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LITERATURE REVIEW

Introduction and purpose of this literature review:

Safety in the workplace is very important. The most effective means to achieve safety, of course, is prevention. However, in some occupations, such as firefighting, there are unavoidable inherent risks. Therefore scientific, data-based evaluation of risks and of the potential effects of those risks ought to best guide the development of protective equipment and other mitigation strategies.

As improved preventive and protective measures are available, one can anticipate a safer workplace. Of course, there may be new risks, currently unforeseen – an example would be the risk of new chemicals that might be produced by industry in the future, which might pose risk to workers in manufacture, but also to firefighters.

Education of workers, and employers, is critical to this process, to cooperate with studying the issues, and to endorse/provide/use the preventive and protective measures available.

In Oregon, there are legal presumptions that certain medical conditions occurring in firefighters are work-related. The concept behind these presumptions is that the occupation of firefighting and exposures of that occupation increase the incidence of these conditions to an extent that it is highly likely that this occupation is the cause of these particular conditions in firefighters.

For such presumptions to be reasonable the presumptions ought to be based on good science, examined regularly for continued accuracy. If a medical condition were to be shown, with good science, to be caused by the occupation of a firefighter, that condition would reasonably be added to the legal presumptions. Similarly, if scientific data were to show that a risk had been mitigated and incidence of a condition were to decrease to that seen in the non-firefighter population, or if a particular condition were to be shown to be caused by something other than conditions of the firefighter occupation, that particular presumption ought to be changed/removed.

As there is nuance to these conclusions, and as it is much less likely that a condition will be removed from the list than added, for political and practical reasons, changes in the law ought to be made with caution.

Another option that has been considered is to create a separate funding source, outside of workers' compensation, to finance the care of medical conditions in firefighters regardless of the relationship of these conditions to the occupation. It is possible that the State of Oregon might take this stance, however, were the State to legislate such support, it should be very clear that scientific medical data would not support every condition for which a worker might wish compensation. The State would be providing financial support for other, non-scientific reasons.

There are two aspects of cancer and firefighters for which data are provided in this review.

The first aspect concerns female cancers. The number of females serving as full-time firefighters, exposed to fires, toxins, and other hazards, has historically been much lower than males. For this reason, there are no robust data for female cancers at this time in history. However, data are being collected by multiple investigators, and some data are available at this time.

It is important to clarify that the addition of science/data-based presumptions for females should not be considered a parity issue but rather a scientific issue. The ovary is not the same as the testis, males have no counterparts to the cervix and uterus, and male breast cancer is significantly different from female breast cancer.

As an example of important nuance, breast cancer is currently included in the list of presumptive conditions in Oregon statute, however, it is reasonable to challenge that presumption in workers who carry high-risk genetic mutations whose effect would be significantly more likely to be the cause of breast cancer than firefighting, in both males and females, or in those who have a family history of breast or ovarian cancer.

The second aspect of this report concerns the risk of bladder cancer. Some data from the distant past, when there was a much higher prevalence of tobacco use/cigarette smoking including among firefighters, suggested an increase in bladder cancer risk, however, most data have been inconclusive, not reaching statistical significance.

Already mentioned is genetic propensity to breast, ovarian and certain other cancers. A different example of nuance, and of ongoing societal improvements in prevention, is related to cancer caused by human papilloma virus (HPV), specifically some head and neck cancers, anal cancers, and cervical cancers. Young people, especially females, are now routinely receiving vaccination against HPV. One can anticipate a marked decrease in cancers caused by HPV in the future. It is reasonable to challenge the presumption that a cancer caused by HPV is more likely than not due to firefighting, especially in the era of improved protective equipment, and

when firefighters are deployed in non-fire roles such as emergency medical personnel, reducing their toxin and hazard exposures.

There are assuredly other currently known risks of select cancers which would not relate to firefighting, and more data will undoubtedly become available in the future.

In summary, the state of the art of data collection and scientific understanding of cause and effect, or biological mechanism, for increased cancer risk in firefighters is complex and nuanced. Smoking and other unhealthful and potential carcinogenic behaviors have been decreasing over time. Protective equipment has increased in quality, and regulations requiring the use of equipment in more situations such as fire investigation have changed. There is a better understanding of the cause of some cancers. And more data are being collected in a more thorough and accurate manner.

