Non-Communicable Diseases Watch
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衞生防護中心 Centre for Health Protection
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What You Need to Know About Metals in Drinking Water on Health?

Key Messages

※ Experience gained from the incident of excess lead in drinking water in 2015 showed that the most important element of clinical management for people having consumed lead contaminated water is cessation of further exposure to contaminated water. Over time, lead will pass out of the body. Screening of blood lead level (BLL) did not affect clinical management. Routine blood taking for BLL testing is not indicated.

※ For antimony, cadmium, chromium, copper and nickel, the World Health Organization (WHO)'s drinking water guideline values are stringent and set at levels substantially lower than those causing clinical poisoning. The risk of consumption of drinking water tainted with these metals causing significant health effects is assessed to be very low. There is no scientific basis for biological screening such as blood test or urine test in case of exposure in drinking water and similar screening programmes are not identified overseas.

※ From the health perspective, it is always good to have blood lead as low as possible. The public should follow the Water Supplies Department's advice to cultivate good habits of water use.

※ Persons with history of consumption of drinking water contaminated with lead and the five metals who experience relevant symptoms or are unduly concerned may consult their doctor for advice and counselling.

※ Parents are reminded to bring their children to Maternal and Child Health Centres (from birth to 5 years of age) and Student Health Service Centres (all primary and secondary day school students) to receive regular developmental surveillance and other preventive health services according to their stage or age of development.

※ Parents of primary and secondary school students may approach teachers or Student Support Team in their schools for advice and support regarding their children's learning and adjustment at school.

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What You Need to Know About Metals in Drinking Water on Health?

Metals are naturally present, ubiquitous in the environment and have widespread uses. As a result, human exposure to metals comes from many various sources and the route of exposure is mainly through ingestion and breathing. Depending on the route, dose, duration, frequency of exposure and vulnerability of the exposed person, exposure to metals can be associated with a wide range of effects. Some metals, such as antimony, cadmium, chromium, copper, lead and nickel, could also be present in internal plumbing systems. Nevertheless, risks of contamination by these metals in drinking water are usually not high if the internal plumbing systems are properly installed and maintained.[1]

Enhanced Water Quality Monitoring Programme (EWQMP)

In September 2017, the Water Supplies Department (WSD) announced the Action Plan for Enhancing Drinking Water Safety in Hong Kong to further safeguard drinking water quality in Hong Kong through a multipronged approach. The Action Plan comprises five components, namely "Drinking water standards and enhanced water quality monitoring programme", "Plumbing material control and commissioning requirements for new plumbing installations", "Water safety plan", "Water safety regulatory regime" and "Publicity and public education".

Under the "Enhanced Water Quality Monitoring Programme", the WSD will randomly selected from all water accounts using a pre-defined random sample selection methodology to monitor the quality of drinking water at the consumers' taps. The Programme, which is voluntary in nature, will test the level of six metals (i.e. antimony, cadmium, chromium, copper, lead and nickel) in water if they are present in the internal plumbing system. The Programme aims to collect local data on various metal parameters for reviewing the drinking water standards with a view to assessing the appropriateness to adopt a standard for some parameters beyond the relevant Guideline Values/Provisional Guideline Values of the World Health Organization (WHO). Details of the programme are available at the WSD's website.[2]

Metals and Their Health Effects

Antimony is used as a replacement for lead in some soldering materials. Significant antimony exposures may occur in occupational settings, such as metal smelting, while total exposure from food and drinking-water is relatively low.[3] Ingesting large amounts of antimony salt may exert a strong irritating effect on the gut and trigger sustained vomiting, abdominal cramps and diarrhoea.[4]

Cadmium has a number of industrial applications such as electroplating, pigment production, manufacture of plastic stabilisers, nickel-cadmium batteries and electronics. As a result of widespread environmental contamination, food is the main source of daily exposure to cadmium.[3] Smoking is another major source of cadmium exposure.[3] Long term consumption of high levels of cadmium may cause damage to the kidneys. Early sign is the presence of protein in the urine. An even higher intake may increase the risk of bone fracture.[5]

