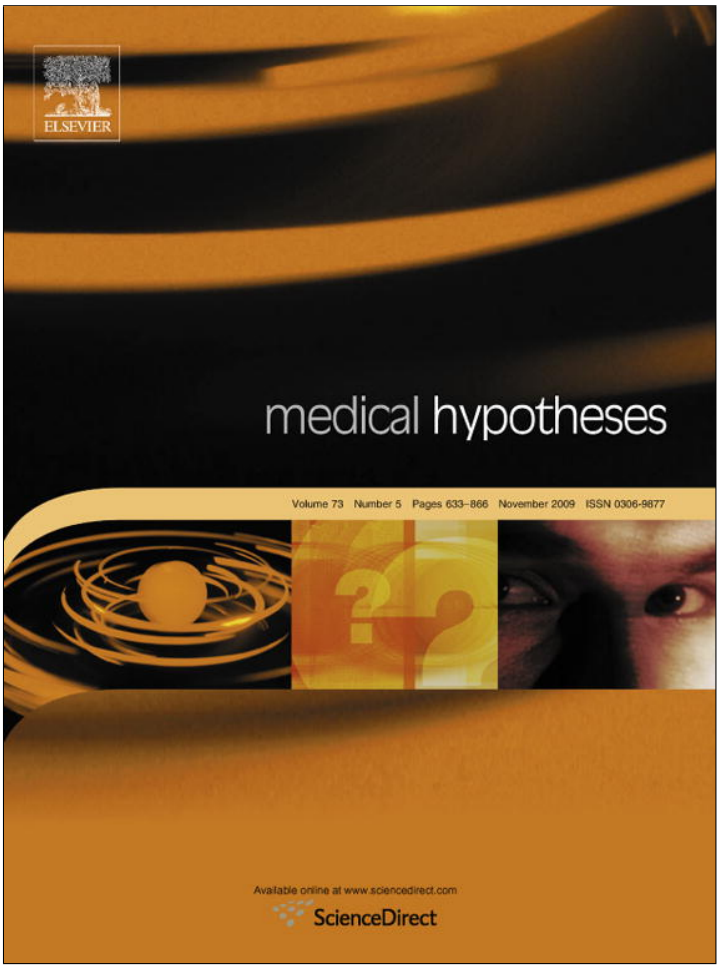
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Most cancer in firefighters is due to radio-frequency radiation exposure not inhaled carcinogens

S. Milham *

Washington State Department of Health (retired) Olympia Washington, USA

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SUMMARY

Recent reviews and reports of cancer incidence and mortality in firefighters conclude that they are at an increased risk of a number of cancers. These include leukemia, multiple myeloma, non-Hodgkin's lymphoma, male breast cancer, malignant melanoma, and cancers of the brain, stomach, colon, rectum, prostate, urinary bladder, testes, and thyroid. Firefighters are exposed to a long list of recognized or probable carcinogens in combustion products and the presumed route of exposure to these carcinogens is by inhalation. Curiously, respiratory system cancers and diseases are usually not increased in firefighters as they are in workers exposed to known inhaled carcinogens. The list of cancers with increased risk in firefighters strongly overlaps the list of cancers at increased risk in workers exposed to electromagnetic fields (EMF) and radiofrequency radiation (RFR). Firefighters have increased exposure to RFR in the course of their work, from the mobile two-way radio communications devices which they routinely use while fighting fires, and at times from firehouse and fire vehicle radio transmitters. I suggest that some of the increased cancer risk in firefighters is caused by RFR exposure, and is therefore preventable. The precautionary principle should be applied to reduce the risk of cancer in firefighters, and workman's compensation rules will necessarily need to be modified.

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Background

In the 1970s I set up a system for coding and analyzing the occupational information on the Washington State death record. Three volumes of these analyses have been published by National Institute of Occupational Safety and Health (NIOSH) beginning in 1976. The final NIOSH volume was published in 1997, and now Washington State occupational mortality data since 1950 is available on-line [1] and is updated automatically. The first monograph, Occupational Mortality in Washington State published by NIOSH in 1976 covering deaths in the years 1950–1971 showed that Washington State firefighters had increased mortality due to brain cancer, malignant melanoma, and non-Hodgkin's lymphoma. None of these cancers had an intuitive connection to inhaled carcinogens.

In 2004, I examined a cluster of three male breast cancers in office workers exposed to high levels of EMF [2]. This added to an already impressive body of reports linking male breast cancer to EMF and RFR [3]. This cancer is so rare that its repeated appearance in EMF/RFR exposure situations functions like a sentinel cancer for these exposures. When a Florida firefighters' cohort was reported as having an increased incidence of male breast cancer [4], the hypothesis that RFR causes some firefighters' cancer was born.

