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Cancer and Other Causes of Death Among Male and Female Farmers From Twenty-Three States

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Occupation and industry codes on death certificates from 23 states for 1984–1988 were used to evaluate mortality risks among white and nonwhite, male and female farmers. Proportionate mortality and proportionate cancer mortality ratios were calculated using deaths among nonfarmers from the same states to generate expected numbers. Among farmers there were 119,648 deaths among white men, 2,400 among white women, 11,446 among nonwhite men, and 2,066 among nonwhite women. Deficits occurred in all race–sex groups for infective and parasitic diseases, all cancer combined, lung cancer, liver cancer, diseases of the nervous system, multiple sclerosis, hypertension, and emphysema. As reported in other studies, white male farmers had excesses of cancer of the lymphatic and hematopoietic system, lip, eye, brain, and prostate. Excesses of cancers of the pancreas, kidney, bone, and thyroid were new findings. Regional patterns were evident, particularly among white men. Significant excesses for accidents, vascular lesions of the central nervous system (CNS), and cancers of the prostate tended to occur in most geographic regions, while excesses for mechanical suffocation, non-Hodgkin's lymphoma, and cancers of the lip, brain, and the lymphatic and hematopoietic system were limited to the Central states. Increases among nonwhite men were similar to those in white men for some causes of death (vascular lesions of the CNS and cancers of the pancreas and prostate), but were absent for others (lymphatic and hematopoietic system, lip, eye, kidney, and brain). Women (white and nonwhite) had excesses for vascular lesions of the CNS, disease of the genitourinary system (white women only), and cancers of the stomach and cervix (nonwhite women only). Cancer of the buccal cavity and pharynx was slightly elevated among women, and white women had nonsignificant excesses of multiple myeloma and leukemia. Excesses for leukemia and non-Hodgkin's lymphoma occurred among white men and women, but not among nonwhites. Excesses for several types of accidental deaths were seen among all race–sex groups. © 1993 Wiley-Liss, Inc.

Key words: leukemia, lymphoma, brain cancer, prostate cancer, agriculture, accidents, nonwhite mortality, female mortality

INTRODUCTION

Surveys of farmers from the United States and other countries have noted excesses for several cancers, including leukemia, lymphoma, multiple myeloma, lip,

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TABLE I. States and Number of Decedent Farmers by Geographic Regions Included in This Study

Region/state	White men	White women	Nonwhite men	Nonwhite women
Northeast	2,929	165	41	5
Maine	1,316	51	3	0
New Hampshire	493	43	1	0
New Jersey	265	24	28	4
Rhode Island	155	14	9	0
Vermont	700	33	0	1
South	42,975	595	9,800	1,924
Georgia	8,089	83	2,597	311
Kentucky	14,082	183	508	14
North Carolina	5,095	93	1,899	371
South Carolina	3,880	119	3,096	950
Tennessee	11,432	108	1,694	278
West Virginia	397	9	6	0
Central	64,776	1,372	1,234	122
Indiana	6,012	134	81	9
Kansas	11,060	144	59	7
Missouri	10,111	137	257	56
Nebraska	4,346	26	19	1
Ohio	8,796	214	133	29
Oklahoma	9,443	279	606	14
Wisconsin	14,808	418	79	6
West	8,968	268	371	15
Colorado	4,859	152	61	5
Idaho	727	12	12	0
Nevada	526	27	60	2
New Mexico	1,189	53	188	7
Utah	1,667	24	50	1
Total	119,648	2,400	11,446	2,066

stomach, brain, soft tissue sarcoma, melanoma of the skin, and prostate [Blair et al., 1985; Pearce and Reif, 1990; Blair and Zahm, 1991]. These cancer excesses occur despite a low mortality among farmers for many other cancers and nonmalignant diseases. The availability of coded industry and job titles on death certificates from 23 states provided the opportunity to evaluate the mortality risks among farmers from different geographic regions of the United States and to compare patterns among men and women and among whites and nonwhites.

METHODS

Since 1984, the National Cancer Institute, the National Institute for Occupational Safety and Health, and the National Center for Health Statistics have supported the coding of occupation and industry titles [U.S. Department of Commerce, 1982] on death certificates from a number of states. This resource was developed as a tool for national surveillance of occupational disease. Mortality records from 23 states, covering the years 1984–1988, were used to evaluate mortality risks among farmers

by geographic region (Table I). Not all states began participating in the program in 1984.

Proportionate mortality ratios (PMR) were calculated for white men (WM), white women (WW), nonwhite men (NM), and nonwhite women (NW), separately. Proportionate cancer mortality ratios (PCMR) were also obtained for each type of cancer. Farmers were defined as decedents whose usual occupation on the death certificate was farmer (Occupation Code 473), and whose industry was agricultural crop products (Industry Code 010), or livestock (Industry Code 011). Expected numbers for the race/sex-specific groups were based on the proportionate mortality experience of decedents with neither an occupational code of farmer, nor an industry code of agricultural products. For the geographic or single state analyses, expected numbers were derived from only the geographic region or state being considered. All PMRs or PCMRs were adjusted for age at death by 5-year categories. Confidence intervals (95% CI) were calculated according to Liddell [1984].

The sign test was used to evaluate the distribution of PMRs or PCMRs from the states that were above and below 1.00 [Armitage, 1973].