Chromium can exist in different chemical forms. Under non-occupational settings, food remains the major source of chromium intake.[6] Chromium (III) is an essential nutrient in the human body.[3] On the other hand, Chromium (VI) is an oxidizing agent overdose of which can be harmful and may lead to gastrointestinal discomfort.[6, 7]

Copper is used to make pipes and valves, and is present in alloys and coatings. Food and water are the primary sources of copper exposure.[3] Copper is an essential nutrient for human. Excessive intake of copper may cause acute gastrointestinal effects and very high level consumption may cause liver and kidney injury.[8]

Lead is a naturally occurring heavy metal which usually presents in a very small quantity in the environment.[9] However, because of the widespread industrial use of lead and its compounds, lead may be found in products such as batteries, lead-based paints, lead-containing ceramics, lead solder, leaded petrol and even cosmetics and herbal medicines. Common sources of lead exposure at very low levels for the general public include urban dust, contaminated food and water.[10] In everyday life, lead is found everywhere and exposure seems unavoidable. Notwithstanding this, it is always good for health to achieve the lowest possible lead exposure.[11] Lead has no biological role. Significant exposure to lead is associated with a wide range of effects, including neurodevelopmental effects, neurological impairment, anaemia, high blood pressure, gastrointestinal symptoms, impaired renal function, impaired fertility and adverse pregnancy outcomes.[12]

Nickel is used mainly in the production of stainless steel and nickel alloys. Food is the dominant source of nickel exposure in the non-smoking, non-occupationally exposed population.[3] Intake from water is generally a minor contributor.[3] The most common effect of nickel on the human body is allergic contact dermatitis caused by nickel-containing metal (e.g. earrings, watch straps) touching the skin.[3] Acute ingestion of high level of nickel can cause nausea, vomiting and diarrhoea.[13] For individuals sensitised to nickel, ingestion of excessive nickel could induce allergy.[14]

Table 1 summarises health information on the six metals in drinking water from the WHO and International Agency for Research on Cancer (IARC).

Local Experience

In 2015, 11 public rental housing estates (PRHE) were found with one or more tap water samples exceeding the provisional guideline value (10 mg/L) of lead in drinking water recommended by WHO. This incident aroused major public concern. At that time, there was no local data pertaining to a similar type and extent of lead exposure through drinking water. Only limited studies[15, 16] had investigated the blood lead levels (BLL) in the local population. After review of overseas and international literatures,[17-20] the Government launched the voluntary BLL screening programme to help understand the potential impact of exposure to excessive lead in drinking water on the health of exposed residents, especially on the more easily affected groups i.e. children aged below 6, pregnant or lactating women. The BLL screening programme was later extended to cover students and staff of schools and kindergartens, for which water samples were also taken for testing of lead.

The voluntary BLL screening programme adopted 5 µg/dL as reference level for BLL among more easily affected groups (i.e. children aged six or below, lactating mothers and pregnant women) and 10 µg/dL for other adults. According to the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) of the United States (US) Centers for Disease Control and Prevention (CDC) in 2012[18] which was current at the time of the lead in drinking water incident in Hong Kong, the reference value of 5 µg/dL for children was based on the 97.5th percentile of the BLL distribution in US children aged 1-5 years and is used to identify children with elevated BLL.

Table 1: Health information on the six metals* in drinking water from the WHO and IARC

