Physical Health & Public Safety Personnel

Dr. Sara A. Jahnke
Center for Fire, Rescue, & EMS Health Research
NDRI–USA, Inc.

Cardiovascular Disease

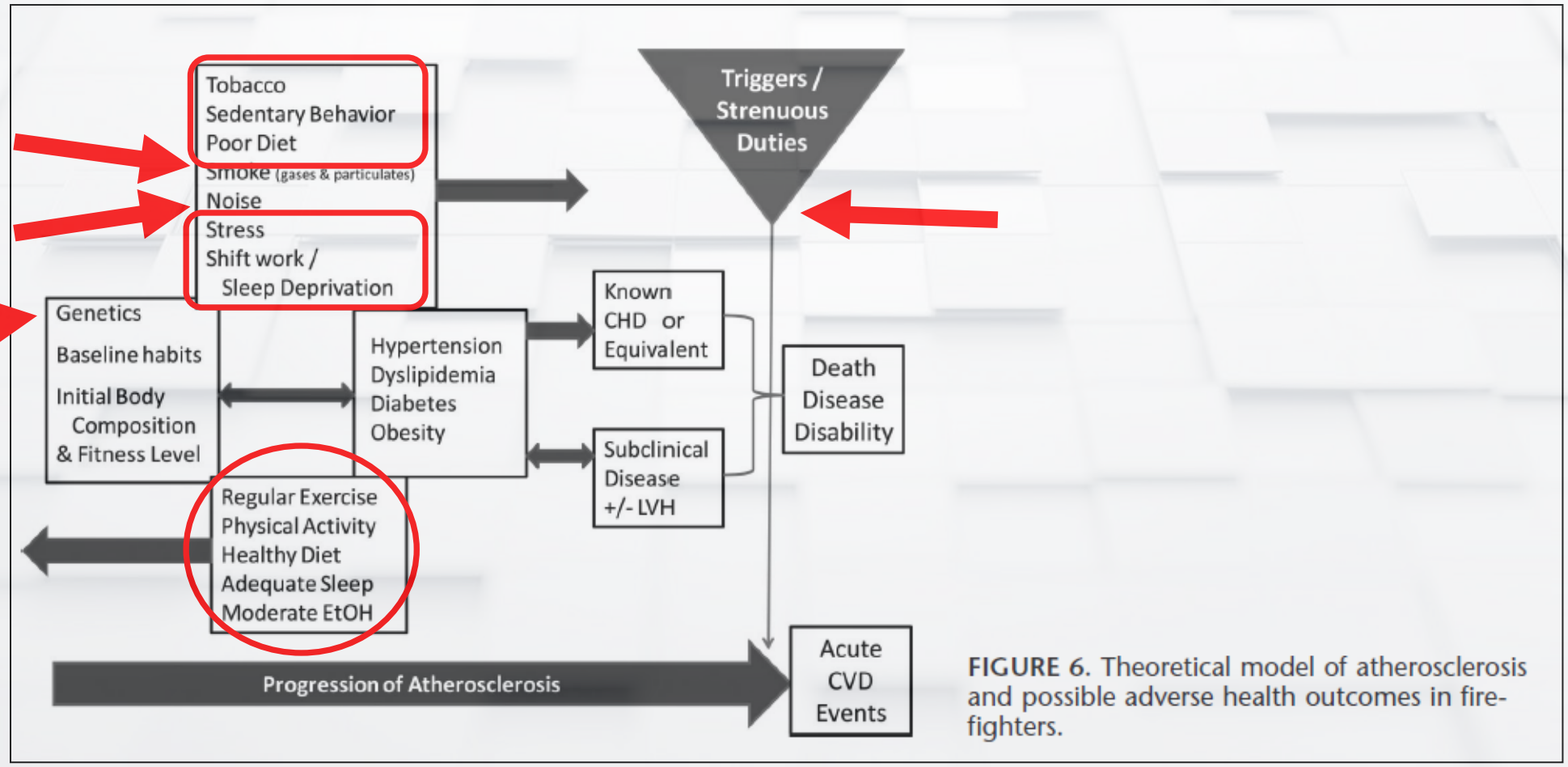


FIGURE 6. Theoretical model of atherosclerosis and possible adverse health outcomes in fire-fighters.

Soteriades et al., 2013

Firefighter Fatality Statistics

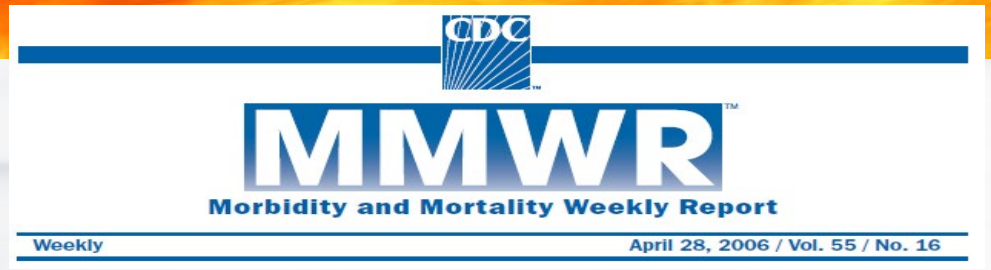


TABLE. Number and percentage of fatalities among career and volunteer firefighters, by cause/contributing cause — United States, 1994–2004

