

Cancer in Humans and Potential Occupational and Environmental Exposure to Pesticides

Selected Epidemiological Studies and Case Reports

by Marion Moses, MD

Editor's note: The following abstracts are a compendium of data resources for additional information on the topic of minority workers.

MORTALITY STUDIES

Alavanja, MCR, Rush, GA, Stewart P, et al. Proportionate mortality study of workers in the grain industry. *Journal of the National Cancer Institute* 1987; 78(2):247-252.

A proportionate mortality study of 1,114 members (all white males) of the American Federation of Grain Millers union who died between 1968-83, compared to the U.S. population. Statistically significant increased risk was found for *pancreatic* cancer (PMR* 191, PCMR of 171 was not significant), and other *lymphoma* (PMR 272 PCMR 249).

Nonsignificant elevated ratios were found for stomach cancer (PMR 141, PCMR 121), bladder cancer (PMR 178, PCMR 155), lymphosarcoma (PMR 216, PCMR 191), Hodgkin's disease (PMR 174, PCMR 153), and leukemia (PMR 170, PCMR 139). Potential pesticide exposures included methyl bromide, ethylene dibromide, carbon tetrachloride, phosphine, and malathion, among others.

Alavanja, MCR, Malher, H, Hayes, RB. Occupational cancer risk associated with the storage and bulk handling of agricultural foodstuff. *Journal of Toxicology and Environmental Health* 1987; 22(3):247-254.

A study of cancer incidence in 2,649 Swedish grain millers (all white males) between 1961-79, compared to the Swedish general population. Statistically significant increased risk was found for *liver* cancer (SIR 238).

Nonsignificant increased ratios were found for cancer of the stomach (SIR 103), colon (SIR

116), kidney (SIR 113), bladder (SIR 125), other lymphoma (SIR 137), and multiple myeloma (SIR 139).

Barthel, E. Increased risk of lung cancer in pesticide-exposed male agricultural workers. *Journal of Toxicology and Environmental Health* 1981; 8:1027-1040.

A proportionate mortality study of 1,658 agricultural pesticide sprayers in East Germany, 169 of whom died between 1948-78, compared to the general population (excluding Berlin). Statistically significant increased risk was found for *lung* cancer (PCMR 180).

Nonsignificant elevated risk was found for cancer of the pancreas (PCMR 146), bladder (PCMR 118) and other genitourinary cancer (PCMR 186). Potential pesticide exposures included Zineb, Maneb, Atrazine, Simazine, Amitrole, arsenic, DDT, Lindane, methyl parathion, toxaphene, DNOC, 2,4-D, 2,4,5-T, among others.

Blair, A, Grauman, DJ, Lubin, JH. Lung cancer and other causes of death among licensed pesticide applicators. *Journal of the National Cancer Institute* 1983; 71(1):31-37.

A mortality study of 3,827 pest control operators licensed in Florida during 1965-66, of whom 378 had died as of January 1, 1977. For those with 20 or more years latency, statistically significant increased risk was found for *lung* cancer (SMR 289), and a nonsignificant elevation for all cancers (SMR 177).

For the entire cohort, nonsignificant elevated risk was found for all cancers (SMR 114), lung cancer (SMR 135) and brain cancer (SMR 200). Potential pesticide exposures included Aldrin, Chlordane, DDT, heptachlor, toxaphene, lindane, chlorpyrifos, diazinon, malathion, dichlorvos, carbaryl, propoxur, bendiocarb, 2,4-D, 2,4,5-T, Paraquat, pentachlorophenol, Captan, folpet, arsenic, methyl bromide, and paradichlorobenzene.

Burnmeister, LE. Cancer mortality in Iowa

farmers, 1971-78. *Journal of the National Cancer Institute* 1981; 66(3):461-464.

A mortality study of 6,402 Iowa farmers who died between 1971 and 1978, compared to 13,809 nonfarmers. Statistically significant increased risk for farmers was found for cancer of the *stomach* (SMR 135), *colon* (SMR 122), *pancreas* (SMR 123), *skin* (SMR 131), *prostate* (SMR 141), *bladder* (SMR 114), *kidney* (SMR 122), *lip* (SMR 206), *Hodgkin's disease* (SMR 137), *leukemia* (SMR 135), *other lymphoma* (SMR 129) and *multiple myeloma* (SMR 147).

Nonsignificant elevated ratios were found for: bone cancer (SMR 126), and brain cancer (SMR 111).

Carlson, ML, Petersen, GR. Mortality of California agricultural workers. *Journal of Occupational Medicine* 1978; 20(1):30-32.

A mortality study in California comparing 2,936 farm laborers with 908 farm operator/managers who died between 1959-61, using state health department tapes indexing death to occupation.

A nonsignificant elevated mortality rate ratio between laborers and managers for all cancers of 1.13 was found.

Coggon, D, Pannett, B, Winter, PD, et al. Mortality of workers exposed to 2 methyl-4 chlorophenoxyacetic acid. *Scandinavian Journal of Work, Environment and Health* 1986; 12:448-454.

