Caring: Indonesian Journal of Nursing Science
Journal homepage: https://talenta.usu.ac.id/IJNS

Mitigation of Environmental Exposure, Pollutants, and Endocrine Disruptors to Reproductive Health: A Literature Review

Nur Afi Darti[1], Open Darnius[2], Diah Lestari Nasution[1], Evi Indriani br. Karo[1]
[1]*Department of Maternal-Child Nursing, Faculty of Nursing, Universitas Sumatera Utara, Medan, Indonesia*
[2] *Faculty of Vocational, Universitas Sumatera Utara, Medan, Indonesia*
Corresponding author: nur.afi.darti@usu.ac.id

ARTICLE INFO
Article history:
Received 18 February 2025
Revised 12 June 2025
Accepted 23 June 2025
Available online
https://talenta.usu.ac.id/IJNS

E-ISSN: 2685-7162

How to cite: Darti, A.N., Darnius, O., Nasution, D.L., Indriani br Karo, E. (2025). Mitigation of environmental exposure, pollutants, and endocrine disruptors to reproductive health: a literature review. *Caring: Indonesian Journal of Nursing Science*, 7(1), 25-36.

https://doi.org/10.32734/ijns.v7i1.20009

ABSTRACT
Women's reproductive health faces escalating threats from environmental pollutants, including airborne particulate matter (PM2.5 and PM10), endocrine-disrupting chemicals (EDCs), heavy metals, and microplastics. These pervasive agents, found in air, food, water, and consumer products, are associated with hormonal imbalances, menstrual irregularities, infertility, adverse pregnancy outcomes, and long-term reproductive dysfunction. This literature review synthesizes current evidence on environmental exposures, specifically focusing on pollutants and EDCs impacting reproductive health. Adhering to the PRISMA framework, articles published between 2020 and 2024 were systematically identified from databases such as PubMed, ScienceDirect, and Google Scholar. Manual selection based on predefined inclusion criteria ensured the relevance and recency of included studies. Findings consistently demonstrate that air pollutants (PM2.5 and PM10) correlate with reduced ovarian reserve and altered estradiol levels. EDCs, such as Bisphenol A (BPA) and phthalates, are linked to early puberty, endometriosis, and infertility. Heavy metals influence age at menarche and menopause, as well as critical pregnancy outcomes like birth weight. Furthermore, microplastics and nanoplastics have been shown to impair placental function and elevate oxidative stress. These cumulative findings underscore the urgent need for comprehensive risk mitigation strategies, encompassing environmental education, behavioral modifications, clinical screening, and policy reform. Nurses are uniquely positioned to play a critical role in promoting reproductive health through education, early detection of environmental risks, and advocacy for safer community environments.

Keyword: Endocrine Disruptors Chemicals, Environmental, Health, Pollutants, Reproductive

1. Introduction

Reproductive health plays a vital role in safeguarding the overall quality of life for both individuals and communities. With growing global concerns regarding reproductive disorders, attention has increasingly turned to environmental influences, particularly pollutants and endocrine-disrupting chemicals (EDCs). These harmful substances, commonly found in air, water, soil, and everyday consumer products, can interfere with the body's hormonal systems, adversely affecting fertility, pregnancy outcomes, and reproductive functionality (Bekkar et al., 2020; Ward et al., 2025; Zhang et al., 2023). The rise in industrial activities, urban development, and consumer product usage has amplified the risk of exposure to such environmental hazards. Evidence shows that toxic substances like heavy metals, pesticides, and volatile organic compounds can disrupt hormonal

balance, impair reproductive function, and elevate the risk of long-term health issues, including infertility and fetal developmental anomalies (Hong et al., 2024; Wan et al., 2024).

Recognizing the importance of reproductive health for future population well-being, early preventive measures must be prioritized, especially among women of reproductive age. This group is particularly susceptible due to the delicate development of the hypothalamic-pituitary-gonadal axis and the finite number of ovarian follicles. Women of reproductive age today bear significant responsibility for future maternal health, breastfeeding, and nurturing subsequent generations (Chung et al., 2020).

Environmental pollutants have been shown to alter hormonal equilibrium and interfere with the intricate physiological processes governing female reproduction (Yaqoob et al., 2023). EDCs mimic or block natural hormones, thereby disrupting the normal hormonal signaling pathways critical for reproductive health (Aborkhees et al., 2020). Notably, research has identified a significant association between elevated air pollutant levels, particularly heavy metals such as Pb, and a reduction in the number of mature oocytes in IVF patients ($p<0.05$) (Deng et al., 2024; Ren et al., 2024).

In addition to traditional pollutants, EDCs found in everyday items such as bisphenol A (BPA), phthalates, and microplastics pose significant health concerns. Women experience disproportionate exposure due to the frequent use of cosmetics and household products containing these substances. For instance, women with elevated BPA serum concentrations are 1.42 times more likely to develop endometriosis (95% CI: 1.10–1.84) (Interdonato et al., 2023). Moreover, the long-term consequences of EDC exposure may not only affect the exposed individual but also extend to future generations, influencing fetal and neonatal development (Kahn et al., 2020).

Exposure to heavy metals, including lead, cadmium, and thallium, has also been associated with shifts in the timing of menarche, earlier onset of menopause, and reduced reproductive lifespan (Huang et al., 2024). These metals can enter the body through various pathways, including food consumption, combustion of biomass fuels, plastic waste burning, and the use of certain cosmetics. These findings underscore the necessity of monitoring both occupational and household environments to mitigate exposure risks.

Fine particulate air pollutants, specifically PM2.5 and PM10, have been found to detrimentally affect reproductive parameters. One-year exposure to PM2.5 has been linked to a reduction in antral follicle count (AFC) by 1.8 follicles per cm^3 (95% CI: -2.4 to -1.2), while PM10 exposure has been associated with increased serum estradiol levels by 14.2 pg/mL ($p<0.01$) (Han et al., 2024). Additionally, emerging contaminants such as microplastics and nanoplastics have been implicated in placental dysfunction, ovarian atrophy, and up to a 30% increase in oxidative stress in animal studies ($p<0.01$), although human evidence remains limited (Wang et al., 2024). Female fertility is particularly at risk, as the finite number of germ cells from birth renders damage irreversible (Begum et al., 2022).

This literature-based review aims to examine the environmental origins and reproductive consequences of key toxic exposures, including air pollutants, EDCs, and heavy metals. It further seeks to present evidence-driven strategies for risk reduction, along with practical implications for nursing and reproductive health advocacy.

