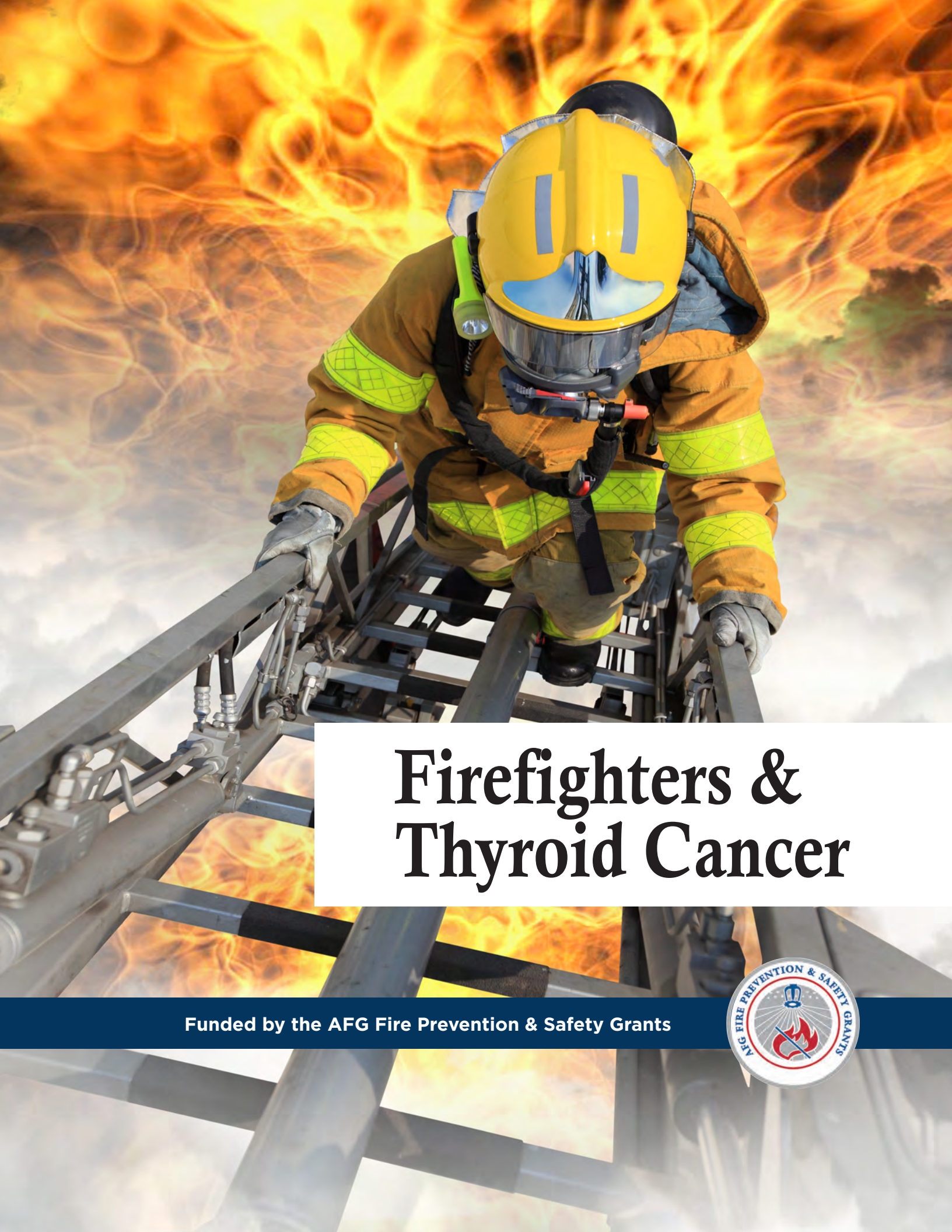

Firefighters & Thyroid Cancer

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GENERAL EPIDEMIOLOGY: THYROID CANCER

In 2021, the American Cancer Society (ACS) estimated 12,150 new cases of thyroid cancer will be diagnosed in men and 32,130 new cases will be diagnosed in women[1]. The ACS anticipates about 2,200 individuals will die from thyroid cancer[1]. 5 year relative survival rates vary greatly depending on the type of thyroid cancer and range from a combined 7% for anaplastic to nearly 100% for papillary[2]. When detected in Stage 1, the survival rate for thyroid cancer is 99%, and when detected at Stage 4, it drops to 76%.

INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC)

In June 2022, IARC convened an international meeting of scientists to re-evaluate firefighting as an exposure related to cancer. They determined the literature supports reclassifying ***firefighting to a Group 1 carcinogen (carcinogenic to humans) based on "sufficient" evidence***[3]. This is the ***highest*** classification of exposure only assigned when there is scientific certainty.

Their statement indicated:

There was also "strong" mechanistic evidence that occupational exposure as a firefighter shows the following key characteristics of carcinogens in exposed humans: "is genotoxic", "induces epigenetic alterations", "induces oxidative stress", "induces chronic inflammation", and "modulates receptor-mediated effects".

It should be noted that IARC criteria and classifications are focused on *scientific levels of certainty* which are more stringent than those focused on the "weight of the evidence"[4] which is often used in cases of workers compensation.

GENERAL RISK FACTORS FOR THYROID CANCER

Most cases of thyroid cancer were not related to any known risk factors, however, known risk factors include:

- **Gender:** Women are three times more likely than men to develop thyroid cancer, although the reasoning for such a pattern is unknown[5].
- **Age:** Women are most often in their 40s and 50s when diagnosed, while men are most often in their 60s and 70s[5].
- **Personal health history:** A number of hereditary conditions have been linked to thyroid cancer including Cowden disease and Carney complex, type 1.
- **Family health history:** Having a first-degree relative with thyroid cancer increased the risk of developing it although the genetic basis is not understood.
- **Body size:** There is a positive correlation between body mass index and risk of thyroid cancer as individuals who are overweight or obese are at a greater risk than those with healthy body weights[5].
- **Radiation exposure:** Radiation exposure is a major risk factor for thyroid cancer and can be a result of medical treatments, power plant accidents, or nuclear weapons. Individuals who received head or neck radiation treatments in childhood are at particular risk for thyroid cancer[5].

OCCUPATIONAL EXPOSURES RELATED TO THYROID CANCER

Firefighters are exposed to a broad range of chemicals, both in the firehouse and during emergency response. Recent research conducted with live burns has begun to identify and

quantify the presence of carcinogens that typically are present on the fire ground. Most alarming are findings that, even when the air appears "clear" there are often ultra-fine respirable particles and gaseous chemicals of several known carcinogens present. Unfortunately, this time period when there is no visible smoke is typically when firefighters remove their personal protective equipment and self-contained breathing apparatus. Particularly noted in the research is the presence of carcinogens such as perfluorooctanoic and perfluorooctanesulfonic acids (PFOA and PFOS), phthalates, dioxins, benzene, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), vinyl chloride, and heavy metals[6–13]. Firefighters face several routes of exposure including inhalation, dermal absorption, secondary exposure through contaminated dust from particulates post incident, and potentially the semi-volatile off-gassing of gear. Many of these same chemicals have been implicated in the development of thyroid cancer[14–18].

Endocrine Disrupting Chemicals

The Endocrine Society has released two statements over the past decade outlining what have been identified as endocrine disrupting chemicals. These synthetic chemicals include polychlorinated biphenyls (PCBs), plastics (bisphenol A), plasticizers (phthalates), dioxins, and some metals[19,20]. Evidence suggests that these chemicals disrupt normal hormone functioning and interrupt normal homeostatic control and reproduction, and play a role in the development of thyroid cancer[14–16].

