Firefighter Health Effects:
Overhaul and Beyond

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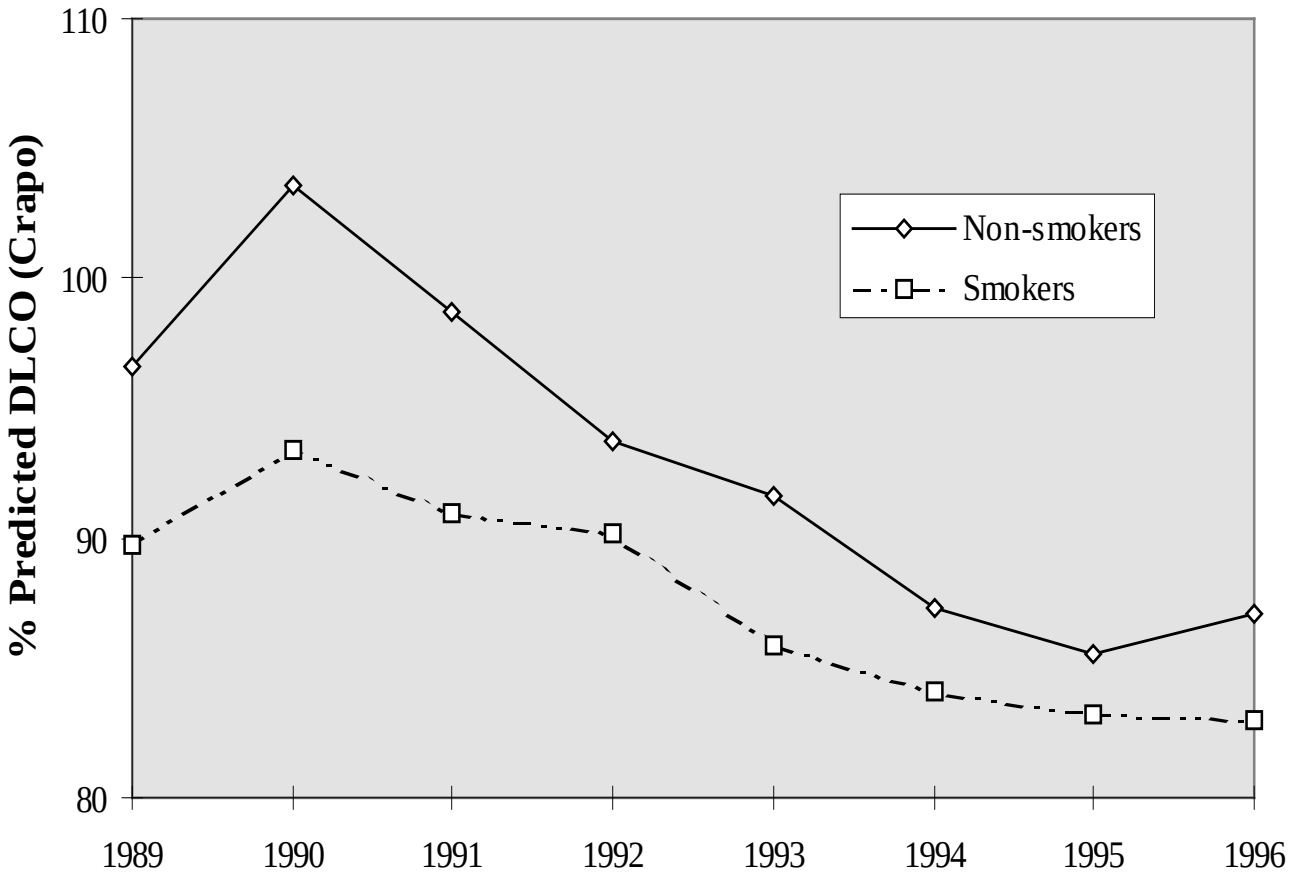
Outline

