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Microplastics and nanoplastics in healthcare: environmental persistence, health implications, and professional awareness

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Microplastics (<5 mm) and nanoplastics (<1 μm) emerged as widespread and persistent environmental pollutants, raising growing concern for human health. These particles result from the fragmentation of larger plastic items or are directly manufactured and have infiltrated ecosystems, food, water, and air. This review examines the environmental persistence, global spread, and health implications of micro- and nanoplastics, with a particular focus on their relevance to healthcare. Special attention is given to dentistry and orthodontics, where plastic use is extensive. Microplastics have been detected in virtually all environments and even in human tissues. Although the long-term health consequences remain uncertain, emerging evidence suggests potential adverse effects, including inflammation, endocrine disruption, and toxicity, particularly from nanoplastics capable of penetrating biological barriers. The healthcare sector contributes significantly to plastic pollution through the widespread use of disposable materials. Dentistry and orthodontics generate considerable plastic waste and microplastic debris, notably from single-use items and clear aligners. However, awareness among healthcare providers remains limited, though preliminary studies indicate that education can significantly increase concern and engagement. Microplastic pollution represents a pressing environmental and public health issue. The healthcare community must acknowledge its dual responsibility, as both a contributor to and a potential mitigator of plastic pollution. Targeted education, sustainable practices, and research are urgently needed.

KEYWORDS

microplastics, nanoplastics, environment, health, aligners

1 Introduction

Plastics have become ubiquitous in modern life, finding use in everything from packaging and textiles to electronics and medical devices. Global plastic production has surged over the past half-century, reaching hundreds of millions of tons per year, yet only a small fraction is effectively recycled (Greyer et al., 2017). Most discarded plastics persist in landfills or leak into natural environments, where they fragment through weathering (sunlight, heat, abrasion) into microplastics (<5 mm) and nanoplastics (<1 μm) (Chamas et al., 2020). These particles are now pervasive pollutants, with over 80% of marine litter composed of plastic debris (Oliveira and Almeida, 2019). Microplastics have been detected in all ecosystems, raising concerns for wildlife and human health. Recognizing the scale of the crisis, the 2022 United Nations Environment Assembly adopted the resolution "End Plastic Pollution," initiating negotiations for a global agreement by the end of 2024 (Editorial. On the plastics crisis, 2023). Although often regarded as an environmental issue, microplastic pollution also intersects directly with human health and healthcare systems. People are daily exposed through contaminated food, water, and air, while healthcare itself contributes substantially to plastic waste via disposable medical and dental materials.

The aim of this paper is to review the environmental persistence and spread of micro/nanoplastics, their known and potential health effects, and the specific relevance of microplastics in healthcare, particularly medicine, dentistry and orthodontics.

2 Environmental persistence and global distribution

Plastic debris does not biodegrade but fragments into smaller pieces, persisting for decades or longer (Chamas et al., 2020). Transported by wind and ocean currents, micro-nano plastics have been detected in mountain snow and polar ice, demonstrating global reach (Allen et al., 2019). Major sources include the breakdown of packaging and fishing gear, shedding of synthetic fibers during laundry, tire abrasion, and formerly, microbeads in cosmetics (now banned in many countries) (Auta et al., 2017). Furthermore, some microplastics are intentionally manufactured, such as industrial resin pellets and powders. Once released, these particles accumulate in oceans, freshwater, and soils, threatening ecosystems. Marine species may ingest microplastics mistaken for food, causing intestinal blockages, reduced feeding, and mortality. Beyond physical harm, microplastics act as vectors for pollutants and pathogens, adsorbing toxins such as PCBs and pesticides and transporting them through food webs. Laboratory evidence links chronic exposure to inflammation, oxidative stress, and reproductive impairment in animals.

Humans are likewise exposed through contaminated food, water, and air. Microplastics have been found in seafood, sea salt, and both bottled and tap water. Estimated ingestion may reach "fifty plastic bags per year" or "one credit card per week" (Pletz, 2022). Airborne fibers in indoor dust also pose respiratory risks (Triantafyllaki et al., 2024). The persistence and ubiquity of microplastics mean that human exposure is chronic and cumulative, underscoring the need for preventive measures to reduce plastic pollution at its source.

