Toxics Link
for a toxics-free world

Report on Endocrine Disrupting Chemicals

Chemical Exposure in Childhood

THE HIDDEN IMPACT OF ENDOCRINE DISRUPTORS

ABOUT TOXICS LINK

Toxics Link is an Indian environmental research and advocacy organisation set up in 1996, engaged in disseminating information to help strengthen the campaign against toxic pollution, provide cleaner alternatives, and bring together groups and people affected by this problem. Toxics Link's Mission Statement "Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world." Toxics Link has unique expertise in areas of hazardous, medical, and municipal wastes, international waste trade, and the emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination, etc. from the environment and public health point of view. We have successfully implemented various best practices and have brought in policy changes in the aforementioned areas apart from creating awareness among several stakeholder groups.

Authors

Lead Author: Tripti Arora, South Asia Regional Coordinator and Gender Coordinator, IPEN

Contributing Author: Senerita Swamy, Programme Officer, Toxics Link

Supervised by: Piyush Mohapatra, Senior Programme Coordinator, Toxics Link

Acknowledgment

We take this opportunity to thank all those who were instrumental in compiling and shaping this report. We would like to thank Mr Ravi Agarwal, Director and Mr Satish Sinha, Associate Director, Toxics Link for their constant support and encouragement for this study. We also extend our gratitude to our fellow colleagues at Toxics Link, for providing support and guidance in finalizing the report.

Toxics Link
for a toxics-free world

CELEBRATING 25 YEARS 1998-2023

H-2, Jangpura Extension
New Delhi - 110014
www.toxicslink.org

Toxics Link
for a toxics-free world

Report on Endocrine Disrupting Chemicals

Chemical Exposure in Childhood

THE HIDDEN IMPACT OF ENDOCRINE DISRUPTORS

Contents

List of Tables

List of Figures

Introduction: Unveiling the Invisible Threat

1.1 The Hidden Danger

CASE STUDIES

Are EDCs Hidden in Baby Feeding Bottles?

Every day, children are unknowingly exposed to harmful chemicals hidden in the products designed for their care and safety. Scientific research has confirmed that endocrine-disrupting chemicals (EDCs) such as Bisphenol A (BPA) can leach from baby feeding bottles and other plastic products, raising serious health concerns. A study conducted in Kenya analysed BPA migration from plastic drinking bottles and baby feeding bottles, finding significant leaching into stored liquids, especially under warm conditions (Kiio et.al., 2019). Similarly, another study conducted in India assessed BPA release from polycarbonate baby bottles (Shrinithivihahshini, et.al., 2014). It found that repeated use and exposure to high temperatures accelerated the chemical's migration into infant formula and liquids (Nuti, et.al., 2024). In 2014, a study by Toxics Link evaluated baby feeding bottles available in the Indian market for Bisphenol A (BPA), a known endocrine-disrupting chemical (EDC) (Toxics Link, 2014). It revealed that 11 out of 14 bottles tested, representing 78.5% of the samples, contained BPA, including those labelled as "**BPA FREE.**" A subsequent study identified BPA in sippy cups, which are also intended for young children (Toxics Link, 2016). Additionally, a global study found BPA in baby feeding and other plastic bottles across eight countries, with 78% of the samples containing either BPA or Bisphenol S (BPS) (Straková, 2022).

11 out of 14 bottles tested, contained BPA, including those labelled as "BPA FREE."

Children (including babies) are exposed to BPA when it leaches from bottles and other containers into beverages and food they consume. BPA and its metabolites have been detected in various bodily fluids, including urine, blood, saliva, umbilical cord blood, placenta, and amniotic fluid. Global data shows that over 90% of the population has BPA present in their bodies (WebMD, 2025). Exposure to BPA in newborns and infants heightens the sensitivity of hormone-sensitive organs to later exposures to estrogens (oestrogen) or chemical carcinogens.

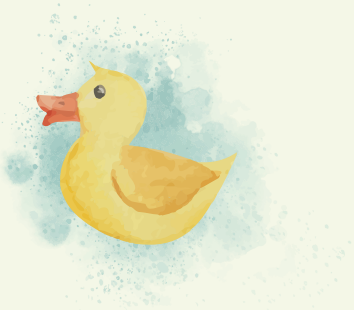
BPA is known for its toxic impacts, particularly on young children and such alarming findings raise concerns and flag an urgent need to have stronger controls on the use of BPA and other EDCs in all children's products.

CASE STUDIES

Are EDCs Hidden in Children's Toys?

In an International Pollutants Elimination Network study (Karlsson and Miller, 2023), 31 plastic toys purchased from ten countries were analysed for chlorinated paraffins. The toys were soft plastic children's toys such as inflatable bouncing toys, rubber ducks, and dolls and were purchased in Benin, Burundi, Cameroon, Democratic Republic of the Congo, India, Malaysia, Mali, Philippines, Uganda, and USA. All tested toys contained both short- and medium-chain chlorinated paraffins (SCCPs and MCCPs), even though SCCPs were banned globally under the Stockholm Convention in 2017.

31 plastic toys purchased from 10 countries contained both SCCPs and MCCPs



1.2 What Are EDCs?

EDCs are defined by the Endocrine Society (Endocrine Society, 2025), as "an exogenous chemical [a chemical from outside the body] or mixture of chemicals that interferes with any aspect of hormone action." There are over 350,000 manufactured chemicals, of which thousands may be EDCs (Gore et.al., 2024). According to World Health Organization's State of the Science 2012 report (IOMC, 2012), over 800 chemicals are known or suspected EDCs. According to a list by TEDX-The Endocrine Disruption Exchange (HEAL, 2019), over 1,400 chemicals have been listed as potential endocrine disruptors. However, no commonly accepted criteria for the identification of EDCs are yet available.

According to Environmental Protection Agency (EPA), EDCs are the "Exogenous agents that interfere with the synthesis, secretion, transport, metabolism, binding action, or elimination of natural blood-borne hormones that are present in the body and are responsible for homeostasis, reproduction and developmental processes

EDCs are substances that can interfere with the hormonal systems of humans and animals. They mimic, block, or otherwise disrupt the normal function of hormones, leading to a range of potential health problems, such as developmental, reproductive, neurological, and immune issues.

EDCs are extraordinarily diverse in their structure and can affect growth, development, and reproduction in diverse ways. They are widely available in many consumer products such as personal care products, household cleaners, food,

plastics etc. They have been linked with many known health implications, especially in women and children across the globe.

EDCs are known to have different impacts on different genders. Women, due to their physiology, biological makeup and social determinates are more exposed and hence more impacted by EDCs. They are also known to cause transgenerational effects, thus impacting many more generations to come.

Due to their ability to disrupt a wide range of hormones, endometriosis, early puberty, altered nervous system function, immune system function, certain cancers, respiratory disorders, metabolic disorders, diabetes, obesity, cardiovascular problems, growth, neurological and learning disabilities, and more have all been linked to adverse human health outcomes caused by EDCs (Rattan et al., 2016).

EDCs are known to cause health problems even at low doses and there may be no safe dose for exposure to EDCs (Diamanti-Kandarakis et.al., 2009; IPCP, 2017). However, regulations typically do not protect against low-dose effects.

Considering these health implications, Strategic Approach to International Chemicals Management (SAICM), now Global Framework on Chemicals (GFC) identifies EDCs as an Emerging Policy Issue (EPI).

There is a growing global concern about EDCs. Efforts have increased over the last three decades on understanding EDCs, and assessing their presence and impacts on environmental and human health. Several countries have also started to regulate certain EDCs in specific products. However, there are still no commonly accepted criteria available for EDCs (IPCP, 2017).

TABLE 1: A FEW EXAMPLES OF ENDOCRINE-DISRUPTING CHEMICALS

Category/Use Example	EDCs
Antibacterials	Triclosan
Biocides	Tributyltin (TBT)
Children's products	Diethyl phthalate (DEP)
Electronics and Building materials	Brominated flame retardants, PCBs, Chlorinated paraffins
Food contact materials	Benzophenones, Bisphenol A
Personal care products	Paraben
Medical tubing	Diethyl phthalate (DEP)
Pesticides	Sulfluramid
Textiles, clothing	Perfluorochemicals, 4-Nonylphenol

Source: Overview Report I: A Compilation of Lists of Chemicals Recognised as Endocrine Disrupting Chemicals (EDCs) or Suggested as Potential EDCs, Prepared by The International Panel on Chemical Pollution (IPCP), 2016.

1.3 Endocrine Disrupting Chemicals and Children

According to the World Health Organization, Children are particularly susceptible to the adverse effects of EDCs due to their developing bodies and organs. Children are exposed to low doses and mixtures of EDCs, which can have different effects depending upon dose and other chemicals present. Exposure during pregnancy and early childhood may impact the health and development of a child for the rest of their life. The exposure to these chemicals during critical periods of development can lead to irreversible health impacts. Given that children are more likely to come into contact with products such as toys, clothing, and personal care products, it is imperative to study the presence and effects of EDCs in these products to safeguard their growth and development. Additionally, behaviours such as frequent hand-to-mouth activity increase their exposure to EDCs present in everyday items.

1.4 Chemical Cocktails: The Hidden Threat

Beyond exposure to individual chemicals, children face a lesser-known risk—the "cocktail effect." This refers to the combined impact of multiple chemicals interacting within the body. While many studies assess specific chemicals in isolation, little is known about how mixtures of chemicals amplify toxicity, particularly in vulnerable populations like children.

> The true chemical burden on our bodies and the environment is unknown, so we have no idea about the full composition of the chemical mixture we are exposed to daily.

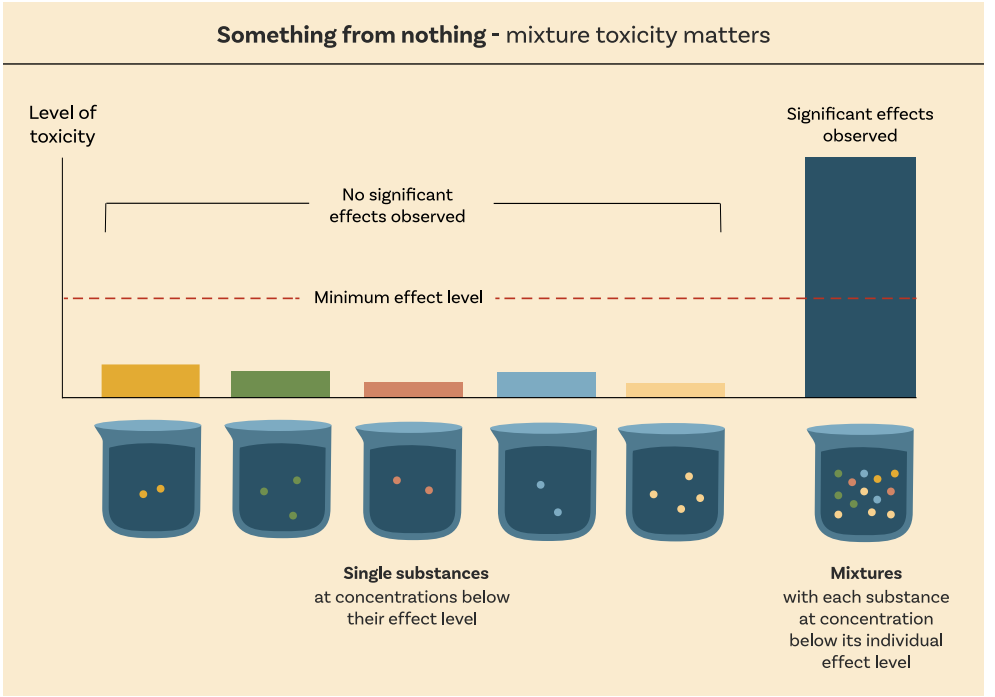
Even low levels of individual chemicals, considered safe by current regulations, can collectively pose significant health risks. We encounter a mixture of chemicals daily through food, water, air, and household products, yet regulatory frameworks primarily assess individual substances, often overlooking these synergistic effects.

A growing body of evidence suggests that chemical mixtures—especially EDCs—can have harmful effects even at concentrations previously deemed insignificant. The **EU Endocrine Disrupter Expert Advisory Group** emphasizes that thresholds of adversity may be extremely low or non-existent, particularly during foetal development and early childhood.

SOMETHING FROM NOTHING

A growing body of evidence indicates that the mixtures of chemicals particularly EDCs can have important adverse effects on health and the environment – even at extremely low concentration when the amount of individual chemicals is considered too small to be of concern.

Figure 1: Something from Nothing



Source: https://chemtrust.org/wp-content/uploads/Chemical-cocktails_CHEMTrust-report_March-2022.pdf

To fully protect children's health, research and regulatory policies must evolve to account for the complexity of chemical interactions. Addressing the cocktail effect is essential to preventing long-term health consequences linked to chemical exposure.

Goals of the Report

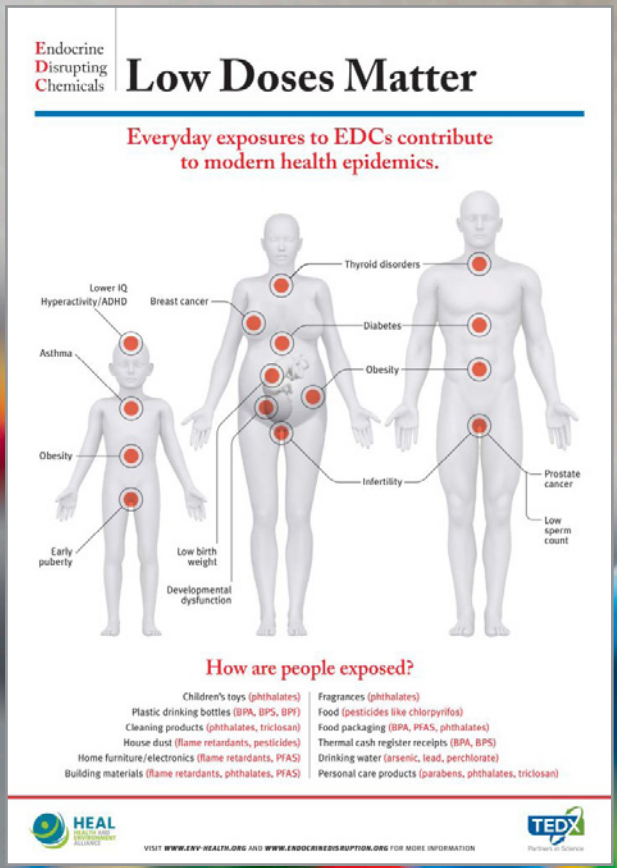
This report aims to:

- **Provide** a comprehensive overview of EDCs and their mechanisms of action.
- **Highlight** the presence of EDCs in various children's products.
- **Discuss** the potential health impacts of EDC exposure on children.
- **Review** current regulations and policies addressing EDCs in children's products.
- **Propose** policy and consumer-oriented recommendations to mitigate risks.