A mortality study of 5,754 workers (all white males) who both manufactured and sprayed MCPA as well as other pesticides from 1947 to 1975 for the same British company. As of December 1983, there were 1,039 deaths, 297 from cancer. Statistically significant increased risk compared to the general rural population was found for *nasal* cancer (SMR 493).

Nonsignificant elevated ratios were found for all cancer (SMR 107), cancer of the *tongue* (SMR 112), *digestive system* (SMR 273), *colon* (SMR 102), *larynx* (SMR 174), *lung* (SMR 115), *nonmelanoma skin* (SMR 306), *prostate* (SMR 132), *testes* (SMR 223), *brain* (SMR 124), *thy-*

*See Figure at the end of article for abbreviations.

roid (SMR 170), nonbladder genitourinary (SMR 227), small intestine (SMR 159), gallbladder (SMR 119), leukemia (SMR 177), multiple myeloma (SMR 162) and soft-tissue sarcoma (SMR 104). Additional potential pesticide exposures included DNOC, copper oxychloride, a variety of organophosphorous insecticides, chlorotriazine herbicides, and 2,4,5-T.

Dezell, W, Grufferman, S. Mortality among white and nonwhite farmers in North Carolina, 1976-1978. *American Journal of Epidemiology* 1985; 121(3):391-402.

A mortality study in North Carolina of 9,245 white and 3,508 non-white (94% black) farmers who died between 1976-78, compared to the general population of the state. Statistically significant increased risk was found in white farmers for *nonmelanoma skin* cancer (PMR 180) and in non-white farmers for *melanoma skin* cancer (PMR 630) and *leukemia* (PMR 190).

Nonsignificant elevated ratios were found in white farmers for melanoma (PMR 120), prostate cancer (PMR 110); and in non-white farmers for brain cancer (PMR 230) and other lymphoma (PMR 120).

Fasal, E, Jackson, EW, Klauber, MR. Leukemia and lymphoma mortality and farm residence. *American Journal of Epidemiology* 1968; 87:267-274.

A mortality study of 1,857 farmers in California who died between 1959-61, compared to nonfarmers in the state.

Nonsignificant elevated ratios were seen in both males and females for leukemia (PMR 114), and in females for Hodgkin's disease (PMR 109), and multiple myeloma (PMR 102).

Gallagher, RP, Threlfall, WJ, Spinelli, JJ, et al. Occupational mortality patterns among British Columbia farmworkers. *Journal of Occupational Medicine* 1984; 26(12):906-908.

A proportionate mortality study of 2,328 British Columbia farmworkers (all males) who died between 1950-78.

Nonsignificant elevated ratios were found for cancer of the stomach (PCMR 126), pancreas (PCMR 124), and prostate (PCMR 109).

Gallagher, RP, Threlfall, WJ, Jeffries, E, et al. Cancer and aplastic anemia in British Columbia farmers. *Journal of the National Cancer Institute* 1984; 72(6):1311-1315.

A proportionate mortality study of 28,032 farmers in British Columbia (all males) who died between 1950-78. Statistically significant increased risk was found for cancer of the *stomach* (PCMR 119), *pancreas* (PMR 112, PCMR 105 not significant), *prostate* (PCMR 113), *lip* (PCMR 191), *leukemia* (PCMR 122), *nasal can-*

cer (PMR 186, PCMR 178 not significant), and *aplastic anemia* (PMR 186, PCMR 178 not significant).

A nonsignificant increased ratio was found for multiple myeloma (PCMR 103).

Mabuchi, K, Lilienfeld, AM, Snell, LM. Cancer and occupational exposure to arsenic: A study of pesticide workers. *Preventive Medicine* 1980; 9:51-77.

A mortality study of 3,141 hourly and salaried men and women who worked four months or more between 1946-74 at a pesticide manufacturing plant in Baltimore, Maryland. As of August, 1977, there were 240 deaths, 56 from cancer. In males, compared to the U.S. general population, statistically significant increased risk was found for *all cancers* (SMR 168), and *lung* cancer (SMR 265).

Nonsignificant increased ratios were found for oral cancer (SMR 201), cancer of the esophagus (SMR 451), stomach (SMR 172), skin (SMR 162) and lymphopietic cancer (SMR 209). The number of female cancer deaths was too small for significance testing; however, an elevated ratio was found for *rectal* cancer (2 observed vs. 0.4 expected). Potential pesticide exposures included lead and calcium arsenate, sodium, zinc and magnesium arsenite, copper acetoarsenite (Paris green), DDT, Aldrin, toxaphene, chlordecone, various organophosphates, various carbamates, 2,4-D, monuron-TCA, and other organic herbicides.

Riihimäki, V, Asp, S, Hernberg, S. Mortality of 2,4-dichlorophenoxy acetic acid and 2,4,5-trichlorophenoxyacetic acid herbicide applicators in Finland. First report of an ongoing prospective study. *Scandinavian Journal of Work, Environment and Health* 1982; 8:37-42.

A mortality study of 1,926 Finnish pesticide sprayers who worked for two weeks or more between 1955-71 as applicators of 2,4-D and 2,4,5-T. As of 1980, 144 had died, 26 from cancer.

