

Mortality of a Police Cohort: 1950–1990

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This study presents findings from an updated retrospective cohort mortality study of male police officers from January 1, 1950 to December 31, 1990 ($n = 2,593$; 58,474 person-years; 98% follow-up). Significantly higher than expected mortality rates were found for all cause mortality (Standardized mortality ratio [SMR] = 110; 95% confidence interval [95% CI] = 1.04–1.17), all malignant neoplasms (SMR = 125; 95%CI = 1.10–1.41), cancer of the esophagus (SMR = 213; 95%CI = 1.01–3.91), cancer of the colon (SMR = 187; 95%CI = 1.29–2.59), cancer of the kidney (SMR = 208, 95%CI = 1.00–3.82), Hodgkin's disease (SMR = 313; 95%CI = 1.01–7.29), cirrhosis of the liver (SMR = 150; 95%CI = 1.00–2.16), and suicide (SMR = 153; 95%CI = 1.00–2.24). All accidents were significantly lower (SMR = 53; 95%CI = 0.34–0.79). Mortality by years of police service showed higher than expected rates for (1) all malignant neoplasms in the 1- to 9-years-of-service group; (2) all causes, bladder cancer, leukemia, and arteriosclerotic heart disease in the 10 to 19-year group; and (3) colon cancer and cirrhosis of the liver in the over 30 years of service group. Hypotheses for findings are discussed. Am. J. Ind. Med. 33:366–373, 1998.

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INTRODUCTION

An estimated 623,000 sworn police officers are employed in the United States [U.S. Department of Justice, 1995], yet few studies of health risks in police work have been conducted. It has been argued that police officers have increased rates of mortality as a result of their occupation. Using U.S. census data from 1950, Guralnick [1963] found standardized mortality ratios (SMRs) for policemen, sheriffs, and marshals to be elevated for arteriosclerotic heart disease, suicide, and homicide. Richard and Fell [1976] found Tennessee police officers to have a high rate of premature death, suicide, and admission to hospitals. Milham [1983] found increased rates for cancers of the colon and liver, diabetes mellitus, arteriosclerotic heart disease, pulmonary embo-

lism, and homicide in Washington state police officers. Age-specific proportionate mortality ratios for arteriosclerotic heart disease were highest for younger officers.

Vena et al. [1986] found that city of Buffalo police officers had increased rates for arteriosclerotic heart disease, digestive cancers, cancers of the lymphatic and hematopoietic tissues (10–19 years employment), brain cancer, and esophageal cancer. Police had a threefold rate of suicide compared to municipal worker controls. Feuer and Rosenman [1986] reported that police and firefighters in New Jersey had significant increased proportionate mortality ratios (PMRs) for arteriosclerotic heart disease, digestive and skin cancers, and skin diseases. PMRs for cirrhosis of the liver and digestive diseases increased as duration of police service increased. An inverse relationship was noted between arteriosclerotic heart disease and latency, indicating that police officers most susceptible to heart disease were affected early in their careers. Demers et al. [1992] compared police and firefighters in three cities in the United States and found police to have higher rates for all causes of death combined. An overall increased rate of suicide was noted in the police, with the highest standardized mortality ratios (SMRs) recorded for officers over the age of 65 (SMR = 301), officers with at least 30 years of service since

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first employment (SMR = 318), officers with more than 30 years of employment (SMR = 318). Forastiere et al. [1994] studied a cohort of urban policemen in Rome, Italy, and found increased rates for ischemic heart disease in officers less than 50 years of age (SMR = 163), colon cancer (SMR = 147), bladder cancer (SMR = 127), non-Hodgkin's lymphoma (SMR = 151), and melanoma (SMR = 234). Bladder cancer rates were significantly increased for patrol car drivers (odds ratio [OR] = 5.14) and kidney cancer for motorcycle officers (OR = 2.27). Additional studies have found police to have higher rates for heart disease, homicide, and suicide [Sardinas et al., 1986; Hill and Clawson, 1988; Dubrow et al., 1988; Quire and Blount, 1990; Violanti et al., 1996a,b].

