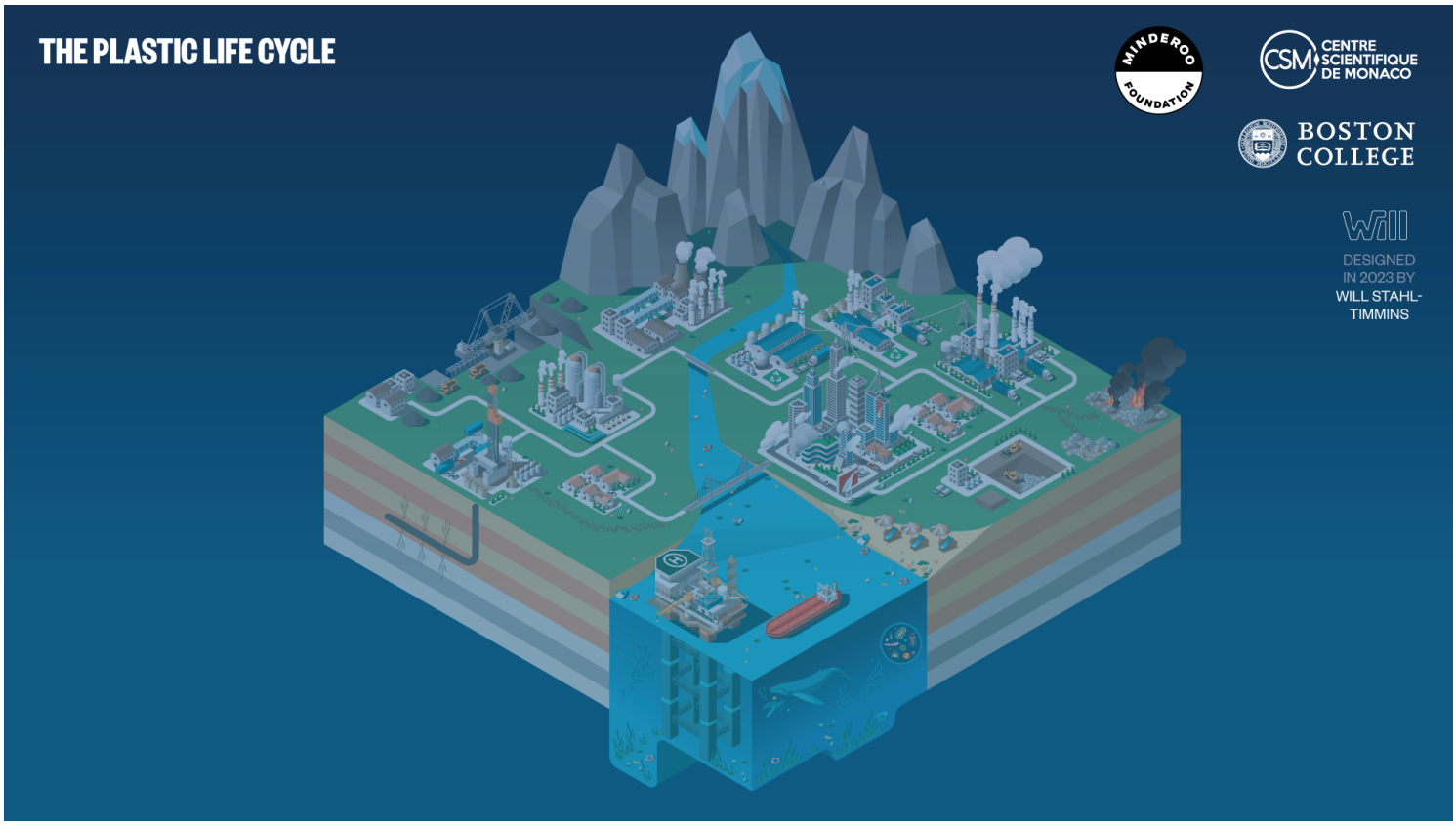
The Minderoo-Monaco Commission

on

Plastics and Human Health

Summary



Philip J Landrigan[1,2], Hervé Raps[2], Christos Symeonides[4] and Sarah Dunlop[4,33], on behalf of the Minderoo-Monaco Commission Authors:

Philip J. Landrigan, MD, MSc,[1,2] Hervé Raps, MD,[2] Maureen Cropper, PhD,[3]Caroline Bald,[1] Manuel Brunner, PhD,[4] Elvia Maya Canonizado, BA,[5] Dominic Charles, MBA,[4] Thomas C. Chiles, PhD,[6] Mary J. Donohue, MA, PhD,[7] Judith Enck, BA,[8]Patrick Fenichel, MD, PhD,[9,10] Lora E. Fleming, MD PhD MPH MSc,[11]Christine Ferrier-Pages, PhD,[12] Richard Fordham, MA, PhD,[13] Aleksandra Gozt, BSc (Hons), PhD,[4] Carly Griffin,[1] Mark E. Hahn, PhD,[14,15] Budi Haryanto, MPH, MSc, PhD,[16,17]Richard Hixson, FRCA FFICM,[18] Hannah Ianelli,[1] Bryan D. James, PhD,[19,20]Pushpam Kumar, PhD,[21] Amalia Laborde, MD,[22] Kara Lavender Law, PhD,[23] Keith Martin, MD, PC,[24] Jenna Mu, BS,[1] Yannick Mulders, PhD,[4] Adetoun Mustapha, PhD, MPH, MSc,[25,26] Jia Niu, PhD,[27] Sabine Pahl, MSc, PhD,[28,29] Yongjoon Park, PhD,[30]Maria-Luiza Pedrotti, PhD,[31] Jordan Avery Pitt, BS,[14] Mathuros Ruchirawat, PhD,[32]Bhedita Jaya Seewoo, PhD,[4,33] Margaret Spring, JD,[5] John J. Stegeman, PhD,[34]William Suk, PhD,[35] Christos Symeonides, MB/ChB (hons),[4] Hideshige Takada, PhD,[36]Richard C. Thompson, PhD,[37] Andrea Vicini, SJ, MD, PhD, STD,[38] Zhanyun Wang, PhD,[39]Ella Whitman,[1] David Wirth, AM, JD,[40] Megan Wolff, PhD, MPH,[8] Aroub K. Yousuf, BA,[1]and Sarah Dunlop, PhD[4,33]

Author information: See page 6

DOI: https://doi.org/10.5334/aogh.4056

Plastics have conveyed great benefits to humanity, made our lives more convenient, and supported some of modern civilization's most significant advances. It is now clear, however, that plastics are neither safe nor cheap. Current patterns of plastic production, use and disposal are wasteful, inefficient and far from circular. They are responsible for significant harms to human health, the economy, and the earth's environment. These harms extend far beyond beach litter and microplastics. Many are invisible. Until now, the extent of these harms has not been systematically assessed, their magnitude not quantified, and their economic costs not counted.

The goal of the Minderoo-Monaco Commission on Plastics and Human Health is to comprehensively examine and make visible the full range of plastics' harms to human health and the earth's environment across the entire plastic life cycle.

Findings and Recommendations. The Minderoo-Monaco Commission on Plastics and Human Health makes four major findings and recommendations in relation to the United Nations Global Plastic Treaty:

1. **Current patterns of plastic production, use and disposal cause disease, disability and premature death. They are destroying the earth's environment. They are not sustainable.** These harms arise at every stage of the plastic life cycle and result in injury to human health from before birth to extreme old age.
   Recommendations
   Production: Reduce production, especially of single-use plastics. Mandate Extended Producer Responsibility.
   Use: Use less, re-use more, and design better materials.
   Disposal: Invest in recycling technologies and controlled disposal. Reduce waste export.
2. **Plastic is complex and toxic.** The thousands of chemicals in plastics - monomers, additives, processing agents, and non-intentionally added substances - leach out of plastics, enter the environment, cause pollution, and result in human exposure. These chemicals are responsible for many of plastics' harms to human and planetary health.
   Recommendations
   Regulation: Chemical inventory. Bans on toxic chemicals. Full hazard assessments for all plastic chemicals.
   Transparency: Full disclosure of chemicals in plastic products.
   Human monitoring: Systematic post-market screening for plastic chemical exposure and epidemiological health evaluation.
3. **Plastic is expensive.** The economic costs of plastics' health damages are very high. In 2015 the health-related costs of plastic production exceeded US$250 billion globally. Greenhouse gas emissions from plastic production cause additional harms to health costing US$341 billion annually. The costs of disease, disability and premature death caused by three plastic chemicals (PBDE, BPA and DEHP) in one country - the USA - exceeded US$920 billion in 2015. These estimates undercount the full costs of plastics' health damages. They are externalized by fossil fuel and plastic manufacturing industries and borne by citizens, taxpayers and governments.
   Recommendations
   Economics: Full cost-benefit analysis of plastic across the entire plastic life cycle.
   Cost-burden: Equitable sharing of currently externalized costs.
4. **Plastic is socially and environmentally unjust.** Plastics' harms disproportionately damage vulnerable populations – the poor, people of color, Indigenous populations, fossil fuel extraction workers, plastic production workers, informal waste and recovery workers, persons living in communities adjacent to fossil fuel extraction, plastic production, and plastic waste facilities, and children.
   Recommendations
   Social justice: Equitable and inclusive participation in the Treaty negotiations.
   Knowledge: Transparency and access to information.

DOI: https://doi.org/10.5334/aogh.4056

What are Plastics? Plastics are complex chemical materials. Over 98% are made from fossil carbon - coal, oil and gas. All plastics are comprised of a carbon-based polymer matrix plus thousands of petrochemicals. Many of these chemicals are highly toxic, and they include carcinogens, neurotoxicants and endocrine disruptors. Plastic-associated chemicals are responsible for many of plastics' harms to human health.

Plastic Production. Global plastic production is increasing exponentially - from under 2 million tons in 1950, to 460 million tons today. Half of all plastic ever made has been made since 2002. Production is on track to triple by 2060. Single-use plastics account for 35–40% of current production. Explosive growth in plastic production reflects a pivot by the multinational corporations that make both fossil fuels and plastics. In response to global climate change and increasing renewable energy, these corporations are decreasing production of fossil fuels for energy, while increasing plastics manufacture.

The Plastic Life Cycle. The plastic life cycle has three phases: production, use, and disposal. In production, fossil carbon feedstocks—coal, gas and oil—obtained through mining, drilling and fracking are transported via ship, rail and pipeline and transformed into a vast array of products. Plastic use occurs in every aspect of modern life and results in widespread exposure to the chemicals incorporated into plastic. Plastic disposal involves landfilling, open burning, thermal conversion, and export from high-income to low-income countries. Plastic recycling is ineffective, with recycling rates of 10% for all plastic and as low as at 1-2% for single-use plastic. An estimated 22 million tons of plastic waste enters the environment each year and is added to the more than 6 trillion tons of plastic waste that now pollute every corner of the planet.

Plastics and Climate Change. Plastic production is highly energy-intensive. It discharges nearly 2 gigatons of CO_2 and other climate-forcing greenhouse gases to the atmosphere each year – more than the annual contribution of Brazil. In 2015, the percentage of fossil fuel used to produce plastic as both energy source and petrochemical feedstock was ~4%, with 67% coming from coal, 23% from petroleum and 10% from gas.

Plastics and the Ocean. The ocean is the ultimate destination for plastic waste. Large plastics as well as microplastic particles now contaminate coastal regions, the sea surface, the deep sea, ocean trenches and polar sea ice worldwide. Many plastics appear to resist breakdown in the ocean and could persist for decades. The impacts of large plastics, including plastic bags, bottles, and fishing gear, entangling and entering the digestive tracts of fish, birds, turtles and marine mammals - are visible, obvious, and disturbing. The impacts of microplastics are less well understood, but appear to disrupt plants, animals, and microbes throughout the marine environment. Microplastic contamination of seafood results in direct, though not well quantified, human exposure to plastics and plastic-associated chemicals. At highest risk are the 3 billion people who depend directly on the ocean as a major source of protein. Marine plastic pollution endangers the ocean ecosystems upon which all humanity depends for oxygen, livelihood, and well-being.