It is very likely that select cancers are indeed increased in firefighters, specifically those with significant exposure in contrast to those in more supportive roles. It is however important to differentiate between those cancers which can be demonstrated to be related to exposure and those for which the data and the biological explanation are not available. Presuming the State of Oregon desires decisions to be based on science, it is important to foster the collection of accurate data and to modify decisions whether in a preventive or a post-hoc fashion according to the sciences as it evolves.

Annotated bibliography:

Bigert, Carolina & Martinsen, Jan & Gustavsson, Per & Sparén, Pär. (2020). Cancer incidence among Swedish firefighters: an extended follow-up of the NOCCA study. *International Archives of Occupational and Environmental Health*. 93. 10.1007/s00420-019-01472-x.

This is a report based on a cohort study meaning that a group of people who are similar in some way are followed over time. A retrospective cohort study looks back in time. There is no control group and no specific treatment. The Framingham heart study is an example as is the Nurses' Health Study.

This particular study is the Swedish component of the Nordic Occupational Cancer (NOCCA) project, including six million people who participated in 1960, 1970, 1980, and 1990. In this group were 8136 male firefighters. The results did not support an overall risk of cancer among Swedish firefighters, except for a possible risk of non-melanoma skin cancer. Specifically, there was not a statistically significant increased risk of bladder cancer noted, with 109 total cases in the population of 8136 firefighters, between 1961 and 2009.

Casjens, S., Brüning, T. & Taeger, D. Cancer risks of firefighters: a systematic review and meta-analysis of secular trends and region-specific differences. *Int Arch Occup Environ Health* 93, 839–852 (2020). <https://doi.org/10.1007/s00420-020-01539-0>

This report is a systemic review of cohort studies, meaning that a group of people who are similar in some way are followed over time. A retrospective cohort study looks back in time. There is no control group and no specific treatment. The Framingham heart study is an example as is the Nurses' Health Study. There have been many firefighter cohort studies over the years.

This analysis includes 25 cohort studies from six different countries.

There is strong evidence that firefighters are exposed to various toxins, however, it is important to distinguish exposure from disease incidence. Many studies have addressed risk, however, "Findings among these studies have been generally inconsistent. Reasons for this might be the lack of included non-occupational risk factors, missing specification of the exposure, period effects, and country-specific differences. All of these meta-analyses did not consider changes over time of firefighting technology, personal protective equipment (PPE), or used materials in buildings, furniture, or vehicles, which might have led to different cancer risks over the past decades. Combustion and pyrolysis products from newer building materials and furnishings (particularly polymers) are believed to be more toxic than smoke from fires in buildings built before these materials were widely used (Alarie 1985). It has been shown in a series of experimental fire tests that the highest pollutant concentrations resulted from the combustion of polymeric materials (Reisen et al. 2014). Polymers have been used in large amounts in Europe and North America since the 1950s (Guidotti and Clough 1992; Alarie 1985; Pedersen et al. 2018). However, the other studies showed that the composition of the smoke produced by fires of various kinds was similar (Austin et al. 2001b, c).

"In the past, PPE of firefighters changed tremendously. The use of modern self-contained breathing apparatus (SCBA) started during the 1960s and 1970s (Misner et al. 1987) and is commonly used today by municipal firefighters, although they are not worn during the whole firefighting activity especially during overhaul (International Agency for Research on Cancer (IARC) 2010; Austin et al. 2001a). In the 1980s, modern firefighting helmets like the F1 helmet and advanced fire and heat resistant suits were introduced (Pedersen et al. 2018; Hasenmeier 2008). The cancer risk in firefighters may also vary between different geographical areas because of probably different exposure patterns depending on work activities and PPE (Howe and Burch 1990; Moher et al. 2009)."

Again these authors found that overall the incidence of cancer in firefighters did not differ from the general population, and the overall incidence of mortality was not only similar to the general population but there was a decrease over time. There were nevertheless supportive data for melanoma of the skin, and prostate cancer and regional differences were observed for

increased risk of bladder cancer. Data available for breast cancer (male or female not separated) were inconclusive, and no data were presented for other specifically female cancers. Casjens noted, optimistically, that “The risk estimates are rather moderate and mostly declining over time. The introduction of innovative firefighting techniques, safer PPE, better communications, and information systems, as well as changes in the awareness of hazards, have provided a safer and healthier working environment for firefighters over time leading to a reduction of overall cancer SIR and SMR. The increase of general preventive medical checkups and possible additional screenings for firefighters might have led to a higher rate of diagnosed prostate cancer and malignant melanoma of the skin in the recent past. However, further efforts must be made to make the job as a firefighter even safer.”