Nonsignificant elevated ratios were found for cancer of the esophagus/stomach (SMR 108, based on 4 cases), lung cancer (SMR 108, 12 cases), prostate cancer (SMR 182, 2 cases) and multiple myeloma (SMR 500, 1 case).

Saftlas, AF, Blair, A, Cantor, KP, et al. Cancer and other causes of death among Wisconsin farmers. *American Journal of Industrial Medicine* 1987; 11:119-129.

A proportionate mortality study of 35,972 Wisconsin farmers (all white males) who died from 1968-76, compared to the general U.S. general population and to nonfarmers in Wisconsin (excluding Milwaukee). Statistically significant increased risk was found for cancer of the *stomach* (PMR 124, PCMR 113), *pancreas* (PMR 110, PCMR 98), *prostate* (PMR

122, PCMR 114), *eye* (PMR 375, PCMR 343), *lymphosarcoma* (PMR 125, PCMR 110 not significant), *Hodgkin's disease* (PMR 155, PCMR 126 not significant), *other lymphoma*, two thirds of which were *multiple myeloma* (PMR 123, PCMR 110 not significant), *lymphopietic cancer* (PMR 123, PCMR 110), and *leukemia* (PMR 120, PCMR 109 not significant).

Elevated ratios not statistically significant were found for cancer of the rectum (PMR 113), bone (PMR 105), skin (PMR 115), testes (PMR 103), kidney (PMR 106), and brain (PMR 110).

Shindell, S, Ulrich, S. Mortality of workers employed in the manufacture of Chlordane: An update. *Journal of Occupational Medicine* 1986; 28(7):4987-501.

A mortality study of 800 persons who worked three months or more from 1946-85, at the only plant that manufactures chlordane in the U.S. (Velsicol plant in Illinois). 181 deaths were traced, 37 from cancer. No statistically significant increased risks were found. Of the 37 cancers, 12 were *lung* (SMR 86), 4 *colon/rectal*, 3 *stomach*, 2 *pancreas*, 2 *renal*, 9 of different types (not specified) and 5 of unknown type.

Infante, PF, Freeman, C. Cancer mortality among workers exposed to chlordane (letter). *Journal of Occupational Medicine* 1987; 29(11):908-909.

A critique of the Shindell mortality study of chlordane workers.

Shindell, S. Cancer mortality among workers exposed to Chlordane (letter). *Journal of Occupational Medicine* 1987; 29(11):909-911.

A reply to the critique by Infante and Freeman.

Stubbs, HA, Harris, J, Spear, RC. A proportionate mortality analysis of California agricultural workers, 1978-1979. *American Journal of Industrial Medicine* 1984; 6:305-320.

A proportionate mortality study in California of 7,504 farmworkers and 7,404 farm owners/managers who died between 1978-79, compared to the state's general population. Statistically significant increased risk was found in white (includes Hispanics) farmworkers for cancer of the *stomach* (PCMR 134), and in non-whites for *brain* cancer (PCMR 155).

Nonsignificant elevated ratios were found in white farmworkers for oral cancer (PCMR 111), cancer of the esophagus (PCMR 121), liver and gallbladder (PCMR 145), larynx (PCMR 129), lung (PCMR 108), bone (PCMR 159), prostate (PCMR 101), other lymphoma (PCMR 107); and in non-whites for cancer of the esophagus (PCMR 115), stomach (PCMR 101), rectum (PCMR 190), liver and gallbladder (PCMR 151)

and other lymphoma (PCMR 114).

Statistically significant increased risk in white farm owner/managers was found for cancer of the prostate (PCMR 122) and other lymphoma (PCMR 150) and in non-whites for cancer of the stomach (PCMR 202), and rectum (PCMR 224).

Nonsignificant elevated ratios were found in white farmer managers for cancer of the stomach (PCMR 109), rectum (PCMR 109), liver (PCMR 137), larynx (PCMR 111), skin (PCMR 130), kidney (PCMR 102) and lymphopoietic (PCMR 105), and in non-whites for cancer of the esophagus (PCMR 127), colon (PCMR 107), liver (PCMR 150), other lymphoma (PCMR 127) and lymphopoietic cancer (PCMR 108).

Wang, HH, MacMahon, B. Mortality of pesticide applicators. *Journal of Occupational Medicine* 1979; 21(11):741-744.

A mortality study using the personnel records of three nationwide pest control companies based in Atlanta, Memphis, and Tucson with members in 40 states, of 16,126 members (all males) employed for three months between 1967-76, and who died in this time period. 311 deaths ascertained, of which 47 were from cancer.

Nonsignificant elevated ratios were found for cancer of the lung (SMR 115), skin (SMR 173), and bladder (SMR 277). Potential pesticide exposures included chlordane, heptachlor, as well as a variety of fumigants, botanicals, carbamates, organophosphates, and other chlorinated hydrocarbons.

Wiklund, K. Trends in cancer risks among Swedish agricultural workers. *Journal of the National Cancer Institute* 1986; 77(3):657-664.

