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Dying for the job: police mortality, 1950–2018

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Abstract

Purpose – This study is a mortality assessment on police officers (68-years, 1950–2018) and includes all causes of death.

Design/methodology/approach – The authors investigated 1,853 police deaths (1950–2018) using sources of mortality that included the National Death Index, NY State, and available records from the Buffalo NY police department. Standardized Mortality Ratios were calculated. Death codes were obtained from 8th and 9th International Classification of Disease revisions in accordance with the year of death.

Findings – Compared to the US general population, white male police officers from 1950–2018 had elevated mortality rates for some causes of death, including diseases of the circulatory system, malignant neoplasms, cirrhosis of the liver, and mental disorders. Black and female officers had lower mortality rates for all causes of death compared to the general population.

Research limitations/implications – The findings of elevated risk for chronic disease among police need to be studied in relation to stress, lifestyle, and exposure to chemical and physical agents. There is a special need to further study officers from minority populations as larger samples become available.

Practical implications – The results of this study will provide police and occupational health practitioners with objective evidence to determine the health impact of work on law enforcement officers.

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Originality/value – This study is longest running mortality assessment on police officers ever conducted (1950–2018) and includes white, black, and female officers.

Keywords Police, Mortality, Cardiovascular disease, Cancer, Occupational health, Epidemiology

Paper type Research paper

Introduction

According to the US Department of Labor Statistics (2020), there were 813,500 law enforcement officers employed in 2019, and this was estimated to increase to 854,200 by 2029. Police work is stressful and dangerous. Officers often must work irregular hours including nights or rotating shifts (Fekedulegn *et al.*, 2016). There is also an elevated prevalence of alcohol use (Violanti *et al.*, 2011), obesity (Gu *et al.*, 2014; Ramey *et al.*, 2011) , reduced physical activity (Fekedulegn *et al.*, 2018) and poor sleep hygiene (Charles *et al.*, 2011) among police officers when compared to the general US population. The police have been faced recently with challenging operational problems, shortage of personnel, defunding threats, protests and riots, and a COVID-19 pandemic. The stress brought about by these changing societal and health circumstances may seriously affect both the mental and physiological health of police officers.

The police suffer disproportionately from numerous health problems including cancer, chronic heart disease, diabetes, metabolic disorders, psychological stress, depression, suicide, and sleep disorders (Franke *et al.*, 1997; Vena *et al.*, 2014). Feuer and Rosenman (1986), in an early mortality study, found that police had elevated mortality for arteriosclerotic heart disease, digestive, and skin diseases. Death from 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. In a mortality study of Buffalo, NY officers from 1950–2005 (Vena *et al.*, 2014) there were significantly higher than expected mortality rates for all-cause mortality for all malignant neoplasms, cancers of the esophagus, colon, and kidney, Hodgkin's disease, cirrhosis of the liver, and suicide. Police appear to die at an earlier age compared to the general US population. Violanti *et al.* (2013) found that, on average, the life expectancy of Buffalo, NY police officers was significantly lower than the US population (mean difference in life expectancy = 21.9 years; 95% Cl:14.5–29.3; $p < 0.0001$). Officers in younger age categories lived fewer years than persons in the general population, suggesting increased health problems among young officers.

The objective of the present study was to examine the mortality of police officers from Buffalo, New York compared to the general US population. The study will span 68 years from January 1, 1950 to December 31, 2018 for white, black, and female officers.

Methods

Study population

The cohort for this study consisted of 2,976 white male officers, 310 black officers, 300 female officers, and 31 officers from other racial groups. Approximately one-third (30.5%) of the black officers were female. Mortality data for black and female officers were only available from January 1, 1980 through December 31, 2018. Officers were excluded from this analysis if they lacked a birth, death or hire date, if they had worked <5 years for the Buffalo NY Police Department between January 1, 1950 and December 31, 2018, if the termination from service date was missing, and they were lost to follow-up. As of December 31, 2018, 62% of white male officers had died, 37% were alive, or lost to follow-up. The employment status for white male officers was as follows: 13 were current officers, 59 had retired, 12 had died while working, 6 had resigned or left service, and the whereabouts for 10 were unknown. The

employment status for black officers was as follows: 14% had retired, <1.9% had died in service, 4% had resigned or left service, 39 were current officers, and 42 were unknown. For female officers, <1% had died in service, 2% had resigned or left service, 12 had retired, 43 were current officers, and 42 were unknown.

Sources of follow-up included the National Death Index (NDI), 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, and obituaries. Death certificates were coded by state mortality coders (nosologists) according to the International Classification of Diseases (ICD) revision in effect at the time of death. In order to update data from earlier years in this study death codes were converted from the 8th to the 9th ICD Revision (https://wwwn.cdc.gov/eworld/Appendix/ICDCodes).

Statistical analysis

The age-and time-specific person-years at risk of dying were calculated for each officer. Person-years takes into account the number of people in the study and the amount of time each person spends in the study. For example, a study that follows 1,000 people for 1 year would contain 1,000 person-years of data. Analyses started with (1) the year of first employment as a police officer, if the inclusion criteria of 5 years employment as 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 were met; and (3) the year 1950 if (1) and (2) above were prior to 1950.

Person-years were counted until the first of three events: (1) the ending date of follow-up of the cohort, or December 31, 2018 for those who remained alive; (2) date of death for those who were deceased; or (3) the date of termination of employment for those who were lost follow-up. For white male, black, and female officers, there were 74,483, 7,876 and 7,164 person-years (respectively) available for a modified life-table analysis. Person-years were combined into 5-year age and 5-year calendar year categories and multiplied by the corresponding age-and time-specific US mortality rates for the relevant reference population to yield the expected numbers of deaths.

Standardized mortality ratio (SMR)

The SMR was used to compare police deaths to deaths in the general US population. The SMR is defined as the ratio of the total number of *observed* deaths in police relative to the total number of *expected* deaths in police; expected deaths being based on rates in general US population (Checkoway *et al.*, 1989).

$$SMR = \frac{\text{Observed number of deaths per year (Police)}}{\text{Expected number of deaths per year (US population)}}$$

An SMR of greater than 1.00 indicates elevated risk. For example, an SMR of 1.50 would mean that the police cohort had a 50% greater likelihood of death from a specific disease than the general US population. Statistical significance between observed and expected deaths was determined by the Mantel-Haenszel chi-square test with one degree of freedom and significance set at $p < 0.05$. 95% confidence intervals (CI) were calculated (Greenland *et al.*, 2016) as follows:

$$LL = [A(1\text{-}1/9\text{A} - 1.96/3\checkmark 1/A)3]/\text{expected}$$
$$UL = [(A{+}1)(1 - 1/9(A+1) + 1.96/3\checkmark 1/(A+1))3]/$$
$$\text{Expected where } A = \text{observed.}$$

Results

Table 1 shows cause-specific mortality for white male police officers from 1950–2018. Mortality from all causes of death combined for these officers was similar to the general population (SMR = 1.01; 95% confidence interval (CI) = 0.96–1.05). Significantly elevated mortality was seen for all malignant neoplasms combined (SMR = 1.14, 1.04–1.25). Cirrhosis of liver (SMR = 1.24, 0.89–1.69) was elevated. Mortality from ischemic heart disease was slightly elevated (SMR = 1.02, 0.93–1.11) and represented the majority of excess deaths among diseases of the circulatory system. Asthma deaths were significantly elevated (SMR = 6.71, 4.20–10.15). Death from all mental disorders was slightly elevated (SMR = 1.09, 0.75–1.54). A lower mortality rate was observed for all respiratory diseases (SMR = 0.73, 0.61–0.88), all external causes (SMR = 0.65, 0.52–0.80), and all accidents (SMR = 0.31, 0.21–0.45).

