High levels of microplastics released from infant feeding bottles during formula prep

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AMBER and Trinity researchers discover infants up to 12 months old injest on average 1,000,000 microplastics every day from baby bottle, based on World Health Organisation guidelines for sterilisation and infant formula preparation. Credit: AMBER, and Trinity College Dublin.

New research shows that high levels of microplastics (MPs) are released from infant-feeding bottles (IFBs) during formula preparation. The research also indicates a strong relationship between heat and MP release, such that warmer liquids (formula or water used to sterilise bottles) result in far greater release of MPs.

In response, the researchers involved—from AMBER, the SFI Research Centre for Advanced Materials and Bioengineering Research, TrinityHaus and the Schools of Engineering and Chemistry at Trinity College Dublin—have developed a set of recommendations for infant formula preparation when using plastic IFBs that minimise MP release.

Led by Dr. Jing Jing Wang, Professor John Boland and Professor Liwen Xiao at Trinity, the team analysed the potential for release of MPs from polypropylene infant-feeding bottles (PP-IFBs) during formula preparation by following international guidelines. They also estimated the exposure of 12-month-old infants to MPs in 48 countries and regions and have just published their findings in the high-profile journal *Nature Food*.

Key findings

- PP-IFBs can release up to 16 million MPs and trillions of smaller nanoplastics per litre. Sterilisation and exposure to high temperature water significantly increase microplastic release from 0.6 million to 55 million particles/l when temperature increases from 25 to 95 °C
- Other polypropylene plastic-ware products (kettles, lunchboxes) release similar levels of MPs
- The team undertook a global survey and estimated the exposure of 12-month-old infants to microplastics in 48 regions. Following current guidelines for infant-feeding bottle sterilisation and feeding formula preparation the average daily exposure level for infants is in excess of 1 million MPs. Oceania, North America and Europe have the highest levels of potential exposure, at 2,100,000, 2,280,000, and 2,610,000 particles/day, respectively
- The level of microplastics released from PP-IFBs can be significantly reduced by following modified sterilisation and formula preparation procedures

Recommended sterilisation and formula preparation procedures

- Sterilising infant feeding bottles
- Sterilise the bottle following WHO recommended guidelines and allow to cool
- Prepare sterilised water by boiling in a non-plastic kettle/cooker (e.g. glass or stainless

steel)

- Rinse the sterilised bottle using room temperature sterilised water at least 3 times

Preparing infant formula

- Prepare hot water using a non-plastic kettle/cooker
- Prepare infant formula in a non-plastic container using at least 70 C water. Cool to room temperature and transfer prepared formula into a high-quality plastic infant feeding bottle

Standard Precautions

- Do not reheat prepared formula in plastic containers and avoid microwave ovens
- Do not vigorously shake the formula in the bottle at any time
- Do not use sonication to clean plastic infant feeding bottles

Studying microplastics through a project of scale

There is growing evidence to suggest that micro and nano plastics are released into our food and water sources through the chemical and physical degradation of larger plastic items. Some studies have demonstrated the potential transfer of micro and nano plastics from oceans to humans via the food chain but little is known about the direct release of microplastics (MPs) from plastic products through everyday use.

Polypropylene (PP) is one of the most commonly produced plastics in the world for food preparation and storage. It is used to make everyday items such as lunch boxes, kettles and infant-feeding bottles (IFBs). Despite its widespread use the capacity of PP to release microplastics was not appreciated until now.

Measuring Polypropylene microplastic release (PP-MPs) from infant feeding bottles (IFB)

Drawing on international guidelines for infant formula preparation (cleaning, sterilising, and mixing techniques), the team developed a protocol4 to quantify the PP-MPs released from 10 representative infant-feeding bottles that account for 68.8% of the global infant-feeding bottle market.

When the role of temperature on the release of PP-MPs was analysed a clear trend emerged; the higher the temperature of liquid inside the bottle, the more microplastics released.

Under a standardised protocol, after sterilisation and exposure to water at 70 C, the PP-IFBs released up to 16.2 million PP-MP per litre. When the water temperature was increased to 95 C, as much as 55 million PP-MP per litre were released, while when the PP-IFB's were exposed to water at 25 C—well under international guidelines for sterilisation or formula preparation—600,000 PP-MP per litre were generated.

Estimating the exposure of 12-month-old infants to MPs from PP-IFBs

Given the widespread use of PP-IFBs and the quantity of MPs released through normal daily use, the team realised the potential exposure of infants to MPs is a worldwide issue. The team estimated the exposure of 12-month-old infants to MPs in 48 countries and regions by using MP release rates from PP-IFBs, the market share of each PP-IFB, the infant daily milk-intake volume, and breastfeeding rates.

The team found that the overall average daily consumption of PP-MPs by infants per capita was 1,580,000 particles.

Oceania, North America and Europe were found to have the highest levels of potential exposure corresponding to 2,100,000, 2,280,000, and 2,610,000 particles/day, respectively.

Mitigating exposure

Given the global preference for PP-IBFs it is important to mitigate against unintended generation of micro and nanoplastics in infant formula. Based on their findings the team devised and tested a series of recommendations for the preparation of baby formula that will help minimise the production of MPs.

They note though, that given the prevalence of plastic products in daily food storage and food preparation, and the fact that every PP product tested in the study (infant bottles, kettles, lunch boxes and noodle cups) released similar levels of MPs, there is an urgent need for technological solutions.

As Professor John Boland, AMBER, CRANN, and Trinity's School of Chemistry explains:

"When we saw these results in the lab we recognised immediately the potential impact they might have. The last thing we want is to unduly alarm parents, particularly when we don't have sufficient information on the potential consequences of microplastics on infant health.

"We are calling on policy makers, however, to reassess the current guidelines for formula preparation when using plastic infant feeding bottles. Crucially, we have found that it is possible to mitigate the risk of ingesting microplastics by changing practices around sterilisation and formula preparation."

Professor Liwen Xiao at TrinityHaus and Trinity's School of Engineering said:

"Previous research has predominantly focused on human exposure to micro and nanoplastics via transfer from ocean and soils into the food chain driven by the degradation of plastics in the environment.

"Our study indicates that daily use of plastic products is an important source of microplastic release, meaning that the routes of exposure are much closer to us than previously thought. We need to urgently assess the potential risks of microplastics to human health. Understanding their fate and transport through the body following ingestion is an important focus of future research. Determining the potential consequences of microplastics on our health is critical for the management of microplastic pollution."

Lead authors, Dr. Dunzhu Li and Dr. Yunhong Shi, researchers at CRANN and Trinity's School of Engineering, said:

"We have to accept that plastics are pervasive in modern life, and that they release micro and nano plastics through everyday use. We don't yet know the risks to human health of these tiny plastic particles, but we can develop behavioural and technological solutions and strategies to mitigate against their exposure."

Dr. Jing Jing Wang, Microplastics Group at AMBER and CRANN, said:"While this research points to the role of plastic products as a direct source of microplastic the removal of microplastics from the environment and our water supplies remains a key future challenge.

"Our team will investigate specific mechanisms of micro and nano plastic release during food preparation in a host of different contexts. We want to develop appropriate technologies that will prevent plastics degrading and effective filtration technologies that will remove micro and nanoplastics from our environment for large scale water treatment and local distribution and use."

More information: Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation, *Nature Food* (2020). DOI: 10.1038/s43016-020-00171-y , www.nature.com/articles/s43016-020-00171-y

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