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All causes of death among veterinarians in the United States during 1979 through 2015

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OBJECTIVE
To assess proportionate mortality from all causes for male and female US veterinarians during 1979 through 2015.

SAMPLE
Death records for 11,620 veterinarians.

PROCEDURES
For this proportionate mortality ratio (PMR) study, information for veterinarians who died during 1979 through 2015 was obtained from AVMA obituary and life insurance databases and submitted to a centralized database of US death records to obtain underlying causes of death. Decedent data that met records-matching criteria were imported into a software program for calculation of PMRs for all causes stratified by sex and indirectly standardized for age, race, and 5-year calendar period with 95% CIs.

RESULTS
11,620 decedents consisted of 11,049 (95%) males and 571 (5%) females with a median age at death of 77 years. Proportionate mortality for all veterinarian decedents was higher than expected for melanoma (PMRs, 2.1 and 2.2 for males and females, respectively), suicide (PMRs, 2.1 and 3.5 for males and females, respectively), and transportation injuries (PMRs, 1.7 and 1.6 for males and females, respectively). Proportionate mortality for all decedents was lower than expected for respiratory cancers (PMRs, 0.6 and 0.5 for males and females, respectively), diabetes mellitus (PMRs, 0.7 and 0.4 for males and females, respectively), heart disease (PMRs, 0.9 and 0.6 for males and females, respectively), and respiratory disorders (PMRs, 0.7 and 0.6 for males and females, respectively).

CLINICAL RELEVANCE
Results indicated proportionate mortality from malignant melanoma, transportation injuries, and suicide for male and female veterinarians was higher than the general population. These data may help stakeholders improve veterinarian workplace safety and health guidelines.

Veterinarians work in environments with numerous occupational hazards.[1–3] Veterinarians are routinely exposed to anesthetic gases, zoonotic diseases, radiation, and work-related mental stress.[1–4] Previous studies have reported the short-term impact of working in veterinary medicine, which indicated animal-related injuries such as kicks, bites, scratches, and needlesticks were the most commonly reported.[1–3,5,6] However, no known studies have evaluated the long-term impact of the occupational hazards of working in veterinary medicine. One way to evaluate the long-term impacts of occupational hazards is through mortality studies. Proportionate mortality ratios (PMRs) might also help identify trends in causes of death that could have been prevented, leading to recommendations that might improve quality of life or life expectancy among veterinarians.

Previous all-cause veterinarian mortality studies do not include female veterinarians. Blair and Hayes published 2 veterinarian mortality studies[7,8] in the early 1980s. The first all-cause mortality study[7] focused on cancer among US veterinarian decedents who died during 1966 through 1977. The second all-cause mortality study[8] evaluated US veterinarians who died during 1944 through 1977. Both of these studies included only veterinarian decedents who were white and male and who predominately specialized in food animal or equine medicine.[7,8] In the 1970s, the female veterinary student population started to increase.[9] In 2019, 63% of US veterinarians were female and over 75% of veterinary school students were female.[10] Furthermore, as companion animals have become more important in society, the

focus of the veterinary profession has shifted to predominately companion animal medicine.[11,12] In 2019, over 75% of all employed US veterinarians worked in companion animal medicine.[10] Other all-cause veterinarian mortality studies have limited the analysis to specific regions or populations in the US. In 1966, a veterinarian mortality study published by Botts et al[13] included only deaths among white male Missouri veterinarians. In 1995, an all-cause mortality study by Miller and Beaumont[14] included female veterinarian decedents but was limited to veterinarian decedents identified through the archives of the California State Board of Examiners in Veterinary Medicine. International veterinarian mortality studies have focused specifically on suicide.[15–19]

Understanding mortality causes among male and female US veterinarians in the context of the changing demographics and species specialization in the veterinary profession could help identify trends in specific causes of death during an expanded study period and describe death patterns by occupational characteristics. The purpose of the study reported here was to conduct an updated assessment of proportionate mortality from all causes among male US veterinarians and to investigate proportionate mortality from all causes among female US veterinarians.

Materials and Methods

Data sources

Veterinarian decedent information for this study was obtained from *JAVMA* obituary information collected by the AVMA and settlements on life insurance policies obtained through AVMA membership. When information was available, the AVMA decedent records provided first, middle, and last names; date of birth; state of death; sex; race; membership status (eg, member or nonmember); name of veterinary school and graduation year; primary employment facility type (eg, general practice, academic, industry, or government); primary function performed (eg, clinical medicine, teaching, research, or regulatory work); and primary species treated. Decedent information from the AVMA was matched to death records in the National Death Index (NDI), a centralized death-records database managed by the CDC National Center for Health Statistics,[20] to obtain each decedent's underlying cause of death. Further information on data sources for this study have been described in a previous report.[21]

Case selection

The AVMA provided demographic and employment information for 13,469 veterinarians who died during 1979 through 2015 **(Figure 1)**. Each AVMA record was reviewed and included if the record contained a date of death between January 1, 1979, and December 31, 2015, full name, and birth month and year. Because of project financial restrictions, 238 AVMA records were excluded using a standard software (SAS version 9.4; SAS Institute Inc.) survey selection procedure. Detailed information on case selection and the record exclusion process has been described in a previous report.[21] Using the NDI submission criteria,[20] 12,501 veterinarian decedents were submitted to NDI, and 11,648 (93.2%) of these matched a single NDI record based on the NDI selection criteria.[20] Available software (Life Table Analysis System [LTAS] version 4.0; CDC National Institute for Occupational Safety and Health) was used to compare specific causes of mortality among the veterinarian decedents to the general US population.[22] Of the 11,648 decedents matched to NDI records, 11,620 (99.8%) met LTAS import requirements (nonmissing data for underlying cause of death and exposure start date) and were included in analyses.

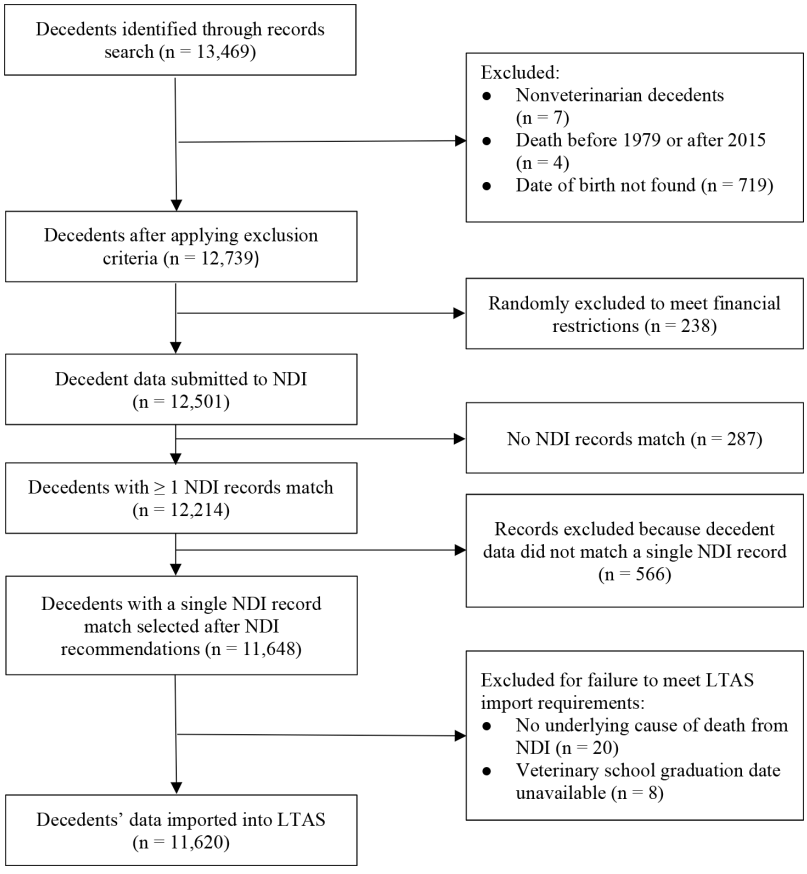

Figure 1—Flow diagram depicting selection, inclusion, and exclusion of death records for use to assess proportionate mortality from all causes among male and female veterinarians in the US from 1979 through 2015. The initial data set for deceased US veterinarians was collected by examination of records from *JAVMA* obituary information collected by the AVMA and terminated life insurance policies obtained through AVMA membership. For study purposes, the date of graduation from veterinary school was considered the exposure start date. LTAS = Life Table Analysis System. NDI = National Death Index.

