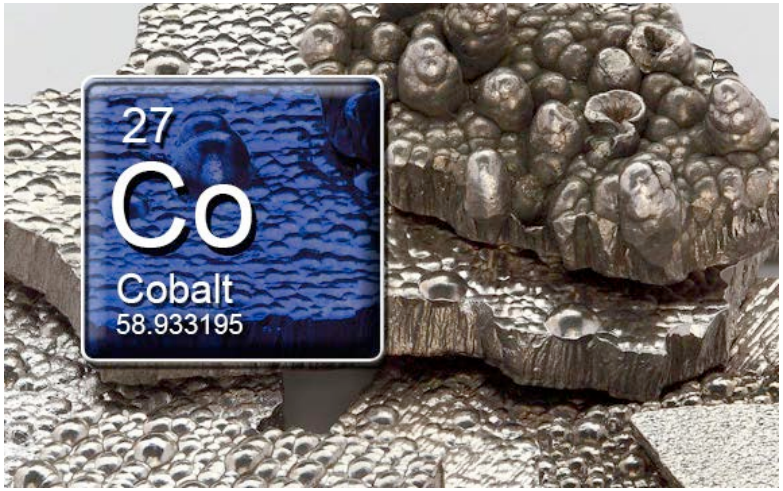
Properties and Human Exposure



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National Institute of Environmental Health Sciences

July 22, 2015

Outline

Properties: Description of cobalt and cobalt compounds

Human exposure to cobalt

Cobalt and Certain Cobalt Compounds

Defining the candidate substance

- Cobalt is a naturally occurring transition element with magnetic properties present in different metallic forms
- More than 100 cobalt compounds have been identified
  - Valences include +2 or +3 and others
  - Various crystalline forms and colors
  - Inorganic and organic
  - Varying in water solubility and bioaccessibility
- “Certain” refers to those compounds that release cobalt ions *in vivo*

Solubility of Various Cobalt Forms

In vivo bioavailability can be represented by a surrogate of solubility in artificial body fluids (i.e. bioaccessibility)

Cobalt Form	Water solubility (grams/100 cc cold water)
Water soluble	
• Cobalt sulfate heptahydrate	60.4
• Cobalt chloride	45
Metal	
• Cobalt metal	0.000875
Poorly water soluble	
• Cobalt(II) oxide	insoluble

Bioaccessibility in gastric fluid is relevant for oral exposure and lysosomal fluid for inhalation of poorly water soluble forms

Bioaccessibility (% solubility):

100% in gastric fluid

92.4%–100% in lysosomal fluid

Bioaccessibility was generally lower for fluids with pH 7.4 (intestinal, alveolar, interstitial, serum)

Source: Stopford *et al.* 2003

Cobalt Metal and Representative Co Compounds

Cobalt Form	Tested in Animals	Genotoxicity Assays
Water soluble		
• Cobalt sulfate heptahydrate	X	X
• Cobalt chloride	X	X
• Cobalt acetate		X
• Cobalt nitrate		X
Metal		
• Cobalt metal	X	X
• Cobalt nanoparticles	X	X
Poorly water soluble		
• Cobalt(II) oxide	X	X
• Cobalt sulfides		X

Human Exposure to Cobalt

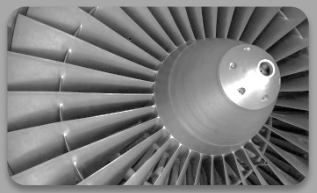
A significant number of people in the United States are exposed to cobalt

- Widespread usage in numerous commercial, industrial and military applications and releases to the environment
- High production volume (> 1 million pounds per year) of cobalt and several cobalt compounds
- Biological monitoring data (urine, blood, hair, nails) indicates exposure in occupational and non-occupational populations.

Uses for Cobalt in the United States

Used in numerous commercial, industrial, and military applications

2012 (U.S.)