Endocrine disruptors that have also been found to be present as products of combustion on the fire ground include:

- ***Dioxins.*** Dioxins are a group of chemicals that are present in chlorine containing chemicals and products (e.g. PVC pipes used as building materials). During incineration, dioxins are released. These chemicals have been found as products of combustion on the fire ground[21], and have been linked to thyroid cancer[18].
- ***Phthalates.*** These are a group of chemicals used to improve the durability, flexibility, and stability of plastics. These are commonly used in home building materials and home décor, such as flooring and blinds. Exposures to these chemicals, which have been found to be present in the fire environment, have been linked to thyroid cancer[18,22,23].
- ***Polychlorinated biphenyls (PCBs).*** PCBs are man-made organic chemicals commonly used as coolants, lubricants in transformers, capacitors, and other electrical equipment. While the chemicals have been banned since the late 1970s due to evidence that they are a probable human carcinogen, they remain in products manufactured prior to the ban and have been found in the fire environment as a product of combustion[24]. Exposure to PCBs has been linked to an elevated risk of thyroid cancer[22].
- ***Polybrominated Diphenyl Ethers (PBDEs).*** PBDEs are a complex grouping of chemicals present in polyurethane foam in furniture, electronics, plastics, and flame retardants. These chemicals exert effects on hormonal systems and the thyroid systems, playing a role in the development of thyroid cancer[14,15]. These products being burned account for the presence of PBDEs on the fire ground.

Shift Work

In 2007, the International Agency for Research on Cancer classified alternative shift work (including evening, night, rotating, and other unspecified schedules) as a probable human

carcinogen[24]. The relationship between shift work and cancer development occurs through several mechanisms, including circadian rhythm disruptions, impacted melatonin secretion and production, and affecting lifestyle choices[25]. Given the nature of the job and emergency calls, it is not surprising that firefighters – who are faced with a career of 24-48 hour shifts and emergency calls during the night – struggle with the negative health implications of shift work. This includes sleep disorders[26,27], a concept with a known relationship to thyroid cancer[28–31].

RISK OF THYROID CANCER AMONG FIREFIGHTERS

Lee et al[32]. examined over 100,000 career Florida firefighters over a 34-year period, identifying 3,760 male firefighter primary cancer incidents using the Florida State Fire Marshall's Office and Florida Cancer Data System. After adjusting for age and year of cancer diagnosis, the authors found **male firefighters had a significantly elevated risk of thyroid cancer** (aOR = 2.17, 95% CI = 1.78-2.66), while **female firefighters were at an even higher risk** (aOR=2.42, 95% CI=1.56-3.74).

This was further corroborated with additional Florida data that found **male firefighters had increased rates** of thyroid cancer (SIR=1.77, 95% CI=1.08-2.73), leading to a **significant risk of thyroid mortality** (SMR=4.82, 95% CI=1.30-12.3)[33], while **female firefighters had even higher rates** (SIR=3.97, 95% CI=1.45-8.65)[34].

A recent meta-analysis echoed those results as Jalilian and colleagues found firefighters **were at a 22% higher risk of developing thyroid cancer** (SMRE=1.22, 95% CI=1.01-1.48)[35].

References

1. Key Statistics for Thyroid Cancer. Accessed December 2, 2021. https://www.cancer.org/cancer/thyroid-cancer/about/key-statistics.html

2. Survival Rates for Thyroid Cancer. Accessed December 2, 2021. https://www.cancer.org/cancer/thyroid-cancer/detection-diagnosis-staging/survival-rates.html

3. Demers PA, DeMarini DM, Fent KW, et al. Carcinogenicity of occupational exposure as a firefighter. *Lancet Oncol*. 2022;23(8):985-986. doi:10.1016/S1470-2045(22)00390-4

4. Guidotti T. Cancer. In: *Health Risks and Fair Compensation in the Fire Service*. Risk, Systems and Decisions. Springer; 2016.