Table 2 contains data on cause-specific mortality for black and female officers from 1980–2018. During the earlier years of this cohort (1950–1980), a low percentage of black officers and women were employed in policing and sufficient death data were not available. In 1980, enough data had become available to provide a preliminary look at mortality in these populations. Among black officers, deaths from all causes were significantly lower compared to the general US black population (SMR = 0.20, 0.12–0.32). Additionally, deaths from all malignant neoplasms, parasitic disease, all circulatory disease and all external causes were significantly lower among black officers than among the US general population. Similar results were found for female officers. These results should be interpreted with caution due to the small numbers of deaths.

Underlying cause of death (9th ICD revision)	Observed Deaths	Expected Deaths	SMR	95%CI
All causes of death (001–999)	1853	1849.8	1.00	0.96–1.05
All infective, parasitic Dz.(001–139)	14	34.77	0.40	0.22–0.68*
All malignant neoplasms (140–209)	475	417.02	1.14	1.04–1.25*
Benign neoplasms (210–229)	2	5.87	0.34	0.04–1.23
Allergic, endocrine, nutritional diseases (240–279)	36	47.76	0.75	0.53–1.04
Diabetes Mellitus (250)	28	36.61	0.76	0.51–1.11
All disease of blood and blood-forming organs (280–289)	4	4.95	0.81	0.22–2.07
All mental, psychoneurotic and personality disease (290–319)	32	29.29	1.09	0.75–1.54
All diseases of nervous system and sense organs (320–389)	34	45.73	0.74	0.51–1.04
All diseases of circulatory system (390–458)	827	837.49	0.99	0.92–1.06
Chronic rheumatic heart disease (393–398)	8	10.37	0.77	0.33–1.52
Ischemic heart disease (410–414)	540	531.52	1.02	0.93–1.11
Cerebrovascular disease (430–438)	96	112.03	0.86	0.69–1.05
All respiratory diseases (460–519)	114	155.31	0.73	0.61–0.88*
Pneumonia (480–519)	32	51.75	0.62	0.42–0.87*
Asthma (493)	22	3.28	6.71	4.20–10.15*
All diseases of digestive system (520–579)	66	74.38	0.89	0.69–1.13
Cirrhosis of liver (571)	40	32.20	1.24	0.89–1.69
All diseases of genitourinary system (580–629)	26	34.20	0.76	0.50–1.11
All external causes (800–998)	87	134.33	0.65	0.52–0.80*
All accidents (800–949)	28	90.63	0.31	0.21–0.45*
Motor vehicle accidents (810–823)	10	38.27	0.26	0.13–0.48*
Suicide (950–959)	31	32.69	0.95	0.64–1.35

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Table 1. Mortality experience of white-male police officers in Buffalo, New York, 1950–2018

Underlying cause of death (9th ICD revision)	Observed Deaths	Expected Deaths	SMR	95%CI
All black officers				
All causes of death (001–999)	18	89.42	0.20	0.12–0.32*
All malignant neoplasms(140–209)	4	18.73	0.21	0.06–0.55*
All infective, parasitic disease (001–139)	2	9.21	0.22	0.02–0.78*
All Dz. Of circulatory system (390–459)	4	25.02	0.16	0.04–0.41*
All external causes (800–999)	3	14.07	0.21	0.04–0.62*
All female officers				
All causes of death (001–999)	22	60.56	0.36	0.23–0.55*
All malignant neoplasms(140–209)	6	15.09	0.40	0.15–0.87*
All infective, parasitic disease (001–139)	0	3.30		
All Dz. Of circulatory system (390–459)	4	18.54	0.22	0.06–0.55*
All external causes (800–999)	3	5.57	0.54	0.11–1.57

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Table 2.
Mortality experience of black and female police officers in Buffalo, New York, 1980–2018

Results for mortality of specific cancer sites for officers are presented in Table 3. Mortality rates for all cancers combined was significantly higher among all officers than in the general population (SMR = 1.14, 1.04–1.25). Elevated mortality for all malignant neoplasms was primarily due to excesses in cancers of the digestive organs and peritoneum (SMR = 1.36, 1.15–1.60), esophagus (SMR = 1.87, 1.17–2.83), colon (SMR = 1.41, 1.04–1.85), as well as leukemia (SMR = 1.57, 1.03–2.28).

Table 4 displays all-cause mortality by demographic and other characteristics related to employment as a police officer. All-cause mortality was significantly higher for officers who died during calendar years 1960–69 and 1980–89 (SMR = 1.18, 1.04–1.33 and SMR = 1.13,

Underlying cause of death (9th ICD revision)	Observed Deaths	Expected Deaths	SMR	95%CI
All malignant neoplasms (140–209)	475	417.02	1.14	1.04–1.25*
Buccal cavity and pharynx (140–149)	14	9.48	1.48	0.81–2.48
Digestive organs and peritoneum (150–159)	149	109.61	1.36	1.15–1.60*
Esophagus (150)	22	11.78	1.87	1.17–2.83*
Stomach (151)	19	15.80	1.20	0.72–1.88
Colon (153)	50	35.57	1.41	1.04–1.85*
Rectum (154)	11	9.14	1.20	0.60–2.15
Liver (155)	12	10.66	1.13	0.58–1.97
Pancreas (157)	25	22.33	1.12	0.72–1.65
Respiratory system (160–165)	146	136.06	1.07	0.91–1.26
Bone (170)	2	1.06	1.89	0.21–6.82
Skin (172–173)	8	9.23	0.87	0.37–1.71
Prostate (185)	42	39.27	1.07	0.77–1.45
Bladder (188)	16	13.96	1.15	0.65–1.86
Kidney (189)	15	10.64	1.41	0.79–2.33
Brain and other CNS (191–192)	13	10.53	1.23	0.66–2.11
Thyroid (193)	2	0.87	2.30	0.26–8.31
Lymphatic and hematopoietic (200–209)	47	42.43	1.11	0.81–1.47
Hodgkin's disease (201)	6	2.66	2.25	0.82–4.90
Leukemia (204–208)	27	17.23	1.57	1.03–2.28*

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Table 3.
All malignant neoplasms by site, among white-male police officers in Buffalo, New York 1950–2018