Plastics and Human Health. Plastic endangers human health and causes disease, disability, and premature death at every stage of its life cycle. Workers who extract coal, oil and gas feedstocks for plastic production, plastic production workers, plastic textile workers and plastic recycling workers suffer increased rates of cardiovascular, pulmonary, metabolic and neurologic diseases, and cancer. During use and also in disposal, plastics release microplastic and nanoplastic fragments along with thousands of toxic chemicals including additives and residual monomers into the environment and into people. Plastic additive chemicals disrupt endocrine function and increase risk for premature births, neurodevelopmental disorders, male reproductive birth defects, infertility, obesity, cardiovascular disease, renal disease, and cancer. National biomonitoring surveys reveal population-wide exposures to these chemicals.

Plastics' Hazards to Infants and Children. Children are not little adults. Infants and young children are growing rapidly with unique physiological and behavioural differences, higher exposures per unit of body weight and longer life expectancies that make them much more vulnerable than adults. Infants in the womb are exposed to plastic chemicals through maternal exposure during pregnancy. These exposures are linked to increased risks of miscarriage, prematurity, stillbirth, low birth weight, birth defects of the reproductive organs,

neurodevelopmental impairment, impaired lung growth, and childhood cancer. Early-life exposures to plastic-associated chemicals increase risk of non-communicable diseases such as heart disease, type 2 diabetes and obesity in childhood and across the human life span.

Plastics' Economic Costs. Because plastic production is polluting and causes disease and death in workers and community residents, it is responsible for health-related economic losses – healthcare costs and productivity losses. In 2015, the health-related costs of plastic production exceeded US$250 billion globally - more than the GDP of New Zealand or Finland. These include costs of occupational injuries; costs of diseases caused by air pollution, benzene, formaldehyde and other toxic materials; and the costs associated with plastics' contribution to climate change. Disease, disability and death caused by three plastic-associated chemicals, PBDE (flame retardant), BPA (monomer) and DEHP (plasticizer) are responsible for additional health costs. PBDE and phthalates cause IQ loss in children following prenatal exposure. IQ loss causes economic losses by reducing lifelong productivity. DEHP causes premature deaths from stroke and cardiovascular disease. In the USA alone, the annual costs of disease caused by PBDE, BPA and DEHP exceed US$920 billion.

Plastics and Social Justice. In addition to the vulnerability of children, plastics' harms are unfairly distributed amongst adults. Groups disproportionately exposed to toxic pollutants released to the air, water and soil. include: people of color, Indigenous populations, fossil fuel extraction workers, chemical and plastic production workers, informal waste and recovery workers, persons living in "fenceline" communities adjacent to fossil fuel extraction, plastic production, and plastic waste facilities. They have high risk of disease, disability, and death caused by plastic and experience increased risks of premature birth, low birth weight, asthma, leukemia, cardiovascular disease, chronic obstructive pulmonary disease, and lung cancer.

Recommendations

The Minderoo-Monaco Commission strongly supports urgent development and adoption of a comprehensive Global Plastics Treaty by the world's nations in accord with the mandate set forth in the March 2022 resolution of the United Nations Environment Assembly (UNEA). Protection of human health, and especially the health of vulnerable populations, needs to be an over-arching goal.

The Minderoo-Monaco Commission urges that a global cap on global plastic production be a core provision of the Global Plastics Treaty. The great power of a production cap is that it will reduce the volume of plastics and plastic waste at its root source and slow the global build-out of plastic production.

