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MICROPLASTIC EXPOSURE AS AN EMERGING CARDIOVASCULAR RISK FACTOR: IMPLICATIONS FOR PUBLIC HEALTH AND PREVENTION

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ABSTRACT

Background: The increasing production and use of plastic materials contribute to the widespread distribution of microplastic (MP) and nanoplastic (NP) particles in the environment. Recent studies have reported microplastics in human blood, vascular tissues (Leslie et al., 2022; Marfella et al., 2024). Available evidence indicates that MP and NP exposure may be linked to biological disturbances such as chronic inflammation, oxidative stress, and prothrombotic activity, which could be relevant to cardiovascular risk (Prattichizzo et al., 2024; Zheng et al., 2024).
Aim: This narrative review aims to present current evidence on microplastic and nanoplastic exposure as a developing public health concern, with particular attention to cardiovascular risk, prevention, and wider societal consequences.
Methods: A narrative review of scientific literature was conducted using PubMed and Google Scholar. Studies published between 2019 and 2025 were considered, particularly experimental, clinical, and epidemiological papers addressing the cardiovascular effects of MP and NP exposure.
Results: Recent research has identified microplastics in cardiovascular tissues, including arterial plaques and thrombi, suggesting a possible relationship between microplastic burden and cardiovascular events (Marfella et al., 2024; Wang et al., 2024). The most frequently proposed mechanisms include inflammatory activation, oxidative stress, endothelial dysfunction, and coagulation pathway involvement. Although current evidence is mostly observational, the consistency of reported findings raises concern about the possible long-term health consequences of chronic microplastic exposure.
Conclusions: Microplastic exposure may constitute an emerging public health issue with possible implications for cardiovascular risk at the population level. Awareness, preventive strategies, and policy-level interventions may help reduce future health burdens. Further studies are needed to clarify causal relationships and support evidence-based recommendations for clinical and public health practice.

KEYWORDS

Microplastics; Nanoplastics; Cardiovascular Disease; Environmental Exposure; Public Health

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1. Introduction

Cardiovascular diseases (CVDs) continue to be the leading cause of death globally, accounting for approximately 20.5 million deaths in 2021, or nearly one third of worldwide mortality (Roth et al., 2024). Although prevention and treatment of established cardiovascular risk factors such as hypertension, diabetes mellitus, dyslipidemia, obesity, and tobacco use have improved substantially, not all cardiovascular events can be explained by these traditional factors alone. This has increased interest in less conventional contributors, including environmental and lifestyle-related exposures.

Microplastic (MP) and nanoplastic (NP) particles have recently attracted growing attention as potential environmental factors influencing human health. Global plastic production has reached approximately 400 million metric tons per year, while projections imply that plastic waste may accumulate in ecosystems up to 13 billion tons by 2050 (Prattichizzo et al., 2024). During environmental degradation, plastic materials fragment into smaller particles that persist in ecosystems and may enter the human body through ingestion, inhalation, or dermal contact.

Evidence from recent studies indicates that MPs and NPs can be detected in several human biological compartments, including blood, placental tissue, and vascular structures (Leslie et al., 2022; Ragusa et al., 2021). In addition, microplastic particles have been reported in atherosclerotic plaques and thrombi, raising questions about their possible involvement in cardiovascular pathology (Marfella et al., 2024; Wang et al., 2024). These observations point to a possible association between chronic microplastic exposure and inflammatory activation, oxidative stress, and endothelial dysfunction, which are important processes in cardiovascular disease development (Zheng et al., 2024).

Apart from their biological effects, microplastics also represent a broader public health challenge. Their presence in everyday environments creates concern not only for individual exposure but also for population-level risk and the potential long-term burden on healthcare systems (Prattichizzo et al., 2024). Public awareness and preventive strategies may therefore become important elements of future cardiovascular risk reduction related to environmental exposures.

Therefore, this narrative review aims to summarize current evidence on microplastic and nanoplastic exposure as an emerging public health issue, with particular emphasis on cardiovascular risk, possible biological mechanisms, prevention, and implications for public health policy. This topic remains underexplored and requires further interdisciplinary investigation. Understanding the potential cardiovascular impact of microplastic exposure may become increasingly important in the context of global environmental change and the rising burden of chronic diseases.

2. Methods

This paper summarizes current literature on microplastic and nanoplastic exposure, with particular attention to cardiovascular implications and public health relevance.

Relevant studies were identified using widely recognized scientific databases, including PubMed and Google Scholar. The search process focused on studies addressing microplastic exposure and its possible links to cardiovascular outcomes. Keywords such as “microplastics”, “nanoplastics”, “cardiovascular disease”, “thrombosis”, “oxidative stress”, and “inflammation” were used in various combinations.