Statistical analysis

PMRs were calculated using LTAS and stratified by sex. The LTAS program indirectly standardizes for age, race, and 5-year calendar period by calculating a weighted sum of proportions for the exposed (study population) and unexposed (general US population) for each stratum, with the weights being the total observed deaths among the exposed population for each stratum.[22,23] The 5-year calendar period PMRs were also used to examine trends over time. PMRs were calculated by dividing the observed number of deaths for a specific cause of death by the expected number of deaths for a specific cause. The LTAS calculated the expected number of deaths by multiplying the total decedent population by the proportion of US deaths for a specific cause.[22,24] Therefore, PMR values > 1.00 indicated the proportionate mortality from a specific cause of death was greater than the general US population.[24] The LTAS assumed a Poisson distribution to calculate *P* values (< 0.05 or < 0.01) and 95% CIs; values were considered statistically significant at $P < 0.05$.[22] Cell sizes of < 5 were suppressed to comply with NDI data presentation requirements.

Results

Study demographics

Of 11,620 decedents included in the analysis, 11,049 (95%) were male and 571 (5%) were female. The median age at death was 77 years (range, 25 to 107 years) for males and 51 years (range, 26 to 100 years) for females **(Table 1)**. Two-thirds (66%) of the decedents worked in an occupational position classified as clinical. Approximately 50% (n = 5,799) of the decedents had available species specialization information; of these, 3,650 (31% of all decedents or 63% [3,650/5,799] of decedents with available species specialization information) worked exclusively or predominantly with companion animals.

Comparison with general US population

Cancer—Male veterinarians were 2.1 (95% CI, 1.74 to 2.49) times as likely to die from brain cancer, 2.1 (95% CI, 1.74 to 2.57) times as likely to die from melanoma, and 1.6 (95% CI, 1.04 to 2.27) times as likely to die from a nonmelanoma type skin cancer, compared with the general US population **(Table 2)**. Among lymphatic and hematopoietic system cancers, male veterinarian decedents were 2.1 (95% CI, 1.14 to 3.49) times as likely to die from Hodgkin lymphoma, 1.9 (95% CI, 1.50 to 2.27) times as likely to die from multiple myeloma, 1.6 (95% CI, 1.35 to 1.82) times as likely to die from leukemia, and 1.3 (95% CI, 1.12 to 1.56) times as likely to die from non-Hodgkin lymphoma, compared with the general US population. Cancer of the pancreas (PMR, 1.5; 95% CI, 1.32 to 1.73) was the only digestive organ cancer and prostate cancer (PMR, 1.4; 95% CI, 1.26 to 1.53) was the only male genital cancer significantly different, compared with the general US population.

Female veterinarian decedents were 2.2 (95% CI, 1.01 to 4.21) times as likely to die from melanoma and 2.5 (95% CI, 1.65 to 3.59) times as likely to die from ovarian cancer, compared with the general

Table 1—Numbers (%) of 11,620 veterinarians who died during 1979 through 2015 stratified by sex and then further grouped by age at death, veterinary position type, and species specialization. Decedents were classified in clinical position if the AVMA decedent record listed their employment facility type as general practice or their primary function performed as clinical medicine. Species specialization was classified according to AVMA market research statistic definitions.

Characteristics	Males (n = 11,049)	Females (n = 571)	Total (n = 11,620)
Age at death (y)			
25–34	90 (< 1)	48 (8)	**138 (1)**
35–44	278 (3)	124 (22)	**402 (3)**
45–54	600 (5)	150 (26)	**750 (6)**
55–64	1,348 (12)	115 (20)	**1,463 (13)**
65–74	2,277 (21)	53 (9)	**2,330 (20)**
≥ 75	6,456 (58)	81 (14)	**6,537 (56)**
Position type			
Clinical*	7,214 (65)	422 (74)	**7,636 (66)**
Nonclinical	3,364 (30)	95 (17)	**3,459 (30)**
Unknown	471 (4)	54 (9)	**525 (5)**
Species specialization†			
Companion animal	3,289 (30)	361 (63)	**3,650 (31)**
Food animal	1,211 (11)	18 (3)	**1,229 (11)**
Mixed animal	583 (5)	29 (5)	**612 (5)**
Equine	270 (2)	21 (4)	**291 (3)**
Other	20 (0.2)	0 (0)	**20 (0.2)**
None or not listed	5,676 (51)	142 (25)	**5,818 (50)**

*Decedents were classified in clinical position if the AVMA decedent record listed their employment facility type as general practice or their primary function performed as clinical medicine.

†Species specialization was classified according to AVMA market research statistic definitions.

Table 2—Proportionate mortality ratios (PMRs) for all cancer-related deaths among the 11,620 veterinarians described in Table 1.

	Males (n = 11,049)			Females (n = 571)		
Cause of death	**No. observed**	**No. expected**	**PMR (95% CI)**	**No. observed**	**No. expected**	**PMR (95% CI)**
All malignant cancer	2,945	2,708.8	1.1* (1.05–1.13)	216	180.6	1.2† (1.04–1.37)
Cancer of buccal cavity and pharynx	42	47.3	0.9 (0.64–1.20)	≤ 5	≤ 5	1.8 (0.37–5.17)
Cancer of digestive organs and peritoneum	743	652.7	1.1* (1.06–1.22)	44	31.7	1.4* (1.01–1.86)
Esophagus	90	83.3	1.1 (0.87–1.33)	≤ 5	≤ 5	2.1 (0.44–6.22)
Stomach	67	63.8	1.1 (0.81–1.33)	≤ 5	≤ 5	0.7 (0.08–2.48)
Intestines	247	223.1	1.1 (0.97–1.25)	16	11.5	1.4 (0.8–2.26)
Rectum	42	45.7	0.9 (0.66–1.24)	≤ 5	≤ 5	1.6 (0.52–3.73)
Liver	70	85.7	0.8 (0.64–1.03)	≤ 5	≤ 5	1.2 (0.39–2.77)
Pancreas	215	142.3	1.5* (1.32–1.73)	13	7.9	1.7 (0.88–2.82)
Cancer of the respiratory system	573	889.7	0.6* (0.59–0.70)	21	39.0	0.5* (0.33–0.82)
Larynx	16	26.2	0.6† (0.35–0.99)	—	—	—
Lung, bronchus, trachea	547	857.5	0.6* (0.59–0.69)	21	38.1	0.6* (0.34–0.84)
Cancer of breast	≤ 5	≤ 5	1.5 (0.48–3.45)	50	40.0	1.3 (0.93–1.65)
Cancer of female genital organs	—	—	—	43	23.9	1.8* (1.30–2.42)
Ovarian	—	—	—	28	11.3	2.5* (1.65–3.59)
Cancer of male genital organs	417	301.8	1.4* (1.25–1.52)	—	—	—
Prostate	416	299.6	1.4* (1.26–1.53)	—	—	—
Cancer of urinary system	205	169.4	1.2* (1.05–1.39)	≤ 5	≤ 5	1.0 (0.26–2.45)
Bladder	123	97.9	1.3† (1.04–1.50)	≤ 5	≤ 5	1.4 (0.17–4.96)
Kidney	82	71.4	1.2 (0.91–1.42)	≤ 5	≤ 5	0.7 (0.09–2.66)
Cancer of other systems or unspecific sites	528	363.1	1.5* (1.33–1.58)	37	25.7	1.4* (1.01–1.98)
Bone	10	4.7	2.1† (1.02–3.92)	≤ 5	≤ 5	1.8 (0.05–10.01)
Nonmelanoma	29	18.7	1.6† (1.04–2.27)	≤ 5	≤ 5	2.9 (0.07–15.85)
Melanoma	105	49.4	2.1* (1.74–2.57)	9	4.1	2.2* (1.01–4.21)
Connective tissue	30	15.3	2.0* (1.32–2.79)	6	2.0	2.9† (1.06–6.32)
Brain	127	60.8	2.1* (1.74–2.49)	12	6.9	1.7 (0.89–3.03)
Cancer of lymphatic and hematopoietic system	432	281.4	1.5* (1.39–1.69)	14	14.3	1.0 (0.53–1.64)
Hodgkin lymphoma	14	6.7	2.1† (1.14–3.49)	—	—	—
Non-Hodgkin lymphoma	148	111.7	1.3* (1.12–1.56)	10	5.2	1.9 (0.93–3.55)
Multiple myeloma	93	50.1	1.9* (1.50–2.27)	—	—	—
Leukemia	177	112.8	1.6* (1.35–1.82)	≤ 5	≤ 5	0.6 (0.18–1.65)

