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Large focus on small plastic particles

PERSPECTIVES

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The presence of plastic in the body does not necessarily indicate a major health risk.

Many recent findings strengthen the suspicion that micro- and nanoplastics (MNPs) are present in the human body, but the amounts and distribution in different organs are still largely uncertain. Whether the presence of plastics has negative health effects is still unknown. Research on MNPs and their effects on health is still an emerging field, with large knowledge gaps and significant technological challenges. Norway can and should contribute more to closing these knowledge gaps.

Among the clinical studies that have received particular attention in recent years are those dealing with plastic in atherosclerotic plaques, plastic in the brain and plastic in the placenta. In the following, we will take a closer look at these studies.

What do the studies say?

In a study in The New England Journal of Medicine, MNPs were investigated as a possible risk factor for cardiovascular disease (1). Atherosclerotic plaques were analysed for plastic and correlated with clinical parameters and inflammatory markers in patients after carotid endarterectomy. In more than half of 300 patients, polyethylene was found in the plaques. There was an association between plastic in plaques and increased risk of cardiovascular disease and death, but the study authors were unable to show a direct causal relationship. A study of mice without apolipoprotein E, which mimics heart disease in humans, supports a possible correlation between exposure to MNPs and the development of atherosclerotic lesions in male mice, but not in female mice (2).

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In a study on plastic in the brain published in the journal Nature Medicine, relatively high concentrations of plastic were detected in the frontal cortex during autopsy (3), with particularly high levels of polyethylene. The study also reported high concentrations of polyethylene in the brains of patients with dementia. However, one possible explanation for these high polyethylene levels is contamination, with residual lipids in the tissue samples potentially affecting the results (4, 5).

In 2024, Italian researchers reported findings of microplastics in 62 placenta samples (6). In another study from Texas, 158 placenta samples were analysed, and the amount of microplastic was significantly higher in placenta from premature pregnancies than in placenta from full-term pregnancies, but no causal relationship has been demonstrated here either. For now, this study has only been published as a preprint (7).

To measure plastic in the studies, pyrolysis-gas chromatography with mass spectrometry (pyrolysis-GC-MS) was employed, and in two of these studies, microscopy was also used to measure MNPs in biological samples.

What is plastic?

Plastic is a complex material consisting of polymers, monomers, intermediates and additives, including pigments, flame retardants, antioxidants and many other chemicals. Plastic is mostly made from oil-based synthetic polymers. The types of plastic we deal with most are polyethylene, polypropylene, polyethylene terephthalate (PET), polyamide (nylon), polystyrene and polycarbonates. Since the 1960s, plastic production has risen sharply, with much of this material still in use or contributing to environmental pollution. By 2060, production volumes are expected to be three times higher than at present (8).

Microplastics are formed from larger plastic particles

Plastic breaks down slowly in nature. Large pieces of plastic break down into smaller pieces through chemical, physical and biological processes, often called macroplastics, and further down to microplastics, which are from 1 µm to 5 mm, and nanoplastics, which are smaller than 1 µm. Since nanoplastic particles are very small, it is difficult to detect them.

The term microplastic was first used in a 2004 publication that describes microscopic plastic fragments (9). There are various definitions for microplastics in the literature, but we define microplastics as persistent,

polymer-containing particles less than 5 mm, including synthetic elastomers like rubber.

The small particles can either be produced or formed unintentionally by the breakdown of larger plastic pieces. Previously, MNPs were specially manufactured and added to products, such as microbeads in cosmetics or other personal care items, but this use is now regulated in Norway and the EU. Today, most MNPs are released during production, use and disposal of plastic products, or simply when the plastic ends up in nature. Consequently, the environment, food, drinking water and air become contaminated. Medical equipment, such as infusion lines, can also be a source of MNPs (10), but the knowledge base about such medical equipment as a source of plastic in the body is far from complete.

