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THE INFLUENCE OF EXPOSURE TO POLLUTANTS ON FEMALE REPRODUCTIVE HEALTH

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ABSTRACT
Introduction: Exposure to environmental pollutants has been recognized as a significant risk factor for female reproductive health. Substances such as endocrine disruptors, heavy metals, and particulate matter can interfere with reproductive physiological processes, resulting in adverse outcomes such as infertility, hormonal changes, and gestational complications. Given the relevance of the theme, this study seeks to synthesize the evidence on the impacts of environmental pollution on reproductive health, highlighting the importance of public policies and preventive actions. Objective: To investigate the influence of exposure to environmental pollutants on female reproductive health, analyzing the biological mechanisms involved, the related outcomes, and the implications for public health policies and sustainable practices. Methodology: This is an integrative literature review conducted in databases such as PubMed, Scopus, Web of Science and Virtual Health Library (VHL). Studies published in the last 10 years, in English, Portuguese and Spanish, that addressed the impacts of environmental pollutants on female reproductive health were included. Data analysis was carried out qualitatively, organizing the results into thematic categories: infertility, hormonal changes, gestational complications and environmental inequalities. Results and Discussion: The results showed that endocrine disruptors directly interfere with hormonal processes, affecting ovulation and oocyte quality. Substances such as bisphenol A and phthalates have been linked to a higher risk of infertility and conditions such as endometriosis. Gestational complications, such as miscarriage and intrauterine growth restriction, have often been linked to exposure to air pollutants. In addition, vulnerable populations, especially low-income women, face greater risk due to environmental inequalities and limited access to health services. Integrated strategies, such as chemical regulation and educational campaigns, were highlighted as essential to mitigate these impacts. Conclusion: Exposure to environmental pollutants significantly affects female reproductive health, reinforcing the need for preventive actions and effective public policies. Promoting sustainable practices and raising awareness of the risks are essential to protecting women's health and reducing environmental inequalities. This study contributes to the advancement of scientific knowledge and the development of strategies that integrate health, environment and well-being.

Keywords: Female reproductive health. Environmental pollutants. Endocrine disruptors. Infertility. Environmental sustainability.

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INTRODUCTION

Women's reproductive health is an essential component for women's quality of life and well-being, being influenced by a complex interaction of biological, social, and environmental factors. In recent decades, increasing exposure to environmental pollutants has become a significant concern for public health, especially in contexts of accelerated urbanization and industrialization. Substances such as heavy metals, pesticides, endocrine disruptors, and particulate matter have been associated with a range of adverse reproductive health-related outcomes, such as infertility, hormonal changes, and pregnancy complications (Wilson 2024).

Environmental pollution, in its various forms, directly impacts biological systems, including the female reproductive system. Recent studies point out that chronic exposure to pollutants can interfere with normal physiological processes, affecting hormone production, ovulation, and egg quality. In addition, evidence indicates that certain chemical substances present in the environment have properties of mimicking natural hormones, causing hormonal imbalances with potential repercussions in the short and long term (Gruber; Ahmad; de Almeida 2024).

Endocrine disruptors, widely present in industrial products and plastics, have been the subject of investigations for their ability to alter the hypothalamic-pituitary-ovarian axis. These substances, even in minute concentrations, have been shown to affect fertility, contributing to the increase in conditions such as polycystic ovary syndrome (PCOS) and endometriosis. In addition, exposure to these compounds during critical periods, such as puberty and pregnancy, can generate transgenerational impacts, increasing vulnerability to infertility and chronic diseases (Gruber; Ahmad; de Almeida 2024).

Infertility is one of the main outcomes associated with exposure to environmental pollutants. According to the World Health Organization (WHO), women of reproductive age face difficulties conceiving, and environmental factors have been increasingly recognized as contributors to this statistic. Pollutants such as bisphenol A (BPA), phthalates, and organochlorine compounds directly affect oocyte quality as well as the uterine environment, making embryo implantation difficult (Franklin 2024).

