POISON PLASTICS

How Chemicals in Everyday Plastics Are Harming Your Health

Paul Angell Foundation

ENVIRONMENTAL JUSTICE FOUNDATION

Protecting People and Planet

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The Environmental Justice Foundation (EJF) exists to protect the natural world and defend our basic human right to a secure environment.

EJF works internationally to inform policy and drive systemic, durable reforms to protect our environment and defend human rights.
We investigate and expose abuses and support environmental defenders, Indigenous peoples, communities and independent journalists on the frontlines of environmental injustice.
Our campaigns aim to secure peaceful, equitable and sustainable futures.

Everyone has the right to a world free from plastic pollution. EJF's plastics campaign champions the right to reduce, the right of people everywhere to secure real cuts in plastic production to protect our natural world, human health and climate.

Our investigators, researchers, filmmakers and campaigners work with grassroots partners and environmental defenders across the globe.

Our work to secure environmental justice aims to protect our global climate, ocean, forests, wetlands, wildlife and defend the fundamental human right to a secure natural environment, recognising that all other rights are contingent on this.

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Registered charity no. 1088128
info@ejfoundation.org | ejfoundation.org

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Acronyms and abbreviations

ADHD = Attention-deficit/hyperactivity disorder

ASD = Autism spectrum disorder

BPA = Bisphenol A

CD = Crohn's disease

CMR = Carcinogenic, mutagenic and reprotoxic

DEHP = Di(2-ethylhexyl) phthalate

EDC(s) = Endocrine disruption/endocrine-disrupting chemicals

GHG = Greenhouse gas

HS = Hidradenitis suppurativa

IQ = Intelligence quotient

MEA(s) = Multilateral environmental agreement(s)

NIAS = Non-intentionally added substances

PBDE(s) = Polybrominated diphenyl ether(s)

PCB(s) = Polychlorinated biphenyl(s)

PMOS = Polyendocrine metabolic ovarian syndrome

PFAS = Per- and polyfluoroalkyl substances

POP(s) = Persistent organic pollutant(s)

PVC = Polyvinyl chloride

Glossary of terms

PBDEs (Polybrominated diphenyl ethers):
Plastic additives used heavily as flame retardants. Flame retardants are often added to electronics, textiles and other items to reduce fire hazard.[1]

BPA (Bisphenol A):
One of the most widely used synthetic compounds in the world. Used extensively in polycarbonate plastics, epoxy resins and as a plastic additive. Found in many commonly used applications including plastic bottles and food containers.[2] BPA is actively being phased out in many countries due to health concerns.[3]

Carcinogenic:
Can cause or promote cancer.[4]

DEHP (Di(2-ethylhexyl) phthalate):
Common plasticiser used to soften PVC and make it more flexible. Found in many plastic products including packaging, toys and particularly medical devices.[5]

Endocrine disruption:
Interference with the hormonal system.[6]

Leaching:
Process by which chemical additives migrate from (micro)plastics into food, water, soil, and living organisms (including humans). Influenced by factors such as temperature, pH, and the physical and chemical properties of additives and surrounding media.[7]

Mutagenic:
Can cause genetic mutations.[8]

NIAS (Non-intentionally added substances):
Substances such as those arising from the degradation of polymers or additives, impurities present in the raw materials, and reaction by-products generated during manufacture and along the entire supply chain.

Oxidative stress:
A state of disturbance and imbalance when there are too many free radicals (unstable molecules) in the body and not enough antioxidants to remove these. Results in measurable damage to cells, tissues and organs.[9]

PCBs (Polychlorinated biphenyls):
Highly carcinogenic and neurotoxic chemicals that were regulated decades ago after being widely used in electrical equipment and other products.[10] They remain pervasive today and new research has revealed that the current generation of by-product PCBs (PCBs that are inadvertently generated during a variety of different chemical processes) may be exceeding peak PCB production of the 1970s.[11]

PFAS (Per- and polyfluoroalkyl substances):
A class of thousands of substances known as 'forever chemicals' due to their high persistence. Applied in virtually all sectors, including in items such as paper and cardboard, cleaning products, non-stick pans, and cosmetics such as toothpaste.[12]

Plasticiser(s):
Substance(s) added to materials (particularly plastics) to make them more flexible, durable and soft.[13]

Plastic chemicals/plastic-associated chemicals:
All chemicals present in plastic materials and products. This includes the polymer backbone, intentionally added substances such as additives and processing aids, and non-intentionally added substances such as impurities, by-products and degradation products.[14] It does not include external contaminants that stick to plastics.

Plastics:
A group of primarily synthetic materials composed of polymers (long chains of molecules). Virgin plastics are manufactured from petrochemical feedstock, which is derived from fossil fuels. Recycled plastics are made from plastic scrap or waste.[15]

POPs (Persistent organic pollutants):
Considered 'silent killers' due to their poisonous, bioaccumulative and persistent nature. Known for their use as pesticides and regulated by the Stockholm Convention.[16]

Reprotoxic:
Can damage the reproductive process.[17]

Specific organ toxicity:
Specific, non-lethal toxic effects on target organs.[18]

EXECUTIVE SUMMARY

Plastics and the chemicals they contain have become deeply embedded in our lives within only a single generation. They are found in the vast majority of items we rely on every day – from food packaging and takeaway containers, to clothing, furniture, hygiene products, infant feeding bottles and children's toys. While global plastic production was under two million tonnes in 1950, today more than 430 million tonnes of plastics are produced annually.[19] Global plastic production has been projected to more than double by 2050 and more than triple by 2100,[20] and it has been estimated that we will have produced two billion tonnes of chemical plastic additives by the end of 2050.[21] Our reliance on plastics has come at a huge environmental cost: around three-quarters of all plastic produced between 1950 and 2017 became plastic waste, with more than 50 million tonnes of plastic waste projected to enter aquatic ecosystems each year by 2030.[22] The plastics industry is now the fastest growing source of industrial greenhouse gas (GHG) emissions.[23] If the global plastics system were a country, it would be the third-largest greenhouse gas emitter in the world by 2040, behind only China and the United States.[24]

Alongside their rapidly mounting environmental impacts, plastics represent a direct and escalating threat to human health. Plastics carry both intentionally added and non-intentionally added chemicals.[25] These tend not to be chemically bonded to plastics, and may therefore leach (migrate) directly from plastic products and materials into food, water, soil, the air, and living organisms, including the human body.[26] Leaching can occur directly from plastic products, as well as from primary (intentionally produced) and secondary (released from the breakdown of larger plastics) micro- and nanoplastics. Plastic chemicals can enter the body via ingestion, inhalation or other types of exposure or contact, such as through the skin.[27]

Ingestion often occurs via food-contact materials. Plastic-associated chemicals can leach from plastic bottles and containers, takeaway cups, fast food packaging, kitchen utensils, and cookware among other items.[28] They can also be ingested via non-food sources, such as toothpaste.[29] Babies and young children are particularly prone to ingesting plastic chemicals, from items such as infant feeding bottles[30] and pacifiers[31], and through unique behaviours such as mouthing of plastic toys[32]. Inhalation is also an important exposure pathway, both in indoor and outdoor environments.[33] Chemicals can be inhaled through airborne microplastics from a range of sources, including the erosion of vehicle tyres, the washing, drying and general wear and tear of synthetic clothing, the deterioration of house furniture, as well as from landfills and construction materials.[34] Car cabins contain high concentrations of plastic chemicals due to their interiors being made primarily of plastics and synthetic textiles.[35] Skin contact is another type of exposure, as chemicals are capable of penetrating the skin barrier.[36] Sources include synthetic textiles and microfibres,[37] cosmetics,[38] and hygiene products among others.[39]

Exposure to chemicals used in the production of plastics has been linked to a range of adverse and often lifelong health impacts. These include infertility, neurodevelopmental disorders, cardiovascular disease and stroke, obesity and diabetes, renal disease, and cancers.[40] Many plastic chemicals are known to be endocrine disruptors, meaning that they interfere with the body's hormones.[41] They have been found to affect the reproductive system in both men and women, lowering sperm quality and increasing the risk of developing conditions such as endometriosis and polyendocrine metabolic ovarian syndrome (PMOS).[42] Exposure during pregnancy or childhood is especially concerning due to the extreme sensitivity of fetal and early childhood development. Children's immature organs and tissues are less able to break down and excrete toxins, allowing these to accumulate in the body and cause harm.[43] Studies have identified links between plastic-associated chemicals and increased risks of miscarriage, premature birth, stillbirth, low birth weight, birth defects, impaired lung growth, lower intelligence quotient (IQ), increased prevalence of child autism and attention-deficit/hyperactivity disorder (ADHD), asthma and childhood cancer.[44]

Our understanding of the magnitude of the plastics-related health crisis is only beginning to unfold. While research has already revealed serious risks to human health and development, major data gaps still remain for thousands of plastic-associated chemicals in common use. The PlastChem project – which synthesised evidence on more than 16,000 chemicals present or marketed for use in plastics – identified more than 4,200 plastic chemicals as hazardous for human health and/or the environment.[45] Concerningly, the analysis found that hazard information is lacking for over 10,000 plastic chemicals, while less than 6% of chemicals potentially used or present in plastics are currently subject

to international regulation.[46] Many more plastic chemicals likely exist, particularly non-intentionally added substances, the majority of which are unknown and untested.[47] In other words, there are likely tens of thousands of chemicals present in plastics worldwide – many in daily use – that may have severe but as yet unknown implications for human health.[48]

The Environmental Justice Foundation (EJF) conducted novel analyses of the PlastChem data to shed light on the risks presented to human health by everyday items containing plastic-associated chemicals.[49] EJF's analysis revealed significant gaps in our understanding of the health risks of chemicals in everyday plastic items. The majority of chemicals (79.2%) in the five use categories analysed – food-contact plastics, textiles, toys, household items, and hygiene and medical items – lacked relevant data to assess human health toxicity, risk of exposure, or both. Alarmingly, 92.8% of chemicals assessed were identified by EJF as presenting a high risk to human health based on their toxicity (carcinogenicity, mutagenicity, reproductive toxicity, organ toxicity, or endocrine-disrupting properties) and risk of exposure (presence in or evidenced release from plastics). Many of the chemicals identified are known or suspected to cause cancer, damage vital organs, disrupt hormones, impair fertility and development, and contribute to chronic disease.

The implications are stark: we are facing a plastic-related health crisis. As scientific evidence continues to build, a precautionary approach to regulating the use of plastic chemicals must be followed to guard against the threat of significant harm to human health. Our analysis, however, revealed the sheer inadequacy of current regulation, which fails to address health risks even where these are well established. Of the high risk chemicals identified, 82.9% are not subject to regulation under any relevant multilateral environmental agreement (MEA), i.e. the Stockholm Convention, the Basel Convention, the Minamata Convention, the Montreal Protocol or the Rotterdam Convention. Crucially, 54.2% of the chemicals identified by EJF as presenting a high risk to human health are neither subject to regulation at the international level, nor in any of the four jurisdictions reviewed by PlastChem (the EU, Japan, South Korea and California).

The ubiquity of plastics in today's world ensures that no one is safe from harm – the plastics crisis affects everyone. Most of us rely on everyday supermarket products that are heavily processed and packaged. In addition, people who live near plastic production, waste and incineration sites face higher cumulative exposure.[50] Plastic production, consumption and pollution therefore pose a universal threat to human health while reinforcing structural inequities and deepening environmental and health burdens on marginalised populations.

Plastics are not just an environmental issue. They are a direct and escalating threat to human health. Without strong, binding global action, plastic production is projected to more than double by 2050, further increasing our exposure to toxic materials and deepening harm.[51] To protect both people and the planet, governments must act swiftly and decisively to reduce plastic production, eliminate hazardous chemicals across the plastics life cycle, and build toxic-free reuse, refill, repair, and other reduction-enabling systems and practices that allow people to live free from the damaging impacts of plastics. Producers must be held responsible and the burden of proof must be placed onto those who profit from this toxic and polluting industry. The ongoing negotiations to establish an international legally binding instrument to address plastic pollution, widely known as the 'Global Plastics Treaty', present an opportunity to accomplish these goals and confront the plastics crisis on a global scale.

- **The majority of chemicals (79.2%) in the five use categories analysed lacked relevant data to assess human health toxicity, risk of exposure, or both.**
- **Alarmingly, 92.8% of chemicals assessed were identified by EJF as presenting a high risk to human health based on their toxicity and risk of exposure.**
- **Of the high risk chemicals identified, 82.9% are not subject to regulation under any relevant multilateral environmental agreement (MEA).**
- **54.2% of the chemicals identified by EJF as presenting a high risk to human health are neither subject to regulation at the international level, nor in any of the four jurisdictions reviewed by PlastChem.**

Recommendations

To reduce the human health impacts of plastics and their associated chemicals, EJF urges governments and their representatives to push for a strong Global Plastics Treaty, but not to rely on action at the global stage to initiate and implement solutions. We call on policy-makers to push for national, regional and plurilateral action while continuing to seek progress at the multilateral level. EJF recommends regulation that includes:

1. Binding targets to drastically reduce the production, supply and trade of primary plastic polymers, with clear and enforceable timeframes for implementation. EJF endorses the 40x40 target proposed by Rwanda and Peru to reduce global primary plastic production by 40% by 2040, with a 2025 baseline.

2. Strong provisions to regulate the use of chemicals of concern throughout the life cycle of plastics (as well as other materials), especially during production. These provisions must include mechanisms to prohibit the production, use and trade of hazardous chemicals based on a precautionary approach, with chemicals tested for hazard before market release (**Box 13**).

3. Strong provisions on transparency and traceability of plastics and associated chemicals throughout their life cycle, to fill information gaps on the threats from plastic-associated chemicals, hold chemical and polymer producers accountable and empower regulatory agencies.

4. Strong provisions to prohibit or restrict the production, use, trade, sales and distribution of toxic and inessential plastic products, especially single-use plastics and plastics with high risk of toxicity and exposure.

5. Strong provisions to improve the design of plastic products with the goal of protecting human health.

6. Strong provisions to support the implementation of toxic-free reuse, refill, repair and other reduction-enabling systems in place of toxic single-use systems.

7. Mechanisms for cross-border cooperation, as well as transparency and traceability measures, to ensure restrictions on production and trade can be effectively enforced.

8. The protection of health and human rights as a primary objective and cross-cutting theme throughout. Regulations should aim to tackle the plastics crisis from a One Health perspective, recognising the need for an integrated approach to addressing threats to the biosphere as a whole, including humans, other living organisms, and ecosystems alike (**Box 14**).

9. Support for urgent multidisciplinary research and education on the human health and environmental impacts of plastics, in order to fill knowledge gaps and align plastics governance with environmental and public health governance.

10. Support for robust, transparent and up-to-date data on the climate, health and biodiversity impacts of plastic production.

EJF calls on governments to guarantee our 'Right to Reduce', i.e. the right to a clean and healthy environment through reducing plastic production and consumption, replacing single-use plastics with toxic-free reuse, refill, repair and other reduction-enabling systems, and regulating the use of toxic plastic chemicals based on a precautionary approach.[52]

A water refill station installed in Bangkok under EJF's Bottle Free Seas project.

