUNA Members Who Died 1985–1988

Cause of death 40 + (ICDA-9)	Years in the union											
	<10 YR		10–20		20–30		30–40		40+		Total	
	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR
All cancers (140–208)	159	1.01	661	1.01 ^a	899	1.01 ^a	1061	1.00	505	1.01	3285	1.00
Stomach cancer (151)	7	1.32	40	1.65 ^a	47	1.47 ^a	48	1.27	28	1.50	170	1.44 ^a
Lung cancer (162)	55	1.13	283	1.15 ^b	334	1.00	381	1.06	155	1.06	1208	1.06 ^b
Thyroid cancer (193)	1	3.61	2	2.12	3	1.19	2	1.43	2	3.05	10	2.24 ^b
	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR
Ischemic heart disease (410–414)	121	1.11	443	0.99	649	0.95	1040	1.05	586	1.07	2839	1.02
Respiratory system (460–519)	23	0.68	102	0.84	207	0.97	349	0.96	248	1.09	926	0.96
Transportation injuries (E800–848)	233	1.35 ^a	128	1.66 ^a	44	1.17	34	1.21	9	0.86	448	1.37 ^a
Falls (E880–888)	23	2.40 ^a	21	1.77 ^a	14	1.15	144	0.79	13	1.09	85	1.34 ^b
Other injuries (E890–928)	96	1.98 ^a	73	1.92 ^a	37	1.37	30	1.16	9	0.73	245	1.61 ^a

^ap<0.01.^bp<0.05.

increased in both periods and significantly increased for those members entering after 1955.

With the exception of transportation injuries, the PMRs for all fatal injuries were significantly elevated among members first employed after 1955 ($p < 0.01$), but the results were lower than expected for those members first employed before 1955. Among members hired prior to 1955, PMRs for ischemic heart disease (PMR = 1.08, C.I. = 1.03–1.14) and diseases of the respiratory system (PMR = 1.12, C.I. = 1.03–1.22) were significantly increased but not among members hired after 1955.

Age at Death

Table VII shows PMRs and PCMRs for selected causes of death by age at death. For all cancers, and especially for cancers of the lung, stomach, and thyroid gland, there was an increased risk of death for each of the 10-year, age-of-death categories after age 30. However, no significant trend was found. For fatal injuries, statistically significant increased risks were observed prior to the age of 60 for transportation injuries, falls, and other types of injuries, except for the 10-year period 40–49 for transportation injuries, which were elevated but not significantly increased. For fatal injuries, the average age at death among all LIUNA members was 44 (median = 39) as compared to age 68 (median = 70) for all other causes of death combined.

TABLE VI. Observed Selected Causes of Death (OBS), Proportionate Cancer Mortality Ratios (PCMRs), or Proportionate Mortality Rates (PMRs), and 95% Confidence Intervals (CI) by Year of Entry in Union Among LIUNA Members Who Died 1985–1988

Causes of death (ICDA-9)	Year of Entry					
	< 1955			≥ 1955		
	OBS	PCMR	95%CI	OBS	PCMR	95%CI
All causes (000–999)	5055	1.00	0.97–1.03	6630	1.00	0.98–1.02
All cancers (140–208)	1346	1.11 ^a	1.05–1.17	1939	1.15 ^a	1.10–1.20
Stomach cancer (151)	65	1.33 ^a	1.03–1.70	105	1.52 ^a	1.24–1.84
Lung cancer (162)	455	1.06	0.97–1.16	753	1.06	0.99–1.14
Thyroid cancer (193)	3	1.71	0.35–5.00	7	2.58 ^b	1.03–5.31
	OBS	PMR	95%CI	OBS	PMR	95%CI
Ischemic heart disease (410–414)	1476	1.08 ^a	1.03–1.14	1363	0.96	0.91–1.02
Diseases of the respiratory system (460–519)	385	1.12 ^b	1.03–1.22	541	1.02	0.95–1.10
Transportation injury (E800–848)	32	0.99	0.68–1.39	416	1.41	0.85–1.53
Falls (E880–888)	20	0.75	0.46–1.16	65	1.77 ^a	1.37–2.26
Other injuries (E890–928)	32	0.97	0.66–1.36	213	1.79 ^a	1.56–2.05

^ap<0.01.^bp<0.05.

Gender and Race

In general, the PMRs for both white males and nonwhite males were similar. In both these groups, “all malignant neoplasms” were significantly elevated (PMR = 1.11, CI = 1.06–1.15 and PMR = 1.18, CI = 1.11–1.26, respectively) as were transportation injuries (PMR = 1.36, CI = 1.22–1.50 and PMR = 1.43, CI = 1.13–1.79, respectively). For white males, significantly increased site-specific cancers were observed for the stomach (PCMR = 1.88) and lung (PCMR = 1.18) and additionally, significantly elevated risks were found for falls (PMR = 1.41) and other injuries (PMR = 1.87) all at $p < 0.01$ (Table VIII). For nonwhite males, significantly increased site-specific cancer risks were also observed for the lung (PMR = 1.25, $p < 0.01$) and stomach (PMR = 1.30, $p < 0.05$) and, in addition, for the thyroid gland (PMR = 4.49, $p < 0.05$), and for transportation injuries (PMR = 1.43, $p < 0.01$) (Table IX). When the PCMR results were run, elevated risks among white males for cancers of the stomach, lung, and thyroid gland remained, but as in the PMR analysis, only cancers of the stomach and lung remained statistically significant. The PCMR results for nonwhite males found elevated cancer risks for the stomach, lung, and thyroid gland (as in the PMR analyses) but only the latter risk remained statistically significant.