Cause/Contributing cause	Career No.	Career (%)	Volunteer No.	Volunteer (%)
Heart attack*	**142**	**(39)**	**306**	**(50)**
Stress/Overexertion	138	(97)	301	(98)
Other	4	(3)	5	(2)
Motor vehicle–related trauma	**44**	**(12)**	**160**	**(26)**
Vehicle collision/crash	30	(68)	116	(73)
Struck by vehicle	12	(27)	33	(20)
Other vehicle-related (e.g., crushed by or fell from a vehicle)	2	(5)	11	(7)
Asphyxiation	**74**	**(20)**	**45**	**(7)**
Caught/Trapped	56	(76)	31	(69)
Other (e.g., lost inside a structure or exposed to smoke)	18	(24)	14	(31)
All other†	**108**	**(29)**	**99**	**(16)**
Caught/Trapped	32	(30)	19	(19)
Fall	8	(7)	15	(15)
Exposure (e.g., to smoke)	9	(8)	14	(14)
Stress/Overexertion	16	(15)	14	(14)
Structure collapse	8	(7)	3	(3)
Other	35	(32)	34	(34)
Total	**368**		**610**	

* For example, myocardial infarction or arrhythmia.
† Includes deaths caused by burns, cerebral vascular accidents, drownings, electrocution, heat exhaustion, and trauma.

For every cardiac LODD,
an estimated

17

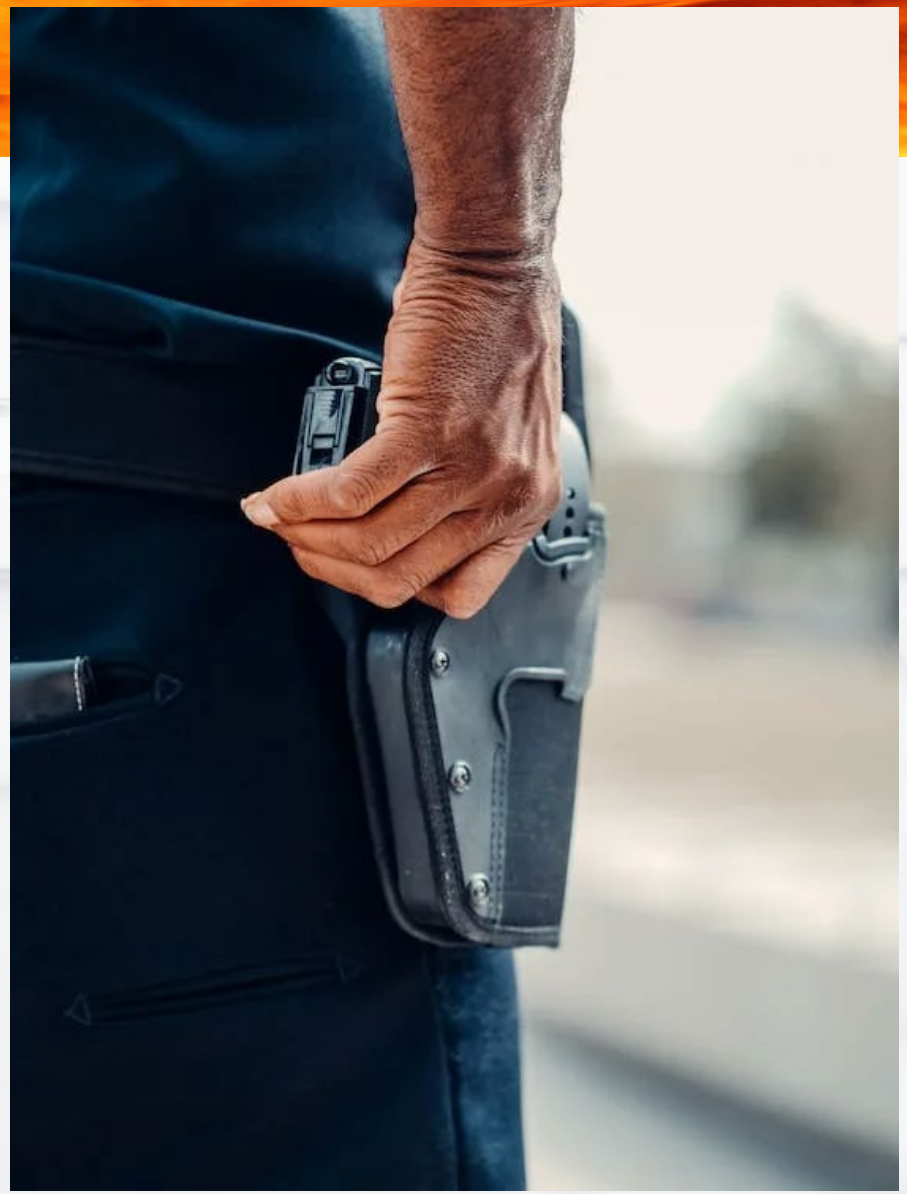
non-fatal cardiac events occur
on duty each year.

