

Microplastics and Human Health: An Emerging Public Health Threat: A Narrative Review

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Microplastics, defined as plastic particles smaller than 5 mm, have emerged as pervasive environmental contaminants with growing implications for human health. Initially studied in marine ecosystems, microplastics are now detected across air, water, soil, and food chains, leading to continuous human exposure. This narrative review synthesises current evidence on sources, exposure pathways, biological mechanisms, and potential health impacts of microplastics from a public health perspective. Humans are exposed primarily through ingestion of contaminated food and drinking water, inhalation of airborne particles, and occupational contact in high-risk industries. Recent studies have demonstrated the presence of microplastics in human stool, placenta, and blood, indicating systemic exposure and raising concerns regarding bioaccumulation. Experimental findings suggest that microplastics may induce inflammation, oxidative stress, and endocrine disruption, either directly or through associated chemical contaminants. Although long-term epidemiological evidence remains limited, potential links with respiratory disorders, cardiometabolic diseases, and reproductive health effects are increasingly discussed. Significant research gaps persist, particularly in exposure assessment, dose-response relationships, and long-term health outcomes. Given their ubiquity and persistence, microplastics represent an emerging environmental health challenge. Strengthening surveillance, promoting plastic reduction strategies, and advancing interdisciplinary research are essential to address this evolving public health threat.

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Introduction

Plastic production has risen dramatically over the past five decades, becoming deeply embedded in modern industry, healthcare, packaging, construction, and daily consumer use. While plastics have provided convenience, durability, and affordability, their large-scale manufacture and widespread disposal have created a persistent and escalating environmental burden. Unlike many organic materials, most conventional plastics are resistant to natural degradation and can remain in the

environment for decades or even centuries. Over time, exposure to sunlight, mechanical abrasion, temperature fluctuations, and microbial activity breaks larger plastic items into progressively smaller fragments. This process of physical, chemical, and biological degradation leads to the formation of microplastics, commonly defined as plastic particles measuring less than 5 millimeters in size. These particles are not only generated from discarded plastic waste but may also originate from synthetic textiles, tire wear, industrial processes, and personal care products. Due to their small size and persistence, microplastics disperse widely across aquatic, terrestrial, and atmospheric environments, raising increasing concerns about ecological balance and potential implications for human health.¹ These particles have been identified in a wide range of environmental settings, including oceans, rivers, lakes, agricultural soil, and even the air we breathe, demonstrating how widely dispersed they have become.² Their presence in remote

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and relatively untouched regions further underscores the extent of global contamination and the ability of microplastics to travel far beyond their original sources. For many years, microplastics were primarily viewed as an environmental issue affecting marine life and ecosystem stability. However, this perspective is gradually shifting as scientific evidence begins to highlight their relevance to human health.³ Increasing detection of microplastics in food, drinking water, and indoor environments suggests that routine, everyday exposure is likely unavoidable for most populations. Moreover, recent studies demonstrating the presence of microplastics within human biological samples have raised important questions about absorption, accumulation, and long-term biological effects. Together, these findings suggest that microplastics are no longer just an ecological concern but represent an emerging environmental exposure with potential health implications. As awareness grows, microplastics are increasingly recognised as a novel and complex risk that deserves urgent attention from the public health community.⁴

Methods

A narrative review of literature on microplastics and human health was conducted using electronic databases including PubMed, Scopus, Web of Science, and Google Scholar. Relevant articles published between 2010 and 2025 were identified using keywords such as microplastics, environmental exposure, and public health. Studies addressing sources, exposure pathways, and health effects of microplastics were included. Data were synthesized narratively to summarize current evidence and public health implications

Sources and Environmental Distribution

Microplastics arise from both primary and secondary sources, reflecting the multiple ways in which plastics enter and persist in the environment. Primary microplastics are deliberately manufactured as tiny particles and are commonly used in industrial abrasives, cosmetic

formulations, and certain personal care products. In contrast, secondary microplastics are formed when larger plastic items—such as packaging materials, bottles, and synthetic fabrics—gradually break down under the influence of sunlight, friction, temperature changes, and microbial activity.⁵ While marine environments have traditionally been viewed as the main sinks for plastic debris due to widespread dumping and runoff, growing evidence shows that land-based ecosystems also play a major role in microplastic generation and accumulation.⁶ Rapid urbanisation, inefficient waste management systems, and the increasing use of synthetic textiles have further intensified environmental contamination, especially in low- and middle-income countries where plastic disposal infrastructure may be limited.⁷ Because microplastics are lightweight, durable, and resistant to degradation, they persist across diverse ecological settings, including water, soil, and air. This widespread persistence creates ongoing and repeated opportunities for human exposure through multiple environmental pathways.⁸