To ensure the inclusion of up-to-date evidence, only studies published between 2019 and 2025 were considered. Both experimental and clinical research articles were included, along with selected review papers that provided important background on exposure pathways and underlying mechanisms.

The selection of studies was based on their relevance to human exposure, biological effects, and potential cardiovascular associations. Particular attention was given to research involving vascular tissues, thrombi, and atherosclerotic plaques. Publications not written in English, as well as studies not directly related to cardiovascular aspects of microplastic exposure, were excluded from the analysis. Case reports were excluded due to their limited ability to reflect population-level findings.

The collected data were analyzed qualitatively, with emphasis on identifying common biological mechanisms, patterns of exposure, and their implications from a public health perspective. No strict limitations regarding study design were applied, allowing for a broad overview of the current state of knowledge. No formal systematic search strategy or PRISMA framework was applied, consistent with the narrative nature of this review.

3. Results

3.1. Sources and routes of human exposure

Human exposure to microplastic (MP) and nanoplastic (NP) particles occurs through several pathways, primarily related to environmental and lifestyle factors. Ingestion appears to be the dominant route, as these particles have been identified in numerous food products, including seafood, fish, salt, honey, and bottled water (Cox et al., 2019; Prattichizzo et al., 2024). Both bottled and tap water contribute to daily exposure (World Health Organization, 2019).

Inhalation represents another relevant pathway. Microplastic particles are present in both indoor and outdoor air, originating from sources such as synthetic textile fibers, tire abrasion, and household dust (Zheng et al., 2024). In addition, the use of plastic containers and kitchen utensils—especially under elevated temperatures—may facilitate the release of microplastic particles into food.

Available estimates imply that annual intake of microplastic particles may reach tens of thousands per individual (Cox et al., 2019). When inhalation exposure is also considered, total intake is likely substantially higher. These values are probably underestimated, given the ongoing increase in plastic production and environmental contamination.

Microplastics have been identified across a wide range of environmental settings, including marine and freshwater ecosystems, soil, and even remote areas such as Arctic ice and mountainous regions (Zheng et al., 2024). Such extensive distribution suggests that human exposure is persistent and, in many cases, difficult to avoid.

In general, exposure to MPs and NPs occurs through multiple pathways, primarily via ingestion and inhalation, with dermal contact considered a possible additional route. From a public health perspective, the omnipresence of microplastics underscores the importance of increasing awareness and developing strategies aimed at reducing long-term exposure.

3.2. Detection of Microplastics in Human Tissues

Recent investigations have increasingly reported the presence of microplastic (MP) and nanoplastic (NP) particles in human tissues. In a notable prospective investigation, microplastics were detected within atherosclerotic plaques obtained from patients undergoing carotid endarterectomy (Marfella et al., 2024). Importantly, their presence was associated with a higher incidence of major adverse cardiovascular events, including myocardial infarction, stroke, and cardiovascular mortality during follow-up.

Further evidence comes from studies reporting the detection of microplastics in human thrombi collected from different anatomical sites, suggesting a potential contribution of MPs to thrombus formation (Wang et al., 2024). In addition, microplastic particles have been identified in coronary arteries affected by atherosclerosis, providing further support for their possible involvement in vascular disease processes (Liu et al., 2024).

Beyond the cardiovascular system, MPs and NPs have been detected in multiple human tissues and biological fluids, such as blood, lungs, liver, placenta, and breast milk (Leslie et al., 2022; Ragusa et al., 2021). In general, these findings suggest that microplastic particles are capable of systemic distribution within the human body.

The identification of microplastics relies on advanced analytical methods, including Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), and pyrolysis gas chromatography–mass spectrometry (Py-GC/MS). While these techniques enable detection and characterization of plastic particles, the absence of standardized protocols remains a significant limitation, making it difficult to directly compare results across studies (Zheng et al., 2024).

In general, the detection of microplastics in human tissues represents an important observation supporting their potential relevance in disease development. Nevertheless, further research is required to better quantify exposure levels and to establish standardized and reproducible detection methods.

3.3. Pathophysiological Mechanisms

The effects of microplastic (MP) and nanoplastic (NP) exposure on the cardiovascular system are likely mediated by several interacting biological processes. Although current knowledge is still limited and largely derived from experimental studies, existing data indicate that these particles may play a role in vascular injury and disease progression (Campanale et al., 2020; Yong et al., 2020).

Persistent activation of inflammatory pathways is considered a key mechanism involved. Microplastic particles can stimulate immune responses, leading to increased release of pro-inflammatory mediators, including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α). Sustained activation of these pathways may contribute to endothelial dysfunction and promote the development of atherosclerotic lesions (Prattichizzo et al., 2024).

Oxidative imbalance represents another important biological pathway. MPs and NPs have been shown to induce the formation of reactive oxygen species (ROS), which may damage endothelial cells, impair mitochondrial activity, and disrupt cellular balance. The interaction between oxidative stress and inflammation may further amplify vascular injury (Zheng et al., 2024).

