Comparing Structural Firefighters' On- and Off-Duty Exposures to Xylenes

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BACKGROUND

Xylenes, a group of three isomeric volatile organic compounds (VOCs) can come from many sources, from petroleum and combustion, to cleaning agents and plastics[1]. Chronic and acute exposure to xylenes through multiple exposure routes has been linked to an assortment of adverse health effects[2,3,4,5,6,7,8]. With a high number of VOCs being released from structural fires, firefighters could potentially face an occupational risk in responding to fires due to potential acute and chronic exposure effects[9]. **Characterizing xylenes exposure in structural firefighters can provide a greater understanding into the occupational risk that xylenes pose to those who could be exposed at a higher frequency.**

Fig. 1 Represents exposure routes, and exposure health effects

HYPOTHESIS

The project aims to characterize the difference in xylenes exposures structural firefighters face while on- versus off-duty. While structural firefighters can be exposed to xylenes both in the home[10] and on the job[11], it is hypothesized average on-duty exposure to xylenes will be greater than the paired off-duty exposure, due to the high number of total VOCs released from structural fires[9].

STUDY DESIGN

Sampling Methods

- Passive sampling devices (PSDs):
  - 2 military-style silicone dog tags; a tag worn 30 on-shift days and a tag worn 30 off-shift days.

Prepared and conditioned using methods outlined by Anderson et al. (2017)[12].

- Background Survey
  - On demographics, work history, and current potential exposure[11].

Firefighters from 2 Kansas City fire station chosen:

- **"high call volume" station**
  - (>12 calls per month; $n_{high\ volume}$= 29)
- **"low call volume" station**
  - (<2 calls per month; $n_{low\ volume}$= 27)

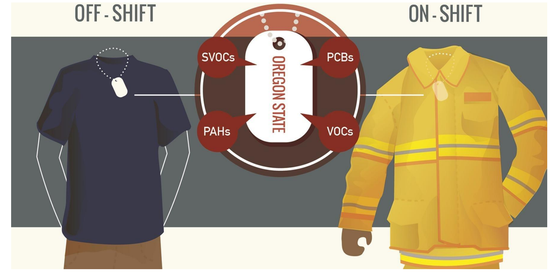

Fig. 2 Graphic represents all analyses done, and on- vs. off-duty exposure components of the study. Taken from "Discovery of firefighter chemical exposures using military-style silicone dog tags." Poutasse C, et al. 2020

RESULTS AND ANALYSIS

Analysis Methods:

Gas Chromatography-Mass Spectrometry

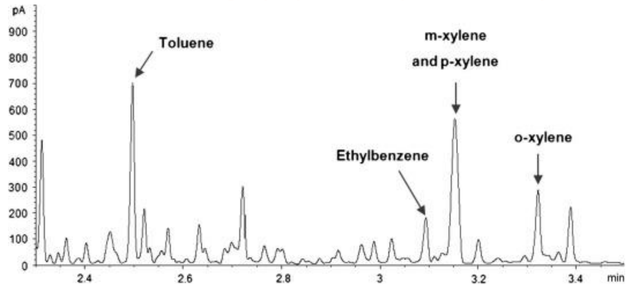

Fig. 3 Chromatograph showing elution of toluene, ethylbenzene, and xylenes on a gas-chromatography-mass spectrometer. Shows coelution of meta- and para-xylene, demonstrating difficulty in distinguishing the isomers. O-xylene is also unable to be detected utilizing the analysis methods due to low recovery rate in extraction.

1. Samples extracted from dog-tags as outlined in *Poutasse C, et al 2020.*
2. Samples analyzed using Agilent 5975C series GC/MS[11].
   1. Coelution of m- and p-xylene creates difficulty in distinguishing the isomers *(Fig. 3)* and o-xylene is not present in the data due to methods used in extraction. Therefore, all data is representative of a mixture of meta- and para-xylene.

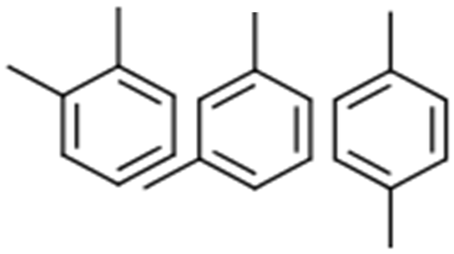

Fig. 4 The isomers of xylene. From left to right: ortho-xylene, meta-xylene, para-xylene

1. *Statistical significance (p=0.042) demonstrated* when comparing paired on-duty exposure and off-duty exposure *(Table 1)*.
2. *Rate of detection was higher* in on-duty tags versus off-duty tags *(Table 2*).
3. *Notable difference* between average on-duty and off-duty exposures *(Fig. 5*).
4. *High variability* in sample concentrations *(Fig. 6*).

Table 1. Shows returned p-values of one-tailed paired t-tests for statistical significance. ***Statistical significance returned for TN-TO comparison (p<0.05).***

	High Call, On Duty vs. High Call, Off Duty *(HN-HO)*	Low Call, On Duty vs. Low Call, Off Duty *(LN-LO)*	Total On Duty vs. Total Off Duty *(TN-TO)*
p-values	0.110	0.106	**0.042**

Table 2. Contains values used analysis. Two samples from high call volume station were removed from analysis due to not having associated paired off-duty tags.