Metallurgical uses

- Superalloys and other alloys
- Medical

> 62%

Chemical uses

- Pigments, driers, catalysts, adhesives
- Animal diets

27%

Cemented carbides and bonded diamonds

- Tungsten carbides (“hard metals”)
- Steel with microdiamonds impregnated into surface cobalt layer

9%

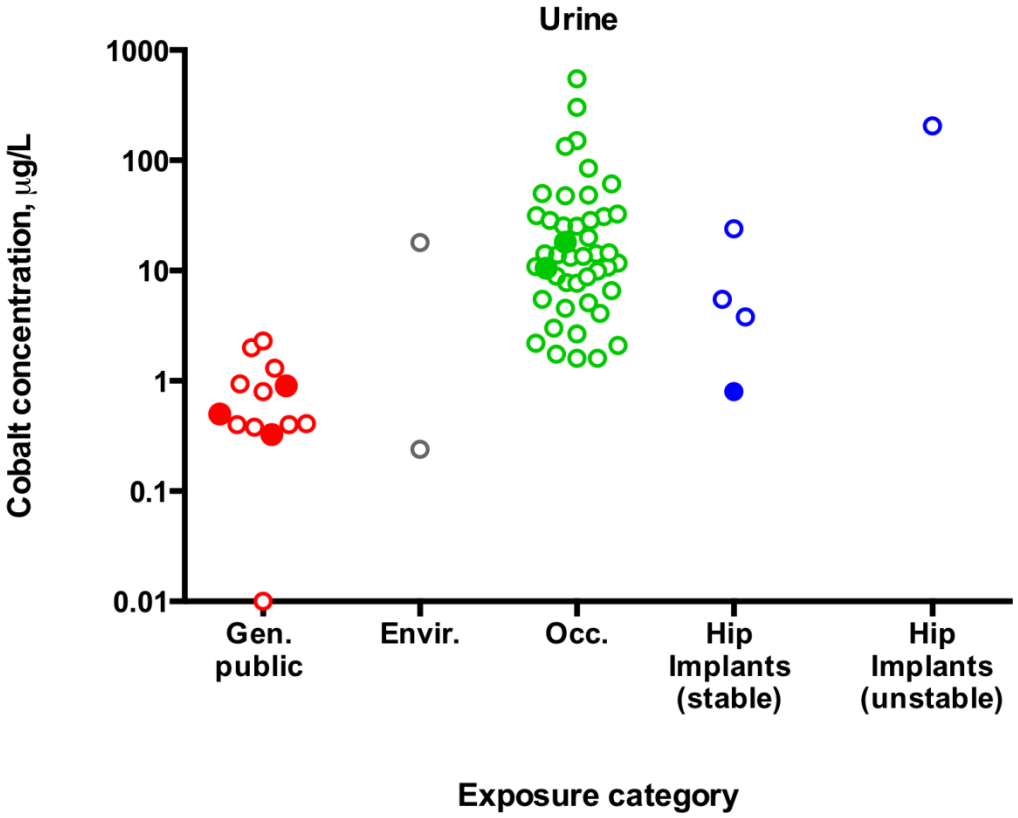
Electronics and green energy

- Rechargeable batteries (computers, mobile phones, vehicles)

< 1%

Cobalt Exposure Levels

Humans are exposed to cobalt in the workplace, from medical procedures, from the environment, and from other sources



In general, cobalt levels in blood, hair, and nails show a similar pattern to those for urinary cobalt.

Each circle represents a mean or median
Filled symbols = U.S. data; open symbols = non-U.S. data

