Children’s health and the environment
WHO training package for the health sector

ELECTRICAL/ ELECTRONIC WASTE AND CHILDREN’S HEALTH
TRAINING FOR HEALTH CARE PROVIDERS
SECOND EDITION

World Health Organization

Notes:
• please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated.

• this is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local or regional situation. Where relevant, adapt the information, statistics and photos within each slide to the particular context in which this module is being presented. For instructions on how to use this module visit: https://www.who.int/publications/i/item/WHO-CED-PHE-EPE-19-12-02;

• Electrical/electronic waste and children’s health is one module from a larger training package focused on children’s environmental health. Consult these other modules where relevant. Throughout Electrical/electronic waste and children’s health, a number of different modules are suggested that contain additional relevant information. To see the full package visit: https://www.who.int/teams/environment-climate-change-and-health/settings-populations/children/capacity-building/training-modules;

• the World Health Organization (WHO) reference number for the module Electrical/electronic waste and children’s health: training for health care providers, second edition is WHO/HEP/ECH/CHE/23.03;

• for more information on WHO’s work on children’s environmental health, please visit: https://www.who.int/health-topics/children-environmental-health.
This image shows discarded electronics in rural Columbia. We can see multiple different items including computer monitors.

Photo:
• © Emerson Rodrigues da Silva.
Learning objectives

• Understand the definition of e-waste, where it originates and how it moves around the world

• Recognize potential toxic hazards and the risks they may pose to children

• Identify children’s exposure scenarios to e-waste

• Learn about diseases that may be related to acute and chronic exposures to chemicals in e-waste

• Consider local interventions and international actions to prevent children’s exposure to e-waste

Note:
This presentation deals with children exposed to chemicals contaminated in air, soil, dust, food, or water due to emissions or effluents from electrical and electronic waste recycling activities. Health care providers are called to play a key role. The learning objectives for this module are:

• understand the definition of e-waste, where it originates and how it moves around the world;

• recognize potential toxic hazards from e-waste and the risks they may pose to children’s health and wellbeing;

• identify exposure scenarios – how, where and when children are at risk to toxicants released through e-waste recycling;

• learn about diseases that may be related to acute and chronic exposures to chemicals in e-waste; and

• consider local interventions and international actions to prevent children’s exposure to e-waste.
Note:
When selecting the slides to include in your presentation, please choose only those of relevance to the region and/or interests of your audience.

This training module includes:
• the magnitude of the e-waste problem and its contribution to environmental pollution
• children’s vulnerabilities and exposure pathways to e-waste
• mechanisms of action and possible child health effects associated with e-waste
• management and prevention, including international initiatives, regulatory measures, local actions at community level and actions that the healthcare sector can take
• success stories: case studies from China, Ghana and Uruguay on prevention measures to reduce children’s exposure to e-waste.

Photo:
• © Kwadwo Ansong Asante. A man carries various e-waste items, Agbogbloshie, Accra, Ghana.
For the first section of this module, we will start with the definition of e-waste and the magnitude of the problem.

**Photo:**
There are multiple definitions of electrical and electronic waste (e-waste). The most widely accepted definition of e-waste comes from the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes. It defines e-waste as:

- “any electrical and electronic equipment, which is waste, including all components, subassemblies and consumables, which are part of the equipment at the time the equipment becomes waste” (1).

E-waste is commonly also known as waste electrical and electronic equipment (WEEE) or used electrical and electronic equipment (UEEE), however for the purposes of continuity in this training module we will only use the term “e-waste”.

References:

Photo:
- © WHO/ Blink Media – Tali Kimelman. This image shows motherboards from computers wait to be recycled at Triex Company in Montevideo, Uruguay.
Although not exhaustive, this graphic illustrates some types of e-waste that may be found in day-to-day life.

Common items found in e-waste include:
- computers, laptops, monitors and motherboards/chips
- wireless devices and other peripheral items
- printers, copiers and fax machines
- telephones, mobile phones, tablets and charging cords
- video cameras
- televisions
- electronic gaming equipment
- stereo equipment
- cathode ray tubes
- batteries
- cables
- lamps and light globes
• large household appliances, including electric stoves, cooling and heating equipment and refrigerators (1).

References:

Figure:
Each year millions of electrical and electronic devices are discarded as products break, or become obsolete, and are discarded by consumers. The discarded devices are considered e-waste and can become a threat to the environment and to human health if they are not treated, disposed of and recycled appropriately. E-waste is the fastest growing solid waste stream in the world, increasing three times faster than the world’s population (1).

In 2019, an estimated 53.6 million tonnes of e-waste were produced globally. On average, this is equivalent to 7.3 kg of e-waste per person. However, globally only 17.4%, or 9.3 million tonnes, was documented as formally collected and recycled. The amount of e-waste produced annually is expected to increase to 74.7 million tonnes by 2030 (2).

E-waste also contains finite resources that can be reused if they are recycled appropriately. The Global E-waste Statistics Partnership (GESP) estimated that in 2019, up to $57 billion USD in raw materials could have been recaptured from e-waste if the iron, copper and gold found within e-waste were properly retrieved and recycled. Thus, e-waste is a valuable commodity and can be an important income stream for individuals’ and even communities’ livelihoods (2).

Inferior practices used to recycle e-waste are contributing to global warming through emissions of greenhouse gases, such as refrigerants found in some temperature exchange equipment. For example, in 2019, inferior recycling of undocumented refrigerators and air conditioners released as much as 98 million tonnes of carbon dioxide (CO$_2$) equivalents into the environment (2). These recycling practices will be discussed later in the module.
National, regional and international organizations are working on how best to define trade conditions and the difference between donations of usable electrical and electronic equipment, which can include important technologies transfers between countries, and the export of e-waste. Despite international regulations targeted to control the transport of e-waste to low- and middle-income countries (LMICs), the transboundary movement of e-waste continues, often illegally. E-waste trade also occurs regionally and between LMICs (2).

E-waste is considered hazardous waste as it contains toxic materials, including mercury, lead and brominated flame retardants (2). Only 17.4% of e-waste was documented as being properly collected and recycled in 2019. Most of the remaining e-waste is likely stored, dumped, exported or recycled under inferior conditions. E-waste is often transported from high-income countries (HICs) to LMICs for dismantling, recycling and refurbishment activities. The amount of e-waste transported illegally to LMICs is unknown, but national estimates for some countries do exist (2-4).

E-waste trade is complex, as in some cases electronic equipment is traded in the form of donations to low-income communities, while in other examples it has become an important source of livelihood. Additionally, it is difficult for authorities to confirm the functioning status of individual items due to the sheer amount of e-waste that is now in global circulation (5,6).

More than 1000 different harmful substances have been identified that are either components of e-waste or components of poor recycling systems (5). Exposure to these substances may place children at risk to multiple toxic effects (5). E-waste is an under-recognized health risk and greater awareness within the health care sector is needed to identify children at risk and its links to disease and health outcomes.

**Note:** the Global E-waste Statistics Partnership (GESP) is a collaboration between the International Telecommunication Union (ITU), United Nations University – Sustainable Cycles (UNU-SCYCLE) and the International Solid Waste Association (ISWA). GESP aims to monitor e-waste flows and assist countries in producing reliable e-waste statistics (8).

**Note:** see *Children and chemicals, Global climate change and child health, Lead, Mercury* and *Persistent organic pollutants* modules for more information.

**References:**


E-waste levels are increasing across the world. The United States of America, countries in Western Europe, China, Japan, India, Brazil and Australia are some of the major producers of e-waste. Over the past 10 years, e-waste production has also been increasing in some countries and areas in Asia, Eastern Europe and Latin America (1).

Informal e-waste recycling sites have been reported across the world. The map here shows locations of informal e-waste dismantling and recycling sites reported in the research literature. This include sites in Bangladesh, Cameroon, Chile, China, Egypt, Ghana, Hong Kong SAR (China), India, Mexico, Nigeria, occupied Palestinian territory, including east Jerusalem, Pakistan, the Philippines, Thailand, Uruguay and Viet Nam (1).