2. Methods

This study was conducted through a systematic literature review of electronic databases, including Google Scholar, ScienceDirect, and PubMed. The search strategy employed the keywords “reproductive health,” AND “environmental exposure,” AND “endocrine disruptors,” AND “women of reproductive age.” Data were synthesized from scientific articles, academic publications, and research reports from official national and international sources.

A thematic analysis was employed to examine the impact of exposure to air pollution, Endocrine Disrupting Chemicals (EDCs), heavy metals, microplastics, and nanoplastics on female reproductive health and to identify potential interventions. The inclusion criteria for selected articles were: publication in English between 2020 and 2024, open-access availability, and a focus on human subjects. The literature analysis followed the PRISMA guidelines, focusing on the sources and routes of exposure and their effects on reproductive health. Based on the findings, recommendations for risk mitigation, policy, and future research were formulated.

3. Results

The initial systematic literature search yielded 188 articles. After the removal of duplicates and due to other reasons, 135 records were screened based on their titles and abstracts, leading to the exclusion of 75 articles that did not meet the review's inclusion criteria. Subsequently, a full-text analysis of the remaining records was conducted, after which only 21 studies fully met the pre-defined inclusion criteria and were included in the literature review. Figure 1 provides a PRISMA flowchart that illustrates the number of studies at each stage of the screening and selection process.

All the articles selected for the final review were published in English. Data were extracted from the final articles, focusing on several key themes: the sources and pathways of exposure to environmental contaminants (specifically air pollution, endocrine-disrupting chemicals, heavy metals, microplastics, and nanoplastics) and their impacts on reproductive health, including effects on reproductive function, pregnancy outcomes, fetal development, pubertal timing, and abnormalities of the reproductive organs. A summary of the included studies is provided in Table 1.

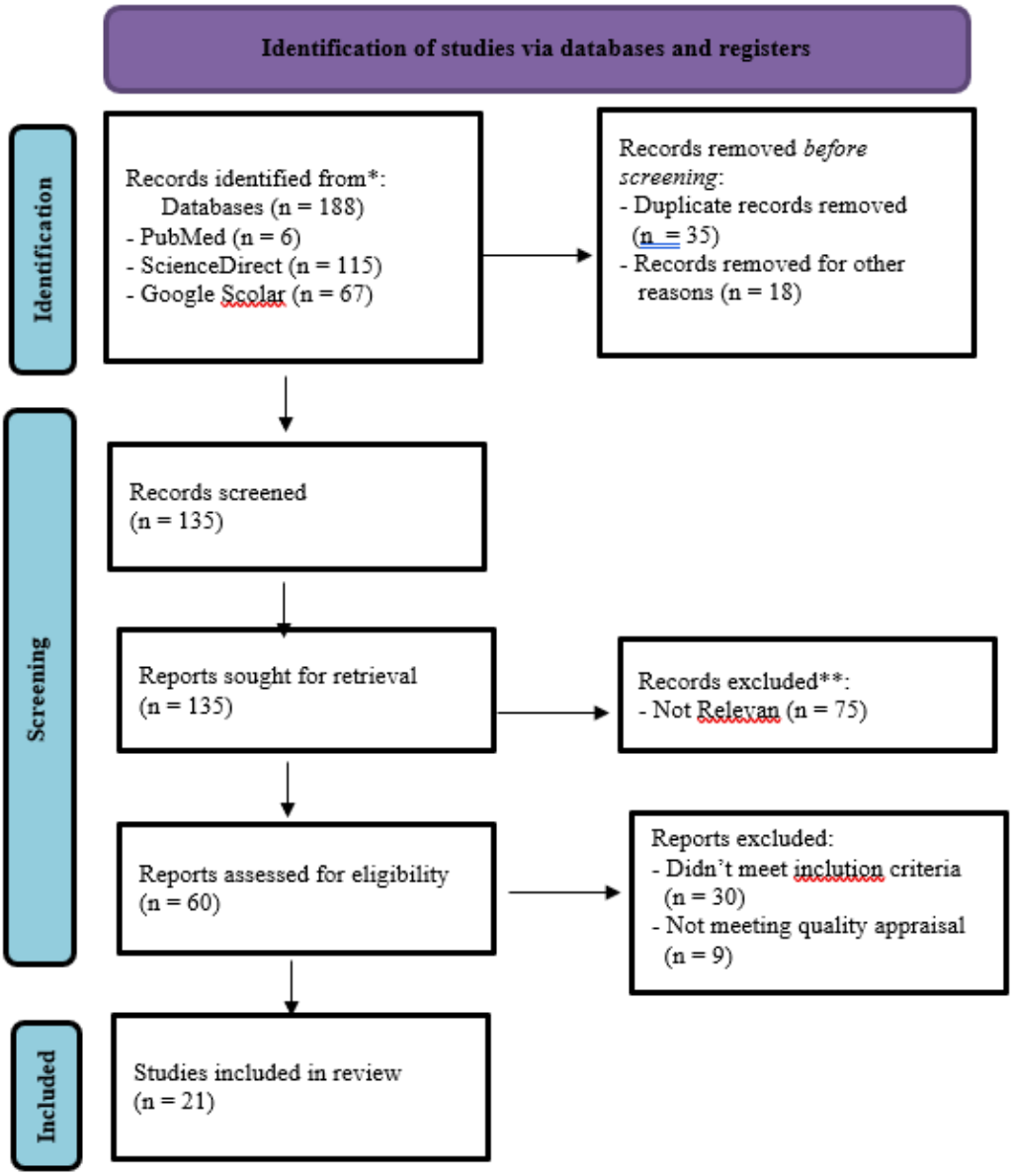

Figure 1 Source: PRISMA 2020 flowchart for systematic observation

3.1. *Air pollution*

Exposure to fine particulate matter, specifically PM2.5 and PM10, is consistently associated with adverse reproductive outcomes in women. For instance, one-year exposure to PM2.5 may reduce the antral follicle count (AFC) by 1.8 follicles per cm^3 (Han et al., 2024), while exposure to PM10 can increase serum estradiol

levels, thereby disrupting hormonal balance and impairing fertility. These pollutants act as indirect endocrine disruptors, contributing to inflammation and oxidative stress that interfere with reproductive health. Vulnerable populations, such as women with a higher Body Mass Index (BMI) or those of advanced reproductive age, are more susceptible to these effects (Han et al., 2024).