A prospective study of the time related trends from 1961 to 1979 in the incidence of cancer in 254,417 Swedish males aged 20 to 69 employed in agriculture in 1960, compared to 1,725,845 controls. Statistically significant increased risk in agricultural workers was found for cancer of the lip (SMR 192), skin (SMR 115), stomach (SMR 107), malignant melanoma (SMR 139), and multiple myeloma (SMR 120). A trend for increasing risk over three time periods (1967-73, 1974-79, 1974-79) was found for cancer of the lip, liver, prostate, nasal and genitourinary cancer.

Wiklund, K. Testicular cancer among agricultural workers and licensed pesticide applicators in Sweden. *Scandinavian Journal of Work, Environment and Health* 1988; 12:630-631.

A prospective study of the incidence of testicular cancer in 254,417 Swedish men employed in agriculture as determined by a 1960 census. Compared to controls a nonsignificant trend for

increasing risk of testicular cancer over time was found—an SMR of 83 in 1961-66 increased to 94 in 1967-73, and to 135 in 1974-79. Eighteen cases of testicular cancer were found in a cohort of 20,245 pest control operators licensed between 1965 and 1976, with 11.6 expected (SMR 155), which was not significant.

Wong, O, Brocker, W, Davis, HV, et al. Mortality of workers potentially exposed to organic and inorganic brominated chemicals, DBCP, TRIS, PBB and DDT. *British Journal of Industrial Medicine* 1984; 41:15-25.

A mortality study of 3,579 workers (all males) employed between 1935 and 1976 in three chemical manufacturing plants, two in Michigan, one in Arkansas. Of 541 who had died as of December, 1976, 112 were from cancer.

Nonsignificant elevated ratios were found for all cancer (SMR 102), cancer of the liver (SMR 124), lung (SMR 131), prostate (SMR 164), testes (SMR 193), bladder (SMR 188), kidney (SMR 145), brain (SMR 132), leukemia (SMR 187), and lymphoctic cancer (SMR 111). The mortality from testicular cancer was significantly higher (SMR 1799, based on two cases) in workers whose common exposure was to methyl bromide. Potential chemical exposures included DBCP, methyl bromide, ethyl bromide, bromochlorobenzene, chlorobromomethane, sodium and potassium bromide, PCBs, PBBs, Tris, and DDT.

CASE-CONTROL STUDIES

Austin, H, Delzell, E, Grufferman, S, et al. Case-control study of hepatocellular carcinoma, occupation and chemical exposures. *Journal of Occupational Medicine* 1988; 29:665-669.

A case-control study of 86 persons aged 18 to 84 at one of five medical centers (Alabama, Duke, Miami, Pennsylvania, and Harvard) with primary liver cancer; 60 men and 26 women; compared to 146 controls with other cancers (except those related to smoking).

Nonsignificant elevated risk was found for: pesticide exposure (RR 2.1), employment in agriculture (RR 1.1), employment in livestock agriculture (RR 1.5), and occupation as farmer or farmworker (RR 1.4). No consistent trend between years of farming and risk for liver cancer was found.

Blair, A, Thomas, TL. Leukemia among Nebraska farmers: A death certificate study. *American Journal of Epidemiology* 1979; 110(3):264-273.

A case-control study in Nebraska of 1,084 white males who died of leukemia from 1957-74, compared to 2,168 deaths from other cancers. Statistically significant increased risk

for leukemia was found in farmers (OR 1.25), with the risk being higher for those born after 1900 (OR 1.64), and even higher for those from high insecticide use counties (OR 1.95).

Blair, A, White, DW. Leukemia cell types and agricultural practices in Nebraska. *Journal of Occupational Medicine* 1985; 40(4):211-214.

A further analysis of the above study of Nebraska farmers in which it was found that farmers from high pesticide and fertilizer-use counties tended to be at higher risk of acute lymphatic, acute myeloid, chronic myeloid, and acute unspecified leukemia than farmers from low use counties.

Blair, A, Everett, G, Cantor, K, et al. Leukemia and farm practices (abstract). *American Journal of Epidemiology* 1985; 122:535.

A population-based case-control study in Iowa and Minnesota of 578 cases of histologically confirmed leukemia in white males aged 30 or older who died between 1980-1983, compared with 1,245 who died of other causes. More cases than controls reported use of dichlorvos on animals (OR 1.8). Pesticides used more frequently by cases than controls included Ethoprop (OR 1.9), nicotine (OR 1.6), Methoxychlor (OR 1.5), and DDT (OR 1.4).

Brown, LM, Pottern, LM. Testicular cancer and farming (letter). *Lancet* 1984; 1:1356.

A case-control study, using death certificates only, from three Washington, D.C. medical centers, of 271 testicular cancer cases, aged 18 to 42 and diagnosed between 1976-1981. Compared to 259 controls with other cancers, a small increase in risk that was statistically significant (OR 1.4) was found for current farmers who grew up in the south.