There were only 36 deaths among white females and 23 deaths among nonwhite females, and none of the site-specific results were found to be statistically significant, partially due to the small number of deaths. For white females, there were a total of 12 cancers observed vs. 12.48 expected, PMR = 0.93, C.I. = 0.50–1.68. The total of the 12 cancers were comprised of three cancers each of the lung and of the breast, two cancers of the intestine, and one each for the pancreas, bladder, one lymphosar-

TABLE VII. Observed Selected Causes of Deaths ((OBS), Proportionate Cancer Mortality Ratios (PCMR), or Proportionate Mortality Ratios (PMR)) by Age at Death Among LIUNA Members Who Died 1985-1988

Causes of death (ICDA-9)	Age at Death														Total	
	<30		30-39		40-49		50-59		60-69		70-79		80+		OBS	PMR
	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PCMR	OBS	PMR
All cancers (140-208)	11	1.02	41	1.02	148	1.01	573	1.00	1065	1.00	958	1.00	489	1.01	3285	1.00
Lung cancer (162)	0	—	6	1.20	54	1.16	244	1.05	445	1.05	340	1.07	119	1.09	1208	1.06 ^a
Stomach cancer (151)	0	—	2	1.60	9	1.73 ^a	29	1.47 ^a	49	1.34 ^a	54	1.52 ^a	27	1.44 ^a	170	1.44 ^a
Thyroid cancer (193)	0	—	3	27.30	0	—	1	1.19	3	2.30	2	1.67	1	1.51	10	2.24 ^a
	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR	OBS	PMR
Ischemic heart disease (410-414)	4	1.33	33	1.25	138	1.15	358	0.97	704	0.98	848	0.98	754	1.11 ^a	2839	1.02
NMRD (460-519) ^b	2	0.77	9	0.80	13	0.59	49	1.63	184	0.88	366	1.20 ^a	303	1.00	926	0.96
Transportation inj. (E800-848)	147	1.21 ^a	122	1.81 ^c	45	1.08	68	1.84 ^a	35	1.23	20	1.00	1	1.06	448	1.37 ^c
Falls (E880-888)	9	2.14 ^a	13	2.71 ^c	12	2.35 ^a	18	2.25 ^a	13	1.49	5	0.39	15	0.85	85	1.34 ^a
Other injuries (E890-928)	46	1.66 ^a	50	2.17 ^c	47	2.49 ^c	36	1.57 ^a	27	1.12	24	1.18	15	0.99	245	1.61 ^c

^ap<0.05.

^bNonmalignant respiratory disease.

^cp<0.01.

TABLE VIII. Observed Number of Deaths, Proportionate Mortality Ratios (PMR), Proportionate Cancer Mortality Ratios (PCMR), and 95% Confidence Intervals Among White Male LIUNA Members Who Died 1985–1988

Causes of death (ICDA-9)	Observed no. of deaths	PMR	95% Confidence intervals
All causes (000–999)	8234	1.00	0.98–1.02
Tuberculosis (010–018)	6	1.11	0.40–2.41
All malignant neoplasms (140–208)	2207	1.11 ^a	1.06–1.15
cancer of stomach (151)	114	1.88 ^a	1.55–2.25
cancer of lung (162)	824	1.18 ^a	1.10–1.26
cancer of thyroid gland (193)	6	1.95	0.71–4.25
Benign neoplasms (210–239)	28	1.22	0.81–1.76
Diabetes mellitus (250)	110	0.89	0.73–1.07
Diseases of the blood (280–289)	16	0.59	0.34–0.96
Alcoholism (303)	24	0.98	0.63–1.46
Diseases of the heart (400–434)	2908	0.99	0.96–1.03
ischemic heart disease (410–414)	2202	1.03	0.98–1.07
Cerebrovascular disease (430–438)	391	0.94	0.85–1.03
Pneumonia (except newborn) (480–486)	213	0.90	0.78–1.03
Emphysema (492)	83	1.10	0.88–1.37
Asthma (493)	11	1.00	0.50–1.79
Pneumoconioses and other respiratory disease (470–478, 494–519)	353	0.97	0.87–1.08
Diseases of the digestive system (520–579)	301	0.98	0.88–1.10
diseases of the stomach (531–537)	29	1.01	0.68–1.46
liver cirrhosis (571)	161	1.12	0.96–1.31
Diseases of the genito-urinary system (580–629)	95	0.81	0.66–0.99
Diseases of the skin (680–686)	3	0.36	0.07–1.05
Diseases of the musculoskeletal system (710–739)	10	0.73	0.35–1.35
Symptoms and ill-defined conditions (780–799)	45	0.50	0.36–0.67
Transportation injuries (E800–848)	368	1.36 ^a	1.22–1.50
Poisoning (E850–869)	39	1.14	0.81–1.56
Falls (E880–888)	67	1.41 ^a	1.09–1.79
Other injuries (E890–928)	196	1.87 ^a	1.61–2.15
Suicide (E950–959)	196	0.91	0.79–1.05
Homicide (E960–978)	82	1.03	0.82–1.27
Proportionate cancer mortality ratios			
Causes of death (ICDA-9)	Observed no. of deaths	PCMR	95% confidence intervals
Cancer of stomach (151)	114	1.69 ^a	1.40–2.03
Cancer of lung (162)	824	1.06 ^b	1.00–1.37
Cancer of thyroid Gland (193)	6	1.78	0.65–3.86