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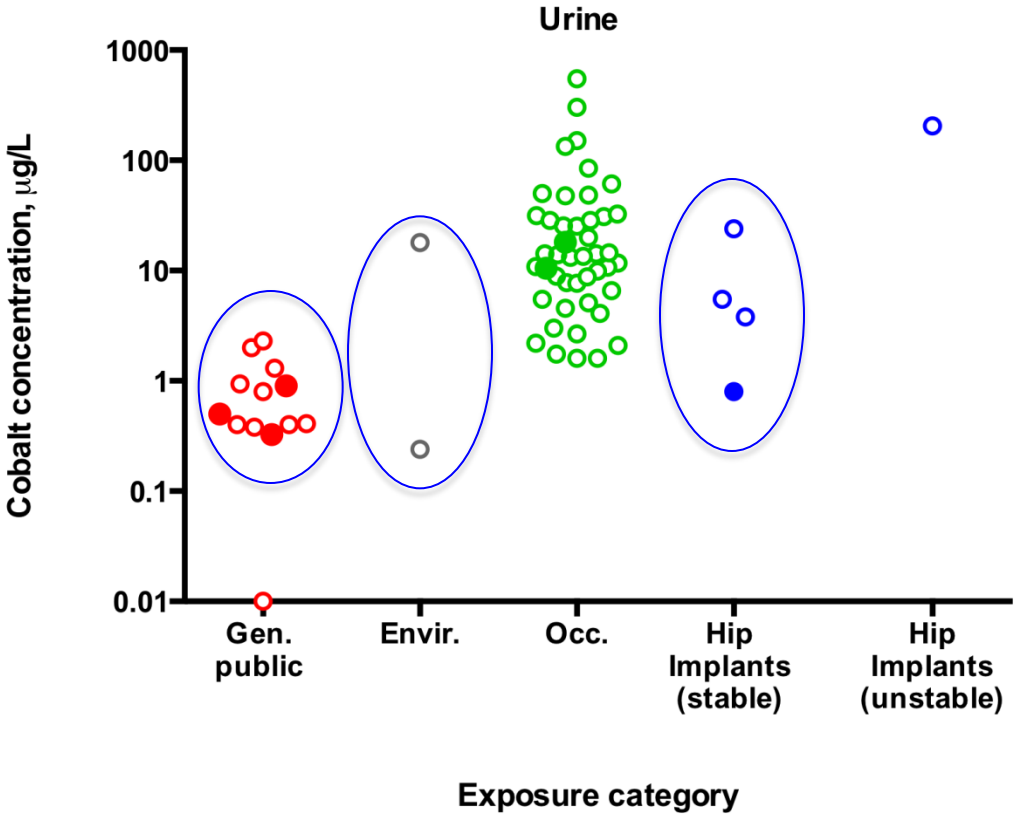

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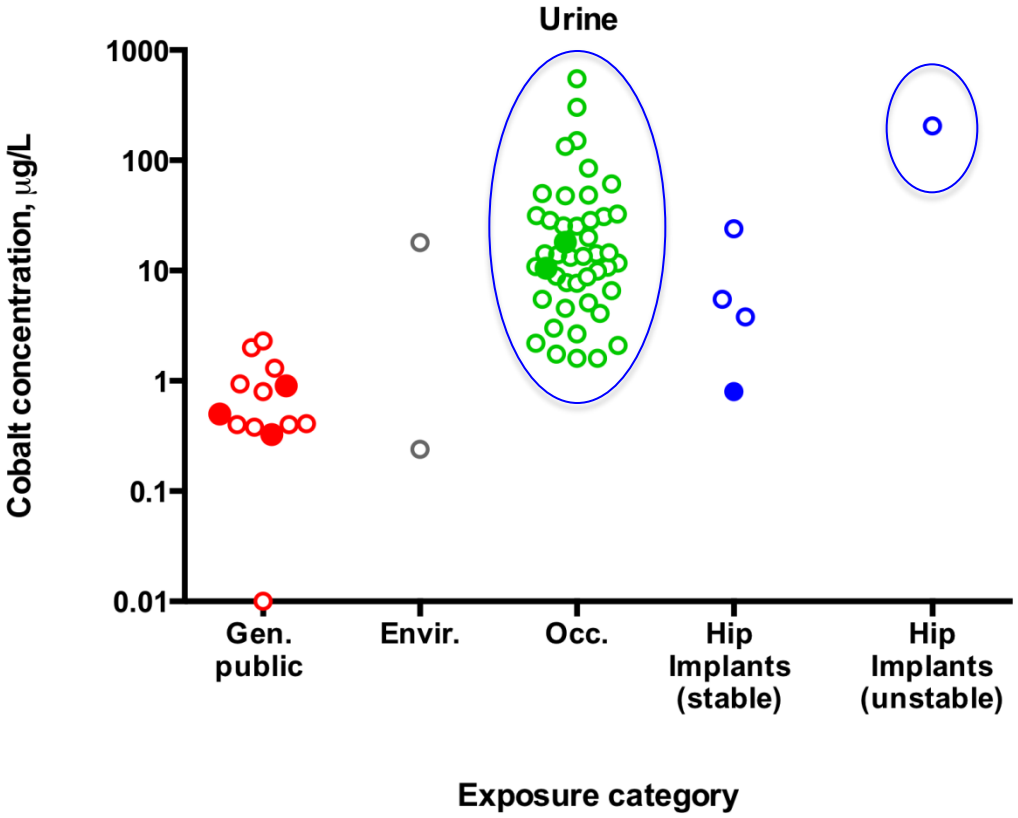