The present study examined mortality data of city of Buffalo, New York, police officers, updated from the originally reported termination date of December 31, 1979 to December 31, 1990. The cohort consisted of police officers who worked a minimum of 5 years for the city of Buffalo between January 1, 1950 and December 31, 1990.

MATERIALS AND METHODS

The cohort consisted of white males ($n = 2,693$). Female officers ($n = 16$) were omitted from the analysis due to the small number of deaths and recent employment status. Sources of follow-up since 1979 included the benefit and pension programs of the city of Buffalo, the New York State Retirement System, New York State Vital Statistics Division, Buffalo Police employment records, Buffalo Police Association publications, obituaries, and the National Death Index (NDI). The employment status of ever-employed police officers was as follows: current workers, 27%; resigned or left service, 7%; retired, 53%; and died in service, 13%. Death certificates were coded by state nosologists according to the International Classification of Diseases (ICD) Revision in effect at the time of death. Codes were subsequently converted for analysis to the Eighth ICD Revision (1968). The age- and time-specific person-years at risk of dying were calculated for each police officer starting with: (1) the year of first employment as a police officer, if the inclusion criteria of 5 years employment with the city of Buffalo were met; (2) the year in which 5 years of employment for the city of Buffalo was completed, if the first year of employment as a police officer was before the five year inclusion criteria was met; or (3) the year 1950 if (1) and (2) above were prior to 1950.

Person-years were counted until the first of two events: the ending date of follow-up of the cohort, December 31, 1990, or date of death. Person-years for those lost to follow-up ended at the date of termination of employment. There were 58,474 person-years available for modified life-table analysis. Person-years were combined into 5-year age, time categories, and multiplied by the corresponding age and time-specific U.S. mortality rates for white males to yield expected numbers of deaths. The statistical significance of the difference between observed and expected

numbers was determined by the Mantel-Haenszel chi-square test with 1 degree of freedom [Mantel and Haenszel, 1959]. Confidence intervals were determined using the following formula [Monson, 1974]:

$$\text{LL} = [A(1 - 1/9A - 1.96/3 \sqrt{1/A})^3]/\text{expected}$$

$$\text{UL} = [(A + 1)(1 - 1/9(A + 1) + 1.96/3 \sqrt{1/(A + 1)})^3]/\text{expected}$$

where A = observed.

RESULTS

Vital status was determined for 98% of policemen resulting in 1,035 observed deaths. Death certificates were obtained for 95% of observed deaths. The average survival rate was 22.5 years, average age of entry into follow-up 36.9 years, average calendar year of entry into follow-up 1961, the average age of death 66 years, and average calendar year of death 1973.

Cause-specific mortality for Buffalo police officers is shown in Table I. Mortality from all causes of death combined for police officers was significantly higher than expected (SMR = 110). Significantly increased mortality was also seen for all malignant neoplasms combined (SMR = 125), cirrhosis of the liver (SMR = 150), and suicide (SMR = 153). A significantly lower mortality rate was observed for all infective and parasitic diseases (SMR = 26), all respiratory diseases (SMR = 70), all accidents (SMR = 53), and motor vehicle accidents (SMR = 37).

Table II shows mortality for specific malignant neoplasm sites. A higher than expected mortality rate for all malignant neoplasms is primarily accounted for in elevated rates for esophageal, colon, and kidney cancers. Mortality for cancers of the rectum, liver, and pancreas was also elevated but not significantly. Rates for kidney cancer (SMR = 208) and Hodgkin's disease (SMR = 313) were significantly elevated. A lower than expected mortality rate was found for prostate cancer (SMR = 72).

Table III displays all cause mortality by age at death and other characteristics related to employment as a police officer. All cause mortality was significantly higher for age categories 50–69 (SMR = 114) and 70–94 (SMR = 110) and during calendar years 1960–1969 (SMR = 119). The younger the starting age, the higher the rate of mortality (started before age 24, SMR = 129). There was a significantly elevated rate of mortality for those employed for a duration of 10–19 years (SMR = 117).