Introduction

We are facing an urgent plastics crisis. Plastics are choking our oceans, infiltrating our ecosystems and fuelling global climate breakdown. While global plastic production was under two million tonnes in 1950, today more than 430 million tonnes of plastics are produced annually.[53] Global plastic production has been projected to more than double by 2050 and more than triple by 2100,[54] and it has been estimated that we will have produced two billion tonnes of chemical plastic additives by the end of 2050.[55] Three-quarters of all plastic produced between 1950 and 2017 became plastic waste.[56] Only 9% of the world's plastic waste is recycled – around half is sent to landfill, 19% is incinerated and the remaining 22% is either burnt, dumped or ends up in the natural environment.[57] More than 50 million tonnes of plastic waste are projected to enter aquatic ecosystems each year by 2030.[58] The plastics industry is the fastest growing source of industrial greenhouse gas (GHG) emissions[59] – currently accounting for 4-5% of global emissions[60] – around 90% of which occur during the process of extracting and converting fossil fuels into plastics (**Box 1**).[61] Annual GHG emissions from the global plastic system are forecast to triple by 2050[62], consuming nearly a third of the global carbon budget for limiting warming to 1.5°C.[63] If the global plastic system were a country, it would be the third-largest greenhouse gas emitter in the world by 2040, behind only China and the United States.[64]

Owing to their durability, versatility and low cost, plastics (**Box 1**) have become ubiquitous in modern society, used in all manner of applications – from the pillows we sleep on, to the clothes we wear, the toothbrushes we use and the containers we eat and drink from. With plastics now infiltrating almost all aspects of daily life, it is becoming increasingly evident that our reliance on plastics has severe implications for our collective health. Of the thousands of chemicals known to be potentially present or used in plastics, many have been found to cause harm to human health. Over time, plastics fragment into micro- and nanoplastics and release toxic chemical additives – such as plasticisers, dyes and flame retardants – into water, soil, food, and the air. These enter the human body primarily via ingestion, inhalation or absorption through the skin.[65] Recent years have seen a proliferation of published research on the extensive health implications of plastics, with plastic chemicals linked to an array of acute and chronic health conditions, including hormone disruption, damage to vital organs, impairment of fertility and neurodevelopment, and increased risk of cancer and heart disease.[66] Vulnerable groups – in particular infants, children and pregnant people – face heightened risks. Plastic-associated exposures have been linked to severe reproductive impacts such as stillbirth and premature birth, while early-life exposures can have lasting developmental effects and increase the risk of non-communicable diseases later in life.[67]

If the global plastic system were a country, it would be the third-largest greenhouse gas emitter in the world by 2040, behind only China and the United States.

Three-quarters of all plastic produced between 1950 and 2017 became plastic waste.

Box 1: What are plastics?

The average person in western Europe uses around 150 kg of plastic per year – more than double the global average of 60 kg.[68] Yet most of us do not know where plastics come from, what they are made of or how they affect our health.

Over 99% of plastics are made from fossil fuels.[69] Oil, coal or gas are refined to obtain petrochemical feedstocks (raw material) such as ethane and naphtha, which are then broken apart to produce chemicals called monomers. These monomers are joined into chains called polymers, which are used to construct plastics as we know them.[70]

The term 'plastic' comes from the Greek 'plastikos' and the Latin 'plasticus', meaning 'capable of being moulded'.[71] Plastics therefore get their name from their ability to be easily shaped and processed. These properties are enhanced for specific applications by the incorporation of chemical additives, such as plasticisers, stabilisers, lubricants, colourants, flame retardants, anti-static agents and fillers, among others.[72] These plastic-associated chemicals are an essential part of plastics, providing functionality for many different uses while significantly contributing to the health hazards of plastics.

Of the thousands of chemicals known to be potentially present or used in plastics, many have been found to cause harm to human health.

In the UK, an estimated 90% of processed foods and 70% of food and drink items come wrapped in plastic packaging, leaving consumers at high risk of exposure to plastic chemicals.

Box 2: A brief history of plastics

Synthetic plastics have only been in existence for around 100 years.[73] The first semi-synthetic plastic, Celluloid, was developed in 1863, when an American company offered a prize to anyone who could create an acceptable substitute for elephant ivory in billiard balls.[74] In 1907, Bakelite followed as the first entirely synthetic plastic and proceeded to be widely used across industries.[75] Many plastic inventions occurred between the two World Wars, and production took off after World War II. Since 1950, plastic production has grown from two million tonnes to 430 million tonnes per year today,[76] with an average annual growth rate of 8.4%.[77]

The ubiquity of plastics in today's world ensures that no one is safe from harm – the plastics crisis affects everyone. Most of us rely on everyday supermarket products that are heavily processed and packaged. In addition, people who live near plastic production, waste and incineration sites face higher cumulative exposure.[78] Plastic production, consumption and pollution therefore pose a universal threat to human health while reinforcing structural inequities and deepening environmental and health burdens on marginalised populations.

Meanwhile, as oil and gas reserves decline, the largest fossil fuel and petrochemical companies are expanding investment into this toxic industry to the detriment of us all. A recent report by Greenpeace found that, since negotiations for a Global Plastics Treaty began in November 2022, seven of these companies – Dow, ExxonMobil, BASF, Chevron Phillips, Shell, SABIC and INEOS – have expanded their capacity to make new plastic by 1.4 million tonnes, locking in pollution and financing harm to our collective health.[79]

New evidence is emerging weekly on the human health impacts of plastics and toxic plastic chemicals. In the context of ongoing negotiations for a Global Plastics Treaty, the Environmental Justice Foundation (EJF) carried out an analysis of publicly available data in the PlastChem database[80] – which synthesises evidence on more than 16,000 chemicals present or marketed for use in plastics – to shed light on the risks presented to human health by everyday items containing plastic-associated chemicals. Our analysis focused on the following use categories: (i) food-contact plastics, (ii) textiles, (iii) toys, (iv) household items, and (v) hygiene and medical items. A semi-structured questionnaire was used to gather insights from scientists who in recent years have published research on the impacts of plastics on human health in peer-reviewed journals. This report presents the findings of our analysis, which reveals both significant health risks and severe deficits in available hazard data for many chemicals found in everyday plastic items. Our findings highlight the urgent need to reduce plastic production and consumption and to eliminate hazardous chemicals across the plastics life cycle to safeguard global health.

Map Ta Phut in Rayong Province, Thailand, hosts one of the world's largest petrochemical complexes.

The toxic chemistry of plastics

Plastics are a public health crisis, yet governments have failed to act accordingly. In recent years, a substantial body of scientific research has revealed how thousands of plastic chemicals are harming our health every day.

Plastic chemicals, or plastic-associated chemicals, are chemicals present in plastic materials and products. They include the polymer backbone, intentionally added substances such as additives and processing aids, and non-intentionally added substances (NIAS) such as those arising from the degradation of polymers or additives, impurities present in the raw materials, and reaction by-products generated during manufacture and along the supply chain.[81] As most added substances are not chemically bound to the plastic polymer, they can leach out into food, water, soil, the air and even the human body.[82] Many plastic chemicals have been found to be toxic to human health and have been labelled as 'chemicals of concern'.[83]

Exposure to plastic chemicals has been linked to a range of adverse and often lifelong health impacts. These include infertility, neurodevelopmental disorders, cardiovascular disease and stroke, obesity and diabetes, renal disease, and cancers.[84] Plastic chemicals have been found to affect the reproductive system in both men and women, lowering sperm quality and increasing the risk of developing conditions such as endometriosis and polyendocrine metabolic ovarian syndrome (PMOS).[85]

Exposure during pregnancy or childhood is especially concerning due to the extreme sensitivity of fetal and early childhood development. Studies have identified links between plastic chemicals and increased risks of miscarriage, premature birth, stillbirth, low birth weight, birth defects, impaired lung growth, lower intelligence quotient (IQ), increased prevalence of child autism and attention-deficit/hyperactivity disorder (ADHD), asthma and childhood cancer.[86]

Human exposure to plastic chemicals

Plastics are present in virtually every industrial sector. They can be found in packaging, household products, electronics, building materials, transport, agriculture and medical devices among other uses.[87] Plastic-associated chemicals used in the manufacture of plastics include plasticisers, such as phthalates, that enhance the flexibility and softness of plastics; antioxidants, such as phenols and arylamines, that mitigate the degradation of plastics by chemicals, light or heat; and flame retardants, such as halogenated compounds, that improve resistance to fire.[88] **Table 1** shows further examples of chemical additives and their applications.

The ubiquity of plastics in today's world ensures that no one is safe from harm.

Table 1: Typical chemical additives and their applications

Additive category	Specific additive group	Example application	Chemical classes	Typical amount (%)
Functional additives influence specific properties such as stability against UV light and heat, resistance to microbes, flame retardancy, durability, softness, hardness, aesthetics, etc.	Light stabilizers	PE, PP, PVC	phenolic benzotriazoles (e.g., UV-328), cadmium compounds (e.g.,cadmium oxide), lead and lead compounds	0.1-10
	Heat stabilizers	PVC	cadmium compounds, lead compounds, nonylphenol, barium and calcium salts	0.1-3
	Antistatic agents	PE films, PE and PP foams, PVC, PP injection moulding applications	long-chain alkyl phenols, ethoxylatedamines, glycerol esters such as glycerol monostearate	0-1
	Antioxidants	LDPE, HDPE, high impact polystyrene (HIPS) and ABS	phenolic antioxidants, phosphites	0.05-3
	Flame retardants	Foam, plastic	brominated and chlorinated flame retardants (BFRs/CFRs)	2-28
	Plasticizers (softeners)	PVC, cellulose plastic	phthalates and short- and medium-chain chlorinated paraffins (SCCPs/MCCPs)	10-70
	Lubricants	PVC, PS/ABS, PP, PE	fatty acid esters, hydrocarbon waxes, metal stearates, amide waxes, ester waxes	0.1-3
	Slip agents	LDPE, PP	erucamide, oleamide, stearamide	0.05-0.15
	Curing agents (hardeners)	Epoxyresins	4,4'-Diaminodiphenylmethane, 2,2'-dichloro-4, 4'- methylenedianiline	0.1-2
	Foaming agents			
	Nucleating agents			
	Blowing agents	PVC, PE, epoxyresins	C,C'-azodi (formamide) (ADCA), fluorinated greenhouse gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6)	0.05-20
	Dispersing agents	Dispersing agent for the production of special plastics, e.g., PTFE	PFOA and similar compounds	
	Biocides	PUR, PVC	organic tin compounds, arsenic compounds, triclosan	0.001-1
	Fragrances	PE, PP, PS, PC, PET, EVA, PLA, nano particles	natural extracts, synthetic fragrances	
	Catalyst	PVC, PE, PP and other non-specified plastics, PUR	chromium and chromium compounds (e.g., chromium trioxide), mercury and mercury compounds	0.1-0.3
	Cross-linker	PE, PP	organic peroxides, BPA, formaldehyde	
Colourants give colour to the final plastic product	Pigments	PVC, PE, PP and other non-specified plastics	cadmium compounds (e.g., cadmium sulfide), chromium compounds, lead chromates	0.01-5
	Soluble azocolorants	polyethersulfone (PES), PA, acrylic	organic-based colorants (e.g., 573-58-0, 1937-37-7)	
Fillers occupy space in plastic materials without changing the functional properties; they replace expensive resins to reduce costs	Mica			
	Talc			
	Kaolin			
	Clay			
	Calcium carbonate			
	Barium sulphate			
Reinforcements are used to enhance mechanical properties such as the strength and elasticity of plastics	Glass fibres			15-30
	Carbon fibres			

Note: Table taken from UNEP[89]

Plastic-associated chemicals are often not chemically bonded to plastics. This means that they can leach (migrate) directly from plastic products and materials into food, water, soil, the air, and living organisms, including the human body. While some chemicals, such as metal compounds, may be bound to the plastic polymer chains, they can still be released from plastics under certain conditions, for example, under high temperatures or when in contact with acidic beverages.[90] Plastic chemicals can leach from both primary plastic products and secondary micro- and nanoplastics that are released from the breakdown of larger plastics.

Leaching is influenced by factors such as temperature, pH, permeability of the polymer matrix, additive size, concentration, solubility, and volatility.[91] High temperatures and pH levels, for example, have been shown to accelerate the release of chemicals from plastics.[92] Leaching may also be intensified by extended exposure to water especially in turbulent conditions.[93] Chemicals with lower molecular weight/molecule sizes leach faster from plastics than larger, heavier chemicals.[94] The fragmentation of plastics into micro- and nanoplastics increases the surface area to volume ratio of plastic particles, which may increase the release of chemicals into surrounding environments (**Box 3**).

Once released from plastics, chemicals may degrade to form other toxic pollutants.[95] Some chemicals (such as persistent organic pollutants - POPs) do not break down easily, so they persist in the environment and may accumulate in living organisms.[96]

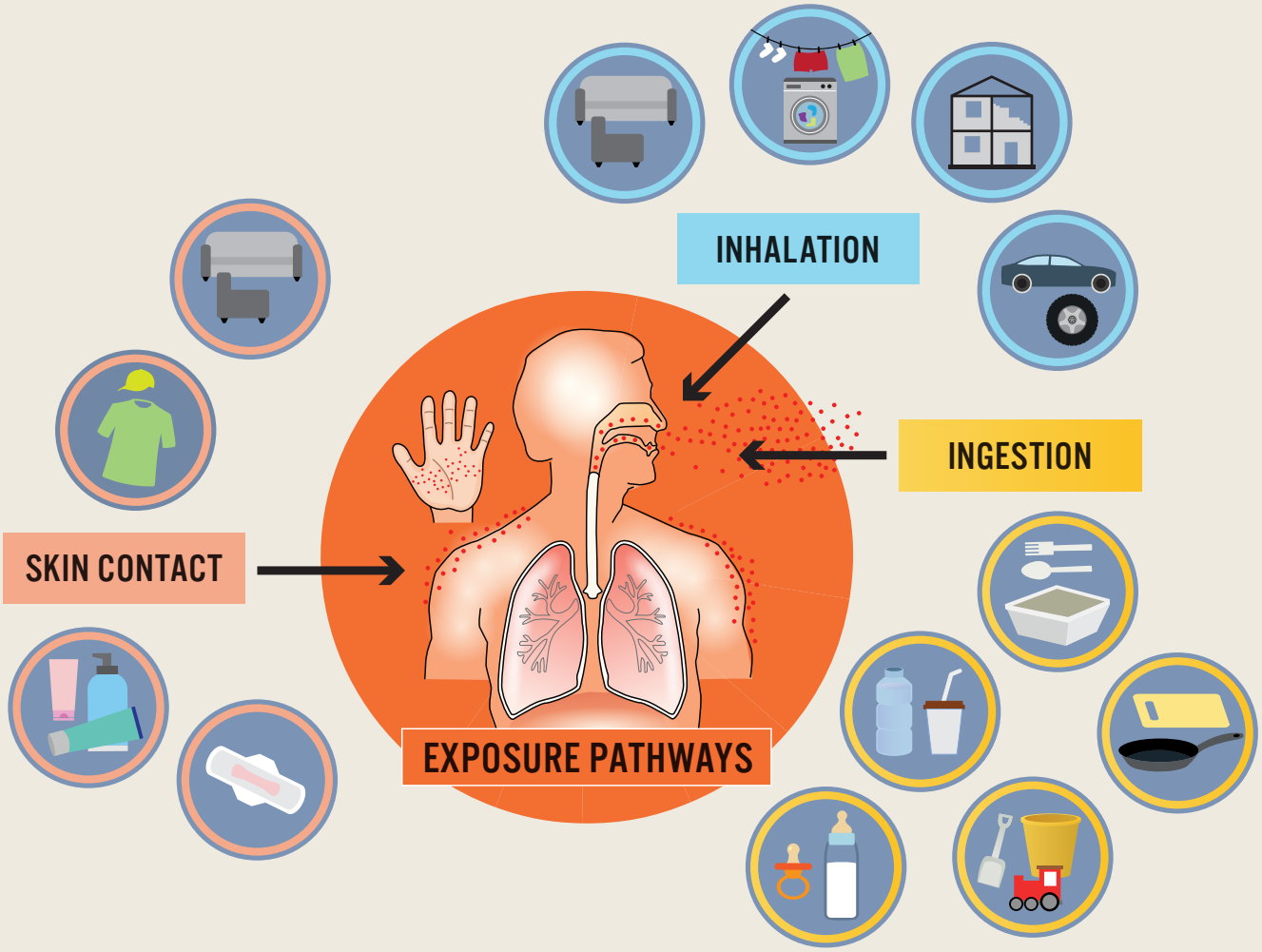
Box 3: The compounding impact of microplastics, chemicals and environmental contaminants

The fragmentation of plastics into ever-smaller pieces – and ultimately into microplastics and nanoplastics – increases the likelihood that chemicals will leach from these plastics and that environmental pollutants will attach to and be transported by them.[97] This is because smaller particles have a larger surface area to volume ratio than larger particles, which increases their sorption capacity.[98] Microplastics can contain thousands of plastic-associated chemicals – including those with known health impacts such as phthalates and bisphenols – which regularly migrate out of these particles and into the environment and human food chains.[99] They have also been identified as key carriers of environmental contaminants such as heavy metals, POPs and antibiotics, which can adsorb onto the surface of the particles and move with them through the food web and into the human body.[100]

Humans are exposed to toxic chemicals at every stage of the plastics life cycle – from production through to use and disposal. Outside of occupational settings, consumer products, dust, air, drinking water and food have all been identified as sources of human exposure to toxic plastic chemicals.[101] A single plastic product can contain complex mixtures of hundreds of additives.[102] These may be carcinogenic and/or mutagenic, and may interfere with the hormonal system, cause damage to organs, and impair the reproductive system.[103] Plastic chemicals enter the human body in three main ways: through ingestion, inhalation and skin contact (**Figure 1**).[104]

Paper takeaway cups are lined with plastic coatings that have been found to contain PFAS, a class of persistent synthetic chemicals known as endocrine disruptors.

