Sources of Exposure

General Populations

- Everyone is exposed to low levels of nickel daily in water and air.
- Low levels of nickel are present in many common foods. The estimated daily intake of nickel from food for the general population in the U.S. is less than 0.5 mg/day.
- Individuals may be exposed to nickel from dermal contact to jewelry, clothing, and toys made with metal containing nickel.
- The estimated daily intake of nickel from dietary supplements in the U.S. is 9.6 to 15 µg/day.
- People living near facilities known to emit nickel, such as oil refineries and coal-fired power plants may have elevated exposures to nickel.
- Users of tobacco products and e-cigarettes may have elevated intake of nickel.

Occupational Populations

- Individuals who work in nickel mining or in the production of nickel and nickel products may be exposed through inhalation, oral, or dermal contact.
- Since nickel containing metals are regularly used in dental applications, dental technicians may have a higher dermal exposure than the general population.

Toxicokinetics and Biomonitoring

Toxicokinetics

- The absorption of nickel is dependent on the form and bioavailability.
- Following inhalation, insoluble nickel may clear from the upper lung via mucociliary transport, swallowed, and absorbed into the gastrointestinal tract. 20-35% of inhaled soluble nickel may absorb into the bloodstream. Oral absorption ranges from 1-40% depending on if consumed with food and water. Nickel penetrates the skin, but dermal absorption is slow and minimal.
- Absorbed nickel enters the bloodstream and distributes to the lung, thyroid, adrenals, kidneys, heart, liver, brain, spleen, and pancreas. A larger portion of less soluble forms may be retained in the lungs.
- Nickel does not undergo metabolism prior to excretion.
- Nickel is primarily excreted through the urine regardless of exposure route. Unabsorbed nickel is typically excreted through feces. Nickel has also been measured in sweat and breast milk. The elimination half-time of nickel ingested from food or water is 28 hours.

NHANES Biomonitoring

- The geometric mean urinary nickel level for all adults in the 2017-2018 NHANES is 1.11 µg/L.

Biomarkers/Environmental Levels

Biomarkers

Nickel can be measured in urine, feces, serum, hair, toenails, and nasal mucosa to indicate exposure. When elevated, these may indicate excess nickel exposure. Currently, there are no reliable effect biomarkers specific to nickel.

Environmental Levels

Air (µg/m³)

- Outdoor, mean range: <0.003–0.18
- Indoor, mean range: 0.003–0.025

Water (µg/L)

- Ground water range: 0–18,200
- Surface water range: 0–6,390
- Drinking water range: 0.55–25
- Seawater range: 0.1–3

Soil and Sediment

- Soils range: 19.8–185 mg/kg
- Sediment range: 6–530 µg/g

Food (mg/kg)

- Mean range: 0.0004–3.2
- Baby food mean range: 0.002–0.419

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2023. Toxicological Profile for Nickel (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

ToxGuide™ for Nickel

Ni

CAS# 7440-02-0

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U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry
www.atsdr.cdc.gov

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Chemical and Physical Information

Nickel is a silvery-white metal.

- Nickel is a metallic solid that is malleable, ductile, ferromagnetic, and a good heat and electricity conductor.
- Metallic nickel occurs naturally and is a group 10 element transition metal. It has a lustrous silvery-white color, exists in a solid state, and is odorless.
- Nickel is commonly used to form alloys with other metals to increase hardness, strength, and corrosion resistance.
- Nickel ammonium sulfate, nickel sulfate, nickel chloride, and nickel nitrate usually exist as hexahydrates, while nickel acetate, nickel cyanide, and nickel sulfamate are in the form of a tetrahydrate. Nickel compounds are solids and colors include a yellow-brown or a blue-green color.
- Metallic nickel is water insoluble, and the solubility of nickel compounds varies. Nickel and its compounds are nonvolatile and exist in the atmosphere in particulate form.

Routes of Exposure

- Inhalation – The public inhales nickel in the atmosphere as it is typically bound to particulate matter. Inhalation can occur in workers who work in nickel mining, refineries, or other industries handling nickel. Communities living near facilities that process or mine nickel can be exposed via inhalation.
- Oral – The public is exposed daily to nickel in foods and water. Nickel is primarily ingested through common food products.
- Dermal – Dermal contact is possible for both the public and workers through skin contact with items containing nickel metal or nickel products. Adults and children may be exposed if handling contaminated soils.

Nickel in the Environment

- Nickel occurs naturally in air, water, soil, and sediments.
- In the atmosphere, nickel is bound to particulate matter where it is dispersed by wind and moved by sedimentation, dry deposition, rain, or snow.
- In water, soluble nickel can dissolve or is bound to particulate matter.
- Nickel is strongly absorbed by soil and sediments. It favors binding with high molecular weight soil humic substances such as agricultural soils.
- Certain plants may uptake nickel from soils since it is necessary for growth.
- Nickel does not bioconcentrate in fish or other aquatic organisms.

Relevance to Public Health (Health Effects)

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

Minimal Risk Levels (MRLs)

Inhalation

- No acute-duration inhalation MRL was derived for nickel.
- A provisional intermediate-duration inhalation MRL of 0.00003 mg Ni/m^3 was derived for nickel.
- A provisional chronic-duration inhalation MRL of 0.00001 mg Ni/m^3 was derived for nickel.

Oral

- No acute- (≤14 days), intermediate- (15-364 days), or chronic-duration (≥365 days) oral MRLs were derived for nickel.

Health Effects

- Contact dermatitis because of nickel sensitivity (allergy) is the most reported effect of dermal nickel exposure. Prevalence of nickel sensitivity among the general population ranges from 11-16% and is more frequently observed in females. A rash typically develops at the site of contact with the nickel or nickel product but can also develop away from the contact site.
- Asthma as an allergic response to occupational exposure has been reported.

Health Effects

- Respiratory illness and death are reported in individuals occupationally exposed to nickel in welding fumes and dusts.
- Gastrointestinal distress and giddiness are reported in workers who drank nickel-contaminated water.
- Intermediate-duration oral exposure studies in animals report alterations in hematological parameters, and histological and biochemical changes in the liver and kidneys.
- Offspring of animals orally exposed to nickel during pregnancy had decreased survival and developmental abnormalities.
- *In vivo* studies of human lymphocytes suggest nickel is clastogenic and can damage DNA.
- The U.S. Department of Health and Human Services (HHS) classifies metallic nickel as reasonably anticipated to be a human carcinogen and has classified nickel compounds as known carcinogens. The International Agency for Research on Cancer (IARC) classifies nickel metals and nickel compounds as carcinogenic to humans. The EPA has classified nickel subsulfide and nickel refinery dust as human carcinogens and has not evaluated the carcinogenicity of soluble nickel salts.

Children's Health

- Children exposed to nickel would be expected to experience effects like those expected in adults. It is unknown if developmental effects seen in exposed animals are expected to be seen in humans.