^ap<0.01.^bp<0.05.

coma, and one of an unspecified site. White females also had four fatal injuries observed vs. 2.57 expected, PMR = 156, C.I. = 0.42–3.98. For nonwhite females, there were a total of seven cancers observed vs. 6.26 expected, PMR = 1.12, C.I. = 0.45–2.31. The seven cancers were two each from the lung and of unspecified site, and one each of the esophagus, breast, and intestine. There were two fatal injuries (both due to transportation) vs. 1.07 expected, PMR = 1.87, C.I. = 0.23–6.74.

TABLE IX. Observed Number of Deaths, Proportionate Mortality Ratios (PMR), Proportionate Cancer Mortality Ratios (PCMR), and 95% Confidence Intervals Among Nonwhite Male LIUNA Members Who Died 1985-1988

Causes of death (ICDA-9)	Observed no. of deaths	PMR	95% confidence intervals
All causes (000-999)	3392	1.00	0.97-1.03
Tuberculosis (010-018)	4	0.39	0.11-1.26
All malignant neoplasms (140-208)	1059	1.18 ^a	1.11-1.26
cancer of stomach (151)	56	1.30 ^b	1.00-1.69
cancer of lung (162)	379	1.25 ^a	1.13-1.38
cancer of thyroid Gland (193)	4	4.49 ^b	1.22-11.47
Benign neoplasms (210-239)	9	1.04	0.48-1.98
Diabetes mellitus (250)	72	0.97	0.76-1.23
Diseases of the blood (280-289)	9	0.78	0.35-1.48
Alcoholism (303)	12	0.55	0.28-0.95
Diseases of the heart (400-434)	1098	1.00	0.94-1.06
ischemic heart disease (410-414)	629	1.01	0.93-1.09
Cerebrovascular disease (430-438)	193	0.84	0.72-0.97
Pneumonia (except newborn) (480-486)	81	0.80	0.64-1.00
Emphysema (492)	22	1.22	0.77-1.85
Asthma (493)	13	1.51	0.80-2.59
Pneumoconioses and other respiratory disease (470-478, 494-519)	125	1.08	0.90-1.29
Diseases of the digestive system (520-579)	111	0.85	0.70-1.03
diseases of the stomach (531-537)	10	0.84	0.40-1.09
liver cirrhosis (571)	46	0.81	0.60-1.09
Diseases of the genito-urinary system (580-629)	74	0.87	0.68-1.09
Diseases of the skin (680-686)	7	0.66	0.27-1.37
Diseases of the musculoskeletal system (710-739)	8	1.12	0.48-2.22
Symptoms and ill-defined conditions (780-799)	28	0.53	0.35-0.76
Transportation injuries (E800-848)	76	1.43 ^a	1.13-1.79
Poisoning (E850-869)	11	1.14	0.57-2.04
Falls (E880-888)	17	1.11	0.64-1.77
Other injuries (E890-928)	48	1.03	0.76-1.37
Suicide (E950-959)	19	0.88	0.53-1.38
Homicide (E960-978)	79	1.20	0.95-1.50
Proportionate cancer mortality ratios			
Causes of death (ICDA-9)	Observed no. of deaths	PCMR	95% Confidence interval
Cancer of stomach (151)	56	1.12	0.84-1.45
Cancer of lung (162)	379	1.06	0.96-1.17
Cancer of thyroid (193)	4	3.83 ^b	1.04-9.80

^ap<0.01.

^bp<0.05.

DISCUSSION

The study population consisted of 11,685 members of the Laborers' International Union of North America (LIUNA) who died between 1985-1988. Because the number of deaths in this study was relatively large, its size was adequate for examining mortality from a number of individual causes. For most individual causes of

death, the study had at least 80% power of detecting a minimum relative risk of at least 2.0 or greater.

Lung Cancer

Malignancy of the lung was the most common site of cancer, accounting for more than one third (1208 out of 3285) of all cancer deaths. The lung cancer risk was elevated in all 10-year periods of length of union membership and in all 10-year, age-at-death groups after the age of 29. Lung cancer excesses were noted for LIUNA members regardless of the year of first union membership (before or after 1955), filing status (claim or no claim), or race (white or nonwhite), and was also consistently elevated among the three largest regions of LIUNA (NY/NJ, Chicago, LA).

Analysis of surveillance data has also shown increased risks for lung cancer among laborers. In three PMR studies, a significantly increased risk for lung cancer was observed among construction laborers. Two of these studies were conducted in the United States; one in California [Peterson and Milham, 1980] and the other in Washington State [Milham, 1983], and one was conducted in England and Wales [Registrar General, 1986].

