Investigation of Heavy Metals
Cerro Grande Fire
Los Alamos, New Mexico
May 2000

CDC Epi-Aid 2000-40

Mitchell Wolfe[1], Josh Mott[1], Ron Voorhees[4], C. Mack Sewell[4], C.M. Wood[3], Dan Paschal[2], Stephen Redd[1]

1 –Air Pollution and Respiratory Health Branch, EHHE, NCEH, CDC

2 – Toxicology Branch, Division of Laboratory Sciences, NCEH, CDC

3 – Radiation Branch, EHHE, NCEH, CDC

4 – New Mexico Department of Health

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Health Effects of Forest Fires

Smoke exposure associated with:

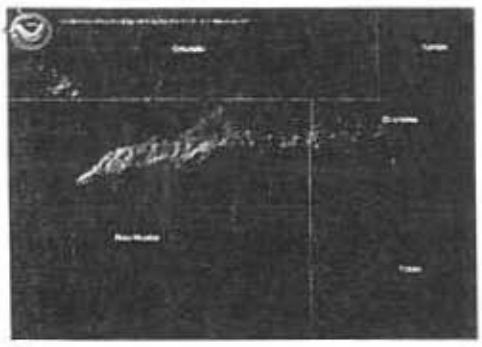
- increased respiratory symptoms
- increased emergency room visits for respiratory diseases
- increased hospitalizations for respiratory diseases (asthma, chronic obstructive pulmonary disease), heart disease

Health effects associated with:

- Being in the area of fires
- Elevated particulate matter

Background
Cerro Grande Fire

- May 4: Controlled burn by Nat'l Park Service begins in Bandelier National Monument adjacent to Los Alamos National Lab (LANL).
- May 5: Declared wildland fire.
- May 10&11: 239 houses burned; 25,000 evacuated.
  - Mandatory: Los Alamos, White Rock
  - Voluntary: Española
- May 18: 100% contained, 47,650 acres
- May 18: NMDOH invited CDC to assist:
  - Mitchell Wolfe, Josh Mott, and C.M. Wood departed May 18th



Background

- Los Alamos National Laboratory
  - Mesas and canyons: elevation 6,200-7,800 ft.
  - 235,000 persons live within 50-mi radius
  - 27,500 acres total: fire burned 7,500 acres of LANL property
  - Fire burned part or all of 112 structures, mostly office trailers and storage sheds.

Objectives

- Assess environmental monitoring data
- Determine necessity of evaluating human exposures to potential contaminants from wildfire smoke
- If needed, conduct a study

Objective 1: Assess environmental monitoring data
Routine environmental monitoring

- LANL: annual environmental surveillance report
  - Air, water, sediments, soils, animals, food
  - Testing for radiation, metals, PCBs, pesticides
  - Results: "acceptable"/background levels of metals in most samples
- Particulate matter (NMED, LANL, Pueblos)
  - Part of fire smoke
  - Routine monitoring at various sites (Santa Fe, Taos, Bernalillo, LANL)
  - Not in Española
- Radiation (LANL/DOE/NMED, EPA)
  - Large network of testing for gamma (real-time monitoring) plus routine airborne particulate samples for gross alpha, beta, gamma or radionuclides
  - Newnet: http://newnet.lanl.gov/stnbytoc.asp
  - Airnet: http://www.air-quality.lanl.gov/AirConc_CerroGrandeFire.htm

Environmental monitoring in response to the fire

NMED Particulate Matter Monitoring Sites in Northern New Mexico

Environmental monitoring in response to the Cerro Grande Fire

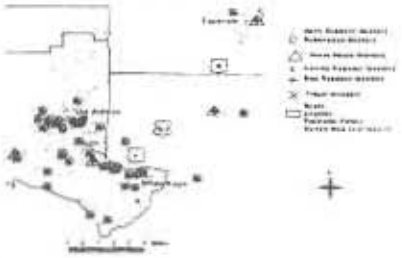
- Particulate Matter (NMED, EPA)
  - Additional sites and intervals in area
  - Española began May 13
  - Results: low except elevated on LANL (TA-54) May 12-13.

Asbestos control, Cerro Grande Fire

Environmental monitoring in response to the Cerro Grande Fire

- **Asbestos**
  - NMED air/wipe samples in Los Alamos town
  - Results
    - Air: low (10 times below occupational standards)
    - Wipe: 11 houses (including 1 school), negative

Radiation and metal monitoring, Los Alamos area



Environmental monitoring in response to the Cerro Grande Fire

- **Radionuclides**
  - Many agencies, individually and through coordinated testing
  - Results
    - Some samples contained small amounts of radioactive material
    - Concentrations well below regulatory levels for safety
    - Radioactive material determined to be from natural sources

Environmental monitoring in response to the Cerro Grande Fire

- **Metals and chemicals (EPA)**
  - 6 monitoring sites around LANL, May 12-17
  - VOCs (toluene, benzene), PAHs (pyrene), pesticides, and metals
  - Only metals in Española, May 14
  - Results: very low VOC, PAH, and metals

Assessment and Recommendations

- **Asbestos**
  - No human testing recommended
- **Radiation**
  - No human testing recommended
- **Metals and chemicals**
  - Human testing recommended for heavy metals

Objective 2: Determine necessity of evaluating human exposures to potential contaminants from wildfire smoke

Why did we test for metals?