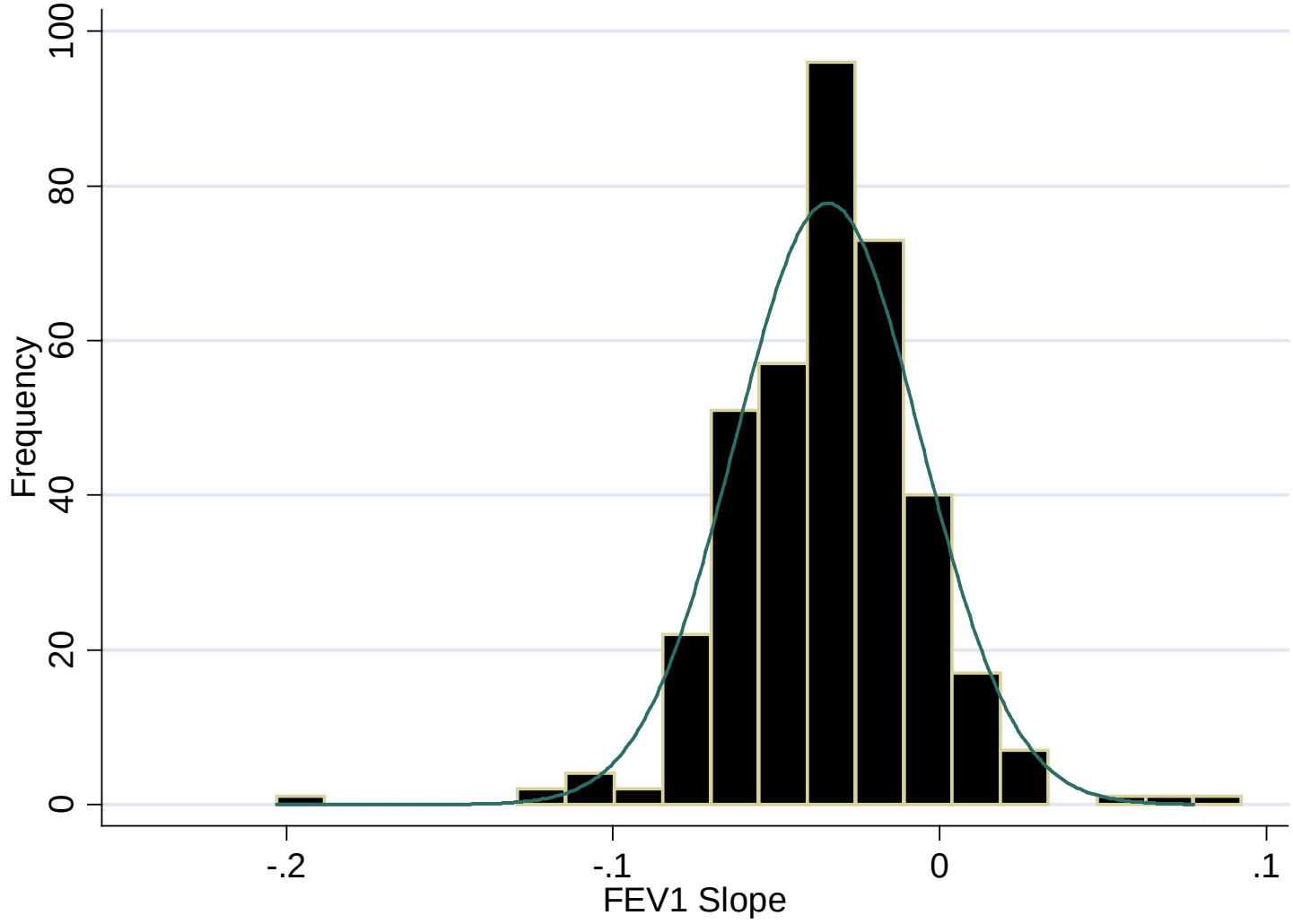
- Chronic respiratory effects & susceptibility
- Respiratory protection
- Overhaul study
- Biomarkers
- Cardiovascular effects
- Complex exposures
- Risk management
- Discussion

Respiratory effects



Burgess et al., Longitudinal decline in measured firefighter single-breath diffusing capacity of carbon monoxide values: A respiratory surveillance dilemma. *Am J Resp Crit Care Med* 1999;159:119-124.

Individual variability



Genotype/phenotype & ΔFEV_1

SNP	genotype	N	Adjusted mean ± s.e.†
IL-10 3699	AA	216	-0.037 ± 0.005‡
	AT	132	-0.031 ± 0.006
	TT	18	-0.012 ± 0.011

†ΔFEV_1(L) adjusted for age, gender, smoking & baseline FEV_1; ‡$p < 0.05$

Burgess JL, et al. Longitudinal decline in lung function: evaluation of interleukin-10 genetic polymorphisms in firefighters. *J Occup Environ Med* 2004;46:1013-22.