Laborers were also found to be at an increased risk for lung cancer in a large PMR study in which the National Institute for Occupational Safety and Health (NIOSH) analyzed data from over 876,000 death certificates from 19 states for the years 1984–1986. The results showed statistically significant PMRs for lung cancer among white males for whom construction laborer (Bureau of Census code 869) was stated on the death certificate as the “usual occupation” ($N = 894$, $PMR = 1.13$, $95\% CI = 1.06-1.21$) [Robinson et al., 1994]. In an update of this study in which almost two million death certificates from 24 states occurring from 1984–1988 were analyzed, a similar significantly increased risk for lung cancer was observed among white male construction laborers ($N = 1690$, $PMR = 1.12$, $95\% CI = 1.07-1.17$). An elevated risk was not seen for lung cancer among black males ($N = 686$, $PMR = 1.01$, $95\% CI = 0.93-1.08$) [Burnett et al., 1994]. In a study of construction workers in England, the incidence of bronchial carcinoma was found to be significantly increased, Standardized Incidence Ratio (SIR) = 1.70 ($CI = 1.0-2.9$) [Coggon et al., 1986].

Standardized Mortality Ratios (SMR) were calculated for two studies for various occupations and industries in the state of California. In the California Occupational Mortality Study (COMS) [California DOH, 1987] and the COMS II [Singleton and Beaumont, 1989], a modification of the COMS study adjusted for smoking, alcohol, and socioeconomic status based upon data from the National Health Interview Survey [Kovar and Poe, 1985], death certificates of workers who died in California in the years 1979–1981 were linked to the 1980 U.S. Census of California. In these studies, construction laborers [Bureau of the Census Occupational code 869, U.S. Dept. of Commerce, 1982] were analyzed as a subset of workers included in the category “other construction workers,” which also included tile setters, carpet and drywall installers, glaziers, insulation workers, and structural metal workers. For white males, the unadjusted SMR for lung cancer among “other construction workers” was 1.63, (C.I. = 1.38–1.86) and among black males, the SMR for lung cancer among “other construction workers” was 2.23 (C.I. = 1.62–2.84). When adjustments were made for smoking, alcohol, and socioeconomic status, there remained elevated, but not statistically significant, risks for lung cancer among both white

(SMR = 1.09, CI = 0.93–1.28) and black (SMR = 1.29, CI = 0.94–1.65) males. Dr. Jay Beaumont, one of the two authors of the COM II study, analyzed the mortality of construction laborers (BOC category 869) as a single occupation (pers. comm.). Among white male construction laborers, the unadjusted lung cancer risk was found to be statistically significantly high, SMR = 1.48 (CI = 1.17–1.85), and among black males the lung cancer risk was also statistically significantly increased, SMR = 2.69 (CI = 1.98–3.57).

Various job subclassifications of construction laborers have been shown to be associated with asbestos exposure, including asbestos removal (during demolition of existing buildings), insulation, cement handlers, concrete chippers and grinders, creosote handlers, and sandblasting [Enterline, 1985; Engholm et al., 1987; Hughes et al., 1987; Kipen et al., 1987]. Asbestos has been used as thermal insulation in drywall, asbestos-cement pipe wrapping, in spray ceilings, paint, floor tile, ceiling tile, roofing materials, and coal tar, among other products. In the past, the construction industry as a whole has been shown to account for an estimated 70–80% of the total U.S. consumption of asbestos fiber [Levine, 1978] of which there were over one million tons [Nicholson, 1986]. It has been estimated that the proportion of construction workers at risk for asbestos exposure during 1958–1972 was 50% (when multistoried buildings were sprayed with asbestos fireproofing material) and 20% during 1940–1957 and 1973–1979 [Nicholson et al., 1982].

Laborers are at an increased risk for asbestos-associated disease due to their exposure to asbestos either directly in the tasks they perform, or indirectly by working in close proximity to other skilled tradesmen. Selikoff reported that U.S. construction workers who sprayed insulation had a sevenfold increased risk of cancer of the lung and of the pleura [Selikoff, 1969]. Furthermore, three reports from Swedish studies have shown an increased risk of lung cancer, mainly attributable to occupational asbestos exposure, among laborers in the construction industry (Englund and Engholm, 1982; Engholm et al., 1987; Fletcher, 1990). A study of the residents in East Anglia, United Kingdom, observed that, upon autopsy, building laborers, mainly those doing demolition work, had the highest asbestos concentrations of all residents surveyed, generally >30,000 fibers/gram [Stovin and Partridge, 1982]. Due to the high rate of exposure, Nicholson et al. [1982] estimated that by the year 2000, 1,900 excess deaths of workers in the construction trades will be due each year to asbestos-related lung cancer and that the excess will remain substantial for three additional decades, although at a somewhat decreased rate.

As early as 1960, Wagner et al., reported that the appearance of asbestosis or mesothelioma was a clear indicator of prior asbestos exposure. In one study in which 70 consecutive patients with pleural mesothelioma had been examined, it was observed that 69 had prior asbestos exposure, and there was some question about number 70 [Selikoff et al., 1965]. In reviewing the death certificates of the LIUNA membership, we observed 20 cases of mesothelioma as the underlying cause of death; 14 cases of mesothelioma (not otherwise specified as to site), 5 cases of pleural mesothelioma, and 1 case of peritoneal mesothelioma. Expected rates of mesothelioma deaths to which to compare our findings were not available, but these deaths are considered to be quite rare in the general population.