3 Human health implications

The entry of micro- and nanoplastics into the human body raises complex questions about potential health effects. Humans are exposed chiefly by ingestion (through food and water) and inhalation of airborne particles. Recent studies have detected micro- and nanoplastic particles lodged in human atherosclerotic plaques and even in brain tissue (Marfella et al., 2024; Nihart et al., 2025). Additionally, scientists have identified microscopic plastics in human stool and placental tissue, confirming that some fraction of ingested particles can be absorbed into the body's circulatory system (Sutkar et al., 2025). These findings underscore that microplastics are not merely passing through the gut—some can penetrate organs. However, the clinical significance of such internal contamination remains unclear, and research is only beginning to evaluate the possible risks.

Experimental evidence suggests several mechanisms of harm. In laboratory and animal studies, high microplastic exposure induces inflammation, oxidative stress, and tissue damage. Rodents consuming large doses develop gastrointestinal inflammation and metabolic alterations, while inhalation of plastic fibers has produced lung lesions (Sutkar et al., 2025). These findings raise concerns that chronic low-level human exposure could contribute to subclinical inflammation or metabolic disturbances. Another concern involves chemical additives in plastics, such as bisphenol A (BPA), phthalates, flame retardants, and heavy metal stabilizers—many recognized as endocrine disruptors or toxins. BPA, for example, binds to hormone receptors and has been linked to reproductive and developmental effects in animals (Ma et al., 2019). Micro- and nanoplastics may act as carriers, delivering these compounds into tissues and potentially disturbing hormonal or cellular processes. Nanoplastics are particularly worrisome, as their minute size allows them to cross cell membranes and possibly the blood–brain barrier, posing risks to the brain and other sensitive organs.

Recent toxicological studies have started to explore the long-term systemic impact of these particles. Evidence indicates that persistent microplastic exposure may alter gut microbiota balance, promote low-grade systemic inflammation, and interfere with lipid metabolism (Leslie et al., 2022; Ragusa et al., 2021). Microplastics have been shown to accumulate in hepatic and renal tissues, suggesting a potential for bioaccumulation and organ-specific stress. Potentially, environmental exposure and ingestion of micro- and nanoplastics may lead to their translocation across biological barriers and accumulation in tissues. This process can generate oxidative stress and activate inflammatory pathways, which might finally contribute to systemic effects, such as immune dysregulation, endocrine disruption and metabolic imbalance. Despite that, at present, no definitive disease or syndrome in humans has been causally attributed to microplastic exposure, but data are limited. Epidemiological studies are virtually nonexistent, and the observed concentrations of microplastics in human samples so far are low, on the order of a few particles per gram of tissue or milliliter of fluid. A recent systematic review concluded that evidence of clinically significant effects on human digestive, respiratory, or reproductive health is inconclusive, highlighting the need for further research (Chartres et al., 2024). Nonetheless, public health authorities have emphasized a precautionary approach given the uncertainty. Notably, certain vulnerable populations could face higher risk: infants and young children may ingest more microplastics relative to their body weight (for example, infant formula prepared in plastic bottles can release millions of microplastic particles per day into the milk (Sutkar et al., 2025), and early developmental stages are especially sensitive to endocrine disruptors. Individuals with pre-existing respiratory conditions might likewise be more susceptible to any airway irritation from inhaled micro-nanoplastics. There are currently no established safety thresholds for micro-nanoplastic intake, but experts generally advise minimizing avoidable exposure. For example, the American Medical Association has advised patients to take simple steps like avoiding the heating of food in plastic containers and limiting certain plastic uses during pregnancy as a prudent measure until more is known (Kuriakose, 2023). In summary, while acute toxicity from environmental microplastics seems unlikely at typical exposure levels, the possibility of long-term, cumulative health effects, via chronic inflammation, immune dysregulation, or chemical disruption, cannot be ruled out. This uncertainty makes it imperative to continue investigating microplastics and to reduce unnecessary environmental contamination as a safeguard for public health.

4 Plastics in healthcare, dentistry, and orthodontics

Modern healthcare is deeply dependent on plastics. Hospitals and clinics use a vast array of single-use plastic items for hygiene and patient care, from gloves, syringes, and intravenous (IV) tubing to sterile packaging, catheters, and disposable instruments. While these products have improved infection control and patient safety, they generate enormous quantities of waste. Due to contamination and regulatory constraints, most medical plastic waste is not recycled, instead ending up in landfills or being incinerated. Dentistry has embraced plastic-based materials and supplies, leading to a significant plastic footprint in day-to-day practice (Martin and Martin, 2025). Disposable suction tips, saliva ejectors, barrier films, prophylaxis cups, plastic bracket trays, and many other items are used once and discarded. A recent review catalogued how the proliferation of such single-use plastics in dentistry over recent decades has dramatically increased clinical waste, raising environmental concerns (Martin and Martin, 2025).