RESULTS

Among farmers from the 23 states, there were 119,648 deaths among white men, 2,400 among white women, 11,446 among nonwhite men, and 2,066 among nonwhite women (Table I). For all race–sex groups, farmers experienced a mortality deficit for infective and parasitic disease, all cancer combined and cancers of the liver and lung, diseases of the nervous system, multiple sclerosis, hypertension, and emphysema (Table II). Significant excesses occurred for cancers of the stomach (NW), pancreas (WM), lip (WM), cervix (NW), prostate (WM,NM), kidney (WM), brain (WM), non-Hodgkin's lymphoma (WM), multiple myeloma (WM), leukemia (WM), lymphatic and hematopoietic system (WM), and for arteriosclerotic heart disease (WM), vascular lesions of the central nervous system (WM,NM,NW), asthma (WM,NM), diseases of the genitourinary system (WW), accidents (WM,WW,NM), motor vehicle accidents (WM,WW,NM), motor vehicle nontraffic accidents (WM), poisoning by pesticides (WW), fires (WM,NM), natural and environmental fatalities (WM,NW), mechanical suffocation (WM), machinery accidents (WM,WW,NM), agricultural machinery accidents (WM,WW,NM), cutting or piercing instrument accidents (WM), electrical current accidents (WM), and suicide (WM). PMRs or PCMRs were greater than 1.00 among all race–sex groups for cancers of the stomach, uterus and prostate, diseases of the genitourinary system, all accidents, motor vehicle accidents, fires, and natural and environmental fatalities.

The excess deaths, i.e., deaths among farmers in excess of those predicted based on the mortality among the nonfarm population, provide an indication of the potential benefits from preventive action. For example, the excess deaths among white men from diseases showing statistically significant excesses are 1,252 for cancer (pancreas 130, lip 12, prostate 574, kidney 50, brain 58, non-Hodgkin's lymphoma 146, multiple myeloma 54, and leukemia 228), 1,287 for vascular lesions of the CNS, 48 for asthma, and 892 for accidents (nontraffic motor vehicle 45, fires, 69, mechanical suffocation 19, machinery accidents 393, and electricity 28).

Mortality risks for selected diseases are shown by geographic region in Table III. Small numbers for specific causes of death among many race–sex groups made

TABLE II. Proportionate Mortality Among Farmers by Race and Sex (PMRs for Non-Neoplastic Diseases and PCMRs for Specific Cancers) *(continued)*

Cause	White men	White women	Nonwhite men	Nonwhite women
Brain	1.15 (447)	1.09 (9)	0.97 (16)	0.38 (1)
	1.05–1.26	0.50–2.07	0.56–1.58	0.00–2.13
Thyroid	1.34 (39)	0.78 (1)	0.55 (1)	1.14 (1)
	0.95–1.83	0.01–4.35	0.01–3.04	0.01–6.36
Non-Hodgkin's lymphoma	1.21 (843)	1.07 (18)	0.71 (24)	1.05 (6)
	1.13–1.30	0.64–1.70	0.46–1.06	0.38–2.28
Hodgkin's disease	1.00 (56)	— (0)	0.73 (2)	— (0)
	0.75–1.29	0.00–3.35	0.08–2.63	0.00–7.18
Multiple myeloma	1.15 (413)	1.78 (14)	0.92 (51)	1.10 (11)
	1.04–1.27	0.97–2.99	0.69–1.22	0.55–1.97
Leukemia	1.27 (1072)	1.45 (24)	0.90 (55)	0.94 (8)
	1.20–1.35	0.93–2.16	0.73–1.27	0.40–1.85
All lymphatic and hematopoietic tissue	1.22 (2380)	1.33 (56)	0.89 (132)	1.01 (25)
	1.18–1.27	1.00–1.72	0.75–1.06	0.65–1.49
Diseases of blood and blood-forming organs	1.07* (383)	0.81 (7)	1.09 (38)	0.53 (4)
	0.97–1.18	0.33–1.67	0.77–1.49	0.14–1.37
Diseases of nervous system	0.85 (1731)	0.91 (39)	0.91 (110)	0.51 (11)
	0.81–10 89	0.65–1.24	0.75–1.10	0.25–0.90
Parkinson's disease	0.86 (470)	0.97 (7)	1.01 (18)	— (0)
	0.78–0.94	0.39–2.00	0.60–1.59	0.00–2.12
Motor neuron disease	0.91 (148)	1.63 (5)	0.44 (3)	— (0)
	0.77–1.07	0.53–3.81	0.09–1.28	0.00–3.22
	0.49 (20)	— (0)	0.51 (1)	— (0)
	0.30–0.75	0.00–2.88	0.01–2.83	0.00–5.98
Epilepsy	1.17 (40)	— (0)	1.35 (18)	1.33 (2)
	0.84–1.60	0.00–4.09	0.80–2.14	0.15–4.78
Rheumatic heart disease	1.13 (214)	1.72 (16)	1.34 (13)	0.28 (1)
	0.98–1.29	0.98–2.80	0.71–2.29	0.00–1.58
Hypertension	0.92 (1162)	0.63 (25)	0.90 (303)	0.91 (80)
	0.87–0.98	0.41–0.93	0.80–1.01	0.72–1.13
Arteriosclerotic heart disease	1.02 (39032)	0.96 (718)	1.03 (2850)	0.96 (533)
	1.01–1.03	0.89–1.04	0.99–1.06	0.88–1.04
Vascular lesions of central nervous system	1.15 (9874)	0.91 (237)	1.38 (1275)	1.38 (338)
	1.13–1.17	0.79–1.03	1.30–1.46	1.23–1.53
Respiratory disease	0.96 (13359)	0.92 (187)	1.02 (950)	0.90 (96)
	0.95–0.98	0.79–1.06	0.95–1.08	0.73–1.09
Emphysema	0.86 (1053)	0.77 (8)	0.68 (39)	0.87 (2)
	0.81–0.92	0.33–1.52	0.48–0.93	0.10–3.16
Asthma	1.39 (171)	0.69 (3)	1.66 (36)	0.83 (4)
	1.19–1.61	0.14–2.01	1.16–2.29	0.22–2.11
Diseases of digestive system	0.86 (3146)	1.04 (87)	0.95 (330)	0.79 (53)
	0.83–0.89	0.83–1.28	0.85–1.06	0.59–1.04
Cirrhosis of liver	0.61 (560)	1.17 (15)	0.66 (59)	0.57 (7)
	0.56–0.66	0.65–1.93	0.50–0.85	0.21–1.17
Diseases of genito-urinary system	1.01 (2628)	1.45 (78)	1.05 (403)	1.17 (91)
	0.97–1.05	1.15–1.82	0.95–1.16	0.94–1.43
Chronic nephritis	0.80 (71)	2.04 (3)	0.82 (14)	0.29 (1)
	0.63–1.02	0.41–5.97	0.45–1.38	0.00–1.62
Λ⓪ accidents	1.29 (3972)	1.50 (79)	1.34 (493)	1.25 (49)
	1.25–1.33	1.19–1.87	1.23–1.47	0.92–1.65
Motor vehicle accidents	1.22 (1370)	1.87 (33)	1.38 (174)	1.09 (10)
	1.16–1.29	1.28–2.62	1.18–1.60	0.52–2.01

