Environmental Chemical Exposures: Biomonitoring in Firefighters

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Presenters:
Rupali Das, MD, MPH, FACOEM¹
Leslie Israel, DO, MPH, FACOEM²

¹ Associate Clinical Professor, UCSF
² Professor, UC Irvine

DISCLOSURES

This session will NOT include discussion of
– any commercial product or device with which I have a relationship
– any off-label or investigational use of a drug or device

Contributors

• Sandra McNeel, DVM¹
• Dina Dobraca, MPH¹
• Miaomiao Wang²
• Ryszard Gajek¹
• Myro Petreas, PhD²
• June-Soo Park, PhD²
• Frank Barley, PhD¹
• Jianwen She, PhD¹
• Sara Hoover, MPH³
• Robert Voss, MPH²

¹ California Department of Public Health; ² Department of Toxic Substances Control, CA EPA; ³ Office of Environmental Health Hazard Assessment, California EPA

Objectives

• Describe current understanding of exposures to chemicals in the environment in firefighters and others
• Present findings from a biomonitoring study of firefighters
• Discuss the challenges of biological monitoring in firefighters

We are what we eat...

...breathe, Lather, Spray...

Human Biomonitoring

The direct measurement of people’s exposure to environmental contaminants by measuring substances, their metabolites, or reaction products in blood, urine, or other [human] specimens.*

• CDC

*Human specimens can include blood (whole or serum), lymphocytes, urine, saliva, adipose tissue, breast milk, nails, hair, and exhaled breath.
Biomonitoring Measures
Exposure From All Sources

Exposure ≠ Disease

Modifying Factors
* Genetics
* Demographics (age, sex, geography)
* Environmental and behavioral stressors
* Nutritional and general health status
* Other exposures and vehicles carrying environmental chemicals

Selected Chemicals That May Be Biomonitored
- Metals
- Polychlorinated biphenyls, dioxins and furans
- Organochlorine pesticides
- Carbamate pesticides
- Organophosphate pesticides
- Pyrethroid pesticides
- Fungicides
- Herbicides
- Polycyclic aromatic hydrocarbons
- Phthalates
- Phytoestrogens
- Pest repellants
- Colinine
- Perfluorinated chemicals
- Brominated flame retardants
- Volatile organic compounds
- Perchlorate
- Bisphenol A & alkylated phenols
- Triclosan
- Speciated arsenic
- Acrylamide

CDC 4th National Report on Human Exposure to Environmental Chemicals

Occupational Biomonitoring: Agents Commonly Tested
- Biomonitoring Specified in OSHA Standards
  - Lead (Pb)
  - Cadmium (Cd)
- Others Somewhat Frequently Performed
  - Arsenic (As)
  - Mercury (Hg)
- Monitoring of Biological Effects Related to Dose
  - Cholinesterase activity (relating to organophosphate or carbamate insecticide exposure)
  - β2-Microglobulin (β2-M) in Urine (Cd-exposed workers)
- Chemical – Biological Target Interaction
  - Carboxyhemoglobin (COHb)

Environmental Chemicals: Found Everywhere
- PAHs
- Phthalates
- PFCs
- PAH/PFC
- PBDEs

Phthalates
- Fragrances
- Cosmetics
- Flexible vinyl plastics

Environmental Chemicals: Found Everywhere
PAHs
Phthalates
PFCs
PAH/PFC
PBDEs
Polycyclic Aromatic Hydrocarbons (PAHs)
Produced when coal, oil, gas, wood, garbage, and tobacco are burned

Perfluorochemicals (PFCs)
Food wrappers and containers
Some firefighting foams
Water-proof clothing, carpets
Non-stick cookware

Polybrominated Diphenyl Ethers (PBDEs)
Electronics
Foam furnishings
Dust

Benzophenone-3 (BP-3)
Sunscreens
Cosmetic products

Why Should We Care?
Chemical Exposures of Potential Concern

- Known toxicity
  - Heavy metals (e.g., lead, mercury): neurodevelopmental effects
- Endocrine disruption
  - E.g., bisphenol A (BPA), perfluorinated compounds (PFCs), phthalates, polybrominated diphenyl ethers (PBDEs)
  - Potential effects include: male reproductive system (e.g., undescended testes, spermatotoxicity); thyroid hormone dysfunction; neurodevelopmental effects
- Mutagenic effects
  - E.g., polycyclic hydrocarbons (PAHs): neural tube birth defects
- Epigenetic effects
  - Lifelong changes in gene programming and expression

US Public Health Biomonitoring Programs

- Federal Government
  - CDC: National Biomonitoring Program
  - National Children's Study (NIH)
- State Government
  - Currently funded by CDC: CA, NY, WA
  - Previously funded by CDC: MN, NH, Rocky Mountain States
  - Other: WI, IL
- Non-governmental organizations
  - Environmental Working Group
  - Environmental Defence’s Toxic Nation (Canada)
California Environmental Contaminant Biomonitoring Program