*2-sided $P < 0.01$. †2-sided $P < 0.05$.
— = No decedents reported.
The PMRs were generated by using Life Table Analysis System software with 95% CIs and 2-sided P values based on an assumed Poisson distribution; values > 1.0 indicate that the proportion of deaths for a specific cause is greater than that for the general US population during the study period, with values of $P < 0.05$ considered significant.

US population. The proportionate mortality for female veterinarian decedents dying from breast cancer was not significantly different from the general US population.

Male and female veterinarian decedents were less likely than the general US population to die from cancer of the respiratory system, with male veterinarian decedents 0.6 (95% CI, 0.59 to 0.70) and female veterinarian decedents 0.5 (95% CI, 0.33 to 0.82) times as likely to die from any respiratory system cancer. Among cancers of the respiratory system, male veterinarian decedents were 0.6 (95% CI, 0.59 to 0.69) times and female veterinarian decedents were 0.6 (95% CI, 0.34 to 0.84) times as likely to die from cancer of the lungs, trachea, or bronchi, compared with the general US population. Additionally, male veterinarian decedents were 0.6 (95% CI, 0.35 to 0.99) times as likely to die from larynx cancer, compared with the general US population.

Noncancer—Male veterinarian decedents were 2.1 (95% CI, 1.87 to 2.32) times as likely to die from intentional self-harm or suicide **(Table 3)**; a detailed analysis of suicide mortality among veterinarians was published previously.[21] Male veterinarian decedents were 1.7 (95% CI, 1.45 to 1.88) times as likely to die from a transportation injury, compared with the general US population. Among transportation-related injuries, male veterinarian decedents were 1.7 (95% CI, 1.33 to 2.02) times as likely to die from injuries in a motor vehicle traffic accident where the decedent was the driver, compared with the general US population. However, the proportionate mortality for male veterinarian decedents was not significantly different from the general US population for motor vehicle traffic injuries where the decedent was a passenger (PMR, 1.2; 95% CI 0.56 to 2.15). Female veterinarian decedents were 3.5 (95% CI, 2.73 to 4.39) times as likely to die from suicide and 1.6 (95% CI, 1.10 to 2.13) times as likely to die from transportation injuries, compared with the general US population.

Male veterinarians were 0.4 (95% CI, 0.28 to 0.65) times as likely to die from tuberculosis or HIV-related diseases, 0.7 (95% CI, 0.59 to 0.79) times as likely to die from diabetes mellitus, 0.7 (95% CI, 0.68 to 0.77) times as likely to die from respiratory disorders, and 0.9 (95% CI, 0.91 to 0.97) times as likely to die from heart disease, compared with the general US population. Female veterinarian decedents were 0.4 (95% CI, 0.14 to 0.83) times as likely to die from diabetes mellitus, 0.6 (95% CI, 0.43 to 0.76) times as likely to die from heart disease, and 0.6 (95% CI, 0.36 to 0.88) times as likely to die from respiratory disorders, compared with the general US population.

Trends of deaths over time

We found little variation among PMRs over time for most cancer mortalities including respiratory, pancreas, and prostate cancers **(Figure 2)**. Proportionate mortality for ovarian cancer among veterinarian decedents had the most variation from 1980 through 2014. Proportionate mortality for nonmelanoma skin cancer peaked during 1980 through 1984

Table 3—Proportionate mortality ratios for all non–cancer-related deaths among the 11,620 veterinarians described in Table 1.

	Males (n = 11,049)			Females (n = 571)		
Cause of death	**No. observed**	**No. expected**	**PMR (95% CI)**	**No. observed**	**No. expected**	**PMR (95% CI)**
Tuberculosis and HIV-related diseases	24	55.0	0.4* (0.28–0.65)	—	—	—
Disease of blood and blood-forming organs	87	58.2	1.5* (1.20–1.84)	≤ 5	≤ 5	1.2 (0.24–3.42)
Diabetes mellitus	184	268.0	0.7* (0.59–0.79)	6	15.7	0.4* (0.14–0.83)
Mental and psychological disorders	270	300.6	0.9 (0.79–1.01)	10	11.9	0.8 (0.40–1.54)
Nervous system disorders	599	425.2	1.4* (1.30–1.53)	17	19.2	0.89 (0.52–1.42)
Heart diseases	3,244	3,455.6	0.9* (0.91–0.97)	50	86.5	0.6* (0.43–0.76)
Hypertension with heart disease	83	104.8	0.8† (0.63–0.98)	≤ 5	≤ 5	0.5 (0.11–1.55)
Ischemic heart disease	2,376	2,651.9	0.9* (0.86–0.93)	36	55.9	0.6* (0.45–89)
Chronic endocardium disease	120	88.9	1.4* (1.12–1.61)	≤ 5	≤ 5	0.7 (0.08–2.49)
Cardiomyopathy	143	124.5	1.1 (0.97–1.35)	≤ 5	≤ 5	0.2 (0.01–1.12)
Other circulatory disorders	998	906.5	1.1* (1.03–1.17)	27	37.8	0.7 (0.47–1.04)
Cerebrovascular disease	678	582.5	1.2* (1.08–1.26)	19	23.3	0.8 (0.49–1.28)
Hypertension without heart disease	55	70.3	0.8 (0.59–1.02)	—	—	—
All respiratory disorders	826	1,141.5	0.7* (0.68–0.77)	22	38.0	0.6* (0.36–0.88)
Pneumonia	224	295.9	0.8* (0.66–0.86)	12	8.7	1.4 (0.71–2.40)
Chronic obstructive pulmonary disease	362	620.9	0.6* (0.52–0.65)	7	19.5	0.4* (0.14–0.74)
Asthma	10	9.7	1.0 (0.49–1.89)	≤ 5	≤ 5	0.4 (0.01–2.40)
All digestive disorders	314	382.6	0.8* (0.73–0.92)	15	29.0	0.5* (0.29–0.85)
Cirrhosis and other chronic liver diseases	90	148.7	0.6* (0.49–0.74)	7	15.0	0.5* (0.19–0.96)
All skin and subcutaneous tissue disorders	11	12.5	0.9 (0.44–1.58)	≤ 5	≤ 5	1.1 (0.03–6.32)
All musculoskeletal disease	32	31.7	1.0 (0.69–1.43)	9	4.4	2.0 (0.93–3.86)
All genito-urinary disease	187	242.0	0.8* (0.67–0.89)	8	8.9	0.9 (0.39–1.77)
All transportation injuries	243	146.7	1.7* (1.45–1.88)	38	24.5	1.6* (1.10–2.13)
Motor vehicle—driver	93	56.4	1.7* (1.33–2.02)	13	7.6	1.7 (0.91–2.91)
Motor vehicle—passenger	10	8.5	1.2 (0.56–2.15)	≤ 5	≤ 5	1.1 (0.29–2.76)
Falls	134	100.4	1.3* (1.12–1.58)	≤ 5	≤ 5	1.6 (0.51–3.68)
Violence	350	192.8	1.8* (1.63–2.02)	82	28.4	2.9* (2.29–3.58)
Intentional self-harm	326	156	2.1* (1.87–2.32)	72	20.7	3.5* (2.73–4.39)