continued

TABLE II. Proportionate Mortality Among Farmers by Race and Sex (PMRs for Non-Neoplastic Diseases and PCMRs for Specific Cancers) *(continued)*

Cause	White men	White women	Nonwhite men	Nonwhite women
Motor vehicle nontraffic accidents	2.69 (72) 2.10–3.38	(0) 0.00–14.43	0.51 (1) 0.01–2.84	(0) 0.00–28.28
Poisoning other than drugs	0.85 (10) 0.41–1.56	10.30 (1) 0.13–57.30	1.35 (6) 0.49–2.94	(0) 0.00–15.88
Poisoning by pesticides	1.02 (1) 0.01–5.65	185.68 (1) 2.43–1033.09	(0) 0.00–43.47	(0) 0 expected
Falls	0.89 (737) 0.82–0.95	1.10 (20) 0.67–1.70	0.79 (40) 0.57–1.08	0.99 (8) 0.43–1.95
Fires	1.50 (208) 1.30–1.72	2.70 (6) 0.99–5.88	1.78 (82) 1.42–2.21	1.47 (8) 0.63–2.90
Natural and environmental fatalities	1.78 (127) 1.49–2.12	1.92 (2) 0.22–6.95	1.17 (33) 0.81–1.65	2.46 (8) 1.06–4.85
Mechanical suffocation	2.50 (32) 1.71–3.53	(0) 0.00–27.59	—(0) 0.00–3.21	(0) 0.00–35.33
Machinery accidents	9.53 (440) 8.66–10.46	51.07 (3) 10.26–149.21	7.10 (20) 4.33–10.96	—(0) 0.00–179.03
Agricultural machinery accidents	14.73 (411) 13.34–16.22	98.13 (3) 19.72–286.73	21.39 (19) 12.87–33.41	—(0) 0.00–246.95
Cutting or piercing instrument accidents	2.78 (11) 1.38–4.97	—(0) 0.00–166.77	1.86 (1) 0.02–10.35	(0) 0.00–51.04
Electrical current accidents	2.43 (47) 1.78–3.23	23.22 (1) 0.30–129.17	2.53 (3) 0.51–7.38	(0) 0.00–351.50
Suicide	1.14 (1365) 1.08–1.20	0.77 (7) 0.31–1.59	0.53 (26) 0.34–0.77	0.88 (2) 0.10–3.19

[a]PMR
[b]Number of deaths
[c]95% confidence interval
[d]PCMRs for cancers.

it difficult to evaluate regional patterns. A focus on statistically significant excesses, however, reveals geographic patterns. All accidents, machinery accidents, vascular lesions of the CNS, leukemia, and cancers of the prostate and lymphatic and hematopoietic systems tended to be excessive in most regions, particularly among WM. Mechanical suffocation, non Hodgkin's lymphoma, multiple myeloma, and cancers of the lip and brain were significantly elevated in only the Central region. The South had a significant deficit of colon cancer and significant excesses for cancer of the stomach, cervix, and eye. Excesses for asthma and cancer of the pancreas occurred in the South and Central regions and Hodgkin's disease and rheumatic heart disease occurred in the West.