Microplastics may also influence coagulation processes. Experimental evidence suggests that MPs can affect platelet activation, alter blood rheological properties, and promote clot formation, potentially increasing the risk of thrombosis (Wang et al., 2024). These effects may be particularly relevant in the context of plaque instability and acute cardiovascular events.

At the cellular level, impairment of nitric oxide (NO) signaling represents another important mechanism. Reduced NO bioavailability may contribute to vasoconstriction, increased vascular stiffness, and a higher tendency toward thrombus formation (Prattichizzo et al., 2024).

To sum up, these observations suggest that microplastic exposure could influence cardiovascular risk through multiple biological pathways. However, it is important to note that most available data originate from experimental models, and further clinical studies are needed to confirm their relevance in human populations.

3.4. Clinical Evidence

Available clinical evidence increasingly indicates a possible relationship between exposure to microplastic (MP) and nanoplastic (NP) particles and cardiovascular disease. Although the currently available evidence is predominantly observational, it provides important indications regarding the potential clinical relevance of microplastic accumulation in human tissues.

In a notable prospective study, microplastics identified within atherosclerotic plaques were associated with a significantly elevated risk of major adverse cardiovascular events, including myocardial infarction, stroke, and cardiovascular mortality (Marfella et al., 2024). These results represent one of the most compelling clinical observations linking microplastic exposure to cardiovascular outcomes.

Additional evidence comes from studies reporting the presence of MPs in human thrombi collected from various anatomical sites, supporting the hypothesis that microplastics may contribute to thrombus formation (Wang et al., 2024). Microplastics have also been detected in patients undergoing cardiac surgery, supporting their presence in the cardiovascular system and possible vascular involvement (Yang et al., 2023).

Findings from experimental and translational research further reinforce these observations. Animal studies have demonstrated that exposure to microplastics may lead to cardiac fibrosis, mitochondrial dysfunction, and enhanced inflammatory responses within cardiac tissue (Li et al., 2020; Zhou et al., 2023), providing mechanistic support for clinical associations observed in human studies.

Nevertheless, it should be noted that most available data remain observational, which limits the ability to establish causal relationships. In addition, variability in exposure assessment, detection methods, and study design reduces comparability across studies. Consequently, well-designed large-scale prospective studies are needed to better define the clinical impact of microplastic exposure. A summary of key studies is presented in Table 1.

In general, existing evidence indicates a potential association between microplastic exposure and increased cardiovascular risk; however, further research is necessary to confirm these findings and to establish clinically meaningful exposure thresholds. Taken together, the available data provide a consistent, although still incomplete, picture of microplastic-related cardiovascular risk.

Table 1. Summary of key studies on microplastics and the cardiovascular system

Study	Type	Population/sample	Key findings
Marfella et al., 2024	Prospective	Atherosclerotic plaques	MPs associated with increased cardiovascular events
Wang et al., 2024	Observational	Human thrombi	MPs detected in thrombi
Yang et al., 2023	Clinical	Cardiac surgery patients	MPs present in cardiovascular system
Liu et al., 2024	Analytical	Human arteries	MPs identified in arterial tissue

Abbreviations: MPs – microplastics

4. Discussion

The available evidence suggests that, although still developing, there may be a link between microplastic accumulation and cardiovascular risk. In this review, we aimed to summarize current knowledge on microplastic and nanoplastic exposure, with a particular focus on their potential impact on the cardiovascular system.

Recent studies have shown that microplastics can be detected in human vascular tissues, including thrombi and atherosclerotic plaques. This supports the idea that these particles are not only present in the body but may also interact directly with the cardiovascular system (Marfella et al., 2024; Wang et al., 2024). While this does not yet confirm a direct causal role, it raises important questions about their involvement in vascular disease processes.

An important point that emerges from the current evidence is that microplastic exposure may not act through a single dominant mechanism, but rather through the simultaneous activation of several interconnected pathways. This combined effect may be more relevant than each individual process considered separately. From this perspective, even relatively low and chronic exposure could have cumulative biological consequences that are not yet fully captured in existing studies.

Several mechanisms could explain these observations. Chronic inflammation, oxidative stress, endothelial dysfunction, and prothrombotic activity are well-known contributors to cardiovascular disease. It is therefore plausible that microplastic exposure may influence these processes and potentially intensify the effects of traditional cardiovascular risk factors.

At the same time, it is worth noting that most of the available evidence is observational. Because of this, it is not possible to draw firm conclusions about causality. In addition, differences in detection techniques and exposure assessment make it difficult to directly compare results between studies.

From a broader perspective, microplastic exposure is becoming an increasingly relevant public health issue. As this exposure is widespread and persistent, even relatively small effects at the individual level could translate into meaningful consequences at the population level.