Exposure (mmol/g)	On-Duty Exposure	Off-Duty Exposure
Average	4.23×10^{-7}	2.39×10^{-7}
Maximum	3.10×10^{-6}	2.71×10^{-6}
Minimum	9.40×10^{-10}	9.40×10^{-10}
Standard Deviation	7.61×10^{-7}	5.40×10^{-7}
Standard Error	1.04×10^{-7}	7.35×10^{-8}
Sample Size	54	54
% Samples with Xylenes Detected	33.3% (18/54)	24.1% (13\54)

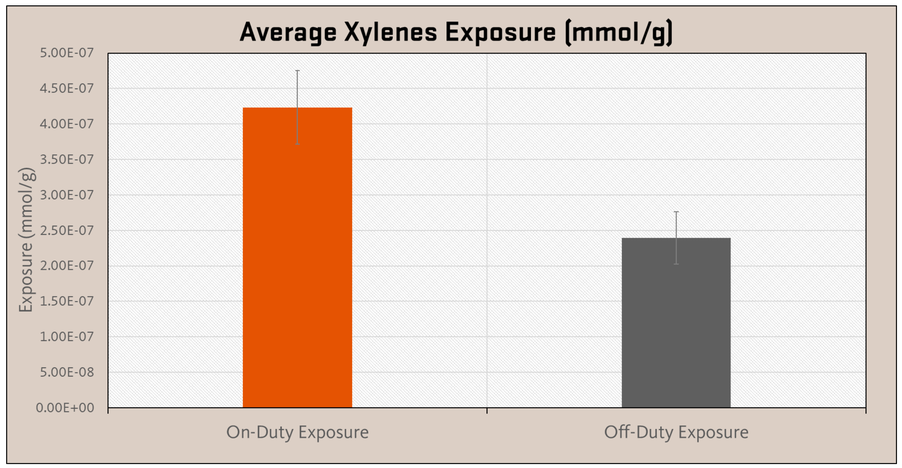

Fig. 5 Bar graph depicting average exposure concentration in millimoles per gram for each distinctive shift status. Error bars represent standard error.

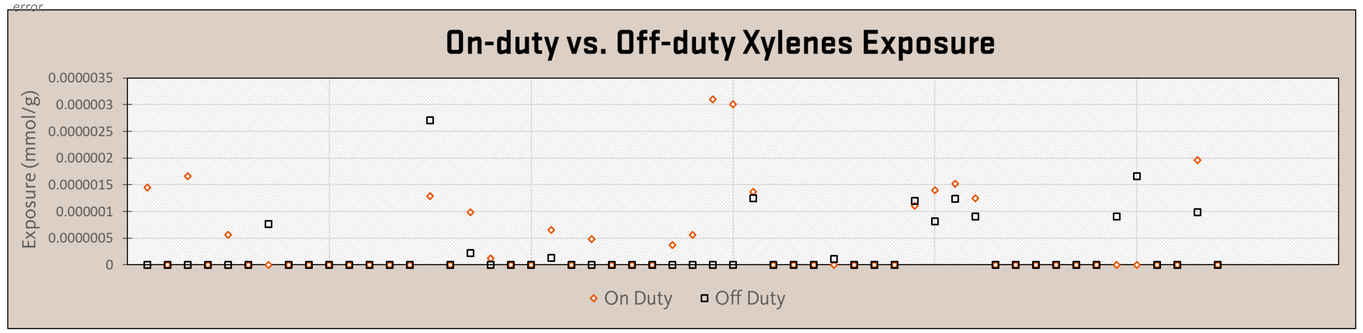

Fig. 6 Scatter plot depicting paired on- and off-duty exposures for all samples. Scatterplot shows most exposures are at the instrument limit of detection (LOD). Concentrations below the limit of detection substituted with the LOD/√2.

CONCLUSIONS

Data show moderate evidence that xylenes exposure was higher in on-duty tags than paired off-duty tags in sampled firefighters (paired student's t-test, p=0.042).

Future Steps with Xylenes

- ***Sources*** can come from in and out of the fire station, accounting for the exposures seen[1,6,7,8].
- Exact ***Pathways*** are unknown due to the nature of the passive sampling devices, and should be elucidated.
- Specific ***Health Effects*** should be quantified and LOAEL, NOAEL studies performed.
- Best practices in ***Minimizing Exposure*** should be studied.

ACKNOWLEDGEMENTS

Acknowledgements: This work would not be possible without firefighter participants and departments, members of NDRI that helped with sample collection, FSES lab members including Clarisa Caballero-Ignacio, Ricky Scott, Jessica Scotten, Teresa Valdez, Caoilinn Haggerty, Ty Bryde, Samantha Samon, Christine Ghetu, and Brianna Rivera. Ilustration by Sean Carver.
Funding: Sheng C. Fang Undergraduate Research Fellowship, E.R Jackman Internship Support Program, FEMA Assistance to Firefighters Grant Program(EMW-2016-FP-000754) and NIEHS Superfund Research Award (P42ES016465)

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