Counts of race, sex, and age-adjusted PMRs and PCMRs greater than 1.00 from individual states (with at least two deaths) are shown for selected causes of death in Table IV. The sign test showed a significant preponderance of deficits for cirrhosis of the liver and cancers of the esophagus, larynx, lung, and bladder. Significant excesses occurred for all accidents, and cancers of the bone, lip, prostate, thyroid, non-Hodgkin's lymphoma, multiple myeloma, and leukemia. Table IV also reiterates regional tendencies for some excesses, such as excesses of brain, non-Hodgkin's lymphoma, multiple myeloma, and leukemia in the Central United States and accidents and prostate cancer in all regions.

TABLE III. Mortality [PMR and Number of Deaths (PCMR for Cancers)] for Selected Causes of Death Among Farmers by Race and Sex by Geographic Region

Cause		Northeast	South	Central	West
Stomach	WM	0.87 (16)	0.99 (192)	1.10 (385)	1.17 (64)
	WW	0.82 (1)	— (0)	1.46 (9)	1.90 (2)
	NM	— (0)	1.06 (100)	0.98 (10)	1.51 (5)
	NW	— (0)	1.90* (23)	— (0)	— (0)
Cardia only	WM	— (0)	0.10* (1)	0.91 (18)	1.84 (4)
	WW	— (0)	— (0)	— (0)	— (0)
	NW	— (0)	1.10 (1)	5.86 (1)	— (0)
	NM	— (0)	— (0)	— (0)	— (0)
Colon	WM	0.89 (60)	0.91* (684)	1.01 (1384)	1.03 (163)
	WW	1.69 (9)	1.08 (131)	0.93 (34)	0.89 (5)
	NM	— (0)	0.81* (124)	0.91 (21)	0.81 (3)
	NW	— (0)	0.97 (37)	1.26 (3)	— (0)
Pancreas	WM	0.74 (19)	1.12* (396)	1.16* (623)	1.23 (95)
	WW	— (0)	1.26 (6)	0.90 (13)	1.52 (4)
	NM	4.01 (1)	1.21 (106)	1.24 (14)	1.14 (4)
	NW	— (0)	0.78 (16)	— (0)	— (0)
Bone	WM	— (0)	1.36 (21)	1.34 (24)	1.63 (4)
	WW	— (0)	— (0)	— (0)	10.51 (1)
	NM	— (0)	0.69 (3)	3.36 (1)	— (0)
	NW	— (0)	— (0)	— (0)	— (0)
Skin	WM	0.90 (8)	1.08 (178)	1.04 (202)	1.12 (37)
	WW	— (0)	1.32 (2)	0.60 (2)	2.20 (2)
	NM	— (0)	1.13 (12)	0.63 (1)	— (0)
	NW	— (0)	1.79 (3)	— (0)	— (0)
Melanoma only	WM	1.03 (6)	0.83 (86)	1.03 (131)	0.97 (21)
	WW	— (0)	0.94 (1)	0.85 (2)	2.75 (2)
	NM	— (0)	1.79 (5)	— (0)	— (0)
	NW	— (0)	1.10 (1)	— (0)	— (0)
Lip	WM	— (0)	1.31 (5)	3.00* (16)	— (0)
	WW	— (0)	— (0)	27.32 (1)	— (0)
	NM	— (0)	— (0)	— (0)	— (0)
	NW	— (0)	— (0)	— (0)	— (0)
Breast	WM	— (0)	0.84 (8)	0.74 (9)	0.59 (1)
	WW	1.43 (8)	0.94 (13)	0.93 (40)	1.18 (10)
	NM	— (0)	1.40 (3)	3.74 (1)	— (0)
	NW	— (0)	0.70 (30)	— (0)	— (0)
Cervix	WW	4.69 (2)	0.59 (1)	0.80 (3)	— (0)
	NW	— (0)	1.86* (21)	— (0)	— (0)
Prostate	WM	1.29* (107)	1.09* (1147)	1.23* (2189)	1.23* (322)
	NM	1.47 (3)	1.13* (500)	0.88 (51)	0.74 (10)
Testis	WM	1.25 (1)	1.05 (14)	0.74 (17)	— (0)
	NM	— (0)	0.89 (4)	5.56 (2)	— (0)
Eye	WM	6.23 (1)	2.35* (8)	1.05 (8)	— (0)
	WW	— (0)	— (0)	— (0)	— (0)
	NM	— (0)	— (0)	— (0)	— (0)
	NW	— (0)	— (0)	— (0)	— (0)
Brain	WM	0.72 (6)	1.05 (154)	1.26* (258)	0.97 (29)
	WW	2.01 (1)	0.51 (1)	1.47 (7)	— (0)
	NM	— (0)	1.02 (14)	0.66 (1)	1.91 (1)
	NW	— (0)	0.39 (1)	— (0)	— (0)
Thyroid	WM	— (0)	1.42 (14)	1.43 (23)	1.02 (2)
	WW	— (0)	4.52 (1)	— (0)	— (0)
	NM	— (0)	1.38 (1)	— (0)	— (0)
	NW	— (0)	1.13 (1)	— (0)	— (0)

continued

TABLE III. Mortality (PMR and Numbewr of Deaths (PCMR for Cancers)) for Selected Causes of Death Among Farmers by Race and Sex by Geographic Region *(continued)*

