

MICROPLASTICS AND HUMAN HEALTH: AN EMERGING MEDICAL-ENVIRONMENTAL PROBLEM

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Abstract

Plastic materials are widely used in packaging, clothing, transport, construction and healthcare. As larger plastic items weather, fragment or shed fibres, small particles known as microplastics can enter air, water, soil and food. Human exposure may occur mainly through ingestion and inhalation, while the contribution of dermal contact remains less clear. Researchers have detected plastic particles in several human samples, including stool, lung tissue, blood and placental tissue, raising important questions about possible biological effects. This narrative review summarises the sources and pathways of exposure, current evidence on potential health consequences, and practical approaches to prevention. Laboratory and animal studies suggest possible mechanisms including oxidative stress, inflammation, changes in immune responses, disruption of intestinal barriers and effects related to chemicals associated with some plastics. Human studies are growing, but they remain limited by small samples, different analytical methods, possible contamination and difficulty establishing cause and effect. Therefore, detection of microplastics in a tissue should not automatically be interpreted as proof that the particles caused disease. Evidence is not yet sufficient to quantify an individual's risk or to attribute specific common diseases to microplastic exposure. A precautionary public-health response is nevertheless reasonable: reducing avoidable plastic pollution, improving waste and wastewater management, limiting unnecessary single-use plastics, and strengthening validated monitoring and long-term human research. The issue calls for collaboration between clinicians, environmental scientists, public-health authorities, industry and communities.

Keywords: microplastics; nanoplastics; human health; environmental pollution; ingestion; inhalation; oxidative stress; public health

1. Introduction

Plastic has become part of everyday life because it is lightweight, durable and relatively inexpensive. These same qualities create a long-term environmental challenge. Plastic bags, bottles, synthetic textiles, tyre wear and packaging can break into smaller pieces, while washing synthetic clothing and the use of some industrial products can release fibres or particles. Once released, particles may move through waterways, soil, indoor dust and the atmosphere. Their small size makes them difficult to remove completely and challenging to measure consistently.

Microplastics are commonly defined as plastic particles smaller than 5 millimetres. Nanoplastics are smaller still, although definitions and size cut-offs vary across studies. Size, shape, polymer type, surface chemistry and attached substances may all influence how particles behave in the environment and interact with biological systems. A fibre, a fragment and a spherical laboratory particle should not automatically be assumed to have identical effects.

The medical concern is straightforward: people encounter these particles through everyday environments, and researchers increasingly report them in biological samples. However, a careful distinction is essential between exposure, biological response and clinical disease. Finding particles in a human sample shows that contact or internal presence may occur; it does not, by itself, demonstrate that the particles caused a particular illness. The World Health Organization (WHO) has emphasised major knowledge gaps and the need for better-quality research on exposure through food, water and air [1,2].



Figure 1. Conceptual illustration of possible microplastic exposure through air, water and food. The image is illustrative and does not represent measured particle concentrations or proven organ injury.

2. Literature overview and approach

This narrative review was prepared from selected authoritative assessments and peer-reviewed reviews and studies identified through targeted searches of PubMed-linked literature and WHO publications. Priority was given to sources discussing environmental exposure, human biomonitoring, health outcomes and methodological limitations, including the WHO reports on drinking water and dietary/inhalation exposure, a 2024 rapid systematic review of digestive, reproductive and respiratory outcomes, and a review of human biomonitoring [1–5]. The purpose is to provide an accessible overview rather than a formal systematic review.

The literature is difficult to compare because studies differ in sampling methods, particle-size detection limits, polymer identification, contamination controls and the types of biological samples examined. Airborne fibres from clothing or laboratory materials can contaminate samples if collection and analysis are not carefully controlled. In addition, studies may count particles, estimate mass, or report polymer signals—measurements that are not interchangeable. These differences limit direct comparisons between studies and make estimates of daily exposure uncertain.

3. Sources and routes of human exposure

3.1 Food and drinking water

Microplastics have been reported in various foods and drinking-water samples. Potential sources include environmental contamination, processing and packaging, and particles deposited during preparation or storage. Seafood has received attention because aquatic organisms can ingest plastic particles, but exposure is not limited to seafood: drinking water, salt, other foods and household dust may also contribute. The relative importance of each source depends on local conditions and on the methods used to measure particles.