	WHO guideline value for drinking water (μg/L)	Key potential health effects*	Concerns on cancer risk
Antimony	20	• Ingesting large amounts of antimony salt may exert a strong irritating effect on the gut and trigger sustained vomiting, abdominal cramps and diarrhoea.	• IARC concluded that antimony trioxide is possibly carcinogenic to humans (Group 2B) on the basis of inhalation study in rats, but that antimony trisulfide was not classifiable as to its carcinogenicity to humans (Group 3). Nevertheless, chronic oral uptake of antimony may not be associated with an additional carcinogenic risk.
Cadmium	3	• Long term consumption of high level of cadmium may cause damage to the kidneys. Early sign is protein in the urine. An even higher intake may increase the risk of bone fracture.	• IARC has classified cadmium and cadmium compounds in Group 1 (carcinogenic to humans). However, there is no clear evidence of carcinogenicity by the oral route.
Chromium	50 (Provisional)	• Chromium (III) is an essential nutrient in the human body. On the other hand, Chromium (VI) is an oxidizing agent overdose of which can be harmful and may lead to gastrointestinal discomfort.	• Studies of occupational exposure to chromium (VI) (chromate production and chromium electroplating) showed increased risk of lung cancer. IARC has classified chromium (VI) compounds as carcinogenic to humans (Group 1), but its carcinogenicity through oral route has not been well-established .
Copper	2000	• Copper is an essential nutrient for human. Excessive intake of copper may cause acute gastrointestinal effects and very high level consumption may cause liver and kidney injury.	• There is no adequate study for the carcinogenicity of copper. IARC has not made any classification for copper.
Lead	10 (Provisional)	• Significant exposure to lead is associated with a wide range of effects, including neurodevelopmental effects, neurological impairment, anaemia, high blood pressure, gastrointestinal symptoms, impaired renal function, impaired fertility and adverse pregnancy outcomes.	• There is some evidence that long-term occupational exposure to inorganic lead may contribute to the development of cancer. IARC classified inorganic lead compounds in Group 2A (i.e. probably carcinogenic to humans) and organic lead compounds in Group 3 (i.e., not classifiable as to its carcinogenicity to humans).
Nickel	70	• The most common effect of nickel on the human body is allergic contact dermatitis caused by nickel-containing metal (e.g. earrings, watch straps) touching the skin. Acute ingestion of high level of nickel can cause nausea, vomiting and diarrhoea. For individuals sensitized to nickel, ingestion of excessive nickel could induce allergy.	• Studies of occupational exposure to nickel (refinery and smelter workers) showed increased risks of lung and nasal cancers. IARC has classified nickel compounds as carcinogenic to humans (Group 1). However, there is a lack of consistent evidence of a carcinogenic risk from ingestion of nickel.

* These metals may enter the human body mainly by mouth and breathing. Depending on the route, concentration and duration, exposure to these metals can be associated with a wide range of effects.

After conducting 5 655 BLL tests covering primarily the more easily affected groups among PRHE residents and children and staff from schools, who had consumed lead-contaminated water, 165 persons, i.e. 2.9%, were found to have mildly elevated BLL (5.0 to 16.7 mg/dL). In other words, 97.1% of the persons tested were found to have normal BLL. Table 2 summarises the first BLL tests conducted.

For cases with elevated BLL, the Department of Health (DH) and the Hospital Authority (HA) developed a care protocol and provided follow-up actions as appropriate, which included health education and advice on reducing lead exposure, lead exposure assessment, preliminary development assessment and surveillance for children, medical consultation and regular retesting of BLL until BLL has returned to normal.

For most people with elevated BLL, their BLL gradually returned to below the reference value after exposure to contaminated water had stopped; for a few exceptional cases which still have mildly elevated BLL, HA is conducting follow up as their BLL continued with a downward trend. Given the mild elevation, no one required chelation therapy or any other specific treatment. It can be concluded that the observed mild elevation of BLL did not and is not expected to result in observable clinical features.

The DH also conducted preliminary developmental assessment and follow-up surveillance for children with borderline raised BLL. As at 31 August 2017, nine children had developmental delay. It is worth noting that before the incident was brought to light, most of the affected children had already been cared for under the Government's child developmental or health services, indicating that the existing system of developmental surveillance service is capable of identifying and caring for these children irrespective of the causes.

Indeed, neurodevelopmental or behavioural problems usually have multifactorial aetiologies[21] including children's socioeconomic, environmental, constitutional and parenting factors. It would be difficult to prove or otherwise if exposure to lead in drinking water had played a contributing role in the developmental status of the children concerned. All children with developmental problems were referred to age-appropriate rehabilitation services. Other children were reminded to attend Maternal Child Health Centres (from birth to 5 years of age) and Student Health Service Centres (all primary and secondary day school students) for routine developmental surveillance.