See Table 2 for the key.

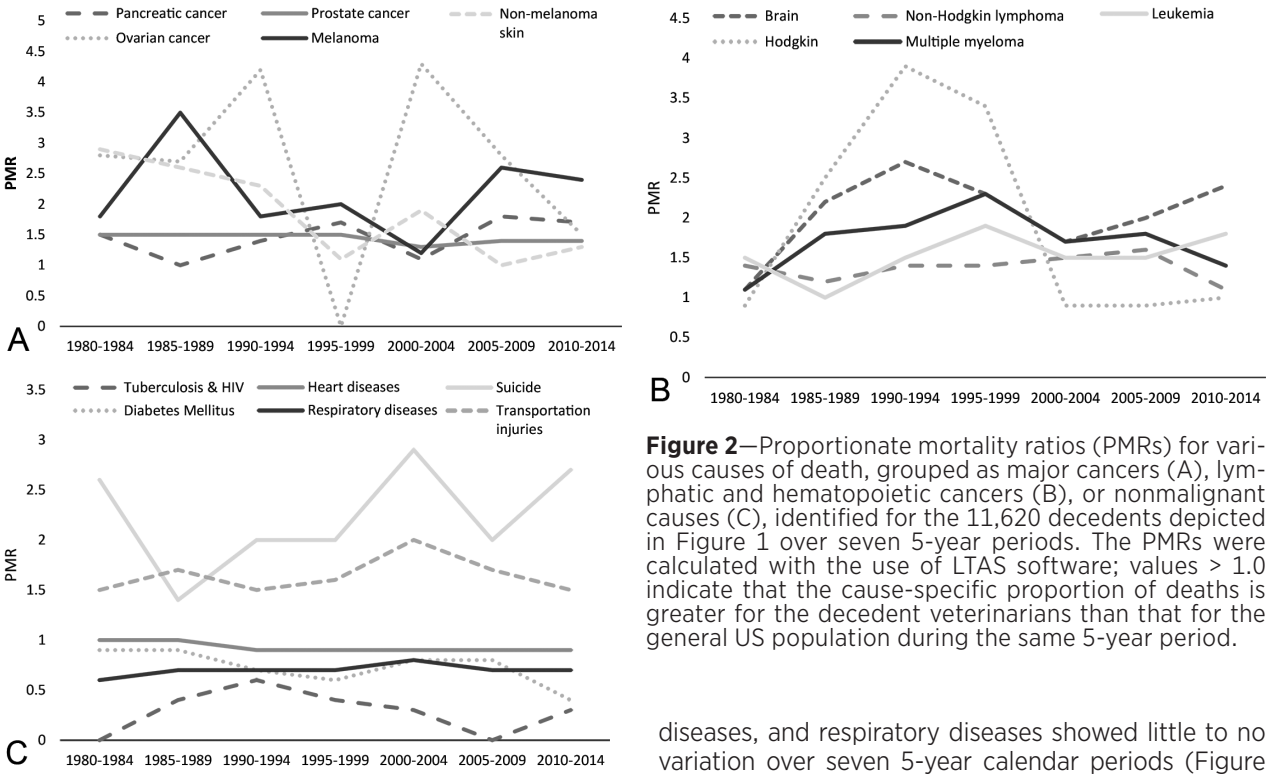

Figure 2—Proportionate mortality ratios (PMRs) for various causes of death, grouped as major cancers (A), lymphatic and hematopoietic cancers (B), or nonmalignant causes (C), identified for the 11,620 decedents depicted in Figure 1 over seven 5-year periods. The PMRs were calculated with the use of LTAS software; values > 1.0 indicate that the cause-specific proportion of deaths is greater for the decedent veterinarians than that for the general US population during the same 5-year period.

at 2.9 and steadily decreased to 1.3 during 2010 through 2014. For Hodgkin lymphoma, proportionate mortality was highest during 1990 through 1994 (3.9) and 1995 through 1999 (3.4) and was otherwise at, or around, 1.

Among the nonmalignant causes of death, the proportionate mortality for diabetes mellitus, heart diseases, and respiratory diseases showed little to no variation over seven 5-year calendar periods (Figure 2). The proportionate mortality for death from transportation injuries was highest during 2005 through 2009 and overall was consistently greater than 1.5. The proportionate mortality for suicide increased over the 7 time periods.

Mortality by species specialization

Among the 5,799 veterinarian decedents for whom species specialization data were available,

Table 4—Proportionate mortality ratios for all causes of death among 5,799 veterinarians described in Table 1 stratified by species specialization during 1979 through 2015.