While these sites have been identified through research literature, this list is not conclusive. E-waste sites are suspected to exist in many other countries but are yet to have been identified. Across the world, e-waste recycling sites can be very diverse in terms of their size and characteristics. In some countries, e-waste sites have developed into entire communities within towns and cities, sometimes with names, such as Agbogbloshie in Accra, Ghana. Many activities are undertaken here, including scavenging, dismantling, refurbishment and resale of electrical and electronic items. Sites such as Agbogbloshie attract economic migrants from across the country and the region (1).

Comparatively, in some Latin American countries, e-waste recycling activities may be more dispersed. Small-scale e-waste recycling activities may be found scattered across neighbourhoods, on street corners and community spaces, as well as within workers’ own homes and backyards and involving all family members, including children. With activities more spread out, vulnerable populations across a
city or town may be exposed to pollution from “micro toxic” sites. The spread of activities also makes it difficult to accurately quantify the magnitude of e-waste recycling activities and estimate the number of people that may be affected (1). In some Latin American countries, families have been living for decades on land that had been previously filled with industrial wastes, including e-waste. (2).

E-waste recycling activities in LMICs include recovery activities that separate gold, silver, copper, zinc, iron, tin, and other metals, found within electrical and electronic items, and preparing them for resale. Evidence suggests that e-waste recycling and other informal activities represent a significant source of financial support for economically disadvantaged families (3).

**Note:** if you have a regional or context specific example of an informal e-waste site, it could be mentioned here.

**References:**


**Map:**

- © WHO.
- Map production: Chemicals Safety and Health Unit, Department of Environment, Climate Change and Health.
E-waste and e-waste recycling activities can cause the release of as many as 1000 different chemicals into the environment (1). Many chemicals found in e-waste and/or released or produced during e-waste recycling activities are known or suspected to cause harm to human health. These include:

- **heavy metals**: Chromium, cadmium, lead, lithium, mercury and nickel;
- **persistent organic pollutants (POPs)**: brominated flame retardants including polybrominated diphenyl ethers (PBDEs), per- and polyfluoroalkyl (PFAS) and polychlorinated biphenyls (PCBs);
- many **polycyclic aromatic hydrocarbons (PAHs)** are released through combustion activities (2); and
- e-waste recycling activities release some known and suspected endocrine disrupting chemicals, such as PCBs and PFAS (3).

The toxicity and environmental properties of some chemicals found in e-waste have not been thoroughly investigated or well studied in the context of e-waste recycling. Most of these chemicals of concern have a long half-life in animals and may bioaccumulate in tissues. Thus, they can be excreted in edible products such as eggs and milk. Likewise, e-waste-related toxic effects can be exacerbated throughout a person’s lifetime (3,4).

New and emerging technologies, such as electric vehicles and electronic cigarettes (e-cigarettes), are growing alternatives to motor vehicles and traditional tobacco cigarettes. They are also classified as e-waste as they contain lithium-ion batteries, plastics and electronic circuitry equipment that requires specialized recycling facilities and processes. While electric vehicles only make up a small percentage of vehicles on the road today, a key challenge for the future is how to prevent and manage the impacts of e-waste produced by electric vehicles, e-cigarettes and other new electronics (5). The challenges
faced by emerging technologies need to be considered and planned for now, so that in the future they can be addressed effectively and safely.

**Note:** see *Children and chemicals, Lead, Mercury* and *Persistent organic pollutants* modules for additional information.

**References:**


The above figure illustrates examples of some toxicants that are found in two electric and electronic items found in day-to-day life. While users are unlikely to have contact with any of these toxicants while the items are functioning, when the electric and electronic items become waste, these toxicants can be released into the environment if they are managed in an unsound manner (1). For example:

- mobile phones contain silver, platinum, copper, gold and cadmium, among other toxicants; and
- computers contain lead, mercury, nickel and brominated flame retardants, among other toxicants (2).

In addition to the above, persistent organic pollutants (POPs) are also found in e-waste in printed circuit boards and thermoplastics that make up many electronic and electrical items. If there is combustion during e-waste recycling activities, polycyclic aromatic hydrocarbons (PAHs) may also be released. About 16 PAHs and POPs, such as brominated flame retardants, have been identified in e-waste and e-waste recycling activities (2).

Furthermore, 36 polychlorinated biphenyls (PCBs) have been identified in e-waste components (2).

17 different polychlorinated dibenzo-p-dioxins (PCDDs), 12 dioxin-like PCB congeners, as well as polychlorinated dibenzofuran (PCDF) congeners, and up to 16 different PAHs have been identified as being released during e-waste combustion (2).

Note: see Children and chemicals and Persistent organic pollutants modules for more information.
References:

Figure:
Improperly managed e-waste materials may pose significant human and environmental health risks. A number of hazardous informal e-waste dismantling recycling practices have been observed at e-waste sites including:

- **Scavenging** generally refers to the activity of picking through piles of e-waste to recover valuable pieces (1).
- Materials that cannot be recycled in the informal sector may end up being dumped. In some areas, large quantities of e-waste are discarded, sometimes dumped on riverbanks, farmland or in bodies of water. Unusable or unwanted items may also be dumped. Chemicals used in acid baths or leaching are also frequently dumped in water or on land (1,2).
- E-waste is frequently landfilled along with regular waste, sometimes by accident when it is discarded with other wastes, and other times on purpose. For example, in contexts where there is no designated hazardous waste facility (1).
- **Opening burning or heating** is used to remove plastic coatings and recover copper. Sometimes other items, such as vehicle tires, are burnt to create high temperatures to burn off plastic coatings. Burning circuit boards by hand is sometimes referred to as “cooking” circuit boards. The photo on the left shows a group men working to recover copper from cables using open burning practices (3). Cable burning is one of the most common e-waste recycling activities and is often considered one of the most hazardous due to the toxic fumes it creates.
- **Acid baths or acid leaching** is used to recover highly valuable materials, such as gold and palladium. In a leaching process circuit boards, memory banks or chips are soaked in acid which may also include cyanide salts, nitric acid or mercury (3).
- **Stripping and shredding** plastic coatings from wires and other components using rudimentary tools.
• manually disassembly of equipment. This occurs when items cannot be repaired. Valuable materials, such as copper and gold are recovered by manually taking apart items containing these materials, which are then sold (2).

Open cable burning, acid baths, and “cooking” circuit boards are the most common e-waste recycling activities in the informal recycling sector as they are quick and require minimal equipment. These activities are also considered the most hazardous to the environment and to human health as they release toxic pollutants into the environment, contaminating the air, soil, dust and water at recycling sites and in neighbouring communities (2).

Note: if you have a regional or local photo illustrating local recovery practices, it can be used here.

Reference:

Photo:
• © WHO/ Abraham Mwaura Thiga. This image shows men at Agbogbloshie, Accra, Ghana burning cables to retrieve copper.
If improperly managed, hazardous emissions can be released through informal e-waste recycling activities and may pose significant human and environmental health risks.

- **Dumping** e-waste on land or water, or in **landfills** is of concern due to the large variety of substances that this waste stream contains. The main problem in this context is the leaching and evaporation of hazardous substances from soil. Besides the leaching of substances in landfills, there is also a risk of vaporization of volatile hazardous substances. For example, metallic mercury found in printed circuit boards and batteries can leach, vaporize and biotransform into organic forms. Dimethyl mercury, an organic form of mercury, has been detected in landfill gases at levels 1,000 times higher than what has been measured in open air (1).

- **Open burning** of e-waste creates fumes consisting of many toxicants. Open burning is one of the main sources of exposure of poly-halogenated dioxins and furans and emissions of heavy metals, including lead, at e-waste recycling areas. Pollutants released and created through opening burning of e-waste contribute to ambient air pollution and can travel significant distances from the source, exposing neighbouring communities, villages and cities (2).

- **Acid baths or acid leaching** creates effluents, or liquid waste, that are discharge into the environment, including water bodies such as rivers and lakes. Effluents from e-waste recycling activities can be highly toxic and may contain mercury and cyanide (2,3).

