Assessing the Pervasive Impact of Microplastics on Human Health: Literature Review

Zainab Waqar

Lahore Grammar School, Pakistan

Microplastics are defined as particles under 5mm (Thompson et al.,2004; NOAA). They are introduced into the environment when larger plastic pieces break into smaller fragments, known as 'secondary' microplastics, or when they are directly produced to be small in size, known as 'primary' microplastics (Anderson et al., 2016). Regardless of their origin, both primary and secondary microplastics pose risks to the environment and human health (Pironti et al.,2021). Microplastics not only act as carriers, for pollutants in the environment (Hartmann et al.,2017) but also transport pathogenic microorganisms (Foulon et al.,2016). Additionally, they may also transport chemical additives in them during the production process that disrupt hormones in marine life, even in small quantities, and pose threats to ocean ecosystems, wildlife, and food sources (Gallo et al., 2018).

Microplastics, because of their smaller size and high molecular weight (Lee et al., 2023) have become widely distributed and pervasive in various environmental settings such as air, water, and soil (Wright et al., 2013). The low biodegradability of these microplastics allows their long-term presence in the environment. This has raised concerns about impacts on human health especially since humans are often at the end of the food chain (Mamun et al., 2023). Humans primarily encounter microplastics through inhalation, ingestion, and through skin contact. Such exposure is associated with health risks including inflammation disruptions, in gut microbiota and the potential for contaminants to enter the body (Pironti et al., 2021).

Concerns are mounting over the prevalence of microplastics in the environment. According to research conducted by Cox et al. (2019), it is revealed that Americans may be unintentionally consuming amounts of these particles each year both through their diet and the consumption of water. Additionally, there is a potential, for increased exposure to microplastics through inhalation from dust (Cox et al.,2019). Multiple studies highlight the potential of microplastics to trigger inflammatory responses, digestive upset, hormonal imbalances, and the spread of disease-causing bacteria. Breathing in microplastics poses significant risks, potentially affecting lung and heart health. Also, skin exposure to microplastics is less studied but could lead to irritation and allergies (Emenike et al., 2023).

A brief literature review was conducted and identified four primary studies that examined the impact of microplastics on human health. This section will discuss the results of each study and will provide a synthesis of the literature and public health implications.

Study 1

Temporal Trends in Microplastic Accumulation in Placentas from Pregnancies in Hawai'i

The cross-sectional study by Weingrill et al., (2023) aimed to investigate the occurrence and levels of microplastics in placentas. In this study, researchers collected and analyzed 20 archived placental samples; 10 from 2006 and another 10 from 2013. These were compared with 10 fresh placental samples obtained in 2021.

The findings revealed a concerning increase in both the presence and concentration of microplastics in samples over time. In 2006, 60% of the placentas contained microplastics, which rose to 90% in 2013, and by 2021, every placenta in the study contained microplastics.

Moreover, there was not only a higher frequency of placentas containing microplastics but also a prominent increase in both the number of particles per placenta and the size of the particles.

Detecting microplastics in placental tissues raises the alarm because these particles can carry harmful chemicals like Bisphenol (BPA) and phthalates; substances known to disrupt hormonal and developmental processes. Multiple researches indicate that even minimal exposure to chemicals such as BPA during pregnancy can lead to complications and may signal a higher risk of certain cancers. Furthermore, early exposure to phthalates is believed to affect development, thyroid function, and metabolic processes. These findings highlight a growing public health concern regarding the impact of exposure during stages of prenatal development. However, it's important to note that this study had limitations as it relied on analyzing placentas from 2006 and 2013 when awareness, about contamination was not widespread. Additionally, the preservation method using polyethylene containers could have influenced the results obtained from these samples.

Study 2

Detection of Microplastics in Human Colectomy Specimens

Ibrahim et al. (2020) carried out a descriptive study to explore the presence and properties of microplastics in colectomy tissue samples. Their research contributes to the growing body of evidence indicating that microplastics can infiltrate organs, particularly focusing on the colon. Therefore, the study aimed to explore whether ingested microplastics accumulate in colectomy samples and provide insights into their properties and chemical composition.

For this study tissue samples were collected from 11 adult individuals residing in Northeastern Peninsular Malaysia with an average age in the mid-40s and a majority being males. These tissue

samples underwent a chemical digestion process to isolate microplastics, which were subsequently analyzed using techniques to determine their abundance, size, shape, and color.

