Lead Poisoning at an Indoor Firing Range

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“I would rather forage for food at a toxic waste dump than shoot regularly at an indoor firing range.”

—Massad Ayoob
The Call

- November 30, 2012
- Washington State Department of Labor & Industries (L&I) requests support from Public Health – Seattle & King County (PHSKC)
- An unknown number of workers at an indoor gun range had elevated blood lead levels (BLLs)
- Some as high as 48 μg/dL

Outline

- Lead in ammunition
- Lead poisoning
- The investigation
- Conclusions
Lead

- Soft, malleable metal
- Widespread
- Easy to extract
- Easy to work with

Uses for Lead
Lead in Ammunition

- Projectile (bullet)
  - Elemental lead
- Primer
  - Lead styphnate
  - Lead azide
  - Lead peroxide
  - Lead nitrite

From Ammunition to the Environment

Photo: Niels Noordhoek
From Ammunition to the Environment

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From Ammunition to the Environment

Firing Range Layout
Firing Range Layout

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[Diagram of a firing range layout with labels for Blower, Shooter Positions, Targets, TRAP, and Air Flow indicated.]
From the Environment to You

Shooters
- Inhaled directly during shooting
- Ingested from unwashed hands
- Ingested from contaminated game meat

Non-shooters
- Take-home lead on shooters’ clothes or skin
- Contaminated game meat
- Working in contaminated areas
Lead Toxicity

Neurological, cardiovascular, renal, reproductive, immunological, gastrointestinal systems

Symptoms
• Numbness/tingling
• Muscle weakness
• Headache
• Memory loss
• Insomnia
• Mood changes
• Cramps, nausea/vomiting

Diagnosis & Treatment

Diagnosis
• Blood lead level (BLL) in μg/dL
• Toxicity with levels ≥5 μg/dL

Treatment
• Removal from lead exposure
• Chelation
Your Examples

There are no regulations to protect the shooting public at any of the nation’s 16,000 to 18,000 indoor gun ranges. Yes, the health department in Seattle decided to act. Do you have other examples of taking action without clear regulatory authority?

Type your examples in the chat box.
Firing Range

- Indoor firing range
  - 8 bays, 24 lanes
- Sand bullet trap
- Jacketed ammo
- Historical lead safety issues
  - BLLs as high as 83 μg/dL

1 bay, 3 shooting lanes

Remodeling Operations

September 2012

- Sand removal and lead recovery
- Construction of second floor range begun

Contaminated sand in parking lot
Methods

Environmental evaluations

Blood lead levels

Worker interviews

Environmental Evaluation

- L&I
  - Inspection, follow-up
- PHSKC Environmental Health
  - Surface wipes, interviews
- Contractors & range owner
  - IH consultants

- Sampling
  - Surface (µg/m²)
  - Air (µg/m³)
  - Personal breathing zone (PBZ) (µg/m³)
Blood Lead Levels

- All directly or indirectly exposed individuals
- Sources
  - Employers
  - Clinics
  - Laboratories
  - State and local blood lead registries

Interviews

- Informal discussions with range owner and construction employers
- Standardized phone interviews with workers
  - Demographics, household members
  - Extent of exposure
  - Lead safety
  - Blood lead testing
  - Health status
  - Any other lead exposures
Results

Environmental Evaluation

• L&I
  • High surface and air levels in off-limits and public areas
  • Range air limits exceeded after 30 minutes exposure
  • Inappropriate ventilation
  • Inadequate lead safety behaviors

• PHSKC Environmental Health
  • High surface lead levels
  • Contamination beyond worksite
Environmental Evaluation

- Contractors
  - High surface and air levels early in construction
  - Surface contamination in vehicles, homes, hotel rooms
- Range owner
  - Poor ventilation in some lanes – closed
  - Contamination in men’s restroom – closed
  - Closed range for three days, hired contractor to clean
  - Improved ventilation system, but…
  - Volunteer shooters with high levels during shooting
  - Public surfaces still contaminated

Blood Lead Levels

![Graph showing blood lead levels over time for range employees.](image-url)
Blood Lead Levels