- **“Cooking,”** in the context of e-waste recycling, often refers to the process of burning circuit boards, often one-by-one, by hand over small fires to extract valuable metals. This process creates fly and bottom ashes potentially contaminated with a variety of pollutants, including lead. “Cooking” circuit boards contributes to ambient air pollution at e-waste sites. Although concentration of pollutants in the air may be highest at the e-waste site, particles and gases can drift considerable
distances into neighbouring areas and cities (2).

- **Shredding** plastic coatings can generate dust of the components being shredded, for example plastics and metals. These shredded materials can pollute dust, air, soil and wastewater (1).

- **Manual dismantling of** e-waste can create both coarse and fine particulate matter and may release toxic metals from inside items into the environment. For example, cathode ray tubes contain lead which, when manually dismantled, they may release lead fumes and dusts that can pollute dust, air and soil. Manual dismantling of e-waste items can contribute to ambient air pollution (1,2).

**Note:** see *Ambient air pollution* module for more information.

**References:**

**Figure:**
In the next section we discuss children’s vulnerabilities and exposure pathways to e-waste recycling activities and pollutants.

Photo:
• © Kwadwo Ansong Asante. A man carries various e-waste items, Agbogbloshie, Accra, Ghana.
As with many environmental hazards, children are often at increased risk from exposure to e-waste toxicants for several reasons. Toxicants released through e-waste recycling activities have been linked to the contamination of water, food, breast milk, soil, dust and air (1,2).

Children have different and unique exposures to e-waste recycling activities when compared to adults. E-waste recycling activities release toxic chemicals that can cross the placenta, for example lead, cadmium and polychlorinated biphenyls (PCBs). Research has suggested that maternal exposure to toxicants released through e-waste recycling activities may affect fetal development (1). Newborns and infants may be exposed to toxicants from e-waste through ingestion of contaminated breast milk (2). However, exclusive breastfeeding up to the first six months, and continued breastfeeding with complementary foods for two years and beyond, is recommended by the United Nations Children’s Fund (UNICEF) and the World Health Organization (WHO) as the best source of nutrition for children (3).

Some toxicants, such as mercury, are at their highest concentration close to the ground. Other chemicals can revolatize from the soil and are also at their highest concentrations close to the ground. As children are closer to the ground, their exposure to some pollutants released through e-waste recycling may be increased compared to adults (2).

Children tend to spend more time outdoors than adults, engaging in sport and play. If a sports ground, school or community is in close proximity to an e-waste recycling site, children may be exposed to higher levels of ambient air pollution from nearby e-waste recycling activities. Young children are also likely to put their hands, toys or other items in their mouths – increasing their risk of ingesting e-waste...
contaminants in the soil, dust or transferred from surfaces. Children with pica are at even higher risk (2,4). Children are also more vulnerable to infection and injury. For instance, small children spend more time on the floor, and thus may be forced to crawl or play around e-waste debris or dust and may enjoy playing with e-waste in home workshops or at e-waste sites (2).

References:

Photo:
Due to their developmental physiology, children are often subjected to higher exposure of pollutants found in e-waste and released through e-waste recycling activities. E-waste has been linked to air pollution and contamination of air, dust, water, food, and soil. Because they are anabolic and rapidly growing, children breathe more air and ingest more food and water relative to their size than adults. Consequently, children have higher intakes of pollutants relative to their size than adults. Children’s bodies metabolize and eliminate toxic substances differently compared to adults. Children’s bodies are not able to break down some hazardous substances and eliminate them (1).

In terms of developmental physiology, children have immature immune, respiratory and central nervous systems and are highly sensitive to many of the pollutants released through e-waste recycling. Infancy and childhood are critical periods of neurodevelopment, when neuronal growth, differentiation, migration, synaptogenesis, and myelination are taking place (2). E-waste contains multiple known or suspected neurotoxicants, such as lead and mercury, that may disrupt normal development of the central nervous system during the prenatal period, infancy, childhood and adolescence. The respiratory system is particularly vulnerable to exposure both during pregnancy and in the early years of life. Some harmful toxicants from e-waste may impact the structural development and function of the lungs (3).

Children are going through windows of vulnerability in which exposure to toxicants from e-waste may lead to permanent alterations in lung function, neurodevelopment, immune system function and thyroid function. While alveolar development is substantially complete by 2 years, lung growth continues through adolescence and parallels somatic growth. It is thought to be complete by approximately 18 years in females and 20-23 years in males. Until adult systems are fully developed,
Exposures to air pollution may alter function in both reversible and irreversible ways (3).

Cognitive immaturity also increases risk to children from e-waste. Young children do not know to stay away from e-waste recycling sites, and the youngest children lack agency to move away at all. Children may not cease activity if they are experiencing ill health effects or injury from e-waste activities (4).

Children have longer life expectancies than adults. Chronic conditions developed in childhood can affect the entire lifetime. Further, the effects of exposure to pollutants released through e-waste recycling activities have time to manifest for diseases with long latency periods. Insults from e-waste recycling activities to children in early life may impact them for years to come (5).

Children depend upon adults to provide a safe environment in which to grow, develop and thrive. Babies who are not yet able to crawl or walk are unable to remove themselves from situations where dangerous e-waste recycling activities occur. Children and adolescents may not be aware of the dangers that e-waste recycling activities pose and may accidentally put themselves in harm’s way (4). Additionally, dumps and landfills, where e-waste may be discarded, are a child’s playground. Children may play in dumps and landfills, accidentally exposing themselves to toxic e-waste.

References:

Photo:
Exposure to e-waste toxicants occurs through contaminants in the air, soil, dust, food, breastmilk and water, which can be touched, inhaled, ingested, or transferred through the placenta.

- **Skin exposure.** Children’s skin may be exposed to toxicants from playing with contaminated toys or other objects, and from take home exposure carried from work on family member’s skin, clothing, shoes or food (1).

- **Children inhale** air contaminated with toxicants from e-waste recycling activities, at home, within communities and at recycling sites. High levels of many toxicants have been found in the air at e-waste recycling sites (2).

- **Ingestion** is children’s primary route of exposure to toxicants from e-waste in both home and community settings. Children may be exposed to toxicants from e-waste through ingestion of contaminated food, water, soil or dust. Frequent hand-to-mouth behaviour in young children can increase exposure to chemicals through ingestion of contaminated dust or soil (1,2). Newborns and infants can also be exposed through ingestion of contaminated breastmilk (3,4).

- **Transplacental exposure.** Pregnant women who are exposed to toxicants from e-waste may expose their unborn child to harmful substances. There is some evidence that a number of toxicants released during e-waste recycling activities can cross the placenta. Some chemicals in e-waste, or released through e-waste recycling activities, can persist in the human body for significant periods of time, such as lead. These chemicals may be present long after e-waste exposure has ceased and can even be recirculated during pregnancy (1,5).
References:

Figure:
There are three primary settings that exposure children to toxicants released through unsound e-waste recycling. The next three slides discuss these exposure settings in greater detail.

**Child labour:**
Children are often involved in waste picking and scavenging, burning discarded e-waste and in manually dismantling it into component parts. In low- and middle-income countries (LMICs), children may serve as a source of cheap labour and their small hands give them an advantage in dismantling small, intricate electronics. These activities directly expose children to injury, high levels of toxicants, corrosive agents, toxic airborne particles and fumes. High levels of toxicants have been recorded on floors, surfaces, in air and soils, in and around e-waste recycling sites. In indoor e-waste recycling facilities poor ventilation leads to even higher levels of toxicants (1,2). Children as young as 5 years of age have been reported working in e-waste recycling in Ghana (1). Working as a waste picker is hazardous labour and is considered one of the worst forms of child labour by the International Labour Organization (ILO). In 2020, the ILO estimated that as many as 16.5 million children were working in the industrial sector, of which waste processing is a subsector. It is still unknown how many children work globally in informal e-waste recycling (3).

