Special Edition: Advanced Clinical Research Internship Session III (2024), Vol. 4 No. S2
https://doi.org/10.47488/dhrp.v4iS2.1

MANUSCRIPT

The Role of Microplastics in Male Fertility Decline: A Review of Hispanic Populations Along the Texas-Mexico Border

Marisol Acosta[1], Jocelyn B. Armendariz[1,2], Juan L. Flores [1,3], Daniella E. Guerrero[1,3], Teresa J. Hidalgo[1,2], Jessica A. López[1,2], Leonel A. Nuñez[1,2], and Angie J. Ruiz[1,2]

[1]DHR Health High School and Community Outreach
[2] South Texas ISD Health Professions
[3] South Texas ISD Medical Professions

Received: July 3, 2024
Accepted for publication: January 24, 2025

Introduction

The pervasive presence of microplastics in the environment poses a significant threat to human health, including reproductive health.[1,3] This literature review focuses on the emerging evidence linking microplastic exposure to male fertility decline, specifically examining studies involving Hispanic populations along the Texas-Mexico border. This region presents a unique context due to factors such as high rates of environmental pollution, potential disparities in healthcare access, and cultural practices influencing exposure.[4,6] The review will systematically evaluate existing research, identify knowledge gaps, and highlight the need for future studies tailored to this vulnerable population. Understanding the impact of microplastics on male fertility within this specific demographic is critical for developing targeted public health interventions.

Microplastics and Male Reproductive Health: A General Overview

Microplastics, defined as plastic particles less than 5 mm in diameter, are ubiquitous pollutants found in various environmental matrices, including air, water, and soil.[2,7] Human exposure occurs through ingestion, inhalation, and dermal contact, leading to microplastic accumulation in various organs, including reproductive tissues.[1, 8-9] Several studies have demonstrated the adverse effects of microplastics on male reproductive health in both animal models and humans.[10,12] These effects include reduced sperm motility, altered sperm morphology, decreased sperm count, and increased oxidative stress.[1,13-14] The mechanisms underlying these effects are not fully understood but may involve oxidative stress, inflammation, and hormonal disruption.[1,14] Furthermore, the type and concentration of microplastics, along with individual susceptibility, may influence the severity of the effects.[8] A study by Hu et al. found microplastics in both canine and human testes, highlighting the pervasive nature of this contamination.[8] The study also

Special Edition: Advanced Clinical Research Internship Session III (2024), Vol. 4 No. S2
https://doi.org/10.47488/dhrp.v4iS2.1

revealed a negative correlation between specific polymers (PVC and PET) and testis weight, suggesting a potential link between microplastic exposure and impaired testicular function.

The Texas-Mexico Border: A Unique Context for Microplastic Exposure

The Texas-Mexico border region presents a unique epidemiological setting for studying the impact of microplastics on male fertility. This region faces several challenges that may exacerbate exposure and increase vulnerability to adverse health outcomes. Firstly, the area experiences high levels of environmental pollution, including air and water contamination, potentially leading to increased microplastic exposure compared to other regions.[15,16] Secondly, the region's socio-economic disparities, including limited healthcare access and high rates of poverty, may hinder early diagnosis and treatment of fertility problems.[4,6] Thirdly, cultural practices and dietary habits within Hispanic communities along the border may influence exposure pathways and susceptibility to microplastic-related health effects. Further research is needed to investigate these factors in detail and assess their combined impact on male fertility outcomes.[17]

Research Gaps and Methodological Considerations

Despite the growing concern, there is a significant lack of research specifically investigating the impact of microplastics on male fertility within Hispanic populations along the Texas-Mexico border. Most existing studies are either broad-based, examining general populations without considering specific demographic factors, or focus on other environmental pollutants impacting male fertility.[18-20] Furthermore, there are methodological challenges in accurately assessing microplastic exposure and its effects. Quantifying microplastic levels in human tissues requires advanced techniques, such as pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS), which may not be readily available for large-scale epidemiological studies.[8,9] Moreover, establishing a causal link between microplastic exposure and fertility decline requires robust epidemiological designs that account for confounding factors, such as lifestyle, diet, and other environmental exposures.[19] Studies should also consider the potential synergistic effects of microplastics with other environmental pollutants, as individuals in this region are likely exposed to a complex mixture of contaminants.[14]