Charbotel, Barbara & Fervers, Beatrice & Jp, Droz. (2013). Occupational exposures in rare cancers: A critical review of the literature. *Critical Reviews in Oncology/Hematology*. 90. DOI; 10.1016/j.critrevonc.2013.12.004.

For this report, Charbotel et.al. analyzed rare cancers, i.e. those with incidence of fewer than 6 cases per 100,000 population per year. 6820 medical articles were identified, from which 187 publications and data from IARC (International Agency for Research on Cancer) were included in this report. To be selected for inclusion, criteria included study design, original-versus review, pathology to accurately identify the cancers, and occupational exposure.

Two reports suggested the association of male breast cancer with alkylphenolic compounds which among other uses are found in fire retardant materials, and with gasoline combustion products. There is no data available in regard to testing for mutations, which is standard medical practice for males with breast cancer at this time, due to increased risk for male breast cancer as well as other types of cancer. The conclusion was that there was insufficient evidence.

Three reports suggested an association between cervical cancer and organic solvents, trichloroethylene, and metalworking fluids. There is no available data on HPV (human papilloma virus) status, and vaccination against HPV, now considered standard of care for girls and young women, and considered for males (due to other HPV related malignancies) – HPV is a known cause of cervical cancer. The conclusion was that there was insufficient evidence.

Four reports suggested the association of ovarian cancer with asbestos; silica dust; diesel exhaust; and trichloroethylene (13 cases of 20,508 aerospace workers; 8 of 4733 occupational exposures) with high cumulative exposure. There were no data provided on genetic mutation status, which is standard medical practice for all diagnoses of ovarian cancer.

These authors did opine that there were supportive data for asbestos exposure and ovarian cancer and noted that ovarian cancer is one of the four cancers considered by the IARC to show sufficient evidence for association with asbestos exposure. Mutation status was not addressed, nor were subtypes of ovarian cancer considered.

There were no data available for tumors of the vulva and vagina.

The authors also noted that, due to the low incidence of rare cancers, results might be inconsistent due to the lack of data alone, and in the same vein, positive associations might be due to chance alone. In other words, it can be difficult to be confident of data with rare occurrences (of any type).

Gaertner, R.R.W., Trpeski, L. & Johnson, K.C. Canadian Cancer Registries Epidemiology Research Group. A case-control study of occupational risk factors for bladder cancer in Canada. *Cancer Causes Control* 15, 1007–1019 (2004). <https://doi.org/10.1007/s10552-004-1448-7>

Gaertner et. al. performed a population-based case-control study of 887 individuals with bladder cancer. Case control was performed in this study using a randomly selected group of individuals of the same age and gender who were asked to provide the same data as those with bladder cancer, through detailed questionnaires.

The group included 8 male firefighters and 13 male firefighter controls, a sample size too small for conclusions. However increased risk was associated with male hairdressers, miners, primary metal workers, and mechanics, as well as female nurses, general clerks, lumber processors, and general laborers. Also smoking, well known as a risk factor, and perhaps dietary factors such as fried foods might have some role.

Glass, Deborah & Monaco, Anthony & Pircher, Sabine & Vander Hoorn, Stephen & Sim, Malcolm. (2019). Mortality and cancer incidence among female Australian firefighters. *Occupational and environmental medicine*. 76. 215-221. DOI: 10.1136/oemed-2018-105336.

Glass evaluated a cohort of 1682 female paid firefighters and 37,962 volunteer firefighters – volunteer being common in Australia. Of note, however, most of the volunteers reported that they had actually attended a few incidents. Removing from the data those who had never been recorded as attending an incident did not change the findings.

For volunteers, the overall risk of mortality and risk from all major causes of death were lower than the general population, whether or not they had attended fires. This may be due to what is called the healthy worker effect.

Most of the paid female firefighters had not served very long/were relatively recent recruits. At this time, there were too few in this cohort to draw conclusions about cancer mortality or incidence. Continued follow-up will be needed to obtain meaningful data.

Jalilian, H., Ziaei, M., Weiderpass, E., Rueegg, C.S., Khosravi, Y. and Kjaerheim, K. (2019), Cancer incidence and mortality among firefighters. *Int. J. Cancer*, 145: 2639-2646. <https://doi.org/10.1002/ijc.32199>

This report is a review of published studies in which, in addition to other criteria, the exposure clearly preceded the outcome and firefighting occupation was compared to the general population, other occupations or “internal comparison was done.” Using the stated criteria of the investigators, 98 studies were reviewed of over 1500 screened. The data came from 11 countries, with data collected from 1950-2014, and a maximum number of 30,057 firefighters included.