In reviewing numerous studies on asbestos exposure, Nicholson [1986] has shown that there is a clear association between the number of mesothelioma deaths and the number of excess lung cancers that are attributable to asbestos exposure. The

ratio of mesotheliomas to excess asbestos-related lung cancers was found to be in the range of 3:1–10:1 depending on magnitude of the exposure, length of exposure, time since onset of exposure (latency), and fiber type (chrysotile, amosite, or crocidolite). With 20 cases of mesothelioma in our study, we would predict 60–200 cases of lung cancer deaths due to asbestos in this population, based upon Nicholson's [1986] findings. We found 71 excess lung cancers in the PCMR analysis (1,208 observed, 1,137 expected) and 203 excess lung cancers in the PMR analysis (1,208 observed, 1,005 expected). Therefore, we would suggest that some LIUNA members had asbestos exposure, albeit possibly limited, varied, and intermittent, which contributed to the lung cancer excess.

Lung cancer in the construction industry has also been implicated in the use of coal tar, asphalt production, welding fumes, and diesel exhaust [Hammond et al., 1976; NIOSH, 1977a; Schenker 1980; Wilson, 1984; Silverstein et al., 1985]. Construction laborers would likely come into contact with some or all of these toxic agents in their normal assignments.

It has been reported that the construction industry in general, and laborers (not elsewhere classified) and skilled construction workers, in particular, have a greater risk of smoking-related diseases because of their smoking experience [Walrath et al., 1985; Hrubec et al., 1992]. Therefore, some of the excess lung cancer risk found among the LIUNA membership, which was of borderline statistical significance, may have been tobacco-related. Siemiatycki et al., [1988] found that relative risk estimates for lung cancer as high as 1.20 could be attributable to confounding bias, even if the results are "statistically significant." Information on smoking status or amount of cigarette smoking among members of this group of laborers was lacking. However, nonmalignant diseases of the respiratory system, which most likely would have been elevated if smoking were greatly increased among LIUNA members, were lower than expected with 926 deaths observed vs. 960.2 deaths expected, PMR = 0.96 (CI = 0.90–1.03). Furthermore, the COMS II report, after adjustment for smoking as well as alcohol and socioeconomic status, still found an elevated risk for lung cancer among the category "other construction laborers" [Singleton and Beaumont, 1989].

Stomach Cancer

Stomach cancer was also significantly elevated in the LIUNA study population. The PMRs were elevated in each 10-year category of length of union membership and significantly elevated in each 10-year category of age-at-death after age 30.

In 1930, cancer of the stomach was the leading cause of death due to all cancers among men in the United States. Today, the risk of stomach cancer has declined remarkably [Devesa et al., 1987]. Yet, after pancreatic and lung cancer, stomach cancer has the poorest 5-year survival rate of all site-specific cancers with only 16% survival over the period 1979–1984 [Axtell et al., 1976]. As of 1989, cancer of the stomach accounted for only 3% of all cancer deaths among U.S. males. Yet, in our group of laborers, stomach cancer accounted for >5% (170/3,266) of all our cancer deaths. It is possible that some of these stomach cancer deaths, however, may have come from a misdiagnosis of peritoneal mesothelioma because of the difficulty of distinguishing the two diseases clinically. Although diet has been a major risk factor for stomach cancer, various environmental factors have also been associated with the etiology of stomach cancer including asbestos exposure [Hammond et al., 1976; Miller, 1978; Selikoff et al., 1979; McDonald et al., 1980], wood dust [Acheson,

1984], coal tar pitch volatiles [Silverstein et al., 1985], and cement [McDowell, 1984]. Selikoff reported that workers in the construction industry spraying insulation had an almost fourfold increased risk of cancer of the stomach and a similar risk for that of the colon and rectum [Selikoff, 1969]. In 1982, Nicholson estimated that by the year 2000, ~500 excess deaths due to gastrointestinal cancers will occur each year to members of the construction trades due to prior asbestos exposure.

Studies of construction workers have shown an elevated risk of stomach cancer. The COMS and COMS II studies observed elevated risks among white male "other construction workers"; SMR = 156, CI = 0.92–2.46 in the COMS study, and SMR = 1.13 (CI = 0.67–1.79) in the COMS II (adjusted) study. For black males the risk for stomach cancer was ~1.00 (PMR = 1.04) in the COMS study but only 0.52 (adjusted) in the COMS II study. In a re-analysis of the COMS study examining only construction laborers (BOC code 869), the results were very similar to those obtained for the group "other construction laborers." For white males, the SMR was 1.57 (CI = 0.75–2.69), and for black males, the SMR was 1.31 (CI = 0.27–3.84). In the PMR study of residents in Washington State (Milham, 1983), the PMR for stomach cancer among construction laborers was elevated (PMR = 1.11) but not statistically significant. In the Registrar General decennial supplement for Great Britain, 1979–1983, the analysis of last full-time occupations of men and women who died aged 16–74, the SMR for stomach cancer among builders was statistically significant at 1.32, and the PMR among builders was slightly elevated at 1.07 but not statistically significant (Registrar General, 1986). In light of the results of our study, as well as the other studies showing an elevated risk of stomach cancer among construction laborers, there is strongly suggestive evidence that construction laborers are at an increased risk for stomach cancer.