A list of some plastic-based materials or devices currently in use in Healthcare and Dentistry, along with its typical usage pattern (disposable single-use vs. reusable multi-use) and the primary plastic polymer used in its construction is presented in Tables 1, 2. All listed items reflect modern standard materials, excluding legacy or obsolete products (Essentra Components US, 2025; Plastics for Dental Equipment,2025).

Beyond disposables, dental materials themselves are often polymer-based. The shift from metal amalgam fillings to resin-based composites eliminated the environmental hazard of mercury, but added new concerns of plastic waste and chemical leaching (Mulligan et al., 2018).

Resin composite restorations are made of polymer matrices that can shed microscopic debris and release trace chemicals. For example, routine dental procedures like drilling or polishing composite fillings produce fine particulate dust (microplastic particles) that can be inhaled or washed into wastewater (Mulligan et al., 2021). Studies have also shown that cured dental composites can leach small amounts of unreacted monomers (such as bis-GMA or TEGDMA) into saliva or rinsing water, especially soon after placement (Van Landuyt et al., 2011). Although the quantities are very low, the presence of these substances highlights the trade-off of using plastics in place of inert metals.

Orthodontic bonding materials similarly contain resin components: when braces (bracket and wires) are removed (debonded), the adhesive resin is ground off, generating dust that in laboratory assays has exhibited estrogenic (hormone-like) activity, likely due to residual bisphenol A (BPA) or related compounds in the particulate (Gioka et al., 2009). Fortunately, the actual exposure levels of BPA from orthodontic adhesives are extremely low (in the nanogram range); a systematic review concluded that any BPA leaching from bonded brackets or aligner materials is far below safety thresholds (Kloukos et al., 2013).

A significant development in dentistry has been the rise of clear aligner orthodontic therapy. Clear aligners offer an esthetic and removable alternative to traditional braces, but their use comes with a substantial plastic burden. As of 2024, well over ten million patients worldwide have undergone clear aligner treatment, entailing the fabrication of hundreds of millions of plastic trays and tens of millions of 3D-printed plastic models for those cases (Slaymaker et al., 2024). A single aligner weighs approximately 2 g, each 3-D printed dental model weighs about 15 g, and only a small fraction of the original aligner sheet is converted into the final product; moreover, typical single patient's treatment can involve 30–50 aligners changed sequentially for each upper and lower arches, plus numerous resin models and plastic packaging, amounting to about 0.5–1 kg of plastic waste per patient by the end of treatment (Camcı and Büyükbayraktar, 2025). Because used aligners are medical/biohazard waste (having been in contact with saliva and oral microbes), they generally cannot be recycled through conventional municipal programs and thus overwhelmingly end up as long-lived trash. The aligner manufacturing process and disposal have therefore introduced a new waste stream that did not exist with traditional metal orthodontic appliances. Moreover, in cases of misfit due to poor compliance or biomechanical issues, some aligners (produced in advance before the start of treatment) may go unused and are discarded while still sealed in their original packaging.

In addition to the waste generated, researchers have begun examining whether the aligners themselves might release microplastics or chemicals during use. Recent testing of clear aligner materials under simulated chewing and thermal conditions found that the aligners do shed measurable microplastic particles, though the estimated amount a patient might ingest is very small (Barile et al., 2025). Minor leaching of certain constituents (for instance, oligomeric additives or polyurethane components) can also occur, especially when aligners are new or exposed to high temperatures, but these are generally at trace levels. A 2025 systematic review reported no evidence of any toxic chemicals being released from commercial clear aligners at levels that would pose a health risk (Ferreira et al., 2025). Nonetheless, case reports have noted rare hypersensitivity reactions to aligner materials in a few patients (including isolated incidents of anaphylaxis), reminding clinicians that even "inert" plastics can occasionally trigger biocompatibility issues (Allareddy et al., 2017). Clear aligners also tend to accumulate bacterial plaque on their surfaces if not cleaned diligently, which can contribute to gingival inflammation or tooth decalcification during treatment, a drawback not generally associated with metal braces that do not cover the teeth (however

TABLE 1 Plastic-based materials or devices currently in use in Healthcare.