CVD in Law Enforcement

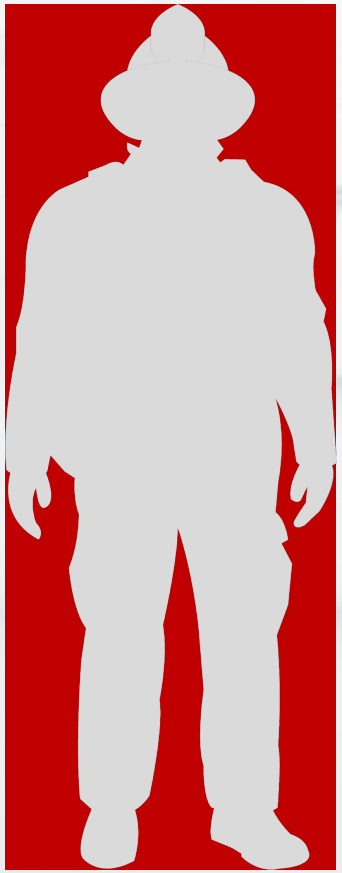
Sudden Cardiac Death most often during:

- Restraint (25%. 34-69x higher)
- Physical Training (20%; 20-23x higher)
- Suspect Pursuit (12%; 32-51x higher)
- Medical/Rescue (8%, 6-9x higher)
- Routine Duties (23%)
- Other (11%)

(Varvarigou, 2014)



Cancer & Firefighting



Brain 32%

Oral Cavity 39%

Esophageal 62%

Mesothelioma 129%

Buccal & Pharynx 23%

Lung 29%

Kidney 27%

Testicular 102%

Multiple Myeloma 53%

Leukemia 14%

Prostate 28%

Intestine 21%

Non-Hodgkin's Lymphoma 51%

Cancer Risk Among Firefighters: A Review and Meta-analysis of 32 Studies

Grace K. LeMasters, PhD
Ash M. Genaidy, PhD
Paul Succop, PhD
James Deddens, PhD
Tarek Sobeih, MD, PhD

uring the course of their work, fi

ORIGINAL ARTICLE

Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009)

Robert D Daniels,[1] Travis L Kubale,[1] James H Yiin,[1] Matthew M Dahm,[1] Thomas R Hales,[1] Dalsu Baris,[2] Shelia H Zahm,[2] James J Beaumont,[3]

this paper adds

ORIGINAL ARTICLE

Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries

Eero Pukkala,[1,2] Jan Ivar Martinsen,[3] Elisabete Weiderpass,[3,4,5,6] Kristina Kjaerheim,[4] Elsebeth Lynge,[7] Laufey Tryggvadottir,[8,9] Pär Sparén,[4] Paul A Demers[10]

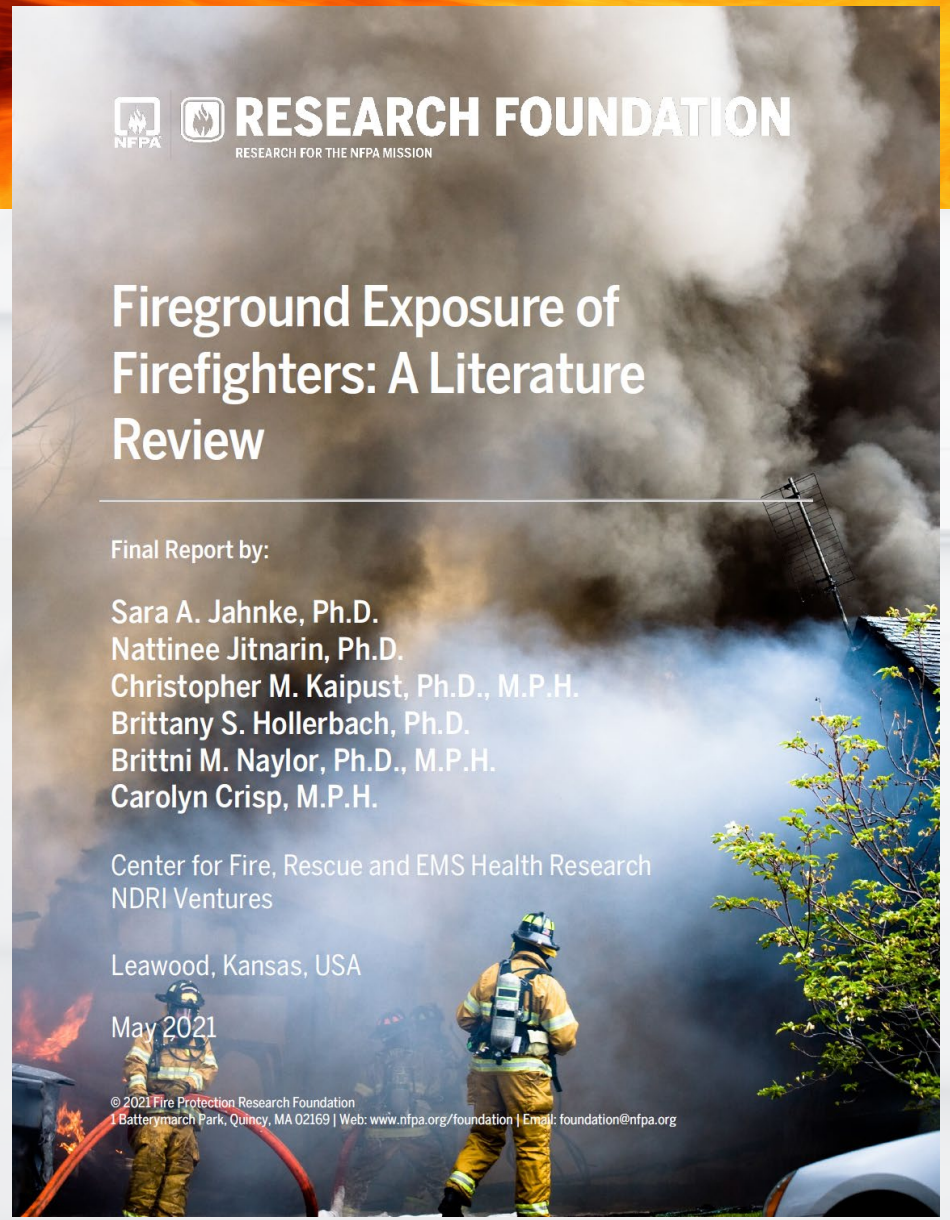
ABSTRACT
Objectives Firefighters are potentially exposed to a wide range of known and suspected carcinogens through their work. The objectives of this study were to