Understanding EDCs

EDCs are exogenous agents that interfere with normal endocrine physiology by affecting hormone synthesis, metabolism, and cellular actions. Infants and children differ significantly from adults in terms of physiology, anatomy, pharmacokinetics, diet, and behaviour, which can influence their response to EDCs.

EDCs can mimic natural hormones like estrogen and testosterone, bind to hormone receptors, and disrupt normal hormonal functions. This can lead to abnormal growth, reproductive issues, and increased susceptibility to certain diseases



The endocrine system is intricate and multifaceted, with each gland and hormone contributing uniquely to overall health and well-being. Additionally, it serves as a key interface between the body and the environment, facilitating development, adaptation, and the regulation of bodily processes essential for maintaining health. EDCs as the name suggests target the Endocrine system and thus affect human bodily functions.

In case of EDCs, the dose makes the poison statement doesn't stand true. Thus, the body's response to various doses of EDCs is often non-linear. Both U-shaped and inverted U-shaped dose response curves may be observed for EDCs. In other words, low doses may exert stronger effect than higher doses. Several studies observed **"low dose effects"** for a variety of endpoints including brain development, sexually dimorphic behaviours, prostate weight, spermatogenesis, hormone levels, bone health, and metabolic endpoints among others (Vandenberg, 2012).

EDCs, like hormones, do not obey "the dose makes the poison."

2.1 Health Impacts of EDCs

Recent research highlights both progress and gaps in understanding the health effects of EDCs. While their influence on human health is evident, complexities such as interactions with other chemicals, age sensitivity, and long-term effects require further study. Key health impacts include:

Neurodevelopmental Issues: EDC exposure, particularly through thyroid hormone interference, has been linked to cognitive deficits, behavioural disorders (ADHD, autism), and impaired brain development.

Hormone-Related Cancers: Rising cases of breast, prostate, and thyroid cancers suggest potential links to EDCs, though further research is needed.

Metabolic Disorders: Evidence suggests a connection between EDCs and obesity, diabetes, and disrupted lipid metabolism.

Immune System Disruptions: Some EDCs may weaken immune responses, increasing vulnerability to infections and autoimmune diseases.

Children's Vulnerability: Developing endocrine systems, higher metabolic rates, and behaviours like hand-to-mouth activity heighten children's exposure risks.

According to the Pure Earth report (2022), 275 million children in India are at risk of elevated BLLs, with devastating consequences for cognitive and neurological development. Lead exposure can impair IQ, reduce academic performance, and increase the likelihood of behavioural disorders.

Table 2: Impacts and Sources of EDCs

Chemical	Human Health Impacts	Gendered Impacts	Children's Health Impacts	Common Sources	Reference
BPA	Infertility, Endocrine Disruption, Obesity, Diabetes, Cardiovascular disorders, Neurological disorders, immune system disorders	Reduced testosterone, lower sperm concentration, prostate and breast cancer, altered mammary gland development, polycystic ovary syndrome (PCOS), and other hormonal disorders	Altered neurodevelopment, obesity, early puberty, ADHD, hyperactivity, anxiety and other behavioural disorders	Baby feeding bottles, food packaging material, food containers, water bottles, epoxy resins in food cans, bottle tops, water pipes, thermal receipts, dental sealants	Pérez-Bermejo et al. (2021); Manzoor et al (2022); Rochester (2013)
Phthalates	Cardiovascularar diseases, endocrine disruption, thyroid disorders, respiratory issues, diabetes, obesity, Liver/kidney/lung damage, Cancer, Neuro-developmental issues, Increased allergic symptoms, Metabolic disorders	Reduced sperm motility and concentration; premature puberty in women, Altered reproductive development & male fertility issues, pregnancy complications including pre-term birth	Asthma, allergies, bronchial issues, developmental delays, Attention-deficit/hyperactivity disorder (ADHD), Autistic behaviours, Lower cognitive and motor development	PVC products (toys, medical devices, building materials), personal care products (shampoos, lotions, fragrances), food packaging, water bottles, medications, diapers, sanitary napkins	Meeker et al. (2009); Radke et al. (2020); Hlisníková et al. (2020); Almeida-Toledano (2024)
Pesticides	Acute effects: eye irritation, rashes, nausea, dizziness, long-term effects: birth defects, cancers, diabetes, respiratory issues, neurological impairment, and immune system disease	Reproductive disorders; infertility, premature ovarian insufficiency (POI), and polycystic ovary syndrome (PCOS), Disrupted menstrual cycle, increased risk of miscarriage, Cancers, Prostate cancer and sperm damage (DNA)	Birth defects, learning disabilities, organ damage, asthma, attention-deficit hyperactivity disorder (ADHD), autism, and abnormal behaviours, childhood cancers, including brain tumours and acute lymphocytic leukaemia	Agricultural products, household pesticides, garden treatments, contaminated food and water	Mostafalou & Abdollahi (2017). Kim et al. (2017) Gore et al. (2015)

Chemical	Human Health Impacts	Gendered Impacts	Children's Health Impacts	Common Sources	Reference
PCBs	Skin conditions, respiratory issues, gastrointestinal discomfort, liver dysfunction, cancer, immune system toxicity, diabetes, thyroid hormone toxicity, nervous system and cardiovascular system disorders	Reproductive toxicity, menstrual disorders, semen quality, motility, and thyroid hormones imbalance	Lower IQ, abnormal reflexes, cognitive deficits, short-term memory, attention, and motor skills, developmental delays, immune system disorders, thyroid hormone imbalance	Transformers, capacitors, electrical equipment, old electrical devices, fluorescent light ballasts, cable insulation, thermal insulation, adhesives, oil-based paint, contaminated food such as dairy products, eggs, meat, fish and water	Faroon et al. (2003) EPA (2024); ATSDR (2000)
BFRs	Endocrine disruption, obesity, thyroid dysfunction, pulmonary ventilation dysfunction, liver toxicity, kidney toxicity, neurotoxicity, reproductive toxicity, carcinogenicity	Reduced fertility in women, breast cancer, early mammary gland development, changes in male reproductive development	Lower IQ, developmental issues, behavioural disorders, obesity	Air, soil, water, electronic appliances, toys, fabric products, plastics, computer casings, circuit boards, textiles, consumer products, contaminated food such as fish and fish products.	Mao et al. (2024) McDermott et al. (2025) Lyche et al. (2015); Fiore et al. (2015)
PFAS	Reduced immune response, hormonal interference, asthma, increased cholesterol, obesity, diabetes, neurodevelopment effects, cardiovascular disorders, thyroid disorders, liver damage	Disrupt hormones such as estrogen and testosterone. Infertility, increased blood pressure in pregnant women, Increased risk of some cancers, including prostate, kidney, and testicular cancers.	Developmental delays, low birth weight, accelerated puberty, bone variations, behavioural changes, autism	Drinking water, soil at waste sites, fire extinguishing foams, manufacturing facilities, contaminated food, food packaging, personal care products, household cleaners, cosmetics, non-stick cookware, clothing, insecticides, electronics	Mišľanová & Valachovičová, (2025); EPA (2023)

Chemical	Human Health Impacts	Gendered Impacts	Children's Health Impacts	Common Sources	Reference
Parabens	Neurotoxicant, Cancer, thyroid disruption	Reproductive disorders such as early puberty, infertility, breast cancer, abnormal cyclicity, premature ovarian failure/menopause, endometriosis, fibroids, and adverse pregnancy outcomes. Lowers testosterone levels in men, decreases sperm count	Disrupts growth, leads to lower birth weight, decreased body length, preterm birth, and increased social, learning, and memory problems	Personal care products such as shampoos, handwash, wipes, perfumes; cosmetics such as lipsticks, mascara, pharmaceutical, wastewater, indoor dust and air, outdoor air and soil	Azeredo et al. (2023); Pulcastro & Ziv-Gal et al. 2024; Boberg et al. (2010)
Lead	Cardivascular problems, kidney damage, seizures, neurological issues, anaemia, increased blood pressure	Decreased sperm count, increases abnormal sperm frequencies, reproductive disorders, miscarriage, stillbirth, premature birth and low birth weight	Brain and nervous system damage causing learning, behavioural, hearing, and speech problems, reduced IQ, hyperactivity, permanent intellectual disability	Lead in paints, toys, furniture, coatings of certain cookware, drinking water through contaminated pipes, contaminated soil, spices, certain cosmetics such as Kohl, sindoor, some imported goods	WHO (2024); Kumar et al. 2018; WHO (2024a); Lanphear et al. (2018); ATSDR (2020)
Arsenic	Skin lesions, skin, Lung, Bladder and kidney cancer, cardiovascular disease, neurodegeneration, and diabetes	Reproductive disorders including decreased sperm count and motility, altered sex hormones, and damage to the testis or ovaries, preterm birth and stillbirth, endometrial cancer, disrupted menstrual cycle, miscarriage, pregnancy losses	Development delays, Impaired learning, intelligence, memory, increased risk of infections, growth problems in male infants, respiratory disorders and skin cancers	Drinking water, meat, fish, and poultry, pesticides and industrial processes such as smelting and electronic processing.	Smith et al. (2017); WHO (2024b); Hu et al. 2024

2.2 Women's Exposure to EDCs: A Pathway to Child Health Risks

Endocrine-disrupting chemicals (EDCs) have profound health impacts across genders, with women being particularly vulnerable due to their hormonal biology and social roles. Women's heightened sensitivity to EDCs arises from hormonal fluctuations during menstruation, pregnancy, and menopause, making them susceptible to reproductive health issues such as infertility, polycystic ovary syndrome (PCOS), endometriosis, and hormone-related cancers like breast and ovarian cancer. EDC exposure during pregnancy is especially concerning, as it can disrupt foetal development, increasing the risk of birth defects, developmental disorders, and long-term health issues in children.

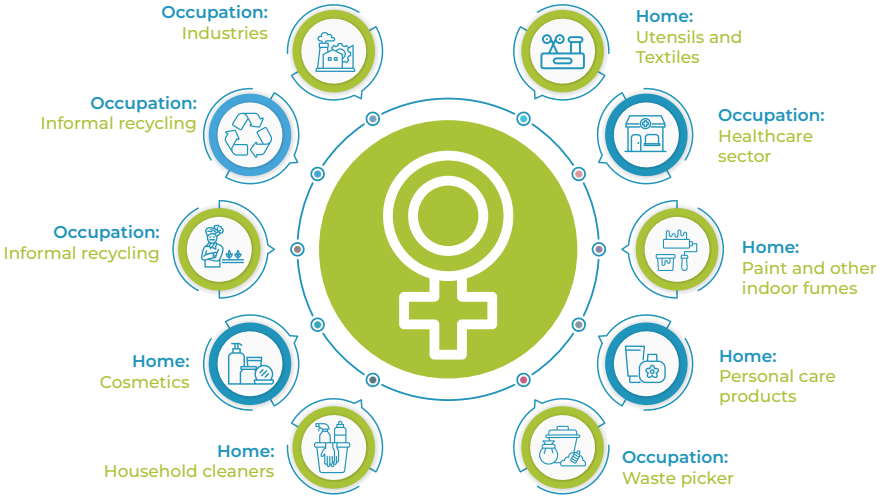
Social and occupational factors exacerbate women's vulnerability. Women are disproportionately represented in industries like textiles, electronics, and healthcare, which involve extensive use of hazardous chemicals. Many women in developing countries lack access to protective equipment and adequate information about chemical risks, facing compounded exposure at work and home. Studies reveal that feminine hygiene products, cosmetics, and household items often contain hidden EDCs, intensifying risks for women and, by extension, their children.

Pregnant women's exposure to EDCs has direct implications for their offspring. Multiple studies, including a Swedish analysis of over 2,300 pregnant women, have found numerous EDCs in biological samples, linking these exposures to complications such as low birth weight, preterm birth, and early puberty in children (IPEN, 2018). Social factors such as unequal access to healthcare, nutrition, and safe living conditions further increase these risks, highlighting the intergenerational impact of EDC exposure.

Addressing women's vulnerabilities is critical for protecting future generations. Ensuring women's participation in chemicals management and prioritizing protective measures can mitigate EDC risks, safeguarding both maternal and child health.

A Swedish analysis of over 2,300 pregnant women, have found numerous EDCs in biological samples (IPEN, 2018).

Figure 2: Sources of exposure to EDCs (Arora, 2023).



2.3 Children's Vulnerability to EDCs: Health Risks and Long-Term Effects

Endocrine-disrupting chemicals (EDCs) are a significant concern for children's health, given their vulnerability during critical stages of development. As mentioned above, even low-level exposure to EDCs during pregnancy, infancy, and childhood can have long-lasting effects on a child's health, as these chemicals can mimic, block, or interfere with the body's natural hormones, which are crucial for growth and development. Altered thyroid hormone action in pregnant women, due to insufficient iodine, autoimmune disease, or EDC exposure, has been linked to cognitive and behavioural issues in their children, including reduced IQ, attention deficit hyperactivity disorder (ADHD), and autism (Cunha et.al., 2023).