Item	Use category	Type of plastic
Disposable syringes	Single-use	Polypropylene (PP)
Intravenous (IV) fluid bags	Single-use	Polyvinyl chloride (PVC)
IV tubing/Infusion sets	Single-use	Polyvinyl chloride (PVC)
Blood storage bags	Single-use	Polyvinyl chloride (PVC)
Oxygen masks *(e.g., for therapy)*	Single-use	Polyvinyl chloride (PVC)
Oxygen tubing/Nasal cannula	Single-use	Polyvinyl chloride (PVC)
Urinary catheters (Vinyl)	Single-use	Polyvinyl chloride (PVC)
IV catheters (Peripheral)	Single-use	Polyurethane (thermoplastic)
Surgical face masks	Single-use	Polypropylene (nonwoven PP fiber)
Isolation/Surgical gowns	Single-use	Polypropylene (spunbonded)
Vinyl Exam gloves	Single-use	Polyvinyl chloride (PVC)
Petri Dishes (culture Plates)	Single-use	Polystyrene (PS)
Plastic test tubes	Single-use	Polystyrene (PS)
Blister Pack packaging *(e.g., pill packs)*	Single-use	Polyvinyl chloride (PVC)
Prescription medicine bottles	Single-use	Polypropylene (PP)
Surgical instrument components *(plastic handles/casings)*	Multi-use	Polycarbonate (PC)
Joint replacement liners *(orthopedic implants)*	Multi-use (implant)	Ultra–High-molecular-weight polyethylene (UHMWPE)

TABLE 2 Plastic-based materials or devices currently in use in Dentistry.

Item	Use category	Type of plastic
Dentures (full/Partial bases)	Multi-use	Polymethyl methacrylate (PMMA acrylic)
Partial Denture clasps	Multi-use	Acetal (Polyoxymethylene) or PEEK polymer
Orthodontic clear aligners	Single-use	Thermoplastic polyurethane (medical-grade)
Orthodontic retainers (Vacuum-formed)	Multi-use	Polyethylene – e.g., HDPE or PETG thermoplastic
Orthodontic brackets (clear/Plastic)	Multi-use	Polycarbonate (PC) composite
Elastomeric ligature ties *(Braces)*	Single-use	Polyurethane Elastomer
Occlusal splints/Mouthguards	Multi-use	Ethylene Vinyl acetate (EVA) copolymer
Disposable impression trays	Single-use	Polystyrene (PS)
Dental instrument Handles	Multi-use	Polypropylene (PP)
Prefabricated temporary crowns	Single-use	Polycarbonate resin (reinforced)
Dental instrument sterilization trays	Multi-use	Acetal (rigid polymer)

plaque can accumulate around brackets and wires). The orthodontic community has only recently started to grapple with these trade-offs: some have questioned whether the convenience of aligners is worth the environmental cost and have called for more sustainable practices and materials in orthodontics. For example, direct 3D printing of aligners may eliminate excess plastic waste from molds, and even new shape-memory polymer aligners could be periodically adjusted rather than swapped out weekly, greatly reducing the number of plastic trays needed per treatment (Panayi et al., 2024). At the same time, aligner manufacturers are exploring improvements such as recyclable aligner plastics and take-back recycling programs, but these are not yet common practices.