Thyroid Cancer

The PMRs and PCMRs for thyroid cancer were unexpectedly high for the LIUNA members. Thyroid cancer is one of the rarest of neoplasms, with an incidence rate of <3 per 100,000 and a mortality rate of ~0.4 per 100,000. Only about 0.2% of all male cancer deaths are due to thyroid cancer. Whereas a cause-and-effect relationship has been demonstrated with radiation [Laird, 1987; Kendall et al., 1992], other risk factors in the etiology of thyroid cancer remain obscure. Exposure to ionizing radiation in the construction industry may occur during the nondestructive testing of the integrity of pipelines, the demolition of laboratories containing radioactive materials and of buildings containing radioactive lighting conductors, and the erection, demolition, or clean-up of nuclear power stations. Thyroid cancer was elevated in all 10-year categories of length of years within the union, by year of entry in the union (before and after 1955), and in each 10-year, age-of-death category (except age 40–49), among white and nonwhite males, and among those members for whom a claim was filed and not filed. A study by Burnett et al. [1994] examining the usual occupation on the death certificate of almost two million decedents from 24 states found that among white construction laborers, the PMR for thyroid cancer was 0.45 (N = 3, CI = 0.09–1.32) and among black construction laborers, the PMR was 1.45 (N = 2, CI = 0.18–5.24). A Swedish study examining the incidence of thyroid cancer and occupation found a decreased risk among unskilled construction laborers [Carstensen et al., 1990]. No study thus far has reported a significantly increased risk of thyroid cancer among construction laborers, although because of the rarity of the

disease, the expected number of deaths is small. Although other studies have not observed an elevation in this cause of death, the consistency of the elevation in our study is strong.

Fatal Injuries

In this study, with the exception of fatal poisonings, there were statistically significant elevations in all death categories due to injuries. The greatest risk occurred among those individuals who were members of LIUNA for the shortest length of time and were younger. Because traumatic deaths are responsible for many more years of potential life lost than are disease-related deaths [CDC, 1986], this result has added importance. Furthermore, since the occupational risk for fatal injuries obviously terminates at retirement, our results, which examined date of death in lieu of date of retirement, which was unavailable, may have unintentionally diluted the fatal injury findings. Based on a review of death certificates, the largest majority of the injuries were due to falls from buildings, scaffolds, or ladders, being hit by a falling object, and being struck by a construction or nonworksites vehicle.

A separate study describing fatal occupational injuries among LIUNA construction laborers during 1988–1989 showed results similar to ours [Vossenias, 1990]. Of all the deaths examined, 47% were due to being struck by a motor vehicle, 22% were due to being caught in, under, or between a building or object, and 21% were due to falls from a building, scaffold, bridge, or roof. The average age at death was 45, similar to our own findings. Other results from this study revealed that the leading cause of death was due to multiple internal injuries (35%) and head injuries (24%) and for 79% of the cases, the time between injury and death was <24 hours.

Other studies examining fatal injuries within the construction industry and among construction laborers, in particular, have also confirmed our findings [Milham, 1983; Registrar General, 1986; Robinson et al., 1988; Stout-Wieland, 1988; Kumar, 1991; NIOSH, 1993; Toscano and Windau, 1993; Burnett et al. 1994]. The National Safety Council (NSC) estimated that 1,800 workers were killed in construction work in 1991. The annual fatality rate over the period 1980–1989 for the construction industry as a whole was 25.61 per 100,000 workers. This rate was >3.5 times the occupational fatality rate for all industries in the United States for the same time period and the second highest of all industries examined behind mining. Among all occupations examined, the annualized fatality rate among nonfarm laborers over the same 10-year period was 17.22 per 100,000 workers, the third highest after transportation operatives and farmers among all occupations examined [NIOSH, 1993]. The Bureau of Labor Statistics first nationwide Census of Fatal Occupational Injuries conducted in 1992 covering all 50 states found that the construction industry had the third highest risk of workplace fatalities (behind agriculture and mining) among all industries examined relative to their share of employment. Construction laborers in this census had the third highest rate of occupational injuries among all occupations examined (behind logging and taxicab drivers), 34 deaths per 100,000 workers [Toscano and Windau, 1993]. Laborers are at an increased risk for electrocutions, evacuations, cave-ins, and confined space injuries [DHHS, 1987; Stanevich and Middleton, 1988]. Kumar [1991] found that laborers reported the highest rate of fatal injuries among all construction workers; most of these occurred to workers with <6 months experience. Construction laborers were also found to have a significantly increased risk from fatal falls in PMR studies conducted in England and Wales

[Registrar General, 1986], Washington State [Milham, 1983], and in a composite death certificate study of 19 U.S. states [Robinson et al., 1993]. Burnett et al., [1994] noted that construction had the highest risk of death from falls and electrical current than any other industry. Specifically, for construction laborers, the PMR for fatal falls was 1.37 (CI = 1.16–1.60) among white males and 1.56 (CI = 1.21–1.98) among black males, and for deaths caused by electrical current, the PMR among white males was 1.67 (CI = 1.24–2.20) and among black males was 1.47 (CI = 0.59–3.03).