As with other investigators, Jalilian et.al. found there was “no statistically significant association between firefighting occupation and incidence of mortality risks of overall cancers,” and “we found an incidence or mortality risk of 0.99” which means if anything, slightly lower than the general population.

However, as have some others, Jalilian found an increased risk of bladder cancer. No data were presented for breast – male or female – nor for any specifically female cancers. The number of female firefighters included in this report is not stated.

Kullberg, Cecilia & Andersson, Tomas & Gustavsson, Per & Selander, Jenny & Tornling, Göran & Gustavsson, Annika & Bigert, Carolina. (2018). Cancer incidence in Stockholm firefighters 1958–2012: an updated cohort study. International Archives of Occupational and Environmental Health. (2018) 91. 285-291. DOI: 10.1007/s00420-017-1276-1.

This report is an update of data from 1080 males who served as firefighters for at least one year in Stockholm between 1931 and 1983. Overall the risk of cancer was low, however, there did appear to be increased risk of stomach cancer in this older cohort. There was no increased risk noted for prostate or melanoma.

Laroche, Elena & L'Espérance, Sylvain. (2021). Cancer Incidence and Mortality Among Firefighters: An Overview of Epidemiologic Systematic Reviews. International Journal of Environmental Research and Public Health. 18. 2519. DOI: 10.3390/ijerph18052519.

This report is a meta-analysis, meaning a compilation of multiple reviews and studies published by others, meeting the specific criteria for which the authors were selecting which to include. From 1072 articles screened, 32 were considered and 11 considered to meet the criteria. These criteria included epidemiologic studies; studies reporting cancer risk estimate addressing risks of harmful exposures; studies reporting on certain cancers specifically brain, colon, bladder, leukemia, and non-Hodgkin's lymphoma; and studies in which the exposure clearly preceded the outcome and the firefighting was compared to the general population or other valid comparisons.

There is overlap with this meta-analysis and some of the other literature here reviewed.

An assessment was made to try to discern bias and quality of data collection.

The main objective of this review was to try to assess the consistency of the conclusions made in available reviews of cancer risk of firefighters. Though there was observed risk noted for several cancers, “These observations must be interpreted with caution. This literature has many limitations and shortcomings. One limitation is that the methodological quality of the reviewed SR’s is generally low. For the most part, the inclusion and exclusion criteria for original studies are absent or not very explicit.”

Laroche concluded, “The results of our review show that statistically some cancers may be more prevalent or may cause more deaths in male firefighters. In order to determine a causal relationship, it is important that a biological mechanism or exposure to a recognized carcinogen be linked to the observed cancers.” “Although the links between exposure to different carcinogens such as asbestos, organic solvents or PAH’s and the incidence of bladder cancer, mesothelioma or non-Hodgkin’s lymphoma have been more thoroughly studied, the biological plausibility for other cancers needs to be better investigated.”

Phrased differently, Laroche is commenting that the quality of the data available is less than ideal and that reasonable biological mechanisms, or reasons why certain exposures might lead to cancer, are frequently not existent. This is important, in that it is unreasonable to presume that every cancer must necessarily be linked to firefighting, or to any occupational exposure for that matter. Some cancers are increased due to other factors, such as for example genetic tendency or previous infection (such as HPV or herpesviruses).

Lee, DJ, Koru-Sengul, T, Hernandez, MN, et al. Cancer risk among career male and female Florida firefighters: Evidence from the Florida Firefighter Cancer Registry (1981-2014). *Am J Ind Med.* 2020; 63: 285– 299. <https://doi.org/10.1002/ajim.23086>

Lee et.al. report on the Florida Firefighter Cancer Registry, which includes three data sources, includes demographics such as date of birth and links to the Florida Cancer Data System, which was mandated in 1981 as a cancer registry. In addition, the Florida State Fire Marshal’s Office has collected and maintained certification records for all firefighters since 1972 for both volunteers and professionals. Thus Lee was able to exclude volunteers or those certified to perform tasks with lesser or no exposure such as fire extinguisher inspectors for future analysis.

Because of this robust cooperation and availability of resources, this report examines risk in over 100,000 career Florida firefighters, including 5059 females, over a 34 year period, an extremely large database.