International Journal of Cancer

Cancer incidence and mortality among firefighters

Hamed Jalilian[1], Mansour Ziaei[2], Elisabete Weiderpass[3,4,5,6], Corina Silvia Rueegg[7], Yahya Khosravi[8] and Kristina Kjaerheim[4]

[1]Department of Occupational Health and Safety, Faculty of Health, Hormozgan University of Medical Sciences, Bandar Abbas, Iran
[2]School of Health and Nutrition, Bushehr University of Medical Sciences, Bushehr, Iran
[3]Department of Community Medicine, Faculty of Health Sciences, University of Tromsø, The Arctic University of Norway, Tromsø, Norway
[4]Department of Research, Cancer Registry of Norway - Institute of Population-Based Cancer Research, Oslo, Norway
[5]Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden



Executive Summary

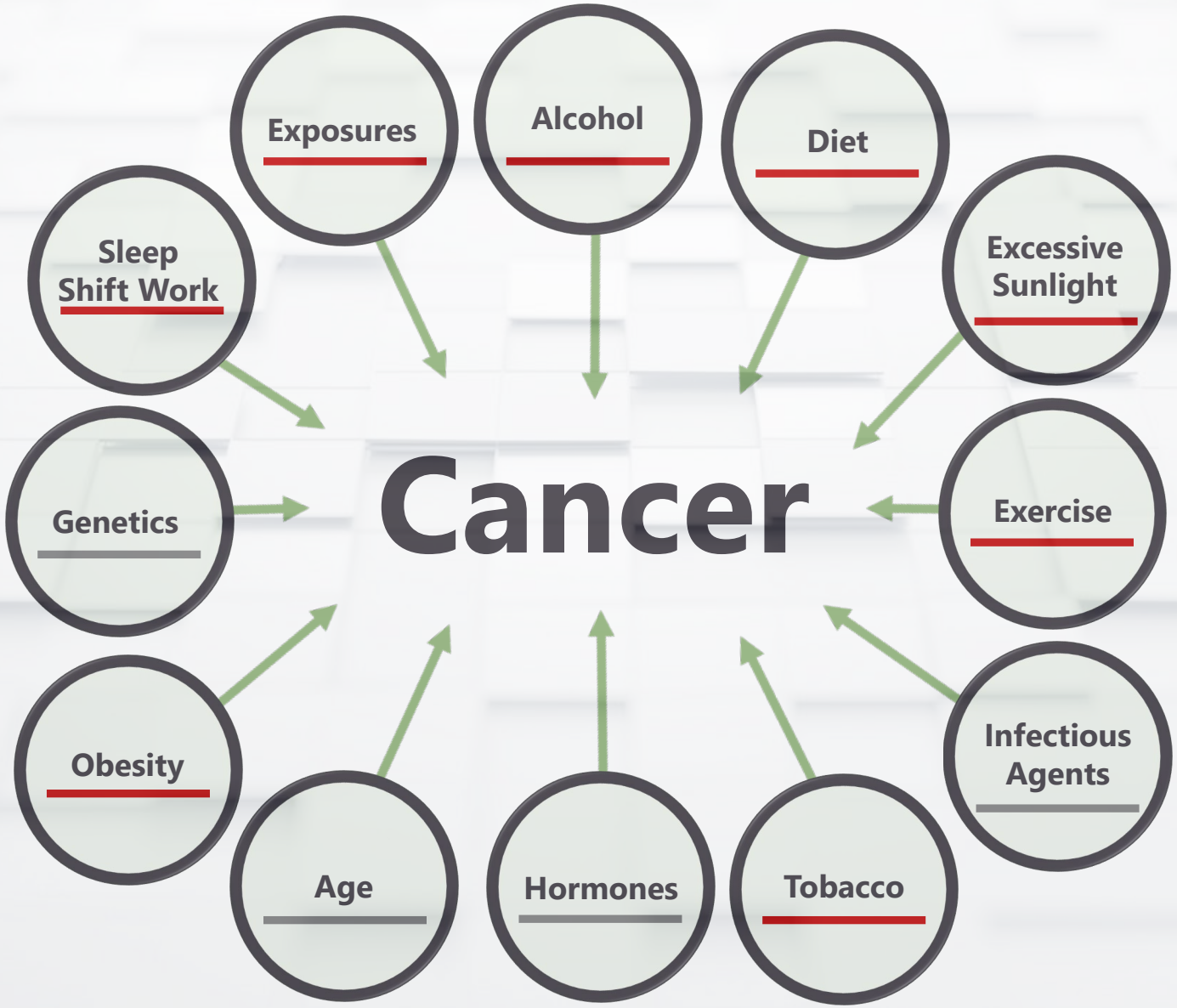
There has been significant interest in the relationship between occupational exposures of firefighters and the increased risk of cancers they face. Understanding the fireground exposures to carcinogens is an important mechanistic link. Given the significant growth in research on this topic, the Fire Protection Research Foundation undertook the task of developing a systematic review of existing literature to outline the current state of the science, summarize the findings, and identify gaps in the literature. A total of 75 articles were included in the analysis with most (68%) being conducted in the last decade.