Cause		Northeast	South	Central	West
Soft-tissue	WM	0.57 (1)	0.80 (30)	0.96 (33)	1.38 (12)
	WW	— (0)	1.80 (1)	1.37 (2)	— (0)
	NM	— (0)	2.08 (10)	— (0)	— (0)
	NW	(0)	(0)	(0)	(0)
NHL	WM	1.08 (17)	1.05 (255)	1.32* (307)	1.20 (64)
	WW	0.78 (1)	1.18 (4)	1.16 (12)	0.53 (1)
	NM	8.83 (1)	0.69 (21)	0.68 (2)	— (0)
	NW	— (0)	0.98 (5)	2.92 (1)	— (0)
Hodgkin's disease	WM	1.57 (2)	1.04 (18)	0.78 (26)	2.42* (10)
	WW	— (0)	— (0)	— (0)	(0)
	NM	— (0)	0.81 (2)	— (0)	— (0)
	NW	— (0)	(0)	— (0)	(0)
Multiple myeloma	WM	1.42 (11)	1.08 (136)	1.20 (233)	1.00 (33)
	WW	— (0)	0.60 (1)	2.55* (12)	1.16 (1)
	NM	— (0)	0.94 (44)	0.80 (5)	2.05 (2)
	NW	— (0)	1.03 (10)	— (0)	0 exp (1)
Leukemia	WM	1.53* (29)	1.14* (324)	1.35* (647)	1.11 (72)
	WW	2.40 (3)	0.92 (3)	1.77* (18)	— (0)
	NM	— (0)	0.87 (46)	1.28 (7)	2.94 (2)
	NW	— (0)	0.99 (8)	— (0)	— (0)
All lymphatic and hematopoietic cancer	WM	1.35* (59)	1.10* (659)	1.29* (1486)	1.17 (180)
	WW	1.25 (4)	0.94 (8)	1.65* (42)	0.41 (2)
	NM	2.56 (1)	0.85 (112)	0.94 (14)	1.71 (5)
	NW	(0)	0.99 (23)	0.72 (1)	35.00 (1)
Rheumatic HD	WM	1.02 (5)	1.22 (57)	1.16 (120)	1.27 (32)
	WW	1.31 (1)	1.13 (2)	1.99 (10)	1.60 (3)
	NM	— (0)	1.22 (9)	0.91 (1)	7.15* (3)
	NW	— (0)	(0)	5.09 (1)	— (0)
Vascular lesions of the central nervous system	WM	1.33* (243)	1.16* (3844)	1.10* (5196)	1.05 (591)
	WW	1.25 (19)	0.99 (69)	0.89 (132)	0.65 (17)
	NM	1.25 (3)	1.29* (1138)	1.23* (110)	1.03 (24)
	NW	1.92 (1)	1.28* (319)	1.23 (16)	1.35 (2)
Asthma	WM	2.62 (6)	1.12 (47)	1.64* (100)	1.04 (18)
	WW	— (0)	0.94 (1)	0.92 (2)	— (0)
	NM	— (0)	1.67* (33)	1.65 (3)	— (0)
	NW	— (0)	0.89 (4)	— (0)	(0)
Accidents	WM	1.13 (70)	1.15* (1441)	1.37* (2042)	1.42* (419)
	WW	1.46 (4)	1.48 (22)	1.38 (37)	1.91* (16)
	NM	2.89 (2)	1.24* (436)	1.04 (27)	1.16 (28)
	NW	— (0)	1.20 (46)	1.67 (3)	— (0)
Machinery accidents	WM	12.71* (6)	4.93* (132)	13.61* (278)	10.76* (24)
	WW	— (0)	62.50 (1)	54.08* (2)	— (0)
	NM	— (0)	5.88* (19)	— (0)	9.99 (1)
	NW	— (0)	(0)	— (0)	(0)
Agricultural machinery accidents	WM	27.14* (5)	6.84* (129)	21.78* (259)	40.74* (18)
	WW	— (0)	110.54* (1)	95.22* (2)	— (0)
	NM	— (0)	14.52* (19)	— (0)	— (0)
	NW	— (0)	— (0)	— (0)	— (0)
Mechanical suffocation	WM	— (0)	0.78 (3)	3.47* (27)	1.84 (2)
	WW	— (0)	— (0)	— (0)	— (0)
	NM	— (0)	— (0)	— (0)	— (0)
	NW	— (0)	(0)	— (0)	— (0)

*$p < 0.05$.

TABLE IV. Number of States for Entire Data Set and by Region With PCMRs* (for Cancers) PMRs* (for Non-Neoplastic Diseases) Greater Than 1.0 for Selected Causes (Only States With at Least Two Deaths Included)