Table IV evaluates all cause and cause-specific mortality by length of police service. Fifty-five percent of the cohort had more than 25 years of police service, and 9% had more than 40 years of service, indicating a higher average number of older, more experienced police officers in the cohort. In addition to significantly elevated total all-cause mortality for police (SMR = 110), there was significantly high mortality for

TABLE I. Mortality Experience of Police Officers, City of Buffalo, 1950–1990

Underlying cause of death (8th ICD revision)	Observed deaths	Expected deaths ^a	Obs/Exp	95% CI
All causes of death (001–998)	1,035	937.33	1.10	1.04–1.17*
All malignant neoplasma (140–209)	247	197.77	1.25	1.10–1.41*
All infective and parasitic disease (001–139)	3	11.93	0.25	0.05–0.73*
Benign neoplasma (210–239)	4	2.23	1.79	0.48–4.59
Allergic, endocrine, nutritional diseases (240–279)	19	16.71	1.14	0.68–1.79
All diseases of the nervous system and sense organs 9320–389)	4	8.81	0.45	0.12–1.16
All diseases of the circulatory system (390–458)	496	493.84	1.00	0.92–1.10
Arteriosclerotic heart disease (410–413)	359	337.87	1.06	0.96–1.18
All CNS vascular lesions (430–438)	55	66.92	0.82	0.62–1.07
All respiratory diseases (460–519)	45	64.35	0.70	0.51–0.94*
All diseases of the digestive system (520–577)	47	40.97	1.15	0.84–1.53
Cirrhosis of liver (571)	29	19.32	1.50	1.00–2.16*
All diseases of the genitourinary system (580–629)	11	13.61	0.81	0.40–1.45
All external causes (800–998)	52	66.18	0.79	0.59–1.03
All accidents (800–849)	23	43.45	0.53	0.34–0.79*
Motor vehicle accidents (810)	7	19	0.37	0.15–0.76*
Suicide (900–959) ^b	26	16.99	1.53	1.00†–2.24*

^aCalculated on the basis of the mortality for U.S. white males, 1950–1990.

^bPolice suicide rates are generally underestimated. In a separate study, suicide rates were adjusted after a thorough background review of all case and by evaluation of a panel of three medical examiners [Violanti et al., 1996b].

95% CI, 95% confidence interval.

*P < 0.05.

those employed for only 10–19 years duration (SMR = 117). Those in the 1- to 9-year (SMR = 145) and 10- to 19-year (SMR = 140) categories had a significantly elevated rate of mortality for all malignant neoplasms. Elevated SMRs in the 1- to 9-year category were found for digestive (SMR = 225) and colon cancer (SMR = 280). In the 10- to 19-year category, significantly elevated rates were noted in cancers of the bladder (SMR = 406), lymphatic and hematopoietic tissues (SMR = 227), and leukemia (SMR = 347). Brain cancer was elevated in the 10- to 19-year (SMR = 265) and 30+ years (SMR = 220) categories. Arteriosclerotic heart disease was significantly elevated in the 10- to 19-years-of-service category (SMR = 120). Mortality for cirrhosis of the liver was significantly higher in the 30+ year group (SMR = 336). The rate of suicide was higher than expected during the first 19 years of service and again after 30 years of service.

Other Significant Results

Standardized mortality ratios for cirrhosis of the liver were significantly high for 55- to 69-year-olds during 1970–1990 (SMR = 165). Rates increased as age increased during that same time period, with an overall significant SMR of 171. During 1950–1990, 55- to 69-year-olds had the highest overall rate for cirrhosis of the liver (SMR = 180).

Suicide was higher than expected for ages 35–44 (SMR = 201) and for 65+ years of age (SMR = 192). The decade with the highest rate of suicide was 1960–1969 (SMR = 243). Suicide rates also increased during the 1980s (SMR = 181). The highest rate of suicide was in the 40+ years of service category (SMR = 163). Overall, increased rates for suicide were noted as years of service increased.

Latency for selected malignant neoplasms is presented in Table V. With less than 20 years latency, there was a fourfold rate of esophageal cancer, a twofold rate of colon cancer, and a fivefold rate of Hodgkin's disease. For 20–29 years latency, there was a twofold rate of brain cancer and a fourfold rate of Hodgkin's disease. For 30–39 years latency, there was a twofold rate of colon cancer, and a near twofold rate of esophageal cancer. A fourfold rate of esophageal cancer, a threefold rate of bladder cancer, and an approximate threefold rate of leukemia were found after 40 years latency.