Biomonitoring studies have been conducted that identified the presence of known human carcinogens (Group 1: benzene, PAHs, PCBs, dioxins, furans, and dioxin-like PCBs), probable carcinogens (Group 2A: guaiacol, organochlorines), and possible carcinogens (Group 2B: 1,4 dichlorobenzene, organochlorines, phthalates, phenolic compounds, PFAAs, heavy metals) on the fireground. Similarly, environmental monitoring studies have found known carcinogens (Group 1: 1,3 butadiene, 2,3,4,7,8 pentachorodibenzofuran, 2,3,7,8-tetrachlorodibenzo-P-dioxin, asbestos, benzene, benzo[a]pyrene, formaldehyde, pentachlorophenol, trichloroethylene), probable carcinogens (Group 2A: acrolein, cyclopenta[cd]pyrene, dibenz[a,h]anthracene, styrene, perchloroethylene), and possible carcinogens (Group 2B: acetaldehyde, benz[a]anthracene, benzo[b]fluoranthene, benzo[c]phenanthrene, benzo[j]fluoranthene, benzo[k]fluoranthene, chrysene, di(2-ethylhexyl)phthalate, crotonaldehyde, dichloromethane, indeno[1,2,3-cd]pyrene, isoprene, methyl isobutyl ketones, naphthalene, trichlorophenol) on the fireground.

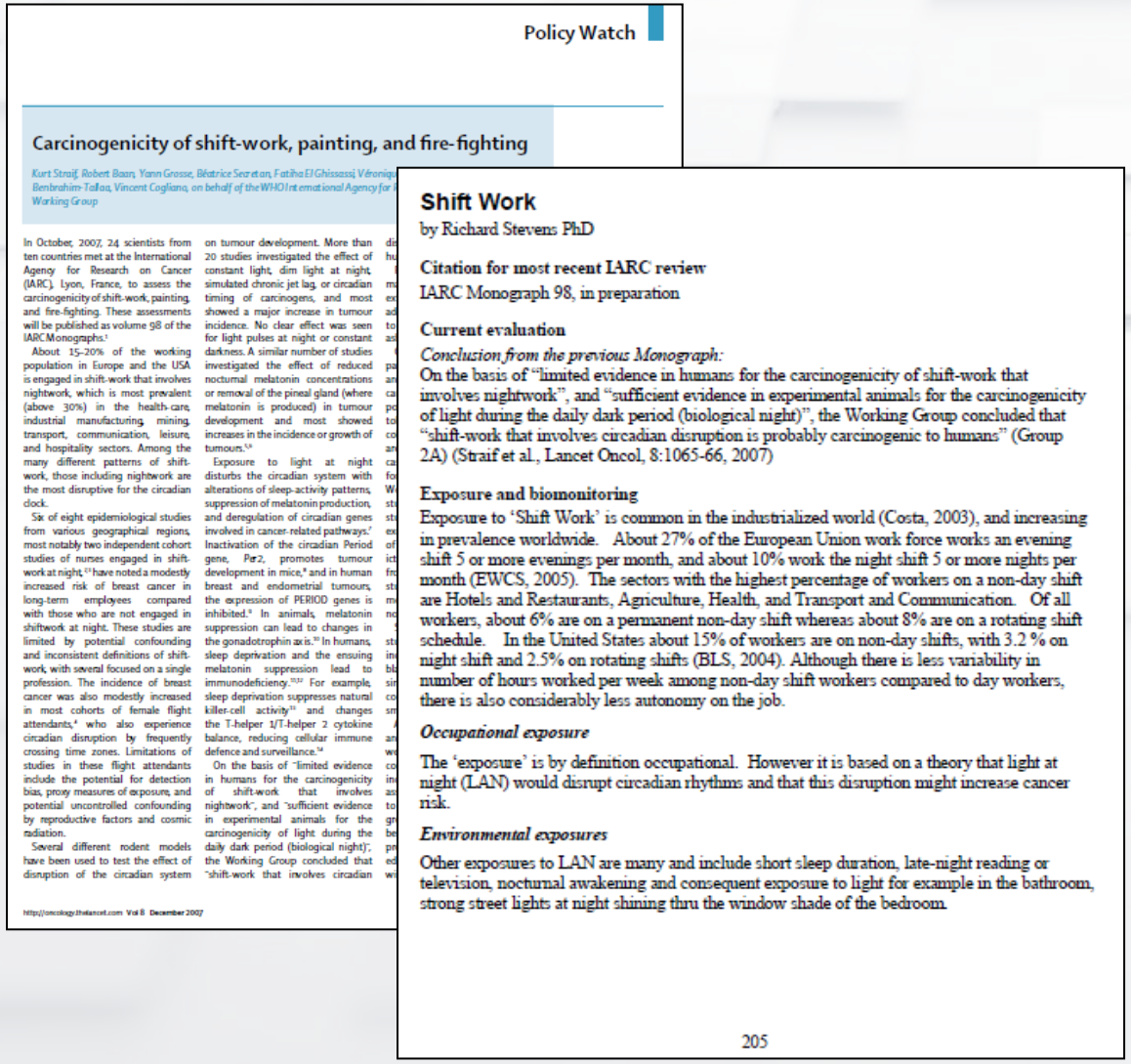
For biomonitoring studies, significant gaps were identified for fire instructors, fire investigators, aircraft rescue and firefighting (ARFF) firefighters, industrial firefighters, and recruits. It was also noted that future research should focus on examining the impact of the changing fire environment as the products of combustion in fires have evolved over the years.