Variable*	Coefficient	p-value
Baseline age (yrs)	-0.002	0.047
Baseline FEV_1 (L)	-0.057	<0.001
Ln(IL-1RA/protein)	0.019	0.025
Weight change (lbs)	-0.001	0.014

*In 67 nonsmoking firefighters; adjusted for race, sex, smoking & asthma

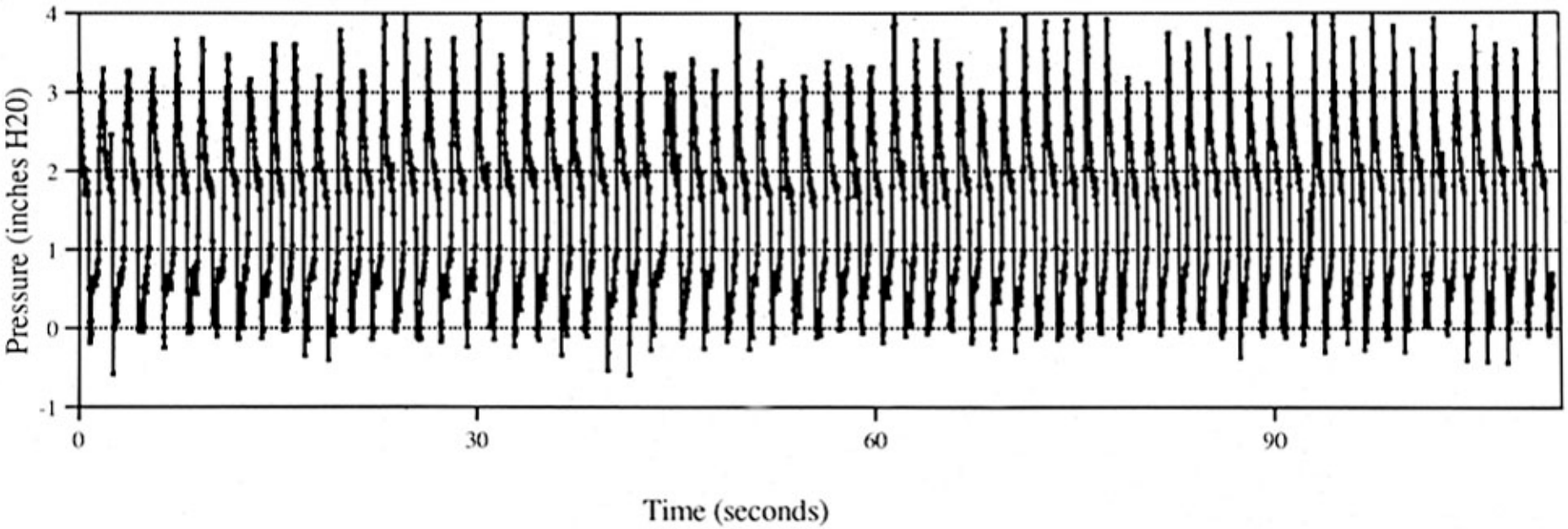
Josyula et al. Cytokine genotype and phenotype effects on lung function decline in firefighters. *J Occup Environ Med* 2007;49:282-288.

Respiratory protection-SCBA

- Self-contained breathing apparatus
- The NIOSH assigned PF is 10,000
- We have shown in the past that firefighters overbreathe their SCBA
- Potential exposure depends on facepiece fit and negative pressure excursions
- Some firefighters have reported black phlegm after using SCBA

Burgess JL, Crutchfield CD. Quantitative respirator fit tests of Tucson firefighters and measurement of negative pressure excursions during exertion. *Appl Occup Environ Hyg* 1995;10:29-36.

Burgess JL, Crutchfield CD. Tucson firefighter exposure to products of combustion: A risk assessment. *Appl Occup Environ Hyg* 1995;10:37-42.



Firefighter #3 facepiece pressure during exertion.

Respiratory protection-APR

- Air purifying respirator
- The NIOSH assigned PF for a full-face APR is 50 against particulates (assuming a HEPA filter) and gases/vapors (assuming appropriate cartridge)
- NIOSH only tests respirators against individual chemicals
- The effectiveness of APRs against mixed exposures are typicially not evaluated

Overhaul study

- Baseline and 1 hour post-overhaul FEV_1, FVC, serum Clara cell protein (CC16), and surfactant associated protein A (SP-A)
- Phoenix firefighters wore full face negative pressure air purifying respirators equipped with combo HEPA/Smart cartridges
- Tucson firefighters wore no respiratory protection
- All firefighters were monitored for exposure

Burgess et al. Adverse respiratory effects following overhaul in firefighters. *J Occup Environ Med* 2001;43:467-473.