In addition to infertility, studies highlight the relationship between environmental pollutants and gestational complications, such as miscarriage, intrauterine growth restriction, and premature birth. Exposure to high levels of particulate matter and air pollution has been associated with a higher incidence of changes in placental

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vascularization, compromising fetal development. These effects have implications not only for maternal health but also for neonatal health, perpetuating health inequalities (Castro 2019).

Another worrying aspect is the impact of pollutants on women's hormonal health. Chemicals present in cosmetics, cleaning products, and processed foods are often associated with changes in estrogen and progesterone levels, hormones that are essential for reproductive health. These hormonal changes can exacerbate pre-existing conditions, such as uterine fibroids and dysmenorrhea, further reducing women's quality of life (Marques; Scallop; Almeida 2024).

The scientific literature shows an intrinsic relationship between exposure to pollutants and the increase in chronic reproductive diseases, such as endometriosis. This condition, characterized by the presence of endometrial tissue outside the uterus, affects millions of women around the world, and is often associated with exposure to endocrine-disrupting chemicals. Endometriosis not only compromises fertility, but is also associated with chronic pain, compromising the mental and emotional health of patients (Castro 2019).

Despite the growing body of evidence, there are still significant gaps in understanding the mechanisms by which pollutants affect female reproductive health. The variability in study results, often attributed to differences in methodological designs, underscores the need for further longitudinal investigations and robust analyses to understand the extent of this impact. In addition, factors such as socioeconomic context and individual genetics can mediate women's vulnerability to these effects (Abi-Habib *et al*., 2024).

The scenario becomes even more alarming in vulnerable populations, such as low-income women and those who live in areas of greater environmental exposure. These populations often face barriers to accessing health care and are more exposed to sources of pollution, which amplifies the negative impacts on reproductive health. Environmental inequality, therefore, is an important challenge for public health policies (Wilson 2024). In this context, the public health approach needs to consider strategies to mitigate exposure to pollutants, combined with preventive and educational measures.

Regulating chemicals in consumer products and promoting sustainable practices are essential to reducing risks to women's reproductive health. In addition, it is crucial to invest in screening programs and early interventions that can identify and treat reproductive conditions related to environmental exposure (Ruíz *et al*., 2024).

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Advances in biomonitoring technologies have allowed for a more accurate assessment of human exposure to pollutants, providing opportunities for a better understanding of the relationship between pollution and reproductive health. These tools, combined with the integration of epidemiological and experimental data, are fundamental for the development of evidence-based policies (Brazil 2025).

Finally, this integrative literature review aims to investigate the influence of exposure to pollutants on female reproductive health, with emphasis on the associated conditions, the biological mechanisms involved, and the implications for clinical practice and public health policies. By exploring these relationships, it is expected to contribute to the expansion of scientific knowledge and to the formulation of effective prevention and care strategies.

THEORETICAL FRAMEWORK

Environmental pollution is a factor widely recognized as one of the major global challenges to human health. It is characterized by the introduction of physical, chemical, or biological agents into the environment, which, in high concentrations, can cause damage to health and the ecosystem. Among the most relevant pollutants for reproductive health are heavy metals, particulate matter, pesticides and volatile organic compounds, often from industrial, agricultural and urban activities. These agents have a significant impact on the balance of ecosystems and directly affect human health, especially in contexts of high exposure (Marconetto *et al*., 2022).

Female reproductive health, in turn, encompasses a set of conditions related to the proper functioning of the reproductive system and the ability to generate offspring. This concept also extends to women's right to live in a healthy environment, with access to medical care, and free from preventable risk factors. Several studies have indicated that reproductive health is particularly sensitive to environmental changes, especially due to exposure to pollutants that interfere with fundamental hormonal and physiological processes. Thus, the relationship between environmental pollution and reproductive health gains relevance, given the increase in exposure to potentially harmful chemical substances (Garrido; Garrido Carneiro 2025).