Character	Observed Deaths	Expected Deaths	SMR	95%CI
Age at death				
<50	105	206.01	0.51	0.42–0.62*
50–69	708	678.31	1.04	0.97–1.12
≥70	1,040	965.49	1.08	1.01–1.14*
p-value for trend			<0.001	
Calendar year of death				
1950–59	153	142.90	1.07	0.91–1.25
1960–69	262	221.72	1.18	1.04–1.33*
1970–79	279	264.51	1.05	0.93–1.19
1980–89	309	272.53	1.13	1.01–1.27*
1990–99	298	285.42	1.04	0.93–1.17
2000–09	299	308.28	0.97	0.86–1.09
2010–18	253	250.14	1.01	0.89–1.14
p-value for trend			0.109	
Age started as police				
<25	451	426.95	1.06	0.96–1.16
25–29	939	908.29	1.03	0.97–1.10
30+	463	514.57	0.90	0.82–0.99*
p-value for trend			0.020	
Years of police service				
<19	190	270.23	0.70	0.61–0.81*
20–29	627	651.75	0.96	0.89–1.04
30+	1,036	927.83	1.12	1.05–1.19*
p-value for trend			<0.001	
Latency years (yrs from onset of work to death)				
<29	269	657.47	0.41	0.36–0.46*
30–39	407	304.26	1.34	1.21–1.47*
40–49	541	398.75	1.36	1.24–1.48*
50+	636	489.34	1.30	1.20–1.40*
p-value for trend			<0.001	

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Table 4. All-cause mortality by selected characteristics, among white-male police officers in Buffalo, New York 1950–2018

1.01–1.27 respectively). Compared to the general population, a starting age of police ≥30 years had the highest mortality rate (SMR = 1.12, 1.05–1.19). Officers in the 30+ years of police service categories had higher than expected mortality rates (SMR = 1.12, 1.05–1.19).

Table 5 displays the mortality risk across decades. All-cause mortality was significantly elevated in the 1960 and 1980s (SMR = 1.18, 1.04–1.33 and SMR = 1.13, 1.01–1.27 respectively) and lower than the general population in all other decades. Mortality from all malignant neoplasms was elevated slightly in all decades and lower than expected in 2010–2018 (SMR = 0.97, 0.73–1.26). Rates for all cancers of the digestive system were slightly elevated in all other decades but lower than expected in 2010–2018. Esophageal cancer rates among officers were elevated across all decades but not significantly higher the general population. Prostate cancer was elevated slightly in the 1950s, 1990s, and 2000–2009 decades but not significantly higher than the general population. Leukemia was slightly elevated in the 1990, 2000, and 2010 decades. All diseases of the circulatory system were significantly higher than expected through the 2010–2018 decade (SMR = 1.28, 1.05–1.55).

Deaths across the length of police service were also analyzed (Table 6). Officers with 1–19 years of police service had slightly elevated mortality rates for all cancers combined

Table 5.
Cause-specific mortality by calendar year of death, among white-male police officers in Buffalo, New York 1950–2018

Underlying cause of death (9th ICD revision)	Calendar year of death: 1950s OBS	EXP	SMR	95% CI	1960s OBS	EXP	SMR	95% CI	1970s OBS	EXP	SMR	95% CI
All causes of death (000–999)	153	142.90	1.07	0.91–1.25	262	221.72	1.18	1.04–1.33*	279	264.51	1.05	0.93–1.19
All infective, parasitic Dz.(001–139)	2	4.09	0.49	0.05–1.77	0	2.11			0	1.74		
All malignant neoplasms (140–209)	33	24.79	1.33	0.92–1.87	62	40.24	1.54	1.18–1.98*	59	54.17	1.09	0.83–1.41
Cancer-Buccal cavity, Pharynx (140–149)	2	0.88	2.27	0.25–8.19	3	1.30	2.30	0.46–6.73	2	1.56	1.28	0.14–4.62
Cancer-Digestive, Peritoneum (150–159)	20	8.93	2.24	1.37–3.46*	18	12.52	1.44	0.85–2.27	19	14.28	1.33	0.80–2.08
Cancer-Esophagus (150)	1	0.64	1.56	0.02–8.68	2	0.95	2.11	0.24–7.61	5	1.22	4.10	1.32–9.57*
Cancer-Stomach (151)	3	2.49	1.21	0.24–3.52	6	2.61	2.30	0.84–5.01	0	2.32		
Cancer-Colon (153)	7	2.24	3.13	1.25–6.45*	8	3.77	2.12	0.91–4.18	6	5.11	1.17	0.43–2.56
Cancer-Rectum (154)	5	1.20	4.17	1.34–9.73*	1	1.53	0.65	0.01–3.64	0	1.50		
Cancer-Liver (155)	1	0.84	1.19	0.02–6.64	0	1.00			0	0.86		
Cancer-Pancreas (157)	3	1.38	2.17	0.44–6.34	1	2.35	0.42	0.01–2.36	5	2.91	1.72	0.55–4.01
Cancer-Respiratory system (160–163)	5	6.22	0.80	0.26–1.88	19	12.26	1.55	0.93–2.42	20	18.88	1.06	0.65–1.64
Cancer-Bone (170)	0	0.21			0	0.22			1	0.20	4.90	0.06–27.24
Cancer-Skin (172–173)	0	0.43			0	0.71			0	0.94		
Cancer-Prostate (185)	3	1.47	2.04	0.41–5.96	1	3.07	0.33	0.00–1.81	3	4.62	0.65	0.13–1.90
Cancer-Bladder (188)	0	0.85			5	1.38	3.63	1.17–8.46*	1	1.77	0.57	0.01–3.15
Cancer-Kidney (189)	0	0.62			3	0.97	3.08	0.62–8.99	2	1.30	1.54	0.17–5.55
Cancer-Brain and other CNS (191–192)	0	0.81			5	1.09	4.57	1.47–10.66*	0	1.35		
Cancer-Thyroid (193)	1	0.08	12.86	0.17–71.56	1	0.10	10.51	0.14–58.46	0	0.09		
Lymphatic and hematopoietic (200–209)	1	2.61	0.38	0.01–2.14	7	4.02	1.74	0.70–3.59	6	5.05	1.19	0.43–2.59
Hodgkin's disease (201)	1	0.45	2.24	0.03–12.44	0	0.55			2	0.43	4.62	0.52–16.68
Leukemia (204–207)	0	1.10			5	1.71	2.92	0.94–6.82	3	2.08	1.44	0.29–4.20
Benign neoplasms (210–229)	0	0.46			0	0.51			1	0.59	1.70	0.02–9.47
Allergic, endocrine, nutritional Dz. (240–279)	4	2.15	1.86	0.50–4.75	5	3.79	1.32	0.43–3.08	5	4.61	1.08	0.35–2.53
Diabetes Mellitus (250)	4	1.88	2.13	0.57–5.45	5	3.27	1.53	0.49–3.57	4	3.82	1.05	0.28–2.68
All Dz. of blood and blood-forming organs (280–289)	0	0.34			0	0.52			0	0.57		
Mental, psychoneurotic, and personality disorders (290–319)	0	0.62			0	0.82			1	1.46	0.68	0.01–3.81

(*continued*)

Table 5.