DISCUSSION

Differences Between the Original and Updated Cohort

This study was conducted to examine updated data for a cohort of Buffalo, New York, police officers. The update

TABLE II. Distribution of Mortality from Malignant Neoplasms by Site, Police Officers, City of Buffalo 1950–1990

Underlying cause of death (8th ICD revision)	Observed deaths	Expected deaths ^a	Obs/Exp	95%CI
All malignant neoplasms (140–209)	247	197.77	1.25	1.09–1.41*
Buccal cavity and pharynx (140–149)	9	5.55	1.62	0.74–3.08
Digestive organs and peritoneum (150–159)	83	54.99	1.51	1.20–1.87*
Esophagus (150)	10	4.7	2.13	1.01–3.91*
Colon (153)	35	18.76	1.87	1.29–2.59*
Rectum (154)	8	5.65	1.41	0.61–2.79
Liver (155)	5	3.93	1.27	0.41–2.97
Pancreas (157)	12	10.42	1.15	0.59–2.01
Respiratory system (160–163)	82	66.82	1.23	0.97–1.52
Prostate (185)	12	16.59	0.72	0.37–1.26
Bladder (1988)	7	6.17	1.13	0.45–2.33
Kidney (189)	10	4.81	2.08	1.00–3.82*
Brain and other CNS (191, 192)	7	5	1.40	0.56–2.88
Thyroid (193)	2	0.38	5.23	0.59–18.80
Lymphatic and hematopoietic cancer (200–209)	23	18.53	1.24	0.78–1.86
Hodgkin's disease (201)	5	1.6	3.13	1.01–7.29*
Leukemia (204)	11	7.6	1.45	0.72–2.58

^aCalculated on the basis of mortality for U.S. white males, 1950–1990.

95%CI, 95% confidence interval; CNS, central nervous system.

*P < 0.05.

increased the number of decedents in the cohort from n = 661 to n = 1,035. The importance of continued mortality surveillance of a cohort is illustrated by some of the important changes in the forces of police mortality since 1979.

1. In the updated cohort, all-cause deaths for police officers showed a significantly higher rate for mortality than expected in the general U.S. white male population (SMR = 110; 95%CI = 1.04–1.17) and was highest in the 10- to 19-year range of employment. From 1950 through 1979, the all-cause SMR was 106; 95%CI = 0.98–1.14.
2. A higher than expected mortality rate for all malignant neoplasms (SMR = 125; 95%CI 1.10–1.41) was found in the updated cohort. Mortality for all diseases of the digestive system increased from a lower than expected rate in 1979 to a higher than expected rate (SMR = 115) through 1990. This was explained in part by a significantly increased rate of cirrhosis of the liver (SMR = 150). Also found were increased rates in specific cancer sites: kidney cancer (SMR = 208) and Hodgkin's disease (SMR = 313).
3. The rate of suicide was found to be significantly higher than the general population (SMR = 153). Before the

TABLE III. All Cause Mortality Among Police Officers by Selected Characteristics, City of Buffalo, 1950–1990

Characteristic	Obs	Exp ^a	Obs/Exp	
			95%CI	
Age at death				
<30	1	0.45	2.22	0.029–12.36
30–49	103	103.66	0.99	0.81–1.20
50–69	513	448.8	1.14	1.04–1.24*
70–94	418	381.4	1.10	1.09–1.20*
Calendar year of death				
1950–1959	152	138.48	1.10	0.93–1.28
1960–1969	262	219.34	1.19	1.05–1.34*
1970–1979	279	265.9	1.05	0.92–1.171
1980–1989	308	283.1	1.09	0.96–1.21
1990	34	30.48	1.12	0.77–1.55
Age started working as police officer				
<24	264	204.59	1.29	1.13–1.45*
25–29	508	437.11	1.16	1.06–1.26*
30+	263	295.47	0.89	0.78–1.01
Latency (years from onset of work to death)				
<20	119	129.98	0.92	0.75–1.09
20–29	321	302.95	1.06	0.94–1.18
30–39	432	385.78	1.12	1.01–1.23*
40+	163	118.71	1.37	1.17–1.60*
No. of years worked as police officer				
1–9	176	171.75	1.02	0.87–1.18
10–19	305	260.68	1.17	1.04–1.30*
20–29	309	283.03	1.09	0.97–1.22
30+	245	221.76	1.11	0.97–1.25

95%CI, 95% confidence interval.