Children, having a higher metabolic rate and less fatty tissue compared to adults, are more affected by the substances they ingest. Their hand-to-mouth behaviour, such as touching, handling, or sucking on furniture, bedding, and toys, increases their exposure to certain chemicals in the home. Concentrations of these potential EDCs, found in common household items, are often much higher indoors than outdoors (Brosché, 2018).

According to WHO, numerous epidemiological studies have shown correlations between EDC exposure and adverse health outcomes in children. For instance, prenatal exposure to certain EDCs, such as polychlorinated biphenyls (PCBs) and dioxins, is associated with reduced birth weight.

Table 3: Presence of EDCs in Children Products and its impacts

Sr No	Endocrine Disrupting Chemicals	Category	Children's Products	Diseases and Dysfunction	Reference
1	Brominated Flame Retardants (BFRs)	POPs/ EDCs	Toys, baby food	Reduced development in children, including impaired psychomotor development and lower IQ performance	EPA (2011)
2	Polychlorinated Biphenyls (PCBs)	POPs	Baby food	Reduced IQ, language, memory and altered behaviour	Jeong et al. (2014); Badley et al. 2023
3	Phthalates	EDCs	Toys, diapers, clothes, shoes, slippers, stationery, teethers, baby wipes, baby lotion, baby soap	Alterations in physical development, lower IQ, hyperactivity, externalizing and internalizing behaviours, and autistic-like behaviours in infants/toddlers	Ejaredar et al. (2015) Kobrosly et al. (2014)
4	Bisphenol A (BPA)	EDCs	Toys, baby formula, baby bottles	Hormone disruption, affecting normal hormone levels and development; potential brain and behaviour problems, with mixed results in animal studies	Rochester (2013); Braun et al. (2011)
5	Per- and Polyfluoroalkyl Substances (PFAS)	POPs	Baby products (clothing, bedding, playmats, snack bags, toys, diapers, cloth diapers)	Higher cholesterol levels, decreased immune response, thyroid changes, liver effects, and increased risk of certain cancers	Sunderland et al. (2019); Grandjean & Budtz-Jørgensen (2013)
6	Triclosan	EDCs	Previously used in soap products (liquid, gel, foam, bar), toothpaste, hand sanitizer, and mouthwash	Increased risk of developing allergies, asthma, and eczema	Anderson & Meade (2014) Savage et al. (2012)
7	Medium-Chain Chlorinated Paraffins (MCCPs) and Short-Chain Chlorinated Paraffins (SCCPs)	POPs	Toys	Liver and kidney damage, endocrine disruption, cancer, and damage to developing brains	Karlsson & Miller (2023)
8	Nonylphenol	EDCs	Cleaning products, detergents	Hormonal disruptions, potential reproductive and developmental effects	Toxics link (2024a); Noorimotlagh et al. (2022)

Developmental and Reproductive Disorders:

Studies have shown that exposure to EDCs during critical periods of development, such as in utero or early childhood, can lead to serious developmental and reproductive health issues. According to a study by IPEN, (2024), the incidence of endocrine-associated paediatric disorders, including male reproductive problems (cryptorchidism, hypospadias, testicular cancer), early female puberty, leukaemia, brain cancer, and neurobehavioural disorders have all risen rapidly over the past 20 years. Additionally, there is growing evidence that early-life exposure to these chemicals can cause early puberty in girls, which is associated with an increased risk of breast cancer later in life.

Neurodevelopmental Impacts:

EDCs have also been linked to neurodevelopmental issues in children. Chemicals like bisphenol A (BPA) and phthalates, commonly found in plastics, can impair brain development, leading to cognitive deficits, behavioural disorders, and a higher risk of conditions such as attention deficit hyperactivity disorder (ADHD) and autism spectrum disorders. EDC exposures have been linked to decreased IQ, increased neurodevelopmental problems, and other neurocognitive conditions (Endocrine Society, 2025).

PCBs have the strongest and longest-known associations with neurological disorders. Other chemicals particularly pesticides and insecticides such as DDT, Chlorpyrifos are also linked with neurotoxicity, ADHD, and other cognitive disorders. Similarly, exposures to polybrominated diphenyl ethers (PBDEs), which were used as flame retardants, are associated with reduced IQ and other cognitive deficits. According to IPEN (2024) the chemicals replacing PBDEs, including so-called "next generation" brominated flame retardants and organophosphate esters, also appear to be harmful to the developing brain.

Metabolic Disorders and Obesity:

The United Nations Environment Programme (UNEP) highlights that EDC exposure in early life is associated with an increased risk of obesity and metabolic disorders. The UNEP Global Chemicals Outlook II report points out that prenatal and early childhood exposure to EDCs like BPA and certain pesticides can predispose children to obesity, insulin resistance, and type 2 diabetes. This is of particular concern as childhood obesity can lead to a host of other health problems, including cardiovascular disease, throughout life.

Immune System Impairment:

EDCs can alter immune responses, potentially leading to an increased susceptibility to infections, allergies, and autoimmune diseases. Children exposed to EDCs may experience altered immune function, making them more vulnerable to environmental challenges and reducing their overall resilience.

EDCs of concerns

3.1 Bisphenol A

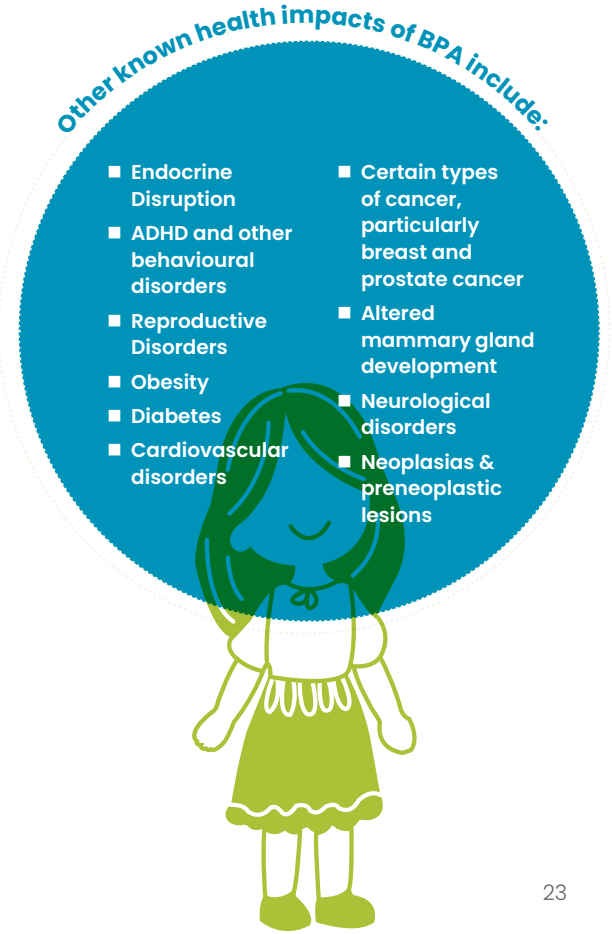
BPA is a synthetic chemical used primarily to make polycarbonate plastics and epoxy resins. It is characterized by its high thermal stability, transparency, and impact resistance, which makes it suitable for manufacturing polycarbonate plastics and epoxy resins. BPA's ability to harden plastics and its resistance to breakage make it a preferred choice in consumer goods. However, its ability to mimic estrogen has raised concerns about its impact on the endocrine system. BPA is present in several everyday items, including:

- Baby feeding bottles
- Plastic water bottles
- Food packaging materials
- Receipt papers
- Certain kitchenware, such as plates, mugs, and storage containers
- Some clothing items, including baby socks, blankets, and onesies
- Dental sealants

BPA interferes with the body's hormone systems, leading to a variety of health issues particularly in women and children. It is known to mimic the structure and function of the hormone estrogen, and disrupt normal hormone activity in the body.

BPA causes development, behavioural and cognitive disorders in infants and children. Exposure to BPA during pregnancy or early childhood can affect the development of the brain, behaviour, and prostate gland in foetuses, infants, and children. Studies suggest that BPA exposure may increase the risk of behavioural problems, such as ADHD, hyperactivity and anxiety.

BPA is largely banned in baby feeding bottles and sippy cups in countries like India, the EU, US, South Korea, Malaysia, and the Philippines. It is restricted in food packaging materials for young children in the EU and Canada.



3.2 PFAS

PFAS are a group of synthetic chemicals characterized by their strong carbon-fluorine bonds, which provide exceptional resistance to heat, water, oil, and chemical degradation. These properties make them highly durable and useful in non-stick cookware, waterproof clothing, food packaging, firefighting foams, and industrial applications.

They are known as "forever chemicals." Many are persistent organic pollutants (POPs) and some have been added to the list of highly toxic globally banned substances under the Stockholm Convention.

It is widely used to reduce friction or resist oil, water, and stains. As a result, PFAS are commonly found in water-resistant and stain-resistant products, including non-stick cookware, raincoats, jackets, and food packaging materials.

Children are exposed to PFAS as early as an infantile age through formula mixed with PFAS-contaminated water and breastmilk from mothers exposed to PFAS. As they grow, additional exposure can occur through contaminated toys and fabrics. Studies have also detected PFAS in baby clothes, carpets, mattress and sofa (Zheng, et.al., 2019; LaKind et.al., 2023; Yang et.al., 2025).

PFAS are known to cause several health impacts including negative impacts on fertility, foetal development and thyroid hormone function. Women

Children are exposed to PFAS as early as an infantile age through formula mixed with PFAS-contaminated water and breastmilk from mothers exposed to PFAS.

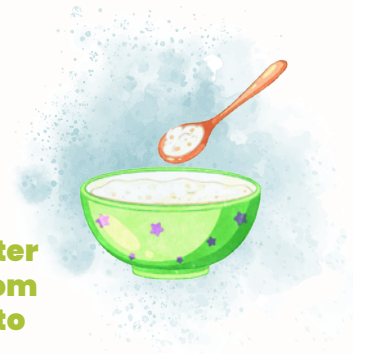
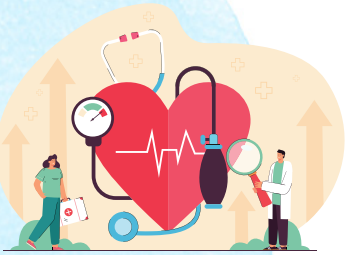


Figure 3: Products containing PFAS; Factsheet on PFAS

and Children are especially affected as combined Per- and Polyfluorinated Alkyl Substance (PFAS) exposure to PFASs can risk immune effects in pregnant women and children. Maternal exposure during pregnancy and breastfeeding may pose developmental and immune concerns in infants (LaKind et.al., 2023).

Health Impacts:

- Neurodevelopment Effects
- Thyroid disorders
- Liver damage
- Immune system suppression
- Developmental delays in children
- Elevated cholesterol
- Pregnancy-induced hypertension or preeclampsia
- Infertility



Countries have started taking regulatory action on PFAS. Denmark, the EU, and Canada have banned the use of certain PFAS in food packaging materials. Some countries have also restricted PFAS in consumer products and firefighting foams.

3.3 Phthalates

Phthalates are esters of phthalic acid and are primarily used as plasticizers to increase the flexibility, transparency, durability, and longevity of plastics. They are commonly found in toys, childcare products, food packaging, and personal care items like shampoos and lotions. Phthalates are colourless, oily liquids that are insoluble in water but mix well with organic solvents.

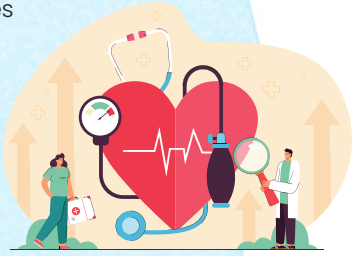
Phthalates are ubiquitously present and are well known endocrine disrupting chemicals. They are generally effective at very low concentration and are particularly harmful during critical phases of life such as pregnancy (foetal development), infancy, early childhood and adolescence. The hormone system is not fully developed at these stages, and effects could be irreversible and visible only in later phase of life. Phthalates can cross the placental barrier and have been measured in the amniotic fluid in humans (Toxics Link, 2020).

Where are phthalates found?

- Many flexible plastics, such as: - Some plastic food packaging, and plastic food storage containers, specifically containers with a label
- Tubing and containers used in medical care
- School products, like binders, art supplies, and lunch boxes
- Soft plastic and inflatable toys
- Water bottles
- Plastic clothes, such as raincoats, backpacks, Shower curtains and footwear
- Fragrances found in some perfumes/colognes, lotions, deodorants, soaps and shampoos, hair sprays, air fresheners, and similar products.
- Nail polish, cosmetics
- Some household products and car care products, such as paints, flooring, adhesives, automobile interiors, sealants and blinds
- Some medications and dietary supplements
- Diapers and sanitary napkins
- Insecticides
- Dielectric fluid in capacitors

Phthalates are known to cause the following health impacts:

- Liver/kidney/lung damage
- Cancer
- Altered reproductive development & male fertility issues
- Type II diabetes & obesity
- Attention-deficit/hyperactivity disorder (ADHD)
- Neuro-developmental issues
- Increased allergic symptoms
- Metabolic disorders
- Autistic behaviours
- Lower cognitive and motor development



Children are exposed to phthalates through the consumption of food and beverages stored in plastic containers, toys, and other products containing phthalates, inhalation of air contaminated with phthalates, or dermal absorption from household cleaners and personal care products. Several studies have

reported the leaching of phthalates, particularly in fatty foods such as dairy products, fish, seafood, and oils that are packaged in plastic. Research from the Swedish Chemical Agency and other studies indicates that young children are at greater risk of phthalate exposure. This increased risk is due to their higher food intake relative to body size, higher respiratory rates, frequent proximity to the floor, and the tendency to put objects in their mouths. Additionally, hand-to-mouth behaviour significantly contributes to the elevated levels of phthalates found in young children (Toxics Link, 2020).

A study by Toxics Link (2019a) detected phthalates in Diapers commonly used in India in the range of 8.2 -302.25 PPM. Several epidemiological studies have reported neurological and reproductive disorders in children due to phthalate exposure. In a study on 209 mother-child samples representing effects of prenatal phthalates exposure on motor skills development, cognitive socio-emotional functioning, and behaviour of children (Balalian, et.al., 2019).