The results obtained were consistent across all specimens examined demonstrating the presence of microplastics at a rate exceeding 300 particles per sample or close to 30 particles per gram of tissue. Filaments were found to be the form of microplastic discovered during the analysis, with the majority being colorless or transparent. Upon examining the composition of the filaments a detailed analysis revealed that a significant portion consisted of polycarbonate, polyamide, and polypropylene.

Although the exact health effects of microplastics on humans are still being determined, different research suggests they might cause gastrointestinal inflammation and other adverse reactions, especially at high levels or with smaller particles. Occupational studies have also suggested a possible link between high exposure to plastics and an increased risk of colorectal cancer. The study also suggests that people with gastrointestinal issues might face a greater risk of microplastics entering the bloodstream, posing broader health risks. Limitations of the study include its reliance on a limited number of available samples collected during routine medical procedures. Furthermore, since stool samples were not analyzed in this study there is room for research to compare the presence and types of microplastics found in fecal matter, versus those identified in colonic tissue.

Study 3

Detection and Characterization of Microplastics in the Human Testis and Semen

In the descriptive study conducted by Zhao et al. (2023), researchers focused on investigating the presence of microplastics (MPs), in semen and testicular tissues. The team collected a total of 30

semen samples and 6 testis samples. The study aimed to assess the frequency and physical features of microplastics and to explore any correlations between their abundance and variables such as age, BMI, and patterns of plastic use.

The findings showed microplastics present in human reproductive tissues and fluids, with a markedly higher concentration in the testis compared to semen. The study indicated that polystyrene (PS) and polyethylene (PE) were the predominant polymers present within the testis, while polyvinyl chloride (PVC) was more commonly found in semen. The size range of these particles varies between the two, with those in the testis being from 20 to 100 micrometers, whereas in semen, they were larger.

Research suggests that PVC and PS could pose significant health risks to humans. For instance, PS exposure in animal models has led to testicular inflammation and diminished semen quality. It also has been linked with decreased sperm count and motility. Furthermore, when microplastics mix with other environmental pollutants, they may become even more toxic to human reproductive health. However, the researchers acknowledged the limitations of their study as a small number of participants, and called for further research, with larger groups to better understand how microplastic exposure may affect male reproductive health.

Study 4

Identification of Microplastics in Human Placenta using Laser Direct Infrared Spectroscopy

Zhu et al. (2023) conducted an observational study, with the aim of detecting and analyzing the presence of microplastics within the human placenta, using an advanced laser direct infrared spectroscopy technique. The research included a sample of 17 healthy volunteers who were between 23 and 36 years of age. An important feature of the study was the strict plastic-free protocol that was precisely followed throughout the collection and preparation points to avoid plastic pollution.

The researchers found 149 microplastics, mainly PVC (polyvinyl chloride), PP (polypropylene), and PBS (polybutylene succinate), averaging 2.7 particles per gram across the samples, with a range from 0.28 to 9.55 particles per gram. These findings are more extensive than previous research, which found microplastics in only parts of the placenta samples.

Multiple studies have evidently proved that PVC is considered highly risky for human health, especially through the food chain, as it's linked to reduced sperm quality and increased risk of liver and brain cancer. PP, while generally regarded as safe by FDA standards, may also pose risks by triggering immune responses. These results highlight the urgent need to examine health risks posed by microplastic exposure during crucial fetal development stages. The study benefits from robust methods and a homogenous participant group, reducing confounding factors, but its small sample size and lack of demographic correlation limit its broader applicability.

Implications and Future Research

The detection of microplastics in human tissues raises significant concerns for public health, particularly regarding prenatal development and gastrointestinal health. Implications include a potential reevaluation of the safety of certain polymers and the need for stronger regulations to limit environmental exposure. Future research should focus on longitudinal studies to better

understand the long-term health impacts, develop more accurate detection methods, and explore the biological mechanisms behind the effects of microplastics. Additionally, there is a need to investigate the efficacy of existing guidelines and to understand the risk factors for vulnerable populations, including pregnant women and individuals with gastrointestinal diseases.