Underlying cause of death (9th ICD revision)	Calendar year of death: 1950s OBS	EXP	SMR	95% CI	1960s OBS	EXP	SMR	95% CI	1970s OBS	EXP	SMR	95% CI
All Dz. of nervous sys. andsense organs (320–389)	1	1.15	0.87	0.01–4.83	2	1.58	1.27	0.14–4.57	1	2.10	0.48	0.01–2.66
All Dz. of circulatory system (390–458)	84	76.82	1.09	0.87–1.35	129	123.23	1.05	0.87–1.24	142	141.56	1.00	0.84–1.18
Chronic rheumatic heart Dz (393–398)	2	2.42	0.83	0.09–2.99	2	1.99	1.01	0.11–3.63	1	1.57	0.64	0.01–3.54
Ischemic heart Dz. (410–414)	62	49.68	1.25	0.96–1.60	104	84.09	1.24	1.01–1.50*	96	99.44	0.97	0.78–1.18
Cerebrovascular Dz (430–438)	10	10.83	0.92	0.44–1.70	9	17.82	0.50	0.23–0.96*	22	20.63	1.07	0.67–1.61
All respiratory Dz. (460–519)	5	6.11	0.82	0.26–1.91	7	13.03	0.54	0.22–1.11	12	18.20	0.66	0.34–1.15
Pneumonia (480–486)	3	2.51	1.20	0.24–3.50	2	4.98	0.40	0.05–1.45	4	6.60	0.61	0.16–1.55
Asthma (493)	0	0.82			1	0.63	1.58	0.02–8.80	0	0.22		
All Dz. of digestive system (520–579)	8	7.16	1.12	0.48–2.20	9	10.28	0.88	0.40–1.66	13	11.45	1.14	0.60–1.94
Cirrhosis of liver (571)	4	3.00	1.33	0.36–3.41	4	4.62	0.87	0.23–2.22	6	6.02	1.00	0.36–2.17
All Dz. of genitourinary system (580–629)	2	2.80	0.71	0.08–2.58	2	3.26	0.61	0.07–2.22	3	3.26	0.92	0.19–2.69
All external causes (800–998)	9	14.88	0.60	0.28–1.15	28	18.68	1.50	1.00–2.17	12	20.78	0.58	0.30–1.01
All accidents (800–949)	3	10.70	0.28	0.06–0.82*	11	13.05	0.84	0.42–1.51	5	13.40	0.37	0.12–0.87*
Motor Vehicle accidents (810–823)	2	5.08	0.39	0.04–1.42	2	6.15	0.33	0.04–1.18	2	6.03	0.33	0.04–1.20
Suicide (950–959)	6	3.52	1.71	0.62–3.71	9	4.41	2.04	0.93–3.88	1	4.86	0.21	0.00–1.14

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Underlying cause of death (9th ICD revision)	Calendar year of death: 1980s OBS	EXP	SMR	95% CI	1990s OBS	EXP	SMR	95% CI	2000–2009 OBS	EXP	SMR	95% CI
All causes of death (000–999)	309	272.53	1.13	1.01–1.27*	298	285.42	1.04	0.93–1.17	299	308.28	0.97	0.86–1.09
All infective, parasitic Dz.(001–139)	1	3.45	0.29	0.00–1.61	5	6.17	0.81	0.26–1.89	5	6.68	0.75	0.24–1.75
All malignant neoplasms (140–209)	82	68.29	1.20	0.96–1.49	92	78.43	1.17	0.95–1.44	92	78.80	1.17	0.94–1.43
Cancer-Buccal cavity, Pharynx (140–149)	2	1.57	1.28	0.14–4.61	1	1.39	0.72	0.01–4.00	3	1.22	2.45	0.49–7.16
Cancer-Digestive, Peritoneum (150–9)	25	16.68	1.50	0.97–2.21	27	18.45	1.46	0.96–2.13	26	19.05	1.36	0.89–2.00
Cancer-Esophagus (150)	2	1.63	1.23	0.14–4.43	5	2.24	2.24	0.72–5.22	3	2.69	1.12	0.22–3.26
Cancer-Stomach (151)	1	2.19	0.46	0.01–2.54	4	2.03	1.97	0.53–5.04	4	1.64	2.44	0.66–6.26

(*continued*)

Table 5.

Underlying cause of death (9th ICD revision)	Calendar year of death 1980s OBS	EXP	SMR	95% CI	1990s OBS	EXP	SMR	95% CI	2000–2009 OBS	EXP	SMR	95% CI
Cancer-Colon (153)	12	6.61	1.81	0.94–3.17	8	6.70	1.19	0.51–2.35	8	6.07	1.32	0.57–2.60
Cancer-Rectum (154)	2	1.24	1.61	0.18–5.82	1	1.24	0.81	0.01–4.49	2	0.98	2.05	0.23–7.38
Cancer-Liver (155)	3	1.06	2.83	0.57–8.28	1	1.71	0.58	0.01–3.25	2	2.32	0.86	0.10–3.11
Cancer-Pancreas (157)	3	3.25	0.92	0.19–2.69	6	3.73	1.61	0.59–3.50	5	4.28	1.17	0.38–2.72
Cancer-Respiratory system (160–163)	34	25.41	1.34	0.93–1.87	25	28.28	0.88	0.57–1.30	27	25.65	1.05	0.69–1.53
Cancer-Bone (170)	0	0.12			0	0.12			1	0.01	145.22	1.90–808.0*
Cancer-Skin (172–173)	2	1.39	1.44	0.16–5.18	2	1.66	1.20	0.13–4.34	3	1.97	1.52	0.31–4.44
Cancer-Prostate (185)	4	6.33	0.63	0.17–1.62	15	8.60	1.74	0.98–2.88	11	8.51	1.29	0.64–2.31
Cancer-Bladder (188)	1	1.86	0.54	0.01–2.98	4	2.22	1.80	0.49–4.62	1	2.87	0.35	0.00–1.94
Cancer-Kidney (189)	5	1.65	3.03	0.98–7.06	1	1.99	0.50	0.01–2.80	3	2.08	1.44	0.29–4.21
Cancer-Brain and other CNS (191–192)	1	1.59	0.63	0.01–3.49	4	1.79	2.23	0.60–5.72	1	1.69	0.59	0.01–3.29
Cancer-Thyroid (193)	0	0.10			0	0.13			0	0.17		
Lymphatic and hematopoietic (200–209)	5	6.16	0.81	0.26–1.90	9	7.69	1.17	0.53–2.22	11	8.40	1.31	0.65–2.34
Hodgkin's disease (201)	2	0.25	8.06	0.91–29.10	0	0.18			1	0.15	6.63	0.09–36.87
Leukemia (204–207)	2	2.44	0.82	0.09–2.95	7	2.93	2.39	0.96–4.92	5	3.40	1.47	0.47–3.43
Benign neoplasms (210–229)	0	0.61			0	0.87			1	1.25	0.80	0.01–4.45
Allergic, endocrine, nutritional Dz. (240–279)	3	5.38	0.56	0.11–1.63	7	8.48	0.83	0.33–1.70	5	11.75	0.43	0.14–0.99*
Diabetes Mellitus (250)	3	4.01	0.75	0.15–2.18	5	6.61	0.76	0.24–1.77	2	8.83	0.23	0.03–0.82*
All Dz. of blood and blood-forming organs (280–289)	0	0.64			1	1.09	0.92	0.01–5.12	2	0.82	2.44	0.27–8.80
Mental, psychoneurotic, and personality disorders (290–319)	3	2.07	1.45	0.29–4.24	1	3.56	0.28	0.00–1.56	15	7.51	2.00	1.12–3.29*
All Dz. of nervous sys. andsense organs (320–389)	2	3.52	0.57	0.06–2.05	4	5.91	0.68	0.18–1.73	10	13.75	0.73	0.35–1.34
All Dz. of circulatory system (390–458)	126	131.28	0.96	0.80–1.14	121	119.83	1.01	0.84–1.21	117	114.70	1.02	0.84–1.22
Chronic rheumatic heart Dz (393–398)	1	0.62	1.61	0.02–8.97	0	0.43			2	0.34	5.91	0.66–21.35
Ischemic heart Dz. (410–414)	86	89.99	0.96	0.76–1.18	80	69.37	1.15	0.91–1.44	65	66.85	0.97	0.75–1.24
Cerebrovascular Dz (430–438)	13	15.32	0.85	0.45–1.45	11	15.04	0.73	0.36–1.31	14	15.64	0.89	0.49–1.50
All respiratory Dz. (460–519)	16	22.95	0.70	0.40–1.13	23	29.10	0.79	0.50–1.19	26	34.13	0.76	0.50–1.12