*Significant at P < 0.05.

^aCalculated on the basis of mortality for U.S. white males.

- update, the suicide rate was approximately equivalent to that of the general population.
4. Mortality rates by selected occupational characteristics (Table IV) changed as a result of the cohort update. Through 1990, ages 50–69 had a significantly high mortality rate for all causes of death (SMR = 140) and officers who started at younger ages had significantly increased rates of mortality (age <24 years, SMR = 129; age 25–29, SMR = 116). This trend was also seen in mortality rates by the number of years of service as a police officer, where officers with 10–19 years of service had the highest significant rates for all causes of death (SMR = 117).

Hypotheses for Results

The following discussions are put forth as hypotheses regarding the impact of the police occupation on the health

TABLE IV. Cause-Specific Mortality by Years of Service as a Police Officer, City of Buffalo, 1950-1990

Causes of death (8th ICD revision)	Years of service as a police officer																			
	1-9				10-19				20-29				30+				Total			
	Obs	Exp	Obs/ Exp ^a	95%CI	Obs	Exp	Obs/ Exp ^a	95%CI	Obs	Exp	Obs/ Exp ^a	95%CI	Obs	Exp	Obs/ Exp ^a	95%CI	Obs	Exp	Obs/ Exp ^a	95%CI
All causes (001-998)	176	171.7	1.02	0.87-1.18	305	260.7	1.17	1.04-1.30*	309	283	1.09	0.97-1.22	245	221.7	1.11	0.97-1.25	1,035	937.3	1.10	1.03-1.17*
All malignant neoplasms (140-209)	42	28.9	1.45	1.04-1.96*	71	50.5	1.40	1.09-1.77*	74	65.1	1.14	0.89-1.42	61	53.2	1.15	0.87-1.47	247	197.7	1.25	1.09-1.41*
Digestive cancer (150-159)	22	9.8	2.25	1.40-3.39*	20	14.9	1.34	0.81-2.07	24	17.02	1.41	0.80-2.09	17	13.3	1.28	0.74-2.04	83	54.9	1.51	1.20-1.87*
Esophageal cancer (150)	1	0.62	1.61	0.02-8.97	4	1.23	3.25	0.87-8.32	4	1.61	2.48	0.66-6.36	1	1.18	0.85	0.01-4.71	10	4.7	2.13	1.01-3.91*
Colon cancer (153)	7	2.5	2.8*	1.12-5.76	9	4.6	1.96	0.89-3.71	8	6.2	1.23	0.55-2.54	11	5.5	2.11	1.01-3.57*	35	18.76	1.87	1.29-2.59*
Respiratory system cancer (160-163)	9	7.4	1.22	0.55-2.30	21	16.7	1.26	0.77-1.92	25	24.04	1.04	0.67-1.53	28	18.8	1.49	0.98-2.15	82	66.82	1.23	0.97-1.52
Bladder cancer (188)	0	0.88	0	—	5	1.23	4.06*	1.31-9.48*	1	2.01	0.49	0.006-2.76	1	1.74	0.57	0.007-3.19	7	6.17	1.13	0.45-2.33
Kidney cancer (189)	1	0.74	1.35	0.01-7.51	3	1.31	3.81	0.46-6.69	2	1.58	1.27	0.14-4.57	4	1.17	3.41	0.91-8.75	10	4.88	2.08	0.98-3.76
Brain cancer (191, 192)	1	1.15	0.87	0.01-4.83	4	1.51	2.65	0.71-6.78	0	1.44	0	—	2	0.91	2.20	0.24-7.93	7	5	1.40	0.56-2.88
Lymphatic and hematopoietic cancer (200-209)	3	3.41	0.88	0.17-2.57	11	4.85	2.27	1.13-4.05*	6	5.33	1.13	0.41-2.45	3	4.73	0.63	0.12-1.85	2	18.53	1.24	0.78-1.86
Hodgkin's disease (201)	2	0.59	3.50	0.38-12.2	2	0.54	3.70	0.41-13.4	1	0.30	3.33	0.04-18.5	0	0.14	0	—	5	1.60	3.13	1.01-7.29*
Leukemia (204)	0	1.27	0	—	7	2.02	3.47	1.38-7.14*	4	2.26	1.77	0.47-4.53	0	1.92	0	—	11	7.6	1.45	0.72-2.58
All diseases of the circulatory system (390-458)	89	84.9	1.05	0.84-1.29	149	141.4	1.05	0.89-1.23	152	153.5	0.99	0.83-1.16	107	113.8	0.94	0.77-1.13	497	493.8	1.01	0.91-1.09
Arteriosclerotic heart disease (410-413)	66	55.7	1.18	0.91-1.5	118	98.3	1.20	1.01-1.43*	102	107.7	0.95	0.77-1.14	73	76.1	0.99	0.75-1.20	359	337.8	1.06	0.95-1.17
All respiratory disease (460-519)	8	6.99	1.14	0.49-2.25	16	14.6	1.10	0.62-1.77	12	20.3	0.59	0.30-1.03	11	22.3	0.49	0.24-0.88*	47	64.3	0.73	0.53-0.97*
Digestive disease (520-577)	8	9.12	0.88	0.37-1.72	16	13.2	1.20	0.69-1.96	12	11.4	1.05	0.54-1.83	11	7.08	1.55	0.77-2.78	47	40.9	1.15	0.84-1.52
Cirrhosis of the liver (571)	4	4.31	0.93	0.24-2.37	10	6.8	1.46	0.70-2.7	7	5.7	1.21	0.49-2.53	8	2.4	3.36	1.43-6.56*	29	19.3	1.50	1.01-2.15*
All external causes (800-998)	15	25.6	0.59	0.32-0.96	22	21.2	1.04	0.65-1.57	9	12.9	0.70	0.31-1.32	5	6.4	0.78	0.25-1.82	51	66.1	0.77	0.57-1.01
Suicide (950-959)	9	5.5	1.64	0.74-3.1	10	5.6	1.77	0.85-3.28	4	3.4	1.17	0.31-3.01	3	1.8	1.69	0.33-4.86	26	16.99	1.53	1.01-2.24*