Moreover, air pollution is linked to a range of adverse pregnancy outcomes, including preterm birth, intrauterine growth restriction (IUGR), and low birth weight (Yaqoob et al., 2023). It can disrupt endocrine function by elevating estradiol levels, which may lead to menstrual irregularities, Polycystic Ovary Syndrome (PCOS), high-risk pregnancies, and an increased risk of breast cancer (Kim, 2024).

Given that over 99% of the global population is exposed to pollution levels exceeding World Health Organization (WHO) thresholds (Zupo et al., 2024), the implementation of comprehensive air quality regulations and public health education is imperative. Nurses are well-positioned to play a crucial role as advocates and educators, particularly in urban and industrial regions. They can raise awareness about the impacts of air quality and promote the early detection of pollution-related reproductive health issues.

3.2. *Endocrine disrupting chemicals (EDCs)*

Endocrine Disrupting Chemicals (EDCs) are environmental substances that interfere with hormone action and are found in air, water, soil, food, and various consumer products. Common EDCs include bisphenol A (BPA), phthalates, parabens, pesticides, and polychlorinated biphenyls (PCBs) (Asori et al., 2022). These chemicals can mimic or block hormonal pathways and have been linked to a range of reproductive health issues, including infertility, miscarriage, Polycystic Ovary Syndrome (PCOS), endometriosis, gestational disorders, and developmental abnormalities (Hassan et al., 2024).

Bisphenol A (BPA), a compound widely used in the production of plastics and resins, is known to disrupt estrogenic pathways. This disruption can adversely affect ovarian reserve, menstrual cycles, and embryo implantation, while also increasing the risks of early puberty and miscarriage (Salami & Rotimi, 2024; Interdonato et al., 2023). Similarly, phthalates, which are prevalent in personal care products and medical devices, have been shown to reduce fertility, increase the risk of miscarriage, and impair oocyte quality. Notably, cumulative exposure to phthalates is particularly high among women who experience recurrent pregnancy loss (Chang et al., 2021).

Due to their widespread presence in everyday products and dietary sources, exposure to EDCs is largely unavoidable. These substances exert their effects primarily through mechanisms of oxidative stress and hormonal disruption, impacting the pituitary gland, ovaries, and uterus (Ao et al., 2024). The combined exposure to multiple EDCs often exacerbates their individual effects. In a clinical context, nurses can play a crucial role in mitigating these risks by providing lifestyle counseling, promoting the use of safer products, and leading environmental health literacy campaigns. Evidence suggests that nurse-led interventions can significantly reduce the body's burden of EDCs (Kim et al., 2021).

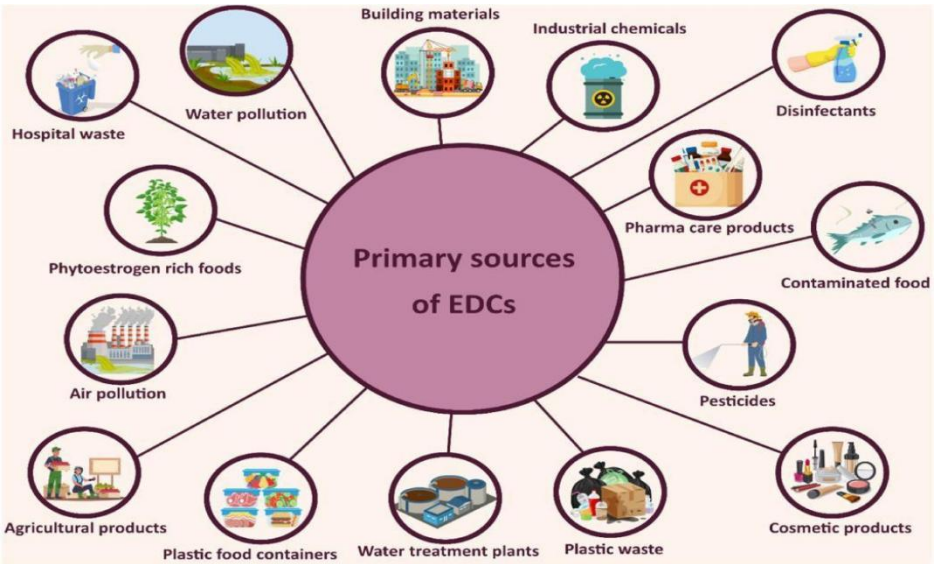

Figure 2 Primary sources of EDCs (Hassan et al., 2024)

3.3. *Heavy metals*

Heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), and chromium (Cr) pose serious threats to reproductive health. These metals are absorbed through contaminated food, air, water, and consumer products. Prenatal exposure to heavy metals correlates with low birth weight, shorter birth length, infertility, dysmenorrhea, and hormonal imbalance (Michael et al., 2022; Fang et al., 2024). According to Kim (2024), these metals are readily absorbed in women and can be transferred to fetuses through the placenta or to infants via breast milk, necessitating early nursing interventions and maternal health protection strategies.

Heavy metals can disrupt hormone synthesis, cross the placental barrier, and cause fetal developmental impairments. Cadmium and lead are especially toxic, linked to spontaneous abortion, menstrual disorders, and Polycystic Ovary Syndrome (PCOS) (Eddie-Amadi et al., 2022). Chronic exposure often occurs in proximity to landfills and mining areas or through the use of cosmetics and personal care products.

Titanium dioxide (TiO2), used in products such as sunscreens and toothpaste, has been associated with low birth weight when blood levels are elevated during early pregnancy (Jin et al., 2021). Because heavy metals are bioaccumulative, public health interventions must include dietary guidelines, occupational safety protocols, and rigorous waste management policies. Nurses play a critical role in supporting exposure assessment and educating women on dietary and environmental risks.

Educational campaigns aimed at reducing exposure from food, water, cosmetics, and workplace or mining environments are crucial, particularly for pregnant women (Haidar et al., 2023). Environmental pollutants and stress triggers can negatively impact ovulation, resulting in various reproductive complications. Cadmium, for example, has a long biological half-life of 10–30 years. Its absorption is exacerbated by iron deficiency—a common condition among menstruating women—which further increases cadmium accumulation in women of reproductive age (Begum et al., 2022).