Among the biological mechanisms that explain the impact of pollutants on female reproductive health, the effects of endocrine disruptors stand out. These substances, widely present in the environment, have the ability to imitate, block or modify the action of

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natural hormones in the body, interfering with hormone regulation processes. As a result, imbalances can occur that affect ovulation, egg quality, and the uterine environment, increasing vulnerability to conditions such as infertility, polycystic ovary syndrome, endometriosis, and menstrual dysfunctions. In addition, these compounds can cause cell damage, directly affecting reproductive tissues and compromising essential processes for the conception and maintenance of pregnancy (Karwacka; Zamkowska; Radwan; Jurewicz2019).

Infertility is one of the most studied consequences in relation to exposure to environmental pollutants. Substances such as bisphenol A, phthalates, and pesticides have been linked to changes in egg and sperm quality, as well as problems with embryonic implantation. These substances can interfere with hormonal signaling, compromising women's reproductive capacity, especially in critical periods, such as puberty and pregnancy. Similarly, exposure to elevated levels of air pollution, such as particulate matter and nitrogen dioxide, is associated with gestational complications, including miscarriages, intrauterine growth restriction, and preterm births (Barreto 2022).

Another relevant aspect is the impact of pollutants on women's hormonal health. Chemicals often found in consumer products, such as cosmetics and processed foods, can alter levels of estrogen and progesterone, hormones that are essential for the balance of the reproductive system. These changes are associated with the worsening of pre-existing conditions, such as uterine fibroids and endometriosis, in addition to contributing to the occurrence of irregular menstrual cycles and more intense menopausal symptoms. Such effects not only compromise women's quality of life, but also reflect gender inequalities in the impact of environmental pollutants (Karwacka; Zamkowska; Radwan; Jurewicz2019).

Endometriosis, a chronic inflammatory condition characterized by the presence of endometrial tissue outside the uterus, has been widely associated with exposure to endocrine disruptors. Studies suggest that these substances can alter the body's immune and hormonal response, favoring the development and progression of the disease. This condition not only compromises fertility but is also associated with debilitating chronic pain, negatively impacting women's physical, emotional, and social health (Silva *et al*., 2023).

Despite the progress in research on the subject, there are still significant gaps in the understanding of the mechanisms by which pollutants affect female reproductive health. Factors such as the level of exposure, the interaction with genetic predispositions, and the socioeconomic background of women need to be further investigated. In addition,

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inequalities in access to health care and exposure to pollutants make vulnerable populations, such as low-income women, even more susceptible to negative impacts (Santos *et al*., 2025).

Environmental inequality emerges, therefore, as a crucial issue in the context of reproductive health. Women who live in densely polluted urban areas or who work in environments with high chemical exposure face greater health risks. In addition, these populations often have limited access to health information and services, making it difficult to identify and manage associated conditions early (Arruda; Mayan; Alves, 2018).

Given this scenario, it is essential to adopt integrated strategies to mitigate the effects of environmental pollution on female reproductive health. Public policies that promote the regulation of chemical substances, combined with educational campaigns, are essential to reduce exposure to risk factors. Likewise, the integration of sustainable practices into daily life, both at the individual and collective levels, can contribute to the protection of reproductive health (BRASIL, 2024).

This integrative literature review seeks to explore the influence of exposure to pollutants on female reproductive health, considering the biological mechanisms involved, the impacts on fertility and gestational complications. Through a critical analysis of the existing literature, it is intended to contribute to the advancement of knowledge on the subject and to the development of policies and practices that promote the health and well-being of women in a world increasingly impacted by environmental pollution.

METHODOLOGY

This integrative literature review was developed with the objective of investigating the influence of exposure to environmental pollutants on female reproductive health. This method was chosen because it enables a broad and critical analysis of relevant studies on the subject, integrating results from different methodological approaches to offer a comprehensive view and identify gaps in knowledge. The guiding question of this review was: "How does exposure to environmental pollutants affect female reproductive health, considering the impacts on biological mechanisms and clinical outcomes?" The formulation of the question was based on the PICO strategy, where the problem (P) refers to female reproductive health, the intervention (I) concerns exposure to environmental pollutants, the comparison (C) involves unexposed populations, and the outcome (O) comprises hormonal changes, infertility and gestational complications.