	Companion animals (n = 3,650)			Food animals (n = 1,229)			Mixed animals (n = 612)			Equine (n = 291)			Other (n = 20)		
Cause of death	No. observed	No. expected	PMR (95% CI)	No. observed	No. expected	PMR (95% CI)	No. observed	No. expected	PMR (95% CI)	No. observed	No. expected	PMR (95% CI)	No. observed	No. expected	PMR (95% CI)
Tuberculosis and HIV-related diseases	12	28.3	0.4* (0.22–0.74)	≤ 5	≤ 5	0.2† (0.03–0.82)	—	—	—	≤ 5	≤ 5	0.3 (0.01–1.88)	—	—	—
All malignant neoplasms	1117	981.5	1.1* (1.1–1.2)	330	311.3	1.0 (0.95–1.18)	171	153.7	1.1 (0.95–1.29)	95	75.4	1.3† (1.02–1.54)	10	5.6	1.8 (0.86–3.30)
Cancer of respiratory system	189	315.8	0.6* (0.52–0.69)	55	104.1	0.5* (0.40–0.69)	33	49.7	0.7† (0.46–0.93)	14	24.2	0.6† (0.32–0.97)	≤ 5	≤ 5	1.9 (0.52–4.85)
Larynx	≤ 5	≤ 5	0.4 (0.12–1.12)	≤ 5	≤ 5	0.6 (0.08–2.33)	≤ 5	≤ 5	1.4 (0.17–5.01)	—	—	—	—	—	—
Lung, bronchus, trachea	181	304.4	0.6* (0.51–0.69)	49	100.3	0.5* (0.36–0.65)	30	47.9	0.6* (0.42–0.89)	14	23.3	0.6 (0.33–1.01)	≤ 5	≤ 5	2.0 (0.54–5.05)
Ovarian	16	7.6	2.1† (1.21–3.43)	≤ 5	≤ 5	3.0 (0.08–17.18)	≤ 5	≤ 5	5.0† (1.02–14.52)	≤ 5	≤ 5	4.7 (0.57–16.93)	—	—	—
Prostate	104	75.3	1.4* (1.13–1.67)	38	29.5	1.3 (0.91–1.77)	20	14.6	1.4 (0.83–2.11)	9	5.6	1.5 (0.69–2.86)	≤ 5	≤ 5	2.6 (0.07–14.39)
Hodgkin lymphoma	≤ 5	≤ 5	1.0 (0.20–2.90)	≤ 5	≤ 5	3.2 (0.66–9.37)	≤ 5	≤ 5	2.2 (0.05–11.98)	—	—	—	≤ 5	≤ 5	34.9 (0.88–194.67)
Non-Hodgkin lymphoma	59	38.7	1.5* (1.16–1.97)	14	12.8	1.1 (0.60–1.84)	7	6.3	1.1 (0.45–2.30)	≤ 5	≤ 5	1.6 (0.53–3.82)	—	—	—
Multiple myeloma	34	17	2.0* (1.38–2.79)	10	5.6	1.8 (0.85–3.27)	7	2.8	2.5† (1.02–5.21)	—	—	—	—	—	—
Leukemia	76	39	2.0* (1.53–2.44)	19	12.8	1.5 (0.89–2.32)	7	6.4	1.1 (0.44–2.27)	6	3.1	1.9 (0.71–4.20)	—	—	—
Cancer of other systems or unspecific sites	219	139.8	1.6* (1.37–1.79)	72	43.3	1.7* (1.30–2.10)	36	21.3	1.7* (1.18–2.34)	21	11	1.9* (1.18–2.91)	≤ 5	≤ 5	3.9 (0.80–2.91)
Nonmelanoma skin	7	6.1	1.2 (0.46–2.36)	≤ 5	≤ 5	1.9 (0.52–4.86)	≤ 5	≤ 5	1.0 (0.02–5.37)	—	—	—	—	—	—
Melanoma	46	20.7	2.2* (1.63–2.97)	13	6.2	2.1† (1.12–3.61)	8	3	2.6† (1.14–5.20)	7	1.7	4.2* (1.67–8.57)	≤ 5	≤ 5	17.4† (2.10–62.66)
Brain	58	27.8	2.1* (1.58–2.70)	19	7.9	2.4* (1.45–3.76)	11	3.9	2.8* (1.41–5.08)	9	2.2	4.0* (1.84–7.63)	≤ 5	≤ 5	5.8 (0.15–32.34)
Diabetes mellitus	58	96.9	0.6* (0.45–0.77)	11	30.1	0.4* (0.18–0.65)	10	15.1	0.7 (0.32–1.22)	≤ 5	≤ 5	0.7 (0.22–1.57)	—	—	—
Heart diseases	896	1007.5	0.9* (0.83–0.95)	352	370.8	1.0 (0.85–1.05)	173	181.2	1.0 (0.82–1.11)	67	80	0.8 (0.65–1.06)	≤ 5	≤ 5	0.8 (0.26–1.85)
All respiratory disorders	206	332.4	0.6* (0.54–0.71)	80	117.8	0.7* (0.54–0.85)	33	60	0.6* (0.38–0.77)	16	25.9	0.6 (0.35–1.00)	—	—	—
All transportation injuries	106	75.6	1.4* (1.15–1.70)	51	22.7	2.2* (1.67–2.95)	31	11.2	2.8* (1.89–3.94)	12	7.9	1.5 (0.79–2.67)	≤ 5	≤ 5	1.4 (0.04–7.78)
Motor vehicle—driver	39	27.7	1.4† (1.00–1.93)	20	9.1	2.2* (1.35–3.40)	14	4.4	3.2* (1.73–5.32)	≤ 5	≤ 5	1.6 (0.52–3.75)	≤ 5	≤ 5	3.0 (0.08–16.94)
Motor vehicle—passenger	≤ 5	≤ 5	0.9 (0.29–2.11)	≤ 5	≤ 5	2.0 (0.41–5.82)	≤ 5	≤ 5	1.3 (0.03–6.98)	—	—	—	—	—	—
Intentional self-harm	226	78.5	2.9* (2.52–3.28)	44	22.5	2.0* (1.42–2.62)	19	11.1	1.7† (1.03–2.67)	9	7.5	1.2 (0.55–2.27)	≤ 5	≤ 5	3.3 (0.40–11.84)

See Table 2 for the key.

PMRs by specialization categories were generally similar to those for the whole study population, although smaller numbers in some categories produced results that were not statistically significant. Deaths among veterinarians in all species specialization categories were higher than expected for melanoma and brain cancer, with deaths among veterinarian decedents who specialized in equine medicine and food animal medicine having the highest PMRs **(Table 4)**. Compared with deaths among the general US population, veterinarians who specialized in companion animal medicine were 1.5 (95% CI, 1.16 to 1.97) times as likely to die from non-Hodgkin lymphoma and 2.0 (95% CI, 1.53 to 2.44) times as likely to die from leukemia. Veterinarian decedents who specialized in companion animal medicine were 2.1 (95% CI, 1.21 to 3.43) times as likely to die from ovarian cancer, compared with the general US population. Results were similar among decedents who specialized in mixed animal medicine, food animal medicine, and equine medicine, although numbers in these groups were small and not all differences were statistically significant. Veterinarian decedents who specialized in companion animal medicine (PMR, 1.4; 95% CI, 1.00 to 1.93), food animal medicine (PMR, 2.2; 95% CI, 1.35 to 3.40), and mixed animal medicine (PMR, 3.2; 95% CI, 1.73 to 5.32) were more likely to die from motor vehicle injuries where the decedent was the driver, compared with the general US population. Among veterinarian decedents who specialized in equine medicine and those categorized as other, PMRs for motor vehicle injuries were above 1, but the differences were not statistically significant. Veterinarian decedents who specialized in companion animal medicine (PMR, 2.9; 95% CI, 2.52 to 3.28), food animal medicine (PMR, 2.0; 95% CI, 1.42 to 2.62), and mixed animal medicine (PMR, 1.7; 95% CI, 1.03 to 2.67) were more likely than the general US population to die from suicide, and the PMR for those categorized as other was also above 1, but the difference was not statistically significant.

Veterinarian decedents specializing in companion animal medicine (PMR, 0.6 [95% CI, 0.52 to 0.69]), food animal medicine (PMR, 0.5; 95% CI, 0.40 to 0.69), mixed animal medicine (PMR, 0.7; 95% CI, 0.46 to 0.93), and equine medicine (PMR, 0.6 ; 95% CI, 0.32 to 0.97] were less likely to die from cancer of the respiratory system, compared with the general US population. Similar results were identified among these 4 species specialization groups with death from diseases of the respiratory systems, compared with the general US population. Veterinarian decedents specializing in companion animal medicine (PMR, 0.6; 95% CI, 0.45 to 0.77) and food animal medicine (PMR, 0.4; 95% CI, 0.18 to 0.65) were less likely to die from diabetes mellitus than the general US population; veterinarian decedents specializing in mixed animal medicine and equine medicine also had PMRs < 1.0, though it was not statistically significant.

Discussion

From 1979 through 2015, both male and female veterinarians had a higher-than-expected proportionate mortality for certain cancers, transportation injuries, and suicide. Our study results are similar to the Blair and Hayes[7] and the Miller and Beaumont[14] veterinary mortality studies, indicating veterinarians remain at higher risk for these causes of death than the general US population. Certain cancers, transportation injuries, and suicide causes of death among veterinarians should be further evaluated and mitigation strategies considered. For example, using industry or occupational coding for the veterinary profession, cancers among veterinarians might be studied using cancer registries, and transportation injuries might be evaluated using workers' compensation data.