Phthalates are banned or restricted in toys and childcare articles in the EU, US, China, India, Japan, and South Korea. Regulations often focus on limiting specific phthalates like DEHP, DBP, BBP, and DINP.

3.4 Nonylphenol

Nonylphenol is an organic compound with a branched structure, primarily used as a surfactant in detergents, cleaning agents, and industrial applications. Its emulsifying, wetting, and dispersing properties make it valuable in a wide range of industries, including textiles and agriculture. It has been identified as a chemical of global concern by United Nations Environment Programme (Toxics Link, 2024a).

Common sources of exposure include detergents and other cleaning agents, food packaging material, cosmetics and pesticides.

Nonylphenol is banned in cleaning products in the EU and Japan due to its environmental toxicity and endocrine-disrupting properties.

Health Impacts:

- Endocrine Disruptor – poses potential harm to immune and reproductive system
- A potential neurotoxin
- Highly irritating and corrosive to the skin and eye
- Can cause reproductive disorders
- Learning disabilities

3.5 Short chained and Medium Chained Chlorinated Paraffins

Chlorinated paraffins are a large group of high production volume industrial chemicals. Approximately one million tonnes and perhaps as much as two million tonnes are produced every year (IPEN, 2023). They are used in a wide range of products with different functions such as flame retardants, adhesives, sealants, and secondary plasticizers. They are especially common in polyvinyl chloride plastics (54% of the global volume usage) but are also used in many other types of plastics, rubber, and paints (UNEP/ POPS/POPRC.19/2, UNEP/POPS/POPRC.12/11/Add.3). They are also widely used in metal working fluids.

Although chlorinated paraffins are toxic, persistent, bioaccumulative and of global concern, and SCCPs have been banned since 2017, these chemicals are still widely found in products all over the world, including children's toys.

SCCPs are chlorinated hydrocarbons with chain lengths of 10-13 carbon atoms. Their high chlorine content provides flame-retardant and water-repellent properties, making them widely used in industrial applications such as textiles, rubber, paints, and sealants. SCCPs are highly viscous and exhibit low volatility, contributing to their persistence in the environment.

MCCPs are similar to SCCPs but have longer carbon chain lengths (14-17 carbon atoms). They are used as flame retardants and plasticizers in industrial applications like cables, sealants, and coatings. MCCPs are resistant to heat and chemical degradation, which makes them durable but also persistent in the environment.

Chlorinated paraffins are highly toxic chemicals used in many plastics, including in plastic children's toys. They are released from plastics throughout its lifecycle. Children can be exposed through skin contact, inhalation, dust, and ingestion. Evidence shows they may cause damage to the liver and kidneys, disrupt the endocrine system, cause cancer, damage developing brains, and pose threats to reproductive health.

Despite of the global ban SCCPs are being widely found in children's toys. According to an IPEN study, testing showed that all 31 toys purchased from ten countries contained both short- and medium-chain chlorinated paraffins.

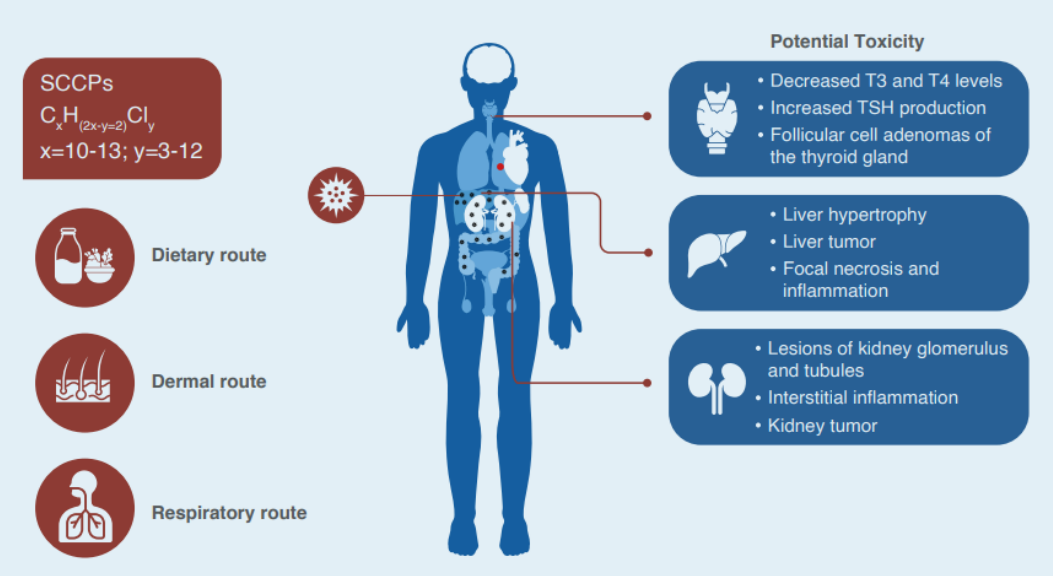
These current exposure levels may exceed the tolerable daily intake and people are exposed

SCCPs are listed under Stockholm Convention for global elimination.

MCCPs is at the last stage of evaluation and is currently not regulated.

through food, household dust, and products. Exposure levels pose greater risks to vulnerable populations including children, pregnant women, and workers.

Figure 4: Health impacts of SCCPs



Source: Toxics Link, 2024b

3.6 Parabens

Parabens are a group of chemicals that are widely used as preservatives in cosmetics and personal care products, food products and pharmaceuticals. They are highly effective in preventing the growth of fungi, bacteria, and yeast that can cause products to spoil, helping to extend shelf life. They are also used as antimicrobials in some paper products, like baby wipes, and some natural and synthetic fabrics.

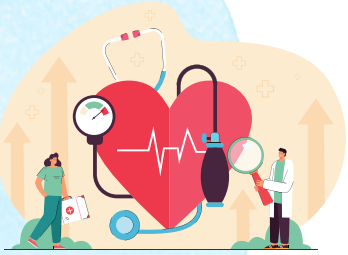
Due to their structural similarity to the estrogen molecule, parabens interfere with nuclear receptors for androgens, estrogens, progesterone, glucocorticoids, and other hormones, classifying them as endocrine disrupting chemicals (EDCs) (Miriyala, et.al., 2024).

Children, due to their ongoing development and increased sensitivity to disruptions in hormone function, may be more vulnerable to the potential health effects associated with exposure to parabens (Tung, et.al., 2024)

Parabens are found in

1. Personal care products, including some:
   - Cosmetics, such as mascara, eye shadow, lipstick, and foundation.
   - Facial cleansers and scrubs.
   - Moisturizers, lotions, and sunscreens.
   - Shampoos, conditioners, and shaving creams.
   - Baby products, such as some lotions, baby wipes, and diaper rash ointments.
2. Household products, such as stain removers and pet shampoos.
3. Clothing and other textiles, such as sportswear, bedding, and upholstery fabric.
4. Over-the-counter and prescription medications.
5. Food, such as some jams and jellies; sauces and syrups; and packaged tortillas, trail mix, and baked goods.

Health impacts:



- **Endocrine disruption:** Parabens can interfere with the body's natural endocrine function. They can also target hormone receptors, such as those for estrogens.
- **Reproductive issues:** Parabens may impact fertility, reproductive cyclicity, and pregnancy outcomes.
- **Skin and eye irritation:** High concentrations of parabens can cause skin and eye irritation and damage.
- **Other health issues:** Parabens have been linked to breast cancer, obesity, and thyroid-related issues.

Parabens are regulated and restricted in various countries. In the European Union (EU), the total concentration of parabens in cosmetics is limited to 8 grams per kilogram, with no single paraben exceeding 4 grams per kilogram. Five parabens (isopropylparaben, isobutylparaben, phenylparaben, benzylparaben, and pentylparaben) are banned. The total concentration of propyl- and butylparaben is recommended to be no more than 1.9 grams per kilogram. In Japan, the limit is set to 1.0%.

Table 4: EDCs Banned in Products by Country

Chemical	Product	Countries Where Regulated
BPA	Baby feeding bottles	India, EU, US, South Korea, Malaysia
BPA	Sippy cups	US, Philippines
Phthalates (DEHP, DBP, BBP, DINP, DIDP, DNOP)	Toys and childcare articles	EU, US, Canada, China, South Korea, Japan
Polycarbonate	Baby bottles	Malaysia, Thailand
Lead	Paints	India, US, EU
Triclosan	Personal care products	EU, US
Short-chain chlorinated paraffins (SCCPs)	Toys	Globally banned under Stockholm Convention
Nonylphenol	Cleaning products	EU, Japan
PFAS	Food packaging materials	Denmark, EU, Canada
PBDEs	Electronics and furniture	EU, US, Japan
Mercury	Thermometers	India, EU, US
PFOA	Various Consumer products	Japan, EU

**Note: Restrictions vary by specific compounds and product types.*

EDCs in Everyday Life:

A Closer Look at Children's Products

Table 5: Common EDCs in Children Products

Children Products	Common EDCs	Images
Baby Feeding Bottles	Bisphenol A and other Bisphenols	
Baby Formula	Bisphenol A	
Diapers	Phthalates, PCBs, Dioxins,	
Toys and playthings	Phthalates, Short-chained chlorinated Paraffins (SCCPs) and Medium-chained chlorinated Paraffins (MCCPs), Brominated Flame Retardants, Bisphenols,	
Food	Pesticides such as Glyphosate	

Children Products	Common EDCs	Images
Children Furniture	BFRs, PFAS	
Personal Care products- Baby shampoo, body wash, powder, moisturizers, wipes and others	Triclosan, Parabens, phthalates	
Water bottles, sippers and other containers	Bisphenols	
Baby Mattresses	BFRs	
Clothing	PFAS	
Stationery	Phthalates, Lead, Cadmium, BPA	

Children Products	Common EDCs	Images
Other household items like Paints	Lead	
Other household items like cookware	PFAS	
Other household items like food packaging material	Bisphenols	
Other household items like electronics	Brominated Flame Retardants	
Other household items like Detergents	Nonylphenol	

Tracking EDC Exposure Across a Child's Developmental Stages:

From Cradle to Classroom

The impacts of endocrine-disrupting chemicals (EDCs) differ across populations due to variations in gender, sex, occupation, and environmental factors, analogous to the diversity in exposure routes. Children are especially susceptible to EDCs, with their vulnerability and the associated effects evolving as they progress from infancy through toddlerhood, childhood, and adolescence into adulthood. The developmental stages influence exposure pathways and physiological responses to these chemicals.

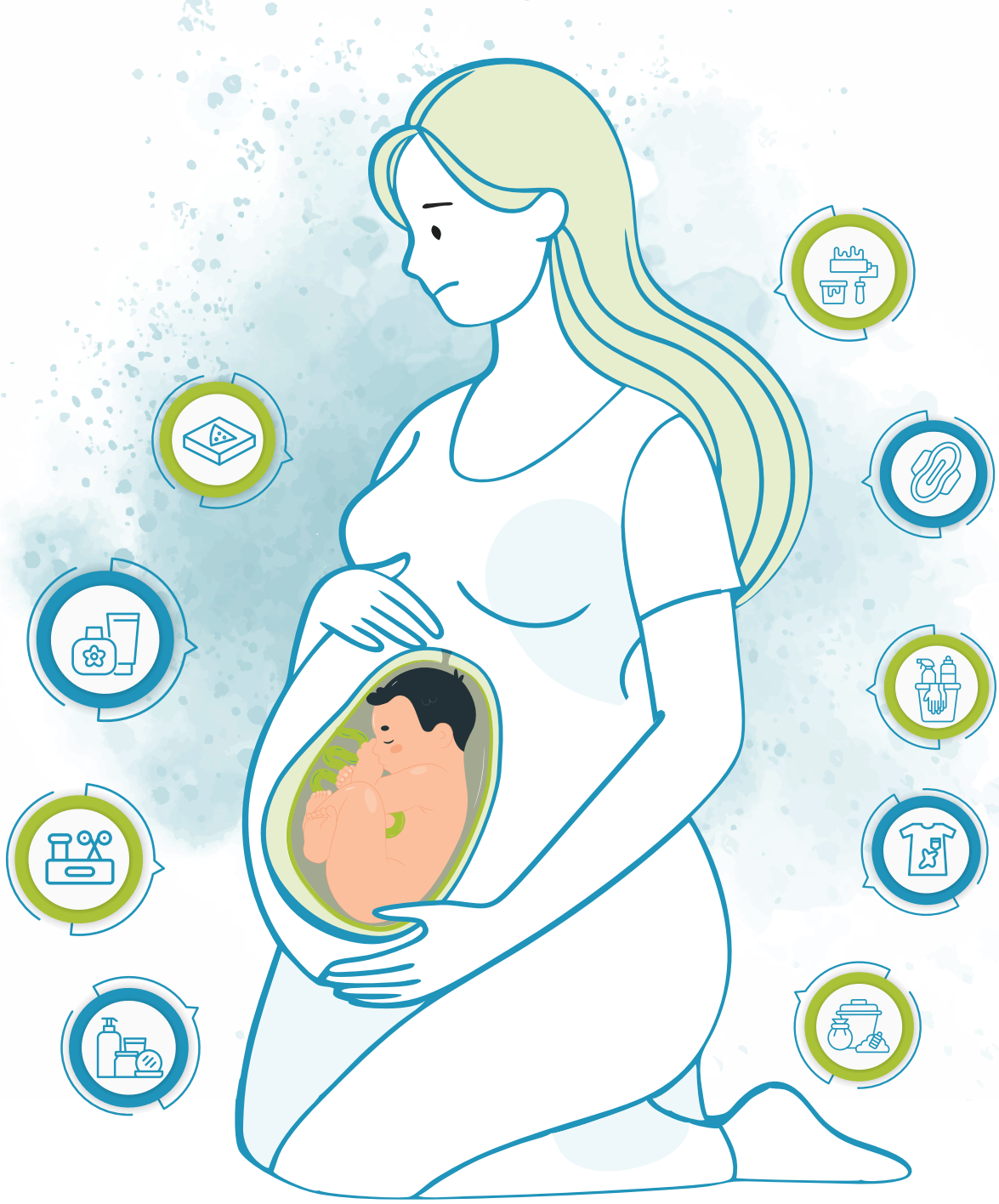
5.1 Foetal Stage: In Utero Exposure

The foetal stage is the most sensitive period for EDC exposure, as the developing foetus is particularly vulnerable to even low levels of these chemicals. Studies have indicated that prenatal exposure to EDCs like bisphenol A (BPA) and phthalates can interfere with the normal development of the endocrine system, leading to long-term health consequences. These chemicals reach the foetus through placental transfer, maternal diet, personal care products, and household chemicals, disrupting development and increasing susceptibility to chronic diseases later in life.

