



Protecting Our Heroes:

Women Firefighters' Health and Wellness

Dr. Brittany Hollerbach

FIRE ENGINEERING®



NDRI USA

Women in Fire & Emergency Services



**In the United States,
women account for:**

- 35% of EMS¹
- 13% of Police²
- 14% of Military³
- 6% of Marine Corps³
- **5-11%** of Fire Service⁴

¹Crowe et al., 2020

²U.S. Bureau of Labor Statistics, 2022

³DoD Health Related Behaviors Survey, 2018

⁴NFPA U.S. Fire Department Profile, 2019

How far we've come



- Molly Williams: first known female firefighter in the U.S. (~1818)
- She was a slave who served with the Oceanus Volunteer Fire Company in NY

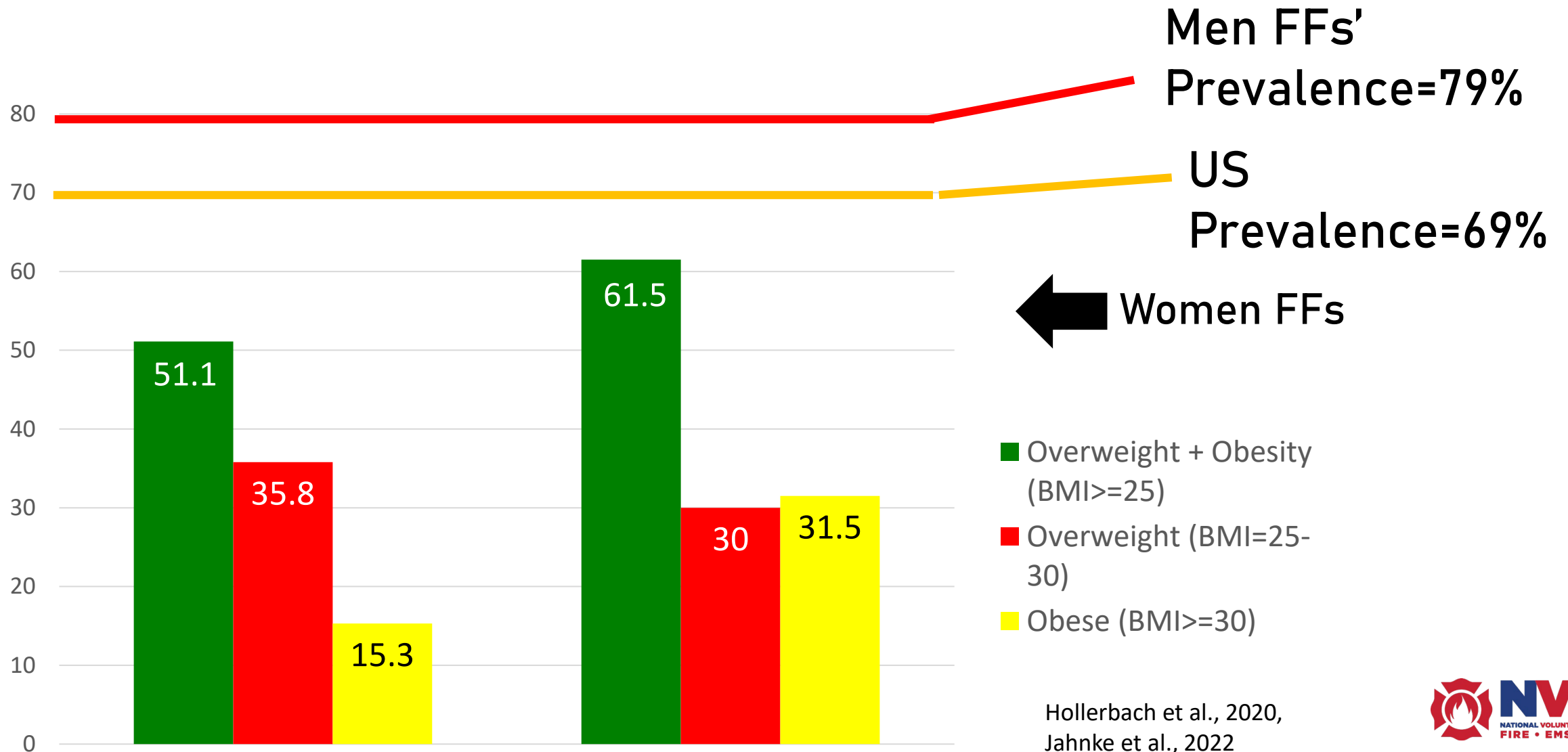
TODAY:

- 74,500 women volunteers
- 18,500 women career firefighters
- *Dedicated & thriving workforce*