(*continued*)

Underlying cause of death (9th ICD revision)	Calendar year of death 1980s OBS	EXP	SMR	95% CI	1990s OBS	EXP	SMR	95% CI	2000–2009 OBS	EXP	SMR	95% CI
Pneumonia (480–486)	3	8.04	0.37	0.07–1.09	9	9.12	0.99	0.45–1.87	7	11.03	0.63	0.25–1.31
Asthma (493)	1	0.33	3.03	0.04–16.86	1	0.37	2.67	0.03–14.84	10	0.22	44.56	21.33–81.96*
All Dz. of digestive system (520–577)	19	10.58	1.80	1.08–2.81*	7	9.80	0.71	0.29–1.47	3	10.51	0.29	0.06–0.83*
Cirrhosis of liver (571)	16	4.99	3.21	1.83–5.21*	5	4.10	1.22	0.39–2.84	2	3.68	0.54	0.06–1.96
All Dz. of genitourinary system (580–629)	4	3.79	1.06	0.28–2.70	6	4.54	1.32	0.48–2.88	1	7.54	0.13	0.00–0.74*
All external causes (800–998)	11	16.00	0.69	0.34–1.23	8	14.19	0.56	0.24–1.11	9	15.36	0.59	0.27–1.11
All accidents (800–949)	3	9.70	0.31	0.06–0.90*	2	8.69	0.23	0.03–0.83*	3	10.13	0.30	0.06–0.86*
Motor Vehicle accidents (810–823)	1	4.24	0.24	0.00–1.31	1	3.51	0.28	0.00–1.58	2	3.42	0.59	0.07–2.11
Suicide (950–959)	7	4.54	1.54	0.62–3.18	4	4.20	0.95	0.26–2.44	3	3.81	0.79	0.16–2.30

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Underlying cause of death (9th ICD revision)	Calendar year of death 2010–2018 OBS	EXP	SMR	95% CI
All causes of death (000–999)	253	250.14	1.01	0.89–1.14
All infective, parasitic Dz.(001–139)	1	8	0.18	0.00–0.98*
All malignant neoplasms (140–209)	55	56.78	0.97	0.73–1.26
Cancer-Buccal cavity, Pharynx (140–149)	1	1.03	0.97	0.01–5.40
Cancer-Digestive, Peritoneum (150–9)	14	14.51	0.96	0.53–1.62
Cancer-Esophagus (150)	4	2.09	1.92	0.52–4.91
Cancer-Stomach (151)	1	1.03	0.97	0.01–5.42
Cancer-Colon (153)	1	3.79	0.26	0.00–1.47
Cancer-Rectum (154)	0	0.73		
Cancer-Liver (155)	5	2.36	2.12	0.68–4.94
Cancer-Pancreas (157)	2	3.64	0.55	0.06–1.98
Cancer-Respiratory system (160–163)	16	15.84	1.01	0.58–1.64
Cancer-Bone (170)	0	0.01		
Cancer-Skin (172–173)	1	1.75	0.57	0.01–3.18

(*continued*)

Table 5.

Table 5.

Underlying cause of death (9th ICD revision)	OBS	Calendar year of death 2010–2018 EXP	SMR	95% CI
Cancer-Prostate (185)	5	6.24	0.80	0.26–1.87
Cancer-Bladder (188)	4	2.61	1.53	0.41–3.92
Cancer-Kidney (189)	1	1.61	0.62	0.01–3.45
Cancer-Brain and other CNS (191–192)	2	1.35	1.48	0.17–5.35
Cancer-Thyroid (193)	0	0.15		
Lymphatic and hematopoietic (200–209)	8	6.32	1.27	0.55–2.49
Hodgkin's disease (201)	0	0.10		
Leukemia (204–207)	5	2.66	1.88	0.61–4.38
Benign neoplasms (210–229)	0	1.11		
Allergic, endocrine, nutritional Dz. (240–279)	7	10.16	0.69	0.28–1.42
Diabetes Mellitus (250)	5	6.99	0.72	0.23–1.67
All Dz. of blood and blood-forming organs (280–289)	1	0.74	1.35	0.02–7.53
Mental, psychoneurotic, and personality disorders (290–319)	12	12.43	0.97	0.50–1.69
All Dz. of nervous sys. and sense organs (320–389)	14	16.53	0.85	0.46–1.42
All Dz. of circulatory system (390–458)	108	84.37	1.28	1.05–1.55*
Chronic rheumatic heart Dz (393–398)	0	0.26		
Ischemic heart Dz. (410–414)	47	43.17	1.09	0.80–1.45
Cerebrovascular Dz (430–438)	17	11.20	1.52	0.88–2.43
All respiratory Dz. (460–519)	25	28.01	0.89	0.58–1.32
Pneumonia (480–486)	4	7.78	0.51	0.14–1.32
Asthma (493)	9	0.14	64.36	29.37–122.2*
All Dz. of digestive system (520–577)	7	8.64	0.81	0.32–1.67
Cirrhosis of liver (571)	3	3.14	0.95	0.19–2.79
All Dz. of genitourinary system (580–629)	8	6.69	1.20	0.51–2.36
All external causes (800–998)	10	13.98	0.72	0.34–1.32
All accidents (800–949)	1	9.71	0.10	0.00–0.57*
Motor Vehicle accidents (810–823)	0	2.2-		
Suicide (950–959)	1	3.24	0.31	0.00–1.72