We identified a higher-than-expected mortality from cancer for both male and female veterinarian decedents for all malignant cancers. Malignant melanoma was one of the largest cancer contributors for the higher-than-expected mortality among male and female veterinarian decedents. An established risk factor for melanoma is exposure to UV rays from the sun, especially among individuals with light-colored skin.[25,26] Veterinarians who work in food animal medicine, mixed animal medicine, and equine medicine spend a substantial portion of working hours outside exposed to UV rays. The PMR for malignant melanoma was higher than expected for all species specializations; however, veterinarian decedents who specialized in equine medicine and mixed animal medicine had the highest PMRs, highlighting that veterinarians who work in these areas of veterinary medicine are at higher risk for melanoma. Because of the occupational risk for injuries and the physical demands of working with large animals in food animal or equine medicine, many veterinarians who start their veterinary career in these species specializations commonly transition to either mixed animal or companion animal medicine later in their career.[11] Species specialization data for this study came from *JAVMA* obituaries and could underestimate the number of veterinarian decedents in food animal medicine and equine medicine species specialization by only reporting the decedents' final species specialization focus. A late career transition from large animal to companion animal medicine could explain the higher-than-expected proportionate mortality for malignant melanoma among veterinarian decedents who specialized in companion animal medicine. Additionally, companion animal veterinarian decedents who started their veterinary career in either food animal or equine medicine could have had substantial occupational exposure to UV rays earlier in their career, leading to development of malignant melanoma later. Also, studies have identified ionizing radiation as a potential risk factor for malignant melanoma in health-care professionals.[27–29] Because veterinarians are involved with performing patient radiographs, the exposure of ionizing radiation through patient radiographs could help explain the higher-than-expected melanoma PMR for veterinarian decedents who specialized in companion animal medicine.[30] Enforcing occupational safety and health guidelines for sun exposure and radiology safety protocols could reduce the number of veterinarian deaths from malignant melanoma.

Among female veterinarian decedents, mortality from ovarian cancer was one of the largest contributors for an overall higher-than-expected proportionate mortality for malignant cancer and suggests female veterinarians might be at higher risk of death from ovarian cancer. Epidemiological studies on ovarian cancer have struggled to define nongenetic factors to identify women who are at risk of developing ovarian cancer; however, several studies have indicated a relationship with reproductive history.[31] Studies[31–33] have indicated women who have given birth and breastfed have a lower risk of ovarian cancer, compared with women who have never given birth or breastfeed. On average, it takes approximately 4 years of time-intensive postgraduate training to earn a doctorate in veterinary medicine, and for most women, these training years occur during the prime reproductive age.[9,34] However, most US veterinary academic institutions are not perceived to be supportive of female student pregnancies.[35,36] Therefore, most female veterinary students delay childbirth until they have completed their veterinary training and obtained some stability in their career.[34,35] Although more studies are needed to understand how pregnancy and breastfeeding impact a women's risk for ovarian cancer, delaying childbirth among female veterinarians could be a risk factor for ovarian cancer. Implementing family-friendly policies into veterinary education might be a starting point to help reduce this risk.[37]

We found a higher-than-expected proportionate mortality for brain cancer and lymphatic and hematopoietic system cancers among male veterinarian decedents. Blair and Hayes[7,8] reported a similar finding for brain cancer and lymphatic and hematopoietic system cancers in their 1980 and 1982 studies. Although no established risk factors have been defined, brain cancers have been associated with radiation, biological agents, and chemical exposures,[8,38–40] and lymphatic and hematopoietic system cancers have been associated with radiation, pesticides, solvents, and viral exposures.[8,38–40] Regardless of species specialization, most veterinarians work in occupational settings involving exposures to radiation, pesticides, solvents, and viruses. Through our trend analysis, we found the proportionate mortality for Hodgkin lymphoma peaked during 1985 through 1999. The increase in proportionate mortality for this condition during the earlier time periods of this analysis could reflect increased understanding of occupational exposures and development of occupational safety and health guidelines. To our knowledge, our study is the first to examine trends in veterinarian mortality over time. Therefore, the relatively low PMR of 0.9 during 1980 through 1984 could be an aberrant data point that needs further examination, and PMRs of 1 or less from 2000 forward could represent better access to health care by veterinarians combined with improved diagnostic capabilities and advancement

in treatment protocols.[41] Interestingly, female veterinarian decedents did not have a higher-than-expected mortality for brain cancer or lymphatic and hematopoietic system cancers. The median age difference between male and female veterinarian decedents in this study, with female decedents younger at death than male decedents, could explain these findings, particularly for cancers with long latency periods. In the 1980s, the number of female veterinarians started to increase when female veterinary students exceeded the number of male veterinary students.[9] The late increase in the female veterinarian population means female veterinarian decedents were more likely to be younger, reducing the median age. One study[41] indicated that the incidence for Hodgkin lymphoma is higher in males than females. Repeating this analysis in 5 to 10 years could increase the power to detect mortality among female veterinarians for multiple causes, including brain cancer and lymphatic and hematopoietic system cancers. Additional studies are needed to understand associations, if any, between veterinary occupational exposures and these cancers.

Of the nonmalignant causes of death, the highest proportionate mortality for both male and female veterinarian decedents was from suicide. In a previous analysis of suicide mortality using this same data set, we described the increasing trends over time and the risk of suicide among veterinarians as multifactorial, including poor work-life balance, high workloads, rising veterinary care costs, professional isolation, high debt-to-income ratio, and lack of mentoring.[21] Furthermore, the Tomasi et al[21] study identified that veterinarian decedents were more likely to use pharmaceutical poisoning as a suicide method, compared with the general US population. In 2019, a study published by Witte et al[42] also illustrated a higher risk of suicide using pharmaceutical poisoning among veterinarians, compared with the general US population, using standardized mortality ratios. Furthermore, Witte et al[42] found euthanasia solution was the most commonly used product among veterinarians decedents who died from pharmaceutical poisoning. Previous suicide studies[17,19,43–45] indicate that individuals considering suicide select accessible and familiar methods. Veterinarians have access and knowledge of pharmaceutical products, pharmaceutical training to calculate a lethal dose, and training to accept euthanasia as a method to relieve suffering in animals.[46–48] Although it does not address the underlying risk factors for suicidal ideation, adapting administrative controls to limit access to controlled drugs might provide an opportunity for veterinarians to receive mental health support before accessing lethal drugs and reduce the impact of suicides on the veterinary profession.[42,49]

Regarding transportation injuries, veterinarian decedents were more likely to die from motor vehicle injuries where the decedent was the driver. Furthermore, veterinarian decedents who specialized in food animal and mixed animal medicine had the highest proportionate mortality from injuries in motor vehicle accident where the decedent was the driver. Veterinarians, especially those who practice food animal, equine, or mixed animal medicine, spend a substantial portion of their time traveling during the workday.[50] A previous all-cause mortality study[7] of US veterinarians reported a higher-than-expected proportionate mortality for transportation injuries. A study by Poole et al[2] indicated vehicular accidents were an occupational hazard for large animal practitioners. Furthermore, a European study[5] reported both small animal and large animal veterinarians were more likely to be in a vehicular accident while commuting for work, compared with physicians and other health-care providers. Enforcing current vehicle safety protocols might reduce the number of deaths from motor vehicle injuries among veterinarians. Recommendations to consider when developing these protocols include reinforcing standard safety laws enforced by local law enforcement, such as preventing distracted driving (eg, restricting cell phone use) and using seat belts, and practice-specific policies or procedures, such as requiring veterinarians to travel with an assistant as a second driver and discouraging other distracted-driving behaviors like eating or drinking while driving.[51]