There were a total of 168 cancers recorded for the female firefighters, of which there were 10 or more cases of breast, bladder, thyroid, melanoma, and lung. Although an earlier report based on the Florida cancer registry had suggested a possible increase in cervical cancer, there was no increase noted in this later and larger report, nor increase noted in other female related cancers. In addition, Lee comments that the data in reference to breast cancer risk is also not

large enough even with pooling of data from others such as Chicago, Philadelphia, and San Francisco. As well, genetic mutation risk is not included in these data.

Bladder cancer risk was not supported in these data, though there was a suggestion. Other reports have noted that bladder cancer risk was significant in cohorts of firefighters many years in the past, perhaps when smoking was more prevalent, and equipment less protective.

Ma, F.; Fleming, LE; Lee, DJ; Trapido, E; Gerace, TA. Cancer Incidence in Florida Professional Firefighters, 1981 to 1999, Journal of Occupational and Environmental Medicine: September 2006 - Volume 48 (9), 883-888. doi: 10.1097/01.jom.0000235862.12518.04

This study included 34,796 male but also 2,017 female firefighters from Florida. There were 970 male and 52 female cases of cancer documented between 1981 and 1999. In this particular study, there was increased incidence of bladder cancer in males, and increase incidence of testicular cancer. Increased incidence of thyroid cancer was found in both males and females. However, this study did not find the increase in incidence of brain, lung, and lymphoma noted in some other reports. None of the data in reference to female cancers reached statistical significance, meaning that the results could as easily be explained by chance, with the most suggestive being 10 cases of breast cancer, no data provided on genetic tendency or family history, and this a very common cancer in women.

Ma, F.; Fleming LE, Lee DJ, Trapido E, Gerace TA, Lai H, Lai S. Mortality in Florida professional firefighters, 1972 to 1999. Am J Ind Med. 2005 Jun;47(6):509-17. doi: 10.1002/ajim.20160. PMID: 15898094.

This report by the same authors includes essentially the same data on 34,796 male and 2,017 female professional firefighters in Florida as the preceding report. In this report, increases were noted in male breast cancer (there was no data presented on genetic mutation status, which is known to increase risk significantly, and evaluation for which is the current standard of care) and thyroid cancer. There was noted increased risk of death from bladder cancer, which did not reach statistical significance, but this increase was most especially noted in those who were certified between 1972 and 1976 – perhaps related therefore to improvements in protective equipment.

Female firefighters had similar morality patterns to Florida women except for atherosclerotic heart disease. The mean years certified for the female professional firefighters was shorter than for the males, 8.7+/- 5.7, versus 14.3+/-8.6. Age at first certification was similar, but age at death was lower, specifically due to atherosclerotic heart disease.

As with some other reports, there was increase in male breast cancer, with no data on genetic mutation status which would affect risk significantly.

Keeping in mind that the cohort was only 2,017 females, and the length of firefighting career was less than the males in this study, “Among female firefighters, there was no significant increase or decrease of overall cancer mortality or of any site- specific cancer including breast and lung. “ Only one case of female breast cancer was recorded, and no female specific cancers were recorded.

McClure, Laura A. et. al. (2019) Availability and accuracy of occupation in cancer registry data among Florida firefighters. PLOS One 14(4): e0215876. 2018 <https://doi.org/10.1371/journal.pone.0215867>

This is a report of a linkage between data from the Florida Cancer Data system 1981-2014 and the Florida State Fire Marshal’s Office 1972-2012.

Among 3928 career firefighters, nearly half were missing a registry-derived occupation code and only 17% had a firefighting code. Males were more likely to have the firefighting code, as were younger registrants or those with more recent diagnoses.

This report highlights some of the issues confounding proper data collection, including a system which makes it easy to have complete and accurate information on which to base decisions. It was also clear that older data were less complete and reliable, and newer, perhaps related to electronic health records, more likely to be accurate.

“Linkage of firefighter data and cancer registry data on a national level would offer unparalleled advantage in providing accurate occupational information for this at-risk population.”

McDiarmid, Melissa A. et al. The firefighting environment risk for breast cancer, gynecologic malignancies and lymphoma: A report prepared for the International Association of Fire Fighters. The University of Maryland Occupational Health Project, June 25, 1999. Obtained from:

http://www.akleg.gov/basis/get_documents.asp?session=32&docid=26848

With the premise that “a substantial portion of the cancer burden is environmentally caused or influenced by environmental agents,” McDiarmid addressed personal, societal, and occupational aspects of select cancers based on information available in 1999.