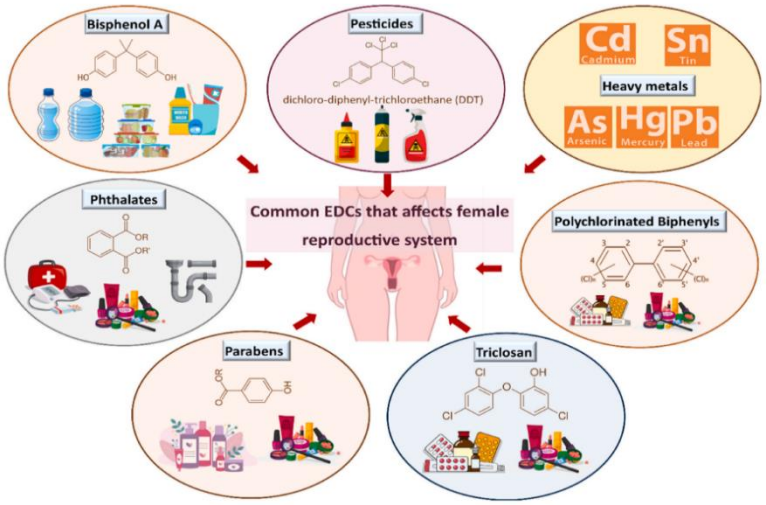

Figure 3 Common EDCs that affect the female reproductive system (Hassan et al., 2024)

3.4. *Microplastics and nanoplastics*

Microplastics (MPs) and nanoplastics (NPs) are emerging contaminants found in food, water, air, and consumer goods. Although not endocrine disruptors by definition, they can act as carriers for endocrine-disrupting chemicals such as BPA, phthalates, and heavy metals, thereby enhancing toxicity (Lee et al., 2023; Lei et.al., 2024). MPs have been detected in reproductive tissues and placentas, indicating systemic exposure (Ye et al., 2024). Kim (2024) emphasized that women of reproductive age and pregnant women are highly susceptible to the harmful effects of these substances, which may penetrate the placental barrier and affect fetal development.

Animal models demonstrate that MPs elevate oxidative stress, damage ovarian tissue, and disrupt placental function. Furthermore, MPs may trigger endometrial inflammation and hormonal imbalances, potentially leading to infertility, early miscarriage, or endometriosis (Wang et al., 2024). Common sources of these plastics include personal care products, packaging, and textile fibers. Therefore, public health actions must target the reduction of single-use plastics and the enhancement of detection technologies. Nurses are

well-positioned to promote behavioral changes, such as reducing the use of plastics, avoiding food packaged in plastic, and advocating for antioxidant-rich diets to counteract oxidative damage.

Taken together, these findings highlight the multifaceted impacts of environmental pollutants on women's reproductive health. The key points are summarized in Table 1.

Table 1 Summary endocrine disruptors; Sources, and the effect on reproductive health

Authors	Endocrine disruptors	Sources	The effect on reproductive health
(Asori et al., 2022) (Chung et al., 2020) (Hassan et al., 2024) (Hong et al., 2024) (Interdonato et al., 2023) (Lakra et al., 2022) (Salami & Rotimi, 2024) (Yaqoob et al., 2023) (Zhan et al., 2022)	Bisphenol A (BPA)	Found in food containers, plastic bottles, canned goods, thermal receipts, dental materials, epoxy resins, polycarbonate plastics, and flame retardants. Used in plastics, rubber, food and beverage containers, epoxy resins, baby bottles, and medical devices. Routine exposure; Ingestion, inhalation, dermal contact, and maternal transmission via the placenta and breast milk.	Causes hormonal imbalances by altering estradiol, Luteinizing Hormone (LH), and Follicle-Stimulating Hormone (FSH) levels, leading to altered menstrual cycles and early puberty. Reduces ovarian follicle count, the number of mature oocytes, and fertilization rates. Induces oxidative stress, causes epigenetic modifications, and interferes with steroidogenesis. Associated with endometrial dysfunction, embryo implantation failure, polycystic ovary syndrome (PCOS), fibroids, endometriosis, and infertility. Increases the risk of miscarriage, low birth weight, and fetal growth restriction due to placental dysfunction. Linked to transgenerational reproductive effects following persistent exposure.
(Asori et al., 2022) (Begum et al., 2022) (Chang et al., 2021) (Chung et al., 2020) (Eddie-Amadi et al., 2022) (Hassan et al., 2024) (Interdonato et al., 2023) (Ribeiro et al., 2024) (Yin et al., 2024) (Zhan et al., 2022)	Phthalates	Present in plastics (PVC), food packaging, toys, flooring, cosmetics, perfumes, shampoos, soaps, medical devices. Found in air, dust, personal care products, household goods.	Associated with PCOS, endometriosis, and variations in the timing of puberty (early or delayed). Causes oxidative stress, reduces oocyte quality, decreases fertility, and disrupts hormonal function. Impairs embryo development and is linked to an increased risk of miscarriage, recurrent pregnancy loss, and fetotoxicity.
(Asori et al., 2022) (Chung et al., 2020) (Hassan et al., 2024)	Parabens	Found in cosmetics, shampoos, lotions, makeup, processed foods, pharmaceuticals.	Linked to shorter and altered estrous and menstrual cycles. Disrupts steroidogenesis and alters the morphology of reproductive tissues. Associated with reduced fertility, altered gestation length, and changes in pubertal development.
(Dong et al., 2024) (Lee et al., 2023) (Lei, et al., 2024)	Microplastics	Primary sources: Manufactured microbeads in personal care products (e.g., toothpaste, scrubs) Breakdown of plastic waste in air, soil, water. Consumer products,	Studies have detected MPs in female reproductive tissues (e.g., adenomyosis, ovarian ectopic cysts, uterine tubes), with potential effects including: Disruption of reproductive tissue integrity. Decreased fertility and impaired intrauterine conditions.

Table 1 Continue

Authors	Endocrine disruptors	Sources	The effect on reproductive health
		such as synthetic textiles, packaging, and disposable items Detected in air, food, and water, and found in marine organisms, leading to human ingestion through the food chain. Surgical procedures and inhalation are also possible exposure routes. Pathways of exposure: Inhalation, ingestion, dermal contact.	Acting as vectors for toxic chemicals, leading to hormonal imbalance and endometrial inflammation. Association with sperm damage, placental contamination, and endometrial dysfunction. Observation of transgenerational effects in some studies.
(Begum et al., 2022) (Eddie-Amadi et al., 2022) (Fang et al., 2024) (Hassan et al., 2024) (Jin et al., 2021) (Michael et al., 2022) (Yaqoob et al., 2023)	Heavy Metals (Pb, Cd, Hg, As, Cr, Ti, etc.)	Sources include industrial pollution, contaminated water, seafood, tobacco smoke, batteries. Food products. Personal care products (e.g., sunscreens, cosmetics). Paints, plastics, and surface coatings. Exposure routes: oral ingestion, inhalation, dermal absorption	Associated with early menarche, delayed menopause, and infertility. High maternal blood titanium (Ti) levels, particularly in early pregnancy, are significantly associated with an increased risk of low birth weight (LBW) in infants.
(Han et al., 2024)	Ambient Air Pollutants (PM2.5, PM10, NO2, etc.)	Emissions from vehicles, industrial processes, domestic fuel use.	Reduce oocyte quality and diminish ovarian reserve. Linked to impaired folliculogenesis. Associated with adverse pregnancy outcomes, including miscarriage, preterm birth, and stillbirth.