Cause	Northeast	South	Central	West	All 23 states	X^2 for sign test
Buccal/pharynx	3 of 4	2 of 5	1 of 7	0 of 2	6 of 18	2.00
Esophagus	1 of 3	0 of 5	2 of 7	0 of 3	3 of 18	8.00[a]
Stomach	2 of 4	2 of 6	6 of 7	4 of 5	14 of 22	1.64
Cardia only	0 of 0	0 of 0	2 of 4	1 of 1	3 of 5	0.20
Colon	2 of 5	1 of 6	4 of 7	2 of 5	9 of 23	1.09
Rectum	2 of 2	1 of 5	4 of 7	1 of 3	8 of 17	0.06
Liver	2 of 2	1 of 5	3 of 7	4 of 4	10 of 18	0.22
Pancreas	2 of 5	4 of 6	6 of 7	4 of 5	16 of 23	3.52
Larynx	1 of 1	1 of 5	0 of 7	1 of 2	3 of 15	5.40[b]
Lung	2 of 5	2 of 6	0 of 7	1 of 5	5 of 23	7.35[a]
Bone	0 of 0	3 of 5	6 of 6	1 of 1	10 of 12	5.33[b]
Skin	1 of 2	3 of 6	4 of 7	2 of 4	10 of 19	0.05
Melanoma only	1 of 2	3 of 6	4 of 7	1 of 3	9 of 18	0.01
Lip	0 of 0	2 of 2	3 of 3	0 of 0	5 of 5	4.05[b]
Breast	2 of 2	1 of 5	2 of 7	2 of 2	7 of 16	0.25
Cervix	0 of 0	3 of 4	1 of 1	0 of 0	4 of 5	1.80
Uterus	0 of 0	2 of 4	3 of 3	0 of 0	5 of 7	1.29
Prostate	4 of 5	6 of 6	7 of 7	5 of 5	22 of 23	19.17[a]
Testis	0 of 0	2 of 5	2 of 6	0 of 0	4 of 11	0.82
Bladder	0 of 4	1 of 5	1 of 7	4 of 5	6 of 21	3.86[b]
Kidney	2 of 2	1 of 5	5 of 7	3 of 5	11 of 19	0.47
Eye	0 of 0	1 of 1	2 of 2	0 of 0	3 of 3	2.08
Brain	1 of 2	2 of 6	5 of 7	1 of 3	9 of 18	0.01
Thyroid	0 of 0	3 of 4	5 of 5	0 of 0	8 of 9	5.44[b]
Soft tissue sarcoma	0 of 0	3 of 5	2 of 7	1 of 2	6 of 14	0.29
Non-Hodgkin's lymphoma	2 of 3	2 of 5	7 of 7	4 of 5	15 of 20	5.00[a]
Hodgkin's disease	0 of 0	3 of 5	3 of 5	1 of 1	7 of 11	0.82
Multiple myeloma	2 of 3	3 of 5	7 of 7	3 of 5	15 of 20	5.00[b]
Leukemia	3 of 4	4 of 6	7 of 7	2 of 5	16 of 22	4.55[b]
All lymphatic and hematopoietic	3 of 5	2 of 6	7 of 7	5 of 5	17 of 23	5.26[b]
Ashthma	2 of 2	4 of 5	6 of 7	1 of 4	13 of 18	3.56
Emphysema	2 of 4	3 of 5	0 of 7	2 of 5	7 of 21	2.33
Cirrhosis of liver	0 of 2	0 of 6	0 of 7	0 of 3	0 of 18	17.01[a]
All accidents	2 of 5	6 of 6	7 of 7	5 of 5	20 of 23	12.57[a]
Suicide	3 of 3	3 of 5	7 of 7	1 of 5	14 of 20	3.20

*Adjusted for race, sex, and age.
[a]$p < 0.01$.
[b]$p < 0.05$.

DISCUSSION

Mortality surveys of farmers, evaluating primarily white men, have noted more favorable mortality than the general population for all causes combined and for most major causes of death. Farmers appear, however, to have excesses for accidents and several cancers [Blair et al., 1985; Pearce and Reif, 1990; Blair and Zahm, 1991]. These patterns were observed among white men in this study, but they are less clear for the other race–sex groups.

The less frequent use of alcohol and tobacco among farmers [Cassel et al.,

1971; Surgeon General, 1985; Walrath et al., 1985] probably accounts for the lower than expected mortality from all cancer combined, lung cancer, emphysema, and cirrhosis of the liver. Even among smokers, men and women farmers appear to have a lower daily consumption of cigarettes than the general population [Surgeon General, 1985]. The number of deaths from atherosclerotic heart disease was about as expected here, although it has been lower in other studies of farmers [see review by Blair and Zahm, 1991].

Consistent with earlier reviews [Blair et al., 1985; Pearce and Reif, 1990; Blair and Zahm, 1991], significant excesses of accidents, non-Hodgkin's lymphoma, multiple myeloma, and leukemia and cancers of the lip, eye, prostate, and brain were observed among white men. Excesses for accidents, leukemia, non-Hodgkin's lymphoma, multiple myeloma, and cancers of the stomach, bone, lip, cervix, uterus, prostate, eye, and thyroid occurred in a majority of the states. Analyses by region suggested some geographic differences. Among WM, mortality from accidents, vascular lesions of the central nervous system, leukemia, and cancer of the prostate tended to be excessive in all geographic regions, while significant excesses for non-Hodgkin's lymphoma and cancers of the lip and brain were restricted to the Central region. This could reflect the larger number of farmers in the Central region than in the Northeast or West, but the South had nearly as many deaths among WM farmers as the Central region and more among NM. Earlier studies also show this tendency of fewer excesses among farmers from states outside the Central region including North Carolina [Delzell and Grufferman, 1985], South Carolina [Une et al., 1987], and New York [Stark et al., 1987] than in Nebraska [Blair and Thomas, 1979], Iowa [Burmeister, 1981], or Wisconsin [Safilas et al., 1987].