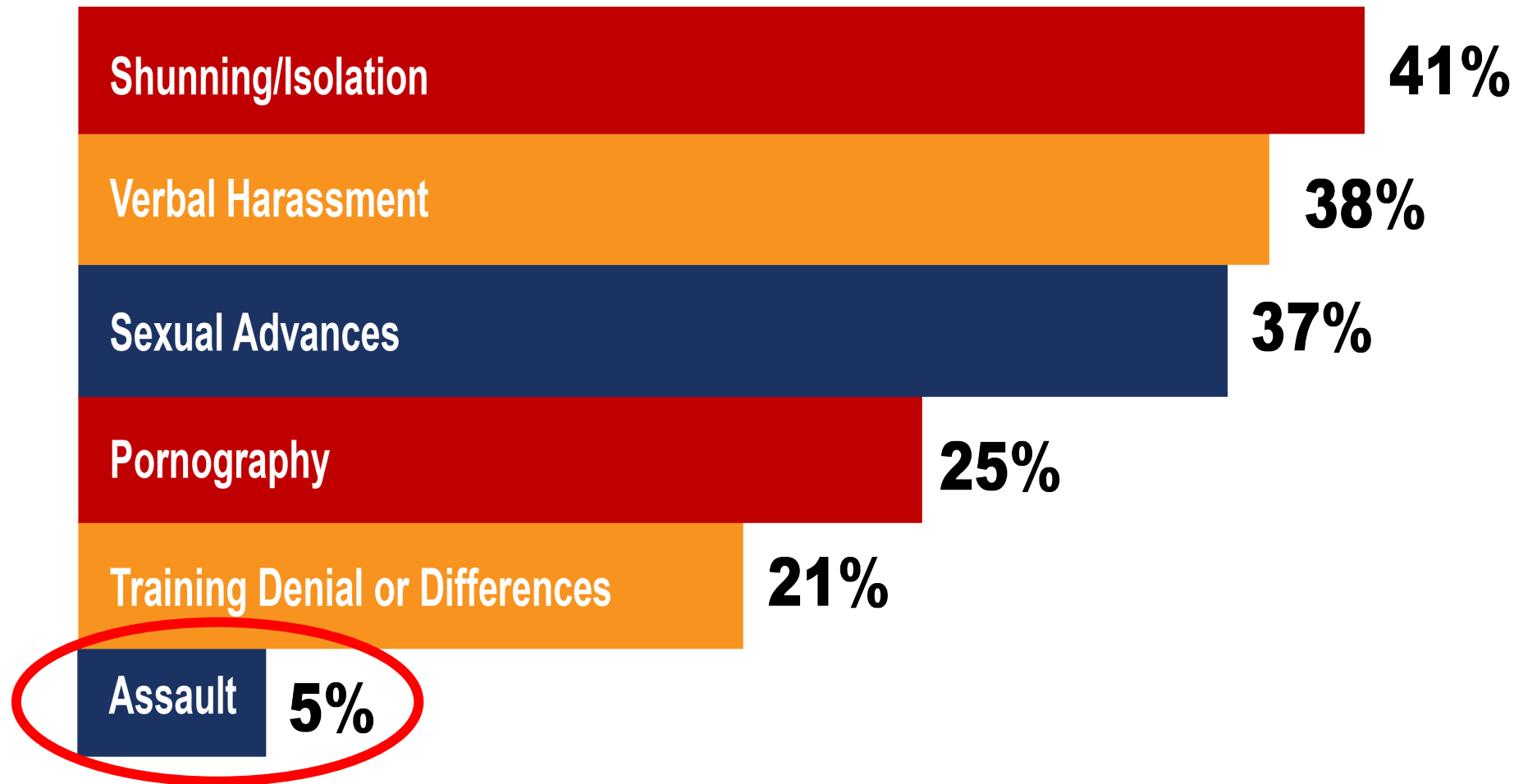
**What should departments know about
the health of women firefighters?**