Figure 1: Pathways of human exposure to plastic chemicals



Exposure to plastic chemicals during childhood is especially concerning due to the extreme sensitivity of early childhood development. Credit: iStock.com/Olga Yastremska

Ingestion is a key exposure pathway for humans. Consumers are directly exposed to toxic chemicals through consumption of food and beverages packaged or prepared in plastics. Chemicals can leach from food-contact plastics such as containers, films, bags, bottles, tubs, cutlery, kitchen utensils, and tableware directly into food and drink.[105] In the UK, an estimated 90% of processed foods and 70% of food and drink items come wrapped in plastic packaging, leaving consumers at high risk of exposure.[106] A recent study identified 28 plastic-associated chemicals in a Nestlé dairy-based baby puree packaged in plastic pouches, among which was 2,4-ditert-butylphenol (2,4-DTBP), a chemical of concern recognised as hazardous to human health and linked to endocrine disruption and obesity.[107]

Chemicals can also leach from other food-contact materials, such as paper fast food packaging coated in plastic, takeaway cups lined with plastic, and cook- and bakeware with non-stick, oil- and moisture-resistant coatings that are often made with per- and polyfluoroalkyl substances (PFAS).[108] Plastic-associated chemicals can also be ingested through non-food sources, such as toothpaste,[109] plastic toys,[110] feeding bottles[111] and pacifiers[112] (mouthed by children).

Studies have repeatedly found detectable BPA migration from infant feeding bottles and pacifiers advertised as 'BPA-free'.[113]

Box 4: Reducing plastic exposure can reduce impact on human health

The Plastic Exposure Reduction Transforms Health Trial, a 2026 study by Harray et al.,[114] examined the relationship between participants' everyday plastic exposure and urinary plastics-associated chemicals levels. The study found that plastic chemical exposure is ubiquitous: 100% of participants excreted multiple plastic-associated chemical metabolites on any given day. However, the trial also demonstrated that interventions such as plastic-free kitchenware, low-plastic personal care products and food sourced from producers that minimise plastic touchpoints lead to a significant reduction in urinary levels of plastic-associated phthalates (up to 44.1%) and bisphenols (up to 58.5%). Adjusting dietary behaviours, limiting highly processed, plastic-packaged and canned foods, and minimising plastic touchpoints in food storage, preparation and handling can therefore significantly reduce levels of plastic chemicals in the human body.

Inhalation is another important exposure pathway. Plastic chemicals have long been detected in both outdoor and indoor environments, including in the air, and in household dust.[115] Indoor environments contain numerous sources of plastic chemicals and are associated with higher chemical compound concentrations – and thus levels of exposure – than outdoor environments.[116] Indoor chemical concentrations often exceed health guidelines, with cases of toxic chemicals – including known carcinogens – still being detected in household dust decades after they were banned.[117] Chemicals can equally be inhaled via airborne microplastics. These originate from a range of sources, including the erosion of synthetic rubber tyres, wear and tear of clothing material, washing and drying of synthetic textiles, deterioration of house furniture, emissions from the synthetic textile industry, construction materials, landfills and sewage sludge.[118]

Box 5: Cars as a source of plastics exposure

Cars are a key source of exposure to plastic chemicals, contributing to both outdoor and indoor pollution. The abrasion of synthetic rubber tyres against road surfaces is a leading contributor to airborne microplastics and related chemicals in outdoor environments. Car interiors are increasingly made of plastics and synthetic textiles such as polyester, which release chemical additives into the air over time.[119] One study found that the amount of styrene in car indoor air was around 1.5 times the tolerable daily intake recommended by the World Health Organization (WHO).[120] New cars in particular release higher amounts of chemicals, and concentrations further increase with higher in-car temperature and relative humidity.[121] Toxic exposures to volatile organic compounds (VOCs) from new car interiors have been associated with 'Sick Car Syndrome'.[122]

Exposure to plastic chemicals through the skin occurs in a number of ways. Synthetic textiles such as clothes, bedding, or furniture fabrics can release chemical additives such as flame retardants upon contact with the skin.[123] Dermal uptake of plastic-associated chemicals also occurs via use of cosmetics and personal care items such as menstrual products (**Box 11**).[124]

Car interiors are increasingly made of plastics. Credit: Pexels/mikebirdy

Thousands of plastic chemicals are harming our health

Exposure to plastic chemicals has been linked to a range of adverse health outcomes. These include impaired neurodevelopment, infertility, obesity and diabetes, cardiovascular disease and stroke, endometriosis and PMOS, renal disease, and cancers.[125] Exposure during pregnancy or childhood is especially concerning due to the extreme sensitivity of fetal and early childhood development, with links to miscarriage, premature birth, stillbirth, low birth weight, birth defects, impaired lung growth, lower IQ, increased prevalence of child autism and ADHD, asthma and childhood cancer.[126] According to one study, the impacts of just three plastic chemicals – BPA, PBDE and DEHP[127] – led to an estimated US$1.5 trillion in economic losses across 38 countries in 2015.[128]

Research on the health impacts of plastic chemicals has failed to keep pace with the sheer number of chemicals used in plastic production. According to the PlastChem project, there are over 16,000 known plastic chemicals present or potentially used in plastics worldwide. While more than 4,200 have been identified as hazardous for human health or the environment (chemicals of concern), hazard information is lacking for over 10,000 of these chemicals and less than 6% are currently subject to international regulation.[129] Many more plastic chemicals likely exist, particularly NIAS, the majority of which are unknown and untested.[130] Experts estimate, for example, that between 30,000 and 100,000 NIAS potentially migrate into food from food-contact materials, including food-contact plastics.[131] In other words, there are likely tens of thousands of chemicals present in plastics worldwide – many in daily use – that may have severe but as yet unknown implications for human health.[132] Our understanding of the magnitude of the plastic-related health crisis is only beginning to unfold.

Where scientific evidence does exist, the range and severity of impacts on human health are alarming. In an umbrella study published in 2024, Symeonides *et al*. reviewed the findings of 52 systematic reviews covering 759 meta-analyses of the effects of plastic-associated chemical exposure. Adverse outcomes were identified for every plastic-associated chemical group studied across a range of bodily systems.[133]

An umbrella study of the effects of plastic-associated chemical exposure, published in 2024, identified adverse outcomes for every plastic-associated chemical group studied across a range of bodily systems.

These included:

- **BPA** (other bisphenols have not been evaluated): decreased anoclitoral distance in infants; type 2 diabetes in adults; insulin resistance in children and adults; PMOS, obesity and hypertension in children and adults; cardiovascular disease.
- **Phthalates**: spontaneous pregnancy loss; decreased anogenital distance in boys; insulin resistance in children and adults; decreased birth weight; type 2 diabetes in adults; early onset of puberty in girls; reduced sperm quality; endometriosis; adverse cognitive development and IQ loss; adverse fine motor and psychomotor development; elevated blood pressure in children and asthma in children and adults.
- **PCBs** (polychlorinated biphenyls): type 2 diabetes in adults; bronchitis in infants; cardiovascular disease; non-Hodgkin's lymphoma; endometriosis; breast cancer. In PCB-poisoned populations, exposure is associated with overall mortality, mortality from hepatic disease (men), cardiovascular disease (men and women) and several cancers.
- **PBDEs** (polybrominated diphenyl ethers): adverse impacts on children's cognitive development and IQ loss; changes in thyroid function.
- **PFAS** (per- and polyfluoroalkyl substances): changes in thyroid function; increased body mass index (BMI) and obesity in children; ADHD in girls; allergic rhinitis.

Table 2 summarises the findings of selected studies that have investigated the impact of plastic chemicals on human health. Many plastic additives are known to be endocrine disruptors, meaning that they interfere with the body's hormones.[134] Plastic chemicals have been linked among other things to breast, lung and blood cancers; an increased risk of heart disease and stroke; respiratory disorders such as asthma and bronchitis; liver disease; and eczema.[135] Plastic chemicals are known to interfere with the reproductive system in both men and women, lowering sperm quality and increasing the risk of developing conditions such as endometriosis and PMOS.[136]

"The most concerning impacts of plastic chemicals on human health are potential effects on fertility, reproduction and development. Also concerning, but less established as far as scientific evidence [is concerned], is the potential impact on common chronic diseases like type 2 diabetes, autoimmune disease or obesity."

Jennifer Thompson, Associate Professor, Cumming School of Medicine, Department of Biochemistry and Molecular Biology, University of Calgary, Canada

"The 'cocktail effect', where multiple chemicals from plastics may interact with each other or with other environmental exposures, such as air pollution, contaminants in water, or compounds in ultraprocessed foods is concerning. While the effects of some individual chemicals are relatively well studied, their combined impact on human health – including potential effects such as endocrine disruption or other forms of toxicity – is still not fully understood. Better understanding these cumulative and long-term effects remains an important area for research."

Vilde Kloster Snekkevik, Research Scientist, Norwegian Institute for Water Research, Norway

There are likely tens of thousands of chemicals present in plastics worldwide – many in daily use – that may have severe but as yet unknown implications for human health.

Table 2: Summary of selected research articles concerning the impact of plastic chemicals on human health

Organ/body system	Examples of plastic chemical associated impacts	References	Findings
Brain	Lowered IQ	Tanner et al. (2020)[137]	Prenatal exposure to plastic chemicals such as phthalates and bisphenols was related to lower IQ in children, particularly among boys. Bisphenol F (BPF), which is often used as a replacement for BPA, was identified as having the greatest impact, suggesting that replacement chemicals do not offer safer alternatives.
	Attention-deficit/hyperactivity disorder (ADHD)	Shoaff et al. (2020)[138]	Exposure to select phthalates was associated with an increased risk of ADHD-related behaviors according to a cross-sectional analysis of data from 205 adolescents participating in a prospective birth cohort study.
	Autism spectrum disorder (ASD)	Tanner et al. (2025)[139]	Mechanistic evidence linking DEHP, a common plasticiser, to child autism and ADHD. Prenatal exposure to DEHP increases ASD and ADHD symptoms through changes in DNA methylation.
Lungs	Asthma	Foong et al. (2023)[140]	This longitudinal study found that prenatal exposure to BPA was associated with increased odds for persistent asthma and phthalates were associated with increased risks for adult asthma in males.
	Allergies (lungs and skin)	Zhou et al. (2017)[141]	Mothers of infants with allergic diseases such as eczema and wheeze had significantly higher urinary BPA levels than those of infants without allergic diseases. This suggests that prenatal exposure to BPA may increase the risk of allergic diseases in very early life.
Skin	Hidradenitis suppurativa (HS)	Williams et al. (2025)[142]	Significantly elevated levels of plastic-associated endocrine-disrupting chemicals (EDCs) – specifically those common in ultra-processed foods – were found in HS tissue. These EDCs inhibit production of the NCSTN protein, which increases inflammation and leads to HS symptoms.
Digestive system	Crohn's disease (CD)	Linares et al. (2021)[143]	BPA significantly enhances systemic inflammatory response in CD patients. BPA was significantly higher in people with active disease versus those in remission.
Liver	Fatty liver disease	Midya et al. (2022)[144]	Cohort study of 1,108 mother-child pairs from six countries suggests prenatal exposure to EDCs increases risk for liver injury in childhood and constitutes a risk factor for pediatric nonalcoholic fatty liver disease.
Bones	Rheumatoid arthritis	Feng et al. (2025)[145]	Study of 9,908 adults found that exposure to brominated flame retardants was associated with increased risk of rheumatoid arthritis. Immune-inflammatory response was indicated as an important linking factor in the development of the disease.

Reproductive system	Miscarriage	Zhang et al. (2020)[146]	Meta-analysis revealed that exposure to phthalates such as DEHP raises the risk of spontaneous pregnancy loss.
	Endometriosis, endometrial cancer	Chitakwa et al. (2024)[147]	Meta-analysis found that exposure to EDCs such as phthalates was significantly associated with risk of oestrogen-dependent diseases such as endometriosis and endometrial cancer. Higher exposure concentrations were linked to more severe disease.
	Fertility	Tzouma et al. (2025)[148]	Systematic review indicates consistent association between exposure to EDCs and adverse reproductive outcomes. This includes infertility, altered hormone levels, impaired semen quality, decreased ovarian reserve, PMOS, and negative outcomes in assisted reproductive technologies such as in vitro fertilisation (IVF).
Genes	Genetic changes	Furlong et al. (2025)[149]	PFAS in firefighters was associated with altered miRNA expression linked to increased risk for chronic diseases such as cancer, blood diseases, autoimmune disorders, neurological outcomes and thyroid disorders.
Endocrine system	Diabetes	Hwang et al. (2018)[150]	Meta-analysis of studies investigating 42,320 subjects indicated BPA concentrations are positively associated with risk of type 2 diabetes in humans.
Heart	Cardiovascular disease	Hyman et al. (2025)[151]	Used a disease burden model to estimate that DEHP exposure deaths represented 13.5% of all cardiovascular deaths among individuals aged 55–64 in 2018. 349,113 out of 356,238 global deaths attributed to DEHP exposure were linked to the use of plastics. DEHP is a commonly used phthalate.
Immune system	Immune dysfunction	Liu et al. (2022)[152]	Meta-analysis of 36 studies with a total of over 22,000 participants found that exposure to chemicals such as BPA is closely linked to dysregulated inflammatory responses. This effect may be linked to a range of chronic diseases including cardiovascular disease, hypertension and diabetes.
Cancers	Thyroid Breast Prostate Testicular	Modica et al. (2022)[153]	Review of articles from 1958 to 2022 demonstrated carcinogenicity of EDCs, including cadmium and dioxin (highly toxic POP by-product of plastic production and disposal) for breast and thyroid cancer; arsenic, asbestos, and dioxin for prostate cancer; and organochlorines/organohalogens for testicular cancer. Newer evidence also indicates involvement of phthalates and BPA in breast, prostate, and thyroid cancers, as well as potential influence of dioxin on ovarian cancer. The results also suggest that fetuses are particularly vulnerable to endocrine disruption.

Figure 2 summarises the status of available scientific information on the hazard level of selected chemical groups in terms of their potential for adverse health impacts. These groups of chemicals, which are commonly found in plastics, have been identified by the PlastChem project as priority groups of concern for regulation based on four criteria: persistence, bioaccumulation, toxicity and mobility (**Table 3**). They include widely used hazardous chemicals such as bisphenols, phthalates and PFAS.