Explanations for these regional patterns are unclear. They should not be due to lifestyle factors that affect the entire population of each state because, in our analyses, the mortality among farmers is compared to nonfarmers in the same state. Excesses that occur in all geographic regions suggest widespread exposures, hazards, or lifestyle factors that are peculiar to agricultural activities. For example, it is not surprising to find high mortality from accidents in all regions because the hazards presented by machinery are universal. Mechanical suffocation is probably restricted to the Central region because it is primarily related to grain production. Agricultural practices (e.g., crops produced, size of farms) vary across the country and our geographic-specific findings may reflect these differences. The excesses for non-Hodgkin's lymphoma and cancers of the lip and brain in the Central region suggests that exposures associated with the production of grains should be more fully evaluated. Studies that focus on specific exposures experienced by individual farmers are necessary to determine whether, and which, agricultural practices might account for these observed regional differences.

Excesses of thyroid, bone and pancreatic cancer are new findings and may be due to chance. Pancreatic cancer has not been conclusively linked to occupations, although associations have been noted with workers in various industries (e.g., rubber, petrochemical, aluminum, metal, and printing) [Mack, 1982, Pietri and Clavel, 1991]. Elevated risks have been observed among subjects reporting personal use of pesticides in a case-control study from Louisiana [Falk et al., 1990]. Pancreatic cancer has also occurred in bioassays among rodents exposed to the insecticide, dichlorvos, and the herbicide, nitrofen [Blair et al., 1990].

The excesses for bone and thyroid cancer occurred only among white men.

These are rare cancers (only 49 deaths occurred from bone cancer and 39 from thyroid cancer). Mortality is not a good measure of the incidence of thyroid cancer because 5-year survival is over 90% [Reis et al., 1991]. Few occupational studies of thyroid cancer are available, but the risk was not elevated among farmers in a study from Sweden [Carstensen et al., 1990]. It is interesting, however, that thyroid tumors have occurred in laboratory animals exposed to parathion, phosphamidon, tetrachlorvinphos, trichlorphon, aminotriazole, asulam, and terbutryn [Blair et al., 1990]. No environmental agent other than radiation is clearly associated with bone cancer [Fraumeni and Boice, 1982]. Osteogenic sarcomas have been reported, however, among monkeys exposed to aflatoxin [Sieber et al., 1979] and aflatoxins have been measured in dust from harvesting and handling corn, situations in which farmers could be exposed [Abramson, 1989]. Ewing's bone sarcoma in children has been associated with parental occupations in agriculture in two case-control studies [Holly et al., 1992; Daigle et al., 1987].

Risks among nonwhite men were similar to those among white men with excess mortality for cancers of the pancreas and prostate, but not for others (i.e., lip, brain, eye, or the lymphatic or hematopoietic system). Nonwhite men also had nonsignificantly elevated mortality from soft tissue sarcoma and cancer of the breast and testis. Testicular cancer has been reported to be excessive among farmers in some studies [Mills et al., 1984; McDowell and Balarajan, 1984], but not in others [Jensen et al., 1984; Brown and Pottern, 1984]. No such increase has been previously reported among nonwhite men. The incidence of testicular cancer is considerably lower among blacks than whites [Reis et al., 1991]. For cancers among nonwhite men, only prostate was significantly elevated. In a study of nonwhite male farmers from North Carolina, excesses occurred for leukemia, melanoma of the skin and brain cancer, but not prostate cancer [Delzell and Grufferman, 1985]. North Carolina farmers in our data had an excess of melanoma of the skin (2 deaths; 0.3 expected), but not of leukemia (9 deaths; 12.0 expected) or brain cancer (4 deaths; 5.1 expected). A study from an earlier time period in South Carolina found that nonwhite male farmers had significant excesses from mortality from diseases of the circulatory system, musculoskeletal system and connective tissue, and fires [Une et al., 1987]. In our data, nonwhite male farmers from the South did not appear to have a mortality pattern different from those from other regions.

Nonwhite women experienced excess mortality from cancers of the stomach and cervix, primarily in the South. The excess for stomach cancer among women was greater than among men. Women also had excesses from multiple myeloma and cancer of the buccal cavity and pharynx. White women had excesses for most of the lymphatic and hematopoietic cancers, as did white men.

The danger from working around machinery and animals is well appreciated and a high mortality rate from accidents in agriculture has been documented previously [Donham, 1989; Myers, 1990; Purschwitz and Field, 1990; Spinelli et al., 1989]. Few studies, however, have reported risks among women. We observed excesses for motor vehicle accidents, poisonings, fires, machinery accidents, and electrocutions among women, as well as among men, in nearly every state.

The number of excess deaths in these data from diseases and accidents showing statistically significant elevations among farmers total 3,479. The number from chronic diseases (2,587) far exceed those from accidents (892). Certain traumatic deaths, however, can be ascribed to "agricultural causes" with certainty, while

deaths from chronic diseases cannot. Preventive action for traumatic deaths may be easier to devise and, therefore, have a more immediate effect on reducing mortality than actions for chronic diseases. Although the associations with chronic diseases are not as obvious or refined, the magnitude of the excess deaths warrants further efforts to identify specific preventable exposures that may be responsible.