Overweight & Obesity Prevalence

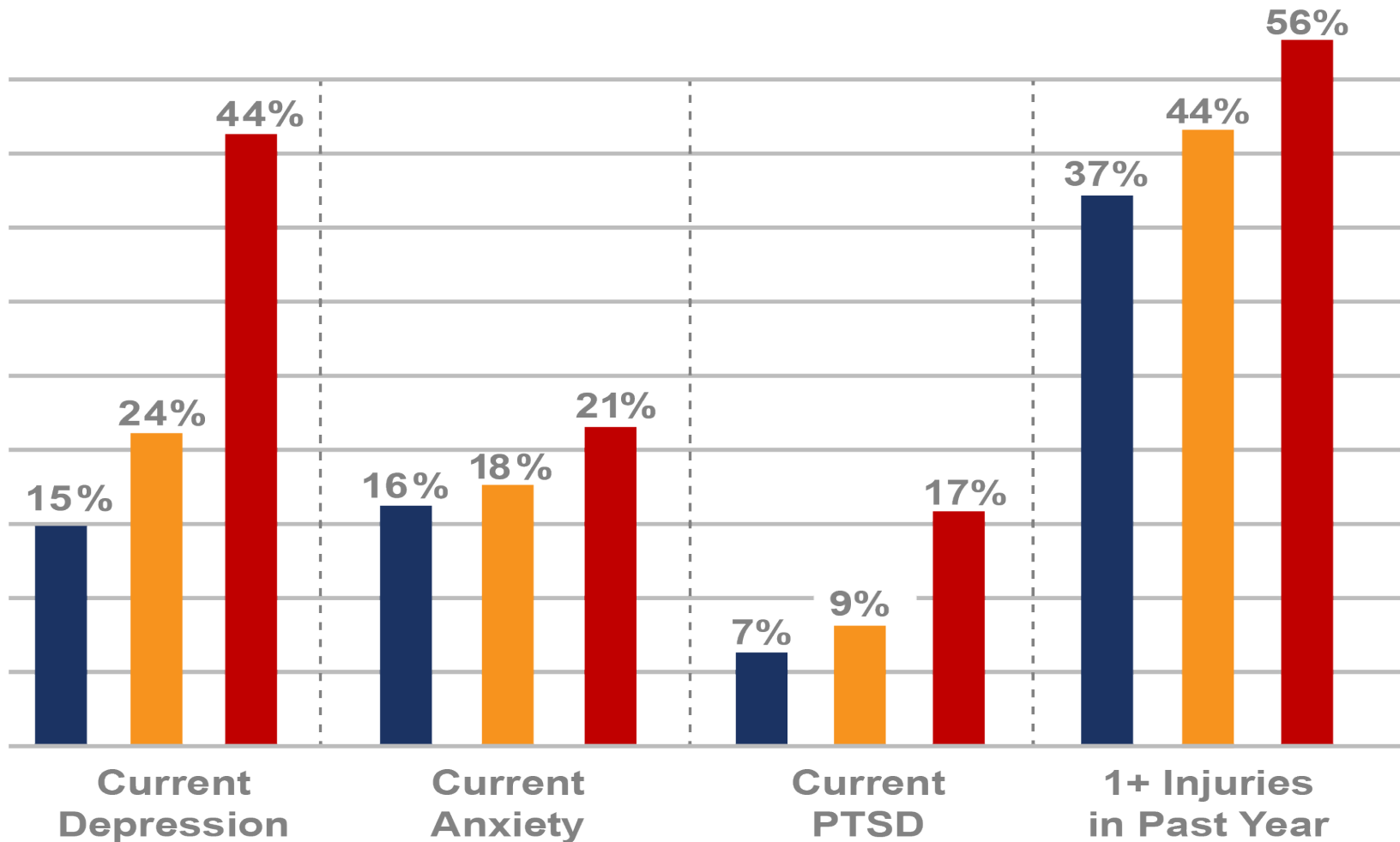


Today's Fire Service



(Jahnke et al., 2019)

Impact on Health



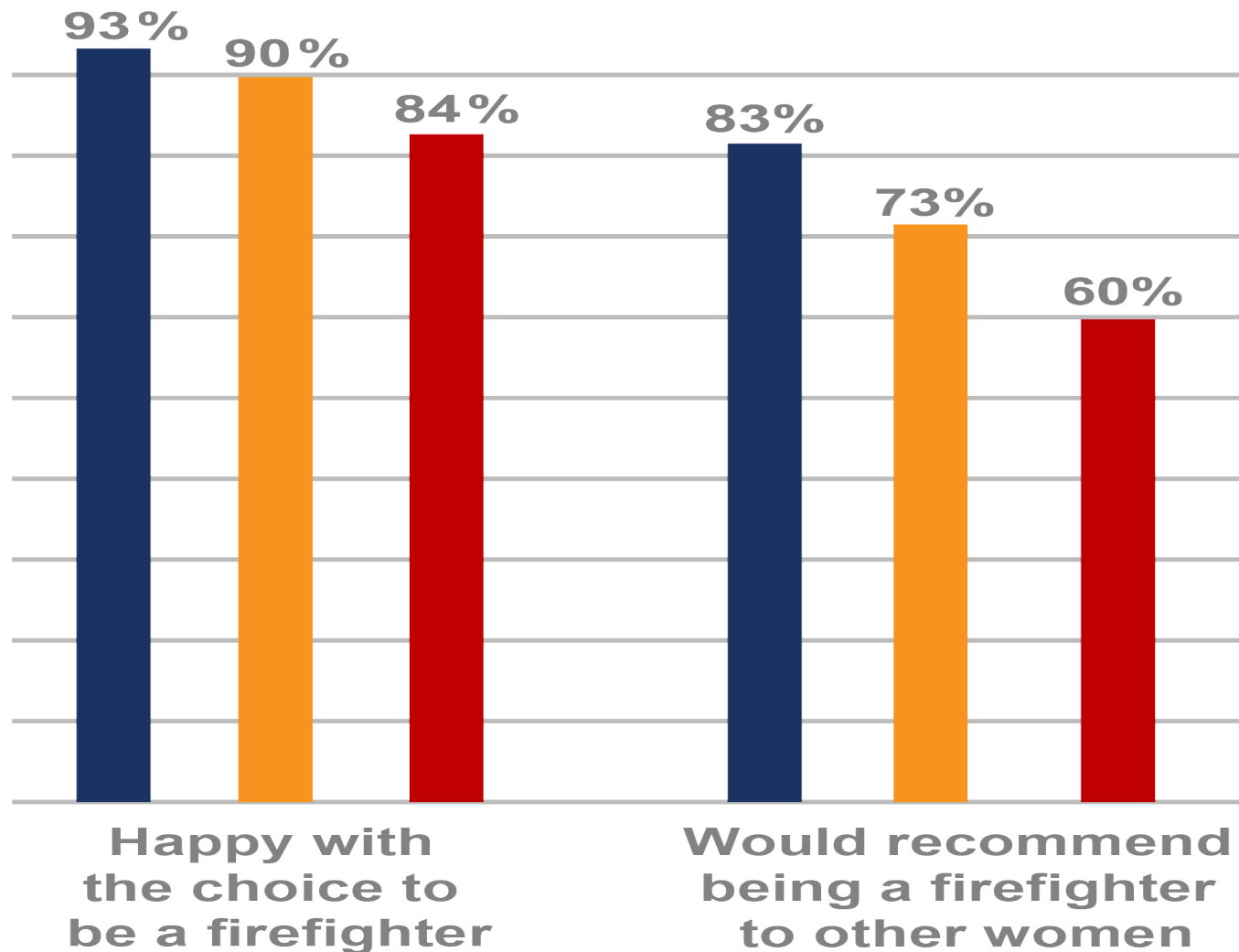
**Increased
Discrimination
& Harassment
= Worse Health**