Plastic waste in healthcare was further spotlighted during the COVID-19 pandemic. To prevent viral spread, the use of single-use personal protective equipment (PPE), masks, gloves, gowns, face shields, etc., skyrocketed in 2020 and 2021. While critical for safety, this surge generated vast amounts of additional medical plastic waste. Disposable masks and gloves have since been found littering streets, rivers, and oceans worldwide, becoming a new form of pollution tied to the pandemic (Ammendolia et al., 2021). Even outside of pandemic conditions, consumer oral health products contribute to microplastic pollution. Until mid-2010s regulatory bans, many toothpastes and cosmetic scrubs contained polyethylene microbeads as abrasives; these microplastics would wash down drains and evade water treatment filtration, later being ingested by marine life. Analyses have confirmed that some toothpaste brands still contain microplastic fragments despite the bans, indicating incomplete compliance or use of alternative plastic particles (Vaz et al., 2019; Madhumitha et al., 2022). Seemingly innocuous items like toothbrushes and floss also add up: an estimated billions of plastic toothbrushes and floss picks are discarded annually, rarely recycled due to their mixed materials (Abed et al., 2023; Lyne et al., 2020). More eco-friendly options (e.g., bamboo toothbrushes, compostable floss) exist but are not yet mainstream. Recognizing the need for change, the concept of "eco-friendly dentistry" has emerged, encouraging dental practices to minimize single-use disposables, implement recycling programs, and choose sustainable materials when possible. Guidelines on environmentally responsible dentistry were published almost 2 decades ago (Farahani and Suchak, 2007), but adoption has been gradual. Together, these examples illustrate how healthcare and dental care, despite their benefits, are intertwined with the microplastic problem through the extensive use of plastics. Reducing this plastic footprint without compromising patient care is an ongoing challenge that the profession is only beginning to address.

5 Awareness and attitudes among healthcare professionals

Despite the emerging evidence of microplastic pollution and its potential health relevance, awareness of this issue within the healthcare community appears to be limited. Topics like microplastics and environmental sustainability have not traditionally been included in medical or dental training, and professional guidelines seldom mention them. A few studies have begun to probe what health professionals and students know about microplastics, with alarming results. In a 2020 pilot survey of public health and medical students in Italy, about one-quarter of respondents had never heard the term "microplastic" before, and overall knowledge scores were low. After receiving a brief educational primer on the topic, however, the students' concern about microplastic risks increased significantly, suggesting that baseline knowledge is lacking but interest can be stimulated with information (Cammalleri et al., 2020). Similarly, a 2024 survey of medical students in Turkey found only moderate awareness of microplastic pollution; students who had more exposure to environmental science (through media or coursework) tended to score higher, indicating educational background plays a role (Uzun and Orhan, 2024). These findings imply that even among the next-generation of health professionals, microplastics have not yet become a standard part of the educational curriculum in a meaningful way.

Among practicing clinicians, there is currently little systematic data, but anecdotal evidence points to variable and generally low awareness. Many dentists and orthodontists are only beginning to realize that their material choices (like plastic aligners or resin restorations) have environmental ramifications, given that discussions of "eco-friendly dentistry" have been marginal until recently. For instance, the orthodontic literature only in 2024 published its first commentary highlighting microplastic release from clear aligners and urging the profession to consider sustainability alongside clinical innovation (Panayi et al., 2024). Where surveys have been done, they suggest a readiness to learn: a recent UK survey reported that while many dental practitioners were concerned about plastic waste in their clinics, most felt unsure how to effectively reduce it or lacked guidance on alternatives (Baird et al., 2022). This mirrors experiences with other emerging public health topics, until awareness is raised and concrete guidelines provided, even well-intentioned professionals may not act. Physicians, outside of certain specialties, have so far viewed microplastics mainly as an environmental issue rather than a direct clinical concern, though that is slowly changing as groups like the American Medical Association acknowledge it as a public health concern (Kuriakose, 2023). Overall, it is evident that substantial knowledge and attitude gaps persist among healthcare providers regarding microplastics. Quantifying these gaps is an important step toward addressing them. By assessing current awareness and perceptions, targeted educational initiatives can be developed to better equip medical and dental professionals to engage with the microplastics problem, both in reducing their own plastic footprint and in advising patients and communities. This recognition of a knowledge deficit in our field is a key motivation for present and future studies.

6 Awareness among researchers and manufacturers

While clinical professionals play a direct role in reducing the plastic footprint within orthodontic practice, manufacturers and researchers share equal responsibility in advancing sustainable innovation. Manufacturers might contribute by developing new recyclable, biodegradable, or bio-based polymers with comparable strength and transparency to conventional plastics, but reducing environmental persistence. The adoption of new production systems, where waste from fabrication and production is collected, reprocessed, and reintegrated, may represents a practical step toward circular manufacturing in dentistry.

From a research perspective, greater emphasis should be placed on life cycle assessment studies to quantify the environmental impact of orthodontic devices from fabrication to disposal. The integration of sustainability criteria in product development and regulatory approval processes may also help market transformation. Finally, fostering environmental awareness among manufacturers, researchers and clinicians requires targeted education, supportive policy incentives and cooperation across universities, industry and healthcare to embed sustainability into daily practice.