The main advantage of these data is the number of deaths, which provided the opportunity to evaluate mortality risks among men and women, whites and nonwhites associated with farming in twenty-three states. There are obvious limitations including the inaccuracy of the occupational and cause of death codes on death certificates, grouping of farmers with different agricultural practices, and the PMR/PCMR analyses. In general, occupational and cause of death coding errors would tend to bias risk estimates toward the null [Checkoway et al., 1989]. The degree of misclassification of cause of death varies by disease. For example, the accuracy is quite good for cancers of the stomach, pancreas, lung, melanoma of the skin, prostate, thyroid, and multiple myeloma, but poorer for connective tissue, colon, rectum, bone, cervix, and eye [Percy et al., 1981]. Dilution of risk estimates from misclassification of cause of disease should not differ among the sex and race groups because these factors had little effect on the accuracy of cause of death [Percy et al., 1981].

The inaccuracy of occupational information on death certifications could introduce considerable dilution bias. Comparison of farming and fishing on death certificates for men with their usual occupation from lifetime work histories showed substantial disagreement, i.e., about 50% [Schade and Swanson, 1988]. No information on female farmers was presented, but for occupations other than housewife, misclassification appeared greater among women than men. The proportion of exact matches on occupation (by three-digit Census codes) was better among whites (47.7% for men and 60.0% for women) than among blacks (28.5% among men and 49.1% among women) [Schade and Swanson, 1988]. Thus, the bias of relative risks among farmers toward the null is probably greater for women than men and for blacks than whites.

Limitations in the PMR/PCMR methodology may also bias risk estimates. For example, when the overall mortality rate in the occupational group of interest is lower than the comparison population (a common phenomenon in occupational studies and true for farmers [Blair and Zahm, 1991]), and PMR will be artificially elevated [Decoufle et al., 1980; Stewart and Hunting, 1988]. On the other hand, a standardized mortality ratio (SMR) of less than one probably indicates that the comparison population is less than ideal; some investigators have suggested using the PMR as an approach to minimize the "healthy worker effect" [Parks et al., 1991]. The use of proportionate cancer mortality ratios (PCMRs) reduces the difference between PMRs and SMRs by eliminating diseases that contribute most heavily to the healthy worker effect [Stewart and Hunting, 1988], which is why we used PCMRs for cancers. Another problem with PMRs is that since the observed and expected numbers for all causes of death combined must be equal, a deficit in one disease must, therefore, be compensated for by an excess elsewhere. Thus, if a true deficit occurs for some diseases (such as tobacco-related diseases among farmers), excesses are created for some other causes. Our analyses by individual states were used to evaluate the possibility that the excesses observed are artificial. PMR excesses caused by true deficits would not be expected to occur for the same diseases in different states. Taking all study limitations into consideration, we feel that mortality risks among farmers estimated here are more likely to be underestimated than overestimated because the dilution effect caused by misclassification of disease and occupation is more severe than the enhancing effect that may occur from the PMR method.

In conclusion, the pattern of mortality excesses and deficits among farmers in this study resembled those observed by others. The excesses were generally small and were not entirely consistent by race, sex and geographic region. Deficits occurred for several tobacco and alcohol-related diseases. The results for white male farmers were similar to those seen in previous studies: excesses of cancers of the lymphatic and hematopoietic system, lip, eye, brain, stomach, and prostate. Significant excesses for various types of accidents, leukemia, and cancer of the prostate tended to occur in all geographic regions, while non-Hodgkin's lymphoma and cancers of the lip and brain occurred mainly in the Central region. Nonwhite males were similar to white males for cancers of the prostate and pancreas, but lacked excesses for cancers of the lymphatic and hematopoietic system, lip, eye, and brain. Excesses for pancreatic, bone, and thyroid cancers among white males were new findings. Sex differences occurred. Cancers of the buccal cavity and pharynx were slightly higher than expected among women, but not among men, and women had no excess of pancreatic, brain, bone, or thyroid cancer. Nonwhite women experienced significant excesses for stomach and cervical cancer. Stomach cancer was more strongly elevated among women than men. Excesses for lymphatic and hematopoietic cancers were restricted to white farmers. Increased risks for several categories of unintentional traumatic deaths highlight other preventable mortality risks in this occupational group.

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Respiratory Health Status in Swine Producers Using Respiratory Protective Devices

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A cross-sectional survey on respiratory health in swine producers showed that 30% of 301 examined men usually used a dust mask when working inside a barn. They did not differ significantly from dust mask nonusers in respect to respiratory symptoms and lung function. This analysis was undertaken to determine whether the respiratory health of dust mask users was associated with reasons why they had started individual respiratory protection. The subjects were recontacted in order to identify those who started using a mask to deliberately prevent symptoms (42 men) and those who started protection because of pre-existing respiratory symptoms (44 men). Not unexpectedly, between-group comparisons of respiratory symptoms and lung function suggest that swine producers who wear dust masks for preventive purposes have better respiratory health than those who wear dust masks because of symptoms or those who do not use individual respiratory protection. The individual reasons for starting dust mask usage should be examined among potential determinants of the outcomes of prospective studies which can then provide more valid assessment of the effect of individual respiratory protection. © 1993 Wiley-Liss, Inc.

Key words: animal confinement workers, respiratory symptoms, lung function, individual respiratory protection

INTRODUCTION

Adverse respiratory effects of working in swine confinement buildings include acute symptoms of irritation of the respiratory tract, increased prevalence of chronic respiratory symptoms, and small decrements in lung function [Dosman et al., 1988; Donham et al., 1989; Rylander et al., 1989]. Given the documented harmfulness of the environment of livestock confinement buildings, one would expect a beneficial effect of respiratory protective devices (dust masks) used by workers employed in

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