**Frequency and Severity of
Discrimination/Harassment**



(Jahnke et al., 2019)

Impact on Recruitment & Retention



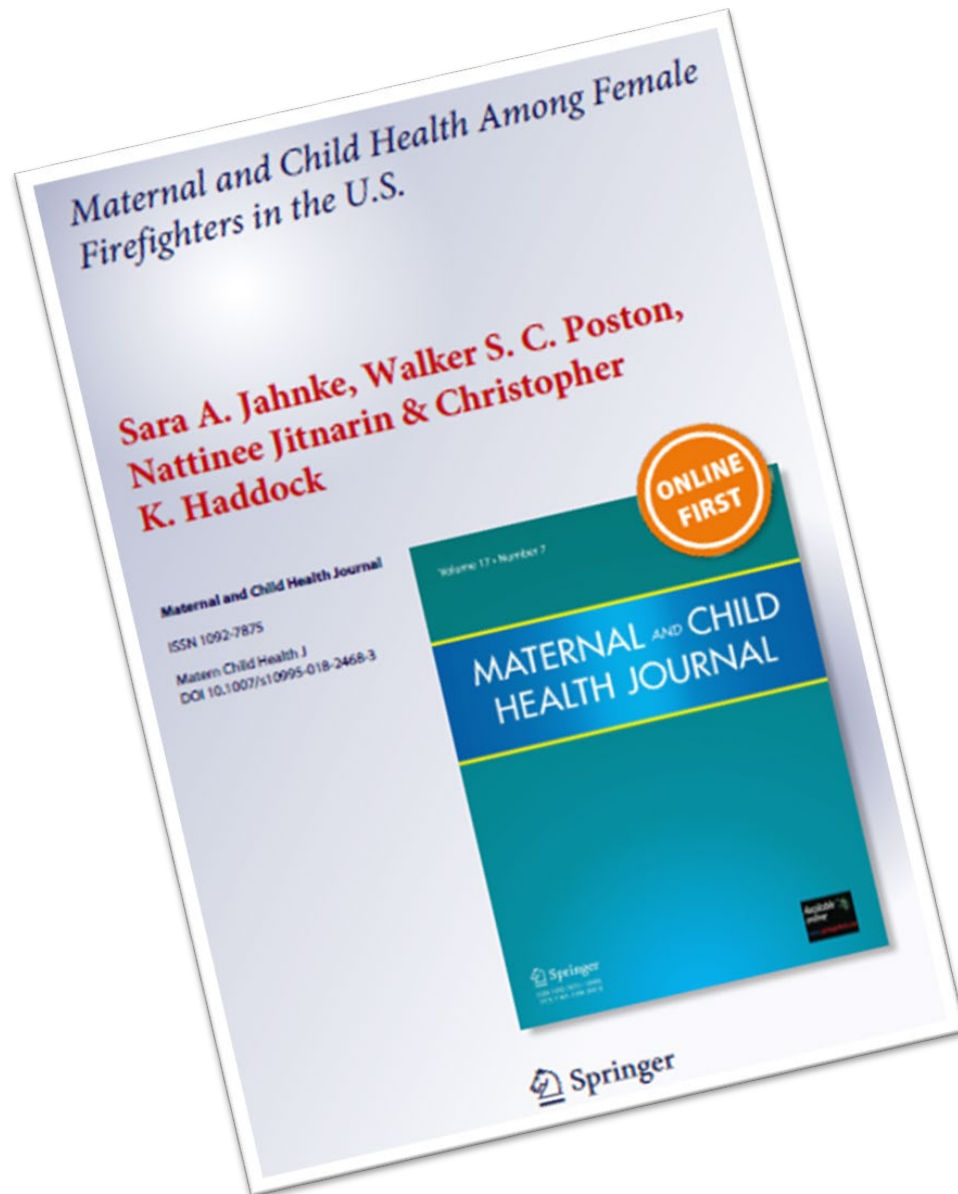
**Even with
some negative
experiences ...
Most women still LOVE
this job**

**Frequency and Severity of
Discrimination/Harassment**



(Jahnke et al., 2019)

Reproductive Health



- Recent research: Miscarriage rates among female firefighters were at least **2.3 times higher** compared to the U.S. National average of 10% (Jahnke, 2018)
- **Preterm birth was higher** among female FFs than the general population

(Jahnke et al., 2018)

What the data says...