EJF assessed the proportion of chemicals classified as hazardous based on values in the PlastChem database for carcinogenicity, germ (reproductive) cell mutagenicity, reproductive toxicity, specific target organ toxicity (STOT) and endocrine disruption. The findings show that, where assessments have been concluded, chemicals in these 15 priority groups were often found to have hazardous properties linked to adverse impacts on human health. For aromatic amines, aromatic ethers, bisphenols and phthalates, for example, nearly all assessed chemicals were associated with adverse health impacts – as were the vast majority of assessed chemicals in the organometallics and azo dyes groups. The findings demonstrate the importance of regulating chemicals by group rather than individually to avoid "regrettable substitutions", whereby chemicals assessed as hazardous are replaced by other similar chemicals which have not yet been assessed.

Table 3: Hazard criteria used by PlastChem to define chemicals of concern

Hazard criterion	Definition
Persistent	Long-term presence of a chemical in air, water, soil or organisms
Bioaccumulative	The potential of a chemical to stay and accumulate in humans and wildlife
Toxic	The potential of a chemical to cause harm to living organisms
Mobile	The potential of a chemical to spread in fresh- and drinking water systems

Source: Wagner, M. *et al.* (2024) *State of the science on plastic chemicals - Identifying and addressing chemicals and polymers of concern*. Available at: https://doi.org/10.5281/ZENODO.10701706.

Workers examining bottled water on the production line of a Chinese factory. Credit: iStock.com/Edwin Tan

Figure 2: Hazard status of selected chemical groups in terms of their potential for adverse health impacts. Proportion of hazardous chemicals was assessed based on values in the PlastChem database for carcinogenicity, germ cell mutagenicity, reproductive toxicity, specific target organ toxicity (STOT) and endocrine disruption.

Top 15 plastic chemical groups of concern	Proportion of hazardous chemicals				
	Carcinogenicity	Germ cell mutagenicity	Reproductive toxicity	Specific target organ toxicity (STOT)	Endocrine disrupting chemicals (EDC)
Aromatic amines	100%	100%	100%	100%	N/A
Aralkyl aldehydes	N/A	0%	100%	100%	N/A
Alkylphenols	50%	67%	92%	100%	100%
Salicylate esters	N/A	0%	100%	100%	N/A
Aromatic ethers	N/A	100%	100%	100%	N/A
Bisphenols	80%	100%	100%	100%	100%
Phthalates	83%	N/A	100%	100%	100%
Benzothiazoles	67%	0%	40%	60%	N/A
Benzotriazoles	100%	0%	100%	100%	N/A
Organometallics	88%	94%	99%	100%	N/A
Parabens	N/A	0%	0%	100%	100%
Azo dyes	87%	96%	83%	93%	N/A
Aceto- and benzophenones	67%	50%	80%	100%	N/A
Chlorinated paraffins	100%	0%	50%	67%	N/A
Per- and polyfluoroalkyl substances	88%	13%	91%	94%	N/A

Source: EJF analysis based on data in the PlastChem database. Percentages represent the proportion of chemicals classified as hazardous out of chemicals that have been assessed and resulted in a conclusive (hazardous vs non-hazardous) finding. Chemicals that are yet to be assessed, are currently under review, or where the findings of the hazard assessment are inconclusive were excluded from the analysis. N/A means no data available or no chemical in the group has a conclusive result. Hazardous thresholds: carcinogenic and mutagenic score ≥ 0.5 (Category 1A/1B, Category 2 or recognised but without a level); reproductive toxicity ≥ 1 (Category 1A/1B or Category 2); STOT = 2 (Category 1); EDC = 2 (Category 1). For the EDC group, no priority-group chemical has a conclusive score of 0 (non-hazardous). Therefore every value is 100% (hazardous) or N/A (no data/conclusive assessment). Note that many groups have very few assessed chemicals so these figures should be interpreted with caution.

These findings are particularly worrying given the widespread use of these chemicals in everyday plastic items. Of the 15 chemical groups analysed, nearly all are present in food-contact plastics, textiles, toys and other household items such as kitchen utensils, according to data retrieved by EJF from the PlastChem database (**Figure 3**). Half of the groups are also used in hygiene and medical applications. Widely used plasticisers such as alkylphenols and phthalates are present in every use category and include chemicals that have been assessed as hazardous to human health across at least four toxicity categories.

Figure 3: Presence of chemical groups of concern in everyday plastic items

Top 15 plastic chemical groups of concern	Food-contact plastics	Textiles	Toys	Household items	Hygiene and medical items
Aromatic amines	PRESENT	PRESENT	PRESENT	PRESENT	
Aralkyl aldehydes		PRESENT		PRESENT	
Alkylphenols	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Salicylate esters	PRESENT	PRESENT	PRESENT	PRESENT	
Aromatic ethers		PRESENT	PRESENT	PRESENT	
Bisphenols	PRESENT	PRESENT	PRESENT	PRESENT	
Phthalates	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Benzothiazoles	PRESENT	PRESENT		PRESENT	
Benzotriazoles	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Organometallics	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Parabens	PRESENT				
Azo dyes	PRESENT	PRESENT	PRESENT	PRESENT	
Aceto/benzophenones	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Chlorinated paraffins	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT
Per- and polyfluoroalkyl substances	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT

Source: EJF analysis based on data in the PlastChem database. See **Methodology** in **Appendix** for further details.

Everyday plastics: convenient or contaminating?

The findings of EJF's analysis on the human health risk of chemicals used in everyday items is presented in the sections below. For the purposes of this analysis, we focus on the following use categories in the PlastChem database derived from the PlasticMAP study[155]: (i) food-contact plastics, (ii) textiles, (iii) toys, (iv) household items, and (v) hygiene and medical items.[156] These categories were selected due to the higher potential for substitution of plastics in these applications, particularly for categories (i) to (iv). EJF considered it important to include toys within the categories examined, due to the extreme vulnerability and specific patterns of behaviour of children which may amplify health impacts and risk of exposure.[157]

It is critical to note that chemicals with a PlasticMAP use category represent only a subset (around a quarter – 24.4%) of total chemicals in the PlastChem database. The PlasticMAP study was unable to assign use categories to all chemicals identified (due to a lack of available information), while PlastChem includes chemicals from additional data sources beyond PlasticMAP.[158] This means there are likely many more plastic chemicals in each of the five everyday use categories than are considered in EJF's analysis (see example in **Box 7**). The risks to human health are therefore likely even greater than presented in the sections below.

As detailed in the **Methodology** section (**Appendix**), chemicals were considered to present a high risk to human health where available data indicates:

1. High or suspected toxicity to human health in terms of being linked to cancer, genetic defects, infertility, hormone disruption and/or harm to organs, AND
2. High or potential risk of exposure as a result of being released from, present in or marketed for use in that category.

The findings of our analysis paint a highly concerning picture. There are currently significant gaps in our understanding of the health risks of chemicals found in everyday plastic items. The majority of chemicals (79.2%) in the five analysed use categories lacked information relevant to assessing their toxicity and exposure risk. Alarmingly, where information relevant to assessing both toxicity and exposure risk was available, 92.8% of chemicals assessed by EJF were found to present a high risk to human health.

As scientific evidence continues to build, a precautionary approach to regulating the use of plastic chemicals must be followed to guard against the threat of significant harm to human health. Our analysis, however, revealed the sheer inadequacy of current regulation, which fails to address health risks even where these are well established. Of the high-risk chemicals identified in EJF's analysis, 82.9% are not subject to regulation under any relevant international agreements (the Stockholm Convention, the Basel Convention, the Minamata Convention, the Montreal Protocol or the Rotterdam Convention). Nearly all high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 54.2% of the high-risk chemicals identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

This section looks in more detail at our exposure to toxic plastic chemicals through each of the above-mentioned everyday plastic uses: food-contact plastics, textiles, toys, household items, and hygiene and medical items. It is worth noting that all of the experts surveyed for this report have taken steps to reduce their own plastic consumption and minimise exposure to the toxic health effects of plastic-associated chemicals and microplastics. Common actions include: avoiding single-use plastics; selecting products without or with less plastic packaging; avoiding synthetic textiles; and choosing fresh, unprocessed and organic foods. Many reported replacing plastic items with reusable alternatives such as glass or metal, especially for food and drink containers. Experts avoid heating food in plastic, and have switched to non-plastic personal care products where possible. While respondents described ongoing, conscious efforts to significantly reduce their personal plastic use, they also noted that completely eliminating plastic is difficult, and that strong regulatory action, research and public education are urgently needed to limit production and exposure, and guide prevention and policy.

Alarmingly, where information relevant to assessing both toxicity and exposure risk was available, 92.8% of chemicals assessed by EJF were found to present a high risk to human health.

Of the high-risk chemicals identified in EJF's analysis, 82.9% are not subject to regulation under any relevant international agreements (the Stockholm Convention, the Basel Convention, the Minamata Convention, the Montreal Protocol or the Rotterdam Convention).

FOOD-CONTACT PLASTICS

Box 6: Key findings

EJF found that:

- **91.6%** of plastic chemicals used in food-contact plastics, for which we have information on both toxicity and exposure risk, **present a high risk to human health**
- **90.6%** of high risk plastic chemicals used in food-contact plastics are **unregulated internationally**
- **76.4%** of chemicals found in food-contact plastics **do not have available data** on toxicity and/or exposure

Credit: iStock.com/AndreyPopov

Food-contact plastics include food packaging such as films, wrap, bags, bottles, containers, and tubs.[159] The release (leaching) of chemical additives from food-contact plastics into food and drink is caused and accelerated by environmental stressors such as abrasion, heat, moisture and sunlight.[160] Plastic-lined paper cups, for example, degrade when exposed to hot water, releasing toxic plastic chemicals such as phthalates and benzotriazoles as well as heavy metals into the liquids they contain.[161] Similarly, milk and soft drink plastic bottles have been found to release higher levels of BPA when stored in summer compared to winter conditions.[162] Microwaveable plastic food containers commonly advertised as 'safe' have been shown to release both intentionally and non-intentionally added substances into food simulants in quantities exceeding recommended limits.[163]

"Coffee cups, instant noodle containers, and takeout packaging often contain plastic linings that degrade when exposed to heat [...] This leads to ingestion of microplastics and release of styrene and other toxic monomers, which are suspected carcinogens and neurotoxins."

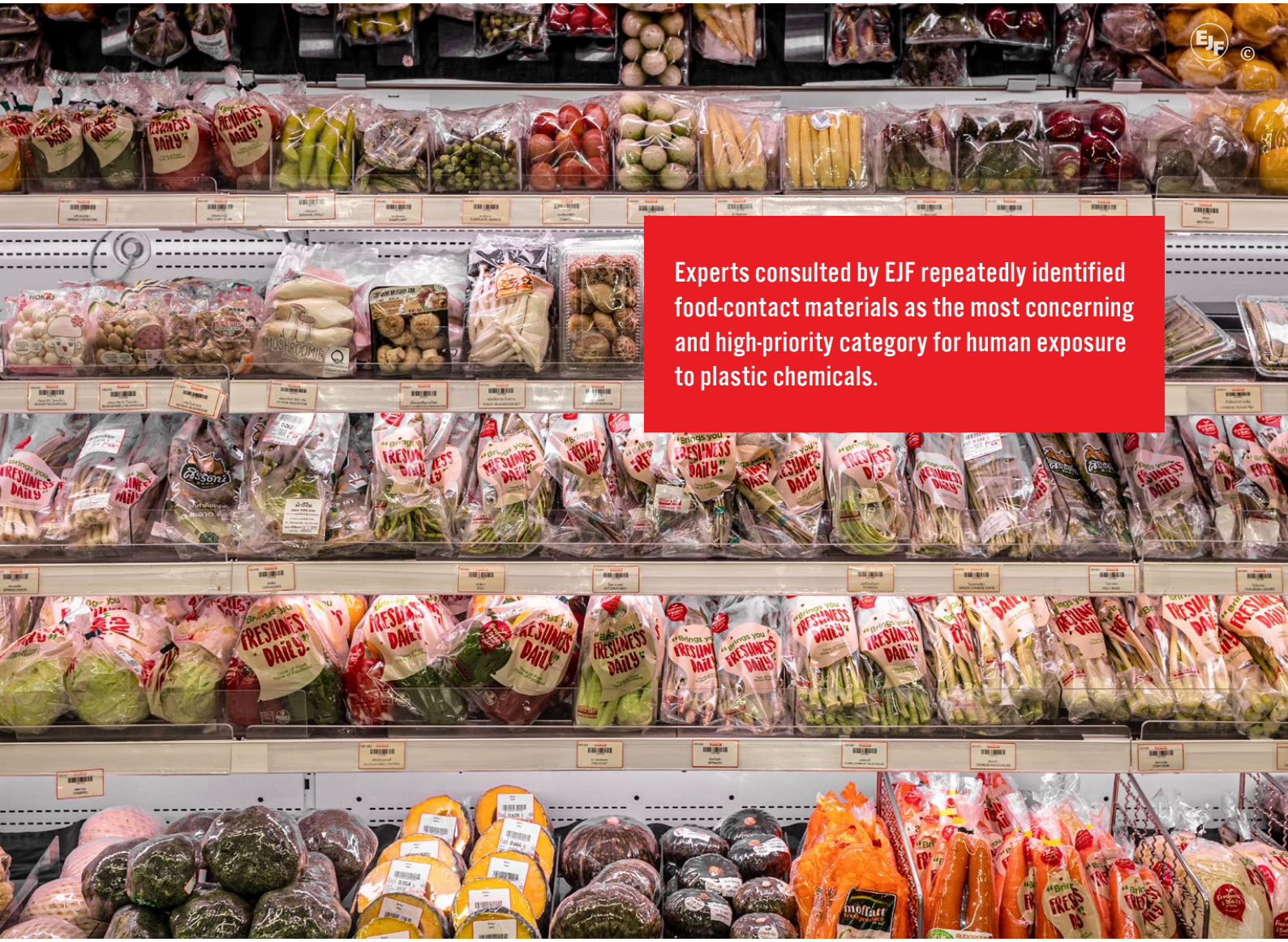
Raffaele Marfella, Professor of Internal Medicine and Director of the Medical and Surgical Sciences Department, University of Campania Luigi Vanvitelli, Italy

Experts consulted for this report identified food-contact materials as the most concerning and high-priority category for human exposure to both microplastics and plastic-associated chemicals. Experts emphasised that this route represents a daily, unavoidable source of ingestion with potential lifelong health consequences. Many explained that heating food in plastic containers accelerates leaching and particle shedding, allowing microplastics and additives such as bisphenols, phthalates, and PFAS to migrate directly into food and beverages. Several respondents expressed particular alarm about bottled water, takeaway packaging and infant feeding bottles, describing these as among the most acute and frequent exposure routes and linking them to endocrine disruption, reproductive and developmental harm, metabolic disorders, and cardiovascular effects.

The PlastChem database contains a total of 2,109 plastic chemicals categorised as used in food-contact plastics (according to PlasticMAP, however, see additional information in **Box 7**). Of those chemicals with information on toxicity, the vast majority (92.7%) have evidence of either high or suspected toxic health effects: 77.1% are considered **highly toxic** and 15.6% are suspected of being toxic to human health (**Figure 4 - A**). Around a third (32.1%) of the identified chemicals with available data on exposure are associated with a **high risk of exposure** due to evidence of their release during use, while 67.9% have a potential for exposure due to evidence of their presence or being labelled for use in food-contact products (**Figure 4 - B**). Around three quarters (76.4%) of chemicals used in food-contact plastics were lacking data on either toxicity, exposure or both (**Figure 5**).