CI, 95% confidence interval.

^aCalculated on the basis of mortality for U.S. white males, 1950-1990.

*P < 0.05.

of its members. Previous research has identified the police profession as a job replete with psychological stress, danger, rotating shifts, family disruption, and exposure to noxious materials (Kroes and Hurell, 1975; Blackmore, 1979; Violanti, 1978; Territo and Vetter, 1981; Vena et al., 1986).

Chronic psychological stress at work has been identified as a possible factor in the etiology of disease. For example, stress may be a catalyst for malignancy at selected sites, as stress may be mediated immunologically and lead to the onset of cancer [Burgess, 1987; Eysenck, 1988; Fox, 1995]. Our findings indicated a significantly elevated overall mortality for malignant neoplasms in police officers and elevated mortality at specific sites. Stress has also been implicated in heart disease [Henry, 1986; Eli and Mostardi, 1986; Eysenck et al., 1991], and our present findings indicate a slightly elevated risk of arteriosclerotic heart disease in police officers. What is interesting is that both all malignant neoplasms and arteriosclerotic heart disease rates are higher in officers with fewer years of service (Table IV). This is

infrequently found in a healthy worker population [McMichael, 1976]. Perhaps stress and stressful traumatic events in police work, among other factors, exacerbate disease states such as cancer or arteriosclerotic heart disease [Paton and Violanti, 1996].

Stress may also be a precipitant for police suicide [Violanti, 1996]. Previous research has found elevated rates of suicide in police officers [McCafferty et al., 1992; Vena et al., 1986; Violanti et al., 1986; Violanti, 1996], and a few studies have suggested a lower rate in police officers [Josephson and Reiser, 1990]. Our present study suggests that the suicide rates have increased, particularly in the 10- to 19-years-of-police-service category (Table V). Previous research has found measured stress to peak at approximately 13 years of police service [Violanti, 1983]. Also, toward the end of the 10- to 19-year period, many officers become concerned about impending retirement at the 20-year mark. Gaska [1980] found a 10-fold risk of suicide among retired police officers.