- Recent research: Miscarriage rates among **volunteer** female firefighters were at least **1.42 times higher** compared to career firefighters
- Among **wildland/WUI** firefighters, **volunteers** had **2.53 times higher** risk of miscarriage compared to career firefighters



(Jung et al., 2021)

Ovarian Reserve

- **AMH** – clinical marker of ovarian reserve
- Recent research: Firefighters had **lower avg AMH** compared to non-firefighters
- Firefighters had **33% lower AMH** value compared to non-FFs
- More research necessary to understand these results

Article

Anti-Müllerian Hormone Levels among Female Firefighters

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Abstract: Female firefighters have occupational exposures which may negatively impact their reproductive health. Anti-müllerian hormone (AMH) is a clinical marker of ovarian reserve. We investigated whether AMH levels differed in female firefighters compared to non-firefighters and whether there was a dose-dependent relationship between years of firefighting and AMH levels. Female firefighters from a pre-existing cohort completed a cross-sectional survey regarding their occupational and health history and were asked to recruit a non-firefighter friend or relative. All participants provided a dried blood spot (DBS) for AMH analysis. Linear regression was used to assess the relationship between firefighting status and AMH levels. Among firefighters, the influence of firefighting-related exposures was evaluated. Firefighters ($n = 106$) and non-firefighters ($n = 58$) had similar age and BMI. Firefighters had a lower mean AMH compared to non-firefighters (2.93 ng/mL vs. 4.37 ng/mL). In multivariable adjusted models, firefighters had a 33% lower AMH value than non-firefighters ($-33.38\% \Delta$ (95% CI: $-54.97, -1.43$)). Years of firefighting was not associated with a decrease in AMH. Firefighters in this study had lower AMH levels than non-firefighters. More research is needed to understand the mechanisms by which firefighting could reduce AMH and affect fertility.

Keywords: anti-müllerian hormone; firefighter health; occupational exposures; reproductive health



Citation: Davidson, S.; Jahnke, S.; Jung, A.M.; Burgess, J.L.; Jacobs, E.T.; Billheimer, D.; Farland, L.V. Anti-Müllerian Hormone Levels among Female Firefighters. *Int. J. Environ. Res. Public Health* **2022**, *19*, 5981. <https://doi.org/10.3390/ijerph19105981>

(Davidson et al., 2022)

Breast Milk

Excretion of polybrominated diphenyl ethers and AhR activation in breastmilk among firefighters

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Alesia M. Jung and Shawn C. Beitel are co-first authors.

The authors certify that all research involving human subjects was done under full compliance with all government policies and the Helsinki Declaration.

Abstract

Excretion of toxicants accumulated from firefighter exposures through breastmilk represents a potential hazard. We investigated if firefighting exposures could increase the concentration of polybrominated diphenyl ethers (PBDEs) and aryl hydrocarbon receptor (AhR) activation in excreted breastmilk. Firefighters and nonfirefighters collected breastmilk samples prior to any firefighting responses (baseline) and at 2, 8, 24, 48, and 72 h after a structural fire (firefighters only). Five PBDE analytes (BDEs 15, 28, 47, 99, and 153) detected in at least 90% of samples were summed for analyses. The AhR *in vitro* DR CALUX bioassay assessed the mixture of dioxin-like compounds and toxicity from breastmilk extracts. Baseline PBDEs and AhR responses were compared between firefighters and nonfirefighters. Separate linear mixed models assessed changes in sum of PBDEs and AhR response among firefighters over time and effect modification by interior or exterior response was assessed. Baseline PBDE concentrations and AhR responses did not differ between the 21 firefighters and 10 nonfirefighters. There were no significant changes in sum of PBDEs or AhR response among firefighters over time postfire, and no variation by interior or exterior response. Plots of sum of PBDEs and AhR response over time demonstrated individual variation but no consistent pattern. Currently, our novel study results do not support forgoing breastfeeding after a fire exposure. However, given study limitations and the potential hazard of accumulated toxicants from firefighter exposures excreted via breastfeeding, future studies should consider additional contaminants and measures of toxicity by which firefighting may impact maternal and child health.

Keywords: firefighters; occupational exposure; polybrominated diphenyl ethers; aryl hydrocarbon receptor activation; maternal and child health.

- **Recent research:** PBDEs and AhR response **did not** differ between firefighters and non-firefighters at baseline, after fire response, or based on interior vs exterior operations
- Given study limitations & potential hazards of accumulated toxins, we **NEED MORE RESEARCH**

(Jung et al., 2023)

Factors that impact reproductive health

- Toxic products of combustion
- Intense thermal environment
- Loud noises
- Psychological & physical strain
- Ill-fitting PPE
- Shift work



Cancer

**Fire fighter
occupational cancer is
the leading cause of
line-of-duty deaths in
the fire service.**

IARC MONOGRAPHS VOL. 132: OCCUPATIONAL EXPOSURE AS A FIREFIGHTER

Occupational exposure as a firefighter is **carcinogenic to humans (Group 1)** on the basis of **sufficient evidence for cancer in humans**



The *IARC Monographs* classification indicates the level of certainty that an agent can cause cancer (*hazard identification*)

Higher level of certainty Lower level of certainty



Cancer types with **sufficient evidence** for cancer in humans:



Cancer types with **limited evidence** for cancer in humans:



Strong mechanistic evidence in exposed firefighters



Exposures of firefighters include combustion products, diesel exhaust, building materials, asbestos, chemicals, shift work, ultraviolet radiation



Firefighters respond to various types of fire



Structure



Wildland



Vehicle

How can we better protect women firefighters?