Table 2: Summary of the first BLL tests conducted

	Children	Pregnant Women	Lactating Mothers	Other Adults (belonging to units supplied with lead-tainted water)	Total
No. of first BLL test	4 915	236	356	148	5 655
No. of mildly elevated result [range, μg/dL]	129 (2.6%) [5.0-15.3]	5 (2.1%) [5.3-8.9]	28 (7.9%) [5.0-9.7]	3 (2.0%) [10.0-16.7]	165 (2.9%) [5.0-16.7]

Reduce Exposure to Metals in Everyday Life

Members of the public should minimise exposure to lead and other metals from all sources in daily living by adopting good dietary practice,[22] good hygiene practice,[23] avoiding common sources of exposure[24] and cultivating good habits of water use.[25]

Good dietary practice

- ✓ Eat a balanced diet so as to avoid excessive exposure to metallic contaminants from a small range of food items. Moreover, soak and wash vegetables, particularly leafy ones, in clean water before they are processed or consumed.
- ✓ Sufficient dietary intake of calcium, iron and vitamin C can help to minimise lead absorption. Food sources of calcium include milk, tofu, and calcium-fortified soymilk. Meat, fish, and dark green leafy vegetables are rich in iron. Fresh fruits such as orange and kiwifruits are good sources of vitamin C.
- ✓ Reduce consumption of foods high in lead, such as lime preserved egg, oyster, and shellfish.
- ✓ A higher calcium intake helps to minimise lead absorption and lower the blood lead level in pregnant women and lactating mothers. Consume two glasses of milk or calcium-fortified soymilk every day; also choose calcium-rich foods, such as tofu, small fish eaten with their bones and green leafy vegetables. You may need to take calcium tablet on top of the prenatal multivitamin and minerals supplement. Seek advice from your doctor or pharmacist.
- ✓ For feeding babies, other than breast milk or formula milk, introduce solid food at around 6 months of age. Apart from iron-fortified baby cereal, meat or fish puree, pureed leafy vegetables and fruits are nutritious first foods. After their first birthday, children can generally share family's foods. They eat better with a regular schedule of 3 main meals and 2 snacks a day. A daily diet with 480ml milk is sufficient to meet their needs for calcium.

Good hygiene practice

- ✓ Dust off your house regularly. Wash your and your children's hands and face frequently to remove any dust and soil that contain metals.
- ✓ Parents and caregivers should wash their hands after handling items which may contain lead.

Avoid common sources of exposure to metals

- ✓ Do not smoke.
- ✓ Do not allow children to swallow or chew paint fragment, or the paint surface of toys and furniture as these metals could be present in some paints.
- ✓ Toys with paints of deeper colour may contain lead. Parents can verify with the retailers or manufacturers or check the product label for statements on the compliance with the ISO, EN71, or ASTM F963-11 safety standards. Remove the toys if you are not sure whether they are safe for children.
- ✓ Individuals who are exposed to lead and lead compound at work are advised to change their clothes and shoes before going home.
- ✓ Refrain from using colour-painted ceramic tableware and cups unless the item is labelled "lead-free" or you are sure that the material used is safe.
- ✓ Ensure good ventilation when using candles and burning incense and wash your hands immediately after handling.
- ✓ Avoid contact with damaged batteries and electronic devices.

Cultivate good habits of water use

- ✓ Run the tap for at least two minutes after long periods of stagnation (for instance, after several hours or overnight) before collecting it for drinking or cooking.
- ✓ As hot water increases the amount of impurities that may leach from pipes and fittings, avoid using water from hot water taps for drinking or cooking.

Conclusion

- Experience gained from the incident of excess lead in drinking water in 2015 showed that the most important element of clinical management for people having consumed lead contaminated water is cessation of further exposure to contaminated water. Over time, lead will pass out of the body. Screening of BLL did not affect clinical management. Routine blood taking for BLL testing is not indicated.

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- From the health perspective, it is always good to have blood lead as low as possible. The public should follow the WSD's advice to cultivate good habits of water use.

- Persons with history of consumption of drinking water contaminated with lead and the five metals who experience relevant symptoms or are unduly concerned may consult their doctor for advice and counselling.

- Parents are reminded to bring their children to Maternal and Child Health Centres (from birth to 5 years of age) and Student Health Service Centres (all primary and secondary day school students) to receive regular developmental surveillance and other preventive health services according to their stage or age of development.

- Parents of primary and secondary school students may approach teachers or Student Support Team in their schools for advice and support regarding their children's learning and adjustment at school.