BPA and phthalates, commonly found in plastics and food packaging, have been detected in the serum, amniotic fluid, breast milk, and urine of pregnant women (Shekhar, et.al., 2017; Maitre, et.al., 2018). Once these chemicals enter the foetal system, they can cross the placenta and accumulate in tissues, impairing placental function and affecting hormone regulation (Tang, Et.al., 2020). Research has shown that phthalate exposure is linked to low birth weight, cardiovascular diseases, cryptorchidism, and developmental abnormalities (Tang et.al., 2020). Lead contamination from water and household dust has been associated with cognitive impairments, reduced IQ, and behavioural issues. Pesticide residues in food consumed by the mother may alter foetal metabolism, contributing to congenital disabilities and hormonal disruptions.

A study on organochlorine pesticides found that these chemicals interfere with placental functions by disrupting hormone production, nutrient transport, and waste elimination, further impacting foetal growth (Kumar, 2004). Additionally, heavy metals such as lead and mercury have no established safe exposure levels during foetal development. The EU Endocrine Disrupter Expert Advisory Group has emphasized that the thresholds for adverse effects from EDC exposure may be extremely low or even non-existent during this sensitive stage (ChemTrust, 2017).

Figure 5: Sources of EDC exposure to mother and foetus



5.2 Infancy: First year of life

Infants are highly vulnerable to EDC exposure due to their developing endocrine systems, rapid growth, and higher relative intake of air, food, and fluids compared to adults. They are exposed to multiple hazardous chemicals through baby bottles, pacifiers, diapers, formula packaging, personal care products, household dust, and plastic toys. Frequent hand-to-mouth behaviour and prolonged contact with soft plastic materials further increase exposure risks.

BPA and phthalates in baby bottles and feeding containers leach into liquids, exposing infants to hormone-disrupting substances. Studies link BPA exposure in infancy to early puberty and metabolic disorders. New-born and infant exposure to BPA has been found to increase the sensitivity of hormone-sensitive organs to later-life exposures to estrogens or chemical carcinogens (Straková et.al., 2022). A 2021 study (Karsauliya, et.al., 2021) in India tested 68 baby formula samples and found detectable concentrations of multiple bisphenols, including BPA, BPS, and BPAF. Additionally, BPA levels in children are generally higher than in adults due to greater food consumption per body weight and dust ingestion linked to hand-to-mouth behaviour (mouthing).

Newborns are susceptible to BPA because of an immature liver function and underdeveloped glucose acidification movement.

Phthalates have also been detected in disposable diapers, exposing newborns to weakly bound chemicals that are easily released. According to the CDC's Fourth National Report on Human Exposure to Environmental Chemicals, phthalates are commonly found in the bodies of Americans, including children. Since they are weakly bound to the materials to which they are added, they are easily released (Leiba and Swanson, 2020). Flame retardants and parabens present in personal care products contribute to immune dysfunction and respiratory issues, compounding health risks.

Lead in household dust and old paint has been shown to impair brain development, reducing cognitive abilities and increasing behavioural disorders. Talc, commonly found in baby powder, is often contaminated with asbestos, a known human carcinogen, posing additional risks to infant health (Toxics Link, 2021).

5.3 Early Childhood (1-5 years)

Early childhood, typically defined as the age range from birth to five years, is a critical period for physical and cognitive development. During this stage, children's bodies are rapidly growing, and their endocrine systems are highly sensitive to

environmental factors, including exposure to endocrine-disrupting chemicals (EDCs).

> Children have higher exposure to some EDCs than adults because they consume more water and greater quantities of specific foods, and have higher ventilation rates, intestinal absorption, surface area to volume ratios, and hand-to-mouth activity.
>
> *Source: (Cunha, et.al., 2023)*

Exposure occurs through multiple sources:

1. Breast Milk and Infant Formula

- BPA, phthalates, and PFAS can pass through breast milk if the mother has been exposed to these chemicals.
- Plastic feeding bottles, are often made with BPA or phthalate-containing plastics, can leach harmful chemicals into infant formula, especially when heated.

2. Baby Products and Toys

- Many baby products, such as plastic toys, teethers, and pacifiers, may contain phthalates or BPA, which can leach out when children chew or suck on them.
- Foam mats, baby strollers, and crib mattresses are often treated with flame retardants like PBDEs (polybrominated diphenyl ethers) and chlorinated paraffins, leading to prolonged exposure through inhalation and skin contact. Several studies have detected SCCPs and MCCPs in toys available in Indian market.
- Children playing with plastic toys may be exposed to increased levels of chlorinated paraffins due to accumulations of the leached chemicals in dust, leaching upon skin contact (dermal uptake), hand-to-mouth behaviours, and through chewing on the toys (oral exposure).

How are children more sensitive to EDCs? Source: (Di Pietro, et.al., 2023)

Higher Exposure Rates: Children take in more water, food, and air relative to their body surface area than adults.

Immature Blood-Brain Barrier: Children's developing blood-brain barrier makes them more vulnerable to neurological harm.

More Permeable Skin: Infants' skin absorbs substances more readily.

Increased Indoor Exposure: Children are exposed to more EDCs indoors and from mouthing objects.

Less Efficient Detoxification: Children's immature biological systems are less effective at detoxifying EDCs.

3. Household Dust

- EDCs from products in the home, such as **flame retardants**, **pesticides**, **lead** and **phthalates**, settle into household dust. Children are particularly vulnerable as they crawl on the floor, touch surfaces, and frequently put their hands in their mouths.

4. Personal Care Products

- Personal care products (PCPs) include lotions, soaps, fragrances, shampoos, and baby wipes. These products often contain **parabens, phthalates** and **triclosan** which are used as preservatives and fragrance carriers. These chemicals can be absorbed through the skin, increasing the risk of hormone disruption.
- In a study conducted by Department of Ecology in State of Washington, tested 43 baby personal care products for five parabens. The products included lotions, wipes, body wash among others. Methyl and propyl paraben were found in 69.7 and 60.3% of the tested products and were the only parabens found at concentrations exceeding 1,000 ppm (Department of Ecology, State of Washington, 2021).

5. Paints, toys, jewellery

Children are often exposed to lead by ingesting dust and chips of paints contaminated with lead. Products such as toys, jewellery, and other items often contains lead.

Lead is a known toxic chemical. It impacts the brain and nervous system, even in small amounts. In children, lead exposure can cause developmental delays, learning disabilities, lower IQ, and behavioural problems. Long-term exposure can lead to serious health problems, including anaemia, kidney damage, and impaired hearing.

6. Clothes

Various classes of chemicals are used in clothing including PFAS, phthalates, Nonylphenol and Flame retardants. PFAS are often used in fabric treatments to make garments resistant to water and stains. This treatment is especially common in waterproof jackets, athletic wear, and even everyday apparel like shirts and trousers. A study by IPEN in 17 countries found that 65% of the clothing samples (Jackets, raincoats, t-shirts) contained PFAS (Straková, et.al., 2023).

Another study by Toxics Link (2019b) found Nonylphenol in Detergents available in India.

7. Food and Water Contaminants

- Exposure to EDCs like BPA, phthalates, and PFAS and other EDCs can occur through food packaging (such as plastic containers and linings of canned foods) and contaminated water. A study by IPEN and 18 member groups found that 54% of 119 samples of food packaging and tableware from 17 countries contained PFAS. PFAS can migrate from packaging into food, and have been linked to cancer, infertility, and endocrine disruption (Straková, et.al., 2023).
- Food also contains pesticides, several of which are EDCs. According to the Endocrine Society, Chlorpyrifos, an insecticide used in commercial agriculture, is a potent neurotoxicant that causes developmental delays, attention problems, and ADHD in children. It is still widely used in India and several other countries in the world.

5.4 School-Age Children (6-12 years)

As children gain independence, their EDC exposure extends to school supplies, uniforms, personal care products, and processed foods. PFAS in school uniforms and nonstick food packaging contribute to metabolic disruption and obesity. Phthalates in backpacks, lunchboxes, and stationery interfere with hormone regulation. Nonylphenol, used in detergents and plastics, affects immune and reproductive function. Studies suggest exposure at this stage contributes to early puberty, increased body fat, and endocrine dysfunction. School environments, including air, dust, and consumer products, add to the cumulative chemical burden.

5.5 Adolescents (13-18 years)

Puberty is a critical period for endocrine system changes, making adolescents highly vulnerable to hormone-disrupting chemicals. Exposure comes from cosmetics, personal care products, fast food packaging, and electronic devices. BPA, phthalates, and parabens in skincare and hygiene products contribute to hormonal imbalances, reproductive health issues, and increased risks of hormone-related cancers. PFAS in clothing, cookware and food packaging continues to pose metabolic and immune risks. Adolescents facing exposure to multiple EDCs that interfere with estrogen and testosterone regulation, affecting reproductive health and increasing risks of conditions like polycystic ovary syndrome (PCOS) and reduced sperm quality. High fast-food consumption, associated with phthalate exposure, further exacerbates these risks. Apart from exposure at home, children are also exposed to EDCs at school.

- **School Supplies and Personal Products:**
  - **Stationery and art supplies** - Heavy metals like lead and cadmium, exposing children through touch and accidental ingestion.
  - **Toys and electronics** - Contain brominated flame retardants (BFRs) and chlorinated paraffins (CPs), which can leach out during use and breakdown.
  - **Sanitary napkins and hygiene products-** Contain phthalates and volatile organic compounds (VOCs), posing long-term exposure risks.
  - **Cosmetics and personal care items** commonly used by teens, such as deodorants, makeup, and lotions, often contain harmful chemicals like parabens, phthalates, and triclosan.
- **School Environment:**
  - **Classroom furniture and building materials** may have flame retardants, phthalates, or other chemicals that are released into the air over time.
  - **Food and beverage containers** from school cafeterias may also contribute to exposure through plastic packaging, utensils, and storage materials that contain BPA, phthalates and nonylphenol.

The presence of EDCs in children's environments can have a profound impact on their health and development, particularly during the critical stages of puberty and adolescence.

Figure 6: EDC exposure across stages of childhood

How EDCs affect children in different stages of their life cycles.

1. **Hormonal Disruptions**: EDCs mimic or interfere with the body's natural hormones, leading to disrupted endocrine function. EDCs, such as BPA, phthalates, and parabens, can lead to early or delayed onset of puberty in girls. Early puberty has been linked to:
    - Increased risk of breast cancer
    - Mental health challenges
    - Reproductive disorders
    - Increased likelihood of developing PCOS, endometriosis and uterine fibroids
    - Irregular menstrual cycles and hormonal imbalances in girls
    - Impact growth patterns, potentially stunting development or causing rapid, uneven growth spurts

2. **Neurodevelopmental Issues**: EDCs like lead, cadmium, and phthalates have been linked to negative impacts on brain development and cognitive function. This may manifest in:
    - Reduced IQ, memory, and learning capabilities.
    - Behavioural problems such as attention deficit hyperactivity disorder (ADHD), anxiety, or aggression.
    - Impaired social skills and difficulties in academic performance.

3. **Reproductive Health Concerns**: Adolescents are at a vulnerable stage for reproductive development, and exposure to chemicals like BPA, phthalates, and parabens can have lasting effects on reproductive health:
    - Boys may experience reduced sperm count and altered testosterone levels later in life.
    - Girls exposed to high levels of EDCs may face fertility issues, early onset of menstruation, or ovarian disorders.
    - Both boys and girls face potential risks of reproductive cancers such as testicular and breast cancer due to prolonged exposure.

4. **Increased Risk of Chronic Diseases**: Long-term exposure to EDCs during childhood and adolescence can increase the risk of developing chronic diseases in adulthood, including:
    - Obesity: EDCs like BPA and phthalates have been linked to weight gain and metabolic disorders, altering the way fat is stored and hormones regulate appetite.
    - Diabetes: Disruptions in insulin production and regulation have been connected to EDC exposure, particularly in relation to BPA and phthalates.
    - Cardiovascular diseases: EDCs contribute to inflammatory processes and oxidative stress, which are precursors to heart disease.

5. **Immune System Effects:** EDCs can impair the immune system's development, making children more susceptible to infections, allergies, and autoimmune diseases. Chemicals like BPA and PFAS have been linked to reduced vaccine efficacy and increased allergic sensitivities in children.