- Provide properly fitting **personal protective equipment**
- Implement **anti-harassment and discrimination policies**
- Develop **pregnancy and family leave policies**
- Offer **reproductive health and wellness programs**
- Promote **inclusive leadership** and mentorship opportunities
- **Recruitment and retention** strategies focused on **gender equity**

Recruitment & Retention

- Women volunteer at higher rates than men
- Recruiting women helps address staffing shortages
- Diverse teams perform better
- Gender inclusivity boosts recruitment and retention
- Women firefighters build community trust



Where to start

- **NVFC** Recruitment & Retention Planning & Funding
- **NVFC** Make Me a Firefighter
- **USFA** Recruitment & Retention
- **Science to the Station** resources
- **The Beltane Guild**



NFPA®

1580

Standard for
Emergency Responder
Occupational Health and Wellness

2025

Includes

NFPA 1581 | NFPA 1582 | NFPA 1583 | NFPA 1584



U.S. Fire Administration
Working for a fire-safe America

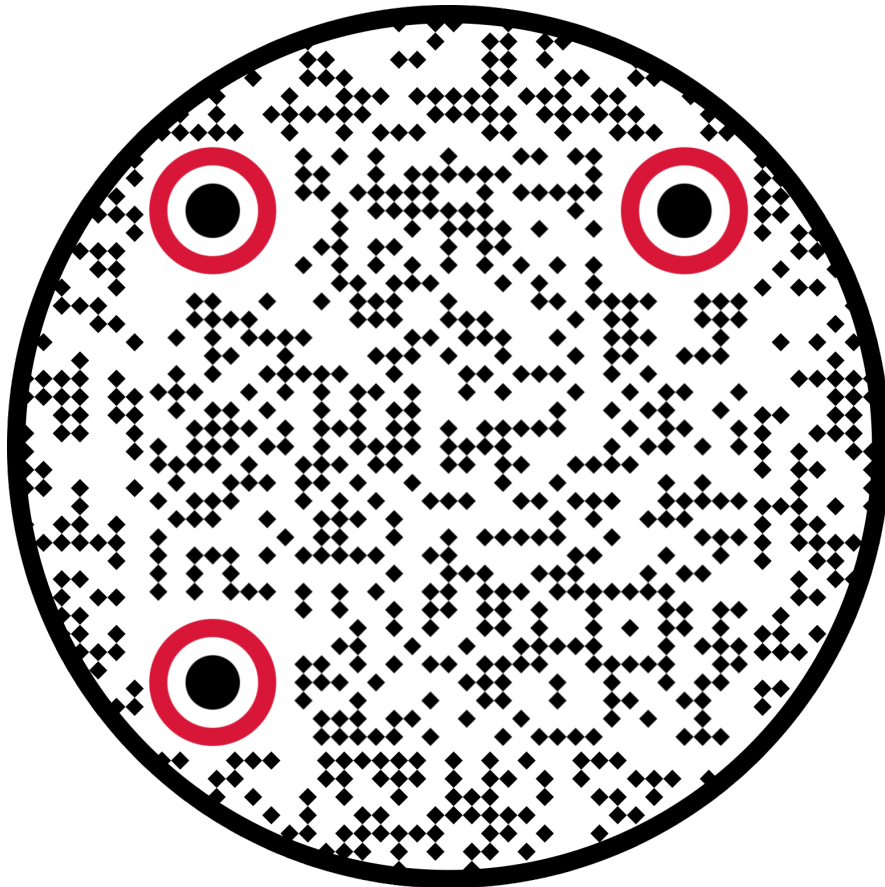
Retention and Recruitment
for the Volunteer
Emergency Services

FA-361 | May 2023



Resources

SCAN CODE TO DOWNLOAD:



Reproductive Health & the Fire Service



DANGERS OF THE JOB

- Toxic products of combustion: CO, PAHs, PFAS, etc.
- Certain chemicals and metals may be absorbed faster by pregnant women
- Some toxins more dangerous to the fetus than to the mother
- Circulation upregulated during pregnancy so the fetus is at increased risk
- Intense thermal environment
- Loud noises
- Psychological and physical strain
- Weight of full equipment: ~45-75 lbs
- Ill-fitting protective equipment
- Shift work
- Wide variation in pregnancy policies (30% of women reported their department had NO pregnancy/maternity leave policy)