The COMS and COMS II study both observed statistically significant elevated risks of death in the only two categories of reported injuries [California DOH, 1987; Singleton and Beaumont, 1990]. Among white males in the group “other construction workers,” the SMRs for the death category “fall from machinery,” were 2.15 (CI = 1.61–2.81) and 1.63 (CI = 1.22–2.14) in the unadjusted and adjusted studies, respectively. The risk for black males was even higher, SMR = 4.76 (CI = 2.53–8.14) and SMR = 2.00 (CI = 1.06–3.41), respectively, for the two studies. For “all other injuries,” the risks were again statistically significant among both white and black males in both the unadjusted and adjusted studies. A re-analysis of the COMS data by Dr. Beaumont for construction laborers (BOC code 869) found statistically significant elevated risks in all four categories of injuries among both white male and black male construction laborers. For transportation injuries, the SMRs were 2.56 (CI = 2.28–2.86) and 1.83 (1.07–2.93) respectively; for poisoning, the SMRs were 3.30 (CI = 2.46–4.52) and 4.67 (CI = 2.33–8.36), respectively; for falls the SMRs were 2.07 (CI = 1.16–3.42) and 4.35 (CI = 1.59–9.47), respectively; and for all other injuries, the SMRs were 2.66 (CI = 2.26–3.42) and 3.84 (CI = 2.19–6.23), respectively.

Occupational mortality surveillance data using death certificates also suggest that injurious deaths among construction workers are in excess [Stout-Wiegand, 1988; Robinson et al., 1995]. Stout-Wiegand [1988] examined >33,000 deaths that had occurred over a 5-year period (1980–1984), which identified “injury at work.” Employment data from the Bureau of Labor Statistics were used to identify occupation. Nonfarm laborers had the highest rates of fatal injury out of all occupational groups analyzed. In the analysis of >876,000 death certificates from 19 states for the years 1984–86, Robinson et al. [1995] observe a significantly increased PMR for “falls” among construction laborers. An epidemiologic study based upon county coroner’s autopsy data by Robinson [1988] of sudden deaths occurring at work in Allegheny County, Pennsylvania, from 1979–1982 showed that the construction industry had the highest age-adjusted fatal injury rate of all workers, 4.4 times as high as the overall rate for the county. A comparison of two national data bases regarding fatal occupational injuries occurring in the United States in 1984, the NIOSH National Traumatic Occupational Fatality (NTOF) and the Bureau of Labor Statistics (BLS) data bases observed that mining and construction were the two industries with the greatest rates of occupational fatalities [Stout-Wiegand, 1988].

Nonfatal Injuries

Injuries that do not result in death are also very frequent among construction laborers. As of 1983, the occupational injury incidence rate for the construction industry was 14.7 per 100 full-time workers, almost twice the national rate of 7.5, and higher than any other industrial division [U.S. DOL, Bulletin 2236, 1983].

Construction workers are injured about 2 1/2 times more frequently than the general work force [Monthly Labor Review, 1981], and construction laborers account for the greatest percentage of all injured construction workers. In an analysis of morbidity from workplace injuries, the Bureau of Labor Statistics surveyed a large sample of construction laborers regarding the hazards associated with their work injuries [U.S. DOL, Bulletin 2252, 1986]. Construction laborers injured in October 1983 were asked to describe their activity, tools, and equipment used, and location at the time of the accident. Over 78% of the injured laborers were under the age of 35, and 74% of the injured laborers had work experience of <1 year. Furthermore, more than one-half of all injured laborers had been on the job less than 1 month, and one out of eight injuries occurred to workers on their first day on the job. Over 25% of the injuries occurred as the result of a falling object. In an analysis of workers' compensation claims data of 359,765 construction injuries occurring in 10 states for the period 1985–1988 [U.S. DOL, 1992], laborers accounted for >23% of all construction worker illnesses and injuries. Similarly, the U.S. Department of Labor [U.S. DOL, 1986] found that 26% of all injuries to construction laborers were due to being struck by a falling object and 38% of all injuries occurred within 1 year of working with the same contractor. Kumar [1991] observed that in Alberta, Canada, construction laborers had the highest number of injuries among all occupational groups examined and accounted for >60% of all lost time claims. Harner [1988] had shown that construction laborers as an occupation had one of the highest rates for amputations and fractures.