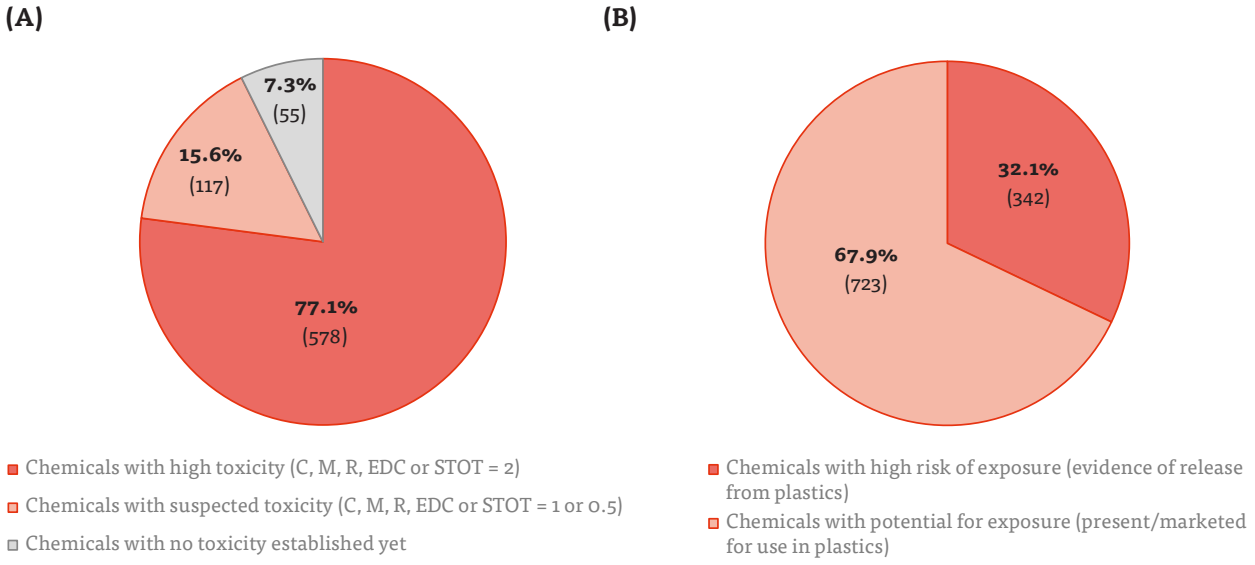
Box 7: Additional sources of data on chemicals in food-contact plastics

While EJF's analysis focused on the PlasticMAP use categories (see **Methodology** in **Appendix**), the actual number of food-contact plastic chemicals in the PlastChem database is significantly higher. The PlastChem database includes more than 5,000 additional food-contact plastic chemicals that were either not identified by PlasticMAP or were not categorised as food-contact plastic chemicals in that study.[164] Additional data sources for food-contact plastic chemicals in PlastChem include the Food Contact Chemicals Database (FCCdb)[165] and the Database on Migrating and Extractable Food Contact Chemicals (FCCmigex)[166] published by the Food Packaging Forum.[167] FCCmigex has been further updated and now includes more food-contact plastic chemicals than are in the current version of PlastChem.[168] Indeed, recent research has identified a total of 15,159 known food-contact chemicals and indicates that this number is likely still underestimated.[169]



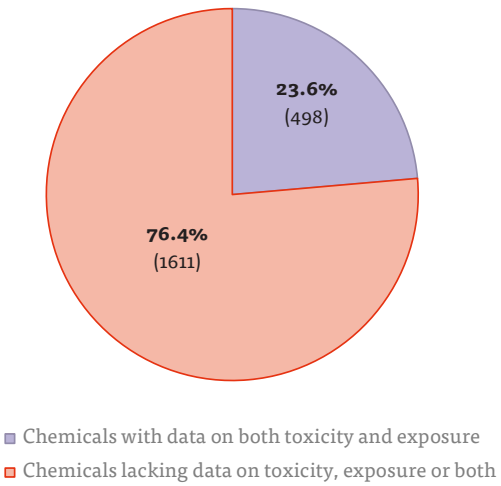
Experts consulted by EJF repeatedly identified food-contact materials as the most concerning and high-priority category for human exposure to plastic chemicals.

Figure 4: (A) Human health toxicity of plastic chemicals in food-contact plastics (B) Human exposure to plastic chemicals in food-contact plastics



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity (A) and exposure (B). With regard to (A), the suspected toxicity group may include some high toxicity chemicals if the level was not specified in the PlastChem database – see **Methodology** for further information.

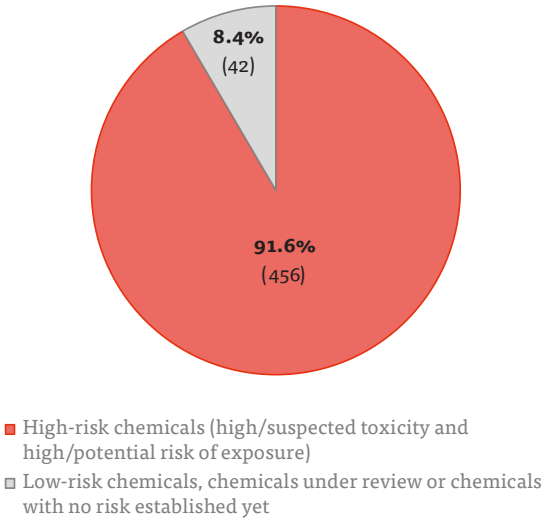
Figure 5: Proportion of chemicals in food-contact plastics for which data are lacking on toxicity, exposure or both



Source: EJF analysis of PlastChem data

Of the 498 plastic chemicals used in food-contact plastics with data on both toxicity and exposure, our analysis found that 91.6% present an overall high risk to human health (**Figure 6**). The vast majority of these high risk chemicals (90.6%) are not subject to regulation under relevant international agreements. Nearly all high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 58.6% of chemicals in food-contact plastics identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California) (**Figure 7**).

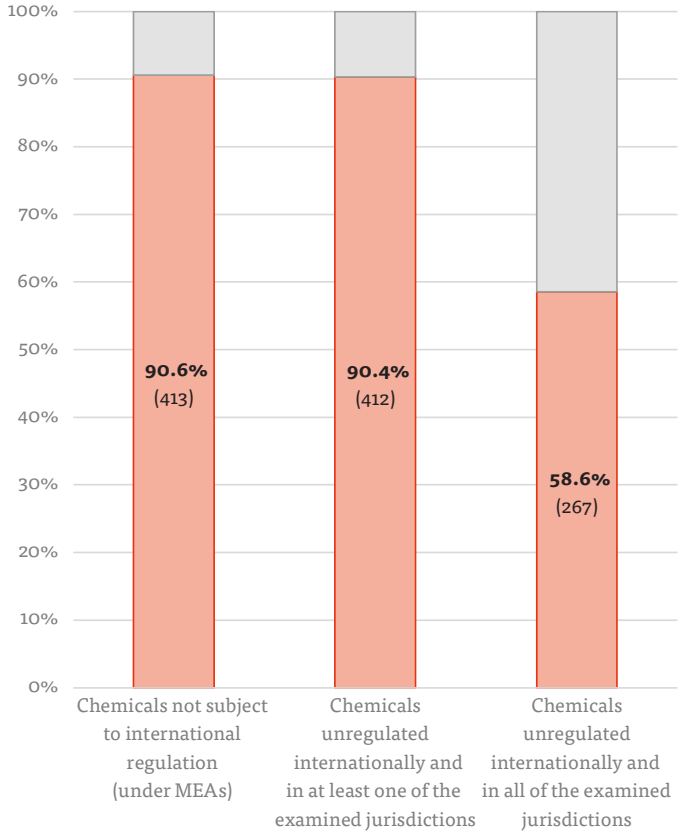
Figure 6: Overall human health risk of plastic chemicals in food-contact plastics



Source: EJF analysis of PlastChem data

Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity and exposure

Figure 7: Regulatory status of high risk plastic chemicals in food-contact plastics



Source: EJF analysis of PlastChem data

Overall, 58.6% of chemicals in food-contact plastics identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

TEXTILES

Box 8: Key findings

EJF found that:

- **92.8%** of plastic chemicals used in textiles, for which we have information on both toxicity and exposure risk, **present a high risk to human health**
- **81.5%** of high risk plastic chemicals used in textiles are **unregulated internationally**
- **75.3%** of chemicals found in textiles **do not have available data** on toxicity and/or exposure

Credit: Pexels/thomas-parker

Textiles are an important use sector for plastic chemicals, which can be found in products such as synthetic clothing, shoes, curtains, linens, carpets, furniture, and pillows, as well as textiles used in buildings, agriculture and transport services.[170] Clothes, for example, are often made of plastic fibres such as polyester, dyed with synthetic colorants and coated with plastic chemicals for specific functionalities such as water resistance.[171] Textile wastewater has been found to contain many toxic plastic chemicals that have carcinogenic and mutagenic effects, including phthalates and phenols.[172] A recent study found that children are exposed to elevated levels of toxic plastic chemicals in their sleeping environments via mattresses, some of which violated national regulations on flame-retardant use in products for children.[173]

"Textiles, worn on the skin, have been very much disregarded until now."

Marja Lamoree, Professor of Analytical Chemistry for Environment and Health, Vrije Universiteit Amsterdam, Netherlands

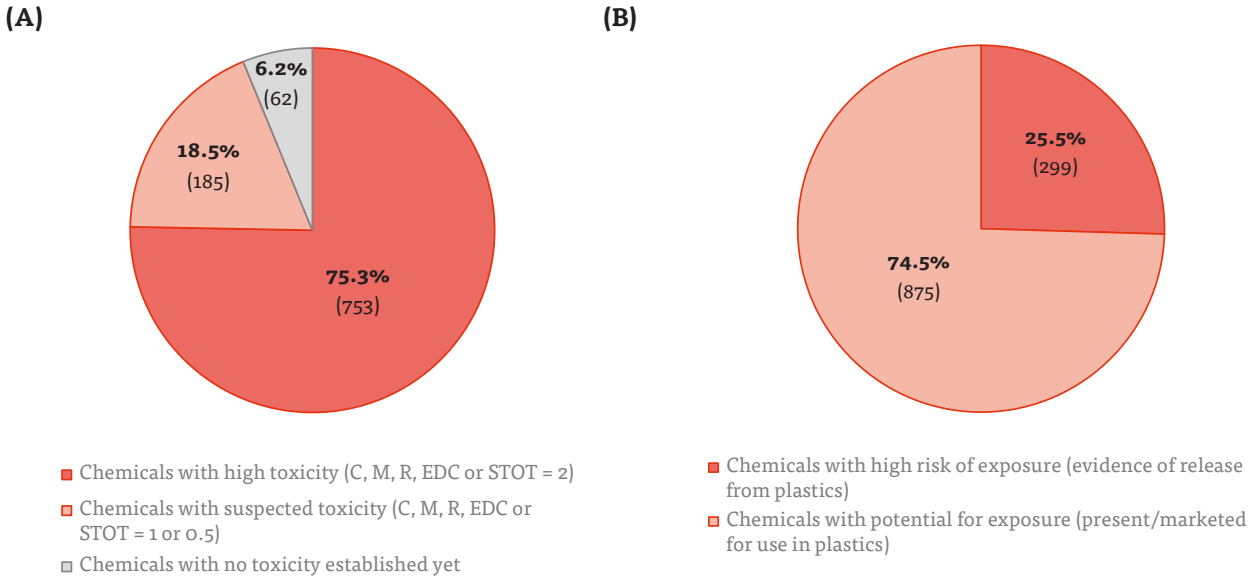
Experts consulted for this report viewed synthetic textiles such as polyester, nylon and acrylic as a major and often underappreciated source of microplastic exposure. They raised concerns about the chemical additives used in textile production, including flame retardants, dyes and plasticisers, which have been linked to cancer and could be absorbed through the skin or inhaled as particles. Overall, respondents viewed textiles such as clothes, carpets and furniture as a widespread, low-visibility exposure route, particularly indoors. They expressed concern that vulnerable groups, including children and workers in textile production and waste-handling, may face disproportionate risks.

"Indoor dust inhalation of MNPs [micro- and nanoplastics] has many sources that are not quantitatively understood: paint MNPs, flooring MNPs, textiles, everyday objects."

Jeroen Sonke, Research Director at the National Centre for Scientific Research, France

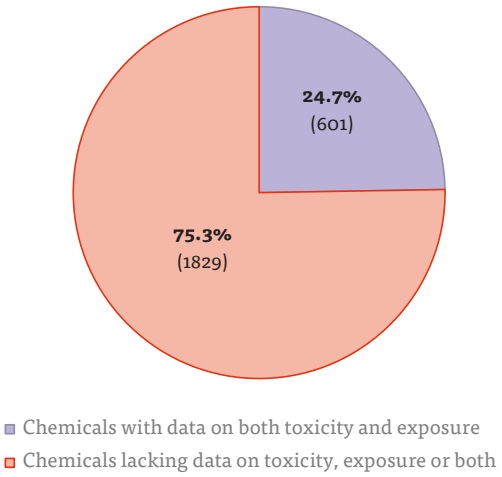
The PlastChem database contains a total of 2,430 plastic chemicals categorised as used in textiles (according to PlasticMAP). Of those chemicals with information on toxicity, the vast majority (93.8%) have evidence of either high or suspected toxic health effects: 75.3% are considered **highly toxic** and 18.5% are suspected of being toxic to human health (**Figure 8 - A**). Around a quarter (25.5%) of the identified chemicals with available data on exposure are associated with a **high risk of exposure** due to evidence of their release during use, while 74.5% have a potential for exposure due to evidence of their presence or being labelled for use in textile products (**Figure 8 - B**). Around three-quarters (75.3%) of chemicals used in textiles were lacking data on either toxicity, exposure or both (**Figure 9**).

Figure 8: (A) Human health toxicity of plastic chemicals in textiles
(B) Human exposure to plastic chemicals in textiles



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity (A) and exposure (B). With regard to (A), the suspected toxicity group may include some high toxicity chemicals if the level was not specified in the PlastChem database – see **Methodology** for further information.

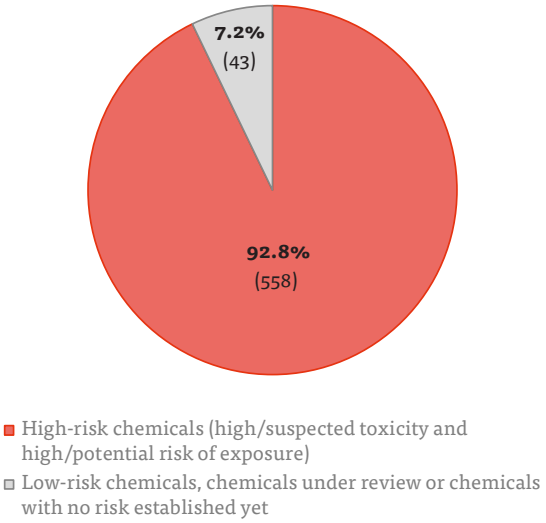
Figure 9: Proportion of chemicals in textiles for which data are lacking on toxicity, exposure or both



Source: EJF analysis of PlastChem data

Of the 601 plastic chemicals used in textiles with data on both toxicity and exposure, our analysis found that 92.8% present an overall high risk to human health (**Figure 10**). The majority of these high-risk chemicals (81.5%) are not subject to regulation under relevant international agreements. Nearly all high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 50.9% of chemicals in textiles identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California) (**Figure 11**).