**References:**
Sources and settings of child exposure

Home-based recycling practices

- Inside homes and backyards or community areas
- Injury if children enter areas of e-waste activity
- Pollutants spread throughout the home
- Linked to high blood lead levels in children

**Home-based recycling practices:**
E-waste is often recovered and recycled within people’s homes and gardens in small-scale or “micro” environments. Home-based recycling practices are a significant source of e-waste toxicant exposure, but are difficult to quantify as they are often hidden or removed from public visibility (1). Home-based and family-run recycling using informal procedures, such as open cable burning, acid baths, and “cooking” circuit boards, puts children at risk of both injury and exposure in their own home or backyard. Even when children are not directly involved in e-waste recycling work, home-based activities can lead to inhalation of toxic airborne particles and fumes, ingestion of contaminated dusts, soil, food and water at home and direct skin exposure to corrosive agents and burns. Home-based recycling practices have been linked to high blood lead levels in children (2).

Parents who engage in e-waste recycling work outside the home (especially work that involves acid baths and open burning) may bring lead-contaminated dusts home on clothing, shoes and other items. This can increase children’s exposure to lead (3).

**References:**
Photo:

- © Xia Huo. A child sits in a chair, China. Behind the child we can see e-waste recycling activities occurring.
Pollution in the surrounding environments:
Regardless of their own occupations or parents’ occupations, children who live, play or go to school near recycling sites can be exposed to e-waste hazards through environment contamination. Rudimentary recycling techniques, coupled with the sheer amount of e-waste processed, result in environmental contamination of the air, soil, dust, food and water. This contamination can travel significant distances from recycling sites and may expose children while they are engaging in other activities, including school, sports or general play. Children spend more time playing outdoors than adults, sometimes playing in landfills, making them particularly vulnerable to environmental contamination. Some environmental pollutants produced through informal e-waste recycling activities can travel significant distances, exposing children and pregnant women in neighbouring communities and cities (1).

References:

Photo:
• © WHO/ Blink Media- Tali Kimelman. A woman stands in front of her home, which is located opposite from the main garbage dump in Montevideo, Uruguay. Burning of e-waste items is known to occur here
The third section of this module discusses the mechanisms of action and possible child health effects associated with e-waste exposure.

Photo:
• © Kwadwo Ansong Asante. A man carries various e-waste items, Agbogbloshie, Accra, Ghana.
Mechanisms by which the toxic components found in e-waste, and which result from recycling activities, have been the subject of a small amount of toxicological research. Three mechanisms of action have been suggested, however while these mechanisms have been studied in other contexts, greater research is needed at e-waste sites. These mechanisms are briefly described below.

- **DNA damage** may play a role in the development of cancerous tumours (1). A small number of studies at e-waste sites have found increased micronuclei frequency associated with e-waste recycling activities and exposure. Increased micronuclei frequency may suggest cell death, cell proliferation and chromosome changes, which can be used as a reliable indicator of DNA damage (2). E-waste studies have found suggestive links between indicators of DNA damage and some heavy metals, including lead, cadmium, chromium and nickel (3).

- **Gene expression** may be altered by organic chemicals and heavy metals found at e-waste sites. However, very little research has been conducted in this context. Cadmium may be linked to altered gene expression in neonates and e-waste exposure may be associated with changes in spermatozoa in men. More research is needed before any conclusions can be drawn (3).

- **Oxidative stress** occurs when there is an imbalance of free radicals and antioxidant defences. Oxidative stress is associated with chronic diseases later in life and may be linked to the development of some childhood diseases (4). Studies have found elevated levels of oxidative stress in children and adults at e-waste recycling sites linked to organophosphate flame retardants, plasticizers, polyaromatic hydrocarbons (PAHs), and some bisphenols (3).

References:


Photo:
• © Jutta Gutberlet. E-waste dismantling for recycling and repair at the cooperative Mãos Dados (Holding Hands) in Ribeirão Pires, the interior of São Paulo state, Brazil.
Research on exposure to toxic components of e-waste and associated child health outcomes is growing. Published in 2013, the first systematic review of e-waste and health effects concluded that evidence was suggestive of an association between e-waste exposure and a number of health outcomes (1). An updated systematic review in 2021 supported these findings and identified additional health outcomes that may have possible links to e-waste exposure (2).

E-waste may be linked to the following health effects in children:
- **Adverse neonatal outcomes**, including increased rates of stillbirth and premature birth
- **Neurodevelopment, learning and behaviour outcomes**
- **Reduced lung, respiratory function and asthma**
- **Other health outcomes** include injury, growth, changes to cardiovascular, immune system and thyroid function

However, too few studies have been conducted to draw conclusions on many of these health outcomes.

The majority of studies investigating associations between e-waste exposure and health outcomes have been conducted at recycling sites in China (please see **Success Story 1** for an example of work and an intervention conducted in Guiyu, China). Additionally, although studies investigating e-waste exposure and health effects have grown significantly over the past 10 years, the heterogeneity of study design, diversity of exposure indicators, size of study populations, diversity of health outcomes and lack of long-term studies and research looking at chemical mixtures, mean that a causal relationship between e-waste and any health outcome cannot yet be drawn (3).
The following slides give more detail on the health outcomes that have been studied and their possible links to particular toxicants found in e-waste or produced through recycling activities.

It should be noted that establishing causality between exposure to environmental toxicants, including e-waste, and particular health outcomes is difficult. While our understanding of environmental and health risks has greatly advanced, so too has the complexity of factors that can affect health (4). E-waste recycling activities is one such example of an environmental health risk that has emerged over the past few decades. Pregnant women and children involved in, or exposed to, e-waste recycling activities and toxicants should be examined by a health professional and monitored.

References:

Photo:
• © WHO/ Anna Kari. Kids play on the garbage dump close to their home. Slum area in Tondo, Manila, Philippines.
Studies conducted at e-waste sites in China have found that toxicants, including heavy metals and organic chemical compounds, released through recycling activities may be linked to a number of adverse neonatal outcomes. For example, maternal exposures to:

- lead released through e-waste recycling practices may be linked to increased rates of stillbirth, premature birth, lower birth weight and lower APGAR scores (1);
- cadmium may be associated with a reduction in neonatal weight and length (2);
- polychlorinated biphenyls (PCBs) may negatively affect neonatal height and weight, APGAR scores, gestational age and body mass index (BMI) (3); and
- polybrominated diphenyl ethers (PBDEs) maybe associated with smaller head circumference at birth, reduced BMI and APGAR scores (4).

However, studies completed at e-waste sites in China investigating neonatal outcomes have not been consistent. This may be due to the complex mixture of metals and organic chemical compounds that individuals are exposed to at one time at e-waste sites. This makes it difficult to distinguish the health effects of a single chemical and more studies are needed on the effects of chemical mixtures and neonatal health outcomes at e-waste sites (5). However, all the chemicals listed above have been studied in other contexts where evidence has found strong associations between adverse neonatal outcomes and the individual chemicals (5).

**Note:** APGAR stands for appearance, pulse, grimace, activity, respiration. It is used to evaluate the health of a newborn soon after birth and determine whether additional care is required (6).
References:

Photo:
• © WHO/ Malin Bring. Baby being weighed on a scale in a doctor’s office, Romania.
Neurodevelopment, learning and behaviour outcomes

E-waste contains a number of recognized neurotoxicants including lead.

Studies at e-waste sites have found associations between lead and:

- reduced neonatal behavioural neurological assessment scores
- changes in child temperament and behaviour
- reduced cognitive and language scores

Findings supported by a large body of research on lead exposure

There is no safe level of lead exposure

E-waste contains a number of recognized neurotoxicants. Lead and cadmium are two of the known or suspected neurotoxicants that are found in e-waste or are produced via informal e-waste recycling activities. They may cross the placenta and have been detected in breast milk (1).

Studies at e-waste recycling sites in China have found associations between elevated blood lead levels and significantly reduced neonatal behavioural and neurological assessment scores, increased rates of attention deficit/ hyperactivity disorder (ADHD), behavioural problems, changes in child temperament, sensory integration difficulties, and reduced cognitive and language scores (2). One study of kindergarten children in China has also suggested an association between cadmium, lead and manganese and behavioural problems (3). Other studies conducted at e-waste sites have not replicated these findings, however children who live in close proximity to e-waste recycling sites have consistently shown significantly higher blood lead levels when compared to a control group (1,4). There is also a large body of research on lead exposure in other settings that supports these findings (1).