Future Research Directions

Addressing the research gaps requires a multidisciplinary approach involving environmental scientists, epidemiologists, reproductive health specialists, and community health workers. Future research should prioritize the following:

Targeted Epidemiological Studies: Conduct large-scale epidemiological studies specifically focusing on Hispanic men along the Texas-Mexico border. Measure microplastic exposure levels (e.g., through blood, semen, or urine samples) and assess their association with various fertility parameters, including sperm count, motility, morphology, and DNA integrity. These studies should employ advanced statistical methods to adjust for potential confounders and investigate dose-response relationships.[8,9]

https://doi.org/10.47488/dhrp.v4iS2.1

Mechanistic Studies: Investigate the biological mechanisms through which microplastics affect male reproductive health. This could involve in vitro studies using human sperm cells exposed to different types and concentrations of microplastics, examining changes in gene expression, oxidative stress markers, and other relevant biomarkers.[21,22] Animal models could also be used to study the long-term effects of microplastic exposure on testicular development and function.[10,11]

Community-Based Participatory Research: Engage Hispanic communities along the border in the research process to ensure culturally appropriate data collection methods and address potential barriers to participation. This approach can improve the relevance and impact of research findings.[23]

Exposure Assessment: Develop robust methods for assessing microplastic exposure in this population, considering diverse exposure pathways (e.g., diet, water consumption, air inhalation) and accounting for potential differences in exposure based on occupation, lifestyle, and residential location.[24]

Synergistic Effects: Investigate the potential synergistic effects of microplastic exposure with other environmental pollutants commonly found in the region, such as heavy metals and pesticides, to better understand the cumulative impact on male reproductive health.[25-26]

Policy Implications: Translate research findings into actionable policy recommendations to reduce microplastic pollution, improve healthcare access, and promote reproductive health within Hispanic communities along the Texas-Mexico border.

Conclusion

The evidence suggests a potential link between microplastic exposure and male fertility decline. However, more research is needed to understand the specific impact on Hispanic populations along the Texas-Mexico border. This region's unique environmental and socio-economic context warrants targeted studies that consider the interplay of multiple factors influencing male reproductive health. By addressing the identified research gaps and employing a community-engaged approach, future investigations can provide critical information for developing effective public health interventions to protect the reproductive health of this vulnerable population. Furthermore, understanding the role of microplastics in this context can contribute to broader efforts to mitigate the global health impacts of plastic pollution. The potential for transgenerational effects of microplastic exposure also necessitates long-term monitoring and investigation to fully understand the long-term health consequences. The alarming decline in male fertility rates globally and the potential contribution of environmental factors such as microplastics underscores the urgent need for further research and targeted public health initiatives. The combination of environmental exposures and socio-economic factors in regions like the Texas-Mexico border highlights the need for a holistic approach to address male fertility decline, considering lifestyle modifications, environmental interventions, and healthcare access improvements. The potential for nutraceuticals to mitigate the negative impact of environmental factors on male fertility warrants further investigation as a potential supplementary approach. The study of delayed diagnosis of tuberculosis in the region also points to broader healthcare access issues that may affect the timely diagnosis and treatment of fertility problems related to microplastic exposure. The impact of economic uncertainty on male fertility further complicates the picture, highlighting the interplay of social and economic factors in reproductive health outcomes. Finally, the consideration of cultural practices and herbal product use within the Hispanic community is essential for developing culturally sensitive public health interventions.

Acknowledgements

Nori Zapata, MSN, RN, Senior Vice President of Education and Career Development, Vanessa Vera, MS, Senior Manager of High School and Community Outreach, Anisa Mirza, Intern Program Coordinator.

Funding:

Funded by DHR Health High School and Community Outreach; DHR Health; South Texas Independent School District.

References

1. Microplastics and Fertility | Exon Publications. Doi.org. Published 2024. Accessed January 21, 2025. https://doi.org/10.36255/microplastics-fertility

2. Landrigan PJ. Human Health and Ocean Pollution. *Annals of Global Health*. 2020;86(1):151. doi:https://doi.org/10.5334/aogh.2831

3. Landrigan PJ, Raps H, Cropper M, et al. The Minderoo-Monaco Commission on Plastics and Human Health. *Annals of Global Health*. 2023;89(1). doi:https://doi.org/10.5334/aogh.4056