- *Metals would still have been present in people when we performed our testing*
- *Incomplete air monitoring data for metals during greatest potential for human exposure*
- *Low levels of metals detected in testing during the fire and in previous routine environmental testing (before the fire)*

Why did we only test some people who were exposed to smoke from the fire?

- *Looked at the "worst-case scenario" – people from groups most exposed to smoke were to be representatives of the exposed population to make sure we didn't miss detection of metals if they were there*
- *Method of sampling was necessary because of our goal to perform testing as quickly as possible on a sample large enough to represent the population*

Objective 3: Conduct study

Research Questions:

1. "Was exposure to smoke from the Cerro Grande Fire associated with elevated levels of metals in people in the area of the smoke from the fire?"

2. "Were metal levels detected in people high enough to have negative health effects or warrant further testing in more people?"

Potential human exposure

- **1,600 firefighters**
  - 1,400 (88%) during May 10-15, when most of LANL burned
- **Several hundred National Guard, City and State Police**
  - Evacuations
  - Roadblocks
  - Traffic control
- **Residents of Española (pop. 9,000) and environs**
  - including Tribal Lands, e.g. San Ildefonso and Santa Clara Pueblos

Screening

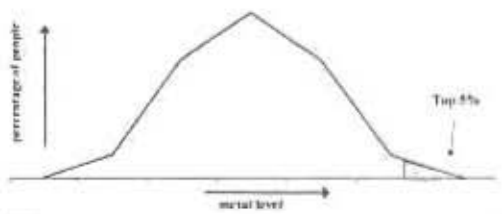
- **Questionnaire and urine sample to exposed and unexposed:**
  - **Firefighters**
  - **Community**
    - **People who were outside a great deal of the time during fire**
    - **National Guard, City Police, Postal, Health Department**
  - **Also tested unexposed in case certain occupations or cities might give you higher metal levels**
- **Definition of "exposure":**
  - **Firefighters: fought fires on LANL during Cerro Grande Fire**
  - **Community: were in Los Alamos or Española May 10 or 11**

Screening (cont.)

- **Lab analysis**
  - **16 metals based on air monitoring, previous LANL surveillance**
  - **Took into account diluted or concentrated urine**
    - **For example, drinking a lot of water**
  - **Reference for expected metal levels: survey of general US population**
  - **Above reference: top 5% of samples in the national survey**
    - **If 100 people, top 5 are "above reference"**
    - **Recently obtained more stringent reference for some study metals**

What does "above reference" mean?

Hypothetical metal distribution



Metal testing

Antimony	Tungsten
Cobalt	Platinum
Nickel	Thallium
Molybdenum	Lead
Cadmium	Uranium
Arsenic	Chromium
Beryllium	Barium
Cesium	Mercury

Results

How many people were tested, and who were they?

Community representatives (135 persons tested)

	Exposure category		Total
	Exposed (n=82)	Unexposed (n=53)	
Los Alamos	41	10	51
Santa Fe	34	4	38
Pueblo (not pictured)			
Espanola	22	0	22
Santa Fe	1	21	22
Rural workers (19 pictured)			
Espanola	4	0	4
Albuquerque	0	0	0
Santa Fe	1	1	2
Health department (24 pictured)			
Espanola	19	5	24
Santa Fe	6	18	24

POSTER

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How many people were tested, and who were they?

Firefighters (92 persons tested)

	Exposure category		Total
	Exposed (n=64)	Unexposed (n=28)	
Los Alamos	42	0	42
Santa Fe	20	1	21
Other (mainly Albuq.)	4	27	31

POSTER

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Research Question 1: "Was exposure to smoke from the Cerro Grande Fire associated with elevated metals"

Analysis

- Remove the effect of other things that can affect metal level other than smoke (age, gender, smoking, city)
- Computer statistical techniques (regression analysis)

For which metals was there a significant association between smoke exposure and metal level?