There is no level of exposure to lead that is known to be without harmful effects (5).

A number of other known or suspected neurotoxicants are found at e-waste recycling sites including mercury, polyaromatic hydrocarbons (PAHs), polycyclic biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and dioxins and furans. While e-waste sites have displayed elevated levels of all these neurotoxicants, they are yet to be studied for neurotoxicity in children in this context (1,4).

Note: for more information see the modules on Children and neurodevelopmental behavioural
intellectual disorders (NDBID), Lead and Mercury.

References:
The respiratory system is particularly vulnerable to damage from environmental pollutants during gestation, childhood and adolescence (1). Many e-waste recycling sites around the world are characterized by highly contaminated air pollution that is produced through open burning and heating and “cooking” practices. These practices release toxicants, including lead, polyaromatic hydrocarbons (PAHs), polycyclic biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and dioxins and furans, in the form of fine particulate matter (PM$_{2.5}$) into the environment (2).

Exposure to air pollution at e-waste recycling sites has been linked to reduced lung function in children aged 5–9 years, including decreased forced vital capacity and forced expiratory volume in 1 second (3,4). Suggestive evidence has found a link between chromium in e-waste and increased levels of cough (4). Manganese in e-waste may increase wheeze in preschool aged children (4). Elevated blood lead levels (more than 5 micrograms per deciliter) in children at e-waste recycling sites may be associated with an increased risk of asthma (4). Exposure to PM$_{2.5}$ from e-waste recycling may weaken airway antimicrobial activity in preschool children and consequently increase vulnerability to respiratory infections (5).

Some pollutants in e-waste or produced through e-waste recycling activities are found in household and ambient air pollution from other sources. Air pollution has been linked to many health effects in children including respiratory infections, asthma development and exacerbation and reduced lung function (6).

**Note:** for more information see Ambient air pollution and Childhood respiratory diseases linked to the environment modules.
Note: if you have a regional or context specific photo of an informal e-waste site displaying air pollution, it could be used here.

References:

Photo:
• © Kwadwo Ansong Asante. Smoke rises from e-waste burning, Agbogbloshie, Accra, Ghana. This photo shows boys and men involved in e-waste burning and several young girls observing and selling items.
Research conducted at e-waste recycling sites has investigated numerous other health outcomes. Adult workers in Ghana, Nigeria and Thailand have reported high rates of insomnia, weakness, muscle atrophy, headaches, cough, chest pain, dizziness and occupational injuries such as cuts, burns and fractures (1-3).

Studies on e-waste exposure and childhood growth parameters, including weight and height, have reported mixed results. Manganese, nickel, lead and polyaromatic hydrocarbons (PAHs), from e-waste recycling activities may be linked to reduced growth, whereas chromium exposure may be associated with increased height and weight. Results may be sex-dependent (4).

Cardiovascular function may be impacted by e-waste recycling activities. Air pollution at e-waste sites has been associated with increased heart rate and norepinephrine in preschool children (5). PAHs and lead exposure from e-waste have also been associated with changes to vascular endothelial inflammation and blood pressure in children (6). Changes to cardiovascular health in childhood may have life-long health impacts.

A small number of studies have investigated the impact of e-waste exposure on children’s immune system. A consistent link has been investigated between lead exposure from e-waste and decreased immune function (4). Other studies have suggested that exposure to heavy metals in e-waste may reduce the development of immunity to infectious diseases, including after vaccination. However, these findings need to be carefully considered as most metals stimulate the immune system (4,7).

Studies on thyroid function and e-waste exposure have been inconsistent. Some studies have found
elevated thyroid stimulating hormone associated with e-waste toxicants, while other studies have identified reduced thyroid stimulating hormone, and some found no significant change at all (4). More research is needed to identify the effects that e-waste may have on thyroid function.

Additional studies have found associations between e-waste exposure and hearing loss, olfactory memory, rapid onset of blood coagulation, sperm quality and male reproductive disorders, changes to liver function and fasting blood glucose. Too few studies on these health outcomes have been completed to draw any conclusions (4,8).

References:

Photo:
• © WHO/ Until Chan. A doctor examines the cardiovascular system of a newborn, China (Hong Kong).
The fourth section of this module discusses management and prevention of e-waste and associated recycling activities. This includes the role of health professionals and actions that can be taken at local, national and international levels.

Photo:
• © Kwadwo Ansong Asante. A man carries various e-waste items, Agbogbloshie, Accra, Ghana.
Health care professionals have a critical role to play in maintaining and stimulating change that will protect children’s environmental health from harmful e-waste recycling activities. Understanding and staying up-to-date on health and diseases associated with e-waste recycling activities will allow us to create spaces that keep children safe and healthy. Health care professionals must look for ways in professional, political and personal lives to support environmental health and sustainable development.

At the one-to-one patient level, we can take an environmental history at each visit, include environmental etiologies in our differential diagnoses, and add environmental considerations to our preventive advice. We can be dissatisfied with the diagnosis of “idiopathic” and look hard for potential environmental causes of disease and disability. We can stay informed about the specific environmental conditions and risks, including e-waste, in our local and regional areas to help us prioritize our activities.

We can identify and publish sentinel cases and develop and write up community-based interventions to detail and share the successes and challenges in e-waste contexts.

We can educate our patients and their families by including environmental protections in our anticipatory guidance during each visit. We can do formal presentations, continue education programs, complete e-learning, and publish case studies on children’s health and e-waste, to share with colleagues and professional students.

We can become vigorous advocates for the environmental health of our children and future
generations. It is not enough to be an informed citizen, we need to write letters and articles, testify at hearings and approach our elected officials with educational and positive messages, avoiding "scare" and "alarmism", but providing evidence for action and clear proposals for remedial and preventive activities.

And we can recognize that as professionals, with an understanding of both health and the environment, we are powerful role models. Our choices will be noticed: they should be thoughtful and sustainable.

Health care professionals and clinics can practice good examples to reduce e-waste and related exposures by:
• ensuring electronic and electric equipment used in clinics (for example, computers and telephones) is appropriately recycled once it reaches end-of-life
• ensuring that guidelines and facilities are available for the proper management of decommissioned electronic medical devices in order to reduce waste and minimize the risk of harmful exposure of personnel, the public and the environment
• repairing equipment rather than purchasing new items, wherever possible
• educating and training staff on the current and local disposal mechanisms of medical e-waste
• developing health care facility e-waste registers (1).

Note: if you have an appropriate local photo of a health worker, you can use it here.

References:

Photo:
• © WHO/ Blink Media – Tali Kimelman. This photo was taken at the Unidad Pediátrica Ambiental (UPA) in Montevideo, Uruguay. Dr Maria Moll is examining a 10-year-old child who has high blood lead levels from playing with metals, especially by putting them in his mouth, from his family’s metal recycling business.
Health professionals are trusted and respected members of communities and this places them in unique positions in identifying e-waste issues and suggesting solutions. During routine community and clinic visits health professionals can:

- **Identify e-waste issues in communities and neighbourhoods.** Identifying localized e-waste issues can play an important part in identifying particular environmental hazards facing children and prescribing useful solutions (1);
- **Educate communities on e-waste-related health issues.** Awareness of health issues linked to e-waste recycling is low among many communities (1);
- **Discuss with communities the e-waste issues in their community and possible actions that can be taken to reduce children’s exposure.** For many people, families and communities involved in e-waste recycling, these activities constitute an important source of income and ceasing these activities may not be a viable option. Health professionals can work with families and communities to find alternative solutions to reduce and prevent children’s hazardous exposures. Solutions should be tailored to the e-waste issues and activities in a particular context (1);
- **Ask questions during clinical and community visits.** The next slide identifies some example questions that can be asked. These questions should be tailored to the patient’s particular context (1);
- **Take a paediatric environmental history at every clinic or community visit.** Basic questions about a child’s environmental exposures can help identify sources of toxicants and reduce and prevent these exposures. A paediatric environmental history can also be used retrospectively when assessing possible causes of disease (2).
The next two slides have more detail on example questions that health professionals can ask and actions that can be suggested to reduce children’s exposure to e-waste toxicants.