She noted that “most of the risk factors for breast cancer development relate to the woman’s lifetime burden of estrogen exposure.” She mentions other factors such as socioeconomic class, alcohol, and tobacco, and specifically mentions two genetic mutations, now known to play a very important role in those women who carry certain mutations.

There are suggestive data for breast cancer risk related to a variety of compounds in the ambient environment, including pesticides such as DDT, ionizing radiation, electromagnetic fields, tobacco smoke and air pollution.

Ovarian cancer is also noted to be associated with genetic mutations and to be more frequent in women who have never had children – pregnancy and oral contraceptives are associated with decreased risk. It is interesting to note that immigrants' risk approaches that of their new host counties, suggesting environmental factors, perhaps including diet.

In general studies of occupational exposure and risk have supported hairdressers and beauticians, and women working in the printing industry in reference to ovarian cancer. Significant exposure to polycyclic aromatic hydrocarbons (PAH) for five to nine years showed a non-statistically significant risk of ovarian cancer; data in reference to pesticides were inconclusive, and strongly suggestive data in reference to women highly exposed to talc/asbestos were presented from several reports.

Data for uterine endometrial cancer supported chemotherapy drugs and ethylene oxide used in the health care industry, but no other environmental agents were noted by McDiarmid.

McDiarmid noted the role of HPV in cervical cancer, as well as cigarette smoking, sexual behavior, hormonal levels, and diet.

McDiarmid and others have studied specific chemicals in the firefighting environment, however, states, "It is important to note that where concentrations are presented, they should not be construed as actual firefighter exposures. Although they represent environmental measurements made within the breathing zone of the firefighter, actual exposures are somewhat less when respiratory protective equipment is properly used. Assuming a nominal protection factor of 2,000 common for the positive pressure demand-type SCBA most commonly used by firefighters, actual exposures 2,000 times less than the concentrations reported can be postulated (Lees, 1995). Short-term higher exposures, perhaps approaching the numbers presented, can be postulated as a result of temporary misfit of respirators, etc. During the overhaul phase, when respiratory protective equipment is less frequently used, however, air concentration of some chemicals may be as high as or higher than those reported during the firefighting phase (Burgess et al. 1979; Barnard et al. 1979). She discusses her methodology of extrapolation of data in reference to particulate and smoke, diesel exhaust, asbestos, and polycyclic aromatic hydrocarbons.

McDiarmid suggests several compounds "to be explored for potential association with breast cancer, the gynecologic malignancies, and lymphomas in women firefighters. These include benzene, 1, 3-butadiene, asbestos, PAH's, diesel exhaust, and estrogenic agents (i.e. DDT). This review does not conclude that there are definite exposures in the firefighting role of women that are causative of these cancers, but rather points to needed research.

Muegge, Carolyn & Zollinger, Terrell & Song, Yiqing & Wessel, Jennifer & Monahan, Patrick & Moffatt, Steven. (2018). Excess mortality among Indiana firefighters, 1985-2013. American Journal of Industrial Medicine. 61. 10.1002/ajim.22918. DOI:[10.1002/ajim.22918](https://doi.org/10.1002/ajim.22918)

This is a study from death certificate data from the Indiana State Dept. of Health, from 1985-2013. 2848 firefighter deaths were recorded, as well as 11,272 matched comparison cases, 4 per firefighter. Heart disease was the leading cause of death in non-firefighters, with malignancy second; the opposite was true for firefighters only in the most recent period, 1995-1999, with cancer as a cause of death in firefighters more than heart disease.

The overall odds of death due to malignancy were higher for firefighters, but interestingly not of the respiratory system nor most other cancers, but of the buccal cavity and pharynx, pancreas, kidneys, and brain higher than the matched control group.

The improvement in cardiovascular mortality is notable and encouraging, in that attention to health on the job might make a significant difference in the risk of illness for firefighters.

Pukkala, Eero et al. "Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries." *Occupational and Environmental Medicine* 71 (2014): 398 - 404.
<http://dx.doi.org/10.1136/oemed-2013-101803>

This is a similar report of the same population as the next article. The conclusions are not materially different.