Research Question 1: "Was exposure to smoke from the Cerro Grande Fire associated with elevated metals"

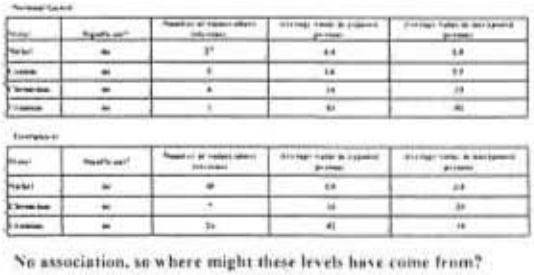
Answer: No positive association of metals with smoke exposure

- Only exception is cadmium in National Guard, but there were only 2 cadmium level above reference, and the difference in levels between exposed and unexposed people was small
- Some negative associations, meaning higher levels in unexposed persons, which would be due to something *other than* smoke

Now let's examine the number of people with metal levels above those found in most people in the general US population

Which metals have more than the expected number of people with levels above those found in most of the general population?
(remember, these metals were not associated with smoke exposure)

Was there an association between smoke exposure and nickel, chromium, cesium or uranium level?



No association, so where might these levels have come from?
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Urine uranium isotopic analyses, Cerro Grande Fire

(specimens with 5 highest values)

Shows that uranium was naturally occurring

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Naturally-occurring uranium concentrations, USA

High levels previously shown in Northern New Mexico water

POSTER

Cesium isotope testing

- Tested sample with highest cesium to determine cesium isotopes
- Isotopes identified as naturally occurring
  - all Cs 133, no Cs 137

Discussion

- Some metal levels in people were above normal
- Of the 16 metals tested, cesium, uranium, chromium, and nickel have more than expected number of people with values above most in the general population
- No association of elevated metals in people with wildfire smoke exposure

Study issues

- Sampling
  - needed to act quickly because as time interval from fire to testing, some metal levels may decrease
- Urine testing
  - could test more people with single urine test than a 24-hour urine collection
- Classification of exposure
  - No biomarker to measure exact amount of exposure, so relied on questionnaire. Since fire smoke was so widespread, questionnaire was likely a good measure of exposure

Summary

- We sought to evaluate human exposures to potential contaminants in wildfire smoke
- Screening for heavy metals was deemed appropriate
- We tested people from groups we expected to be most exposed
- Data don't show that metals detected in people were associated with wildfire smoke exposure
- But, we found more people than expected had metal levels of uranium, cesium, chromium, and nickel that were greater than those found in most of the general US population

Acknowledgments

Los Alamos Fire Dept.
Santa Fe Fire Dept.
Albuquerque Fire Dept.
Santa Fe National Forest
Albuquerque National Guard
Espanola City Police
Santa Fe City Police
Espanola Post Office
Santa Fe Post Office
Albuquerque Post Office
Espanola Health Department
Santa Fe Health Department

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Further Discussion

- **Research Question 2: "Were metal levels detected in people high enough to cause negative health effects, or to warrant further testing in more people?"**
  - Issues with specific metals
    - possible sources of nickel, cesium, and chromium
  - Retesting?
  - Clinical follow-up?

Expected and Observed Number of Elevated Metal Values

Cerro Grande Fire

Metal	Number Of Tests	Number Expected to be elevated	Number of elevated tests observed
Arsenic	227	11	2
Barium	227	11	8
Beryllium	227	11	2
Cadmium	227	11	3
Cobalt	212	11	0
Chromium	227	11	23
Cesium	227	11	20
Mercury	227	11	5
Molybdenum	181	9	8
Nickel	227	11	116
Lead	227	11	0
Platinum	227	11	0
Antimony	208	10	0
Thallium	227	11	0
Uranium	227	11	105
Tungsten	208	10	0

Summary of Selected Final Regression Models

	Metal	Final Model	Beta[1]	P[2]	Number of elevated values	GM[3] exposed	GM[3] unexposed	Adj[4] R^2	F[5]	$C^{2(6)}$
	Initial model: exposure age gender smoking city cityxexp (interaction term)									
National Guard	Arsenic	Exp city cityxexp	17.6	.00	0	4.6	7.5	.21	.00	.15
National Guard	Cadmium	Exp age gender	1.7	.00	2	.39	.33	.26	.00	.08
	Initial model: exposure age gender smoking city occupational group cityxexp (interaction term)									
Firefighters	Arsenic	Exp city smoke cityxexp	-13.4	.05	1	3.9	6.9	.08	.03	.04
Firefighters	Cesium	Exp city age gender smoke cityxexp	-7.5	.03	7	3.9	4.5	.22	.00	.04

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	Initial model: exposure age gender smoking city cityxexp (interaction term)									
National Guard	Cesium	Exp age	-1.3	.06	5	3.6	5.5	.18	.00	.24
National Guard	Chromium	Exp age gender	1.0	.77	6	.16	.19	.17	.01	-.04
National Guard	Nickel	Exp age	1.7	.08	27	6.4	2.8	.13	.01	06
National Guard	Uranium	Exp gender age city cityxexp	4.3	.45	24	.03	.02	.12	.05	.10
	Initial model: exposure age gender smoking city occupational group cityxexp (interaction term)									
Firefighters	Chromium	Exp gender smoke	-1.1	.27	7	.16	.20	.68	.03	.11
Firefighters	Nickel	Exp city gender	1.1	.89	48	5.8	3.8	.08	.02	.01
Firefighters	Uranium	Exp	1.3	.32	24	.02	.18	.00	.32	.11