**Note:** if you have examples of actions that have been taken in your context or region they can be used here.

**References:**


Key questions: That health professionals can ask

- Do you know of any pollution problems in your neighbourhood?
- Do you know if cables or other materials are burned nearby?
- Does anyone recycle electrical or electronic devices in your home or surrounding neighbourhood?
- Do you know if anyone in your household or neighbourhood has elevated blood lead levels?

Health professionals can ask their patients and families key questions that can help in detecting and identifying health disorders associated with e-waste exposures. Examples of questions that can be asked include:

- Do you know of any pollution problems in your neighbourhood?
- Do you know if any cables or other materials are burned nearby?
- Does anyone recycle electrical or electronic devices in your home or surroundings?
- Do you know if anyone in your household or neighbourhood has elevated blood lead levels?

Detecting toxic exposures in the parents’ work environment or in children’s homes or neighbourhoods may also support diagnosis and treatment of disease. Adapt these questions to the specific context of each patient and include the answers in an environmental history (1,2).

Note: If you have examples of questions that have been useful in your context or region they can be used here.

References:
There are suggestions that health professionals can make to children, their families and communities to reduce children’s exposure to dangerous toxicants in e-waste. Adapt these actions to the specific context of each patient.

Some examples include (1,2):

- **removing work clothes and shoes before entering the home.** This can help to reduce take-home exposures from e-waste recycling that may be carried on clothing and shoes;
- **if possible, wash clothes that have been used for e-waste recycling work separately from other clothes and other household members’ clothes.** This can help reduce and prevent transferral of toxicants from work clothing to other clothing, or other household members’ clothing;
- **if working indoors, keep the room well-ventilated by opening windows and doors.** Well-ventilated rooms help to reduce the amount of dust and polluted air from e-waste recycling activities;
- **remove children from e-waste recycling work wherever possible.** While this may be difficult for some families due to financial constraints, it is important that children and their families and caregivers understand the risks associated with informal e-waste recycling work and the benefits of reducing and eliminating child labour in e-waste recycling;
- **maintain good hygiene – always wash hands, face and other body parts that contact e-waste and recycling residue with soap and water.** This can help prevent the ingestion and transferal of e-waste toxicants. If possible, washing after completing work and before entering residential areas should be encouraged;
- **do not recycle e-waste at home wherever possible.** Home-based recycling activities are important sources of exposure to e-waste toxicants in children. Reducing and eliminating these activities in
the home and communal areas can significantly reduce a child’s daily exposure. Some contaminants produced through e-waste recycling activities can remain in the environment if further action is not taken, such as lead in dust and soil. Additional measures, such as indoor and outdoor remediation, may need to be taken to clean-up home and community environments; and

- **keep children away from e-waste recycling activities and sites.** It may be impossible to eliminate e-waste recycling activities in the home or community, however it is important to keep children away from these activities, and the sites where they occur, as much as possible.

**Note:** if you have examples of successful actions that have been suggested or used in your context or region they can be mentioned here.

**References:**
Management and prevention: local

Communities can work together to help manage and prevent local e-waste exposure by:

- **creating a designated space or area for these activities.** Ensure the designated area has adequate hygiene facilities and is not located close to residential areas, schools, playgrounds, sports facilities, water and food sources (1);
- **organizing designated e-waste collection days.** Some local councils and private companies can organize e-waste collection days by request (2);
- **organizing community-based education sessions on the dangers of e-waste and ways to reduce exposure.** Ensure that education sessions are tailored to context-specific needs (2);
- **organizing e-waste repair workshops and encourage the 3Rs – Reduce, Reuse, Repair.** Electrical and electronic items can often be repaired if they have small or minor faults (2); and
- **lobbying your local government to create e-waste collection points and facilitate safer recycling activities.** Central and easily accessible e-waste collection points can help create safer disposal of e-waste. Low-cost technologies, equipment and tools exist to make e-waste recycling safer for workers and the community. See Case Study 2 – Ghana for an example of a safer recycling initiative (2).

**Note:** if you have examples of successful activities to reduced e-waste exposure that have been developed or used in your context or region they can be mentioned here.

**References:**
1. Work improvement for safe home: action manual for improving safety and health of e-waste
workers. New Delhi: International Labour Organization; 2019
accessed 6 September 2022).

Children and adolescents are future consumers of electrical and electronic devices and need to be empowered and informed on the dangers that e-waste can pose to their community, and to communities across the world.

Children and adolescents can be powerful advocates for change. The above infographic gives some ideas for how children and adolescents can take action to reduce e-waste and “become e-waste community champions.” Children and adolescent can get involved by:

- creating a local e-waste recycling network and collection days
- inviting the community to participate
- organizing educational sessions to learn about the dangers of e-waste
- petitioning local government for designated e-waste collection points
- organizing e-waste repair workshops
- asking schools to run session on the dangers of e-waste and ways to prevent it.

Figure:
At the national level, governmental action is vital to reduce exposure to e-waste. National governments can take many actions to help protect their citizens from e-waste exposures. Governments can:

- **Adopt and enforce high-level agreements, such as the Basel Convention.** A number of regional and international conventions exist that aim to ensure the sound management of waste from cradle to grave, including e-waste. The Basel Convention also aims to limit and control the illegal movement of e-waste between countries. E-waste is covered under several conventions due to its many toxic components (the next slide discusses these conventions in greater detail); and

- **Develop and implement national e-waste management legislation that protects health.** In 2019, 71% of the global population was covered by some form of national e-waste legislation. However, in many cases this legislation is incomplete or poorly enforced. National e-waste legislation can help to identify e-waste streams, establish collection and management facilities and provide safe and healthy methods of e-waste recycling;

- **Incorporate health protection measures into national legislation.** Furthermore, systems to evaluate the harms and benefits to health of policy choices need to be embedded into policies and interventions from their inception;

- **Monitor e-waste sites and surrounding communities.** This includes monitoring and testing e-waste sites and surrounding communities for air, water, dust and soil contamination. Workers and communities should be informed of the monitoring results, with the protection of children and pregnant women of the highest priority; and

- **Eliminate child labour.** Children who work are not always considered child labourers. Child labour is defined as work that deprives a child of their childhood, their potential and dignity, and that is harmful to a child’s physical and mental development. As e-waste contains a range of toxic
chemicals and metals, children who work with e-waste may be exposed to hazardous materials that is detrimental to their health, and e-waste recycling is therefore considered child labour (1).  

**Note:** if you have examples of national policies, regulations or measures to reduced e-waste exposure that have been developed or used in your country they can be mentioned here.

**References:**
Various international commitments exist to control the transboundary movements of e-waste and reduce hazardous substances that can be found in e-waste.

- **Basel Convention** controls the transboundary movement of hazardous wastes and their disposal. It is a comprehensive environmental agreement in relation to tackling the issues surrounding e-waste and its management. In 2023, the Basel Convention had 190 parties, and 14 Basel Convention Regional and Coordinating Centres have been established for capacity building and technology transfer. In 2019, the Ban Amendment to the Basel Convention entered into force. It prohibits the movement of hazardous wastes from countries of the Organisation for Economic Co-operation and Development (OECD), the European Commission countries and Liechtenstein to other States that are party to the Basel Convention.

- **Stockholm Convention on Persistent Organic Pollutants (POPs)** requires parties to eliminate production, and restrict import and export, of POPs. As of 2023, there are 186 parties to the Stockholm Convention and it eliminates, restricts or requires the reduction where possible, of the use of 35 different POPs.