448
18 '99

SCOTT
9 25 '98

Results-smoke exposure (ppm)

Analyte	n*	Tucson	n*	Phoenix
Formaldehyde	21/22	0.11±0.18	19/19	0.26 ±0.25
Acetaldehyde	5/23	0.16±0.01	18/19	0.38±0.49
Respirable dust†	0/24		11/19	6.18±7.80
Benzene	0/23		10/20	0.56±0.47
HCl	6/23	0.21±0.11	9/19	0.89±0.62
H_2SO_4†	4/23	0.27±0.01	10/19	3.40±3.63

* # of measurements exceeding LOD/ # of samples collected; † Measured in mg/m^3

Carbon monoxide	18	12.2±10.5	13	34.1±34.7
Nitrogen dioxide	18	0.003±0.005	13	0.008±0.007
Sulfur dioxide	18	0.45±0.40	13	1.52±1.42

Overhaul biomarkers

Group	n	CC16*	SP-A*	n	FVC (L)	FEV_1 (L)
TFD	25	8.9±3.5	287±144	19	5.42±0.72	4.10±0.62
TFD-OH	25	**12.3±3.6**†	306±157	19	5.36±0.73	3.94±0.65
PFD	26	9.6±3.5	250±117	26	5.44±0.68	4.22±0.51
PFD-OH	26	**14.6±5.2**†	**334±141**†	26	**5.29±0.74**†	**4.09±0.56**†

*units μg/L; † $p < 0.01$

Interpretation

- Adverse respiratory effects occurred during overhaul despite the use of air purifying respirators
- Individual chemical exposure levels within acceptable limits

Support/standby exposures

- Study of trainees in Alberta, Canada
- SCBA used to extinguish fire in training facility
- No use of SCBA during support/standby activities
- Significant reduction in FEV_1 with exposure

Yue, et. al. Lung function and airway inflammation in firefighting trainees following live-fire exercises. *Am J Resp Crit Care Med*. 2007;175:A805.

Biomarkers

Each illness and disease may require <u>different exposure/biomarker metrics</u>

- Biomarkers of early disease
  - e.g. carotid IMT
- Biomarkers of effect
  - e.g. inflammation
- Measures of internal dose
  - e.g. urinary metabolites
- Susceptibility biomarkers
  - e.g. genetic polymorphisms

Ideal ⇓ ⇓ ⇓ ⇓ ⇓ Less ideal

Genotoxicity studies

- Increased micronuclei in buccal cells (India)[1]
- Increased susceptibility to mitomycin C induced SCE correlated with number of fires fought in previous 24 hours (USA)[2]
- No increase in urinary 8-OHdG (Korea)[3]
- 20% of NYC firefighters had evidence of asbestos-related pulmonary disease (USA)[4]

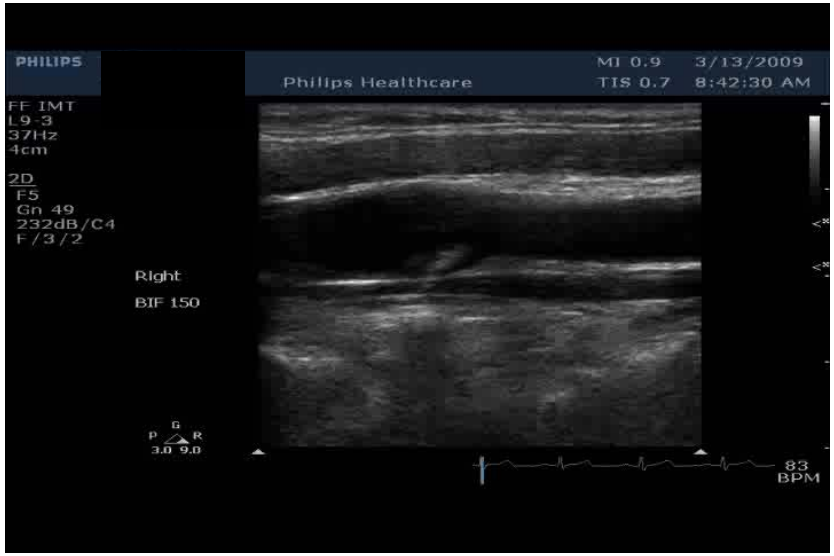
1. Ray et al. Micronucleus frequencies and nuclear anomalies in exfoliated buccal epithelial cells of firefighters. *Int J Hum Genet* 2005;5:45-8
2. Liou et al. Biological monitoring of fire fighters – sister chromatic exchange and polycyclic aromatic hydrocarbon-DNA adducts in peripheral blood cells. *Cancer* Res 1989;49:4929-4935.
3. Hong et al. Influence of genetic susceptibility on the urinary excretion of 8-hydroxydeoxyguanosine of firefighters. *Occup Enivron Med* 2000;57:116-121.
4. Markowitz et al. Asbestos exposure and fire fighting. *Ann New York Acad Sci* 1991;643:573-581.