The gap analysis identified several areas of needed research within environmental monitoring including studies of carcinogens through wildland fires, exposures through electrical/transformer fires, ARFF exposures, and training fires. Additional research by type of data collection such as through gear samples and passive sampling devices also were identified. Finally, additional research on major events is needed through real-time environmental monitoring.

Clearly, the fireground – by its very nature – is a high-risk environment with a number of carcinogenic exposures for any responder on the scene. Understanding these risks is an important foundation for understanding health and environmental impacts and for identifying and promoting mitigation and prevention efforts.


Cancer
Exposures
Alcohol
Diet
Sleep
Shift Work
Excessive
Sunlight
Genetics
Exercise
Obesity
Infectious
Agents
Age
Hormones
Tobacco

Sleep & Shift Work



Policy Watch

Carcinogenicity of shift-work, painting, and fire-fighting

Kurt Straif, Robert Baan, Yann Grosse, Béatrice Secretan, Fatiha El Ghissassi, Véronique Benbrahim-Tallaa, Vincent Cogliano, on behalf of the WHO International Agency for Research on Cancer Monograph Working Group

In October, 2007, 24 scientists from ten countries met at the International Agency for Research on Cancer (IARC), Lyon, France, to assess the carcinogenicity of shift-work, painting, and fire-fighting. These assessments will be published as volume 98 of the IARC Monographs.[1]

About 15–20% of the working population in Europe and the USA is engaged in shift-work that involves nightwork, which is most prevalent (above 30%) in the health-care, industrial manufacturing, mining, transport, communication, leisure, and hospitality sectors. Among the many different patterns of shift-work, those including nightwork are the most disruptive for the circadian clock.

Six of eight epidemiological studies from various geographical regions, most notably two independent cohort studies of nurses engaged in shift-work at night,[2,3] have noted a modestly increased risk of breast cancer in long-term employees compared with those who are not engaged in shiftwork at night. These studies are limited by potential confounding and inconsistent definitions of shift-work, with several focused on a single profession. The incidence of breast cancer was also modestly increased in most cohorts of female flight attendants,[4] who also experience circadian disruption by frequently crossing time zones. Limitations of studies in these flight attendants include the potential for detection bias, proxy measures of exposure, and potential uncontrolled confounding by reproductive factors and cosmic radiation.

Several different rodent models have been used to test the effect of disruption of the circadian system on tumour development. More than 20 studies investigated the effect of constant light, dim light at night, simulated chronic jet lag, or circadian timing of carcinogens, and most showed a major increase in tumour incidence. No clear effect was seen for light pulses at night or constant darkness. A similar number of studies investigated the effect of reduced nocturnal melatonin concentrations or removal of the pineal gland (where melatonin is produced) in tumour development and most showed increases in the incidence or growth of tumours.[5,6]

Exposure to light at night disturbs the circadian system with alterations of sleep-activity patterns, suppression of melatonin production, and deregulation of circadian genes involved in cancer-related pathways.[7] Inactivation of the circadian Period gene, Per2, promotes tumour development in mice,[8] and in human breast and endometrial tumours, the expression of PERIOD genes is inhibited.[9] In animals, melatonin suppression can lead to changes in the gonadotrophin axis.[10] In humans, sleep deprivation and the ensuing melatonin suppression lead to immunodeficiency.[11,12] For example, sleep deprivation suppresses natural killer-cell activity[13] and changes the T-helper 1/T-helper 2 cytokine balance, reducing cellular immune defence and surveillance.[14]

On the basis of "limited evidence in humans for the carcinogenicity of shift-work that involves nightwork", and "sufficient evidence in experimental animals for the carcinogenicity of light during the daily dark period (biological night)", the Working Group concluded that "shift-work that involves circadian

Shift Work

by Richard Stevens PhD

Citation for most recent IARC review

IARC Monograph 98, in preparation

Current evaluation

Conclusion from the previous Monograph:

On the basis of "limited evidence in humans for the carcinogenicity of shift-work that involves nightwork", and "sufficient evidence in experimental animals for the carcinogenicity of light during the daily dark period (biological night)", the Working Group concluded that "shift-work that involves circadian disruption is probably carcinogenic to humans" (Group 2A) (Straif et al., Lancet Oncol, 8:1065-66, 2007)