- **The Minamata Convention on Mercury** is a global treaty to protect human health and the environment from the adverse effects of mercury. It was agreed at the fifth session of the Intergovernmental Negotiating Committee on mercury in Geneva, Switzerland in January 2013, and adopted later that year in October 2013 at a Diplomatic Conference (Conference of Plenipotentiaries), held in Kumamoto, Japan. As of 2023, there are 139 parties to the Minamata Convention.

Two regional conventions exist that aim to curb the import of hazardous substances, including e-waste.
and its components.

- **The Bamako Convention** is a treaty of African nations prohibiting the import into Africa of hazardous waste, including radioactive waste. The Bamako Convention was a response to the difficulties that the Basel Convention faced in prohibiting hazardous trade to low- and middle-income countries (LMICs). The Bamako Convention also aims to ensure wastes are disposed of in an environmentally sound manner, promote cleaner production and establish the precautionary principle. The Bamako Convention was adopted in 1991 and in 2023 has 25 parties (4).

- **The Waigani Convention** is modelled on the Basel Convention and bans the importation of hazardous and radioactive wastes into the 16 members of the Pacific Island Forum. It also aims to control the transboundary movement and management of hazardous wastes within the South Pacific region. The Waigani Convention was adopted in 1995 and entered into force in 2001. As of 2023, there are 12 parties to the Waigani Convention (5).

The World Health Assembly (WHA) has developed resolutions that are relevant to e-waste. The WHA, convened in 2010, approved resolution **WHA63.25 - improvement of health through safe and environmentally sound waste management.** This resolution urged Member States to assess health aspects of waste management and supports greater awareness, improved cooperation and increased capacity in e-waste management (6). Resolution **WHA69.4 - the role of the health sector in the strategic approach to international chemicals management towards the 2020 goal and beyond** is also relevant. It aims to achieve the sound management of chemicals throughout their life cycle so that chemicals are used and produced in ways that lead to minimization of significant adverse effects on human health and the environment (7).

References:
A number of international initiatives and programmes exist to aid in the management of international e-waste flows and prevent hazardous exposures.

- **World Health Organization’s (WHO) Initiative on E-waste and Child Health** was launched in 2013, following the Geneva Declaration on E-waste and Children’s Health (1). The WHO Initiative is contributing to other international e-waste programmes and is running pilot projects in countries in Latin America and Africa. These pilot projects are developing frameworks to protect children’s health from e-waste exposures that can be adapted and replicated in other countries and settings. The WHO Initiative aims to:
  - Increase access to evidence, knowledge and awareness of the health impacts of e-waste
  - Improve health sector capacity to manage and prevent risks, track progress and promote e-waste policies that better protect child health
  - Improve monitoring of exposure to e-waste and the facilitation of interventions that protect public health, especially the health of the most vulnerable (2).

- **The E-waste Coalition** is a joint collaboration of 10 United Nations (UN) agencies and other international organizations. The Coalition aims to raise awareness, increase knowledge, provide integrated support to countries in preventing, reducing, collecting, recycling and disposing of e-waste sustainably and support the development of a circular economy (3).

- **Solving the E-waste Problem (StEP) Initiative** was launched in 2007. It is a collaboration between UN agencies, the private sector, nongovernmental organizations (NGOs) and governmental agencies. StEP completes scientific assessments and reviews of the situation of e-waste at national levels, conducts research on the entire life-cycle of electrical and electronic items, funds pilot projects on reducing e-waste and seeks to foster safe and sustainable recycling practices (4). StEP
has conducted several country-level reports on the state of e-waste and e-waste recycling management in Africa, Asia and South America.

- **The Global E-waste Statistics Partnership (GESP)** is a collaboration between the International Telecommunication Union (ITU), United Nations University – Sustainable Cycles (UNU-SCYCLE) and the International Solid Waste Association (ISWA). GESP aims to monitor e-waste flows and assist countries in producing reliable e-waste statistics. GESP produces the global e-waste monitor every four years and has produced several regional e-waste monitors (5).

**References:**


The final section of this module success stories from three different e-waste recycling sites around the world.

If you have appropriate regional or local case studies that display e-waste interventions, you can use them here.

Photo:
The town of Guiyu in China is widely considered one of the largest e-waste recycling sites in the world. Made up of thousands of small-scale enterprises and family-run workshops, Guiyu has been recycling e-waste from across the world since the late 1980s. The e-waste recycling industry in Guiyu has attracted large numbers of migrants from across the country and estimates have suggested that as much as 20 million tonnes of e-waste are recycled here every year in thousands of e-waste businesses. Research conducted in Guiyu has suggested that in 2011 as many as 80% of families living in the area are involved in e-waste recycling activities (1).

Informal recycling practices in Guiyu have included manual dismantling, circuit board “cooking” and heating, acid baths and burning of cables and plastics. These activities led to high-levels of environmental contamination in and around Guiyu. For example, research conducted in Guiyu found:

- **elevated lead and cadmium levels** in road dust and soil, including in community areas in Guiyu such as schools and kindergartens (2);
- **high levels of polychlorinated biphenyls (PCBs)** in the air, soil and some food items, such as fish (3);
- **elevated levels of polybrominated diphenyl ethers (PBDEs)** in dust, in particular house dust (4).

Early research completed at Guiyu found high blood lead levels in children. One study, conducted in the early 2000s, found that 82% of children under the age of 6 who participated in the study had blood lead levels over 10 micrograms per decilitre (5).
E-waste recycling workers and residents of Guiyu have reported high incidence of multiple adverse health outcomes in children including:

- breathing problems
- skin damage
- headaches
- nausea
- vertigo
- gastric issues, including ulcers (5,6).

References:


Photo:

- © Xia Huo. A child sits in front of piles of waste items, China.
In the early 2000s, in response to reports of high blood lead levels in children in Guiyu (1), the Government of China introduced new measures and policies aimed at reducing exposure to harmful heavy metals released through e-waste recycling. These measures were implemented at national and community levels.

At the national level, China, imposed stricter import regulations on the movement of transboundary e-waste into the country, which may have led to some reduction in the amount of foreign e-waste arriving at Guiyu (2). Additionally, the Government of China required that all informal, residential e-waste businesses relocate to a designated area where protective measures are in place (3).

At the community level, interventions to reduce children’s blood lead levels were completed in collaboration with researchers working in Guiyu. Initiatives focused on educating workers and residents in Guiyu of the dangers of lead poisoning and methods of preventing or reducing children’s exposure to lead. This was done through in-person educational sessions, posters and pamphlets (4,5).

Following these interventions, research has indicated decreasing trends in children’s average blood lead level at Guiyu. Between 2004 and 2018, research has found a drop in average blood lead level in preschool children in Guiyu from 15.3 micrograms per decilitre to 4.86 micrograms per decilitre. Additionally, studies have suggested that the proportion of children with blood lead levels over 5 micrograms per decilitre has decreased over time. Policy and regulations changing the way e-waste is recycled in China may be partially responsible for these trends. However, further research is needed to confirm these trends and contributing factors (6).

Success story 1: Guiyu, China

- In response to high blood lead levels in children, the Chinese Government introduced new measures and policies
  - Stricter e-waste import regulations
  - Formal e-waste recycling workshops
  - Community education:
    - In-person sessions
    - Posts, pamphlets
    - Methods to prevent lead poisoning

**Average blood lead levels in children in Guiyu have gradually decreased**
References:
Agbogbloshie is located in Accra, the capital city of Ghana. It had been the most famous and well-studied e-waste recycling site in the African Region, and remains the subject of many research articles, documentaries and interventions. Until the eviction of the e-waste recyclers and total ban of recycling activities by city authorities on the site in July 2021, Agbogbloshie had been a major destination for e-waste from Europe, as well as other high-income countries (HiCs) (1). Despite this ban, some residual burning with light smoke hanging in the horizon can still be seen in the area.

A number of different estimates exist, which illustrate the size and complexity of e-waste recycling that was occurring at Agbogbloshie. For example:

- the Basel Convention had estimated that approximately 215,000 tonnes of e-waste was arriving in Ghana annually from other countries (1);
- estimates from 2009 have suggested that Agbogbloshie was home to between 40,000–80,000 people. Other estimates have suggested that as many as 6000 people were working in Agbogbloshie in e-waste recycling in some capacity. Migrants from around the country travelled to Agbobloshie for economic reasons (2). The e-waste recycling and refurbishment sector was estimated to employ as many as 200,000 people across Ghana (2,3).