Cancers increased in firefighters

Firefighters have been shown to be at increased risk of developing a number of cancers. A recent review of 32 studies and a meta-analysis of cancer risk among firefighters [5] concluded that multiple myeloma, non-Hodgkin's lymphoma, prostate cancer and testicular cancer were probably associated with firefighting, and that leukemia, skin cancer, malignant melanoma, brain cancer, cancer of the rectum, colon, stomach, buccal cavity and pharynx were possibly associated with firefighting. Another review [6] adds urinary bladder cancer to the probable list. A 2005 study links male breast cancer and thyroid cancer with firefighting [4].

Carcinogenic exposures in firefighters

Firefighters are exposed to a long list of carcinogens in combustion products including asbestos [7], polycyclic aromatic hydrocarbons [8], benzene [9], lead [10] and aromatic amines [11]. The major route of exposure to these carcinogens is by inhalation. Inhalation of carcinogens ordinarily leads to development of respiratory cancers. For example, coke oven workers [12] who inhale coal tar pitch volatiles, and copper smelter workers [13] who inhale arsenic trioxide are at increased risk of developing lung cancer. Respiratory cancers, including lung and laryngeal cancers and respiratory diseases like bronchitis and emphysema, are usually not at increased risk in firefighters. The 32 paper review and

* Address: Washington State Department of Health (retired) Olympia Washington, 2318 Gravelly Beach Loop NW, Olympia WA 98501, USA. Tel.: +1 360 866 0256.
E-mail address: smilham2@comcast.net.

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meta-analysis [5] concludes that lung cancer is unlikely to be associated with firefighting.

EMF/RFR exposure and cancer

In 1982, I was the first to show that workers in jobs with an intuitive exposure to electricity had increased mortality due to leukemia [14]. Since then, non-Hodgkin's lymphoma [15], brain cancer [16], malignant melanoma [17], and male breast cancer [2,3] have been shown to have increased mortality or incidence in electrical workers. The upward turn of malignant melanoma incidence has been ecologically linked to the roll out of television and frequency modulation radio transmission in the 1950s with increased RFR exposure of populations [18]. Malignant melanoma has increased incidence in electronic workers [17] and in office workers exposed to strong EMF fields [19]. High frequency voltage transient exposure (a type of RFR) of teachers in a southern California school has been linked to an increased incidence of malignant melanoma, thyroid and uterine cancer [20]. Amateur radio operators [21] exposed to RFR in their hobby, have increased mortality due to leukemia, multiple myeloma and other lymphatic cancers. Childhood leukemia has increased incidence in populations living near powerful terrestrial antennas which emit RFR [22–24]. A cluster of cancer of the testes has been reported in traffic policemen who held the live radar unit in their laps while on duty [25].

EMF and RFR exposure of firefighters

Firefighters are exposed to RF from transmitters which are at times located in the firehouse. Fire vehicles and trucks area also equipped with two-way radio systems which can expose vehicle occupants to RFR, and personal transceivers expose the firefighters to RFR while communicating at the fire scene. US firefighters' radio systems are described in great detail in a National Institute of Occupational Safety and Health (NIOSH) document [26].

Hypothesis

Many of the cancer types with an increased incidence in firefighters are caused by firefighters' occupational exposure to radio-frequency radiation. Current thinking attributes the cancer increase to inhalation of carcinogenic combustion products. The nature of the inhaled carcinogens has certainly changed over time, since building materials and furnishings have changed increasingly to man-made materials. Yet, the Washington State occupational mortality data set showed that brain cancer and malignant melanoma were already in excess in firefighters' deaths occurring in the period 1950–1971 and continue to be in excess since then. The same data set showed that men with intuitive exposure to EMF's and RFR had increased mortality due to leukemia, brain cancer and non-Hodgkin's lymphoma [1]. An office workers cohort with high EMF exposure showed a cancer increase, with a high risk of malignant melanoma [19]. School teachers exposed to a type of RFR had increased incidence of malignant melanoma and thyroid cancer [20].

Evaluation of this hypothesis

The most difficult part of an evaluation of this hypothesis, as in all occupational cancer studies, is characterizing the past EMF/RFR exposures which caused these cancers, so that cancer latencies can be factored in. If historical RFR exposure can be added to the exposure information available on firefighters, cohort and case-control incidence or mortality studies should be able to test this hypothesis.

Consequences of this hypothesis

One of the most important facets of this hypothesis is that many firefighters' cancers may be preventable. Workman's compensation rules for work-initiated cancers will need revision. Like many other potential occupational carcinogens, it would be wise to exercise the precautionary principle to minimize RFR exposure in firefighters before definitive proof of carcinogenicity is available.