- Range Employee
- Construction Worker

Graph showing blood lead levels over time from 8-Sep to 6-Jan.
Range Employee Interviews

• 39/42 range employees
• None had other significant occupational or home lead exposures
• Highest BLLs
  • Supervising shooters
  • Cleaning the range
  • Removing and sifting the sand
  • Longer hours
• Lack of support by management for personal protective equipment (PPE)

Contractor Interviews

• 100/117 workers interviewed
• Highest BLLs: longer hours, metal workers, demolition, cleaning
• 75% without lead safety training
• 55% without any respirator use on-site
• Non-occupational lead exposures
  • Hunting, fishing
  • Home remodeling
  • Car repair
  • No indoor shooters
Public Exposure

- Many single males among workers
- Household members
  - Of range employees – all BLL <5 µg/dL
  - Of construction workers – 6 with BLL >5 µg/dL
- 9 construction workers stayed in a hotel
- Public notice
  - Pamphlets sent to workers
  - Posted lead hazard warnings at range
  - Print, web, and television news
- One frequent shooter had BLL 12.9 µg/dL

“Gun range under fire over lead in blood of workers”
— Seattle Times, 13FEB2013

“Inexcusable Exposure: Unprotected Workers, Toxic Lead At Gun Range”
— Lynne Peeples, Huffington Post, 20FEB2013

“Gun range workers claim they were poisoned by lead”
— King 5 News, Seattle, 12FEB2013
Clinical Impact

- Symptoms with >10 µg/dL
  - 11/20 range employees
  - 14/26 construction workers
  - Headache, muscle/joint pain, irritability, insomnia, fatigue, abdominal cramps, vomiting, constipation, loss of appetite, dizziness
- Decreasing BLL after removal from work
- None needed chelation
- None hospitalized

Limitations

- Lack of authority to compel cooperation
- Possible bias from 60% response
- Only 6–13% response among household members
- Did not have historical BLL data
- Historical versus current lead exposure
Conclusions

• Largest reported occupational lead exposure at an indoor gun range

• Both construction workers and range employees were exposed to disturbed lead dust without adequate PPE or lead safety training

• Number affected was likely higher
Discussion

• Occupational lead safety standards should have been enforced by both range management and contracting employers

• OSHA occupational lead standards date from 1978
  • Medical removal at ≥50 µg/dL

• No protective standards for firing range customers

Worker Recommendations

• Update worker protection standards
  • Lower environmental lead limits
  • Increase frequency of testing
  • Remove from exposure lower blood lead levels

• Require medical monitoring of indoor firing range employees
Perpetual Investigation Machine

Before we can close you down we have to know it's not safe

Give us your data, or we will close you down.

To know it's not safe we have to have your data

Public Recommendations

- Increase awareness of lead hazards among shooters
- Ensure “best practices”
  - Lead-free ammunition
  - Solid bullet traps
  - Cleaning and testing of air and surfaces
  - Routine blood lead testing
  - Medical removal at 10 µg/dL
  - No hand-to-mouth on the range
  - Cleaning skin and clothes
Public Recommendations

• Specify environmental lead levels to keep BLL <5 µg/dL
  • Integrated Exposure Uptake Biokinetic Model (IEUBK)
  • Predict BLLs from inhalation and hand-to-mouth exposures

• Discourage use of indoor ranges by children and women of child-bearing age

Marketing to Women and Children
Marketing to Women and Children

“Texas Gun Range to Host Birthday Parties for Children”
—ABC News, June 8th, 2012

Public Health Opportunities

• Educate contractors on the lead hazards expected with firing range construction sites
• Educate range operators and shooters who consider lead exposure as “normal”
• Incorporate lead exposure controls into firing range permits
• Develop in-house testing capability
• Secure stable funding for lead registries
  • Detection
  • Inspection
  • Enforcement
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Reducing Occupational Lead Exposures in Industries Where Lead Is Used

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Basic Lead Exposure Reduction Approach

1° Airborne emission control
- Substitution/elimination/reduction
- Limit aerosolization
- Capture at source

2° Housekeeping
- Limit re-entrainment
- Focus efforts near source
- Disposal: limit exposure