The Treaty needs to extend beyond microplastics and marine litter to **include all of the many thousands of chemicals incorporated into plastics**

The Treaty needs to mandate **health-protective standards for plastics and plastic additives,** including: reductions in the **chemical complexity** of plastics, full disclosure and **transparency** of the chemical composition of plastics and plastic products, **traceability** of plastic products in the waste phase, **pre-market testing** of all plastic chemicals as well as systematic post-market **human biomonitoring** and health evaluation. International cooperation will be essential to implementing and enforcing these standards.

The Global Plastic Treaty needs to **ban or severely restrict manufacture of unnecessary, single-use plastics**

The Treaty needs to mandate **Extended Producer Responsibility (EPR)** for all plastic products, through which plastic producers are financially and legally responsible for the recovery, recycling or proper disposal of the materials they produce.

The Treaty needs to explore listing some plastic polymers and plastic-associated chemicals as **Persistent Organic Pollutants (POPs)** under the Stockholm Convention.

The Treaty needs to address the disproportionate impacts of plastics on vulnerable populations. **Protection of human rights** needs to be an explicitly articulated, core goal of the Global Plastics Treaty

The Treaty needs to strengthen **restrictions on transnational export of plastic waste** through interface with the Basel and London Conventions.

Treaty development and implementation will require a **Permanent Science Policy Advisory Body.**

Conclusion

There is much about plastic and its hazards that we still do not know, and more research is needed. But we now know very clearly that plastics' harms to human health and the global environment are extremely serious. And we know that in the absence of urgent intervention, these harms will get much worse. **We know enough to act, and we cannot use lack of complete knowledge about plastics' harms as an excuse for inaction.**

Manufacture and use of essential plastics may continue. But reckless increases in fossil-fuel-based plastic production, and especially increases in the manufacture of an ever-increasing array of unnecessary single-use plastic products, need to be curbed.

It is our generation's moral and ethical duty to confront the plastics crisis and to act courageously to protect our children's health and preserve our Common Home.

Key References

1. Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. *Sci Adv*. 2017; 3(7): e170078. doi.org/10.1126/sciadv.1700782
2. Landrigan PJ, Stegeman JJ, Fleming LE, et al. Human Health and Ocean Pollution. *Annals of Global Health*. 2020;86(1):151. doi.org/10.5334/aogh.2831
3. Wang C, Liu Y, Chen WQ, Zhu B, Qu S, Xu M. Critical review of global plastics stock and flow data. *J Ind Ecol*. 2021; 25(5): 1300–1317. doi.org/10.1111/jiec.13125
4. Thompson RC, Pahl S. Plastics, the environment and society: current consensus and future directions. In: *Plastics and the Environment*. 2018; 177–187. doi.org/10.1039/9781788013314-00177
5. Andrady AL, ed. *Plastics and the Ocean: Origin, Characterization, Fate, and Impacts*. John Wiley & Sons; 2022. doi.org/10.1002/9781119768432
6. Pitt JA, Aluru N, Hahn ME. Microplastics in marine food webs. In: Shumway SE, Ward JE, eds. *Plastics in the Sea: Occurrence and Impacts*. Elsevier; 2023
7. Garcia-Gonzales DA, Shonkoff SBC, Hays J, Jerrett M. Hazardous air pollutants associated with upstream oil and natural gas development: a critical synthesis of current peer-reviewed literature. *Annu Rev Public Health*. 2019; 40(1): 283–304. doi.org/10.1146/annurev-publhealth-040218-043715
8. Azoulay D, Villa P, Arellano Y, et al. *Plastic & Health: The Hidden Costs of a Plastic Planet*. Center for International Environmental Law; 2019. Accessed December 23, 2022. https://www.ciel.org/wp-content/uploads/2019/02/Plastic-and-Health-The-Hidden-Costs-of-a-Plastic-Planet-February-2019.pdf.
9. Cabernard L, Pfister S. A highly resolved MRIO database for analyzing environmental footprints and green economy progress. *Sci Total Env*. 2021; 755(Pt 1): 142587. DOI: https://doi.org/10.1016/j.scitotenv.2020.142587
10. Attina TM, Hauser R, Sathyanarayana S, et al. Exposure to endocrine-disrupting chemicals in the USA: a population-based disease burden and cost analysis. *Lancet Diabetes Endocrinol*. 2016; 4(12): 996–1003. DOI: https://doi.org/10.1016/S2213-8587(16)30275-3
11. Beaumont NJ, Aanesen M, Austen MC, et al. Global ecological, social and economic impacts of marine plastic. *Mar Pollut Bull*. 2019; 142: 189–195. doi.org/10.1016/j.marpolbul.2019.03.022
12. Bai Y, Givens JE. Ecologically unequal exchange of plastic waste? A longitudinal analysis of international trade in plastic waste. *J World-Syst Res*. 2021; 27(1): 265–287. doi.org/10.5195/jwsr.2021.1026