The lower-than-expected proportionate mortality for heart disease, diabetes mellitus, and respiratory diseases might be explained by veterinarians' socioeconomic status and educational training. Compared with the general US population and owing to their higher socioeconomic status, veterinarians likely have greater access to health care than the general US population to medically manage these health conditions. Furthermore, veterinarians' medical training provides them with an understanding of these health conditions and familiarity with early warning signs of when to seek medical treatment. Smoking is a risk factor associated with heart disease, diabetes mellitus, and respiratory disease.[52,53] Although we do not know the prevalence among US veterinarians, individuals in higher socioeconomic positions and other health-care professionals are less likely to smoke, compared with the general US population.[54–56] A lower smoking prevalence among veterinarians might also partially explain the lower-than-expected proportionate mortality for heart disease, diabetes mellitus, and respiratory diseases among veterinarian decedents.

This study has several limitations. Although PMRs provide information on cause of death among a population with an unknown denominator, PMRs do not allow for comparison with other studies or populations.[21] Standardized mortality ratio is a stronger statistical indicator that allows for comparisons among populations but requires a population denominator.[24] Additionally, cause-specific PMRs are mutually dependent. A higher cause-specific PMR for one cause would result in a lower cause-specific PMR for another cause.[21,24,57] However, the cause-specific PMRs in our study followed a similar pattern as the Blair and Hayes[7] and Witte et al[19] studies, thus supporting our study findings. We analyzed the underlying cause of death listed on the death certificate; therefore, our results do not consider the contributing factors for

each veterinarian decedent's cause of death. By not including the contributing factors in our analysis, our PMRs might have underestimated the true burden of some disease processes. Although we were able to include more females than previous studies, repeating this analysis in 5 to 10 years would, because of the inherent lag time of mortality studies, allow more representation among female veterinarian decedents. Finally, we were unable to link any cause of death to occupational exposure. Although we cannot directly compare our results to the Blair and Hayes studies,[7,8] the consistency of results among these studies indicates veterinarians are at greater risk for the causes of death discussed. Further studies should be considered to determine whether occupational exposures are related to these results.

The findings from the present study provide useful information for the AVMA, state veterinary medical associations, veterinary schools, and employers when reviewing or developing veterinary professional worker safety and health guidelines and plans. The findings also highlight the need for improvement in veterinarian suicide prevention and family-friendly polices to support veterinarians' mental and physical health. Further studies are needed to explore associations between occupational exposure and higher mortality among veterinarians.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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References

1. Fowler HN, Holzbauer SM, Smith KE, Scheftel JM. Survey of occupational hazards in Minnesota veterinary practices in 2012. *J Am Vet Med Assoc*. 2016;248(2):207–218. doi:10.2460/javma.248.2.207
2. Poole AG, Shane SM, Kearney MT, McConnell DA. Survey of occupational hazards in large animal practices. *J Am Vet Med Assoc*. 1999;215(10):1433–1435.
3. Poole AG, Shane SM, Kearney MT, Rehn W. Survey of occupational hazards in companion animal practices. *J Am Vet Med Assoc*. 1998;212(9):1386–1388.
4. Gibbins JD, MacMahon K. Workplace safety and health for the veterinary health care team. *Vet Clin North Am Small Anim Pract*. 2015;45(2):409–426, vii–viii. doi:10.1016/j.cvsm.2014.11.006
5. Nienhaus A, Skudlik C, Seidler A. Work-related accidents and occupational diseases in veterinarians and their staff. *Int Arch Occup Environ Health*. 2005;78(3):230–238. doi:10.1007/s00420-004-0583-5
6. Landercasper J, Cogbill TH, Strutt PJ, Landercasper BO. Trauma and the veterinarian. *J Trauma*. 1988;28(8):1255–1259. doi:10.1097/00005373-198808000-00020
7. Blair A, Hayes HM. Cancer and other causes of death among US veterinarians, 1966–1977. *Int J Cancer*. 1980;25(2):181–185.
8. Blair A, Hayes HM Jr. Mortality patterns among US veterinarians, 1947–1977: an expanded study. *Int J Epidemiol*. 1982;11(4):391–397.
9. Annual Data Report 2016–2017. Association of American Veterinary Medical Colleges. Last modified January 2017. Accessed March 24, 2021. https://www.aavmc.org/data/files/data/2017%20aavmc%20public%20data-%20final.pdf
10. Market research statistics—US veterinarians, 2019. AVMA. Last modified March 2020. Accessed March 24, 2021. https://www.avma.org/resources-tools/reports-statistics/market-research-statistics-us-veterinarians-2019#categories
11. Hoblet KN, Maccabe AT, Heider LE. Veterinarians in population health and public practice: meeting critical national needs. *J Vet Med Educ*. 2003;30(3):287–294. doi:10.3138/jvme.30.3.287
12. Maccabe AT, Matchett KE, Hueston WD. The need for public-health veterinarians as seen by future employers. *J Vet Med Educ*. 2008;35(2):269–274. doi:10.3138/jvme.35.2.269
13. Botts RP, Edlavitch S, Payne G. Mortality of Missouri veterinarians. *J Am Vet Med Assoc*. 1966;149(5):499–504.
14. Miller JM, Beaumont JJ. Suicide, cancer, and other causes of death among California veterinarians, 1960–1992. *Am J Ind Med*. 1995;27(1):37–49.
15. Faragher T. Suicide in Australian veterinarians. *Aust Vet J*. 2008;86(7):249. doi:10.1111/j.1751-0813.2008.00323.x
16. Bartram D. Suicide by veterinary surgeons. *Vet Rec*. 2008;162(4):132. doi:10.1136/vr.162.4.132-a
17. Jones-Fairnie H, Ferroni P, Silburn S, Lawrence D. Suicide in Australian veterinarians. *Aust Vet J*. 2008;86(4):114–116. doi:10.1111/j.1751-0813.2008.00277.x
18. Hem E, Haldorsen T, Aasland OG, Tyssen R, Vaglum P, Ekeberg O. Suicide rates according to education with a particular focus on physicians in Norway 1960–2000. *Psychol Med*. 2005;35(6):873–880. doi:10.1017/s0033291704003344
19. Mellanby RJ. Incidence of suicide in the veterinary profession in England and Wales. *Vet Rec*. 2005;157(14):415–417.
20. National Death Index user's guide. CDC National Center for Health Statistics. Last modified March 2013. Accessed March 24, 2021. https://www.cdc.gov/nchs/data/ndi/ndi_users_guide.pdf
21. Tomasi SE, Fechter-Leggett ED, Edwards NT, Reddish AD, Crosby AE, Nett RJ. Suicide among veterinarians in the United States from 1979 through 2015. *J Am Vet Med Assoc*. 2019;254(1):104–112. doi:10.2460/javma.254.1.104
22. Life Table Analysis System. National Institute for Occupational Safety and Health. Last modified 2014. Accessed March 26, 2021. https://www.cdc.gov/niosh/ltas/pdf/LTAS-manual-2014.pdf
23. Robinson CF, Schnorr TM, Cassinelli RT, et al. Tenth revision US mortality rates for use with the NIOSH Life Table Analysis System. *J Occup Environ Med*. 2006;48(7):662–667. doi:10.1097/01.jom.0000229968.74906.8f
24. Roman E, Beral V, Inskip H, McDowall M, Adelstein A. A comparison of standardized and proportional mortality ratios. *Stat Med*. 1984;3(1):7–14.
25. Rastrelli M, Tropea S, Rossi CR, Alaibac M. Melanoma: epidemiology, risk factors, pathogenesis, diagnosis and classification. *In Vivo*. 2014;28(6):1005–1011.
26. Gandini S, Sera F, Cattaruzza MS, et al. Meta-analysis of risk factors for cutaneous melanoma: II. Sun exposure. *Eur J Cancer*. 2005;41(1):45–60.
27. Vågerö D, Swerdlow AJ, Beral V. Occupation and malignant melanoma: a study based on cancer registration data in England and Wales and in Sweden. *Br J Ind Med*. 1990;47(5):317–324. doi:10.1136/oem.47.5.317
28. Rix BA, Lynge E. Cancer incidence in Danish health care workers. *Scand J Soc Med*. 1996;24(2):114–120. doi:10.1177/140349489602400205
29. Eklund G, Izikowitz L, Molin C. Malignant tumours in Swedish dental personnel: a comparative study with the total population as well as with some specific occupational groups. *Swed Dent J*. 1990;14(6):249–254.
30. Fritschi L. Cancer in veterinarians. *Occup Environ Med*. 2000;57(5):289. doi:10.1136/oem.57.5.289