4. Discussion

The recent literature has identified a number of reproductive health effects associated with various environmental pollutants. Exposure to these pollutants, particularly Endocrine Disrupting Chemicals (EDCs), demonstrates a strong association with reproductive health disorders in women.

Among all pollutants analyzed, Bisphenol A (BPA) ranks highest in both the frequency and complexity of its effects on the reproductive system. These effects include hormonal disruptions involving estradiol, Luteinizing Hormone (LH), and Follicle-Stimulating Hormone (FSH), reduced ovarian follicle counts, and impaired embryo implantation. Furthermore, BPA exposure is linked to increased risks of infertility and pregnancy complications (Asori et al., 2022; Hong et al., 2024). BPA acts through mechanisms that mimic estrogen, which can either stimulate or inhibit natural endocrine activity, thereby systemically affecting female reproductive pathways (Rochester, 2013).

Phthalates, commonly found in household products and cosmetics, are also associated with a range of disorders, such as polycystic ovary syndrome (PCOS), pubertal abnormalities, miscarriage, and poor embryo quality (Begum et al., 2022); Ribeiro et al., 2024). The primary mechanisms of phthalate-induced toxicity involve oxidative stress and the disruption of steroidogenesis, both of which contribute to diminished ovarian reserve and impaired embryonic development (Wang & Qian, 2021).

Although reported less frequently than BPA and phthalates, parabens still exhibit significant effects,

including altered menstrual cycles, disrupted puberty, and reduced fertility (Hassan et al., 2024); (Chung et al., 2020). Long-term exposure to parabens has been linked to histological alterations in reproductive tissues, particularly in in vivo studies.

Microplastics have emerged as a contemporary threat of increasing concern. Beyond their role as carriers of toxic chemicals, microplastics have been directly detected in female reproductive tissues, including the uterus and ovaries (Dong et al., 2024; Lei et al., 2024). Recent studies suggest that microplastics may compromise endometrial tissue integrity, reduce fertility, and trigger inflammatory responses that interfere with pregnancy (Ye et al., 2024).

Exposure to heavy metals (e.g., lead [Pb], cadmium [Cd], mercury [Hg], and titanium [Ti]) also has substantial impacts on female fertility. These metals are known to cause hormonal imbalances, reduce oocyte quality, and increase the risk of low birth weight infants (Han et al., 2024). Due to their bioaccumulative nature and environmental persistence, heavy metals pose a long-term threat to reproductive health, particularly in communities located near landfills and industrial zones (Tchounwou et al., 2012).

Finally, ambient air pollutants such as fine particulate matter (PM_2.5) and nitrogen dioxide (NO_2) have been linked to decreased oocyte quality, miscarriage, and preterm birth (Lee et al., 2023). Chronic exposure to air pollution may impair folliculogenesis and reduce ovarian reserve through mechanisms involving oxidative stress and systemic inflammation (Mahalingaiah et al., 2016).

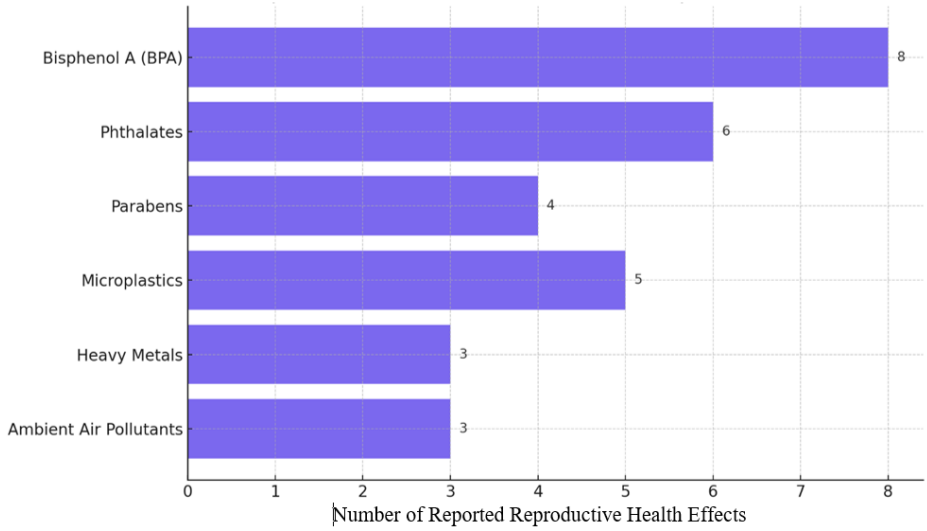

Figure 4 The number of reproductive health effects

Overall, the observed patterns indicate that most pollutants exert their effects through synergistic mechanisms involving hormonal disruption, oxidative stress, and inflammation, ultimately diminishing female reproductive function. Consequently, effective mitigation strategies for environmental exposure must adopt a multidisciplinary approach encompassing chemical regulation, public education, and the development of community-based monitoring technologies.

5. Conclusion

Environmental exposure to a range of pollutants—including fine particulate matter (PM2.5 and PM10), endocrine disruptors (e.g., bisphenol A, phthalates, and dioxins), heavy metals, and microplastics—is known to significantly impair reproductive health. Specifically, exposure to PM2.5 and PM10 has been associated with a reduced antral follicle count (AFC) and hormonal disruptions affecting the menstrual cycle and fertility in women. Furthermore, endocrine disruptors such as BPA are linked to an increased risk of endometriosis and infertility via hormonal imbalances. Heavy metals have also been shown to affect the age of menarche and the overall reproductive lifespan, underscoring the critical need to control sources of these environmental contaminants.