Potential CONSEQUENCES

- **Infertility/reduced fertility**
 - Increased use of fertility drugs among women FFs (8.7% for first pregnancies to 15.0% for fourth pregnancies)¹
 - Increased rates for adverse pregnancy, childbirth, and puerperium outcomes²
 - Exposure to heat may lead to delayed conception³
 - Increased rates of infertility among FFs (16%) compared to national average (6%)⁴
- **Menstrual/ovulatory cycle disorders**
 - Different phases of the menstrual cycle and oral contraceptive use can impact thermoregulation⁵
 - Shift work (including evening, night, or irregular shifts) can result in altered menstrual cycle length, increased menstrual pain, and changes in duration and amount of menstrual bleeding; can also result in changes in hormone secretion⁶
- **Sex-hormone imbalances**
 - Noise-exposed women were more likely to experience hormonal disturbances and idiopathic infertility than nonexposed controls⁷
- **Miscarriage**
 - Miscarriage rates among FFs 2.3 times higher compared to national average (29.1% vs 13.5%)^{1,4}
 - Excessive bending/crouching associated with elevated risk of miscarriage⁸
 - Preliminary data shows miscarriage rates higher among volunteer than career FFs (volunteer FFs had 1.42 times the risk of miscarriage)¹
 - Among wildland and WUI, volunteers 2.53 times more likely to have miscarriage than career FFs¹
- **Stillbirth**
 - High ambient temperatures associated with shorter gestation periods and greater occurrence of stillbirth^{9,10}
- **Birth defects**
 - Maternal hyperthermia associated with neural-tube defects during early pregnancy¹¹
 - Exposure to carbon monoxide and high temperatures may increase the risk of birth defects¹²
- **Child developmental disorders**
 - Birth defects are a leading cause of infant mortality and developmental disabilities in the US¹³
 - Occupational exposure has been linked to a number of birth defects but there is little literature examining developmental disorders of FF offspring
- **Premature birth**
 - FFs had higher rates of pre-term birth compared to national average (11.6-16.7% vs 9.6%)^{1,4}
 - Shiftwork has been connected to miscarriage and pre-term labor¹⁴
 - Among structural FFs, volunteers 1.47 times as likely to have preterm birth compared to career FFs¹
 - Among wildland and WUI, volunteers 2.82 times more likely to experience preterm birth than career FFs¹
 - Exposure to air pollution & non-occupational wildfire smoke during pregnancy associated with increased risk of pre-term birth^{15,16}
- **Low birth-weight babies**
 - Loud noises may result in lower fetal weight and increased risk of fetal mortality¹⁷
- **Work Restriction**
 - Timing of when work restriction is started may influence risk¹⁸
 - Women who started restricting their work during the 2nd trimester appeared to have lower risk for preterm birth compared to women who started work restriction in the 3rd trimester or who didn't restrict work at all¹⁸

Male Reproductive Health is Affected Too!

- Danish FFs had 46-53% increased risk of male-factor infertility compared to general workers¹⁹
- Male infertility 46-53% higher than general population²⁰
- Paternal employment as a FF was associated with ventricular septal & atrial septal defects among offspring²¹
- Semen parameters (e.g., volume, sperm concentration, total sperm count, motility, normal forms) of FFs were lower than male fertility reference values published by the World Health Organization²²
- Increased fire exposure is also associated with reduced sperm parameters²³

Solutions & Next Steps

- Check out NFPA 1582, Section 9.12, 2020 ed.
- Limit exposures with appropriate decontamination (see NFPA 1585)
- Take this guide and discuss options with your physician
- Know your department's policy or suggest adding one if there isn't one already

FOR MORE INFORMATION & REFERENCES,
Scan the QR code with
your phone →



Resources



OB/Gyn Health Resource Guide for Firefighters

Firefighters are required to work in extreme conditions that may impact their health. Below are considerations for OB/Gyns when making decisions about clearance for duty.

The NFPA has determined essential job tasks for firefighters to be:

1. Wearing personal protective gear (weighing on average 50 lbs.) and self-contained breathing apparatus (SCBA)(an additional 15-20 pounds) while conducting firefighting tasks such as lifting and carrying heavy objects, advancing hoselines, using power tools, forcing entry through doors and/or windows, and making rescues in extreme temperatures for prolonged periods of time.
2. Wearing SCBAs with a positive pressure facepiece or HEPA filter that requires increased respiratory workload.
3. Exposure to known and expected carcinogens (e.g. benzene, PAHs, arsenic, asbestos) through inhalation and/or dermal absorption.
4. Potentially climbing 6 or more flights of stairs in full PPE carrying tools of approximately 20-40 lbs.
5. Wearing encapsulating and insulated PPE that leads to significant fluid loss and can elevate core temperature to 102.2°F.
6. Wearing PPE during search and rescues dragging a person (up to >200 lbs) to safety.
7. Wearing PPE while advancing hoseline approximately 150ft. often upstairs or ladders.
8. Wearing PPE while performing strenuous tasks such as climbing ladders, crawling in dark, narrow or uneven services that may be icy or wet – and in instances that might include downed power lines and other hazards.
9. Performing tasks over a long period in an unpredictable environment that may not have scheduled rest periods, meals, or hydration.
10. Operating fire trucks/other vehicles with emergency lights and sirens.
11. Conducting critical, time sensitive work in stressful and hazardous environments.
12. Communicating while wearing full PPE in the presence of high background noise and poor visibility.
13. Functioning as a team where sudden incapacitation can result in mission failure, risk of injury or death.
14. Working in shifts. Career firefighters typically work in 24 or 48 hours shifts and volunteer firefighters typically are on call 24 hours a day, 7 days a week. The known implications of shift work (e.g. increased risk of cancer, cardiovascular disease, fertility issues, and miscarriage) are of concern.