Exposure and biomonitoring

Exposure to 'Shift Work' is common in the industrialized world (Costa, 2003), and increasing in prevalence worldwide. About 27% of the European Union work force works an evening shift 5 or more evenings per month, and about 10% work the night shift 5 or more nights per month (EWCS, 2005). The sectors with the highest percentage of workers on a non-day shift are Hotels and Restaurants, Agriculture, Health, and Transport and Communication. Of all workers, about 6% are on a permanent non-day shift whereas about 8% are on a rotating shift schedule. In the United States about 15% of workers are on non-day shifts, with 3.2 % on night shift and 2.5% on rotating shifts (BLS, 2004). Although there is less variability in number of hours worked per week among non-day shift workers compared to day workers, there is also considerably less autonomy on the job.

Occupational exposure

The 'exposure' is by definition occupational. However it is based on a theory that light at night (LAN) would disrupt circadian rhythms and that this disruption might increase cancer risk.

Environmental exposures

Other exposures to LAN are many and include short sleep duration, late-night reading or television, nocturnal awakening and consequent exposure to light for example in the bathroom, strong street lights at night shining thru the window shade of the bedroom.

May be due to interruption of circadian rhythms

Suppression of melatonin at night

World Health Organization – Shift work is "Probable Carcinogen"

World Health Organization

Sleep Disorders in Firefighters

- Barger et al. 2016
- 6,933 firefighters from 66 fire department
- 37.2% screened positive for any sleep disorder
- 28.4% obstructive sleep apnea
- 6.0% insomnia
- 9.1% shift work disorder
- 3.4% restless leg syndrome

Sleep Disorders in Firefighters

- Those who screened positive vs. not
- Twice as likely to report a motor vehicle crash
- More than twice as likely (OR = 2.41) to report falling asleep while driving
- More than twice as likely to report CVD (OR=2.37)
- Double risk of diabetes (OR-1.91)
- Three times as likely to report depression (OR=3.10) and anxiety (OR=3.81)

Sleep Disorders in Law Enforcement

- Rajaratnam et al. 2011
- 4,957 LEO participants
- 40.4% screened positive for at least one sleep disorder
- 33.6% obstructive sleep apnea
- 6.5% moderate/severe insomnia
- 5.4% shift work disorder
- 28.5% Excessive Daytime Sleepiness
- 26.1% falling asleep driving, last month

Sleep Disorders in Law Enforcement

- More likely to make administrative error (17.9% vs 12.7%, OR 1.43)
- More likely to fall asleep while driving (14.4% vs 9.2%, OR 1.51)
- Making error or safety violation (23.7% vs 15.5%, OR 1.63)
- More likely to exhibit uncontrolled anger toward suspects (34.1% vs 28.5%, OR 1.25)
- More absenteeism (26.0% vs. 20.9%, OR 1.23)
- More likely to fall asleep during meetings (14.1% vs. 7.0%, OR 1.95)

COVID:
WHAT IS THE RISK TO FIRST RESPONDERS

First Responders were 2.01 times(IRR; OR=1.44-2.79) more likely to contract COVID-19 than other HEALTH CARE WORKERS

JAMA Health Forum

Original Investigation

Incidence of SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential Workers During a Prevaccination COVID-19 Surge in Arizona

Katherine D. Ellingson, PhD; Joe K. Gerald, MD, PhD; Xiaoxiao Sun, PhD; James Hollister, BS; Karen Lutrick, PhD; Joel Parker, MS; Patrick Rivers, MPP; Shawn C. Beitel, MS; Zoe Baccam, BS; Julie Mayo Lamberte, MSPH; Lauren Grant, MS; Elizabeth Kim, MSPH; Rachana Bhattarai, BVSc&AH, MS, PhD; Kenneth Komatsu, MPH; Jennifer Meece, PhD; Preeta K. Kutty, MD, MPH; Mark G. Thompson, PhD; Jefferey L. Burgess, MD, MS, MPH

Abstract

IMPORTANCE Understanding the relative risk of SARS-CoV-2 infection across occupations can inform guidance to protect workers and communities. Less is known about infection risk for first responders and other essential workers than for health care personnel.

OBJECTIVE To compare the prevaccination incidence of SARS-CoV-2 infection among first responders and other essential workers with incidence among health care personnel.

DESIGN, SETTING, AND PARTICIPANTS This was a prospective cohort study of health care personnel, first responders, and other essential workers in Arizona from July 20, 2020, to March 14, 2021. Participants were seronegative at enrollment, had frequent direct contact with others at work, worked at least 20 hours per week, and submitted weekly nasal swab specimens for real-time reverse transcriptase polymerase chain reaction analysis. Data analyses were performed from April 19, 2021, to June 4, 2021.

EXPOSURES Occupation was the primary exposure of interest. Confounders assessed were sociodemographic characteristics, health status, community exposure, and work exposure.

MAIN OUTCOMES AND MEASURES Crude incidence of SARS-CoV-2 infection was defined as the sum of first positive SARS-CoV-2 infections in participants divided by person-weeks at risk. Negative binomial regression was used to model SARS-CoV-2 infection by occupation to estimate unadjusted and adjusted incidence rate ratios (IRRs). The least absolute shrinkage and selection operator (LASSO) method was used to generate a parsimonious multivariable model.