Strategic measures are essential to mitigate risks to reproductive health from environmental pollutants. These include stricter regulations on endocrine disruptors, enhanced public education, and the development of collaborative research. Furthermore, evidence-based approaches must be integrated into policies to protect

vulnerable populations, such as women of reproductive age and pregnant women. Given the rise in environmental exposures, a concerted effort among scientists, policymakers, and the community is crucial for developing effective prevention and mitigation strategies to safeguard the reproductive health of current and future generations.

Nurses, as frontline healthcare providers and advocates, are instrumental in both mitigating exposure risks and promoting reproductive health through education, early intervention, and policy engagement. Continued research, cross-sector collaboration, and public health innovation are essential to safeguard reproductive health for current and future generations, ensuring that environmental factors are systematically addressed within the broader context of women's health care.

6. Recommendations for Risk Mitigation

Mitigating the reproductive health risks posed by environmental pollution requires a synergistic approach that involves policy enforcement, public education, individual behavioral change, and integration into health service systems. The health impacts of air pollution extend beyond the individual, creating substantial economic and public health burdens, such as increased healthcare costs associated with infertility and other reproductive disorders. Therefore, stricter enforcement of air quality regulations, including adherence to World Health Organization (WHO) pollution thresholds, is imperative. Practical mitigation strategies, such as urban greening, improved public transportation, and traffic control, can also contribute significantly to reducing exposure to airborne pollutants.

Evidence regarding heavy metal exposure highlights the urgent need for robust controls over key sources, including industrial waste, contaminated seafood, and polluted groundwater. Prioritizing improved waste management practices and strengthening food safety standards are essential steps. Furthermore, the implementation of biomarker monitoring for heavy metals should be encouraged to enable the early detection and prevention of long-term reproductive complications.

The widespread environmental threat posed by microplastics and nanoplastics demands a coordinated global policy response. While several countries have introduced bans on single-use plastics, there remains a pressing need to expand technologies for detecting and managing plastic pollution. At the community level, public campaigns promoting reduced plastic consumption and proper waste segregation are critical for minimizing exposure and protecting reproductive health.

7. Implication for Nursing

Based on the findings of this review, mitigating the risks associated with environmental pollutants—such as air pollution, endocrine-disrupting chemicals (EDCs), heavy metals, and microplastics—is essential to safeguard women's reproductive health. Risk mitigation should involve multi-level strategies, from individual behavioral changes to community education and policy advocacy, with nurses playing a strategic role in implementing health and environmental interventions.

At the individual and household levels, raising awareness among women of reproductive age, particularly pregnant women, about sources of environmental exposure in daily life is a crucial first step. Educational efforts should emphasize the importance of avoiding plastic-packaged foods, limiting the use of personal care products containing BPA, parabens, or microplastics, and choosing locally sourced organic food when available. Furthermore, improving indoor air quality through proper ventilation and the use of basic air filtration systems is highly recommended.

Community and institution-based interventions are equally important. Health education programs tailored to vulnerable groups, such as pregnant women, industrial workers, and residents living near waste disposal sites, should be developed and widely implemented. Nursing organizations and educational institutions are encouraged to integrate environmental and reproductive health issues into their curricula and community health practices.

In clinical nursing practice, environmental risk assessments should be incorporated into routine reproductive health evaluations. Nurses must be equipped to identify environmental risk factors during health promotion and disease prevention activities. Moreover, nurses can serve as change agents by advocating for environmentally friendly behaviors within the community and delivering evidence-based counseling on exposure reduction and reproductive health protection.

Through multi-sectoral collaboration and the active involvement of nursing professionals in education, advocacy, and environmentally sensitive care, the protection of women's reproductive health from increasing environmental pollution can be significantly enhanced.

References

Aborkhees, G., Raina-Fulton, R., & Thirunavokkarasu, O. (2020). Determination of Endocrine Disrupting Chemicals in Water and Wastewater Samples by Liquid Chromatography-Negative Ion Electrospray Ionization-Tandem Mass Spectrometry. Molecules, 25(17), 1–15. https://doi.org/10.3390/molecules25173906

Ao, J., Zhu, W., Jiang, W., Zeng, X., Qiu, W., Yin, S., Wang, W., & Zhang, J. (2024). The mixture of non-persistent endocrine-disrupting chemicals in relation to endometriosis. Ecotoxicology and Environmental Safety, 286(September), 117129. https://doi.org/10.1016/j.ecoenv.2024.117129

Asori, M., Odei, J., Katey, D., Abuosi, T. A., & ... (2022). Impacts of endocrine disruptors on reproductive health in the era of increased personal care and beauty products usage. Bulletin of the National …, Query date: 2025-05-01 11:23:39. https://doi.org/10.1186/s42269-022-00732-0

Balali-Mood, M., Naseri, K., Tahergorabi, Z., Khazdair, M. R., & Sadeghi, M. (2021). Toxic Mechanisms of Five Heavy Metals: Mercury, Lead, Chromium, Cadmium, and Arsenic. Frontiers in Pharmacology, 12(April), 1–19. https://doi.org/10.3389/fphar.2021.643972

Begum, M. R., Ehsan, M., & Ehsan, N. (2022). Impact of environmental pollution on female reproduction. Fertility &Reproduction, Query date: 2025-05-01 11:23:39. https://doi.org/10.1142/S266131822230001X

Bekkar, B., Pacheco, S., Basu, R., Basu, R., & Denicola, N. (2020). Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. JAMA Network Open, 3(6), 1–13. https://doi.org/10.1001/jamanetworkopen.2020.8243

Chang, W. H., Chou, W. C., Waits, A., Liao, K. W., Kuo, P. L., & Huang, P. C. (2021). Cumulative risk assessment of phthalates exposure for recurrent pregnancy loss in reproductive-aged women population using multiple hazard indices approaches. Environment International, 154, 106657. https://doi.org/10.1016/j.envint.2021.106657

Chung, C. W., Park, J., Song, J. E., & Park, S. M. (2020). Determinants of Protective Behaviors Against Endocrine Disruptors in Young Korean Women. Asian Nursing Research, 14(3), 165–172. https://doi.org/10.1016/j.anr.2020.07.002

Deng, L., Chen, G., Duan, T., Xie, J., Huang, G., Li, X., Huang, S., Zhang, J., Luo, Z., Liu, C., Zhu, S., He, G., Dong, X., Liu, T., Ma, W., Gong, Y., Shen, X., & Yang, P. (2024). Mixed effects of ambient air pollutants on oocyte-related outcomes: A novel insight from women undergoing assisted reproductive technology. Ecotoxicology and Environmental Safety, 280(May), 116525. https://doi.org/10.1016/j.ecoenv.2024.116525