5. Thyroid Cancer Risk Factors. Accessed December 2, 2021. https://www.cancer.org/cancer/thyroid-cancer/causes-risks-prevention/risk-factors.html

6. Fabian T, Borgerson J, Kerber S, et al. *Firefighter Exposure to Smoke Particulates*. Underwriters Laboratories Inc; 2010:6.

7. Baxter CS, Hoffman JD, Knipp MJ, Reponen T, Haynes EN. Exposure of Firefighters to Particulates and Polycyclic Aromatic Hydrocarbons. *J Occup Environ Hyg*. 2014;11(7):D85-D91. doi:10.1080/15459624.2014.890286

8. Fent KW, Eisenberg J, Snawder J, et al. Systemic Exposure to PAHs and Benzene in Firefighters Suppressing Controlled Structure Fires. *Ann Occup Hyg*. 2014;58(7):830-845. doi:10.1093/annhyg/meu036

9. Fent KW, Alexander B, Roberts J, et al. Contamination of firefighter personal protective equipment and skin and the effectiveness of decontamination procedures. *J Occup Environ Hyg*. 2017;14(10):801-814. doi:10.1080/15459624.2017.1334904

10. Fent KW, Evans DE, Booher D, et al. Volatile Organic Compounds Off-gassing from Firefighters' Personal Protective Equipment Ensembles after Use. *J Occup Environ Hyg*. 2015;12(6):404-414. doi:10.1080/15459624.2015.1025135

11. Kirk KM, Logan MB. Firefighting instructors' exposures to polycyclic aromatic hydrocarbons during live fire training scenarios. *J Occup Environ Hyg*. 2015;12(4):227-234. doi:10.1080/15459624.2014.955184

12. Kirk KM, Logan MB. Structural Fire Fighting Ensembles: Accumulation and Off-gassing of Combustion Products. *J Occup Environ Hyg*. 2015;12(6):376-383. doi:10.1080/15459624.2015.1006638

13. Robinson MS, Anthony TR, Littau SR, et al. Occupational PAH Exposures during Prescribed Pile Burns. *Ann Occup Hyg*. 2008;52(6):497-508. doi:10.1093/annhyg/men027

14. Zhang Q, Hu M, Wu H, et al. Plasma polybrominated diphenyl ethers, urinary heavy metals and the risk of thyroid cancer: A case-control study in China. *Environ Pollut*. 2021;269:116162. doi:10.1016/j.envpol.2020.116162

15. Zhang Y, Guo GL, Han X, et al. Do Polybrominated Diphenyl Ethers (PBDEs) Increase the Risk of Thyroid Cancer? *Biosci Hypotheses*. 2008;1(4):195-199. doi:10.1016/j.bihy.2008.06.003

16. Fiore M, Oliveri Conti G, Caltabiano R, et al. Role of Emerging Environmental Risk Factors in Thyroid Cancer: A Brief Review. *Int J Environ Res Public Health*. 2019;16(7):1185. doi:10.3390/ijerph16071185

17. Kassotis CD, Herkert NJ, Hammel SC, et al. Thyroid Receptor Antagonism of Chemicals Extracted from Personal Silicone Wristbands within a Papillary Thyroid Cancer Pilot Study. *Environ Sci Technol*. 2020;54(23):15296-15312. doi:10.1021/acs.est.0c05972

18. Marotta V, Malandrino P, Russo M, et al. Fathoming the link between anthropogenic chemical contamination and thyroid cancer. *Crit Rev Oncol Hematol*. 2020;150:102950. doi:10.1016/j.critrevonc.2020.102950

19. Gore AC, Chappell VA, Fenton SE, et al. EDC-2: The Endocrine Society's Second Scientific Statement on Endocrine-Disrupting Chemicals. *Endocr Rev*. 2015;36(6):E1-E150. doi:10.1210/er.2015-1010