Cardiovascular disease

- Carotid intima-media thickness (CIMT)

LDL-C (mg/dl)	CIMT ≤75th %	CIMT >75th %	Crude OR (95% CI)	Adjusted OR* (95% CI)
<100 (ref)	161	28	---	---
100-129	161	53	1.89 (1.14-3.14)	1.73† (1.01-2.97)
130-159	64	43	3.86 (2.21-6.74)	3.36 (1.84-6.17)
≥160	34	20	3.76 (1.81-7.81)	2.86 (1.39-5.90)

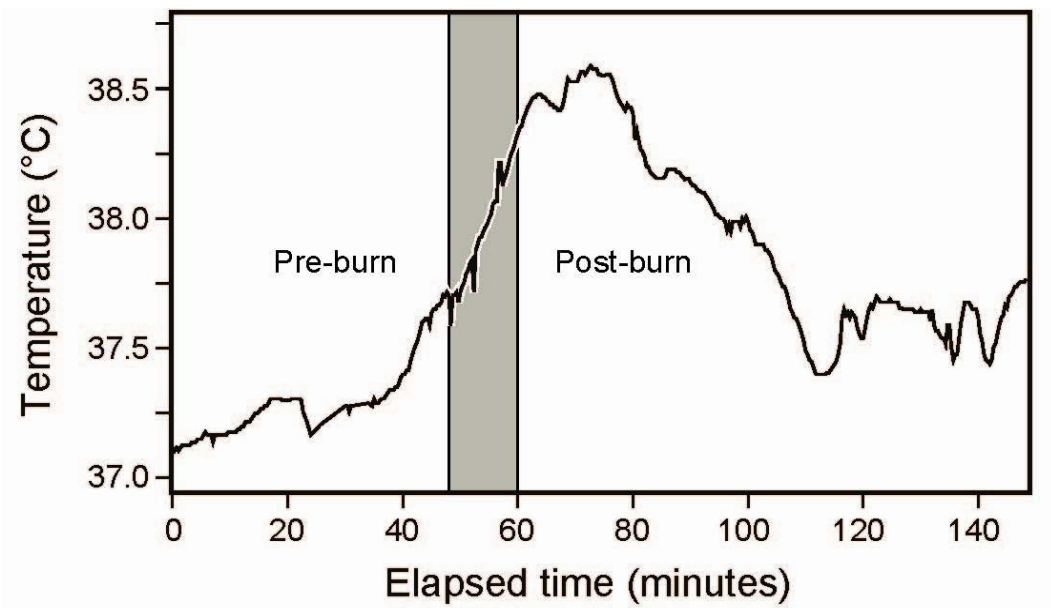
n = 597; *Adjusted for gender, smoking, hypertension, and HDL-C; †for age <45 yrs OR=3.59 (1.38-9.4)