Dong, C., Xu, H., Lin, Y., Zhang, B., Yu, Z., Xie, Y., Ma, D., & Yu, J. (2024). Microplastics detected in three types of female reproductive organs using micro-Raman spectroscopy. Ecotoxicology and Environmental Safety, 285(September), 117099. https://doi.org/10.1016/j.ecoenv.2024.117099

Eddie-Amadi, B. F., Dike, C. S., & ... (2022). Public {Health} {Concerns} of {Environmental} {Exposure} {Connected} with {Female} {Infertility}. IPS Journal of …, Query date: 2025-05-01 11:23:39. https://journals.ipsintelligentsia.com/public-health/index.php/ijph/article/view/1

Fang, H., Lin, D., Zhang, Z., Chen, H., Zheng, Z., Jiang, D., & Wang, W. (2024). Association of coexposure to perfluoroalkyl and polyfluoroalkyl compounds and heavy metals with pregnancy loss and reproductive lifespan: The mediating role of cholesterol. Ecotoxicology and Environmental Safety, 286(September), 117160. https://doi.org/10.1016/j.ecoenv.2024.117160

Haidar, Z., Fatema, K., Shoily, S. S., & Sajib, A. A. (2023). Disease-associated metabolic pathways affected by heavy metals and metalloid. Toxicology Reports, 10(March), 554–570. https://doi.org/10.1016/j.toxrep.2023.04.010

Han, Z., Liu, J., Liang, T., Yin, J., Wei, J., Zeng, Q., Cao, W., Liu, C., & Sun, S. (2024). Exposure to ambient particulate matter and ovarian reserve impairment among reproductive age women in China. Journal of Hazardous Materials, 480(August), 136212. https://doi.org/10.1016/j.jhazmat.2024.136212

Hassan, S., Thacharodi, A., Priya, A., Meenatchi, R., Hegde, T. A., R, T., Nguyen, H. T., & Pugazhendhi, A. (2024). Endocrine disruptors: Unravelling the link between chemical exposure and Women's reproductive health. Environmental Research, 241, 117385. https://doi.org/10.1016/j.envres.2023.117385

Hong, S., Kang, B. S., Kim, O., Won, S., Kim, H. S., Wie, J. H., Shin, J. E., Choi, S. K., Jo, Y. S., Kim, Y. H., Yang, M., Kang, H., Lee, D. W., Park, I. Y., Park, J. S., & Ko, H. S. (2024). The associations between maternal and fetal exposure to endocrine-disrupting chemicals and asymmetric fetal growth restriction:

a prospective cohort study. Frontiers in Public Health, 12(Query date: 2025-05-01 11:23:39). https://doi.org/10.3389/fpubh.2024.1351786

Huang, J., Zhang, Y., King, L., Wang, J., Nie, P., Xie, Q., Chen, H., Wan, X., Li, Z., Zhao, Y., & Xu, H. (2024). Associations of urinary heavy metals with age at menarche, age at menopause, and reproductive lifespan: A cross-sectional study in U.S. women. Ecotoxicology and Environmental Safety, 283(May). https://doi.org/10.1016/j.ecoenv.2024.116950

Interdonato, L., Siracusa, R., Fusco, R., Cuzzocrea, S., & Di Paola, R. (2023). Endocrine Disruptor Compounds in Environment: Focus on Women's Reproductive Health and Endometriosis. International Journal of Molecular Sciences, 24(6). https://doi.org/10.3390/ijms24065682

Jin, Y., Li, Z., An, H., Pang, Y., Li, K., Zhang, Y., Zhang, L., Yan, L., Wang, B., Ye, R., Li, Z., & Ren, A. (2021). Environmental titanium exposure and reproductive health: Risk of low birth weight associated with maternal titanium exposure from a nested case-control study in northern China. Ecotoxicology and Environmental Safety, 208(November 2020), 111632. https://doi.org/10.1016/j.ecoenv.2020.111632

Kahn, L. G., Philippat, C., Nakayama, S. F., Slama, R., & Trasande, L. (2020). Endocrine-disrupting chemicals: implications for human health. The Lancet Diabetes and Endocrinology, 8(8), 703–718. https://doi.org/10.1016/S2213-8587(20)30129-7

Kim, J. H. (2024). Environmental health and women's health nursing. Women's Health Nursing, 30(3), 175–177. https://doi.org/10.4069/whn.2024.08.20

Kim, J. H., Kwak, J. M., & Kang, H. (2021). Web-based behavioral intervention to reduce exposure to phthalate metabolites, bisphenol A, triclosan, and parabens in mothers with young children: A randomized controlled trial. International Journal of Hygiene and Environmental Health, 236(January), 113798. https://doi.org/10.1016/j.ijheh.2021.113798

Lakra, A. B., Ray, S., & Bhatia, T. (2022). Impact of endocrine disrupting chemicals on human reproductive system: a toxicological perspective. Nat Environ Pollut Technol, Query date: 2025-05-01 11:23:39. https://www.academia.edu/download/88513961/nept.2022.v21i01.pdf

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

Lei, J., Ma, Q., Ding, X., Pang, Y., Liu, Q., Wu, J., Zhang, H., & Zhang, T. (2024). Microplastic environmental behavior and health risk assessment: a review. Environmental Chemistry Letters, Query date: 2025-05-01 11:23:39. https://doi.org/10.1007/s10311-024-01771-x

Mahalingaiah, S., Hart, J. E., Laden, F., Farland, L. V., Hewlett, M. M., Chavarro, J., Aschengrau, A., & Missmer, S. A. (2016). Adult air pollution exposure and risk of infertility in the Nurses' Health Study II. Human Reproduction, 31(3), 638–647. https://doi.org/10.1093/humrep/dev330

Martin, L., Zhang, Y., First, O., Mustieles, V., Dodson, R., Rosa, G., Coburn-Sanderson, A., Adams, C. D., & Messerlian, C. (2022). Lifestyle interventions to reduce endocrine-disrupting phthalate and phenol exposures among reproductive age men and women: A review and future steps. Environment International, 170, 107576. https://doi.org/https://doi.org/10.1016/j.envint.2022.107576