Pukkala, Eero & Martinsen, Jan & Lyng, Elsebeth & Gunnarsdóttir, Hólmfríður & Sparén, Pär & Tryggvadóttir, Laufey & Weiderpass, Elisabete & Kjaerheim, Kristina. (2009). Occupation and cancer-follow-up of 15 million people in five Nordic countries. *Acta oncologica* (Stockholm, Sweden). 48. 646-790. 10.1080/02841860902913546.
DOI:10.1080/02841860902913546

The data for this study were taken from census data from 15 million people in 5 Nordic countries, and their cancer registries. 16,422 male firefighters were included, one of the largest available study groups.

Pukkala et.al. found a slightly increased risk for all cancer sites combined, in contrast to many other reports. In this report there was notable excess prostate cancer in younger men (30-49 years) and melanoma, but not in older men. In older men, non-melanoma skin cancer, adenocarcinoma of the lung, and mesothelioma incidence were increased. And, interestingly, the incidence of testicular cancer was decreased. No male breast cancer was noted, although the authors did discuss some data on male breast cancer associated with shift work. Increased risk of bladder cancer was not seen, with a total of 194 cases in 16,422 firefighters.

Soteriades, Elpidoforos & Kim, Jaeyoung & Christophi, Costas & Kales, Stefanos. (2019). Cancer Incidence and Mortality in Firefighters: A State-of-the-Art Review and Meta-Analysis. *Asian Pacific Journal of Cancer Prevention*. 20. 3221-3231. DOI: 10.31557/APJCP.2019.20.11.3221.

This report is a meta-analysis, meaning a combination of many similar research reports, encompassing 49 reports published between 1966 and 2007. Necessary for inclusion in this analysis were quantitative data on original reports and specific firefighter data. There were several types of study design, which might make statistical conclusions less definite.

Studies were designated as good or as adequate based on a modified MOOSE guideline, described. Support for increased risk for bladder cancer incidence and mortality were specifically not seen regardless of the designation applied by the research team. No data were presented for breast cancer – male or female – or for any specific female cancers. The total number of firefighters, and the number of females, were not presented.

As do other researchers, Soteriades comments on changing equipment and job duties:

“Furthermore, we need to consider changes in personal protective equipment that might have affected the current levels of exposure in comparison to those reported in previously published studies.”

“The most significant development in the recent history of firefighting has been the gradually increasing and now widespread use of the positive pressure Self Contained Breathing Apparatus (SCBA) by firefighters. This respirator has contributed to a significant decrease of smoke exposure during fire suppression operations. In addition, current significantly lower exposure levels of firefighters, especially during fire suppression operations, reflect not only on the use of improved personal protective equipment such as SCBA, but also on the decreasing number of structural fires overall, suggesting that there is not only a marked decrease in peak exposures during fires but also a decrease in cumulative exposures as a direct effect of the decreasing number of fires.

“On the other hand, despite the use of SCBA during active fire suppression, Burgess et al., (2001) reported recently that firefighters who participate in overhaul operations and do not use SCBA or other respirators, exhibit acute adverse respiratory changes. Such repeated exposures may have other cumulative effects over time, potentially contributing to long-term adverse health effects including cancer. SCBA is, usually, not worn during overhaul, and although other respirators are indicated, it is not always standard practice to use them.

“Furthermore, we should consider that during brush and forest fires, firefighters tend to have an increased risk of pulmonary sequelae compared to those associated with structural firefighting. This discrepancy is more likely the result of decreased use / decreased level of respiratory protection in these workers than from differences in the constituents of the fire smoke to which they are exposed (Harrison et al., 1995). Nevertheless, the vast majority of studies used in the current meta-analyses, do not involve forest firefighters, and therefore, may not reflect the exposures and risks experienced by that specific subgroup of firefighting professionals.

“It is also worth noting that several recent studies have documented or estimated the time spent on different duties by firefighters (Kales et al., 2003; Kales et al., 2007) and the results clearly show that fire suppression operations do not exceed, at most, 5% of the overall annual duties of firefighters (Austin et al., 2001). Similarly, the time spent on non-fire emergency duties appears to be relatively high (approximately 25%). For example, about 90% of emergency calls according to the National Fire Protection Association (NFPA) involve non-fire emergencies, primarily the provision of emergency medical services. The estimated time spent for non-emergency fire station duties is even higher (approximately 50%) in contrast to the general public notion that firefighters spend most of their time directly in fire-related duties (NFPA, 2007). “

U.S. Fire Administration/FEMA publication. Emerging health and safety issues among women in the fire service. March 2019. Obtained from: https://www.usfa.fema.gov/downloads/pdf/publications/emerging_health_safety_issues_women_fire_service.pdf

This is a FEMA report from 2019, addressing multiple aspects of concern for the health and safety of female firefighters. Issues discussed range from recruitment and retention issues, health behavior, proper equipment, mental health, discrimination and harassment, and cancer risk.

