JAMA Insights

Microplastics and Human Health

Shruthi Mahalingiah, MD; Kari C. Nadeau, MD, PhD; David C. Christiani, MD, MPH

Plastics production and use reached 435 million tons in 2020 (up from 234 million tons in 2000) and by 2040 is expected to further increase by 70%. Plastics are synthetic materials composed of polymers, such as polyester, polyethylene, copolymers of polypropylene, and polyurethane, that vary in chemical composition and often contain additives. Although more than 13 000 chemicals are associated with plastics, 10 groups of chemicals are identified as being of major concern due to their high toxicity and potential to migrate or be released from plastics. These include specific flame retardants, certain UV stabilizers, per- and polyfluoroalkyl substances (PFAS), phthalates, bisphenols, alkylphenols and alkylphenol ethoxylates, biocides, certain metals and metalloids, and polycyclic aromatic hydrocarbons.

Multimedia

CME at jamacmelookup.com

Microplastics

Plastics smaller than 5 mm are termed *microplastics*, which enter the body primarily through inhalation or ingestion after plastic litter in the environment degrades into smaller plastic fragments. Inhaled particles that have a diameter of 2.5 µm or smaller can enter the alveoli of the lungs and the bloodstream and accumulate widely in the tissues.[1] Many foods, beverages, and drinking water sources contain microplastics, which can enter the body upon ingestion. A 2020 study performed in Mexico evaluated microplastic contamination in 57 common beverages (soft drinks, beer, cold tea, and energy drinks). Of the beverages evaluated, 48 samples showed detectable microplastics, 36 samples contained less than 5 microplastic particles/L, 9 samples had 5 to 10 microplastic particles/L, and 3 samples contained 11 to 30 microplastic particles/L, with the highest abundance of microplastics (mean [SD], 28 [5.29] particles/L) recorded in a beer sample.[2] Many clothing pieces, cosmetics, and other personal use products contain microplastics and use of these products may lead to increased exposure through accidental ingestion or aerosolized inhalation. A 2024 review of 38 studies investigating 2379 cosmetic and personal care products reported 16.4% (n = 390) contained microplastics. Face scrub was the most commonly tested product (46.8% of total products tested) and 26.5% of the face scrubs tested contained microplastics.

Microplastics' unique surface area, defined by coarse shapes and heterogeneous material, enables them to act as a vehicle for various contaminants. Specifically, microplastics act as sorbents that adsorb or absorb various pollutants on their surface primarily through hydrophobic or electrostatic means and by pore filling (physically accumulating environmental contaminants, such as microbes, polycyclic aromatic hydrocarbons, and heavy metals, and encasing them in micro or nanopores) interactions.[3] In vitro studies using human cell lines, organoids (3-dimensional, miniature organ structures grown in the laboratory that mimic the structure and function of real organs), and animal studies have shown that microplastic exposure increases oxidative stress, production of reactive oxygen species, cell membrane organelle damage, immune response, and DNA damage.[4] Liver organoid exposure to polystyrene microplastics induced hepatotoxicity with increased alanine aminotransferase and aspartate aminotransferase in the supernatant (liquid above a solid phase) and compromised antioxidant balance, suggesting oxidative stress and an increase in inflammatory response observed via elevated interleukin-6 levels, even at the lowest dosage used in this study (0.25 µg/mL; mean [SD], 102 [7] items/mL).[5]

Methods of Detecting Microplastics

Current detection methods for microplastics, such as microscopy, spectroscopy (analysis of the spectrum of light that a substance emits or absorbs), and thermal analysis are being used, and most studies focus on detecting polystyrene particles.[6] Many techniques have been validated, standardized, and published; however, methodological limitations include difficulty of isolation from complex environmental or biological samples and identification of each microplastic type. More robust and standardized methodologies for detecting and quantitating microplastics are being studied.

Presence of Microplastics in Human Tissues

Studies have reported the presence of microplastics in many human tissues and organs, including the lungs, brain, blood, liver, kidneys, heart and circulatory system, spleen, colon, testes, ovarian follicular fluid, and placenta as well as in human breast milk and infants' first stools. Longitudinal studies suggest increased microplastic concentrations in biological tissues over the past several decades. Levels of microplastics were statistically higher among 24 individuals in 2024 compared with 28 individuals in 2016 in postmortem human brain tissue (median, 4917 µg g^{-1} vs 3345 µg g^{-1}) and liver tissue (103.7 µg g^{-1} vs 432.9 µg g^{-1}).[7] A study using spectroscopy reported a substantial increase in the frequency and concentration of microplastics in human placentas in Hawai'i from 2006 to 2021.[8] Based on examination of 10 placental samples in each time frame, microplastics were detected in 60% in 2006, 90% in 2013, and 100% in 2021. Average microplastic particles per 50 g of placental tissue increased from 4.1 in 2006 to 7.1 in 2013 to 15.5 in 2021. The increase in the number of microplastics per 50 g of placenta tissue from 2021 reached statistical significance in comparison with 2006 samples ($P < .001$) and 2013 samples ($P < .05$).[8]