[1]beta for exposure variable
[2]p-value for exposure variable
[3]GM = geometric mean
[4]Adjusted R-squared of final model
[5]F = p-value for ANOVA F-test for entire model
[6]C-squared = part correlation of "exposure variable (i.e. the ihcrease in R due to "exposure" value)

Occupational Group by City and Exposure
Cerro Grande Fire

Occupational Group	Exposure category		Total
	Exposed (n=83)	Unexposed (n=52)	
National Guard			
Albuquerque	14	10	24
Santa Fe	24	4	28
Police			
Española	23	0	23
Santa Fe	2	19	21
Postal workers			
Española	9	0	9
Albuquerque	0	2	2
Santa Fe	1	7	8
Health department			
Española	10	0	10
Santa Fe	0	10	10
Firefighters			
Los Alamos	42	0	42
Santa FEW	20	1	21
Other (mainly Albuq.)	4	25	29

Naturally-occurring Uranium Concentrations, USA, 1993

Urine Uranium Isotopic Analysis, Cerro Grande Fire (n=9)

Uranium Isotope Abundance Measurements						
	Analysis Date: 6-26-00	Instrument ELAN 6000 Quadrupole ICPMS				
			U-234	U-235	U-236	U-238
Natural Uranium Isotope Abundance is			0.0055%	0.72%	Na	99.27%
			Observed Isotope Abundances (%)			
Observed U Concentration (ppb)			U-234	U-235	U-236	U-238
Samples from Los Alamos Fire Study (case # 00-0033)						
0076	2.3 ppb		0.00	0.76	-0.01%	99.21%
		std dev	0.00	0.12%	0.05%	0.14%
0600	1.4 ppb		0.00	0.82%	-0.02%	99.21%
		std dev	0.00	0.13%	0.09%	0.21%
0095	0.8 ppb		0.00	0.85%	-0404%	99.13%
		std dev	0.00	0.22%	0.10%	0.32%
0100	0.9ppb		0.00	0.80%	0.01%	99.16%
		std dev	0.00	0.11%	0.13%	0.205
0103	1.0 ppb		0.00	0.77%	0.04%	99.15%
		std dev	0.00	0.24%	0.09%	0.21%
0.104	3.4 ppb		0.00	0.72%	-0.01%	99.28%
		std dev	0.00	0.07%	0.02%	0.08%
0.111	0.8 ppb		0.00	0.77%	0.01%	99.25%
		std dev	0.00	0.27%	0.23%	0.33%
0001	1.4 ppb		0.00	0.80%	-0.01%	99.21%
		std dev	0.00	0.13%	0.05%	0.12%
0009	0.7 ppb		0.00	0.83%	-0.05%	99.21%
		std dev	0.00	0.35%	0.05%	0.04%

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- Many agencies, individually and through coordinated testing
- Results:
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Environmental monitoring in response to the Metals and chemicals (EPA)

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- Volatile Organic Compounds--VOCs (toluene, benzene), Polyaromatic Hydrocarbons--PAHs (pyrene), pesticides, and metals
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Metals and chemicals
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Which metals have more than the expected number of people with levels above those found in most of the general population?
(remember, these metals were not associated with smoke exposure)

Naturally-occurring uranium concentrations, USA

High levels previously shown in Northern New Mexico water

Cesium isotope testing

- Tested sample with highest cesium to determine cesium isotopes
- Isotopes identified as naturally occurring
  - all Cs 133 (naturally occurring)
  - no Cs 137

Discussion

- Some metal levels in people were above normal
- Of the 16 metals tested, cesium, uranium, chromium, and nickel have more than expected number of people with values above most in the general population
- No association of elevated metals in people with wildfire smoke exposure

Study issues

- **Sampling**
  - needed to act quickly because in time interval from fire to testing, some metal levels may decrease

- **Urine testing**
  - could test more people with single urine test than a 24-hour urine collection

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Summary

- We sought to evaluate human exposures to potential contaminants in wildfire smoke
- Screening for heavy metals was deemed appropriate
- We tested people from groups we expected to be most exposed
- Data don't show that metals detected in people were associated with wildfire smoke exposure
- But, we found more people than expected had metal levels of uranium, cesium, chromium, and nickel that were greater than those found in most of the general US population

Further Discussion

- **Research Question 2: "Were metal levels detected in people high enough to cause negative health effects, or to warrant further testing in more people?"**
  - Issues with specific metals
    - possible sources of nickel, cesium, and chromium
  - Re-testing?
  - Clinical follow-up?