Routes of Human Exposure

Humans can be exposed to microplastics through several everyday pathways, most commonly ingestion, inhalation, and to a lesser extent, skin contact. Among these, ingestion is considered the primary route, as microplastics have been identified in a variety of commonly consumed items such as seafood, table salt, bottled water, and processed foods.⁹ Drinking water is now recognised as an important source of exposure, with studies detecting microplastics in both bottled and tap water across different geographic regions.¹⁰ In addition to dietary intake, inhalation of airborne microplastics is gaining attention as a significant yet underappreciated route. Indoor environments, in particular, may contain higher concentrations due to the shedding of fibres from synthetic clothing, household furnishings, and accumulated urban dust.¹¹ Certain occupational

Table 1: Major sources of microplastics in the environment

Source Type	Examples	Pathway into Environment
Primary microplastics	Microbeads in cosmetics, industrial abrasives	Direct release during product use or manufacturing
Textile fibers	Synthetic clothing such as polyester and nylon	Released during washing and enter wastewater systems
Tire wear particles	Vehicle tire abrasion	Transported via road runoff into soil and water
Plastic packaging waste	Bottles, bags, food containers	Fragmentation due to UV radiation and mechanical stress
Industrial plastic pellets	Resin pellets used in plastic production	Accidental spills during manufacturing or transport

groups may face even higher levels of exposure, especially individuals involved in waste handling, textile production, or plastic recycling activities where airborne particles are more prevalent.¹² Although absorption through the skin appears relatively minimal compared to other routes, repeated and prolonged contact with products containing microplastics may still contribute to overall exposure over time.¹³ Together, these pathways suggest that microplastic exposure is not limited to specific settings but may be an unavoidable part of modern daily life.

Evidence of Microplastics in Human Tissues

Improvements in laboratory techniques and analytical methods have made it possible to identify extremely small plastic particles within human biological samples. Using refined spectroscopic and microscopic tools, researchers have detected microplastics in human stool samples, providing direct evidence that these particles are ingested and pass through the gastrointestinal system.¹⁴ While this initially suggested that most microplastics might simply be eliminated from the body, subsequent investigations have revealed more complex findings. The identification of microplastics in placental tissue has raised important questions about maternal–fetal exposure and the possibility that these particles may cross biological barriers during pregnancy.¹⁵ Such observations have intensified concerns about potential effects on early development, although the long-term consequences remain unclear. More recently, microplastics have also been detected in human blood samples, indicating that some particles may enter systemic circulation and travel beyond the digestive tract.¹⁶ These discoveries challenge earlier assumptions that microplastics are only transient contaminants within the body. Instead, they suggest the potential for tissue interaction, persistence, and possibly bioaccumulation under certain conditions.¹⁷ While the clinical significance of these findings is still being investigated, they highlight the need for careful evaluation of internal exposure and its possible health implications.

Biological Mechanisms and Toxicity

The health effects of microplastics are complex and likely depend on several interacting factors, including particle size, shape, chemical composition, and the presence of additives or attached contaminants.¹⁸ Not all microplastics behave in the same way within biological systems. Smaller particles, especially nanoplastics, are of particular concern because their tiny size may allow them to cross biological barriers and enter the bloodstream or tissues more easily. Once inside the body, these particles may trigger inflammatory responses and promote oxidative stress, processes that are commonly linked with chronic disease development.¹⁹ Another important aspect of microplastic toxicity is their ability to act as carriers for other harmful substances. Microplastics can adsorb environmental pollutants such as heavy metals, persistent organic pollutants, and endocrine-disrupting chemicals, potentially increasing the overall toxic burden when these particles are ingested or inhaled.²⁰ Experimental and laboratory-based studies have suggested possible effects including immune system alterations, cellular damage, and disturbances in metabolic pathways. However, while these findings raise valid concerns, clear cause–effect relationships in human populations are still being explored, and more long-term research is needed to understand the true magnitude of health risks.¹⁸

Potential Health Implications

Although long-term population-based evidence is still limited, emerging research points toward several possible health implications of microplastic exposure. One of the key concerns is chronic low-grade inflammation, which may arise when microplastics persist within tissues. Such inflammatory responses are increasingly recognised as contributors to cardiometabolic conditions and other non-communicable diseases.¹⁹ In addition, many plastics contain or carry chemicals that can interfere with hormonal regulation. Exposure to these endocrine-disrupting substances has raised concerns about potential effects on reproductive health, fertility, and early developmental outcomes.²⁰

Table 2: Evidence of microplastics detected in human biological samples

<i>Biological sample</i>	<i>Key findings</i>	<i>Study</i>
Human stool	Presence of multiple plastic polymers in all participants	Schwabl et al. ¹⁴
Placental tissue	Microplastic particles detected in the maternal and fetal sides	Ragusa et al. ¹⁵
Human blood	Plastic particles identified in systemic circulation	Leslie et al. ¹⁶
Lung tissue	Microplastics identified in surgical lung samples	Recent environmental exposure studies

Inhalation is another pathway of concern, particularly for respiratory health. Airborne microplastics may irritate the airways and could worsen symptoms in individuals with pre-existing lung conditions such as asthma or chronic obstructive pulmonary disease.¹¹ The impact may be more pronounced in settings with higher indoor pollution or occupational exposure. Certain groups are likely to be more vulnerable than others. Children, for instance, may experience greater exposure relative to body weight, while pregnant women may face additional concerns related to fetal development. Workers in industries involving plastics, textiles, or waste handling may also encounter higher and more prolonged exposure levels. Together, these observations suggest that the health burden of microplastics may not be evenly distributed and could disproportionately affect already vulnerable populations.¹²