6. Navigating the Regulatory landscape: Policies and Protection

EDCs are being identified as a threat to both human health and environmental safety. International organizations, research institutions and CSOs are contributing to evidences of EDCs being a major concern. Several countries have taken policy measures to regulate several EDCs. Some of them are given below:

Table 6 Overview of policies and regulations

Sr. No	Countries	Restriction	Regulatory bodies
1	**Australia**	The Australian Competition and Consumer Commission (ACCC) enforces restrictions on the use of certain phthalates in children's toys. The regulatory framework does not specifically list all endocrine-disrupting chemicals.	Australian Competition and Consumer Commission (ACCC)
2	**Brazil**	Regulates phthalates in toys and childcare products; specific limits for certain phthalates are set. BPA is banned in the manufacture of baby bottles and other similar products intended for children under 3 years of age.	Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), National Institute of Metrology, Quality and Technology (INMETRO)
3	**Canada**	Health Canada implemented a ban on BPA in the production of baby bottles. The regulation under the Canada Consumer Product Safety Act (CCPSA) restricts BPA in food contact materials and other products. Specific limits for certain phthalates.	Canada Consumer Product Safety Act (CCPSA), Canada's Phthalates Regulations, Canadian Environmental Protection Act CEPA 1999
4	**China**	Phthalates including DEHP, DBP, and BBP are restricted in toys and childcare articles. Polycarbonate baby feeding bottles and other infant feeding bottles are prohibited. Additives in adhesives and paint coatings are restricted.	General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), GB Standards
5	**India**	The regulation of endocrine-disrupting chemicals (EDCs) in children's products is managed through various safety standards. BPA is restricted in Baby Feeding Bottles. BIS restricts certain phthalates and BPA in children's products. The Draft Chemicals (Management and Safety) Rules 2019 lists 15 phthalates.	The Consumer Protection Act, 2019, The Toys (Quality Control) Order, 2020, Bureau of Indian Standards (BIS) IS 9873-9-2017, Food Safety and Standards (Foods for Infant Nutrition) Regulations, 2020

Sr. No	Countries	Restriction	Regulatory bodies
6	**Indonesia**	Food contact plastics with maximum permitted content of 600 µg/kg are allowed.	Regulation of the National Agency of Drug and Food Control (Badan Pengawas Obat dan Makanan/BPOM) Number 20 of 2019 concerning Food Packaging
7	**Japan**	Regulates various endocrine-disrupting chemicals. Phthalates in restricted in Toys. BPA is regulated primarily in food contact materials and baby products, including feeding bottles. PFOA (Perfluorooctanoic Acid) is restricted in many consumer products.	Chemical Substances Control Law (CSCL), Food Sanitation Law, Japanese Industrial Standards (JIS)
8	**Malaysia**	Polycarbonate Baby bottles are prohibited.	P.U. (A) 35/12 of the Food Regulations 1985 (since March 1st, 2012)
9	**Philippines**	BPA is banned in baby bottles and sippy cups. It has also restricted phthalates in toys for children under 3 years old. The restrictions prohibit certain phthalates, including BBP, DBP, DEHP, DIBP, DIDP, DINP, and DNOP, from exceeding 0.1% in toys and childcare articles.	Food and Drug Administration of the Philippines (Food Packaging Forum, 2019)
10	**South Africa**	BPA is banned in baby bottles. Regulations are in place for phthalates in children's toys to ensure safety which determines that the specified plastics and accompanying additives do not contain the statutorily prohibited . phthalates (DEHP, DBP, BBP, DINP, DIDP, DNOP) in concentrations above 0.1 percent. (United States Consumer Product Safety Commission, 2017)	Department of Health, South African Bureau of Standards (SABS) 1308: Prohibition of Children's Toys and Child Care Articles Containing Specified Phthalates: Determinations Regarding Certain Plastics
11	**South Korea**	Restrictions on DEHP, DBP, BBP, and DINP in toys. BPA is banned in baby bottles and other feeding products intended for children under 6 years old.	Act on the Registration and Evaluation of Chemicals (AREC), Ministry of Environment

Sr. No	Countries	Restriction	Regulatory bodies
12	**Thailand**	Thailand banned the use of BPA in infant feeding bottles on March 1, 2011. In addition, the Office of the Consumer Protection Board requires a mandatory warning label on infant and children's tableware containing BPA. It also issued a new standard in 2022 for toy safety which includes restrictions on phthalates. This standard applies to toys and their accessories intended for children under 14 years of age.	Thai Food and Drug Administration (Thai FDA) TIS 685-1:2562 (2019)
13	**EU**	Ban on phthalates and BPA in toys and childcare articles. DEHP, DBP, BBP, and DIBP are prohibited in concentrations above 0.1% by weight in toys for children under 14. Restrictions on BPA in food packaging for children up to 3 years old.	Toy Safety Directive 2009/48/EC, Directive (EU) 2011/8/EU, Regulation (EU) 2018/213, Regulation (EC) No 1907/2006
14	**US**	The Consumer Product Safety Improvement Act (CPSIA) restricts certain phthalates in toys and childcare articles. The FDA restricts BPA in baby bottles and sippy cups in 2012 and bans BPA-based epoxy resins in infant formula packaging.	FDA, Consumer Product Safety Improvement Act (CPSIA), Rule 77 FR 41899, FDA's Final Rule on BPA in Baby Bottles and Sippy Cups (2012)

Regulatory Gaps

EDCs are found in several consumer products which have differential impacts on different populations based on their sex, gender, occupation, social roles, and vulnerability among others. Not only do the sources of exposure vary, but the types of EDCs that are exposing a certain population at a point in time also vary and are most often overlooked. Also, some chemical substances are not dangerous when present at doses below the defined thresholds, but can be toxic when combined which is also known as the "Cocktail effect". However, many existing regulations do not cover the full range of EDCs or fail to consider this cumulative exposure.

Some of the major gaps include:

1. Weak and fragmented regulations

The regulation of EDCs remains a complex and evolving area. The regulations that currently exist do not take into account EDCs as a class of chemicals and mostly ban a single chemical in a single or a class of products. Some countries focus on specific sectors such as food safety (regulating BPA in food containers) rather than comprehensive chemical regulation.

There is no single, comprehensive regulation specifically targeting EDCs.

This leads to weak regulation and regrettable substitution. For example, the BPA ban in baby feeding bottles led to the replacement of BPA by BPS- Bisphenol S, which is equally toxic. Regulations that focus on banning specific chemicals without addressing the broader category of chemicals with similar structures or properties, lead to the use of equally hazardous substitutes.

Regrettable substitution:

Regrettable substitution" refers to the practice of replacing a harmful chemical with another that is later found to be equally or more hazardous. This issue often arises when regulations or public pressure lead to the banning or restriction of a specific chemical, prompting manufacturers to switch to alternative substances without thorough evaluation of their safety. Over time, these substitutes can prove to be just as problematic, leading to a cycle of harm and remediation.

2. Poor implementation

Many countries, especially in the developing world, there is a lack of understanding of the complexity of such issues. Coupled with a lack of political will, insufficient funding for regulatory agencies, lack of trained personnel, and inadequate monitoring and compliance mechanisms the regulatory frameworks are not as robust as they

need to be. Even when regulations exist, they may be undermined by loopholes that allow industries to continue using harmful chemicals. This can occur due to vague language in regulations, exemptions for certain industries, or lack of penalties for non-compliance.

In India, despite regulations banning BPA in baby feeding bottles, it continues to be used. Companies often mislead consumers with false claims that their products are "BPA-free." Similarly, although the Indian government set a limit of 90 ppm for lead in paints in 2016, tests conducted by Toxics Link revealed that several paints manufactured in India still contain high levels of lead.

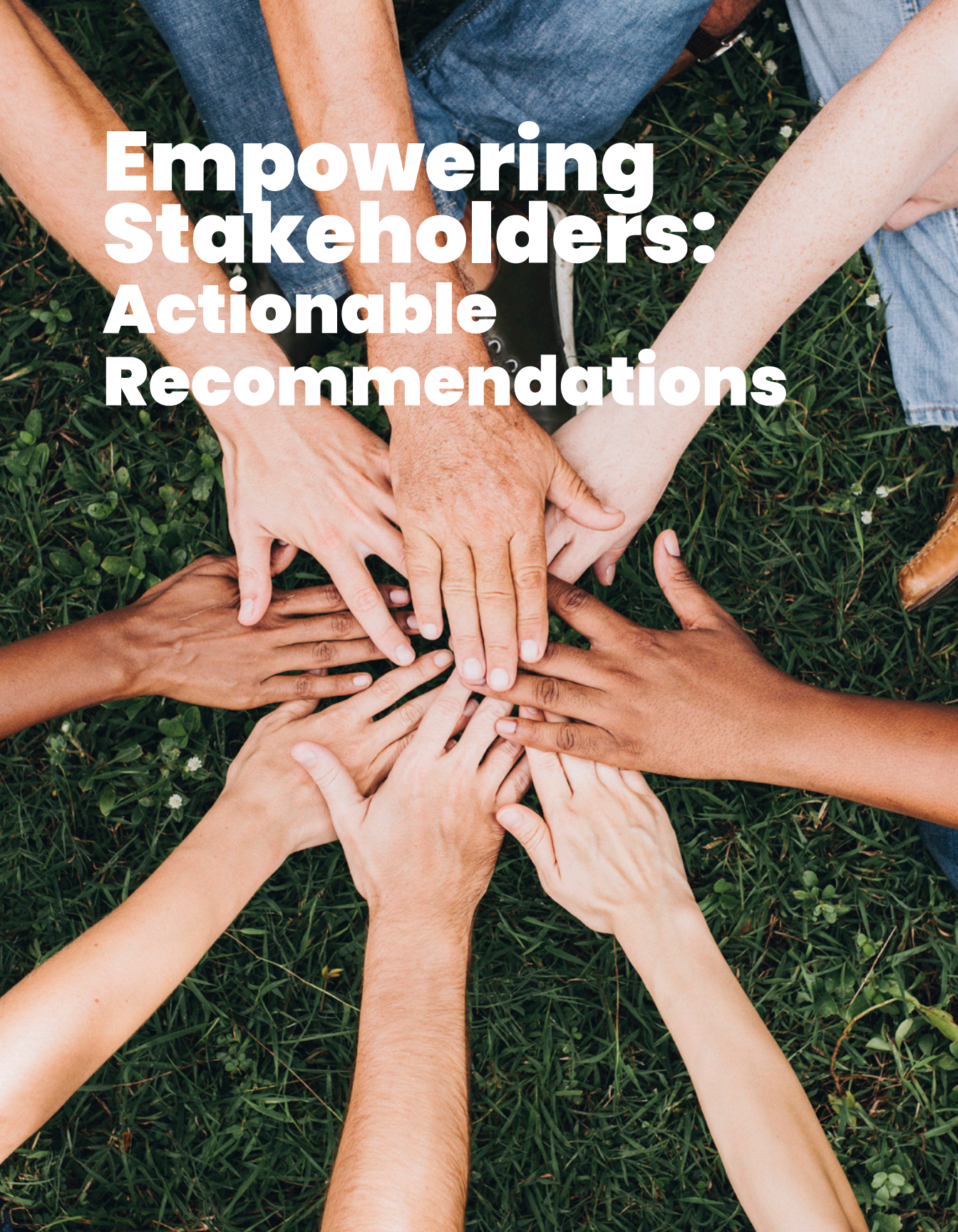
The global trade chain also weakens the implementation of the regulations as many countries import goods from regions with weaker EDC regulations. Products containing EDCs may enter markets with stricter regulations, complicating enforcement efforts.

Another major reason behind the poor implementation is the lack of testing facilities. Many chemicals currently in use have not been adequately tested for endocrine-disrupting properties. Regulatory agencies often lack the resources or mandate to screen all existing chemicals comprehensively, leading to gaps in regulation.

3. Underrepresented groups

The existing fragmented framework also fails to represent vulnerable groups during its formulation and implementation. Women and Children, low-income communities, Indigenous people, workers in high-risk occupations, and rural and marginalized populations are groups that are differentially exposed and impacted. The existing literature on EDCs lacks data specific to different vulnerable groups and hence the derived legislations and policies also fail to include these groups and thus protect them.

The poor formulation and implementation of EDC regulations globally is a multifaceted issue that requires coordinated efforts at national, regional, and international levels. Addressing the challenges of inconsistent regulations, economic pressures, and enforcement gaps is essential to protect human health and the environment from the harmful effects of EDCs.



Empowering Stakeholders: Actionable Recommendations

Endocrine-disrupting chemicals (EDCs) are pervasive, found across various sectors and products, and often contaminate drinking water and food. While some countries have begun addressing well-known EDCs like Bisphenol A, it is crucial to implement more targeted actions to protect the health of children and women specifically.

Action can be taken at multiple levels: **Regulatory, industrial and consumer.**

For Policymakers

To reduce EDC risks in India, regulators should strengthen safety standards for children's products, restrict harmful chemicals, and mandate regular testing. A class-wide ban on EDCs can prevent regrettable substitution, while data collection on EDC presence and impacts is urgently needed. Enhanced surveillance and enforcement will ensure compliance, supported by public awareness campaigns and consumer resources. Investment in research and innovation is critical for safer alternatives.

Governments should also prioritize protections for women, particularly in food, consumer products, and workplaces. This includes mandatory chemical assessments for EDC properties affecting women, setting tolerable daily intake levels, and product labelling requirements. Companies should identify and replace suspected EDCs, especially in products for women and children, and assess workplace exposures for female workers. Awareness campaigns can empower women to make safer choices and reduce their exposure.

What can the government do?

- Implement stricter regulations on EDCs.
- Regulate EDCs as a class of chemicals.
- Ban all EDCs in all children products
- Generate sex and gender differentiated data.
- Promote research on safer alternatives.
- Prioritize protection of vulnerable groups particularly women and children.
- Establish a control mechanism for monitoring compliance of products on the market to established legislation.
- Establish legally binding rules for EDCs labelling of consumer products.
- Support substitution of EDCs containing products, with already existing alternatives to rapidly transition towards non-toxic, recyclable materials.

For Manufacturers

- **Ensure Transparency and Traceability in Supply Chains:**
  Manufacturers should ensure full transparency in supply chains by verifying the chemical composition of materials and maintaining records accessible to regulators and consumers. Robust traceability systems help identify risks and ensure safer products reach the market.

- **Enhance Product Labelling for Consumer Awareness**
  Clear, standardized labelling is key to empowering consumers. Products, especially those for children, should clearly indicate the presence of EDCs, potential risks, and safer usage guidelines, helping buyers make informed choices.

- **Adopt and Promote Safe Alternatives**
  Manufacturers must phase out harmful EDCs and invest in research to develop safer, non-toxic alternatives. Prioritizing such materials not only protects health but also strengthens market competitiveness for sustainable products.

- **Collaborate to Develop Industry Standards**
  Industry-wide collaboration with regulators, NGOs, and other stakeholders is essential to establishing uniform safety guidelines. Participation in setting standards will help manufacturers align with policies that prioritize public health and environmental protection.