RESULTS The study cohort comprised 1766 Arizona workers (mean age [SD], 43.8 [11.1] years; 1093 [61.9%] female; 401 [22.7%] were Hispanic and 1530 [86.6%] were White individuals) of whom 44.2% were health care personnel, 22.4% first responders, and 33.4% other essential workers. The cohort was followed up for 23 393 person-weeks. Crude incidence of SARS-CoV-2 infection was 6.7, 13.2, and 7.4 per 1000 person-weeks at risk for health care personnel, first responders, and other essential workers, respectively. In unadjusted models, first responders had twice the incidence of infection as health care personnel (IRRs, 2.01; 95% CI, 1.44-2.79). While attenuated, this risk remained elevated in adjusted LASSO-optimized models (IRR, 1.60; 95% CI, 1.07-2.38). Risk of infection among other essential workers was no different than for health care personnel in unadjusted or adjusted models.

CONCLUSIONS AND RELEVANCE This prospective cohort study found that first responders had a higher incidence of SARS-CoV-2 infection than health care personnel, even after adjusting for

(continued)

JAMA Health Forum. 2021;2(10):e213318. doi:10.1001/jamahealthforum.2021.3318

Key Points

Question Before COVID-19 vaccine availability, how comparable were rates of SARS-CoV-2 infection among health care personnel, first responders, and other essential workers?

Findings This prospective cohort study of 1766 unvaccinated seronegative Arizona workers using self-administered reverse-transcription polymerase chain reaction testing found that first responders had a significantly higher incidence of SARS-CoV-2 infection than health care personnel, even after controlling for sociodemographic characteristics and underlying health and exposure indicators.

Meaning The findings of this cohort study indicate that first responders warrant greater public health attention in context of the COVID-19 pandemic given their higher rates of SARS-CoV-2 infection.

Author affiliations and article information are listed at the end of this article.

Jung *et al. Environ Health* (2021) 20:116
https://doi.org/10.1186/s12940-021-00800-4

Environmental Health

RESEARCH Open Access

Occupational factors and miscarriages in the US fire service: a cross-sectional analysis of women firefighters

Alesia M. Jung[1*], Sara A. Jahnke[2], Leslie K. Dennis[1,3], Melanie L. Bell[1], Jefferey L. Burgess[3], Nattinee Jitnarin[2], Christopher M. Kaipust[2] and Leslie V. Farland[1,4]

Abstract

Background: Evidence from previous studies suggests that women firefighters have greater risk of some adverse reproductive outcomes. The purpose of this study was to investigate whether women firefighters had greater risk of miscarriage compared to non-firefighters and whether there were occupational factors associated with risk of miscarriage among firefighters.

Methods: We studied pregnancies in the United States fire service using data from the Health and Wellness of Women Firefighters Study ($n = 3181$). We compared the prevalence of miscarriage among firefighters to published rates among non-firefighters using age-standardized prevalence ratios. We used generalized estimating equations to estimate relative risks (RRs) and 95% confidence intervals (CIs) between occupational factors (employment (career/volunteer), wildland firefighter status (wildland or wildland-urban-interface/structural), shift schedule, fire/rescue calls at pregnancy start) and risk of miscarriage, adjusted for age at pregnancy, education, gravidity, BMI, and smoking. We evaluated if associations varied by age at pregnancy or employment.

Results: Among 1074 firefighters and 1864 total pregnancies, 404 pregnancies resulted in miscarriages (22%). Among most recent pregnancies, 138 resulted in miscarriage (13%). Compared to a study of US nurses, firefighters had 2.33 times greater age-standardized prevalence of miscarriage (95% CI 1.96–2.75). Overall, we observed that volunteer firefighters had an increased risk of miscarriage which varied by wildland status (interaction p-value< 0.01). Among structural firefighters, volunteer firefighters had 1.42 times the risk of miscarriage (95% CI 1.11–1.80) compared to career firefighters. Among wildland/wildland-urban-interface firefighters, volunteer firefighters had 2.53 times the risk of miscarriage (95% CI 1.35–4.78) compared to career firefighters.

Conclusions: Age-standardized miscarriage prevalence among firefighters may be greater than non-firefighters and there may be variation in risk of miscarriage by fire service role. Further research is needed to clarify these associations to inform policy and decision-making.

Keywords: Firefighters, Occupational health, Women's health, Reproductive health, Epidemiology, Miscarriage, Spontaneous abortion

Background

In 2018 there were over 1.1 million estimated firefighters in the United States (US), 8% of whom were women [1]. Firefighters face specific occupational exposures (toxic substances and physical hazards) that may influence risk

*Correspondence: ajung1@email.arizona.edu
[1] Department of Epidemiology and Biostatistics, Mel and Enid Zuckerman College of Public Health, University of Arizona, 1295 N Martin Ave, Tucson, AZ 85724, USA
Full list of author information is available at the end of the article

- Recent research: Miscarriage rates among female firefighters were at least 2.3 times higher compared to the U.S. National average of 10% (Jung, 2021)

- Volunteer firefighters had a 42% higher rate of miscarriage than career

Questions?

Dr. Sara A. Jahnke
sara@hopehri.com
913-238-5648