Burmeister, LF, Van Lier, SF, Isaacson, P. Leukemia and farm practices in Iowa. *American Journal of Epidemiology* 1982; 115(5):720-728.

A case-control study in Iowa of 1,675 white males over age 30 who died of leukemia between 1964-78, compared to 3,350 controls. Farmers had a statistically significant elevated risk for leukemia (OR 1.24), even higher in those who died between 1971-78 (OR 1.39). Significant excess mortality was also seen in high herbicide use counties for those born after 1900 (OR 1.60).

Burmeister, LF, Everett, GD, Van Lier, SF, et al. Selected cancer mortality and farm practices in Iowa. *American Journal of Epidemiology* 1983; 118(1):72-77.

A case-control study in Iowa of 8,290 white males who died of cancer from 1964-78, (4,827

prostate, 1,812 stomach, 1,101 nonHodgkin's lymphoma, 550 multiple myeloma). Farmers were found to have statistically significant excess mortality from *multiple myeloma* (OR 1.5), *nonHodgkin's lymphoma* (OR 1.3), *stomach cancer* (OR 1.3) and *prostate cancer* (OR 1.2).

Cantor, K, Everett, G, Blair, A, et al. Farming and nonHodgkin's lymphoma (abstract). *American Journal of Epidemiology* 1985; 122(3):535.

A case-control study of 622 Iowa and Minnesota white males, aged 30 or more who died of nonHodgkin's lymphoma between 1980-1983, compared to 1,245 men who died of other causes. A suggestion of excess mortality for farmers from *small cell lymphocytic lymphoma* (RR 1.35) was found, especially in those reporting use of high volume pesticides 20 or more years prior. Increased risk was associated with exposure to nicotine (OR 2.0), lindane (OR 1.9), 2,4,5-T (OR 1.9), glyphosate (Roundup) (OR 1.9), atrazine (OR 1.6), and Cyanazine (OR 1.6). Evidence of elevated risk of all types of nonHodgkin's lymphoma was found for uses of DDT (OR 1.5), chloramben (OR 2.2) and Carbofuran (OR 1.6).

Cantor, KP, Blair, A. Farming and mortality from multiple myeloma: A case-control study with the use of death certificates. *Journal of the National Cancer Institute* 1984; 72(2):251-255.

A case-control study of 411 deaths from multiple myeloma in Wisconsin white males (except Milwaukee), aged 30 or more who died from 1968-76, compared to 725 controls with smoking-related causes of death excluded. Statistically significant excess mortality was found in the farmers for *multiple myeloma* (OR 1.4), which was greater in those 65 and older (OR 1.5), and for those who died between 1968-70 (OR 1.9). Significant association with pesticide use was found for high insecticide use counties for those born after 1905 (OR 2.8).

Everett, G, Blair, A, Cantor, K, et al. Environmental chemical exposures as risk factors for leukemia and non-Hodgkin's lymphoma (abstract). *American Journal of Epidemiology* 1985; 122(3):535-538.

A population-based case-control study in Iowa and Minnesota based on interviews of 1200 white males (or their proxies) diagnosed with leukemia and nonHodgkin's lymphoma between 1980-1983. Statistically significant increased risk of *leukemia* was associated with exposure to insecticides (OR 1.5) and herbicides (OR 1.86). Significant increased risk for *nonHodgkin's lymphoma* was associated with exposure to methyl bromide (OR 2.82), insecticides (OR 1.9), herbicides (OR 2.06), and pentachlorophenol (OR 1.86).

Hear, SK, Blair, A, Holmes, FF, et al. Agricultural herbicide use and risk of lymphoma and soft-tissue sarcoma. *Journal of the American Medical Association* 1986; 256(9):1141-1147.

A population-based case-control study of 442 white male Kansas residents aged 21 or older diagnosed with soft-tissue sarcoma, Hodgkin's disease, and nonHodgkin's lymphoma from 1976 through 1982, compared to 948 controls from the general population of the state.

Nonsignificant increased risk of nonHodgkin's lymphoma was associated with herbicide use (OR 1.6).

Statistically significant increased risk was found for those exposed to herbicides more than 20 days a year (OR 6.0), and frequent users who mixed or applied the herbicides themselves (OR 8.0). The excess mortality was associated with use of phenoxyherbicides, specifically 2,4-D (OR 2.2). Neither soft-tissue sarcoma nor Hodgkin's disease were found to be related to herbicide exposure.

Colton, T. Herbicide exposure and cancer. *Journal of the American Medical Association* 1986; 256:1176-1178.

Editorial comments on the study described above.

McDowall, M, Balaraman, R. Testicular cancer and employment in agriculture (letter). *Lancet* 1984; 1:510-511.

Preliminary data from a case-control study in progress, using death certificates, of 2,434 males over age 15 who died from testicular cancer in England and Wales from 1971 to 1980. Agricultural workers were found to be at increased risk of *testicular cancer* (OR 1.42), the risk being significant in farmers and farm managers (OR 1.85), but not in farmworkers (OR 0.9).

Milham, S. Jr. Leukemia and multiple myeloma in farmers. *American Journal of Epidemiology* 1971; 91(1):307-310.