Limitations and Strengths

Like all epidemiologic studies, this one had some potential strengths and limitations that should be considered. If the PMRs are to be considered a good approximation of the SMRs, it requires the assumption that the all-cause mortality rate be the same for both the group under study (LIUNA members) and the comparison group (i.e., the all-cause SMR = 100) [DeCouflé et al., 1980]. If the all-cause SMR for the LIUNA members would actually be >100, the PMRs would tend to underestimate the true risk, or vice versa, and may not detect all real associations. A re-analysis of COMS study for construction laborers only (BOC 869) by Beaumont observed an overall SMR of 2.10 (N = 1703, CI = 2.00–2.20) for white males and 3.16 (N = 624, CI = 2.92–3.42) for black males. If these results better estimate the true relative risk estimates for construction laborers, the PMRs in this study may have underestimated the true cause-specific mortality results among construction laborers. However, the COMS study cohort was somewhat different than ours. The COMS study included both union as well as nonunion construction laborers, was limited to persons ages 16–64, and evaluated those construction laborers who died in the state of California between 1979–1981. Therefore, these differences in the study populations could have produced somewhat different mortality results. However, studies comparing PMRs with SMRs have shown that PMRs are useful indicators of disease risk showing a high correlation with SMRs in most cases, and especially when there is a financial interest for survivors to report deaths among inactive workers [Beaumont et al., 1981; St. Claire and Butler, 1981; Roman et al., 1984] as was the case among LIUNA members. Therefore, this PMR study, it is believed, would approximate the results obtained in an SMR analysis.

A potential limitation in the PMR methodology is that the magnitude of each cause of death is dependent upon the magnitude of the PMRs for other causes of death. This can be especially important if a specific common cause has a relatively high or low mortality. If the PMR for the common cause of death is high, the PMRs for other causes are artificially deflated, and vice versa. Typically in a working population, the risk for heart disease is lower than expected due to the so-called healthy worker effect, and, therefore, in a PMR study the other causes would be artificially elevated. This particular study did not suffer from this potential problem. The most common cause of death, heart disease, had a PMR of 0.99, with > 4,000 deaths.

Another aspect of PMR studies, and this study in particular, is that members who terminate their employment prior to retirement or death are not included in the analyses. It has been shown [Redmond and Breslin, 1975; Fox and Collier, 1975] that these individuals tend to have different mortality patterns than individuals who remain employed through retirement. In active and retired employees, relatively fewer cancer deaths are found as compared with terminated employees because cancer deaths are not sudden and cancer patients will usually leave employment some time prior to death. Therefore, it is possible that malignant neoplasms were underestimated in our study since workers who left the union before retirement or death were not included in our analyses.

PMR studies are retrospective and therefore use existing records as the basis for analysis. Exposures, as in this study, are not monitored. In addition, specific exposures to which each laborer would be exposed, are difficult, if not impossible, to evaluate since local unions in general do not track sites or specific job tasks performed when a laborer is dispatched to a particular construction job. The types, intensity, and length of exposures of the individuals are unknown.

PMR study results are based on death certificate data, which have little information on potential confounding factors such as tobacco and alcohol use and socioeconomic status. Tobacco smoking has been known to be associated with lung cancer, nonmalignant respiratory diseases and heart disease, the latter two diseases which were not elevated in our study. Excessive alcohol use might be associated with an increased risk of alcoholic deaths, cirrhosis of the liver, and esophageal cancer; however, these results were not higher than expected in this study. Socioeconomic status is usually determined by income and years of education, which have been associated with certain diseases. Lacking information to control for these various confounders might result in spuriously elevated or decreased PMRs. However, the results in the COMS II SMR study controlling for all three of these risk factors still found increased risks among construction laborers for several of the causes of death found to be elevated in our membership.

The representativeness of the group studied relative to all LIUNA members had to be considered as a strength of the study. We chose all deaths for the years 1985–1988 as our study group for three reasons. First, the number of deaths, almost 12,000, had sufficient power for examining the results for most causes of death. Second, the deaths from 1985–1988 were the most recent and, therefore, are the most representative of both current and past work practices and exposure. Third, all membership data had been computerized since 1985, making the study more accurate, as well as more efficient to complete. Finally, multiple significance testing may have resulted in associations that arose from chance alone, a limitation in most epidemiological studies.

Summary and Recommendations

In summary, our results among members of the Laborers' International Union of North America seem to confirm and strengthen earlier findings of increased risk of lung and stomach cancer, as well as an increased risk of fatal injuries in the earlier years of employment, among construction laborers. The reason for the increased risk for thyroid cancer found is unclear and other studies have not observed this finding. However, elevated mortality from thyroid cancer in our study was consistently observed in categories of longer duration, in all age-at-death groupings and in various regions of the country. The excess from the chronic diseases found may be due to the exposures received directly, in the tasks the laborers perform, and/or indirectly by the laborers working in close proximity to other trades persons on the construction site. The significantly elevated risks of fatal injuries among construction laborers was probably due to the types of jobs they are required to perform.

Based upon the results of this study, the following recommendations are offered that may help reduce morbidity and mortality from job-related causes: (1) conduct a more detailed characterization of the types of fatal and non-fatal injuries occurring among construction laborers to develop programs to prevent repeated occurrences of similar injuries, i.e., what type of injury occurred (e. g., struck by object, fall, etc.), what task was being performed, what event(s) preceded the injury, when did the injury occur (time of day or year), how long had the laborer been on the job, etc., (2) conduct more specific studies to evaluate exposure-response associations by specific job tasks and duties, (3) develop a surveillance database to monitor the safety and health status of workers on a continual basis, (4) educate laborers in the importance of safe work practices and the mandatory use of personal protective equipment, (5) initiate smoking cessation and other health promotion programs, (6) provide material safety data sheets on all job sites, and (7) require safety and health management plans to be developed and utilized at all construction contracting sites.

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