4. Valentine Sampson Alia, Ed Wong Alvarado, Diaz EM, Reinhart H. FRI520 Disparities in Available Surgeons and Specialty Physicians Providing Endocrine-related Health Care Coverage to Populations in South Texas and the Rio Grande Valley. *Journal of the Endocrine Society*. 2023;7(Supplement_1). doi:https://doi.org/10.1210/jendso/bvad114.1865

5. Forero-Quintana A, Grineski SE. Delayed Diagnosis of Tuberculosis in the U.S.-Mexico Border Region: a Health Narratives Approach. *Research in the Sociology of Health Care*. Published online January 2012:45-65. doi:https://doi.org/10.1108/s0275-4959(2012)0000030005

6. Essigmann HT, Aguilar DA, Perkison WB, et al. Epidemiology of Antibiotic Use and Drivers of Cross-Border Procurement in a Mexican American Border Community. *Frontiers in Public Health*. 2022;10. doi:https://doi.org/10.3389/fpubh.2022.832266

7. De Sales-Ribeiro C, Brito-Casillas Y, Fernandez A, Caballero MJ. An End to the Controversy over the Microscopic Detection and Effects of Pristine Microplastics in Fish Organs. *Scientific Reports*. 2020;10(1). doi:https://doi.org/10.1038/s41598-020-69062-3

8. Chelin Jamie Hu, Garcia MA, Nihart A, et al. Microplastic Presence in Dog and Human Testis and Its Potential Association with Sperm Count and Weights of Testis and

Epididymis. *Toxicological Sciences*. 2024;200(2). doi:https://doi.org/10.1093/toxsci/kfae060

9. L Weina, H Yena, Liang H, Huan Z, Gang L, Ge L. P-762 Discovery and Quantification of Microplastics in Human Cumulus Granulosa Cells. *Human Reproduction*. 2024;39(Supplement_1). doi:https://doi.org/10.1093/humrep/deae108.1081

10. DiBona ER, Haley C, Geist SJ, Seemann F. Developmental Polyethylene Microplastic Fiber Exposure Entails Subtle Reproductive Impacts in Juvenile Japanese Medaka (*Oryzias latipes*). *Environmental Toxicology and Chemistry*. 2022;41(11):2848-2858. doi:https://doi.org/10.1002/etc.5456

11. Sun Z, Wu B, Yi J, et al. Impacts of Environmental Concentrations of Nanoplastics on Zebrafish Neurobehavior and Reproductive Toxicity. *Toxics*. 2024;12(8):617-617. doi:https://doi.org/10.3390/toxics12080617

12. Simran Kauts, Mishra Y, Singh MP. Impact of Polyethylene Terephthalate Microplastics on Drosophila Melanogaster Biological Profiles and Heat Shock Protein Levels. *Biology*. 2024;13(5):293-293. doi:https://doi.org/10.3390/biology13050293

13. Cai T, Boeri L, Miacola C, et al. Can Nutraceuticals Counteract the Detrimental Effects of the Environment on Male fertility? a Parallel Systematic Review and Expert Opinion. *Minerva Endocrinology*. Published online September 2024. doi:https://doi.org/10.23736/s2724-6507.24.04218-0

14. Mohajer N, Culty M. Impact of Human-Relevant Doses of Endocrine Disrupting Chemical and Drug Mixtures on Testis Development and function. *Reproduction*. Published online October 1, 2024. doi:https://doi.org/10.1530/rep-24-0155

15. Dávila GH. Joint Air Pollution Sampling Program in Twin Cities on the U.S.-Mexico border. *PubMed*. 1976;10(3):241-246.

16. Pinakana SD, Mendez E, Ibrahim I, Majumder MS, Raysoni AU. Air Pollution in South Texas: a Short Communication of Health Risks and Implications. *Air*. 2023;1(2):94-103. doi:https://doi.org/10.3390/air1020008

17. Levario MA. *Fevered Measures: Public Health and Race at the Texas-Mexico Border, 1848–1942* by John McKiernan-González (review). *Southwestern Historical Quarterly*. 2013;117(1):100-101. doi:https://doi.org/10.1353/swh.2013.0067

18. Kerna NA. An Overview of the Causes and Consequences of Male Fertility Decline. *Perceptions in Reproductive Medicine*. 2019;3(1). doi:https://doi.org/10.31031/prm.2019.02.000555

19. Skakkebaek NE, Rajpert-De Meyts E, Buck Louis GM, et al. Male Reproductive Disorders and Fertility Trends: Influences of Environment and Genetic Susceptibility. *Physiological Reviews*. 2016;96(1):55-97. doi:https://doi.org/10.1152/physrev.00017.2015