A case-control study based on a previous occupational mortality study, confined to leukemia/lymphoma group of cancers of 4,444 farmers compared to an equal number of controls using occupation as stated on death certificates in state files in Oregon and Washington. Statistically significant increased risk in farmers for *multiple myeloma* and *leukemia* was found (based on chi-square analyses of frequencies).

Mills, PK, Newell, GR, Johnson, DE. Testicular cancer associated with employment in agriculture and oil and natural gas extraction. *Lancet* 1984; 1:207-209.

A case-control study of 347 patients with histologically confirmed germ-cell testicular

cancer diagnosed at M.D. Anderson Hospital in Houston, Texas, between 1977-1980. Statistically significant increased risk for *testicular cancer* was found to be associated with agricultural employment (OR 4.18), and was even higher for those whose present occupation was in farming (OR 6.27).

Mills, PK, Newell, GR. Testicular cancer risk in agricultural occupations (letter). *Journal of Occupational Medicine* 1984; 26(11):798-799.

A brief discussion of testicular cancer as found in other studies and the author's findings as described above.

Morris, PD, Koepsell, TD, Daling, JR, et al. Toxic substance exposure and multiple myeloma: A case-control study. *Journal of the National Cancer Institute* 1986; 76(6):987-994.

A case-control study from SEER (Surveillance Epidemiology and End Results) cancer registry data in selected counties in the states of Washington and Utah, and in metropolitan Detroit and Atlanta, of 698 cases of *multiple myeloma* newly diagnosed between 1977-1981, compared to 1,683 controls from the general population of the four study areas. Of the 20 exposure categories studied, the highest risk was for subjects who reported past exposure to pesticides (OR 2.6), which was statistically significant. In those cases where exposure was self-reported the risk was even higher (OR 2.9).

Musicco, M, Filippini, G, Bordo, BM, et al. Gliomas and occupational exposure to carcinogens: Case-control study. *American Journal of Epidemiology* 1982; 116(5):782-790.

A case-control study in Milan, Italy, of 42 cases of *primary brain cancer*, compared to 42 patients with other neurological disease at the same institute. Farmers were found to be at increased risk for *glioma* (OR 5.0).

Nandakumar, A, Armstrong, BK, deKlork, NH. Multiple myeloma in Western Australia: A case-control study in relation to occupation, father's occupation, socioeconomic status, and country of birth. *International Journal of Cancer* 1986; 37:223-228.

A case-control study in Western Australia of 249 deaths from multiple myeloma between 1975-1984, compared to 996 control who died from other causes.

Statistically nonsignificant increased risk for multiple myeloma was found in farmers (OR 1.36). No relationship was found with farming as the father's occupation (OR 0.88).

Pearce, NE, Smith, AH, Howard, JK, et al.

NonHodgkin's lymphoma and exposure to phenoxyherbicides, chlorophenols, fencing work, and meat works employment: A case-control study. *British Journal of Industrial Medicine* 1986; 43:75-83.

A case-control study in New Zealand of 83 cases of adult males with nonHodgkin's lymphoma, diagnosed between 1977-1981, compared to 168 controls with other cancers and 228 general population controls.

Nonsignificant increased risk for nonHodgkin's lymphoma was found for farmers exposed to chlorophenols (OR 1.4), for fencing work (OR 2.0), and meat works employment (OR 1.8), with greatest risk for employment in both activities (OR 5.7).

Pearce, NE, Smith, AH, Fisher, DO. Malignant lymphoma and multiple myeloma linked with agricultural occupations in a New Zealand cancer registry-based study. *American Journal of Epidemiology* 1985; 121(2):225-237.

A case-control study in New Zealand of 734 white males aged 20 or older who died from lymphoma and multiple myeloma between 1977-1981, compared to 2,986 deaths from other cancers.

A nonsignificant increased risk of lymphoma and multiple myeloma was associated with agricultural occupation (OR 1.25).

Statistically significant increased risk for lymphoma and multiple myeloma was found for orchard farming (OR 5.51); for nonHodgkin's lymphoma in farmers diagnosed before age 65 (OR 1.76) and for multiple myeloma as well (OR 2.22).

Schumacher, MC. Farming occupations and mortality from nonHodgkin's lymphoma in Utah: A case-control study. *Journal of Occupational Medicine* 1985; 27(8):580-584.

A case-control study in Utah of 228 white males who died from nonHodgkin's lymphoma between 1967-1982, compared with 293 deaths from colon cancer. Statistically significant increased risk of nonHodgkin's lymphoma was found for farmers diagnosed between 1952-65 (OR 6.6) and between 1966-71 (OR 3.1). Elevated risk ratios were also found for rural versus urban residence for 1952-1966 (OR 3.3), 1966-71 (OR 3.4), 1972-77 (OR 2.4), but none were significant.

Stomhagen, A, Slade, J, Altman, R, et al. Occupational risk factors and liver cancer. *American Journal of Epidemiology* 1983; 117(4):443-454.