References

Anderson, A. G., Grose, J., Pahl, S., Thompson, R. C., & Wyles, K. J. (2016). Microplastics in personal care products: Exploring perceptions of environmentalists, beauticians and students. *Marine Pollution Bulletin, 113*(1-2), 454–460. https://doi.org/10.1016/j.marpolbul.2016.10.048

Cox, K. D., Covernton, G. A., Davies, H. L., Dower, J. F., Juanes, F., & Dudas, S. E. (2019). Human consumption of microplastics. *Environmental Science & Technology, 53*(12), 7068-7074. https://doi.org/10.1021/acs.est.9b01517

Emenike, E. C., Okorie, C. J., Ojeyemi, T., Egbemhenghe, A., Iwuozor, K. O., Saliu, O. D., Okoro, H. K., & Adeniyi, A. G. (2023). From oceans to dinner plates: The impact of microplastics on human health. *Heliyon, 9*(10), Article 20440. https://doi.org/10.1016/j.heliyon.2023.e20440

Foulon, V., Le Roux, F., Lambert, C., Huvet, A., Soudant, P., & Paul-Pont, I. (2016). Colonization of Polystyrene microparticles by Vibrio crassostreae: Light and electron microscopic investigation. *Environmental Science & Technology, 50*(20), 10988–10996. https://doi.org/10.1021/acs.est.6b02720

Gallo, F., Fossi, C., Weber, R., Santillo, D., Sousa, J., Ingram, I., Nadal, A., & Romano, D. (2018). Marine litter plastics and microplastics and their toxic chemicals components:

The need for urgent preventive measures. *Environmental Sciences Europe*, *30*(1), 13. https://doi.org/10.1186/s12302-018-0139-z

Ibrahim, Y. S., Tuan Anuar, S., Azmi, A. A., Wan Mohd Khalik, W. M. A., Lehata, S., Hamzah, S. R., Ismail, D., Ma, Z. F., Dzulkarnaen, A., Zakaria, Z., Mustaffa, N., Tuan Sharif, S. E., & Lee, Y. Y. (2020). Detection of microplastics in human colectomy specimens. *JGH Open: An Open Access Journal of Gastroenterology and Hepatology*, *5*(1), 116–121. https://doi.org/10.1002/jgh3.12457

Lee, Y., Cho, J., Sohn, J., & Kim, C. (2023). Health effects of microplastic exposures: Current issues and perspectives in South Korea. *Yonsei Medical Journal*, *64*(5), 301–308. https://doi.org/10.3349/ymj.2023.0048

Mamun, A. A., Prasetya, T. A. E., Dewi, I. R., & Ahmad, M. (2023). Microplastics in human food chains: Food becoming a threat to health safety. *The Science of the Total Environment*, *858*(Pt 1), 159834. https://doi.org/10.1016/j.scitotenv.2022.159834

National Ocean Service. (n.d.). Microplastics. National Oceanic and Atmospheric Administration. Retrieved November 1, 2023, from https://oceanservice.noaa.gov/facts/microplastics.html

Pironti, C., Ricciardi, M., Motta, O., Miele, Y., Proto, A., & Montano, L. (2021). Microplastics in the environment: Intake through the food web, human exposure and toxicological effects. *Toxics*, *9*(9), 224. https://doi.org/10.3390/toxics9090224

Weingrill, R. B., Lee, M. J., Benny, P., Riel, J., Saiki, K., Garcia, J., Oliveira, L. F. A. M., Fonseca, E. J. D. S., Souza, S. T., D'Amato, F. O. S., Silva, U. R., Dutra, M. L., Marques, A. L. X., Borbely, A. U., & Urschitz, J. (2023). Temporal trends in

microplastic accumulation in placentas from pregnancies in Hawai'i. *Environment International, 180,* 108220. https://doi.org/10.1016/j.envint.2023.108220

Wright, S. L., & Kelly, F. J. (2017). Plastic and human health: A micro issue? *Environmental Science & Technology, 51*(12), 6634-6647. https://doi.org/10.1021/acs.est.7b00423

Zhao, Q., Zhu, L., Weng, J., Jin, Z., Cao, Y., Jiang, H., & Zhang, Z. (2023). Detection and characterization of microplastics in the human testis and semen. *The Science of the Total Environment, 877*, 162713. https://doi.org/10.1016/j.scitotenv.2023.162713

Zhu, L., Zhu, J., Zuo, R., Xu, Q., Qian, Y., & An, L. (2023). Identification of microplastics in human placenta using laser direct infrared spectroscopy. *The Science of the Total Environment*, *856*(Pt 1), 159060. https://doi.org/10.1016/j.scitotenv.2022.159060