The authors state, “There is concern about cancer among women firefighters; however, the small proportion of women in the fire service has confounded researchers and resulted in a lack of knowledge regarding cancer and women firefighters. Also, due to small sample sizes, many studies do not include women, or they are unable to report on cancer statistics among women firefighters.”

Although this report references data suggestive of increased risk for several cancers, such as breast or bladder, “wide confidence intervals also raise questions about the degree of significance of these findings.” Confidence intervals are one-way statisticians evaluate how likely results are to be real, versus caused by chance.

This report recommends that cancer risk may be reduced by programs that address nutrition, exercise, tobacco use, alcohol use, and mental health. Specifically, as well the report recommends “invest in additional, high-performing protective gear and firehouse supplies in order to reduce exposures.”

Concluding remarks state, “ultimately, overall nonspecific cancer incidence and mortality must be more thoroughly examined to make meaningful assessments of cancer trends in the women firefighter community. To better distill meaningful data, larger sample sizes stratified by workplace role and/or duration of service are necessary.”

Watkins, Emily R; Walker, Anthony; Mol, Eric; Jahnke, Sara; Richardson, Alan. J. Women Firefighters' Health and Well-Being: An International Survey, *Women's Health Issues*, Volume 29, Issue 5, 2019, 424-431, ISSN 1049-3867, <https://doi.org/10.1016/j.whi.2019.02.003>.

840 women firefighters from 14 “western” countries completed an online survey addressing demographics, working life, personal protective equipment, and health. All health reports were self-reported. There was a difference in how women perceived their physical and mental health according to which country, specifically women from the EU were more positive.

Many reported heat-related illness; many felt their menstrual cycle affected their response to fire exposure (though 39% did not answer this question). Many were “worried” about how menopause might affect their working lives – there was an association between worry and country, with those in the UK more worried. There was also clear concern about musculoskeletal injuries and ability to continue this active job for one’s full career length. There was a trend for increased shortness of breath and cough, which might or might not reflect asthma based on these data. Also, there was concern expressed by 17% in reference to mental health/PTSD, a percentage not different from other studies of male firefighters.

80% reported access to training/gym facilities.

42% of all firefighters and 66% of UK firefighters had access to female-specific PPE.

This study did not address the incidence of malignancy/cancer/

Laroche, Elena & L'Espérance, Sylvain. (2021). Cancer Incidence and Mortality Among Firefighters: An Overview of Epidemiologic Systematic Reviews. *International Journal of Environmental Research and Public Health*. 18. 2519. DOI: 10.3390/ijerph18052519.

Youakim, Sami. (2006). Risk of Cancer Among Firefighters: A Quantitative Review of Selected Malignancies. *Archives of environmental & occupational health*. 61. 223-31. [10.3200/AEOH.61.5.223-231](https://doi.org/10.3200/AEOH.61.5.223-231). DOI:[10.3200/AEOH.61.5.223-231](https://doi.org/10.3200/AEOH.61.5.223-231)

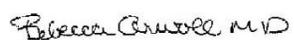
This is an overview, in which 11 suitable reports (of over 1,000 records in databases) were reviewed carefully; these were systemic reviews, covering 104 original scientific studies, from the time period of 1959 to 2018. Most of the research was reported after 1981. The results consistently supported increased incidence in firefighters of rectal, prostate, bladder, and testicular cancers, as well as mesothelioma and malignant melanoma, compared to the general population, in Youakim’s opinion. Youakim specifically addressed bias and issues with eligibility for the study, data collection, and study appraisal to determine the most reliable data for this report. Youakim did note that the overall incidence of cancer among firefighters “do not differ from a reference population.”

Youakim did opine that the data, although inconsistent, overall did support an increased risk of bladder cancer in three of the 11 analyzed studies.

Male breast cancer was addressed – there was not a firm conclusion. Of note, there is no mention of genetic testing in these male firefighters who developed breast cancer. Current medical state of the art is to have genetic testing performed on any male with breast cancer, due to the known risk of not only breast but other cancers associated with certain mutations.

These studies did not specifically exclude females, however, there is no specific mention of evaluation of female firefighters in this careful overview.

Respectfully submitted,



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