Known and Potential Health Effects Associated With Microplastics

Observational studies have shown an association of microplastics with adverse health effects, although this does not prove causation. In a study of 257 patients with asymptomatic carotid artery disease, microplastics (polyethylene) were found in the excised carotid artery plaque of 58.4% of patients (n = 150; mean [SD] level, 21.7 [24.5] µg/mg of plaque) and 12.1% (n = 31) also had measurable amounts of polyvinyl chloride (mean [SD] level, 5.2 [2.4] µg/mg

of plaque).[9] Patients with detectable microplastics in excised carotid artery plaque had a 4.5 times higher risk (20.0%; 30/150 patients) of a composite of myocardial infarction, stroke, or death from any cause at 34 months of follow-up than those in whom microplastics were not detected (7.5%; 8/107 patients).[9] A postmortem study reported that brain tissue obtained from 12 patients with dementia had higher levels of microplastics than those obtained from 52 individuals without dementia (26 076 μg g^{-1} vs 4131 μg g^{-1}; $P < .001$).[7] Further research into potential mechanisms of organ dysfunction and disease associated with microplastics is ongoing.

Policies to Reduce Plastic Pollution

Although many local and national policies exist to limit plastic pollution, few comprehensive international agreements are currently in place to decrease plastic pollution. Agreements that have been reached include the 2019 Basel Convention Plastic Waste Amendments, which control transboundary movements of plastic waste into countries with limited recycling options (such as insufficient recycling plants or lack of technical expertise to recycle in an environmentally sound manner), and the MARPOL Annex V, a legally binding agreement signed by more than 150 countries that prohibits ships from dumping plastic waste into the ocean. The United Nations Global Plastics Treaty has been in negotiation since March 2022 after a resolution was adopted to develop an international, legally binding agreement on plastic pollution, including in the marine environment, with a goal of addressing "the full life cycle of plastics, including their production, design, and disposal."

Conclusions

Microplastics have been detected in human tissues at increasing rates and are associated with known and potential adverse health effects, raising concerns over the high levels of plastic pollutants in the air, water, and soil. International cooperation to limit plastic pollution and to find environmentally safe plastic alternatives is needed.

ARTICLE INFORMATION

Author Affiliations: Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts.

Corresponding Author: David C. Christiani, MD, MPH, Department of Environmental Health, Harvard T.H. Chan School of Public Health, 665 Huntington Ave, Bldg I, Room 1401, Boston, MA 02115 (dchris@hsph.harvard.edu).

Published Online: October 15, 2025. doi:10.1001/jama.2025.14718

Conflict of Interest Disclosures: Dr Mahalingiah reported receiving grants from Apple and Massachusetts General Hospital. Dr Nadeau reported being a consultant for Excellergy; serving on the advisory board of Aravax; owning stock options in Phylaxis, IgGenix, Seed Health, ClostraBio, and COUR; being a National Scientific Committee member at Immune Tolerance Network; and owning patents. No other disclosures were reported.

Note: Source references are available through embedded hyperlinks in the article text online.

REFERENCES

1. Xing YF, Xu YH, Shi MH, Lian YX. The impact of PM2.5 on the human respiratory system. *J Thorac Dis*. 2016;8(1):E69-E74. doi:10.3978/j.issn.2072-1439.2016.01.19

2. Shruti VC, Pérez-Guevara F, Elizalde-Martínez I, Kutralam-Muniasamy G. First study of its kind on the microplastic contamination of soft drinks, cold tea and energy drinks—future research and environmental considerations. *Sci Total Environ*. 2020;726:138580. doi:10.1016/j.scitotenv.2020.138580

3. Khan S, Mumtaj ZA, Khan AR, et al. Reviewing the role of microplastics as carriers for microorganisms in absorbing toxic trace elements. *Environ Sci Pollut Res Int*. 2024;31(34):46806-46819. doi:10.1007/s11356-024-34070-7

4. Moorthy S, Kesavan S, Bhaskaran S, et al. Evidence, mechanisms, and clinical implications of microplastics and nanoplastics as emerging cardiovascular risk factors: a narrative review. *Cureus*. 2025;17(6):e85696. doi:10.7759/cureus.85696

5. Cheng W, Li X, Zhou Y, et al. Polystyrene microplastics induce hepatotoxicity and disrupt lipid metabolism in the liver organoids. *Sci Total Environ*. 2022;806(pt 1):150328. doi:10.1016/j.scitotenv.2021.150328

6. Di Fiore C, Ishikawa Y, Wright SL. A review on methods for extracting and quantifying microplastic in biological tissues. *J Hazard Mater*. 2024;464:132991. doi:10.1016/j.jhazmat.2023.132991

7. Nihart AJ, Garcia MA, El Hayek E, et al. Bioaccumulation of microplastics in decedent human brains. *Nat Med*. 2025;31(4):1114-1119. doi:10.1038/s41591-024-03453-1

8. Weingrill RB, Lee MJ, Benny P, et al. Temporal trends in microplastic accumulation in placentas from pregnancies in Hawai'i. *Environ Int*. 2023;180:108220. doi:10.1016/j.envint.2023.108220

9. Marfella R, Prattichizzo F, Sardu C, et al. Microplastics and nanoplastics in atheromas and cardiovascular events. *N Engl J Med*. 2024;390(10):900-910. doi:10.1056/NEJMoa2309822