20. Diamanti-Kandarakis E, Bourguignon JP, Giudice LC, et al. Endocrine-disrupting chemicals: an Endocrine Society scientific statement. *Endocr Rev*. 2009;30(4):293-342. doi:10.1210/er.2009-0002

21. Pesatori AC, Consonni D, Rubagotti M, Grillo P, Bertazzi PA. Cancer incidence in the population exposed to dioxin after the "Seveso accident": twenty years of follow-up. *Environ Health*. 2009;8(1):39. doi:10.1186/1476-069X-8-39

22. Alsen M, Sinclair C, Cooke P, Ziadkhanpour K, Genden E, van Gerwen M. Endocrine Disrupting Chemicals and Thyroid Cancer: An Overview. *Toxics*. 2021;9(1):14. doi:10.3390/toxics9010014

23. Miao H, Liu X, Li J, et al. Associations of urinary phthalate metabolites with risk of papillary thyroid cancer. *Chemosphere*. 2020;241:125093. doi:10.1016/j.chemosphere.2019.125093

24. Straif K, Baan R, Grosse Y, et al. Carcinogenicity of shift-work, painting, and fire-fighting. *Lancet Oncol*. 2007;8(12):1065-1066. doi:10.1016/S1470-2045(07)70373-X

25. Wang XS, Armstrong MEG, Cairns BJ, Key TJ, Travis RC. Shift work and chronic disease: the epidemiological evidence. *Occup Med Oxf Engl*. 2011;61(2):78-89. doi:10.1093/occmed/kqr001

26. Barger LK, Rajaratnam SMW, Wang W, et al. Common sleep disorders increase risk of motor vehicle crashes and adverse health outcomes in firefighters. *J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med*. 2015;11(3):233-240. doi:10.5664/jcsm.4534

27. Vargas de Barros V, Martins LF, Saitz R, Bastos RR, Ronzani TM. Mental health conditions, individual and job characteristics and sleep disturbances among firefighters. *J Health Psychol*. 2013;18(3):350-358. doi:10.1177/1359105312443402

28. Luo J, Sands M, Wactawski-Wende J, Song Y, Margolis KL. Sleep Disturbance and Incidence of Thyroid Cancer in Postmenopausal Women The Women's Health Initiative. *Am J Epidemiol*. 2013;177(1):42-49. doi:10.1093/aje/kws193

29. De Lumban T c., Balachandran D, Pacheco G, et al. Sleep Disturbances in Thyroid Malignancies. In: *A69. SRN: WHAT CAN WE LEARN FROM CLINICAL AND EPIDEMIOLOGICAL STUDIES IN SLEEP?*. American Thoracic Society International Conference Abstracts. American Thoracic Society; 2019:A2282-A2282. doi:10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A2282

30. He Y, Meng Z, Jia Q, et al. Sleep Quality of Patients with Differentiated Thyroid Cancer. *PLOS ONE*. 2015;10(6):e0130634. doi:10.1371/journal.pone.0130634

31. Malaguarnera R, Ledda C, Filippello A, et al. Thyroid Cancer and Circadian Clock Disruption. *Cancers*. 2020;12(11):3109. doi:10.3390/cancers12113109

32. 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(4):285-299. doi:10.1002/ajim.23086

33. Ma F, Fleming LE, Lee DJ, et al. Mortality in Florida professional firefighters, 1972 to 1999. *Am J Ind Med*. 2005;47(6):509-517. doi:10.1002/ajim.20160

34. Ma F, Fleming LE, Lee DJ, Trapido E, Gerace TA. Cancer Incidence in Florida Professional Firefighters, 1981 to 1999: *J Occup Environ Med*. 2006;48(9):883-888. doi:10.1097/01.jom.0000235862.12518.04

35. Jalilian H, Ziaei M, Weiderpass E, Rueegg CS, Khosravi Y, Kjaerheim K. Cancer incidence and mortality among firefighters. *Int J Cancer*. 2019;145(10):2639-2646. doi:https://doi.org/10.1002/ijc.32199

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