A case-control study in New Jersey of 265 cases of primary liver cancer, diagnosed between 1975 and 1979, compared to 265 cases selected from hospital records and 265 cases selected from state death certificate records.

Statistically significant increased risk of liver cancer was found associated with agriculture (RR 2.08), agricultural production or services (RR 2.08), and for occupation of farm laborer (RR 1.89). Nonsignificant elevated ratios were found for horticulture (RR 1.83), and in farm owner/managers (RR 1.23).

Vinels, P, Terracini, B, Ciccone, G, et al. Phenoxy herbicides and soft-tissue sarcomas in female rice weeder: A population-based case-referent study. *Scandinavian Journal of Work, Environment and Health* 1986; 13:9-17.

A case-control study in three rice-growing provinces of northern Italy of 68 cases (31 females) of soft-tissue sarcoma diagnosed between 1981-1983, compared to 158 population-based controls (73 females). Fifteen (40.5%) of the male cases had worked in agriculture compared to 26 (30.5%) of the controls. Fourteen (45%) of the female cases had worked in agriculture compared to 21 (28.5%) of the controls. Of the living women, exposure to phenoxy herbicides increased risk (OR 2.7), but not in living men (OR 0.91).

Woods, JS, Polissar, L, Severson, RK, et al. Soft-tissue sarcoma and nonHodgkin's lymphoma in relation to phenoxyherbicide and chlorinated phenol exposure in western Washington. *Journal of the National Cancer Institute* 1987; 78(5):899-910.

A case-control study in 13 counties of western Washington state of 128 cases of soft-tissue sarcoma, and 576 cases of nonHodgkin's lymphoma, in males aged 20 and older who were diagnosed between 1981-1984, compared to 694 controls without cancer. Statistically significant increased risk for nonHodgkin's lymphoma was found for farmers (OR 1.33), forestry herbicide applicators (OR 4.80), and for those with 15 or more years of occupational exposure to phenoxyherbicides 15 years prior to their diagnosis of cancer (OR 1.71). Pesticide exposures associated with increased risk of nonHodgkin's lymphoma were DDT (OR 1.82), and lead arsenate (OR 1.60); the elevated ratio associated with exposure to chlordane (OR 1.61) was not statistically significant. No increased risk for soft-tissue sarcoma was found.

CHILDHOOD CANCER

Gold, E, Gordis, L, Tonascia, J, et al. Risk factors for brain tumors in children. *American Journal of Epidemiology* 1979; 109(3):309-319.

A case-control study of 84 children with primary brain cancer in Baltimore, Maryland, diagnosed between 1965-1975, compared to 76 children without cancer, and 112 children with

other types of cancer. Compared to the normal controls children with brain cancer were more likely to have been exposed to insecticides in the home (OR 2.3). There was no difference when compared to cancer controls.

Hemminki, K, Saloniemi, I, Salonen, T, et al. Childhood cancer and parental occupation in Finland. *Journal of Epidemiology and Community Health* 1981; 35:11-15.

A case-control study using birth records, of the occupations of parents of all children less than age 15 diagnosed with cancer in Finland from 1959-1975. Statistically significant increased risk of cancer in children was associated with the mother being a farm wife (OR 2.2, 1969-75), or food worker, mainly bakers (OR 4.0, 1959-68); and for fathers' occupation in agriculture, gardening, and forestry (OR 1.42).

Infante, PF, Epstein, SS, Newton, WA, Jr. Blood dyscrasias and childhood tumors and exposure to chlordane and heptachlor. *Scandinavian Journal of Work, Environment and Health* 1978; 4:137-150.

Reports of five cases of neuroblastoma diagnosed in Ohio at the same pediatric hospital in 1975. All of the children had had prenatal and/or extensive environmental exposure to chlordane. Also reported was a case of aplastic anemia in a 15-year-old boy with exposure to chlordane and Isotox and a 9-year-old girl with leukemia with chlordane exposure only.

Infante, PF, Newton, WA. Prenatal chlordane exposure and neuroblastoma (letter). *New England Journal of Medicine* 1975; 240:308.

The first report of the neuroblastoma cases described above.

Kern County Health Department: Epidemiologic study of cancer in children in McFarland, California, 1985-1986: Phase I, Statistical Considerations, Current Environment. *Bakersfield, California* 93305, November 1986.

The first report of the findings of an investigation of an increased number of childhood cancer cases in the agricultural community of McFarland, California, with a population of approximately 6,400. From 1975 to 1985 when three cases of cancer in children less than 15 would have been expected, ten were observed. For the period of 1982 to 1985 when one case would have been expected, eight were observed.

The number and types of tumors observed and year of occurrence are: two leukemias (1978, 1978), two Wilms' tumor (1982, 1984), one astrocytoma (1982), one nonHodgkin's lymphoma (1983), one osteogenic sarcoma (1984), one fibrosarcoma (1985), and one rhab-

domyosarcoma (1985). An excess of fetal and infant deaths (miscarriages and stillbirths) also occurred in the time period from 1981 to 1983. No current environmental cause was found.