TABLE V. Latency Analysis for Selected Malignant Neoplasms, Police Officers, City of Buffalo, 1950-1990

Cause of death (8th ICD revision)	No. of years from onset of work to death															
	<20				20-29				30-39				40+			
	Obs/Exp ^a		95%CI		Obs/Exp ^a		95%CI		Obs/Exp ^a		95%CI		Obs/Exp ^a		95%CI	
	Obs	Exp ^a	Obs	Exp	Obs	Exp ^a	Obs	Exp	Obs	Exp ^a	Obs	Exp	Obs	Exp ^a	Obs	Exp
Cancer of esophagus (150)	2	0.51	3.92	0.44-14.1	2	1.68	1.19	0.13-4.29	4	2.02	1.98	0.53-5.06	2	0.49	4.08	0.45-14.7
Cancer of colon (153)	4	1.95	2.05	0.55-5.15	10	6.06	1.65	0.78-3.03	17	8.34	2.03	1.18-3.26*	4	2.4	1.66	0.44-4.26
Cancer of lung (162)	11	7.45	1.47	0.73-2.64	24	22.64	1.06	0.67-1.57	36	27.2	1.32	0.92-1.83	7	5.87	1.19	0.47-2.45
Cancer of bladder (188)	0	0.42	0	—	0	1.87	0	—	4	2.91	1.37	0.36-3.51	3	0.96	3.12	0.62-9.1
Cancer of kidney (189)	1	4.82	0.20	0.002-1.1	53	2.76	1.08	0.21-3.17	6	6.42	0.93	0.34-2.03	0	0	0	—
Cancer of brain (191)	2	1.27	1.57	0.17-5.68	4	1.87	2.13	0.57-5.47	1	1.61	0.62	0.008-3.45	0	0.26	0	—
Hodgkin's disease (201)	3	0.58	5.17	1.03-5.1	12	0.49	4.08	0.45-14.7	0	0.41	0	—	0	0.11	0	—
Leukemia (2040)	2	1.24	1.61	0.18-5.8	24	2.41	1.65	0.44-4.24	23.06	0.65	0.07-2.35	3	0.88	3.40	0.68-9.86	

^aCalculated on the basis of mortality for U.S. white males, 1950-1990.

95%CI, 95% confidence interval.

*Significant at $P < 0.05$.

In our original cohort, the suicide rate for police was approximately equal to that of the white male U.S. population, which was significant because police are expected to be healthier (psychologically and physically) than the general male population, which includes the unemployed and institutionalized [McMichael, 1976]. Through 1990, the suicide rate among police was significantly higher than that of the white male general population. This indicates that the risk of suicide among a healthy police work group has increased.

The reasons for police suicide are complex and stress may be but one of many dimensions. Ivanoff [1994] suggested that relationship problems play a large part in police suicide. Other work suggests that the availability of firearms may be a factor, since approximately 95% of all police suicides involve a firearm [Violanti, 1996]. Alcohol use or dependency has also been found to be a factor in police suicide [Wagner and Brzczek, 1983; Violanti et al., 1984; Ohno, 1995].

Approximately 25% of police officers have been reported as dependent on alcohol [Kroes, 1986], and alcohol appears to be related to feelings of police stress [Violanti et al., 1984]. Alcohol use has been shown in previous epidemiological studies as an important factor in the etiology of cirrhosis of the liver [Gordon and Doyle, 1987; Williams et al., 1988; Mandell et al., 1992; Saunders and Latt, 1993]. Our present result of a significantly elevated cirrhosis of the liver rate (SMR = 150) may be associated with excessive alcohol use among officers in our cohort. With the exception of 1-9 years of police service, cirrhosis of the liver was

elevated across all years of service categories and had a 3.3-fold mortality rate for officers with more than 30 years service (Table IV).