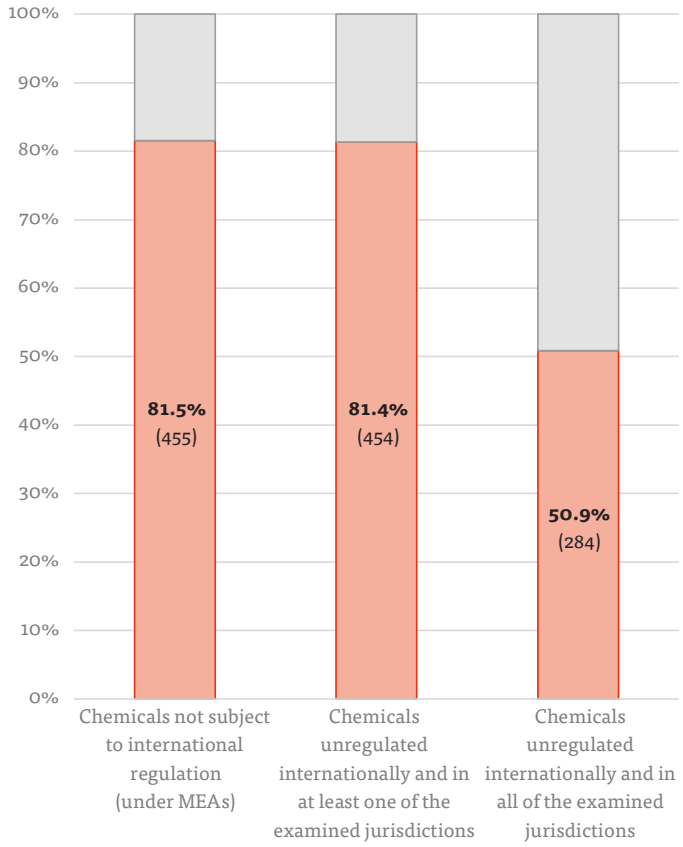
Figure 10: Overall human health risk of plastic chemicals in textiles



Source: EJF analysis of PlastChem data

Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity and exposure

Figure 11: Regulatory status of high risk plastic chemicals in textiles



Source: EJF analysis of PlastChem data

Overall, 50.9% of chemicals in textiles identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

TOYS

Box 9: Key findings

EJF found that:

- **88.9%** of plastic chemicals used in toys, for which we have information on both toxicity and exposure risk, **present a high risk to human health**
- **84.7%** of high risk plastic chemicals used in toys are **unregulated internationally**
- **53.4%** of chemicals found in toys **do not have available data** on toxicity and/or exposure

Credit: iStock.com/Natalia Deriabina

Children's toys have been found to contain a number of plasticisers, flame retardants, colorants and fragrances, including phthalates, phosphates and adipates.[174] Examples of children's toys that may contain plastic chemicals include plastic building blocks, figures, dolls, puzzles, tricycles, scooters, pedal cars, and swings.[175] Soft toys in particular contain high amounts of plasticisers to give them special features like increased flexibility.[176] Damaged toy surfaces compound exposure risk as they facilitate the leaching of chemical additives.

> ***"Toys are concerning because of the hand-to-mouth contact in young children."***
>
> Lindsay Cahill, Associate Professor, Department of Chemistry, Memorial University of Newfoundland and Labrador, Canada

The presence of hazardous plastic chemicals in toys is particularly concerning given children's distinct susceptibility and vulnerability to their toxic effects.[177] Experts surveyed for this report consistently identified toys and childcare products as a critical concern for children's health. The most frequently cited reason was mouthing and chewing behaviour, which directly increases ingestion of chemicals. Respondents pointed to soft plastic toys, pacifiers and teethers as potential sources of phthalate and bisphenol leaching. They also called attention to the risk of ingesting small fragments such as glitter.

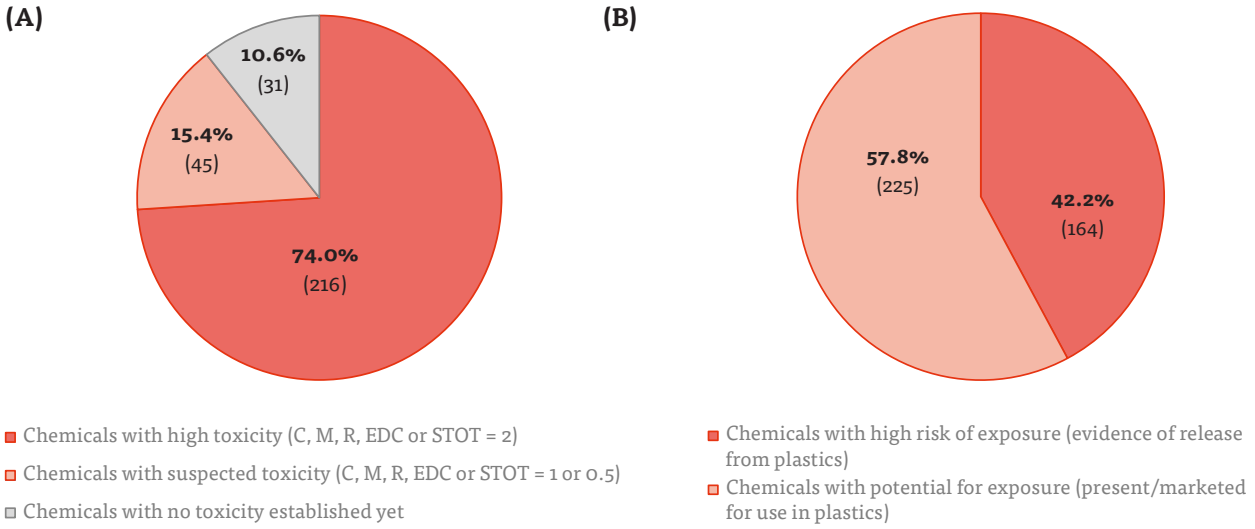
> ***"From a developmental point of view, IQ loss (shown for PDBEs, aromatic ether) is irreversible for children."***
>
> Jeroen Sonke, Research Director, National Centre for Scientific Research, France

> ***"The greatest harm and impact on public health stems from exposure that occurs in early life (prenatal and childhood) because children are more vulnerable to exposure and exposure during sensitive windows of development can have persistent effects on organ function."***
>
> Jennifer Thompson, Associate Professor, Cumming School of Medicine Department of Biochemistry and Molecular Biology, University of Calgary, Canada

Respondents agreed that early-life exposure to plastic chemicals poses disproportionate risks, including endocrine disruption, reproductive toxicity and developmental neurotoxicity, which may have lifelong and intergenerational consequences. Children's immature organs and tissues are less able to break down and excrete toxins, allowing these to accumulate in the body and cause harm.[178] Children also consume more food, fluids and air per kilogramme of body weight than adults do, and have a greater surface area to weight ratio.[179] This further increases their exposure to toxic chemicals and puts them at a higher risk of developing developmental disorders.[180]

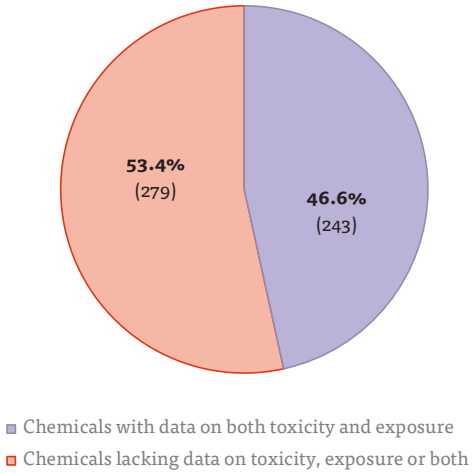
The PlastChem database contains a total of 522 plastic chemicals categorised as used in toys (according to PlasticMAP). Of those chemicals with information on toxicity, 89.4% have evidence of either high or suspected toxic health effects: 74.0% are considered **highly toxic** and 15.4% are suspected of being toxic to human health (**Figure 12 - A**). 42.2% of the identified chemicals with available data on exposure are associated with a **high risk of exposure** due to evidence of their release during use, while 57.8% have a potential for exposure due to evidence of their presence or being labelled for use in toy products (**Figure 12 - B**). Over half (53.4%) of chemicals used in toys were lacking data on either toxicity, exposure or both (**Figure 13**).

Figure 12: (A) Human health toxicity of plastic chemicals in toys
(B) Human exposure to plastic chemicals in toys



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity (A) and exposure (B). With regard to (A), the suspected toxicity group may include some high toxicity chemicals if the level was not specified in the PlastChem database – see **Methodology** for further information.

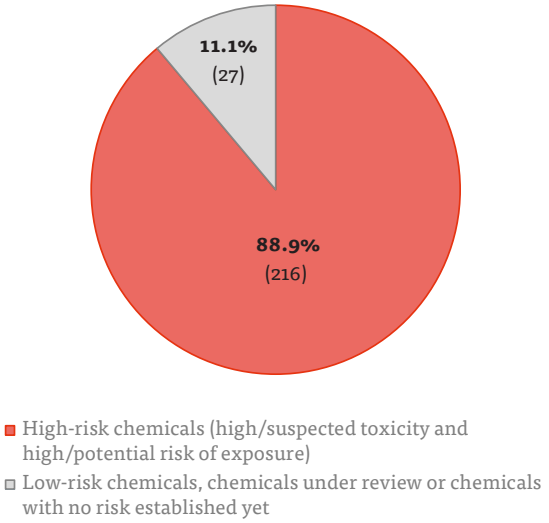
Figure 13: Proportion of chemicals in toys for which data are lacking on toxicity, exposure or both



Source: EJF analysis of PlastChem data

Of the 243 plastic chemicals used in toys with data on both toxicity and exposure, our analysis found that 88.9% present an overall high risk to human health (**Figure 14**). The majority of these high risk chemicals (84.7%) are not subject to regulation under relevant international agreements. Nearly all high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 52.8% of chemicals in toys identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California) (**Figure 15**).

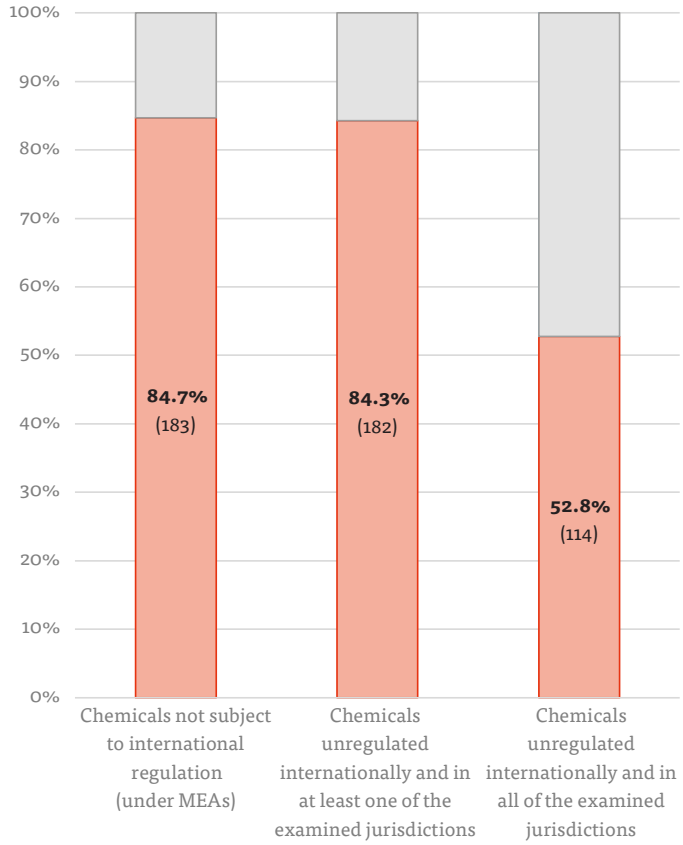
Figure 14: Overall human health risk of plastic chemicals in toys



Source: EJF analysis of PlastChem data

Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity and exposure

Figure 15: Regulatory status of high risk plastic chemicals in toys



Source: EJF analysis of PlastChem data

Overall, 52.8% of chemicals in toys identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

HOUSEHOLD ITEMS

Box 10: Key findings

EJF found that:

- **92.4%** of plastic chemicals used in household items, for which we have information on both toxicity and exposure risk, **present a high risk to human health**
- **85.0%** of high risk plastic chemicals used in household items are **unregulated internationally**
- **65.7%** of chemicals found in household items **do not have available data** on toxicity and/or exposure

Our homes aggregate many sources of microplastics and toxic chemicals, making them a critical environment for exposure. Not only does indoor air accumulate significantly more microplastics than outdoor air,[181] but many of the items found within households, from furniture to kitchen utensils to cleaning products, are sources of plastic particles and chemicals that migrate into the surrounding environment and human body.[182] Examples of household items that may contain plastic chemicals include kitchen utensils, tools and equipment, tableware, buckets, brooms, mops, sponges, gardening tools, toilet articles, office supplies, school supplies, and decorative articles.[183]

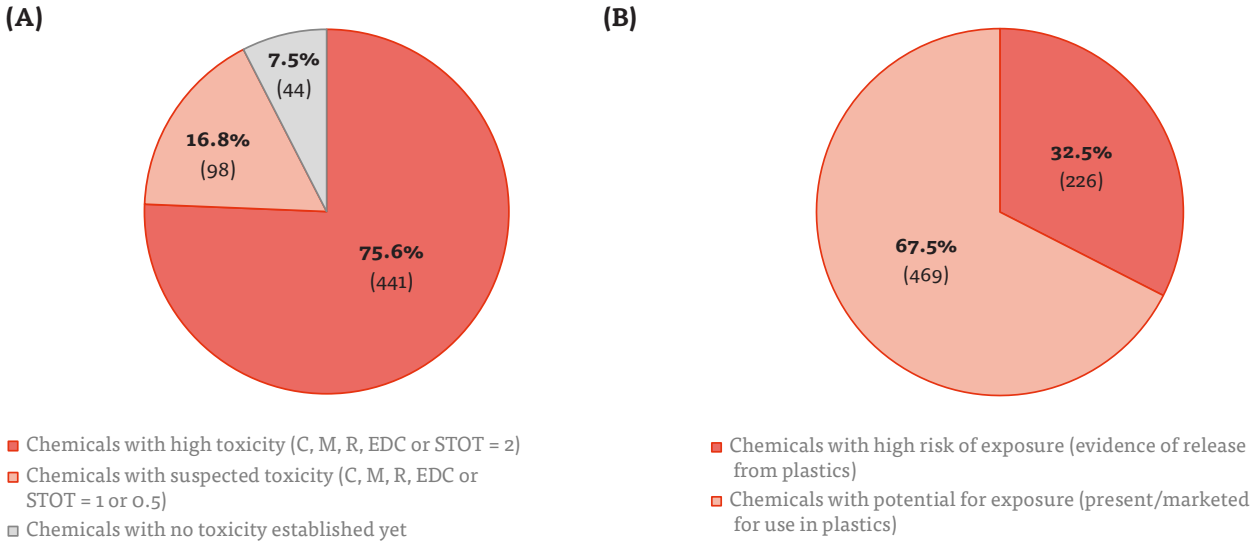
Survey respondents expressed strong concern over household plastics as a pervasive but poorly quantified source of plastic exposure. Items such as kitchenware, cleaning products, furniture, flooring and paints were among those cited as microplastic and plastic chemical emitters. Respondents emphasised that households are a key setting of chronic exposure, where individuals are continuously in contact with airborne and surface-bound microplastics through household dust. This is dangerous particularly for groups spending more time indoors, such as the elderly or people with limited mobility.

> ***"It is concerning how extensively plastics are used in our daily life, such as in our kitchens, and how heating, scratching, or degrading them may increase the release of particles and chemicals."***
>
> Vilde Kloster Snekkevik, Research Scientist, Norwegian Institute for Water Research, Norway

The PlastChem database contains a total of 1,197 plastic chemicals categorised as used in household items (according to PlasticMAP). Of those chemicals with information on toxicity, the vast majority (92.4%) have evidence of either high or suspected toxic health effects: 75.6% are considered **highly toxic** and 16.8% are suspected of being toxic to human health (**Figure 16 - A**). Around a third (32.5%) of the identified chemicals with available data on exposure are associated with a **high risk of exposure** due to evidence of their release during use, while 67.5% have potential for exposure due to evidence of their presence or being labelled for use in household products (**Figure 16 - B**). Nearly two-thirds (65.7) of chemicals used in household items were lacking data on either toxicity, exposure or both (**Figure 17**).