Lowengart, RA, Peters, JM, Cicioni, C, et al. Childhood leukemia and parents' occupational and home exposures. *Journal of the National Cancer Institute* 1987; 79(1):39-46.

A case-control study of 123 children aged ten or less with leukemia diagnosed between 1980-1984, compared to 123 controls. Statistically significant increased risk of *acute lymphocytic leukemia* was found for children when either parent used household pesticides once a week or more (OR 3.8) or garden pesticides or herbicides once a month or more (OR 6.5); if the mother used household (OR 3.2) or garden (OR 9.0) pesticides; and if the father used household (OR 4.0) pesticides. Use of garden pesticides by the father (OR 5.0) increased the risk, but was not significant.

Pratt, CB, Rivera, G, Shanks, E, et al. Colorectal carcinoma in adolescents. Implications regarding etiology. *Cancer* 1977; 40:2464-2472.

A case report of nine children with *colorectal cancer* (very rare in children), diagnosed at the same hospital between 1974-1975. Eight of the children were from rural areas of Mississippi, Arkansas, or Tennessee and had had exposure to insecticides.

Reeves, JD. Household insecticide-associated blood dyscrasias in children (letter). *American Journal of Pediatric Hematology/Oncology* 1982; 4:438-439.

A report of 15 children aged 2 to 17 years who were reported to the blood dyscrasia clinic at Travis Air Force Base Medical Center in California. The most common exposure was inhalation of household aerosol sprays containing DDVP-Baygon. The most prolonged exposure was in a child with *juvenile chronic myelogenous leukemia* whose mattress had been sprayed twice weekly for most of his life. Eleven children had *aplastic anemia*, and three *acute lymphoblastic leukemia*.

Alvanja, MCR, Blair, A, Merkele, S, et al.

Mortality among agricultural extension agents. *American Journal of Industrial Medicine* 1988; 14:167-176.

A proportionate-mortality and case-control study of 1,495 white male agricultural extension agents in the Cooperative Extension Service of the U.S. Department of Agriculture who died between January 1, 1970 and December 31, 1979, compared to the USDA mortality file exclusive of the agricultural extension workers.

Statistically significant excess mortality in the proportionate-mortality study was found for *colon cancer* (PMR 1.46), *prostate cancer* (PMR 1.50), *kidney cancer* (PMR 2.00), *brain cancer* (PMR 2.08), *lymphatic and hematopoietic cancer* (PMR 2.16), *Hodgkin's disease* (PMR 2.72), *nonHodgkin's lymphoma* (PMR 2.32), *multiple myeloma* (PMR 1.97), and *leukemia* (PMR 1.80).

In the case-control study, statistically significant increased risk was found only for *leukemia* (OR 1.92), which also showed a significant increase in risk with increased number of years as an extension agent. A nonsignificant increased risk was found for nonHodgkin's lymphoma (OR 1.21) and multiple myeloma (OR 1.05), both of which also showed a nonsignificant increase in risk with increased number of years as an extension agent.

CASE REPORTS

El Zayadi, A, Kahlis, A, El Sammy, N, et al. Hepatic angiosarcoma among Egyptian farmers exposed to pesticides. *Hepato-gastroenterology* 1986; 33:148-150.

Case report of 14 patients diagnosed with *angiosarcoma of the liver* at the same hospital in Egypt from 1980 to 1984. Ten of the 14 had a history of 11 to 20 years (mean = 14) of chronic recurrent exposure to agricultural pesticides as sprayers of a variety of organophosphates, organochlorines, and arsenates.

Markovitz, A, Crosby, WH. Chemical carcinogenesis: A soil fumigant, 1,3-dichloropropene as possible cause of hematologic malignancies. *Archives of Internal Medicine* 1984; 144:1409-1411.

A case report of two firemen involved in the clean-up of a tank-truck spill of 1,3-dichloropropene, both of whom developed

FIGURE Abbreviations

PMR	Proportionate Mortality Ratio
PCMR	Proportionate Cancer Mortality Ratio
SMR	Standard Mortality Ratio
SIR	Standard Incidence Ratio
RR	Risk Ratio
OR	Odds Ratio

malignant lymphoma six years later. A case of acute myelomonocytic leukemia in a farmer sprayer is also discussed.

Prabhakar, JM. Possible relationship of insecticide exposure to embryonal cell cancer (letter). *Journal of the American Medical Association* 1978; 240:288.

A report from Illinois of two cases of *testicular cancer* in 1976 in 30-year-old men diagnosed within one year of each other. Both had worked at the same canning plant where they had occupational exposure to pesticides.

Weininger, RB, Davis, G, Hawks, CD. Herbicides and cancer (letter). *Journal of the American Medical Association* 1987; 257:2292.

A report of 92 cases of *nonHodgkin's lymphoma* diagnosed from 1975-1985 in upstate New York. The incidence of 15.3/100,000 (not age-adjusted), compared to SEER data (Surveillance Epidemiology and End Results) of 10.1/100,000 for the U.S. This elevated ratio of 1.51 was stated to support the Hoar study (vide supra), but no data reported regarding whether or not herbicide exposure was a risk factor in the cases.