Environmental exposures may also be associated with disease among police officers. Our present findings of increased rates of lymphatic and hematopoietic cancers, specifically Hodgkin's disease and leukemia, are examples. Police officers have the possibility of work exposure to carbon monoxide from motor vehicles, chemicals on the highway, gun cleaning solvents, and fingerprint powders, which theoretically may contribute to these diseases [Bisby, 1977; Capellaro et al., 1990; Van Netten et al., 1990; Forastiere et al., 1994]. Recent studies have found high levels of lead in the blood of police officers exposed to firearms, ammunition, and fingerprint powder [Van Netten et al., 1990].

There is no present empirical evidence that measures the risk of exposure that police officers have to noxious or hazardous materials on the roadway. The transportation of such materials by commercial vehicles may present an increased exposure risk for officers who patrol those roadways.

Present findings of increased rates of hematopoietic and brain cancers were also of interest. Other research has found elevated rates of these diseases in persons exposed to electromagnetic frequency (EMF) fields [Savitz, 1993; Garland et al., 1990; Loomis and Savitz, 1990; Jauchem and Merritt, 1991]. Police officers are exposed to radio transmissions and radar frequencies in vehicles and police stations.

Although a significant association between these cancer sites and EMF has not been found in police work, Davis and Mostifi [1993] found a significant increased rate for testicular cancer among police officers who reported use of hand-held radar units inside of the police vehicle. Violanti (unpublished study) found a 68% increased probability for all-cause cancer with increased exposure time to police radar ($OR = 1.98, P < 0.05$). Officers were, on average, exposed to radar 74% of the time that they were enforcing speeding laws. Hand-held radar units (used inside the police vehicle) had associations with self-reported cancer of the testicle, breast, and prostate.

Limitations

Our study provided statistical but not necessarily causal associations between police work exposure and disease states. As is true with most retrospective designs, we had limited data on confounding factors related to lifestyle, ethnicity, alcohol use, smoking, social class, work conditions, and exposure measures to disease-producing sources. Our study did, however, allow for evaluation of calendar year of employment, length of police service, year of initial employment, and age at start of employment.

When the mortality experience of a working population such as the police is compared with the U.S. general population, workers are generally found to have lower mortality. This is often referred to as the "healthy worker effect" [McMichael, 1976]. Despite this effect, many police mortality rates were *higher* than expected in the general population that contains the unemployed, ill, and institutionalized.

Perhaps the best way to deal with the healthy worker effect is to find a comparison group that is very similar to the study population except in exposures of interest. Our own previous research applied this method, using a regional group of Buffalo, New York, municipal workers as controls for police officers. Observed mortality rates for heart disease, cancer and suicide were elevated among police in this previous study to much the same degree as they were in the present study [Vena et al., 1986]. We were unable to conduct a similar regional analysis in the present study because updated information was not available for municipal worker controls.

Our present study found police rates elevated similar to those of other studies that have compared the police with control populations. For example, Feuer and Rosenman [1986] found that police rates were higher than firefighter mortality rates in all infective, digestive, diabetes, vascular, and suicide ICD categories. Sardinas et al. [1986] found significantly elevated ischemic heart disease rates among police officers as compared to firefighter rates. Gute [1982] compared police to mortality rates in Rhode Island and found elevated police rates for myocardial infarction. Mil-

ham [1983] found elevated mortality rates among Washington state police in cancers of the large intestine and liver, cirrhosis of the liver, arteriosclerotic heart disease, and homicide. Dubrow and Wegman [1983] compared police with regional controls in 12 occupational mortality studies. Cancer of the large intestine was found to have an aggregate elevated rate among police of 1.22. Elevated police risk of large intestinal tract cancer was found in four of the seven studies, and malignant melanoma in three of the studies.

Future studies of disease risk among police should include prospective identification of potential confounders which affect causal relationships between disease and occupation. Although present findings suggest that police officers have significantly elevated statistical rates for a number of diseases, very little is known about contributing occupational factors to such diseases. If subsequent research reinforces our results, perhaps police administrations might consider relevant prevention methods for officers to include health education (alcohol use), physical exercise, and stress management. The elevated rate of suicide found among police officers indicates a need for suicide awareness education and increased psychological services in police work [McCafferty et al., 1992; Ivanoff, 1994; Violanti, 1996]. No simple answers exist for the prevention of disease in police work. This study may help in a small way to understand some of the long-term health effects of this occupation and provide a basis for future research.

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