7 Discussion and conclusion

Microplastics and nanoplastics have rapidly gained recognition as a novel environmental health challenge. Once considered mere environmental debris, these persistent plastic fragments are now known to permeate ecosystems and enter the human body, with unknown long-term consequences. The healthcare field finds itself entwined with this issue on multiple fronts: on one hand, medical and dental practices are contributors to plastic pollution (through extensive use of disposables and polymer-based materials), and on the other hand, healthcare professionals have a duty to safeguard human wellbeing, which increasingly includes understanding and mitigating environmental exposures. A recent 2025 white paper (Eliades et al., 2025) has also addressed the seriousness of the environmental and health impact of microplastics. Some of their recommendations are consistent with ours: developing sustainable guidelines; education and awareness for both the public and healthcare providers and staff; sustainable office practices. Therefore, the principle “first, do no harm” is extending beyond the clinic walls to encompass ecological stewardship.

Confronting the microplastic pollution dilemma will require concerted efforts spanning environmental science, industry innovation, and public policy. The healthcare sector has an important role to play in each of these areas. By raising their own awareness and that of their patients, healthcare providers can help shift societal behaviors toward reduced plastic use and better waste management. Moreover, within clinical practice, several evidence-based strategies can mitigate the plastic footprint while maintaining patient safety and treatment efficacy. Dental professionals can prioritize reusable or biodegradable alternatives when infection control standards permit—for example, stainless steel suction tips, reusable impression trays, and biodegradable barrier films in place of disposable plastics (Farahani and Suchak, 2007). Participation in specialized recycling programs for dental plastics, including aligner collection or cartridge recovery initiatives, further contributes to waste reduction when supported by manufacturers and local authorities. For example, some aligner companies and dental product makers have begun pilot take-back programs to collect and recycle used devices, a practice that could be expanded.

Furthermore, the implementation of digital workflows might also play a crucial role: replacing traditional plaster casts with intraoral scanning and virtual setups significantly will reduce the use of consumable materials and shipping-related waste (Kuriakose, 2023). In orthodontics, innovative approaches such as direct 3D printing of aligners minimize polymer offcuts generated during thermoforming (Camcı and Büyükbayraktar, 2025), while shape-memory polymers and bio-based resins show promise for the production of durable, recyclable appliances (Editorial. On the plastics crisis, 2023). Complementary sustainability measures—such as energy-efficient sterilization, green procurement policies, and staff training in waste segregation—can further enhance environmental performance. Finally, patient education about proper device disposal and recycling channels ensures that sustainability extends beyond the clinic. Collectively, these strategies align with the World Federation of Orthodontists’ recent recommendations for promoting a more sustainable, responsible, and environmentally conscious profession (Eliades et al., 2025).

Ultimately, reducing microplastic pollution will require close collaboration between the healthcare and environmental sectors, moving beyond working in isolation. Clinicians need accessible information on emerging hazards like microplastics so they can respond knowledgeably to patient concerns and advocate for healthier environments. Over time, as evidence evolves, professional organizations may develop guidelines (for instance, recommending best practices to minimize plastic waste in clinics, or advising patients on safer consumer choices to reduce microplastic exposure). By proactively engaging with the issue now, the healthcare community can help preempt more serious health impacts down the line.

Future studies may start with assessment of healthcare professionals (physicians, dentists, and orthodontists) knowledge/awareness, attitudes and behavior regarding the health, and environmental impact of microplastics. This could be a survey. Ultimately, development of a bioplastic that has no health or environmental consequences would make a huge impact on our health and the planet.

In conclusion, microplastic pollution is not just an environmental predicament but a burgeoning public health concern, one that the medical and dental professions must actively address. The awareness and actions of healthcare providers can influence public attitudes, drive demand for sustainable products, and policies. In the coming years, as more evidence about microplastics emerges, the healthcare sector’s engagement will be crucial in translating science into meaningful prevention and advocacy. Through continued research, education, and collaboration, healthcare professionals can help steer society toward solutions that curb plastic pollution and protect global health for generations to come.

Author contributions

DR: Conceptualization, Writing – original draft. AB: Conceptualization, Writing – original draft. NW: Writing – original draft. GG: Supervision, Writing – review and editing. AM: Writing – review and editing. OC: Writing – review and editing. MC: Supervision, Writing – review and editing.

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