For Parents and Caregivers:

Indian consumers should be aware of endocrine-disrupting chemicals (EDCs) in everyday products. Common EDCs include phthalates, brominated flame retardants (BFRs), lead, Bisphenol A (BPA), parabens, triclosan, PFAS, and nonylphenol. These chemicals are found in children's toys, personal care products, food packaging, household products, clothing, and furniture. To minimize exposure, choose products labelled as free from these harmful chemicals and stay updated on regulations.

Key tips:

- Look for EDC-free labels.
- Avoid plastic containers for food storage.
- Choose non-plastic toys and baby products.
- Use lead-free paints for children's items.
- Avoid using non-stick cookware and switch to safer alternatives such as cast iron or steel.

- Choose personal care products free from parabens and phthalates. Choose natural oils and products for children.
- Select natural fibre clothing for children, such as cotton.

For Educators and Advocates:

- **Develop educational programs on EDCs**
  Create programs for all age groups, integrated into schools, workshops, and online platforms, to educate about the risks of EDCs and how to avoid them.
- **Create informative materials**
  Produce brochures, fact sheets, videos, and social media content to raise awareness about where EDCs are found, their risks, and how to reduce exposure. Distribute through schools, healthcare providers, and online channels.
- **Advocate for policy changes**
  Collaborate with environmental groups, health organizations, and policymakers to push for stronger regulations on EDCs in consumer products, particularly those for children.
- **Engage in Collaborative Research and Data Collection**
  Partner with research institutions to study the prevalence and impact of EDCs in specific communities. Use this data to influence policies and tailor educational programs.
- **Promote Safe and Sustainable Practices in Schools**
  Encourage schools to use non-toxic cleaning supplies, BPA-free containers, and safe materials. Promote sustainable practices like reducing plastic use and supporting eco-friendly alternatives.

8. Conclusion: Toward a Toxics-Free Future

The presence of Endocrine Disrupting Chemicals (EDCs) in children's products represents a critical and growing concern for public health. These chemicals, commonly found in everyday items such as toys, baby bottles, clothing, and personal care products, have the potential to interfere with the delicate hormonal systems of developing children. The effects of EDCs are far-reaching, contributing to developmental delays, reproductive issues, and long-term health challenges that may not manifest until later in life.

As scientific evidence continues to highlight the dangers of EDC exposure, the responsibility falls on manufacturers and regulators to take proactive measures. Manufacturers must lead the charge by embracing safer alternatives and innovating new materials that do not compromise on safety or functionality. Regulatory bodies play a crucial role in enforcing stricter standards and ensuring that products on the market are free from harmful chemicals. Increased transparency and better labelling practices will empower consumers to make informed choices that prioritize the health of their children.

The shift towards EDC-free products is not just a matter of consumer preference; it is a public health imperative. As awareness grows, so does the demand for products that are both safe and sustainable. The transition away from harmful chemicals is a necessary step towards ensuring that future generations can grow up in an environment that supports their health and well-being.

In conclusion, addressing the issue of EDCs in children's products requires a collaborative effort from all sectors of society. By supporting safer alternatives, advocating for stronger regulations, and educating consumers, we can significantly reduce the risks associated with EDC exposure. Protecting children from the harmful effects of these chemicals is an investment in the future—a future where every child has the opportunity to grow up healthy, strong, and free from unnecessary chemical risks.

9. References

Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Polychlorinated Biphenyls (PCBs).* U.S. Department of Health and Human Services, Public Health Service, Nov. 2000, www.atsdr.cdc.gov/ToxProfiles/tp17.pdf.

Almeida-Toledano, L., Navarro-Tapia, E., Sebastiani, G., Ferrero-Martínez, S., Ferrer-Aguilar, P., García-Algar, Ó., ... & Gómez-Roig, M. D. (2024). Effect of prenatal phthalate exposure on fetal development and maternal/neonatal health consequences: A systematic review. *Science of The Total Environment,* 175080. https://www.sciencedirect.com/science/article/pii/S0048969724052306

Anderson, Stacey E., and B. Jean Meade. "Potential Health Effects Associated with Dermal Exposure to Occupational Chemicals." International Journal of Environmental Research and Public Health, vol. 11, no. 8, Aug. 2014, pp. 8089-8108, doi:10.3390/ijerph110808089. https://pmc.ncbi.nlm.nih.gov/articles/PMC4270264/

Agency for Toxic Substances and Disease Registry (ATSDR). (2020). Toxicological profile for lead. https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf

Arora Tripti (2023) Women's Health and Chemical Exposures. https://ipen.org/sites/default/files/documents/women_and_chemicals_factsheet.pdf

Azeredo, D. B. C., de Sousa Anselmo, D., Soares, P., Graceli, J. B., Magliano, D. A. C., & Miranda-Alves, L. (2023). Environmental endocrinology: parabens hazardous effects on hypothalamic–pituitary–thyroid axis. *International journal of molecular sciences, 24*(20), 15246.

Badley, J. R., Wilson, R. J., Werner, A. S., Smiley-Jewell, S. M., & Lein, P. J. (2023). The neurotoxicity of polychlorinated biphenyls (PCBs). In *Advances in Neurotoxicology* (Vol. 10, pp. 27-79). Academic Press. https://www.sciencedirect.com/science/article/abs/pii/S2468748023000280

Balalian, A. A., Whyatt, R. M., Liu, X., Insel, B. J., Rauh, V. A., Herbstman, J., & Factor-Litvak, P. (2019). Prenatal and childhood exposure to phthalates and motor skills at age 11 years. *Environmental research, 171,* 416-427.

Braun, J. M., & Hauser, R. (2011). Bisphenol A and children's health. *Current opinion in pediatrics, 23*(2), 233-239. https://journals.lww.com/co-pediatrics/abstract/2011/04000/bisphenol_a_and_children_s_health.18.aspx

Bretveld, R. W., Thomas, C. M. G., Scheepers, P. T. J., Zielhuis, G. A., & Roeleveld, N. (2006). Pesticide exposure: The hormonal function of the female reproductive system disrupted? Reproductive Toxicology, 22(2), 292–300. https://doi.org/10.1016/j.reprotox.2006.03.007

Blake, B. E., & Fenton, S. E. (2020). Early life exposure to per- and polyfluoroalkyl substances (PFAS) and latent health outcomes: A review including the placenta as a target tissue and possible driver of cardiometabolic and reproductive outcomes. Toxicology, 443, 152565. https://doi.org/10.1016/j.tox.2020.152565

Boberg, J., Taxvig, C., Christiansen, S., & Hass, U. (2010). Possible endocrine disrupting effects of parabens and their metabolites. *Reproductive Toxicology, 30*(2), 301-312. https://www.sciencedirect.com/science/article/abs/pii/S089062381000078X

Brosché, S. (2018). *Women, chemicals and the SDGs*: *Gender review mapping with a focus on women and chemicals*: *Impact of emerging policy issues and the relevance for the Sustainable Development Goals,* IPEN.

ipen.org/sites/default/files/documents/ipen-gender-chemicals-report-v1_6dw-en.pdf

CHEM Trust (2022) CHEMICAL COCKTAILS The neglected threat of toxic mixtures and how to fix it. https://chemtrust.org/wp-content/uploads/Chemical-cocktails_CHEMTrust-report_March-2022.pdf

Chem Trust (2017) No Brainer: The impact of chemicals on children's brain development: a cause for concern and a need for action. https://www.chemtrust.org/wp-content/uploads/chemtrust-nobrainer-mar17.pdf

Cunha, Y. G. D. O., Amaral, G. C. B. D., Felix, A. A., Blumberg, B., & Amato, A. A. (2023). Early-life exposure to endocrine-disrupting chemicals and autistic traits in childhood and adolescence: a systematic review of epidemiological studies. *Frontiers in Endocrinology, 14,* 1184546.

Department of Ecology, State of Washington (2021). Parabens in Children's Products. https://apps.ecology.wa.gov/publications/documents/1404016.pdf

Di Pietro, G., Forcucci, F., & Chiarelli, F. (2023). Endocrine disruptor chemicals and children's health. *International Journal of Molecular Sciences, 24*(3), 2671.

Diamanti-Kandarakis, E., Bourguignon, J. P., Giudice, L. C., Hauser, R., Prins, G. S., Soto, A. M., ... & Gore, A. C. (2009). Endocrine-disrupting chemicals: an Endocrine Society scientific statement. Endocrine reviews, 30(4), 293-342. https://doi.org/10.1210/er.2009-0002

Ejaredar, M., C Nyaza, E., Ten Eycke, K., Dewey, D. (2015), "Phthalate Exposure and Childrens Neurodevelopment: A Systematic Review." *Environmental Research,* vol. 142, pp. 51-60, doi:10.1016/j.envres.2015.06.014. https://pubmed.ncbi.nlm.nih.gov/26101203/

Endocrine Society, (2025) Endocrine-Disrupting Chemicals https://www.endocrine.org/advocacy/position-statements/endocrine-disrupting-chemicals

Endocrine Society, (2025) Impact of EDCs on Neurological and Behavioural Systems https://www.endocrine.org/topics/edc/what-edcs-are/common-edcs/neurological

Environmental Protection Agency. Brominated Flame Retardants. EPA Science Inventory, 2011, https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=226582

Environmental Protection Agency. (2023). Our Current Understanding of the Human Health and Environmental Risks of PFAS. https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas

Environmental Protection Agency. (2024, April 22). Learn about polychlorinated biphenyls. https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls

Faroon, O., Jones, D., & De Rosa, C. (2003). Toxicological profile for polychlorinated biphenyls (PCBs). Agency for Toxic Substances and Disease Registry (ATSDR). https://www.atsdr.cdc.gov/toxprofiles/tp17.pdf

Fiore, M., Floridia, A., Ledda, C., Mauceri, C., & Ferrante, M. (2015). Brominated flame retardants: environmental contamination, exposure sources and potential negative health effects. *Igiene e Sanita Pubblica, 71*(5), 527-537. https://europepmc.org/article/med/26722829

Food packaging Forum (2019) Philippines bans BPA in baby bottles. https://foodpackagingforum.org/news/philippines-bans-bpa-in-baby-bottles#:~:text=In%20a%20press%20release%20published,six%20month%20period%20to%20recall

Gore, A. C., Chappell, V. A., Fenton, S. E., Flaws, J. A., Nadal, A., Prins, G. S., Toppari, J., & Zoeller, R. T. (2015). EDC-2: The Endocrine Society's Second Scientific Statement on Endocrine-Disrupting Chemicals. Endocrine Reviews, 36(6), E1–E150. doi:10.1210/er.2015-1093 https://pubmed.ncbi.nlm.nih.gov/26544531/

Gore, A.C., La Merrill, M.A., Patisaul, H.B., and Sargis, R. (2024). Endocrine Disrupting Chemicals: Threats to Human Health. The Endocrine Society and IPEN. https://ipen.org/sites/default/files/documents/edc_report-2024-final-compressed.pdf

Grandjean, Philippe, and Esben Budtz-Jørgensen (2013). "Immunotoxicity of Perfluorinated Alkylates: Calculation of Benchmark Doses Based on Serum Concentrations in Children." *Environmental Health,* vol. 12, no. 35, doi:10.1186/1476-069X-12-35. Immunotoxicity of perfluorinated alkylates: calculation of benchmark doses based on serum concentrations in children | Environmental Health

HEAL, (2019) Health and Environmental Alliance, https://www.env-health.org/infographic-low-doses-matter/

Hlisníková, H., Petrovičová, I., Kolena, B., Šidlovská, M., & Sirotkin, A. (2020). Effects and mechanisms of phthalates' action on reproductive processes and reproductive health: a literature review. *International journal of environmental research and public health, 17*(18), 6811. https://www.mdpi.com/1660-4601/17/18/6811

Hu, K., Islam, M. A., Parvez, F., Bhattacharya, P., & Khan, K. M. (2024). Chronic exposure of arsenic among children in Asia: A current opinion based on epidemiological evidence. *Current Opinion in Environmental Science & Health, 39,* 100558. https://www.sciencedirect.com/science/article/abs/pii/S246858442400028X

IPEN, (2018) Women, Chemicals and the SDGs Gender Review Mapping With A Focus On Women And Chemicals: Impact Of Emerging Policy Issues And The Relevance For The Sustainable Development Goals. Women, Chemicals and the SDGs

Jeong, Y., Lee, S., Kim, S., Choi, S.-D., Park, J., Kim, ... & Moon, H.-B. (2014)**.** Occurrence and exposure assessment of polychlorinated biphenyls and organochlorine pesticides from homemade baby food in Korea. *Science of the Total Environment, 470–471,* 1370–1375. https://doi.org/10.1016/j.scitotenv.2013.10.041

Karlsson, T. and Miller, P. (2023) Are Your Children's Toys Hazardous Waste? High levels of chlorinated paraffins in plastic toys from ten countries. International Pollutants Elimination Network (IPEN), .https://ipen.org/sites/default/files/documents/chlorinated_paraffins_report-102023.pdf

Karsauliya, K., Bhateria, M., Sonker, A., & Singh, S. P. (2021). Determination of bisphenol analogues in infant formula products from India and evaluating the health risk in infants associated with their exposure. *Journal of Agricultural and Food Chemistry, 69*(13), 3932-3941.

Kiio, K. L., Mbui, D., Michira, I., & Njenga, H. (2019) Analysis of Bisphenol A in drinking water bottles and baby feeding bottles using Polyaniline/Bentonite Modified Glassy Carbon Electrode Biosensor.

Kim, K. H., Kabir, E., & Jahan, S. A. (2017). Exposure to pesticides and the associated human health effects. Science of the Total Environment, 575, 525–535. https://doi.org/10.1016/j.scitotenv.2016.09.009

Kobrosly, R. W., Evans, S., Miodovnik, A., Barrett, E. S., Thurston, S. W., Calafat, A. M., & Swan, S. H. (2014). Prenatal phthalate exposures and neurobehavioral development scores in boys and girls at 6–10 years of age. *Environmental health perspectives, 122*(5), 521-528. https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1307063

Kumar, S. (2004). Occupational exposure associated with reproductive dysfunction. *Journal of occupational health, 46*(1), 1-19.