WHO's 2019 assessment concluded that available evidence at that time suggested a low health risk from microplastics in drinking water, while stressing that the data were limited and further research was needed [1]. Its 2022 report broadened the assessment to dietary and inhalation exposure and identified substantial uncertainties in exposure measurement and toxicity [2]. These assessments should be interpreted as evaluations of the evidence available at the time, not as proof that all particle types, sizes or exposure levels are harmless.

3.2 Air and indoor dust

People may inhale airborne particles released from synthetic textiles, household dust, industrial processes, vehicle tyre wear and the breakdown of plastic materials. Indoor environments deserve attention because people spend substantial time inside buildings, where fibres can be released from clothing, furnishings and other materials. Larger inhaled particles may be trapped in the upper airways and cleared, whereas smaller particles may behave differently. The amount that reaches the lower respiratory tract and the fraction retained in tissue depend on particle characteristics and breathing conditions.

3.3 Occupational and other exposure settings

Workers in plastic production, recycling, textile manufacturing, waste sorting and related industries may encounter higher concentrations of plastic dust or fibres than the general population. Actual exposure varies with tasks, ventilation, material handling and protective measures. Occupational hygiene—including source enclosure, effective ventilation, housekeeping that avoids resuspending dust, and appropriate respiratory protection based on risk assessment—can reduce inhalation exposure. More studies are

needed to define the contribution of occupational microplastics to long-term health outcomes.

4. Potential biological effects and health concerns

4.1 Inflammation and oxidative stress

Experimental studies have proposed several mechanisms by which some micro- and nanoplastics could affect cells. Particles may interact with cell membranes, trigger inflammatory signalling or contribute to oxidative stress, a condition in which reactive molecules exceed the body's capacity to neutralise them. These effects depend strongly on particle size, shape, dose, polymer, surface characteristics and experimental conditions. Many experiments use concentrations or exposure routes that may not closely reflect everyday human exposure, so results should not be translated directly into a prediction of clinical harm.

4.2 Digestive system and gut microbiome

Ingested particles may pass through the digestive tract, while a smaller fraction of certain particles may interact with intestinal surfaces or potentially cross biological barriers. Animal and laboratory studies have reported changes in intestinal inflammation, barrier function and gut microbial patterns under some experimental conditions. Human evidence is still limited, and it is not established that ordinary environmental exposure to microplastics causes a specific digestive disease. Future studies need reliable exposure estimates and validated clinical outcomes, rather than relying on particle detection alone.

4.3 Respiratory system

Inhalation is a plausible route of exposure, particularly for airborne fibres and dust. Experimental research suggests that some particles can provoke local inflammatory responses or cellular stress. Human studies have detected plastic particles in respiratory samples and lung tissue, including in occupational contexts, but the extent to which environmental microplastic exposure independently contributes to asthma, chronic obstructive pulmonary disease or other respiratory conditions remains uncertain. Smoking, air pollution, workplace chemicals and other factors must be carefully considered in any clinical study.

4.4 Reproductive and developmental health

Plastic-associated chemicals and some particle exposures have raised concerns about reproductive and developmental health. Laboratory and animal studies have investigated sperm quality, reproductive hormones, placental interactions and developmental endpoints. Some observational human studies have reported particles in reproductive-related samples, but sample sizes are often small and confounding is difficult to exclude. It would be premature to conclude that microplastics are a proven cause of infertility, miscarriage or adverse birth outcomes. Research should distinguish effects of the plastic particle itself from effects of additives or other chemicals associated with plastic products.

4.5 Cardiovascular and other systemic outcomes

Emerging studies have reported micro- or nanoplastics in blood and in some vascular specimens, and investigators are exploring possible associations with inflammation and cardiovascular events. These findings are important signals for further investigation, but they do not yet establish a causal relationship. Potential confounders, analytical contamination and the difficulty of quantifying particle burden must be addressed. Evidence concerning neurological, metabolic and long-term cancer outcomes is also incomplete, and strong claims should be avoided until replicated human studies are available.