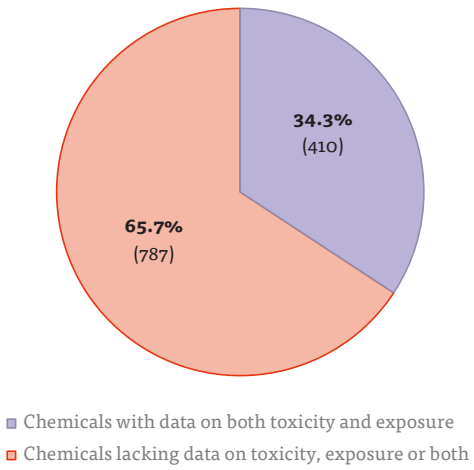
Non-stick cookware coatings are typically plastic-based, and contain PFAS, a class of persistent synthetic chemicals.

Figure 16: (A) Human health toxicity of plastic chemicals in household items (B) Human exposure to plastic chemicals in household items



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity (A) and exposure (B). With regard to (A), the suspected toxicity group may include some high toxicity chemicals if the level was not specified in the PlastChem database – see **Methodology** for further information.

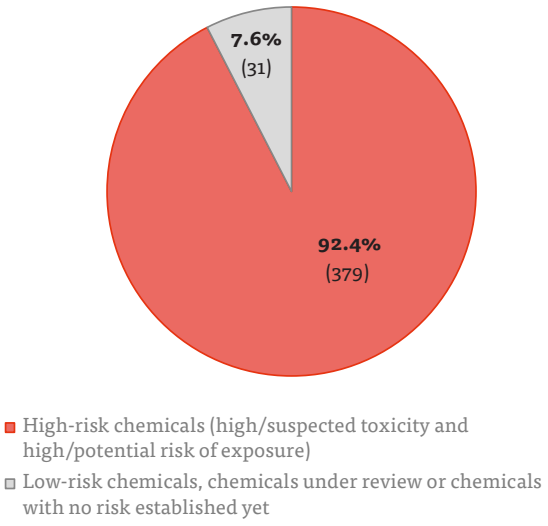
Figure 17: Proportion of plastic chemicals in household items for which data are lacking on toxicity, exposure or both



Source: EJF analysis of PlastChem data

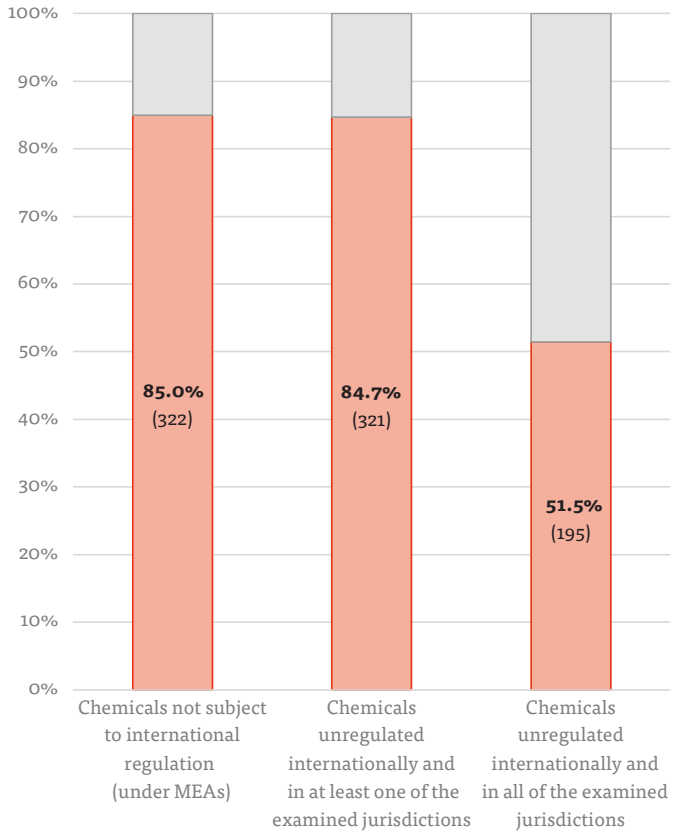
Of the 410 plastic chemicals used in household items with data on both toxicity and exposure, our analysis found that 92.4% present an overall high risk to human health (**Figure 18**). The majority of these high risk chemicals (85.0%) are not subject to regulation under relevant international agreements. Nearly all high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 51.5% of chemicals in household items identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California) (**Figure 19**).

Figure 18: Overall human health risk of plastic chemicals in household items



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity and exposure

Figure 19: Regulatory status of high risk plastic chemicals in household items



Source: EJF analysis of PlastChem data

Overall, 51.5% of chemicals in household items identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

HYGIENE AND MEDICAL ITEMS

Box 11: Key findings

EJF found that:

- **92.6%** of plastic chemicals used in hygiene and medical items, for which we have information on both toxicity and exposure risk, **present a high risk to human health**
- **92.0%** of high risk plastic chemicals used in hygiene and medical items are **unregulated internationally**
- **50.6%** of chemicals found in hygiene and medical items **do not have available data** on toxicity and/or exposure

Credit: Pexels/rdne

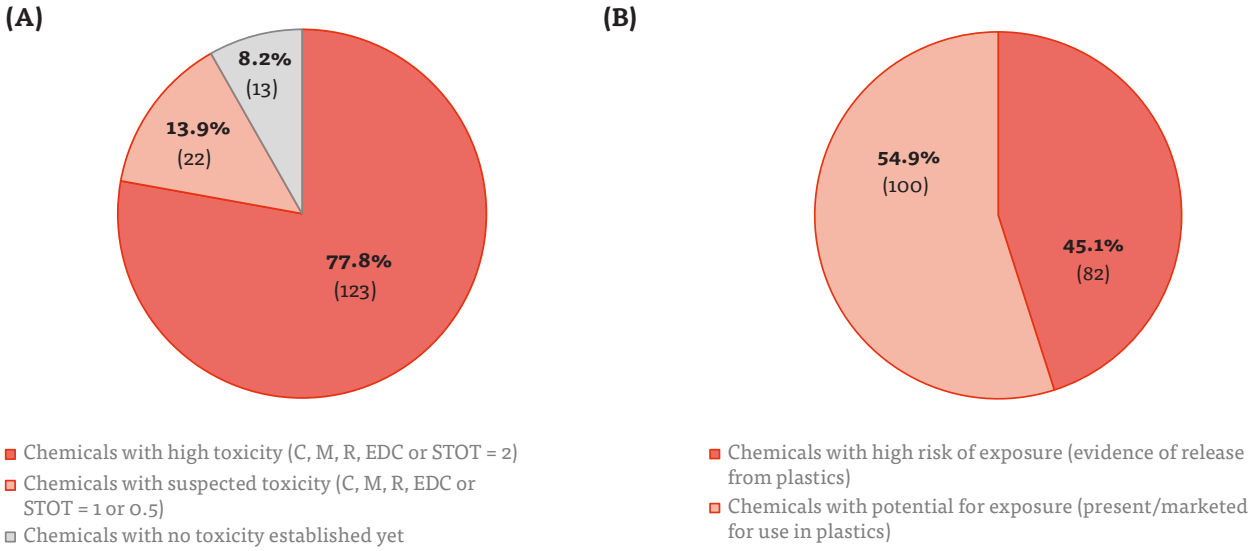
Plastics have become ubiquitous in the hygiene and medical sector due to their versatility, convenience and low cost. They are used in protective masks, band-aids, patches, syringes, hairbrushes, hair pins, tampons, toothbrushes, dental floss, tubing, prosthetic devices, implants, pill casings, and dialysis materials, among many others.[184] However, their use for functional benefits and to reduce infection risks comes at its own cost.[185] Since the late 1960s[186], researchers have documented that plastic chemicals are highly susceptible to leaching when in contact with substances such as blood, plasma and other solutions[187]. Studies have shown, for example, that infants on infusion lines may be exposed to daily intakes of plastic chemicals that are up to 160,000 times higher than safe limits.[188] This puts already vulnerable populations at even greater risk.

> ***"Hygiene and medical items can release particles directly into the body through mucosal or parenteral exposure, posing high systemic risk."***
>
> Raffaele Marfella, Professor of Internal Medicine and Director of the Medical and Surgical Sciences Department, University of Campania Luigi Vanvitelli, Italy

Alongside food-contact plastics, experts consulted for this report described hygiene and medical plastics as the most alarming sources of toxic plastic chemical exposure, primarily because they involve direct bodily contact or internal administration. Medical exposure can be substantial, in particular for newborns in neonatal care, patients receiving intravenous (IV) treatment or people undergoing surgery. Particular concern was expressed about catheters, IV bags, tubing and other medical devices, many of which are made from PVC softened with phthalates or other additives that can leach directly into the body. Concerns also extended to personal care and hygiene products, which are often marketed as safe despite limited testing of their long-term effects. Several respondents highlighted menstrual hygiene products as an overlooked but important source of plastic exposure (**Box 12**). They noted that these products involve prolonged and intimate contact with plastic materials, allowing for potential absorption of microplastics and chemical additives through highly permeable tissue.

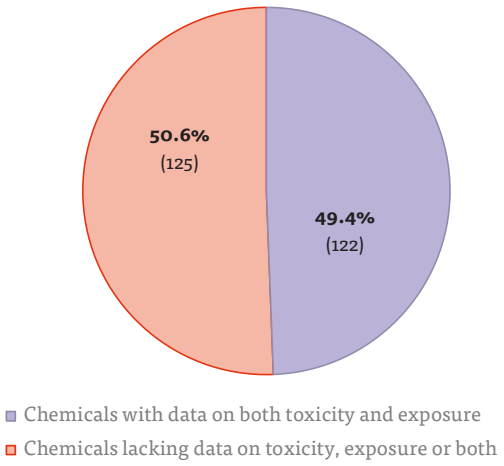
The PlastChem database contains a total of 247 plastic chemicals categorised as used in hygiene and medical items (according to PlasticMAP). Of those chemicals with information on toxicity, the vast majority (91.7%) have evidence of either high or suspected toxic health effects: 77.8% are confirmed **highly toxic** and 13.9% are suspected of being toxic to human health (**Figure 20 - A**). 45.1% of the identified chemicals with available data on exposure are associated with a **high risk of exposure** due to evidence of their release during use, while 54.9% have potential for exposure due to evidence of their presence or being labelled for use in hygiene and medical products (**Figure 20 - B**). Over half (50.6%) of chemicals used in hygiene and medical items were lacking data on either toxicity, exposure or both (**Figure 21**).

Figure 20: (A) Human health toxicity of plastic chemicals in hygiene and medical items (B) Human exposure to plastic chemicals in hygiene and medical items



Source: EJF analysis of PlastChem data
Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity (A) and exposure (B). With regard to (A), the suspected toxicity group may include some high toxicity chemicals if the level was not specified in the PlastChem database – see **Methodology** for further information.

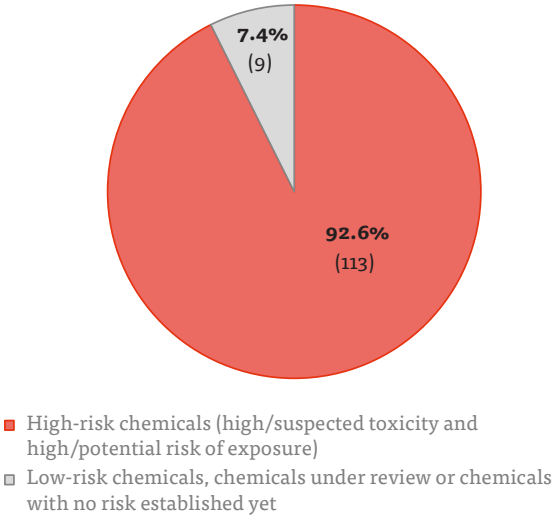
Figure 21: Proportion of chemicals in hygiene and medical items for which data are lacking on toxicity, exposure or both



Source: EJF analysis of PlastChem data

Of the 122 plastic chemicals used in hygiene and medical items with data on both toxicity and exposure, our analysis found that 92.6% present an overall high risk to human health (**Figure 22**). The vast majority of these high risk chemicals (92.0%) are not subject to regulation under relevant international agreements. All high-risk internationally unregulated chemicals were also found to be unregulated in at least one of the examined jurisdictions. Overall, 61.9% of chemicals in hygiene and medical items identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California) (**Figure 23**).

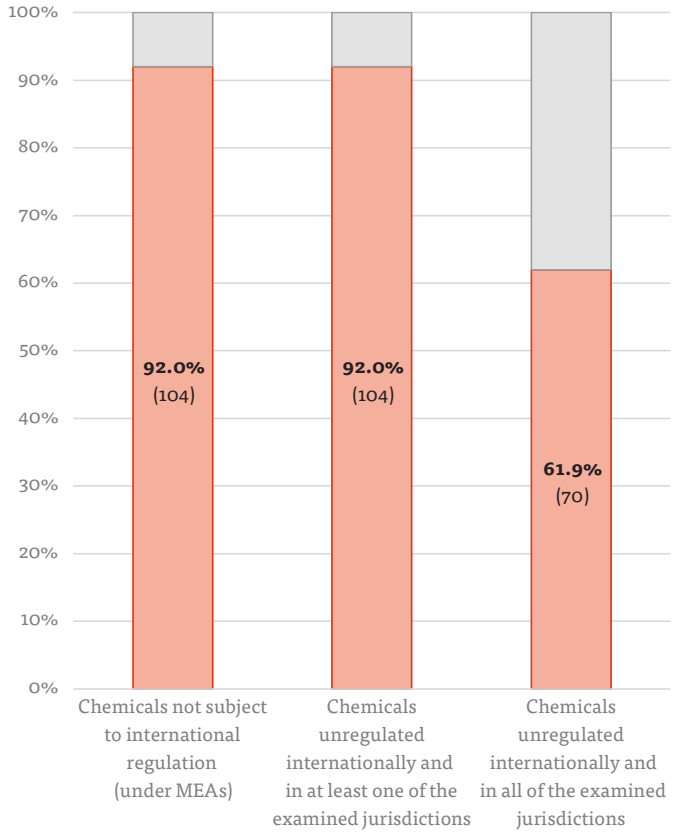
Figure 22: Overall human health risk of plastic chemicals in hygiene and medical items



Source: EJF analysis of PlastChem data

Note: Values are expressed as a proportion of the total number of chemicals with data on toxicity and exposure

Figure 23: Regulatory status of high risk plastic chemicals in hygiene and medical items



Source: EJF analysis of PlastChem data

Overall, 61.9% of chemicals in hygiene and medical items identified by EJF as presenting a high risk to human health were not subject to regulation at the international level nor in any of the four jurisdictions under review (the EU, Japan, South Korea and California).

Box 12: Menstrual products – an overlooked but high risk exposure pathway for toxic plastic chemicals

Menstrual products are often overlooked in exposure studies despite their high risk factor. Plastic additives have been found in all types of products, including single-use pads, panty liners and tampons, as well as reusable pads, menstrual underwear and menstrual cups.[189] They have been found to contain measurable levels of EDCs including phthalates, phenols and parabens.[190] Vaginal and vulvar tissues are known to have a higher absorption capacity compared to other skin tissues, which makes menstruating individuals more vulnerable to the impacts of leaching.[191] A recent study that examined the toxicity of menstrual pads found that all tested pads shedded microplastics. Additionally, all but four pads (which bore an 'organic' label) reduced cell viability, indicating the leaching of bioactive substances.[192] Another study revealed that levels of exposure to several phthalates from menstrual pads were much higher than those reported from indoor dust ingestion.[193]

Menstrual products have been found to contain measurable levels of plastic chemicals.

Phthalate concentrations of sanitary pads and diapers have been found to be significantly higher than those in other plastic consumer products.[194]

Conclusion

Plastics have become embedded in every aspect of modern life – but at an immense hidden cost. This report has highlighted substantial scientific evidence that leaves no room for doubt as to the potentially severe health impacts of unbridled plastic consumption. Thousands of plastic chemicals – many known to cause cancer, disrupt hormones, damage vital organs, and impair fertility and child development – remain unregulated and unmonitored. Babies and children may suffer routine and intense exposure, whether through plastic toys, pacifiers or infant feeding bottles, and are extremely vulnerable to toxic plastic effects.