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Data collection was carried out between [month and year] and followed a rigorous search process in the scientific databases PubMed, Scopus, Web of Science, and Virtual Health Library (VHL). Controlled and uncontrolled descriptors in Portuguese and English, such as "female reproductive health", "environmental pollutants", "endocrine disruptors", and "fertility", combined with Boolean operators to maximize the sensitivity of the search, were used. Studies published in the last 7 years, in English, Portuguese and Spanish, that directly addressed the impacts of environmental pollutants on female reproductive health were included. Duplicate articles, studies that were not fully available, and those that did not have a direct relationship with the topic investigated were excluded.

After the initial search, all titles and abstracts were analyzed by two independent reviewers, following previously established inclusion and exclusion criteria. Eligible studies were read in full to ensure relevance and methodological quality, and any disagreement was resolved by a third reviewer. To ensure the reliability of the information, studies of high methodological quality were prioritized, including systematic reviews, longitudinal studies, clinical trials, and cohorts.

Data extraction was performed using a standardized form, which included information about the authors, year of publication, location of study, type of pollutant investigated, outcomes analyzed, methodology used, and main findings. These data were organized in a matrix, allowing the categorization of the results by recurrent themes, such as infertility, hormonal changes, gestational complications, and chronic diseases related to the reproductive system.

Data analysis followed a qualitative approach, emphasizing the similarities and differences between the selected studies, as well as the consistency of the results found. In addition, the gaps in knowledge and the methodological limitations identified were highlighted, with the aim of pointing out directions for future research. The results were presented in a descriptive and synthetic way, facilitating the understanding of the relationship between environmental pollutants and the impacts on female reproductive health.

Finally, this review followed the ethical guidelines for bibliographic research, respecting academic and scientific integrity in the analysis, interpretation, and presentation of results. Although the methodology adopted sought rigor and precision, limitations inherent to review studies are recognized, such as the possibility of publication biases and

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the dependence on secondary data, which were mitigated as far as possible through rigorous criteria for the selection and analysis of articles.

RESULTS AND DISCUSSION

The results of this integrative review show that exposure to environmental pollutants has a significant impact on female reproductive health, affecting essential biological processes, such as hormone regulation, fertility, and pregnancy maintenance. The studies analyzed highlight that substances such as endocrine disruptors, heavy metals, and particulate matter are among the main harmful agents. These pollutants, often present in industrial products, plastics, and air pollution, act directly on the hypothalamic-pituitary-ovarian axis, compromising reproductive functions and predisposing women to conditions such as infertility and menstrual changes (Panagopoulos *et al*., 2023).

Table 1: Main categories of environmental pollutants, their mechanisms of action, and observed outcomes in female reproductive health.

CATEGORY	ASSOCIATED POLLUTANTS	MECHANISMS OF ACTION	OBSERVED EVENTS	REFERENCES
Endocrine Disruptors	Bisphenol A (BPA), Phthalates, Pesticides	Hormone mimicry and blockade, interference with the hypothalamic-pituitary-ovarian axis	Infertility, menstrual changes, transgenerational effects	(Gruber; Ahmad; De Almeida 2024).
Heavy Metals	Prickly pear, Mercúrio, Cadmio	Cellular damage, interference with hormonal signaling	Reduction in ovarian reserve, failures in fertilization	Franklin (2024), Panagopoulos *et al*. (2023)
Particulate Matter	Air pollution, nitrogen dioxide	Oxidative stress, interference with placental vascularity	Miscarriage, intrauterine growth restriction, preterm delivery	Fernandes (2021)
Volatile Organic Compounds	Cleaning products, cosmetics, plastics	Changes in estrogen and progesterone levels, activation of inflammatory processes	In endometrials, myomas uterinos, dysmenorreia	Marques; Scallop; Almeida (2024). File Stachiw Militão (2019)
Socioeconomic Factors	Pollution in vulnerable urban areas	High environmental exposure, limited access to healthcare	Higher prevalence of adverse outcomes in vulnerable populations	Melo *et al*. (2024), Santos *et al*. (2025)

Source: Authors 2025.