Michael, T., Kohn, E., Daniel, S., Hazan, A., Berkovitch, M., Brik, A., Hochwald, O., Borenstein-Levin, L., Betser, M., Moskovich, M., Livne, A., Keidar, R., Rorman, E., Groisman, L., Weiner, Z., Rabin, A. M., Solt, I., & Levy, A. (2022). Prenatal exposure to heavy metal mixtures and anthropometric birth outcomes: a cross-sectional study. Environmental Health: A Global Access Science Source, 21(1), 1–15. https://doi.org/10.1186/s12940-022-00950-z

Musial, J., Krakowiak, R., Mlynarczyk, D. T., Goslinski, T., & Stanisz, B. J. (2020). Titanium dioxide nanoparticles in food and personal care products—what do we know about their safety? Nanomaterials, 10(6), 1–23. https://doi.org/10.3390/nano10061110

Pulcastro, H., & Ziv-Gal, A. (2024). Parabens effects on female reproductive health – Review of evidence from epidemiological and rodent-based studies. Reproductive Toxicology, 128, 108636. https://doi.org/https://doi.org/10.1016/j.reprotox.2024.108636

Ren, M., Fang, M., Liu, J., Lu, Q., Bao, H., Zhuang, L., Meng, F., Pan, B., Yan, L., Li, Z., Xu, J., Han, B., Bai, Z., Tian, C., Wang, Y., & Wang, B. (2024). Applying hair exposome for linking environmental exposure to reproductive health: A comprehensive review and research perspective. Hygiene and Environmental Health Advances, 9, 100086. https://doi.org/10.1016/j.heha.2023.100086

Ribeiro, B., Mariana, M., Lorigo, M., Oliani, D., & ... (2024). Association between the {Exposure} to {Phthalates} and the {Risk} of {Endometriosis}: {An} {Updated} {Review}. Biomedicines, Query date: 2025-05-01 11:23:39. https://www.mdpi.com/2227-9059/12/8/1932

Rochester, J. R. (2013). Bisphenol A and human health: a review of the literature. Reproductive Toxicology. https://www.sciencedirect.com/science/article/pii/S0890623813003456

Salami, E. A., & Rotimi, O. A. (2024). The impact of Bisphenol-A on human reproductive health. Toxicology Reports, 13, 101773. https://doi.org/10.1016/j.toxrep.2024.101773

Srnovršnik, T., Virant-Klun, I., & Pinter, B. (2023). Polycystic Ovary Syndrome and Endocrine Disruptors (Bisphenols, Parabens, and Triclosan)—A Systematic Review. Life, 13(1). https://doi.org/10.3390/life13010138

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Molecular, clinical and environmental toxicicology Volume 3: Environmental Toxicology. Molecular, Clinical and Environmental Toxicology, 101, 133–164. https://doi.org/10.1007/978-3-7643-8340-4

Wan, S., Wang, X., Chen, W., Xu, Z., Zhao, J., Huang, W., Wang, M., & Zhang, H. (2024). Polystyrene Nanoplastics Activate Autophagy and Suppress Trophoblast Cell Migration/Invasion and Migrasome Formation to Induce Miscarriage. ACS Nano, 18(4), 3733–3751. https://doi.org/10.1021/acsnano.3c11734

Wang, J., Zhao, C., Feng, J., Sun, P., Zhang, Y., & ... (2024). Advances in understanding the reproductive toxicity of endocrine-disrupting chemicals in women. Frontiers in Cell and …, Query date: 2025-05-01 11:23:39. https://doi.org/10.3389/fcell.2024.1390247

Wang, L., Wang, Q., Yao, Y., Zhou, J., Cai, X., Dai, T., Song, C., Li, Y., Li, F., Meng, T., Sheng, H., Guo, P., Zhang, Q., & Zhang, X. (2024). Critical windows for exposure to chemical composition of ambient particulate matter and human semen quality decline. Science of the Total Environment, 955, 176991. https://doi.org/10.1016/j.scitotenv.2024.176991

Wang, M., Wu, Y., Li, G., Xiong, Y., Zhang, Y., & Zhang, M. (2024). The hidden threat: Unraveling the impact of microplastics on reproductive health. Science of the Total Environment, 935(May), 173177. https://doi.org/10.1016/j.scitotenv.2024.173177

Wang, Y., & Qian, H. (2021). Phthalates and their impacts on human health. Healthcare (Switzerland), 9(5), 1–9. https://doi.org/10.3390/healthcare9050603

Ward, G., Correia Watts, M. P., & Hansson, S. R. (2025). The unintended consequences of modernity: Pollution and its effect on reproductive, maternal and fetal health. Pregnancy Hypertension, 40(April 2024), 101204. https://doi.org/10.1016/j.preghy.2025.101204

Yaqoob, A., Jeelani Mir, G., Khan, S., & Ahmad Dar, B. (2023). Effect of Environmental Contaminants on Female Reproductive Health: A Narrative Review. BME Horizon, 1(3), 0–0. https://doi.org/10.37155/2972-449x-vol1(3)-86

Ye, J., Ren, Y., Dong, Y., & Fan, D. (2024). Understanding the impact of nanoplastics on reproductive health: Exposure pathways, mechanisms, and implications. Toxicology, 504(February), 153792. https://doi.org/10.1016/j.tox.2024.153792

Yin, A., Mao, L., Zhang, C., Du, B., Xiong, X., Chen, A., Cheng, L., Zhang, Z., Li, X., Zhou, Y., & Jiang, H. (2024). Phthalate exposure and subfecundity in preconception couples: A nested case-control study. Ecotoxicology and Environmental Safety, 278(May), 116428. https://doi.org/10.1016/j.ecoenv.2024.116428

Zhan, W., Yang, H., Zhang, J., & Chen, Q. (2022). Association between co-exposure to phenols and phthalates mixture and infertility risk in women. Environmental Research, 215(P1), 114244. https://doi.org/10.1016/j.envres.2022.114244

Zhang, W., Cui, Y., & Liu, J. (2023). The association between aldehydes exposure and female infertility: {A} cross-sectional study from {NHANES}. Medicine, Query date: 2025-05-01 11:23:39. https://journals.lww.com/md-journal/fulltext/2023/06230/the_association_between_aldehydes_exposure_and.43.aspx

Zupo, R., Castellana, F., Nawrot, T. S., Lampignano, L., Bortone, I., Murgia, F., Campobasso, G., Gruszecka Kosowska, A., Giannico, O. V., & Sardone, R. (2024). Air pollutants and ovarian reserve: a systematic review of the evidence. Frontiers in Public Health, 12(2), 1425876. https://doi.org/10.3389/fpubh.2024.1425876