These findings expose not only a public health crisis, but also a profound failure of governance and corporate accountability.

The scientific evidence is clear: failure to reduce the production and use of plastics and toxic plastic chemicals endangers human health and violates our fundamental right to a clean, safe and healthy environment. The plastics crisis weighs most heavily on vulnerable groups, compounding existing injustices. Addressing it is not only a matter of environmental protection, but a matter of human rights and health equity. Plastics have become ubiquitous in our day-to-day lives, leaving us exposed to potentially severe ill-effects that cannot be entirely avoided or mitigated by individual efforts to reduce consumption. Governments must act swiftly and decisively to reduce plastic production, eliminate hazardous chemicals across the plastics life cycle, and prioritise toxic-free systems and practices that focus on the reduction of production and consumption. Producers must be held responsible and the burden of proof must be placed onto those who profit from this toxic and polluting industry. A strong, legally binding Global Plastics Treaty must place human health and environmental justice at its heart, ensuring transparency and accountability all the way from production to disposal.

Two women sorting plastic waste in a flooded area of Chattogram, Bangladesh. Credit: Pexels/mumtahina-tanni

Credit: iStock.com/Bevan Goldswain

Recommendations

To reduce the human health impacts of plastics and their associated chemicals, EJF urges governments and their representatives to push for a strong Global Plastics Treaty, but not to rely on action at the global stage to initiate and implement solutions. We call on policy-makers to push for national, regional and plurilateral action while continuing to seek progress at the multilateral level. EJF recommends regulation that includes:

1. Binding targets to drastically reduce the production, supply and trade of primary plastic polymers, with clear and enforceable timeframes for implementation. EJF endorses the 40x40 target proposed by Rwanda and Peru to reduce global primary plastic production by 40% by 2040, with a 2025 baseline.

2. Strong provisions to regulate the use of chemicals of concern throughout the life cycle of plastics (as well as other materials), especially during production. These provisions must include mechanisms to prohibit the production, use and trade of hazardous chemicals based on a precautionary approach, with chemicals tested for hazard before market release (**Box 13**).

3. Strong provisions on transparency and traceability of plastics and associated chemicals throughout their life cycle, to fill information gaps on the threats from plastic-associated chemicals, hold chemical and polymer producers accountable and empower regulatory agencies.

4. Strong provisions to prohibit and restrict the production, use, trade, sales and distribution of toxic and inessential plastic products, especially single-use plastics and plastics with high risk of toxicity and exposure.

5. Strong provisions to improve the design of plastic products with the goal of protecting human health.

6. Strong provisions to support the implementation of toxic-free reuse, refill, repair and other reduction-enabling systems in place of toxic single-use systems.

7. Mechanisms for cross-border cooperation, as well as transparency and traceability measures, to ensure restrictions on production and trade can be effectively enforced.

8. The protection of health and human rights as a primary objective and cross-cutting theme throughout. Regulations should aim to tackle the plastics crisis from a One Health perspective, recognising the need for an integrated approach to addressing threats to the biosphere as a whole, including humans, other living organisms, and ecosystems alike (**Box 14**).

9. Support for urgent multidisciplinary research and education on the human health and environmental impacts of plastics, in order to fill knowledge gaps and align plastics governance with environmental and public health governance.

10. Support for robust, transparent and up-to-date data on the climate, health and biodiversity impacts of plastic production.

EJF calls on governments to guarantee our 'Right to Reduce', i.e. the right to a clean and healthy environment through reducing plastic production and consumption, replacing single-use plastics with toxic-free reuse, refill, repair and other reduction-enabling systems, and regulating the use of toxic plastic chemicals based on a precautionary approach.[195]

"The production of plastics needs to be strongly regulated at both national and international levels, and alternative infrastructures to those that circulate plastic products need to exist."

Maya Weeks, Research Affiliate, Davis Feminist Research Institute, University of California, USA

"Stronger regulation and preventive policies are essential to protect vulnerable populations and reduce the global burden of chronic disease linked to plastic exposure."

Raffaele Marfella, Professor of Internal Medicine and Director of the Medical and Surgical Sciences Department, University of Campania Luigi Vanvitelli, Italy

Box 13: The Precautionary Principle

EJF advocates for taking a precautionary approach to plastic chemical regulation. This means that chemicals should be assessed based on their hazards. Regardless of risk of exposure, any chemical that has a certain hazard (carcinogenicity, mutagenicity, reproductive toxicity, organ toxicity, or endocrine-disrupting properties) must be banned, rather than regulated on the basis of concentration. Where hazard information for a specific chemical is lacking, chemicals should be banned if part of known chemical groups of concern. These blanket bans are important in order to avoid regrettable substitutions – i.e. the replacing of known hazardous chemicals with not-yet-known hazardous chemicals that are structurally similar but lack safety data. Taking a precautionary approach also allows for the design of policy frameworks that are adaptive and can account for advancements in scientific information on plastic chemicals.

Box 14: One Health and the plastics crisis

Plastics are now regarded as the single anthropogenic contaminant with the widest spectrum of exposure across all levels of biology, threatening the health of humans, plants and animals alike.[196] The interconnectedness between the health of the biosphere as a whole, including humans, all other living organisms, and the ecosystems they constitute and depend on, is also known as One Health.[197] Tackling the plastic crisis from a One Health perspective aims to address the health of humans, animals and ecosystems in an integrated manner,[198] enabling better decision-making, prevention and preparedness. The concept is gaining traction as a means of addressing the multilayered and interdependent facets of the plastics crisis.[199]

Appendix: Methodology

To understand the risks associated with plastic chemicals in everyday products, EJF carried out an analysis of publicly available data in the PlastChem database (v1.0).[200] PlastChem was an independent project funded by the Norwegian Environment Agency which synthesised evidence on more than 16,000 chemicals present or marketed for use in plastics. The project resulted in a report and database containing information on the chemicals analysed, systematically identifying and prioritising chemicals of concern based on four hazard criteria: persistence, bioaccumulation, mobility and toxicity.

EJF conducted novel analyses of the PlastChem data to shed light on the risks presented to human health by everyday items containing plastic-associated chemicals. For this analysis, we focused on the chemicals associated with the following use categories: (i) food-contact plastics, (ii) textiles, (iii) toys, (iv) household items, and (v) hygiene and medical items. The categories of everyday plastic items are based on the industrial sector categories in the PlastChem database derived from the PlasticMAP study.[201] The PlasticMAP database identifies more than 10,000 relevant plastic monomers, additives and processing aids on the global market and categorises them based on substance types, use patterns and hazard classifications.

It is critical to note that chemicals with a PlasticMAP use category represent only a subset (around a quarter – 24.4%) of total chemicals in the PlastChem database. The PlasticMAP study was unable to assign use categories to all chemicals identified (due to a lack of available information), while PlastChem includes chemicals from additional data sources beyond PlasticMAP.[202] This means there are likely many more plastic chemicals in each of the five everyday use categories than are considered in EJF's analysis (see example in **Box 7**). The risks to human health are therefore likely even greater than presented in this report.

EJF considered chemicals to present a high risk to human health if they are known to be toxic or suspected of being toxic, and if we are at risk of being exposed to them because they are used or present in and in some cases known to be released from plastics. This approach aligns with the precautionary principle (**Box 13**).

High risk to human health = high/suspected toxicity AND high/potential risk of exposure

Toxicity was determined based on PlastChem criteria for carcinogenicity, mutagenicity, reproductive toxicity, endocrine disruption and specific organ toxicity. Chemicals allocated a 2 – the highest possible score – by PlastChem in any of these categories were classified as highly toxic, while those scoring 1 or 0.5 were classified as suspected of being toxic to human health (**Table A1**).

Table A1: EJF's toxicity classification of chemicals used in everyday plastics based on PlastChem indicators and EU criteria on the Classification, Labelling and Packaging (CLP) of chemicals

PlastChem indicators[203]			Regulation (EC) No 1272/2008[204]	EJF classification
Hazard criteria	Score	Definition		
Carninogenicity (C)	2	Chemical is carcinogenic 1A or 1B	Category 1A, known to have carcinogenic potential for humans, classification is largely based on human evidence. Category 1B, presumed to have carcinogenic potential for humans, classification is largely based on animal evidence.	High toxicity
	1*	Chemical is recognised as carcinogenic but without specifying the level	/	Suspected toxicity
	0.5	Chemical is carcinogenic level 2	Category 2, suspected human carcinogens.	
	0	Chemical is not carcinogenic	/	Toxicity not established
Mutagenicity (M)	2	Chemical is mutagenic 1A or 1B	Category 1A, based on positive evidence from human epidemiological studies. Substances to be regarded as if they induce heritable mutations in the germ (reproductive) cells of humans. Category 1B, based on: - positive result(s) from heritable germ cell mutagenicity tests in live mammals; or - positive result(s) from somatic (non-reproductive, not heritable) cell mutagenicity tests in live mammals, in combination with some evidence that the substance has potential to cause mutations to germ cells. It is possible to derive this supporting evidence from mutagenicity/ genotoxicity tests in germ cells in live mammals, or by demonstrating the ability of the substance or its metabolite(s) (intermediates or end products of metabolism) to interact with the genetic material of germ cells; or - positive results from tests showing mutagenic effects in the germ cells of humans, without demonstration of transmission to progeny (offspring); for example, an increase in the frequency of aneuploidy (the condition of having an abnormal number of chromosomes) in sperm cells of exposed people.	High toxicity
	1*	Chemical is recognised as mutagenic but without specifying the level	/	Suspected toxicity
	0.5	Chemical is mutagenic level 2	Category 2, substances which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans.	
	0	Chemical is not mutagenic	/	Toxicity not established

Reproductive toxicity (R)	2	Chemical is reproductive toxic 1A or 1B	Category 1A, known human reproductive toxicant, classification based on evidence from humans. Category 1B, presumed human reproductive toxicant, largely based on data from animal studies.	High toxicity
	1*	Chemical is reproductive toxic 2 or recognised as reproductive toxic but without specifying the level	Category 2, suspected human reproductive toxicant.	Suspected toxicity
	0	Chemical is not reproductive toxic	/	Toxicity not established
Endocrine disruption (EDC)	2	Chemical is an endocrine-disrupting chemical category 1	Category 1, known or presumed endocrine disruptors for human health, based on evidence from at least one of the following: a) human data; b) animal data; c) non-animal data providing an equivalent predictive capacity as data in points a or b. Such data shall provide evidence that the substance meets all the following criteria: (a) endocrine activity; (b) an adverse effect in an intact organism or its offspring or future generations; (c) a biologically plausible link between the endocrine activity and the adverse effect.	High toxicity
	0.25	Chemical's assessment is under development or inconclusive	/	Toxicity not established
	0	Chemical is not an endocrine-disrupting chemical category 1	/	Toxicity not established
Specific organ toxicity (STOT) - repeated exposure	2	Chemical is toxic for a specific target organ after repeated exposure (STOT RE) 1 or 2	Category 1, substances that have produced significant toxicity in humans or that, on the basis of evidence from studies in experimental animals, can be presumed to have the potential to produce significant toxicity in humans following repeated exposure. Category 2, substances that, on the basis of evidence from studies in experimental animals, can be presumed to have the potential to be harmful to human health following repeated exposure.	High toxicity
	0	Chemical is not toxic for a specific target organ after repeated exposure (STOT RE) 1 or 2	/	Toxicity not established

Notes: *The PlastChem database allocates chemicals a score of 1 if they are recognised as carcinogenic/mutagenic/reprotoxic but the level is not specified. It is therefore possible that some of the chemicals within this group are actually known or presumed to cause cancer, induce genetic mutations and/or be toxic for reproduction (high toxicity).

Exposure risk was determined based on PlastChem indicators for use, presence and release of chemicals in and from plastics. Chemicals known to be released from plastics were classified as presenting a high risk of exposure, while those simply known to be used or present in plastics, without evidence of release, were classified as presenting a potential risk of exposure (**Table A2**).

Table A2: EJF's exposure classification of chemicals used in everyday plastics based on PlastChem indicators

PlastChem indicators		EJF classification
Exposure indicator	**Meaning**	
Release = 1	Chemicals with scientific evidence demonstrating their release (leaching) from plastics	High risk of exposure
Presence = 1	Chemicals detected in plastics in scientific studies	Potential risk of exposure
Use = 1	Chemicals marketed for being added to plastics	

For chemicals identified as presenting a high risk to human health based on application of the above criteria, we conducted a rapid review of their regulatory status based on available information in the PlastChem database. The PlastChem database contains information on the regulatory status of each chemical in major markets – the European Union (EU), Japan, South Korea, and, in the United States, the state of California (**Table A3**) – as well as internationally under the Basel Convention, the Minamata Convention, the Montreal Protocol, the Rotterdam Convention, and the Stockholm Convention (**Table A4**). In the absence of information about applicable regulations in other US states or at the federal level, the regulatory status of relevant chemicals within the US as a whole was not reviewed. We note that the US has not ratified the Basel Convention, the Rotterdam Convention or the Stockholm Convention, leaving US consumers and communities particularly vulnerable to the health risks associated with plastic and other toxic chemicals.

Table A3: National/regional regulations examined by the PlastChem project and used for EJF's analysis of the regulatory status of high risk chemicals

Jurisdiction	Regulation lists examined by PlastChem
EU	REACH restriction, REACH authorization, REACH SVHCs, EU toy restriction and EU toy allergenic fragrances, and ROHS Directive
Japan	ISHA and CSCL
South Korea	Accidents, CMR, Hazardous Chemicals and Intensive Control
US	California P65

Notes: REACH = Registration, Evaluation, Authorisation, and Restriction of Chemicals, SVHCs = Substances of Very High Concern, ROHS = Restriction of Hazardous Substances, P65 = Proposition 65, ISHA = Industrial Safety and Health Act, CSCL = Occupational Safety and Health Law, CMR = carcinogenic, mutagenic or reprotoxic.

Table A4: Multilateral environmental agreements (MEAs) examined by the PlastChem project and used for EJF's analysis of the regulatory status of high risk chemicals

MEA	Regulation lists and chemicals examined by PlastChem	Participants
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Annexes A and B	191 parties, incl. the EU, Japan and South Korea[205] The US has **not** ratified this Convention
Minamata Convention on Mercury	Mercury and chemicals containing mercury	153 parties, incl. the EU, Japan, South Korea and the US[206]
Montreal Protocol on Substances that Deplete the Ozone Layer	Annexes A, B, C and E, as well as the phasing-down of production and consumption of hydrofluorocarbons (HFCs) listed in Annex F	198 parties, incl. the EU, Japan, South Korea and the US[207]
Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade	Annex III	168 parties, incl. the EU, Japan and South Korea[208] The US has **not** ratified this Convention
Stockholm Convention on Persistent Organic Pollutants (POPs)	Annex A (elimination), Annex B (restriction) and Annex C (unintentional production), chemicals included in the eleventh meeting held from 1.–12.03.2023 (i.e., Methoxychlor, Dechlorane Plus, UV-328), PAHs as they are considered POPs under the UNECE Convention on Long-Range Transboundary Air Pollution, PBDD and PBDF	186 parties, incl. the EU, Japan and South Korea[209] The US has **not** ratified this Convention

Notes: PAHs = polycyclic aromatic hydrocarbons, PBDD = polybrominated dibenzo-p-dioxins, PBDF = polybrominated dibenzofurans.

EJF's analysis of the regulatory status of high-risk chemicals aims to provide an initial indication of the extent to which chemicals that present as high risk to human health are regulated in key jurisdictions. It is limited to the consideration of the regulations/MEAs reviewed by PlastChem and does not distinguish between the level or types of control imposed which can range in severity, for example, from prior informed consent procedures to the restriction of specific chemicals of concern.

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Environmental Justice Foundation (EJF)
Gensurco House, 3-5 Spafield Street
London, EC1R 4QB, UK
tel: +44 (0) 207 239 3310
info@ejfoundation.org, ejfoundation.org
Registered charity No. 1088128

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