Kumar, S. (2018). Occupational and environmental exposure to lead and reproductive health impairment: an overview. Indian journal of occupational and environmental medicine, 22(3), 128-137. https://journals.lww.com/ijoe/fulltext/2018/22030/Occupational_and_Environmental_Exposure_to_Lead.3.aspx

LaKind, J. S., Naiman, J., Verner, M. A., Lévêque, L., & Fenton, S. (2023). Per-and polyfluoroalkyl substances (PFAS) in breast milk and infant formula: A global issue. Environmental research, 219, 115042.

Lanphear, B. P., Rauch, S., Auinger, P., Allen, R. W., & Hornung, R. W. (2018). Low-level lead exposure and mortality in US adults: A population-based cohort study. The Lancet Public Health, 3(4), e177–e184. https://doi.org/10.1016/S2468-2667(18)30025-2

Leiba Nneka and Swanson Sydney (2020) EWG's Healthy Living: Guide to Safer Diapers. https://www.ewg.org/research/diaper-guide

Lyche, J. L., Rosseland, C., Berge, G., & Polder, A. (2015). Human health risk associated with brominated flame-retardants (BFRs). Environment International, 74, 170–180. https://doi.org/10.1016/j.envint.2014.09.006. https://www.sciencedirect.com/science/article/abs/pii/S0160412014002736

Maitre, L., Robinson, O., Martinez, D., Toledano, M. B., Ibarluzea, J., Marina, L. S., ... & Coen, M. (2018). Urine metabolic signatures of multiple environmental pollutants in pregnant women: an exposome approach. *Environmental science & technology, 52*(22), 13469-13480. https://pubmed.ncbi.nlm.nih.gov/30285427/

Manzoor, M. F., Tariq, T., Fatima, B., Sahar, A., Tariq, F., Munir, S., ... & Ibrahim, S. A. (2022). An insight into bisphenol A, food exposure and its adverse effects on health: A review. *Frontiers in nutrition, 9,* 1047827. https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2022.1047827/full

Mao, H., Lin, T., Huang, S., Xie, Z., Jin, S., Shen, X., ... & Ding, Y. (2024). The impact of brominated flame retardants (BFRs) on pulmonary function in US adults: a cross-sectional study based on NHANES (2007–2012). *Scientific Reports, 14(1),* 6486. https://pmc.ncbi.nlm.nih.gov/articles/PMC10948772/#:~:text=Our%20study%20demonstrates%20that%20both%20individual%20and,can%20lead%20to%20impaired%20pulmonary%20ventilation%20function.&text=Previous%20studies%20have%20demonstrated%20that%20BFRs%20possess,threats%20to%20both%20animal%20and%20human%20health6%E2%80%9311.

Mostafalou, S., & Abdollahi, M. (2017). Pesticides: an update of human exposure and toxicity. *Archives of toxicology, 91*(2), 549-599. https://pubmed.ncbi.nlm.nih.gov/27722929/

McDermott, A., Juárez, M., Wade, M. G., Patten, S. A., & Plante, I. (2025). Exposure to Brominated Flame Retardants During Pregnancy and Lactation Increases the Prevalence of Breast Lesions and Cancer-Associated Pathways in Sprague-Dawley Rats. *Reproductive Toxicology,* 108928. https://www.sciencedirect.com/science/article/pii/S0890623825000991

Meeker, J. D., Sathyanarayana, S., & Swan, S. H. (2009). Phthalates and other additives in plastics: Human exposure and associated health outcomes. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2097–2113. https://doi.org/10.1098/rstb.2008.0268

Miriyala A., Murthy M.B. S. S.: Ananth Rupesh Kattamreddy. (2024) The Global "Paraben Toxicity" Discourse: A Call for Indian Doctors and Researchers to Step in. National Board of Examination - Journal of Medical Sciences, Volume 2, Issue 2. https://natboard.edu.in/ejournal/article/publish/1024013199.pdf?2108959470

Mišľanová, C., & Valachovičová, M. (2025). Health Impacts of Per-and Polyfluoroalkyl Substances (PFASs): A Comprehensive Review. *Life, 15*(4), 573. https://www.mdpi.com/2075-1729/15/4/573

Naujokas, M. F., Anderson, B., Ahsan, H., Aposhian, H. V., Graziano, J. H., Thompson, C., & Suk, W. A. (2013). The broad scope of health effects from chronic arsenic exposure: update on a worldwide public health problem. *Environmental health perspectives, 121*(3), 295-302.

Noorimotlagh, Z., Mirzaee, S. A., Silva Martinez, S., Rachoń, D., Hoseinzadeh, M., & Jaafarzadeh, N. (2022). Environmental exposure to nonylphenol: A potential endocrine disruptor. *Environmental Research, 214*(3), 113934. https://doi.org/10.1016/j.envres.2022.113934

Nuti, F., Fernández, F. R., Severi, M., Traversi, R., Fanos, V., Street, M. E., ... & Papini, A. M. (2024). Study of Endocrine-Disrupting Chemicals in Infant Formulas and Baby Bottles: Data from the European LIFE-MILCH PROJECT. *Molecules, 29*(22), 5434.

Pérez-Bermejo, M., Mas-Pérez, I., & Murillo-Llorente, M. T. (2021). The role of the bisphenol A in diabetes and obesity. *Biomedicines, 9*(6), 666. https://www.mdpi.com/2227-9059/9/6/666

Pulcastro, H., & Ziv-Gal, A. (2024). Parabens effects on female reproductive health–Review of evidence from epidemiological and rodent-based studies. ***Reproductive Toxicology***, 108636. https://www.sciencedirect.com/science/article/abs/pii/S0890623824001035

Pure Earth (2022) ASSESSMENT OF LEAD IMPACT ON HUMAN AND INDIA'S RESPONSE. Lead-Report-India-CSIR-NITI-Ayog-June-2022.pdf

Radke, Elizabeth G., et al. "Phthalate Exposure and Metabolic Effects: A Systematic Review of the Human Epidemiological Evidence." Environment International, vol. 144, Nov. 2019, pp. 106096, doi:10.1016/j.envint.2020.106096. https://pubmed.ncbi.nlm.nih.gov/31196577/

Rochester, J. R. (2013). Bisphenol A and human health: A review of the literature. Reproductive Toxicology, 42, 132–155. https://doi.org/10.1016/j.reprotox.2013.08.008

Savage, Jessica H., et al. "Urinary Levels of Triclosan and Parabens Are Associated with Aeroallergen and Food Sensitization." Journal of Allergy and Clinical Immunology, vol. 130, no. 2, Aug. 2012, pp. 453-460, doi:10.1016/j.jaci.2012.05.006. https://pubmed.ncbi.nlm.nih.gov/22704536/

Shekhar, S., Sood, S., Showkat, S., Lite, C., Chandrasekhar, A., Vairamani, M., ... & Santosh, W. (2017). Detection of phenolic endocrine disrupting chemicals (EDCs) from maternal blood plasma and amniotic fluid in Indian population. *General and comparative endocrinology, 241,* 100-107.

Shrinithivihahshini, N. D., Mahamuni, D., & Praveen, N. (2014). Bisphenol A migration study in baby feeding bottles of selected brands available in the Indian market. ***Current science***, 1081-1084.

Smith, A. H., Marshall, G., Roh, T., Ferreccio, C., Liaw, J., & Steinmaus, C. (2017). Lung, bladder, and kidney cancer mortality 40 years after arsenic exposure reduction. Journal of the National Cancer Institute, 110(3), 241–249. https://doi.org/10.1093/jnci/djx201

State of the Science of Endocrine Disrupting Chemicals, (2012) Summary for Decision-Makers https://iris.who.int/bitstream/handle/10665/78102/WHO_HSE_PHE_IHE_2013.1_eng.pdf?sequence=1

Straková, J., Brosché, S., Brabcová, K. et al., (2023). Toxics in our Clothing: Forever Chemicals in Jackets and Clothing from 13 Countries.

https://ipen.org/sites/default/files/documents/clothing-chemicals-v12.pdf

Straková, J., Brosché, S., Grechko, V., et al., 2023. Forever Chemicals in Single-use Food Packaging and Tableware from 17 Countries, IPEN

https://ipen.org/sites/default/files/documents/ipen-packaging-report-fin-opr-25012024.pdf

Straková, J., Grechko, V., Brosché, S., Karlsson, T., Buonsante, V. (2022) A call to action: free children from BPA's toxic legacy. International Pollutants Elimination Network (IPEN). https://ipen.org/sites/default/files/documents/ipen-bpa-2021-v1_6q.pdf

Sunderland, E. M., Hu, X. C., Dassuncao, C., Tokranov, A. K., Wagner, C. C., & Allen, J. G. (2019). A review of the pathways of human exposure to poly-and perfluoroalkyl substances (PFASs) and present understanding of health effects. Journal of exposure science & environmental epidemiology, 29(2), 131-147. https://www.nature.com/articles/s41370-018-0094-1

Tang, Z. R., Xu, X. L., Deng, S. L., Lian, Z. X., & Yu, K. (2020). Oestrogenic endocrine disruptors in the placenta and the foetus. *International journal of molecular sciences, 21*(4), 1519.

The International Panel on Chemical Pollution (IPCP), (2017) Overview Report I: Worldwide initiatives to identify endocrine disrupting chemicals (EDCs) and potential EDC. https://wedocs.unep.org/bitstream/handle/20.500.11822/25633/EDC_report1.pdf?sequence=1&isAllowed=y

Toxics Link, (2014) Bottles can be Toxics An Investigative study on Bisphenol-A (BPA) in baby feeding bottles in India. https://toxicslink.org/wp-content/uploads/2022/08/BPA%20study%20report.pdf

Toxics Link, (2016) Beware of Toxic Sippy Cups An Investigative study on Bisphenol - A (BPA) in Sippy cups in India https://toxicslink.org/wp-content/uploads/2022/08/Study-on-Bisphenol-A-BPA-in-Sippy-cups-BPA-Sippy-Cups-2016.pdf

Toxics Link (2019a), What's in the Diaper? https://saicmknowledge.org/sites/default/files/publications/Whats%20in%20the%20Diaper.pdf

Toxics Link (2019b) Nonylphenol Dirty Trail Detergent to Water Bodies. https://toxicslink.org/publications/reports/nonylphenoldirty-trail-detergent-to-water-bodies

Toxics Link, (2020); Fact Sheet: PHTHALATES. https://toxicslink.org/wp-content/uploads/2022/08/Phthalate%20Factsheet.pdf

Toxics Link, (2021) Issues And Concerns of Talcum Powder in India. https://ipen.org/sites/default/files/documents/toxicslink_2021_talc_report.pdf

Toxics Link (2023) Lead in Solvent-Based Paints for Home Use in India. https://toxicslink.org/wp-content/uploads/2023/08/India%20Lead%20Paint%20Report%20Summary%20(October%202023).pdf

Toxics Link, (2024a), Nonylphenol- An Endocrine Disrupting Chemical. https://toxicslink.org/wp-content/uploads/2024/10/A%20report%20on%20Nonylphenol-%20An%20Endocrine%20Disrupting%20Chemical.pdf

Toxics Link, (2024b). Factsheet: Chlorinated Paraffins. https://toxicslink.org/wp-content/uploads/2024/01/Toxic%20Link%20-%20Chlorinated.pdf

Tung, C. J., Chen, M. H., Lin, C. C., & Chen, P. C. (2024). Association between parabens exposure and neurodevelopment in children. Environment International, 188, 108671.

United States Consumer Product Safety Commission. (2017). Prohibition of children's toys and child care articles containing specified phthalates: Determinations. Federal Register, 82(168), 49938-49954. Retrieved from Federal Register website https://www.federalregister.gov/

documents/2017/08/30/2017-18387/prohibition-of-childrens-toys-and-child-care-articles-containing-specified-phthalates-determinations#:~:text=The%20rule%20creates%20a%20new%20part%201308,statutorily%20prohibited%20phthalates%20(DEHP%2C%20DBP%2C%20BBP%2C%20DINP%2C

U.S. Environmental Protection Agency. (2025). Learn more about PCBs. https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls#:~:text=They%20have%20been%20shown%20to,system%20and%20other%20health%20effects.

Vandenberg Laura, (2012) When the dose doesn't make the poison: low dose effects & endocrine disrupting chemicals. https://www.efsa.europa.eu/sites/default/files/event/documentset/120614l-p07.pdf

WebMD, (2025) What Is BPA and Is It Safe? https://www.webmd.com/children/bpa#:~:text=BPA%20Basics,-BPA%20is%20a&text=More%20than%2090%25%20of%20us,for%20babies%20and%20young%20children.

World Health Organization. "Lead Poisoning and Health." World Health Organization, 2024, www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health.

World Health Organization. "Lead Poisoning." *World Health Organization, 27 September 2024a. https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health*

World Health Organization. "Arsenic." *World Health Organization,* 15 Feb. 2024b, www.who.int/news-room/fact-sheets/detail/arsenic.

WHO, (2025) Providing information on endocrine disrupting chemicals and child health. https://www.who.int/activities/providing-information-on-endocrine-disrupting-chemicals-and-child-health

Yang, Y., Wang, J., Tang, S., Qiu, J., Luo, Y., Yang, C., ... & Cao, H. (2025). Per-and polyfluoroalkyl substances (PFAS) in consumer products: An overview of the occurrence, migration, and exposure assessment. *Molecules, 30*(5), 994.

Zheng, G., Boor, B. E., Schreder, E., & Salamova, A. (2019). Indoor exposure to per-and polyfluoroalkyl substances (PFAS) in the childcare environment. *Environmental Pollution, 258,* 113714.

H-2, Jangpura Extension
New Delhi - 110014, India
T: +91-(0)11-49931863

https://www.instagram.com/toxics_link/
https://www.facebook.com/toxicslink
https://twitter.com/toxicslink
https://www.youtube.com/toxicslink
www.toxicslink.org