Note(s): SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

Table 6. Cause-specific mortality by years of police service, among white-male police officers in Buffalo, New York 1950–2018

	Years of police service											
	0–19				20–29				30+			
Causes	Obs	Exp	SMR	95%CI	Obs	Exp	SMR	95%CI	Obs	Exp	SMR	95%CI
All causes of death (000–999)	190	270.23	0.70	0.61–0.81*	627	651.75	0.96	0.89–1.04	1,036	927.83	1.12	1.05–1.19*
All infective, parasitic Dz.(001–139)	1	8.58	0.12	0.00–0.65*	1	12.95	0.08	0.00–0.43*	12	13.25	0.91	0.47–1.58
All malignant neoplasms (140–209)	57	50.08	1.14	0.86–1.47	172	157.64	1.09	0.93–1.27	246	209.30	1.18	1.03–1.33*
Cancer-Buccal cavity, Pharynx (140–149)	4	1.18	3.38	0.91–8.65	5	3.72	1.34	0.43–3.13	5	4.57	1.09	0.35–2.55
Cancer-Digestive, Peritoneum (150–9)	17	12.33	1.38	0.80–2.21	47	40.80	1.15	0.85–1.53	85	56.48	1.50	1.20–1.86*
Cancer-Esophagus (150)	2	1.28	1.57	0.18–5.66	7	4.84	1.44	0.58–2.98	13	5.65	2.30	1.22–3.93*
Cancer-Stomach (151)	2	1.86	1.08	0.12–3.89	6	5.41	1.11	0.40–2.41	11	8.53	1.29	0.64–2.31
Cancer-Colon (153)	6	3.87	1.55	0.57–3.38	14	12.73	1.10	0.60–1.85	30	18.97	1.58	1.07–2.26*
Cancer-Rectum (154)	1	1.07	0.93	0.01–5.20	4	3.20	1.25	0.34–3.20	6	4.87	1.23	0.45–2.68
Cancer-Liver (155)	0	1.27			5	4.23	1.18	0.38–2.76	7	5.15	1.36	0.54–2.80
Cancer-Pancreas (157)	3	2.48	1.21	0.24–3.54	7	8.67	0.81	0.32–1.66	15	11.19	1.34	0.75–2.21
Cancer-Respiratory system (160–163)	17	14.80	1.15	0.67–1.84	56	53.82	1.04	0.79–1.35	73	67.44	1.08	0.85–1.36
Cancer-Bone (170)	0	0.25			2	0.33	6.01	0.67–21.69	0	0.47		
Cancer-Skin (172–173)	0	1.71			5	3.67	1.36	0.44–3.18	3	3.85	0.78	0.16–2.27
Cancer-Prostate (185)	4	2.88	1.39	0.37–3.56	16	12.82	1.25	0.71–2.03	22	23.57	0.93	0.58–1.41
Cancer-Bladder (188)	1	1.22	0.82	0.01–4.57	4	4.96	0.81	0.22–2.07	11	7.78	1.41	0.70–2.53
Cancer-Kidney (189)	1	1.34	0.75	0.01–4.16	5	4.28	1.17	0.38–2.73	9	5.03	1.79	0.82–3.40
Cancer-Brain and other CNS (191–192)	2	2.38	0.84	0.09–3.03	7	4.23	1.65	0.66–3.41	4	3.91	1.02	0.28–2.62
Cancer-Thyroid (193)	0	0.12			1	0.34	2.93	0.04–16.29	1	0.40	2.47	0.03–13.77
Lymphatic and hematopoietic (200–209)	6	6.94	0.86	0.32–1.88	16	15.72	1.02	0.58–1.65	25	19.77	1.26	0.82–1.87
Hodgkin's disease (201)	3	1.14	2.64	0.53–7.71	2	0.77	2.61	0.29–9.41	1	0.76	1.31	0.02–7.32
Leukemia (204–207)	3	2.75	1.09	0.22–3.19	9	6.25	1.44	0.66–2.73	15	8.24	1.82	1.02–3.00*
Benign neoplasms (210–229)	1	1.09	0.92	0.01–5.10	1	2.16	0.46	0.01–2.58	0	2.62		
Allergic, endocrine, nutritional Dz. (240–279)	3	6.47	0.46	0.09–1.35	11	18.20	0.60	0.30–1.08	22	23.09	0.95	0.60–1.44
Diabetes Mellitus (250)	2	4.76	0.42	0.05–1.52	8	13.83	0.58	0.25–1.14	18	18.02	1.00	0.59–1.58
All Dz. of blood and blood-forming organs (280–289)	0	0.68			1	1.69	0.59	0.01–3.29	3	2.58	1.16	0.23–3.40
Mental, psychoneurotic, and personality disorders (290–319)	6	4.88	1.23	0.45–2.68	14	11.22	1.25	0.68–2.09	12	13.20	0.91	0.47–1.59

(*continued*)

Table 6.

Causes	Years of police service: 0–19 Obs	Exp	SMR	95%CI	20–29 Obs	Exp	SMR	95%CI	30+ Obs	Exp	SMR	95%CI
All Dz. of nervous sys. and sense organs (320–389)	2	6.59	0.30	0.03–1.10	16	17.39	0.92	0.53–1.49	16	21.75	0.74	0.42–1.19
All Dz. of circulatory system (390–458)	57	92.57	0.62	0.47–0.80*	263	285.73	0.92	0.81–1.04	507	459.18	1.10	1.01–1.20*
Chronic rheumatic heart Dz (393–398)	1	3.39	0.30	0.00–1.64	4	3.37	1.19	0.32–3.04	3	3.61	0.83	0.17–2.43
Ischemic heart Dz. (410–414)	37	58.19	0.64	0.45–0.88*	169	183.10	0.92	0.79–1.07	334	290.24	1.15	1.03–1.28*
Cerebrovascular Dz (430–438)	5	10.41	0.48	0.15–1.12	24	35.31	0.68	0.44–1.01	67	66.31	1.01	0.78–1.28
All respiratory Dz. (460–519)	12	15.75	0.76	0.39–1.33	43	54.42	0.79	0.57–1.06	59	85.14	0.69	0.53–0.89*
Pneumonia (480–486)	9	5.67	1.59	0.72–3.01	7	16.98	0.41	0.17–0.85*	16	29.09	0.55	0.31–0.89*
Asthma (493)	1	0.54	1.87	0.02–10.38	9	1.11	8.14	3.72–15.46*	12	1.64	7.32	3.78–12.79*
All Dz. of digestive system (520–577)	11	13.95	0.79	0.39–1.41	21	28.14	0.75	0.46–1.14	34	32.29	1.05	0.73–1.47
Cirrhosis of liver (571)	9	7.40	1.22	0.55–2.31	13	13.30	0.98	0.52–1.67	18	11.50	1.57	0.93–2.47
All Dz. of genitourinary system (580–629)	5	4.79	1.04	0.34–2.43	8	11.61	0.69	0.30–1.36	13	17.80	0.73	0.39–1.25
All external causes (800–999)	26	59.29	0.44	0.29–0.64*	24	40.45	0.59	0.38–0.88*	37	34.59	1.07	0.75–1.47
All accidents (800–949)	9	40.34	0.22	0.10–0.42*	5	26.27	0.19	0.06–0.44*	14	24.02	0.58	0.32–0.98*
Motor Vehicle accidents (810–823)	4	20.50	0.20	0.05–0.50*	2	9.88	0.20	0.02–0.73*	4	7.89	0.51	0.14–1.30
Suicide (950–959)	9	13.02	0.69	0.32–1.31	10	11.00	0.91	0.44–1.67	12	8.67	1.38	0.71–2.42