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Cobalt Exposure Varies by Industry

Which industries have the highest exposure to cobalt?

- Diamond abrasives/cutting wheels
- Hard-metals production
- Production: Co powder/compounds
- Diamond polishers
- Pottery painting
- Co oxide workers
- Ni refinery workers
- Glaze workers
- Gen Public

Medical Exposures to Cobalt

Unstable surgical implants may be associated with high levels of exposure

- High urinary or blood cobalt associated with unstable hip implants containing Co-Cr-Mo alloys
- > 100,000 hip replacements/yr in the United States
- Implants may become unstable or fail due to excessive wear or corrosion by body fluids
- Action levels for further testing have been set at 7 µg/L (MHRA) and 10 µg/L (Mayo Clinic) for blood cobalt
- Cobalt is also a component of some dental prostheses

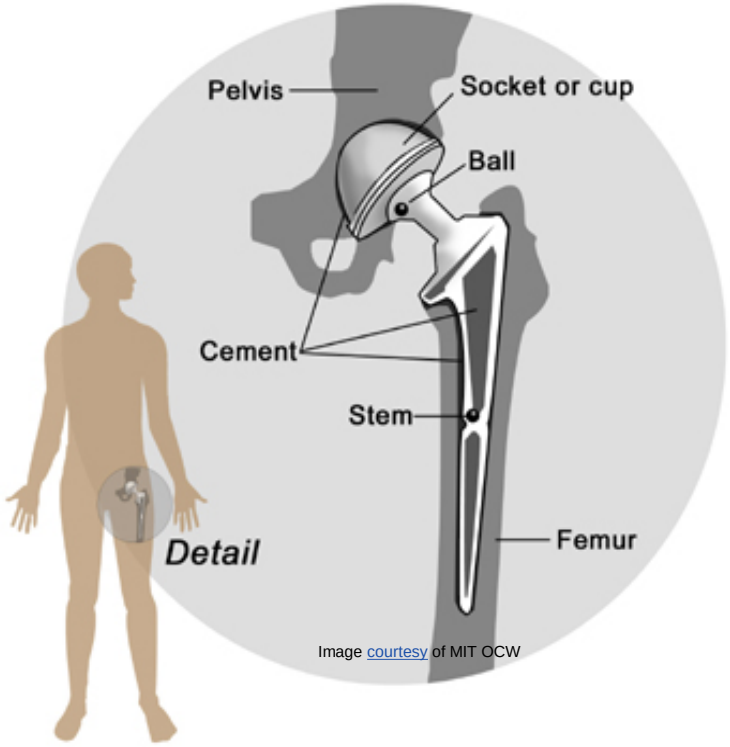


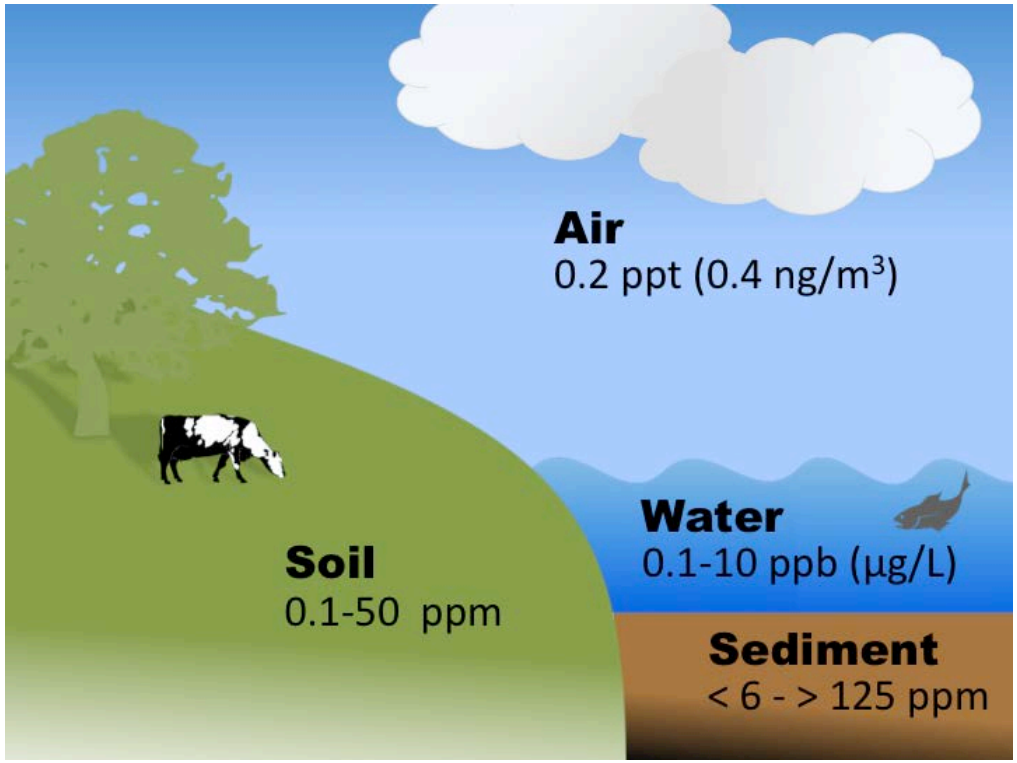
Image courtesy of MIT OCW

Environmental Exposures to Cobalt

Evidence for potential environmental exposure comes from environmental releases, biomonitoring, and environmental monitoring

- > 5 million pounds of cobalt and cobalt compounds were released from 723 U.S. facilities in 2013 (USEPA TRI).
- Elevated urinary cobalt levels have been reported in people living near mining operations in Guatemala and Mexico.

Environmental Levels



Other Cobalt Exposures

Other sources of exposure to the general public

- Food is the largest source of exposure to the general public (3.4 to 11.6 µg/day for the U.S.) (Pennington and Jones 1987).
- Various brands of tobacco contain cobalt at concentrations ranging from less than 0.3 to 2.3 µg/g dry weight; 0.5% of the cobalt content is transferred to mainstream smoke.
- Cobalt is present in some household consumer products.
  - Cleaners, detergents, and soaps

Properties and Human Exposure

Clarifications?

Reviewer Questions

- Comment on whether the chemical identity and description of cobalt and certain cobalt compounds (Section 1: Chemical Identification and Properties) are clear and technically accurate.
- Comment on whether the information on use, production, and human exposure to cobalt and certain cobalt compounds (Section 2: Human Exposure, Appendix B) is clear and technically accurate.
  - Identify any information that should be added or deleted.
- Comment on whether adequate information is presented to document past and/or current human exposure to cobalt and certain cobalt compounds in the United States. Exposure can be inferred by data on usage, production, or evidence for exposure in the workplace, from the environment or consumer products, diet, or medical products.