The main e-waste recycling activities in Agbogbloshie included: scavenging through waste for valuable materials and items for resale; retrieving precious materials through manual dismantling; and open burning practices. Images and footage taken in Agbogbloshie were often characterized by dark plumes of smoke rising over the waste site and neighbouring communities. This can be seen in the photo on the slide. Open burning practices and activities contributed significantly to air pollution in Agbogbloshie (4).
Agbogbloshie also had a lively repair, refurbishment and resale market for electrical and electronic items (2). Research has suggested that the repair and refurbishment work conducted at sites, such as Agbogbloshie, is an important contributing factor in creating affordable technologies for low-income communities in African countries (1). Young men and boys made up the majority of e-waste recycling workers in Agbogbloshie, however women and young girls were found in the area selling water and food to workers (2,5).

Significant environmental pollution has been recorded at Agbogbloshie. For example, the highest ever reported levels of brominated dioxins in chicken eggs were recorded in Agbogbloshie (6). Studies have shown high levels of heavy metal contamination in soils, including elevated levels of lead, copper and zinc (7). Elevated levels of polybrominated diphenyl ethers (PBDEs) have been detected in soils and workers and residents are at risk of high levels of particulate matter (PM), including fine PM, and polycyclic aromatic hydrocarbons (PAHs) in air pollution (4,8).

References:

Photo:
• © WHO/ Abraham Thiga Mwaura. Workers and a drinks vendor watch as e-waste is burnt.
In 2014, the international non-profit organization, Pure Earth, in partnership with Green Advocacy Ghana, established a pilot e-waste recycling facility that aimed to improve basic health and safety conditions. The facility enables workers to safely and efficiently strip and recycle copper and aluminium, without burning the plastic sheathing. The project has gone through multiple adaptations. For example, the original machines used for stripping, while appropriate for large cables, were found to be unsuitable for small wires and cables, and new machines had to be purchased to provide more suitable methods. The photo featured in this slide shows an example of a wire-stripping machine.

The project also trained workers in the use of the machines. The recycling centre is supported by the Government of Ghana, which supported the project with additional training at the facility, as well as delivering training to workers throughout Agbogbloshie (1-3).

Projects aimed at reducing air pollution continue at Agbogbloshie, supported by partnerships including Green Advocacy Ghana, the Government of Ghana and international government agencies. For example, an incentive programme is being implemented to purchase cables, batteries, thermoplastics and cathode-ray tubes from scavengers, which are then sent to a formal recycler for appropriate disposal. This project aims to reduce air pollution from informal e-waste recycling activities while ensuring that workers do not lose their livelihoods (4).

Pure Earth has run additional projects at Agbogbloshie that concentrate on education. These projects have also included community “walk-throughs” with messaging to highlight the dangers of burning e-waste and methods to make e-waste recycling safer, and school and hospital visits with a focus on educating children, parents and healthcare workers of the dangers of lead poisoning (5,6). In 2021, the
United Nations Children’s Fund (UNICEF) announced plans to support the Ghana Health Service in introducing childhood blood lead testing, with a focus on at-risk populations, including children working in or living near waste recycling (7).

References:

Photo:
• © Antonio Pascale. Wire stripping machine at the WEEE Centre in Nairobi, Kenya. Used with copyright permission.
According to the Global E-waste Statistics Partnership (GESP), Uruguay produces one of the highest amounts of e-waste per person in Latin America (1). Informal e-waste recycling sites in Uruguay are largely located in the capital city of Montevideo, where small scale recycling businesses tend to be scattered throughout residential neighbourhoods. Generally, these businesses are found in low socio-economic neighbourhoods (2). Very little research has been conducted in these neighbourhoods. However, cable burning to extract valuable copper is believed to be the most significant e-waste recycling activity and is linked to lead contamination in soil and dust in homes and community areas. Cable burning has been occurring in Montevideo for at least 10 years (3).

One study has found that 1 in 4 instances of high childhood blood lead levels in Uruguay is linked to e-waste recycling activities. Additionally, the youngest children were found to have the highest blood lead levels (3).

References:
Photo:

- © WHO/ Blink Media – Tali Kimelman. The Felipe Cardozo neighbourhood is a settlement located across from the main garbage dump in Montevideo, Uruguay.
In response to reports of high blood lead levels in Uruguayan children, several projects have been undertaken over the past 10 years.

In 2012 the international non-profit organization, Pure Earth, in partnership with the City of Montevideo and local researchers, undertook a Toxic Site Identification Program in Montevideo. This included identifying toxic hotspots in Montevideo as well as training members of the national health department in assessments tools that help to identify contaminated sites, at-risk populations, key pollutant information, human exposure pathway data and sampling data (1,2).

Additionally, researchers conducted outreach visits that included educational sessions for community members in e-waste recycling areas on environmental exposure pathways, such as hygiene, dust removal and nutritional practices. Pure Earth and the City of Montevideo undertook soil remediation - removing lead-contaminated soil and replacing it with clean fill. These measures was associated with both a decrease in soil lead levels and children’s blood lead levels (3,4).

More recently, the Unidad Pediátrica Ambiental (UPA) located at the Claveaux Center for Health, has collaborated with the State Health Services Administration to reduce children’s blood lead levels. The UPA is conducting outreach visits with at-risk communities and families that raise awareness of the dangers of e-waste recycling. During these visits, the UPA is also teaching health professionals to recognize signs of informal e-waste recycling activities and increasing capacity to diagnose and treat illnesses associated with e-waste recycling, in particular illnesses linked to lead exposure in children. At the UPA, doctors are monitoring and treating children with high blood lead levels (5). The photo in this slide shows a visit with one of the UPA’s patients, a 3-year-old child who developed a high blood lead
level after playing with metals found near his house.

References:

Photo:
• © WHO/ Blink Media – Tali Kimelman. A 3-year-old child has blood drawn during a check-up at Unidad Pediátrica Ambiental (UPA) in Montevideo, Uruguay. The child has high levels of lead in his blood from playing with the metals found near his house, which is located in a neighbourhood where e-waste recycling takes place.
For more information on children and e-waste exposures see the additional World Health Organization (WHO) training package on children’s environmental health for the health care sector (1). The following modules may be of particular interest:

- Air pollution package
- Children and chemicals
- Global climate change and child health
- Lead
- Mercury
- Persistent organic pollutants (POPs)

To read more on e-waste and children see the below recommended references:

- Children and digital dumpsites: e-waste exposure and child health (2)
- Health consequences of exposure to e-waste (3), published in 2013 and the updated systematic review published in 2021 (4)
- Prevention-intervention strategies to reduce exposure to e-waste (5).

References:


The World Health Organization (WHO) has developed and collaborated with multiple agencies to create a range of resources that may be useful for further information and spreading awareness on e-waste and child health:

- **WHO e-waste and child health infographic package** is a set of 10 illustrative infographics that highlight issues linked to e-waste and key messages on actions that can be taken. These can be shared and are available in all United Nations (UN) languages (1);
- **The e-waste challenge massive open online course** is a multi-agency collaboration between the Secretariat of the Basel, Rotterdam and Stockholm conventions, EIT Climate-KIC, University of Leuven, EIT RawMaterials Academy, International Telecommunication Union, World Resources Forum and WHO. It consists of 5 mini-courses, of 6–8 hours each. It is online and free for anyone to complete (2);
- **Managing the harmful effects of e-waste in Uruguay** is an article published by WHO in 2021 that discusses the collaborative pilot project underway in the country (3); and
- **UNU-WHO survey on e-waste and its health impact on children** was undertaken and published in 2013 and aimed to identify existing knowledge and key stakeholders working on e-waste and child health (4).

References:
2. UNEP. The e-waste challenge massive open online course. Geneva: Secretariat of the Basel


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