Uncertain health effects

In 2022, the World Health Organization (WHO) published a report summarising the possible health effects of MNPs (11). In general, very little is known about the health effects. Animal studies have reported effects on the gut and liver, but the WHO report concludes that the studies have methodological weaknesses and that it is not possible to draw reliable conclusions about either human exposure levels or health risks associated with MNPs.

> ***«Animal studies have reported effects on the gut and liver, but the WHO report concludes that the studies have methodological weaknesses»***

Another recently published article shows that it is likely that MNPs are absorbed into the body from the gut or lungs (12). Many of the studies that investigate exposure in humans and health outcomes, however, have weaknesses, which means that it is currently almost impossible to conclude whether plastic in blood or organs has negative health effects (12). Theoretically, the smallest plastic particles will more easily be absorbed in the gut and lungs, circulate in the bloodstream, and pass through biological membranes and thus be absorbed into tissue and cells. We can therefore assume that the greatest health risk will be associated with exposure to particles smaller than 1 µm, i.e. nanoplastics.

In addition, concern is growing about chemicals in plastics. In a recently published review article from NTNU, the authors find that up to 16,000 chemicals may be added to plastics (13). Data on the environmental and health hazards of many of these chemicals remain limited. Population-based studies in Norway and other countries show that the population is exposed to known plastic chemicals, including phthalates and bisphenols (14).

Challenging research

One of the problems described in the WHO report is that many toxicological studies to date have been conducted using pure, spherical polystyrene particles, rather than particles derived from plastic products that have been exposed to environmental impacts. The pure polystyrene particles are readily available from suppliers of chemicals. In contrast, other types of particles—including nanoplastic particles that have been subjected to environmental impacts in a process called weathering—must be produced in specialised laboratories. Producing enough weathered particles necessary for toxicological research is a significant challenge. Microplastics are not a single substance, but a heterogeneous group of materials that vary widely in size, polymer type, chemical composition, shape and surface properties, which makes toxicological testing challenging when attempting to replicate real-world exposure.

To date, the effects of MNPs have mostly been studied in cell cultures with relatively high concentrations of plastic. It has not always been demonstrated whether MNPs actually interact with or are taken up by cells during experiments. There is also uncertainty regarding whether the particles used in studies accurately reflect those encountered by humans. Cell death, oxidative stress, effects on mitochondria, cytokine release, DNA damage and changes in signalling pathways have been reported in several studies (15–18). However, the results of these studies are subject to uncertainty, and a critical attitude is needed. However, since similar effects of other types of nanoparticles (titanium dioxide or silver and black carbon) have been reported, it can be assumed that a causal relationship is likely (11, 19).

Contamination causes complications

Measuring the amount of MNP in blood or organs is technically challenging (20). There is a high risk of contamination with plastic materials during collection and processing of biological samples, and strict quality procedures are necessary to minimise and prevent such contamination. Not all laboratories have established these procedures. A review article shows that all analyses of MNPs in blood and placenta reported so far have methodological weaknesses, especially in terms of controlling for contamination during sampling and processing (12).

> ***«Measuring the amount of MNP in blood or organs is technically challenging»***

This is yet another reason to take a critical approach when planning studies and interpreting scientific findings on the amount of MNP in human samples. In particular, the use of existing samples collected for other purposes is discouraged if contamination is not accounted for. Furthermore, there are

currently no sufficiently robust methods for measuring the smallest plastic particles, such as nanoplastics, which are likely the most toxicologically relevant.

The way to more knowledge

Although it is likely that plastic particles are present in the human body, this should not give rise to undue alarm. The detection of plastics in the human body does not necessarily imply a health risk. Unfortunately, current knowledge is insufficient to make such an assessment. The findings should encourage further studies and collaboration within research communities. Meanwhile, measures are needed to reduce plastic production and to develop materials that do not release microplastics.

Research on MNPs is technically challenging and requires specialised equipment, key expertise and adapted laboratories. Norway has several strong research groups capable of contributing, if this area is made a national priority and funded accordingly.

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