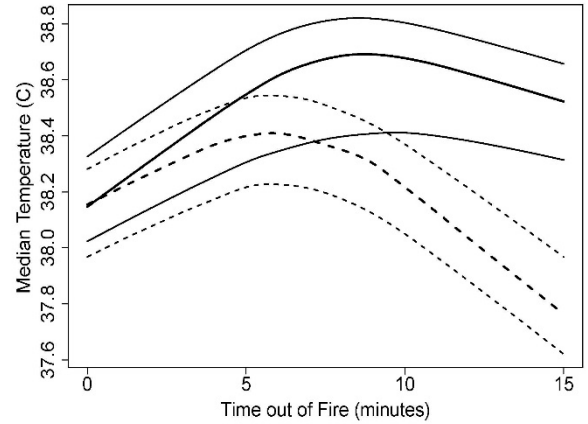


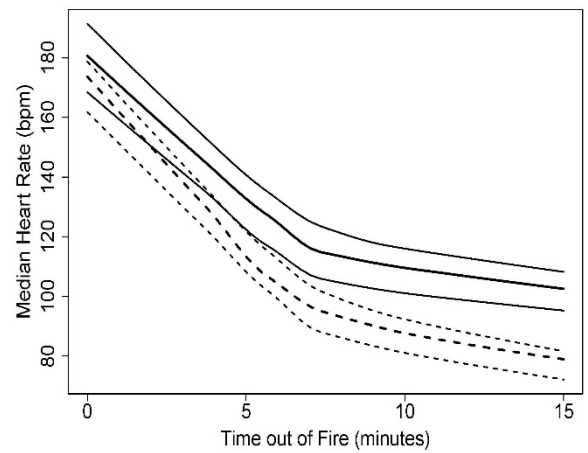
Burgess et al. Risk factors for subclinical atherosclerosis in firefighters. *J Occup Environ Med* 2012;54:328-335.

Heat exposure / rehabilitation

- Increased core temperature
- Increased blood coagulability
- Active cooling effective







Burgess et al. Acute cardiovascular effects of fire-fighting and active cooling during rehabilitation. *J Occup Environ Med* 2012;54:1413-20.

Complex exposures/breastmilk

Study initiated and maintained by Dawn Bolstad-Johnson with Phoenix Fire Dept.

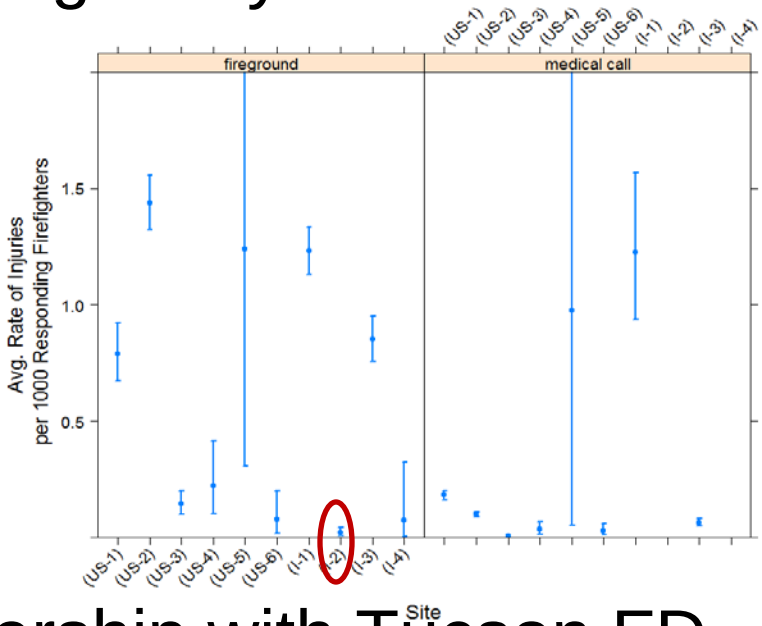
- Objective is to inform decisions on when to breastfeed following fighting a fire
- Baseline and repeated sampling of breastmilk post-fire
- Includes non-firefighter control samples
- Analysis for PBDFs and in-vitro toxicology assays planned

Complex exposures/biodiesel

- Comparison of health effects from exposure to diesel and biodiesel blend-powered equipment in an underground mine
- Multiple exposure assessment
  - Particles
  - gases
- Multiorgan toxicity assessment
  - Lung (spirometry, sputum analysis, exhaled NO)
  - Cardiovascular (Flow mediated dilation, inflammatory markers)
  - Systemic (exhaled CO, urinary 8-OHdG)

Risk management

- FEMA-funded study demonstrated lowest injury rates in UK FD with advanced risk mgmt. systems



- NIOSH-funded study in partnership with Tucson FD
  - Implementing risk management interventions
  - Evaluating effects on injury rates
  - Added cost-effectiveness component
  - http://spifi.publichealth.arizona.edu/

Discussion

- SCBA recommended during overhaul (although canisters show promise)
- Respiratory and other exposures may lead to cardiovascular disease in firefighters
- The toxicity of complex exposures is not well understood and needs to be measured
- Better biomarkers of early health effects needed
- New technology and study findings need to be incorporated into risk management programs