20. Damilare Rotimi, Shio Kumar Singh. Implications of Lifestyle Factors on Male Reproductive Health. *JBRA*. Published online January 1, 2024. doi:https://doi.org/10.5935/1518-0557.20240007

21. Henriques MC, Santiago J, Patrício A, Herdeiro MT, Loureiro S, Fardilha M. Smoking Induces a Decline in Semen Quality and the Activation of Stress Response Pathways in Sperm. *Antioxidants*. 2023;12(10):1828. doi:https://doi.org/10.3390/antiox12101828

22. Santiago J, Silva JV, Santos MAS, Fardilha M. The Ageing sperm: Molecular Mechanisms Underlying the age-associated Decline in Human Sperm Quality. *Human Reproduction*. 2022;37(Supplement_1). doi:https://doi.org/10.1093/humrep/deac107.110

23. Parker A, Johnson-Motoyama M, Mariscal ES, Guilamo-Ramos V, Reynoso E, Fernandez C. Novel Service Delivery Approach to Address Reproductive Health Disparities within Immigrant Latino Communities in Geographic Hot Spots: an Implementation Study. *Health and Social Work*. 2020;45(3). doi:https://doi.org/10.1093/hsw/hlaa014

24. Metzger R, Delgado J, Herrell R. Environmental Health and Hispanic children. *Environmental Health Perspectives*. 1995;103(suppl 6):25-32. doi:https://doi.org/10.1289/ehp.95103s625

25. Montano L, Maugeri A, Volpe MG, et al. Mediterranean Diet as a Shield against Male Infertility and Cancer Risk Induced by Environmental Pollutants: a Focus on Flavonoids. *International Journal of Molecular Sciences*. 2022;23(3):1568. doi:https://doi.org/10.3390/ijms23031568

26. Wirth JJ, Mijal RS. Adverse Effects of Low Level Heavy Metal Exposure on Male Reproductive Function. *Systems Biology in Reproductive Medicine*. 2010;56(2):147-167. doi:https://doi.org/10.3109/19396360903582216

27. Hunt KN, Kelly AG, Faubion L, et al. Fertility Knowledge and Educational Experiences of Graduating Medical Students: a Multi-Institution Survey. *Journal of women's health*. 2024;33(8). doi:https://doi.org/10.1089/jwh.2023.1016

28. F Farlie. O-174 Marginal gains: Can Small Actions in the ART Lab Improve the Environmental Impact of Medically Assisted reproduction? *Human Reproduction*. 2024;39(Supplement_1). doi:https://doi.org/10.1093/humrep/deae108.203

29. Strazzullo M, Matarazzo MR. Epigenetic Effects of Environmental Chemicals on Reproductive Biology. *Current Drug Targets*. 2017;18(10). doi:https://doi.org/10.2174/1389450117666161025100125

30. Aitken J. The Decline and Fall of Human Fertility. *Fertility & Reproduction*. 2023;05(04):230-230. doi:https://doi.org/10.1142/s2661318223740444

31. Tennenbaum SR, Bortner R, Lynch C, et al. Epigenetic Changes to Gene Pathways Linked to Male Fertility in Ex Situ Black-footed Ferrets. *Evolutionary Applications*. 2024;17(1). doi:https://doi.org/10.1111/eva.13634

32. Nahata L, Stanek CJ, Theroux CI, Olsavsky AL, Quinn GP, Creary SE. Fertility Testing Knowledge and Attitudes in Male Adolescents and Young Adults with SCD and Their caregivers: a Pilot Study. *Blood Advances*. 2022;6(12):3703-3706. doi:https://doi.org/10.1182/bloodadvances.2022007004

33. Hellstrand J, Nisén J, Myrskylä M. Economic Uncertainty and Men's fertility: Analysing the 2010s Fertility Decline in Finland by Field of Education and Employment Characteristics. *Max Planck Institute for Demographic Research*. Published online January 2025. doi:https://doi.org/10.4054/mpidr-wp-2025-001

34. Rivera JO, González-Stuart A, Ortiz M, Rodríguez JC, Anaya JP, Meza A. Guide for Herbal Product Use by Mexican Americans in the Largest Texas-Mexico Border community. *PubMed*. 2006;102(2):46-56.