References

[1] Milham S. Occupational mortality in Washington State 1950–1989 DHHS, National Institute of Occupational Safety and Health 1997 DHHS (NIOSH) Publication No. 96–133. Updated data available online at: https://fortress.wa.gov/doh/occmort/ [occupational code for firefighters is 850].
[2] Milham S. A cluster of male breast cancer in office workers. Am J Ind Med 2004;46(1):86–7.
[3] Erren TC. A meta-analysis of epidemiologic studies of electric and magnetic fields and breast cancer in women and men. Bioelectromagnetics 2001(Suppl. SS):105–19.
[4] Ma F, Fleming LE, Lee DJ, Trapido E, Gerace TA, Lai S, et al. Mortality in Florida professional firefighters 1972–1999. Am J Ind Med 2005;47(6):509–17.
[5] Le Masters GK, Genaidy AM, Succop P, Deddens J, Sobeih T, Barriera-Viruet H, et al. Cancer risk among firefighters: a review and meta-analysis of 32 studies. J Occcup Environ Med 2006;48:1189–202.
[6] Bogucki S, Rabinowitz PM. Occupational health of police and firefighters. In: Rosenstock L, Cullen MR, Brodkin CA, editors. Textbook of clinical occupational and environmental medicine. Philadelphia: Elsiever Saunders; 2005. p. 272–81.
[7] Markowitz S, Garibaldi K, Lillis R, Landrigan P. Asbestos exposure and firefighting. Ann NY Acad Sci 1992;643:573–6.
[8] Moen BF, Ovrebo S. Assessment of exposure to polycyclic aromatic hydrocarbons during firefighting by measurements of urinary l-hydroxypyrene. J Occup Environ Med 2001;39:515–9.
[9] Caux C, O'Brien C, Viau C. Determination of firefighter exposure to polycyclic aromatic hydrocarbons and benzene during fire fighting using measurement of biologic indicators. Appl Occup Environ Hyg 2002;17:379–86.
[10] van Wijngaarden E, Dosemeci M. Brain cancer mortality and potential occupational exposure to lead. Findings from the National Longitudinal Mortality Study 1979–1989. Int J Cancer 2006;119:1136–44.
[11] Kellen E, Zeegers M, Paulussen A, Vlietinck R, Vlem EV, Veulemans H, et al. Does occupational exposure to PAHs, diesel and aromatic amines interact with smoking and metabolic genetic polymorphisms to increase the risk of bladder cancer? The Belgian case control study on bladder cancer. Cancer Lett. 2007;245:51–60.
[12] Costantino JP, Redmond CK, Bearden A. Occupationally related cancer risk in coke oven workers: 30 years of followup. J Occup Environ Med 1995;37(5):597–604.
[13] Lubin JH, Pottern JM, Stone BJ, Fraumeni Jr JF. Respiratory cancer in a cohort of copper smelter workers: results from more than 50 years of follow-up. Am J Epidemiol 2000;181(6):554–65.
[14] Milham S. Mortality from leukemia in workers exposed to electrical and magnetic fields. N Engl J Med 1982;307(4):240.
[15] Milham S. Mortality in workers exposed to electromagnetic fields. Environ Health Perspect 1985;62:297–300.
[16] Savitz DA, Loomis DP. Magnetic field exposure in relation to leukemia and brain cancer mortality among electric utility workers. Am J Epidemiol 1995;141(2):123–34.
[17] Vagero D, Ahlbom A, Olin R, Sahlsten S. Cancer morbidity among workers in the telecommunications industry. Br J Ind Med 1985;42(3L):191–5.
[18] Hallberg O, Johansson O. Melanoma incidence and frequency modulation (FM) broadcasting. Arch Environ Health 2002;57(1):32–40.
[19] Milham S. Increased incidence of cancer in a cohort of office workers exposed to strong magnetic fields. Am J Ind Med 1996;30(6):702–4.
[20] Milham S, Morgan LL. A new electromagnetic exposure metric: high frequency voltage transients associated with increased cancer in teachers in a California school. Am J Ind Med 2008;51:586–97.
[21] Milham S. Increased mortality in amateur radio operators due to lymphatic and hematopoietic malignancies. Am J Epidemiol 1988;127(1):50–4.
[22] Hocking B, Gordon J, Grain HL. Cancer incidence and mortality and proximity to TV towers. Med J Aust 1996;165:601–5.
[23] Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A, et al. Adult and childhood leukemia near a high power radio station in Rome, Italy. Am J Epidemiol 2002;155(12):1096–103.
[24] Ha M, Im H, Lee M, Kim, Gimm Y, Peck J. Radio-frequency radiation. Exposure from AM radio transmitters and childhood leukemia and brain cancer. Am J Epidemiol 2007;166(3):270–9.
[25] Davis RL, Mostofi FK. Cluster of testicular cancer in police officers exposed to hand-held radar. Am J Ind Med 1993;24(2):231–3.
[26] Firefighters radio communication. 2003 Report prepared by TriData Corporation for NIOSH. www.cdc.gov/niosh/fire/pdfs/FFRCSch2.pdf.