PREGNANCY OUTCOMES

Miscarriage

Firefighters were 2.3 times more likely to miscarry than general population ^[1,2]. Volunteer firefighters experienced higher risk of miscarriage compared to career firefighters.

Pre-term Labor

Approximately 12% of livebirths to female firefighters were < 37 weeks gestation. ^[3] Compared to the general US population, female firefighters had 2.8 times the risk of pre-term birth. Going to light duty during the first trimester, compared to the third trimester was associated with 37% reduction in risk of preterm birth although the result was not statistically significant.



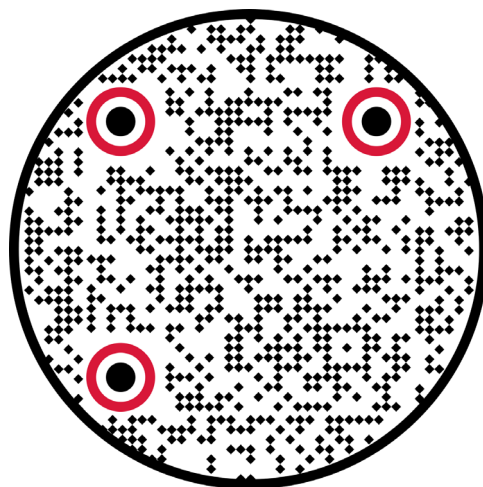
Follow this link, bit.ly/3yX8lfA or Scan the QR code for screening tools, resources, references & more

- Take this to your doctor
- Facilitates a conversation
- NFPA job tasks
- Pregnancy outcomes
- Child health outcomes
- Gynecologic health & fertility
- Cancer

Resources

- Self-reported infertility and fertility treatment utilization is high among women firefighters
- 16% of women firefighters reported experiencing infertility
- 81% who experienced infertility utilized fertility treatment

SCAN CODE TO DOWNLOAD:



GYNECOLOGIC HEALTH & FERTILITY

There has been limited research on the influence of firefighting on fertility and gynecologic health, but emerging research suggests that:

- Female firefighters have 30% lower age-adjusted anti-müllerian hormone levels compared to the general population^[4], which may influence fertility and age at menopause.

- Self-reported infertility and fertility treatment utilization is also high among female firefighters, based on self-report^[2].

Approximately 16% of female firefighters reported experiencing infertility, and 81% who experienced infertility utilized fertility treatment, which may be a marker of infertility severity.

Male firefighters have been found to be 46% more likely to access IVF than their peers^[2].

Labor and Delivery Complications

Research has suggested that female firefighters are at elevated risk (RR:1.55) of labor and delivery complications.^[6]

Breastmilk

While initial data from a pilot study suggested an increase in carcinogens up until 72 hours post fire, a larger follow-up study by Jung et al. that measured polybrominated diphenyl ethers (PBDEs) and aryl hydrocarbon receptors (AhRs) found there was not a difference in PBDEs or AhRs between pre-fire and 24, 48, or 72 hours post incident breastmilk^[7]. Further, there was not a statistically significant difference between the levels of PBDEs or AhRs among firefighters and non-firefighters. It should be noted that this study was limited to only these classifications of chemicals. PFAS - a concern for firefighters - has been found to be of concern in breastmilk.

Child Health Outcomes

Preliminary evidence suggests offspring of male firefighter are at increased risk for birth defects^[8]. They were 3 times more likely to have total anomalous pulmonary venous return, 60% more likely to be born with cleft palate, 2.2 times more likely to have cleft lip, and 2.2 times more likely to have transverse limb deficiency than non-firefighters.

These associations have not been studied in female firefighters.

Cancer

Firefighting has been classified as a Group 1 Carcinogen by the International Agency for Research on Cancer^[9]. Cancers with sufficient evidence for elevated risk in firefighters include bladder and mesothelioma. Cancers with limited evidence for elevated risk in firefighters include colon, melanoma, and non-Hodgkins lymphoma.

While data is limited due to small sample sizes, there is some evidence that women firefighters may be at increased risk for breast, cervical, and ovarian cancer due to the risks of the job.

Risk Considerations During Pregnancy





	Trauma	Chemicals	Other Risks
First Trimester 	Fetal trauma is mitigated due to the location of the uterus	Avoid exposure to heavy metals, hydrocarbons, carbon monoxide	Heat, noise, radiation, shift work, infections
Second Trimester 	Fetal trauma is increased due to the intra-abdominal position after 13 weeks	Avoid exposure to heavy metals, hydrocarbons, carbon monoxide	Heat, noise, radiation, shift work, infections
Third Trimester 	Fetal trauma is increased due to the intra-abdominal position after 13 weeks	Avoid exposure to heavy metals, hydrocarbons, carbon monoxide	Heat, noise, radiation, shift work, infections
Lactation 	No additional risk	Avoid exposure to heavy metals, hydrocarbons, carbon monoxide	Pumping and dumping considerations post-fire

Table adapted from NFPA 1582, Appendix C, Table C.7

March 2023



**FAMILY PLANNING POLICY TEMPLATES
FERTILITY TREATMENT GRANTS
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Questions?



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nvfcoffice@nvfc.org

Dr. Brittany Hollerbach
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www.science-alliance.org

www.nvfc.org



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