13. Simon N, Raubenheimer K, Urho N, et al. A binding global agreement to address the life cycle of plastics. *Science*. 2021; 373(6550): 43–47. doi.org/10.1126/science.abi9010
14. Bergmann M, Almroth BC, Brander SM, et al. A global plastic treaty must cap production. *Science*. 2022; 376(6592): 469–470. doi.org/10.1126/science.abq0082
15. High Ambition Coalition to End Plastic Pollution (HAC). High Ambition Coalition to End Plastic Pollution homepage. High Ambition Coalition to End Plastic Pollution. Published January 5, 2023. Accessed January 5, 2023. https://hactoendplasticpollution.org/.

Author information

CORRESPONDING AUTHOR: Philip J. Landrigan, MD, MSc Global Observatory on Planetary Health, Boston College, Chestnut Hill, MA, US; Centre Scientifique de Monaco, Medical Biology Department, MC landriganp@bc.edu

[1]Global Observatory on Planetary Health, Boston College, Chestnut Hill, MA, US
[2]Centre Scientifique de Monaco, Medical Biology Department, MC
[3]Economics Department, University of Maryland, College Park, US
[4]Minderoo Foundation, AU
[5]Monterey Bay Aquarium, US
[6]Biology Department, Boston College, US
[7]University of Hawai'i Sea Grant College Program, US
[8]Beyond Plastics, Bennington College, US
[9]Université Côte d'Azur
[10]Centre Hospitalier, Universitaire de Nice, FR
[11]European Centre for Environment and Human Health, University of Exeter Medical School, UK
[12]Centre Scientifique de Monaco, Marine Biology Department, MC
[13]Norwich Medical School, University of East Anglia, UK
[14]Biology Department, Woods Hole Oceanographic Institution, US
[15]Woods Hole Center for Oceans and Human Health, US
[16]Department of Environmental Health, Universitas Indonesia, ID
[17]Research Center for Climate Change, Universitas Indonesia, ID
[18]College of Medicine and Health, University of Exeter, UK
[19]Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution
[20]Department of Biology, Woods Hole Oceanographic Institution, US
[21]United Nations Environment Programme, KE
[22]Department of Toxicology, School of Medicine, University of the Republic, UY
[23]Sea Education Association, US
[24]Consortium of Universities for Global Health, US
[25]Nigerian Institute of Medical Research, Lagos, Nigeria
[26]Lead City University, NG
[27]Department of Chemistry, Boston College, US
[28]University of Vienna, Austria
[29]University of Plymouth, UK
[30]University of Massachusetts Amherst, US
[31]Laboratoire d'Océanographie de Villefranche sur mer (LOV), Sorbonne Université, FR
[32]Chulabhorn Research Institute (CRI), TH
[33]School of Biological Sciences, The University of Western Australia, AU
[34]Biology Department and Woods Hole Center for Oceans and Human Health, Woods Hole Oceanographic Institution, US
[35]Superfund Research Program, National Institutes of Health, National Institute of Environmental Health Sciences, US
[36]Laboratory of Organic Geochemistry (LOG), Tokyo University of Agriculture and Technology, JP
[37]International Marine Litter Research Unit, University of Plymouth, UK
[38]Theology Department, Boston College, US
[39]Technology and Society Laboratory, WEmpa-Swiss Federal Laboratories for Materials and Technology, CH
[40]Boston College Law School, US