From a clinical perspective, although direct recommendations cannot yet be established, increasing awareness of microplastic exposure may become relevant in future cardiovascular risk assessment and prevention strategies.

Future research should focus on well-designed prospective studies, as well as on improving and standardizing methods for detecting and quantifying microplastics. A better understanding of exposure levels and their biological relevance will be essential for determining whether these particles have a real clinical impact and for developing effective prevention strategies. These findings may also have implications for future environmental health policies and interdisciplinary research linking environmental exposure with chronic disease risk.

4.1. Public Health and Policy Implications

The global spread of microplastic contamination in the environment is increasingly recognized as a relevant public health issue with potential long-term societal consequences. Continuous exposure at the population level may contribute to the growing burden of chronic diseases, including cardiovascular conditions, thereby placing additional strain on healthcare systems (Prattichizzo et al., 2024; Zheng et al., 2024).

From a public health standpoint, raising awareness of microplastic exposure and its possible health effects is an important step toward risk reduction. Educational initiatives focused on limiting plastic use, promoting safer food storage practices, and encouraging environmentally responsible behaviors may help decrease overall exposure (World Health Organization, 2019).

At the regulatory level, coordinated policy actions are required to address the sources of environmental contamination. Measures aimed at reducing plastic production, improving waste management, and limiting environmental release of plastic particles may play a crucial role. In addition, the development of standardized methods for detecting microplastics in food, water, and human tissues is essential for improving research consistency and supporting the creation of evidence-based recommendations (Zheng et al., 2024).

The development and wider implementation of biodegradable alternatives may represent a long-term approach to reducing microplastic pollution. However, their effective adoption will depend on further technological advances as well as appropriate regulatory support.

Collectively, mitigating microplastic exposure will require coordinated efforts across healthcare systems, public institutions, and policymakers. Given the potential implications for population health, early preventive measures and continued research may be key to reducing future cardiovascular and societal health burdens.

4.2. Limitations and Future Research Directions

Although the available body of evidence regarding microplastic (MP) and nanoplastic (NP) exposure is steadily increasing, several important limitations should be taken into account. One of the main challenges is the lack of standardized methods for detecting and quantifying microplastic particles in biological samples, which significantly reduces the comparability of findings across studies (Zheng et al., 2024). Variability in analytical techniques, including Raman spectroscopy, Fourier-transform infrared spectroscopy (FTIR), and pyrolysis gas chromatography–mass spectrometry (Py-GC/MS), may further contribute to inconsistencies in reported results.

A key limitation is the predominance of observational data in the current literature. While such studies provide valuable insights, they do not allow for the establishment of clear causal relationships between microplastic exposure and cardiovascular outcomes. Consequently, the associations observed so far require confirmation in well-designed prospective investigations.

In addition, a considerable proportion of mechanistic evidence is derived from experimental and animal models. These conditions may not accurately reflect real-world human exposure, as the concentrations of microplastics used in laboratory settings often exceed those typically encountered in the environment. This limits the direct translation of these findings into clinical practice (Campanale et al., 2020; Yong et al., 2020).

A further limitation is the absence of clearly defined thresholds for safe levels of microplastic exposure in humans. At present, there is no consensus regarding what levels of MPs and NPs may be considered harmful, which complicates the interpretation of existing data and the development of clinical recommendations.

Future research should therefore focus on establishing standardized detection protocols and conducting large-scale prospective cohort studies to better assess the long-term health effects of microplastic exposure. Moreover, further investigation into the role of different polymer types, particle sizes, and associated chemical additives may provide deeper insight into their biological impact. Such efforts could ultimately support the development of evidence-based guidelines and more effective public health strategies.

From a translational perspective, linking experimental findings with clinical outcomes remains a key challenge.

5. Conclusions

Available data suggest that exposure to microplastic (MP) and nanoplastic (NP) particles may be associated with adverse cardiovascular effects mediated by mechanisms such as inflammation, oxidative stress, endothelial dysfunction, and prothrombotic activity (Prattichizzo et al., 2024; Zheng et al., 2024). The identification of microplastics in human vascular tissues and thrombi further supports their potential clinical relevance (Marfella et al., 2024; Wang et al., 2024).

Although the available data are largely observational and do not allow for definitive conclusions regarding causality, the consistency of reported findings highlights the need for further investigation. From a public health perspective, microplastic exposure may represent an emerging environmental risk factor with potential implications for population health.

Increasing awareness, implementation of preventive strategies, and development of policy-level interventions may contribute to reducing long-term health risks associated with environmental exposure. At the same time, further research is needed to better understand the clinical significance of microplastic accumulation and to support the development of evidence-based recommendations for both clinical practice and public health policy.

These findings emphasize the importance of interdisciplinary approaches integrating environmental science, medicine, and public health.

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