- Determine levels of chemicals in Californians
- Establish trends in the levels over time
- Assess effectiveness of public health efforts and regulatory programs

www.biomonitoring.ca.gov

Mandatory Results Communication

- Individual participants may request and receive complete results
- For known health risks, staff must recommend appropriate follow-up

Biomonitoring Structure

California Department of Public Health
- Epidemiology, Laboratory
- Department of Toxic Substances Control Laboratory
- Office of Environmental Health Hazard Assessment Toxicology, SGP
- Scientific Guidance Panel (SGP)
- Public Participation
- Centers for Disease Control and Prevention (CDC)

*Lead Agency

Biomonitoring California Studies
California Firefighters

- San Francisco Firefighters
  - PCBs, OCPs, PBDEs
  - Shaw 2013
- Response to World Trade Center collapse
  - Various chemicals
    - Edelman 2003
    - PFCs
    - Tao 2008; Jin 2011
- Saudi Arabia
  - Heavy metals
  - Al-Maliki 2009

Firefighters Exposed to Chemicals

- Various types
  - Parent compounds: phthalates
  - Combustion products: PAHs
  - Re-entrained from soil: lead
- Many associated with disease
  - Carcinogens: benzene, PAHs
  - Potential reproductive toxins: PFCs
- Potential sources
  - Occupational: fires, salvage, overhaul, protective equipment
  - Non-occupational: diet, hobbies, home & outdoor environment

Edelman 2003; Fabian 2011; Odigie 2011; Shaw 2013

Limited Biomonitoring in Firefighters

- San Francisco Firefighters
  - PCBs, OCPs, PBDEs
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- Response to World Trade Center collapse
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  - Heavy metals
  - Al-Maliki 2009
Biomonitoring in Firefighters who Responded to WTC Collapse

Edelman 2003

PAH levels Detected in Firefighter Environments

• PM2.5 and submicron particles:
  • Overhaul
  • Firehouses

• PAHs:
  • Firehouses
  • Face and neck wipe samples

Baxter 2014

Increased Cancer Rates in Firefighters

• Excess cancer mortality
  • SMR=1.14, 95% CI 1.10–1.18
    • Digestive (SMR=1.26, 95% CI 1.18–1.34)
    • Respiratory (SMR=1.10, 95% CI 1.04–1.17)

• Excess malignant mesothelioma
  • SMR=2.00, 95% CI 1.03–3.49

Daniels 2013

Firefighter Occupational Exposures (FOX) Study*

• Collaborative effort of CDPH, Biomonitoring CA, UC Irvine, and a Southern California Fire Authority

• Recruitment at wellness & fitness examination (n=101)

*Approved by relevant Institutional Review Boards; informed consent obtained

Firefighter focus groups & interviews
Evaluate study materials

Test biosample collection and handling protocols

FOX Data Collection
Firehouses UC Irvine
Field Testing
Recruitment
Blood and urine collection

6-9 months receive some results by mail (metals, nonpersistent chemicals)

Online survey after receiving second set of test results

Participant Feedback

FOX Project Design

Test biosample collection and handling protocols

Analysis of results

18 months receive balance of results by mail (persistent chemicals)

Study evaluation questionnaire

Project staff contact info provided

FOX Data Collection

Results Reporting

Analytes Measured

Bisphenol A (BPA), triclosan, parabens
Hydroxy polycyclic aromatic hydrocarbons (OH-PAHs)
Metals in blood (Cd, Hg, Mn, Pb)
Metals in urine (As)
Organochlorine pesticides (OCPs)
Perfluorinated compounds (PFCs)
Phthalates
Polychlorinated diphenyl ethers (PBDEs)
Polychlorinated biphenyls (PCBs)
Pyrethroid and Organophosphate (OP) metabolites
Selected brominated flame retardants (BFRs)

* UC Irvine and Biomonitoring California
Results will be presented

Results Returned to Firefighters: Lead as an Example

Results Returned to Firefighters: PFCs

Graphical Display of Results

Frequently Asked Questions: PFCs

Discussion:

- Practical applications
- Follow-up protocol for elevated levels
- Possible exposures pathways
- Challenges with interpretation of findings
  - How do you explain results when you don’t know what they mean?
- Unanswered questions
  - Identifying source(s) of exposure
  - Work-relatedness and workers’ compensation
**Limitations**

- Limited sample size
- Occupational vs. environmental exposures not definitively differentiated
  - Questionnaire length limited
  - Environmental sampling limited
  - Logistical issues limited follow up

**Conclusions**

- Firefighters have increased exposure to some chemicals – predictors?
- PPE should be used properly to reduce exposure
- Hygiene in firehouses is very important (hand hygiene, PPE storage, decontamination of gear)

**Acknowledgments**

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**Questions ?**