Note(s):SMR: Standardized mortality Ratio, 95% CI: 95% confidence interval, *Statistical significance at $p < 0.05$

(SMR = 1.14, 0.86–1.47). Cancers of the digestive system combined and cancer of the esophagus and colon were elevated but not significantly. Deaths due to all external causes, all accidents, and motor vehicle accidents occurred less frequently than expected. Officers with 20–29 years of police service had a significant risk of death from asthma (SMR = 8.14, 3.72–15.46). Officers with ≥30 years of police service had significantly elevated mortality for all causes of death (SMR = 1.12, 1.05–1.19), all malignant neoplasms (SMR = 1.18, 1.03–1.33), digestive cancers (SMR = 1.50, 1.20–1.86), Esophageal cancer (SMR = 2.30, 1.22–3.93), Colon cancer (SMR = 1.58, 1.07–2.26), Leukemia (SMR = 1.82, 1.02–3.00), and all diseases of the circulatory system (SMR = 1.10, 1.01–1.20). Suicide was slightly elevated (SMR = 1.38, 0.71–2.42) in this group.

Discussion

This study examined the mortality experience of Buffalo, New York, police officers spanning 68 years (1950–2018). White male police officers exhibited elevated mortality for all malignant neoplasms, asthma, and cirrhosis of the liver. Deaths from circulatory diseases were similar to the general population; except for Ischemic heart disease which was elevated. Officers with <19 years of service had elevated deaths from all malignant neoplasms, including digestive, colon, and respiratory cancer. Similar elevations were seen in the 20–29 years of service group. In the 30+ years of service group, death were significantly elevated for all causes, all malignant neoplasms, including esophageal, colon cancers, and leukemia. SMRs were also significantly elevated in the 30+ group for all diseases of the circulatory system, including Ischemic heart disease. Suicide was slightly elevated in this group.

Black and female officers had significantly lower mortality rates for all causes of death compared to the general population. However, caution should be used when interpreting these results due the small sample size of this cohort. This study was among the first to assemble a cohort of black and female officers large enough to conduct a preliminary risk assessment for all-cause mortality. The importance of continued mortality surveillance of officers of color and women is illustrated by increasing levels of minority populations in police work since the 1980s and the preliminary findings of the healthy worker effect in black and female officers. The healthy worker effect is characterized by relatively lower mortality rates from all causes combined and from selected causes of death. This possibly masks an increased risk of the disease under study (McMicheal, 1976) and is likely due to the use of the US mortality as a comparison that includes the unemployed and institutionalized who exhibit higher mortality than those who are employed and not institutionalized.

Mortality from cardiovascular disease (CVD)

Deaths from diseases of the circulatory system were elevated in officers with longer service time. The elevated rates are further evidence of morbidity and risk of death among police. Persons who enter police work are generally part of a healthy work population but appear to deteriorate physically and psychologically as years of police service increase (Vena *et al.*, 2014). Violanti *et al.* (2020) conducted a 22-year study of CVD using data from the National Law Enforcement Officer Memorial Fund database. While these deaths were only for on-duty deaths, they reflect the cardiovascular problems in this profession. Deceased officers ranged in age from 21 to 74 years, with the majority (74.3%) being 40–60 years of age. Circulatory related disease (52.6%) was the most common cause of death. The average age of on-duty death from CVD was 48 years of age. Circulatory-related deaths included a fatal heart attack (81.8%), stroke (2.1%), cardiac arrest (2.1%) and probable circulatory causes (e.g., 14.1% collapsed during training exercise, myocardial infarction, unresponsive after chest pains). The average age of on-duty deaths due to heart attacks was 46.5 years.

The metabolic syndrome, a collection of three or more out of five cardiovascular risk components, has also been observed among police officers with an estimated prevalence of 26.7% (Hartley *et al.*, 2012). A cross-sectional study of metabolic syndrome in a sample of male police officers in Texas found that prevalence of CVD in male police officers was higher than in the American male population, placing law enforcement officers at increased risk for future CVD morbidity and mortality (Humbarger *et al.*, 2004). Garbarino and Magnavita (2015) found that the most common components of metabolic syndrome in police constables were hypertriglyceridemia and low HDL cholesterol, and 22.7% police constables were hypertensive. Interestingly, the majority of fatal heart attacks in the present study occurred among 40–50 year-old men.

Police officers who often work under conditions of high stress may be more susceptible to CVD. A meta-analysis of workplace stressors and health outcomes showed that stressors, such as work-family conflict, job insecurity, high job demands, low job control, and lack of social support, were associated with poor physical health, and poor mental health (Goh *et al.*, 2015). The study also showed that high job demands raised the odds of having a physician-diagnosed illness by 35%. Another study reported that job strain increased the likelihood of CVD by 23% (Kivimäki *et al.*, 2012). Stress may play a major role in the development and maintenance of obesity in individuals that in turn can lead to CVD (Van der Valk *et al.*, 2018). Andrew *et al.* (2017) found that perceived lack of support was associated with compromised cardiac vagal control among female officers further suggesting cardiogenic perturbations with organizational stress. Stress and obesity are related (van der Valk *et al.*, 2018) and obesity may add to health problems among police officers. A recent study suggested that overweight and obesity were more prevalent among law enforcement personnel than among the general population (Ramey *et al.*, 2011). Lack of regular physical exercise is one of the occupational risk factors contributing to the higher prevalence of elevated blood pressure, metabolic syndrome, and CVD among emergency responders (Kales *et al.*, 2009).

Cancer

Death from all malignant neoplasms were slightly elevated in officers with less than 29 years of service and significantly elevated in officers with over 30 years of service. Psychosocial factors have been indicated in cancer risk (Violanti *et al.*, 2013; Wirth *et al.*, 2013). Studies suggest that stress may affect cancer risk at certain anatomical sites and in some populations (Wirth *et al.*, 2013). The risk of cancers of the lymphatic and hematopoietic tissues seen in police mortality studies seen in this study is interesting because other research has shown that leukemia and lymphoma can be caused by substantial psychological stress (Vena *et al.*, 2014). Digestive cancers were significantly higher in officers, especially cancers of the esophagus and colon. Deaths from leukemia were significantly elevated for older officers (30+ years of service). The increased risk for mortality of cancer of the colon could be due to a combination of risk factors including lack of physical exercise (Oruc and Kaplan, 2019), the somewhat sedentary physical activities of police work (Vena *et al.*, 2014), job stress, and irregular dietary habits (Spiegelman and Wegman, 1985).