31. Webb PM, Jordan SJ. Epidemiology of epithelial ovarian cancer. *Best Pract Res Clin Obstet Gynaecol*. 2017;41:3–14. doi:10.1016/j.bpobgyn.2016.08.006
32. Wentzensen N, Poole EM, Trabert B, et al. Ovarian cancer risk factors by histologic subtype: an analysis from the ovarian cancer cohort consortium. *J Clin Oncol*. 2016;34(24):2888–2898. doi:10.1200/JCO.2016.66.8178
33. Luan NN, Wu QJ, Gong TT, Vogtmann E, Wang YL, Lin B. Breastfeeding and ovarian cancer risk: a meta-analysis of epidemiologic studies. *Am J Clin Nutr*. 2013;98(4):1020–1031. doi:10.3945/ajcn.113.062794
34. Balasch J, Gratacós E. Delayed childbearing: effects on fertility and the outcome of pregnancy. *Curr Opin Obstet Gynecol*. 2012;24(3):187–193. doi:10.1097/GCO.0b013e3283517908
35. Rosenbaum MH, Wayne AS, Molter BL, Mueller MK. Perceptions of support and policies regarding pregnancy, parenting, and family planning during veterinary training at United States veterinary medical training institutions. *J Am Vet Med Assoc*. 2018;253(10):1281–1288. doi:10.2460/javma.253.10.1281
36. Molter B, Wayne A, Mueller MK, Gibeley M, Rosenbaum MH. Current policies and support services for pregnant and parenting veterinary medical students and house officers at United States veterinary medical training institutions. *J Vet Med Educ*. 2019;46(2):145–152. doi:10.3138/jvme.0917-119r
37. Wayne AS, Mueller MK, Rosenbaum M. Perceptions of maternal discrimination and pregnancy/postpartum experiences among veterinary mothers. *Front Vet Sci*. 2020;7:91. doi:10.3389/fvets.2020.00091
38. Zeeb H, Blettner M. Adult leukaemia: what is the role of currently known risk factors? *Radiat Environ Biophys*. 1998;36(4):217–228. doi:10.1007/s004110050075
39. Dich J, Zahm SH, Hanberg A, Adami HO. Pesticides and cancer. *Cancer Causes Control*. 1997;8(3):420–443. doi:10.1023/a:1018413522959
40. Blair A, Zahm SH. Agricultural exposures and cancer. *Environ Health Perspect*. 1995;103(suppl 8):205–208. doi:10.1289/ehp.95103s8205
41. Shenoy P, Maggioncalda A, Malik N, Flowers CR. Incidence patterns and outcomes for Hodgkin lymphoma patients in the United States. *Adv Hematol*. 2011;2011:725219. doi:10.1155/2011/725219
42. Witte TK, Spitzer EG, Edwards N, Fowler KA, Nett RJ. Suicides and deaths of undetermined intent among veterinary professionals from 2003 through 2014. *J Am Vet Med Assoc*. 2019;255(5):595–608. doi:10.2460/javma.255.5.595
43. Hawton K, Clements A, Simkin S, Malmberg A. Doctors who kill themselves: a study of the methods used for suicide. *QJM*. 2000;93(6):351–357. doi:10.1093/qjmed/93.6.351
44. Skegg K, Firth H, Gray A, Cox B. Suicide by occupation: does access to means increase the risk? *Aust N Z J Psychiatry*. 2010;44(5):429–434. doi:10.3109/00048670903487191
45. Roberts SE, Jaremin B, Lloyd K. High-risk occupations for suicide. *Psychol Med*. 2013;43(6):1231–1240. doi:10.1017/S0033291712002024
46. Bartram DJ, Baldwin DS. Veterinary surgeons and suicide: a structured review of possible influences on increased risk. *Vet Rec*. 2010;166(13):388–397. doi:10.1136/vr.b4794
47. Scotney RL, McLaughlin D, Keates HL. A systematic review of the effects of euthanasia and occupational stress in personnel working with animals in animal shelters, veterinary clinics, and biomedical research facilities. *J Am Vet Med Assoc*. 2015;247(10):1121–1130. doi:10.2460/javma.247.10.1121
48. Volk JO, Schimmack U, Strand EB, Vasconcelos J, Siren CW. Executive summary of the Merck Animal Health Veterinarian Wellbeing Study II. *J Am Vet Med Assoc*. 2020;256:1237–1244. doi:10.2460/javma.256.11.1237
49. Nett RJ, Witte TK, Tomasi SE, Fowle KA. Storage of euthanasia solution as a factor in addressing veterinarian suicides. *J Am Vet Med Assoc*. 2020;256(12):1321–1322. doi:10.2460/javma.256.12.1321
50. Gabel CL, Gerberich SG. Risk factors for injury among veterinarians. *Epidemiology*. 2002;13(1):80–86. doi:10.1097/00001648-200201000-00013
51. Preventing work-related motor vehicle crashes. National Institute for Occupational Safety and Health. Last modified March 2015. Accessed March 26, 2021. https://www.cdc.gov/niosh/docs/2015-111/pdfs/2015-111.pdf?id=10.26616/NIOSHPUB201511
52. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. *J Am Coll Cardiol*. 2004;43(10):1731–1737. doi:10.1016/j.jacc.2003.12.047
53. Sattar N, Sorensen T, Taylor AE, Morris R, Munafo MR. Smoking and diabetes risk: building a causal case with clinical implications. *Lancet Diabetes Endocrinol*. 2015;3(12):918–920. doi:10.1016/S2213-8587(15)00341-1
54. Frank E, Brogan DJ, Mokdad AH, Simoes EJ, Kahn HS, Greensberg RS. Health-related behaviors of women physicians vs other women in the United States. *Arch Intern Med*. 1998;158(4):342–348. doi:10.1001/archinte.158.4.342
55. Winkleby MA, Jatulis DE, Frank E, Fortman SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health*. 1992;82(6):816–820. doi:10.2105/ajph.82.6.816
56. Wagenknecht LE, Perkins LL, Cutter GR, et al. Cigarette smoking behavior is strongly related to educational status: the CARDIA study. *Prev Med*. 1990;19(2):158–169. doi:10.1016/0091-7435(90)90017-e
57. Breslow NE, Day NE. Statistical methods in cancer research. IARC Workshop 25–27 May 1983. *IARC Sci Publ*. 1987;(82):1–406.