3° Personal hygiene
- Protective clothing
- Use practices to limit oral intake
- Leave work lead-free

Lead Standard*
Must comply based on air monitoring (8-hour time weighted average)

- Action level: 30 μg/m³
- Permissible exposure limit: 50 μg/m³

*Division of Occupational Safety & Health and Occupational Safety & Health Administration
Regulatory Elements

• Exposure monitoring (2 or 4 times annually)
• Engineering control and work practices
• Respiratory protection
• Protective work clothing
• Housekeeping
• Hygiene facilities and practices
• Medical surveillance (blood lead level monitoring)
• Worker training

Exposure Control Hierarchy

Engineering controls
• Material substitution
• Ventilation
• Noise controls

Administrative controls
• Job rotation
• Change in work practices
• Housekeeping

Personal protective equipment
• Head, hand, body, foot protection
• Respiratory protection
Assessing Lead Exposure

- **Personal air sampling**
  - Worker’s breathing zone
  - Monitored for 8-hour workshift

- **Surface samples**
  - Not regulatory requirement
  - Housing & Urban Development 200 μg/ft² guideline

- **Blood lead level (BLL)**
  - Every 6 months
  - BLL >40 μg/dL; every 2 months
  - Removal at 60 μg/dL; BLL monthly

Assessing Surface Lead Levels in Vietnam Using Hand Held X-ray Spectrometer
Substitution & Elimination

Consumer products

Lead-free ammunition

Lead-free solder

Substitution Example

• Galvanize welds in marine setting
• Pb (35-55%), Sn (20-25%) and Zn (15-25%)
• Exposure levels: 21-35 μg Pb/m³ air (> 30 μg/m³ AL)
• Company apprised of regulatory compliance effort
• Alternative Pb-free product put in use

Preparation (grinding & heating)

Application (rubbing stick or wire brush)
Reducing Lead Dust Generation

- Example: cleaning floors with a vacuum instead of sweeping
- Observe and understand process
- Monitor airborne lead levels to identify factors that affect generation

Melting Lead

- Melting point: 621°F;
- Boiling point: 3164°F
- Lead vapors → cool → fume (“tiny” particles)
- Melt lead at low temp, prevent vapor generation
Urban Lead Mining Operation

- Lead & poly encased communication cables
- Pulled from underground vaults
- Cut into segments
- Loaded for shipment to China
Exposure Monitoring Results

- Personal exposure: 67 to 153 μg Pb/m³ air
- Exposure thought to be from cutting
- Air samples collected for different tasks: poly & lead cable, different cutting devices
- 135 μg/m³ cutting lead cable
- 108 μg/m³ cutting poly cable
- Lead deposited on floor from dragging lead cable

**Recommendation:** modify operation to eliminate cable dragging on floor

Ventilation

- Suction to capture contaminant
- Most effective if captured at source (local exhaust ventilation)
Gun Range Ventilation

- Source capture not possible
- General (or dilution) ventilation
- Sophisticated push/pull system needed

Air pushed
- Non-turbulent flow
- Evenly distributed

Smoke pulled at end of building
- 15% > than push
- Disposal?
Battery Manufacturing

Pasting

PbO/H₂SO₄ paste applied to lead grids

Grid stacking

manual

automatic (less lead released to workplace)

Housekeeping

- Clean surfaces of fugitive lead emissions
- Lead body burden perhaps largely from ingestion
- Clean without re-entraining lead dust
Personal Hygiene

- Limit skin contact with protective clothing
- Provide clean & dirty change rooms and showers
- Eliminate possibility of taking lead home

Worker Training

- Worker understands hazard and how to reduce exposure
- Essential elements
  - Health effects
  - Operations that result in exposure
  - Medical surveillance, ventilation controls
  - Housekeeping and hygiene practices to limit oral intake
  - Potential for taking lead home
Summary

• Lead exposure and associated blood lead levels minimized through diligent practices
• Control, housekeeping, and personal hygiene
• Respiratory exposure relatively easy to control
• Oral ingestion exposure route requires great diligence and attention

Questions?