Other risk factors for cancer include changes in behavior, increasing exposure to carcinogens related to lifestyle, and the effects of stress on humoral or cellular immunity leading to an increase in susceptibility. These interrelated risk factors may combine with biological risks such as exposure to alcohol, caffeine, and cigarettes to produce multiple predispositions to disease. Indeed, occupational stress has been shown to lead to variation in cancer related cigarette, coffee, and alcohol consumption (Wirth *et al.*, 2013). The excessive alcohol consumption among police officers has been characterized as one of the coping mechanisms to the stressors of the job (Violanti *et al.*, 2011). The elevated risk for esophageal cancer and for cirrhosis in the police cohort in the current study may be due to increased alcohol and tobacco consumption (Li *et al.*, 2016).

The potential for law enforcement exposure to hazardous materials in the United States is high. This is evidenced by several police mortality studies, which show an increased risk for cancers associated with chemical exposures (Vena *et al.*, 2014). Officers are often called upon to investigate traffic accidents involving hazardous materials, or handle disaster situations where chemicals are released in the air. More than 60,000 chemicals are produced annually in the United States, of which the US Department of Transportation considers approximately 2,000 are hazardous (https://www.federalregister.gov/documents/2020/05/11/2020-06205/hazardous-materials-harmonization-with-international-standards). Violanti *et al.* (2020) found that cancer deaths among police had increased from 1997 to 2018. The majority of most recent cancer deaths were among officers involved with rescue and recovery during and after the 911 terrorist attack, suggesting possible exposure to potentially harmful chemicals, carcinogens, or hazardous substances as the risk factor. This included World Trade Center, Pentagon, and Shanksville, Pennsylvania locations. The majority of deaths from cancer were due to lung cancer and associated lung diseases.

Shift work is a required part of policing and has been associated with cancer. Abnormal DNA methylation (methylation helps to regulate DNA) is an established early event in cancer and likely other human diseases and it has been more prevalent in shift workers. Abnormal DNA methylation may underlie stress-related disease susceptibility related to shift work (Rashid *et al.*, 2001). Sleep loss, which is perhaps the most common complaint among shift workers, also alters DNA methylation patterns (Gaine *et al.*, 2018). Immune system dysregulation due to shiftwork or sleep disruption may foster tumor development. Shift work has been linked with increased risks for prostate, breast, and colorectal cancer, as well as non-Hodgkin's lymphoma, and the International Agency for Research on Cancer concluded that shift work is a probable human carcinogen. Several recent studies support and extend these observations (Hansen and Stevens, 2012).

Mental disorders

An interesting result in the present study concerned police deaths associated with mental, psychoneurotic and personality disorders. These categories are additions to ICD-9 death codes (ICD-9-CM Diagnosis Code 290–319: Unspecified nonpsychotic mental disorders). Officers had a slightly higher risk of death from mental disorders than that of the general population. Younger officers had the highest risk. This type of death may be a result of exposures to chronic stress and trauma. People with mental disorders have a mortality rate 2.22 times higher than the general population (Walker *et al.*, 2015). Syed *et al.* (2020) conducted a meta-analysis estimating the prevalence and risk factors for mental health problems among police personnel worldwide. The overall prevalence was 14.6% for depression, 14.2% for post-traumatic stress disorder (PTSD), 9.6% for a generalized anxiety disorder, 8.5% for suicidal ideation, 5.0% for alcohol dependence, and 25.7% for hazardous drinking. Fox *et al.* (2012) reported that 24% of their police sample reported PTSD, 9% depression, and 19% alcohol abuse. Only 46.7% had ever sought mental-health services. A survey study by Jetelina *et al.* (2020) on 446 officers found that 12% reported a lifetime mental health diagnosis, and 26% had positive screening results for current mental illness symptoms. Officers with mental difficulties may also have high rates of adverse health behaviors, including smoking, physical inactivity, and poor diet which add to mortality risk (Walker, 2015).

Implications for police practice

Physical health, well-being, safety and efficiency at work are important factors for any police department to consider. The results of this study will provide police practitioners with objective information to determine the impact of work on law enforcement officers, their

health, safety, and performance. With such evidence in hand, police agencies can better plan specific and detailed prevention strategies. When one considers the monetary and human costs of health-impaired officers, it is essential to promote awareness and plausible prevention strategies.

Prevention of cardiovascular disease and mental health among police not only saves lives but also is cost-effective. In order to replace an officer, the cost to recruit, hire, equip, and fully train a police officer from the time they submit their initial application to the time they can function independently may exceed $100,000 and take up to eighteen months (Police Foundation, 2020). According to the Health Care Blue Book (2019), it would cost approximately $8.4 million to help prevent cardiovascular disease, while the cost of treatment is $26.7 million (Health Blue Book, 2019). Mental health and substance abuse treatment is forecasted to reach $280.5 billion in 2020, rising from $171.7 billion in 2009 (SAMHSA, 2019).

There are limitations to the present study. The findings of increased risk for deaths from chronic disease need to be further studied in relation to work, psychosocial, and lifestyle risk factors, including reactions to stress and exposure to chemical and physical agents. Little is known of how multiple exposures combine or interact to elicit changes in long-term risks of chronic disease. The inclusion of minority populations is scarce in police mortality studies. Although we were able to gain a preliminary look at mortality rates among black and female officers, it was not possible to stratify the results for blacks by gender nor the results for women by race due to small sample sizes. As additional data becomes available on minority deaths, it is important that we look at comparisons of types and span of such deaths. In future analysis, larger numbers of black officers and women who are employed in police work may help to provide a more accurate number of deaths in this population. Lastly, while the present study provides a retrospective analysis of police mortality over a long period of time it is geographically limited. Geographic and cultural differences may affect results. National samples are needed to verify and extend the present results.

Results of this research will increase our understanding of the health impact of police work over time particularly as it may relate to major diseases such as cancer, cardiovascular disease and general indicators of health or longevity. This knowledge can contribute to ongoing research in the field of stress research leading to better techniques for treating and preventing stress among workers in high-stress occupations. Future research can also assess whether stress, lifestyle, and work exposure mediate the rate at which disease progresses. There also remain questions on whether police work stressors increase the risk of disease by disrupting biological factors associated with immune system, neurological, and other organ system functions. As we continue to examine the health of police officers, there is evidence that this occupation will have not only an immediate, but also a long-term effect of police health and mortality. Exposure at work can have a profound impact on police officers, and future research should include etiologic studies that can evaluate potential occupational factors that lead to increased risks for morbidity and mortality.

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