Public Health Significance

From a public health standpoint, microplastics present a multifaceted and still-evolving environmental challenge. Unlike many conventional pollutants, microplastics are extremely widespread, highly persistent, and capable of accumulating within ecosystems and potentially within the human body. These characteristics make them particularly difficult to monitor and manage using traditional environmental health frameworks.³ One of the major barriers to effective risk assessment is the absence of standardized methods for measuring exposure and defining safe limits. Variations in sampling techniques, particle identification, and reporting standards make it challenging to compare findings across studies and translate them into clear regulatory guidance.⁴

The burden of microplastic pollution is also unevenly distributed. Low- and middle-income countries often face greater challenges due to rapid urbanization, limited waste management infrastructure, open dumping, and reliance on informal recycling systems.⁷ These conditions can increase environmental contamination and elevate population exposure, particularly in vulnerable communities. Addressing microplastics therefore requires a coordinated and multisectoral response. Strengthening environmental regulations, improving waste management practices, promoting sustainable material use, and enhancing public awareness are all essential components of mitigation efforts. In addition, community-level risk communication will play an important role in helping individuals understand exposure pathways and adopt safer practices.⁶

Environmental health systems must also integrate routine monitoring of microplastics into existing surveillance frameworks for water quality, air pollution, and food safety. Establishing standardized exposure indicators will enable public health authorities to identify high-risk populations and evaluate the effectiveness of regulatory interventions. Risk communication strategies should focus on practical preventive measures such as reducing single-use plastics, improving household waste segregation, and promoting safer occupational practices in industries with potential plastic exposure. Incorporating microplastic awareness into school health education and community outreach programs may further support long-term behavioral change and environmental sustainability.^{21,22}

Research Gaps and Future Directions

Despite the rapid expansion of research on microplastics in recent years, several important knowledge gaps still persist. Much of the existing evidence comes from laboratory studies or short-term observational data, making it difficult to draw firm conclusions about long-term health effects. Well-designed longitudinal human studies are needed to better understand dose-response relationships and to determine how chronic exposure may influence disease risk over time.⁴ Another major challenge lies in the lack of standardized methodologies. Differences in sampling techniques, particle detection methods, and reporting practices make it difficult to compare findings across studies or build a consistent body of evidence.¹⁷

Another important consideration is the potential cumulative effect of low-dose exposure over long periods, particularly in urban populations where environmental plastic contamination is continuously increasing. Unlike traditional pollutants that degrade relatively quickly, microplastics persist in ecosystems and may interact with other environmental stressors such as air pollutants, heavy metals, and climate-related factors. These combined exposures could amplify health risks through synergistic biological mechanisms, including chronic inflammation and immune dysregulation. Understanding these interactions will be essential for developing comprehensive environmental risk assessment models and guiding evidence-based public health policies.²³

There is also growing concern about nanoplastics, which are even smaller than microplastics and may have greater potential to cross biological barriers and

interact with cells and tissues. However, research in this area is still limited, and more focused investigation is required to clarify their biological behaviour and health implications.¹⁹ Moving forward, progress in this field will depend on stronger collaboration across disciplines. Environmental scientists, toxicologists, clinicians, and public health professionals must work together to generate meaningful evidence and translate it into practical recommendations. Such interdisciplinary efforts will be essential for guiding policy development, informing risk communication, and shaping preventive strategies aimed at reducing future health risks associated with plastic pollution.²⁰

Conclusion

Microplastics have moved beyond being viewed merely as an environmental curiosity and are now increasingly recognised as a genuine public health concern. The growing body of evidence demonstrating their widespread presence in air, water, and food, along with their detection in human biological samples, highlights the scale of exposure in everyday life. Emerging research describing possible biological mechanisms, including inflammation and cellular stress, further strengthens the need to take this issue seriously. Although clear cause-and-effect relationships between microplastic exposure and specific diseases are still being explored, the current evidence is sufficient to justify a precautionary approach.

Applying the precautionary principle means taking early preventive measures even while scientific understanding continues to evolve. Efforts such as improving environmental surveillance, reducing unnecessary plastic use, and promoting sustainable alternatives can help limit future exposure. At the same time, strengthening research into exposure pathways and long-term health outcomes will be critical for guiding informed decision-making. Public awareness and policy-level interventions must also progress alongside scientific advances. In addition to environmental control measures, integrating microplastic risk assessment into national public health planning will be essential for future preparedness. Policymakers should prioritize investment in waste management infrastructure, promote biodegradable material alternatives, and support interdisciplinary research to better understand exposure thresholds and long-term health outcomes. Such proactive strategies can help reduce environmental contamination and protect vulnerable populations from emerging environmental health threats.²¹ Together, these steps can

help reduce the potential health burden associated with microplastics and support more sustainable interactions between human populations and the environment.

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