- More information on health effects of lead and other five metals and ways to minimise metal exposure from all sources in daily life is available at http://www.chp.gov.hk/en/content/40434.html. A practical management guide for doctor's reference is also available.

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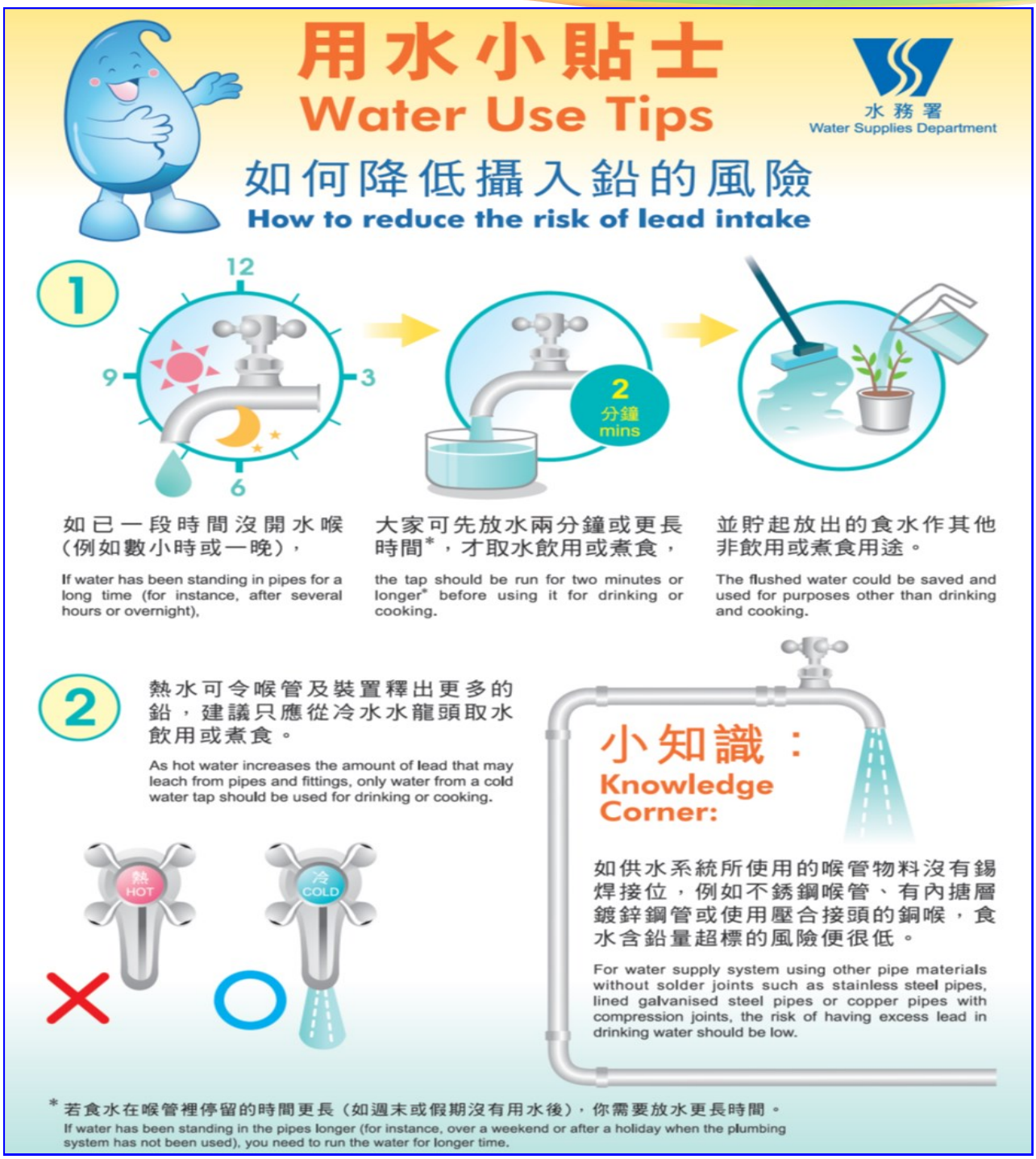

Further details of water use tips are available at the WSD's website: http://www.wsd.gov.hk/en/core-businesses/water-quality/water-use-tips/index.html.

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