5. Summary of evidence

Topic	What the literature suggests	Main limitation
Exposure	People can encounter microplastics through food, water and air.	Sources and doses are difficult to compare.
Human detection	Particles or polymer signals have been reported in several human samples.	Contamination control and analytical methods vary.
Inflammation / oxidative stress	Mechanisms are supported mainly by experimental evidence.	Dose and particle type may not reflect real-world exposure.
Digestive / respiratory health	Animal and laboratory findings raise plausible concerns.	Causal human evidence remains limited.

Reproductive cardiovascular outcomes	Early human studies are investigating possible associations.	Small samples, confounding and uncertain exposure measures.
Population-level risk	Reducing unnecessary plastic pollution is a reasonable preventive goal.	Individual clinical risk cannot yet be quantified reliably.

Table 1. Overview of current evidence. This is a qualitative synthesis, not a formal grading of certainty for every outcome.

6. Prevention and public-health response

Because the science is still developing, prevention should focus on sensible measures that reduce avoidable plastic release without creating unnecessary fear. Individuals can use durable alternatives to disposable products where practical, avoid heating food in plastic containers unless the product is specifically designed for that use, follow local guidance for food storage, and reduce littering. These actions may reduce some exposures, but no household measure can guarantee complete avoidance of microplastics. Bottled water should not be assumed to be universally safer than tap water; water quality depends on local supply and treatment.

At community and policy levels, the largest opportunities often lie upstream: reducing unnecessary single-use plastics, improving collection and recycling systems, preventing pellet and industrial dust loss, upgrading wastewater treatment where feasible, and designing products that shed fewer particles. Healthcare facilities can review avoidable disposable plastic use while preserving infection prevention and patient safety. Environmental monitoring should use harmonised methods so results can be compared across regions and over time.

Clinicians should respond to questions with balanced communication. There is currently no validated routine clinical test that can diagnose a person's illness as being caused by microplastic exposure, and testing for particles in a biological sample is not a standard screening procedure. Patients should not be encouraged to buy unproven detoxification products or undergo unnecessary tests. Instead, clinicians can support evidence-based environmental health practices and explain what is known, what remains uncertain, and why reducing pollution is worthwhile even before every health effect is resolved.

7. Research priorities

Future research should use standard definitions and validated methods to identify particle size, shape, polymer type and concentration. Field and laboratory blanks, strict contamination control, transparent reporting and independent replication are essential. Longitudinal human studies are needed to test whether measured exposure precedes health outcomes, and researchers should control for age, occupation, smoking, diet, socioeconomic conditions and other environmental pollutants. Studies should also distinguish the effects of particles from additives, plastic-associated chemicals and contaminants carried on particle surfaces. Finally, researchers should prioritise outcomes that matter clinically, rather than treating detection alone as evidence of disease.

8. Discussion

Microplastics illustrate a wider challenge in environmental medicine: a contaminant may be widespread before its long-term health effects are fully understood. Public concern is understandable, especially when particles are reported in human tissues. Yet uncertainty cuts both ways. It is not scientifically appropriate to claim that microplastics are harmless under all conditions, nor to state that they have been proven to cause a wide range of chronic diseases. Current evidence supports concern, improved monitoring and prevention, while requiring restraint in causal claims.

The issue cannot be solved by individual behaviour alone. People have limited control over the particles present in ambient air, municipal water, food systems and workplaces. Manufacturers, regulators, waste-management services, researchers and healthcare professionals all have roles. A proportionate approach combines reduced plastic leakage with better evidence and transparent communication. This can protect environmental quality now while building the knowledge needed for future clinical guidance.

9. Conclusion

Microplastics are an emerging environmental-health concern because exposure through food, water and air is widespread and particles have been reported in several human samples. Experimental evidence suggests possible inflammatory, oxidative and barrier-related effects, but the clinical significance of everyday exposure and the causal links to specific human diseases remain uncertain. The most responsible response is neither alarmism nor dismissal. It is to reduce avoidable plastic pollution, strengthen occupational and environmental controls, standardise analytical methods and invest in well-designed human studies. Clear communication should acknowledge uncertainty while supporting practical, evidence-informed prevention.

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