One of the main findings was the relationship between endocrine disruptors, such as bisphenol A (BPA) and phthalates, with hormonal imbalances. Studies by Franklin (2024)

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and Gruber; Ahmad; De Almeida (2024) demonstrated that these compounds mimic or block the action of natural hormones, resulting in changes in ovulation, hormone production, and oocyte quality. In addition, exposure to these pollutants in critical periods, such as puberty and pregnancy, proved to be particularly harmful, with the potential to generate transgenerational effects. These findings reinforce the need for stricter control in the regulation of these substances in products for daily use.

Infertility is another outcome widely associated with exposure to pollutants. Longitudinal studies, such as those of Silvia; Carreiró; Sanches-Silva *et al*. (2023) and Fernandes (2021), indicated that women exposed to high levels of pesticides and heavy metals have a higher risk of fertilization failures and reduction in ovarian reserve. Exposure to particulate matter, common in densely polluted urban areas, was associated with changes in intrauterine air quality, negatively impacting embryo implantation and early pregnancy development. These results highlight the relevance of public policies aimed at reducing air pollution, especially in metropolitan regions.

Gestational complications also emerged as a recurring theme in the studies evaluated. Research such as those by Fernandes (2021) and Castro (2019) has identified that pollutants such as nitrogen dioxide and organochlorine compounds are associated with adverse outcomes, including miscarriage, intrauterine growth restriction, and premature births. Prolonged exposure to these pollutants has been shown to interfere with placental vascularization, compromising the adequate supply of oxygen and nutrients to the fetus. These findings suggest that environmental exposure not only affects maternal health but also contributes to adverse neonatal outcomes, perpetuating health inequalities.

Endometriosis, a chronic inflammatory condition that affects millions of women worldwide, has been highlighted in several studies as strongly associated with exposure to endocrine disruptors. Studies such as those of Marques; Scallop; Almeida (2024) and Wen *et al*. (2019) indicated that chemical substances present in cosmetic and plastic products interfere with inflammatory and immunological processes related to the development of the disease. These results indicate the need for preventive strategies and greater awareness of the risks associated with the use of these products.

Another important aspect identified was the impact of pollutants on women's hormonal health. Lima Studies; Stachiw; Militão (2019) points out that compounds such as polycyclic aromatic hydrocarbons, present in vehicle smoke and cigarettes, are associated with changes in estrogen and progesterone levels. These changes not only contribute to

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reproductive dysfunctions, but also increase the risk of conditions such as uterine fibroids and dysmenorrhea. These findings reinforce the importance of preventive interventions that reduce exposure to these chemical agents.

Although advances in biomonitoring have allowed a better understanding of human exposure to pollutants, reviewed studies, such as those by Moreira (2023) have pointed out limitations related to variability in methodological designs and the difficulty of accurately measuring individual exposure levels. In addition, contextual differences, such as access to health care and socioeconomic factors, proved to be determinants of women's vulnerability to the effects of pollutants. This underscores the need for longitudinal studies that consider these factors for a more robust analysis.

Another highlight was the environmental inequality observed in vulnerable populations. Studies by Melo *et al*. (2024) and Santos *et al*. (2025) showed that low-income women and residents of densely polluted urban areas had a higher risk of adverse reproductive health outcomes. These populations often face barriers to accessing health care and greater exposure to sources of pollution, such as poor industries and transportation systems. These data highlight the importance of environmental equity policies to mitigate these impacts.

From the point of view of public policies, the results point to the need for stricter regulations regarding the use of potentially harmful chemical substances, as well as for the implementation of educational programs that promote awareness about the risks of exposure to pollutants. In addition, it is recommended to strengthen strategies aimed at promoting sustainable practices that can reduce human exposure and protect the environment (Brasil, 2025).

Despite advances in the field, there are still significant gaps that need to be explored. Studies, such as those of Bellato; Olive tree; Cupertino (2019), indicate that the psychological and transgenerational impact of exposures was less addressed. These points represent opportunities for future research, which can expand understanding of the global impacts of exposure to pollutants on women's health.

CONCLUSION

The present integrative literature review revealed that exposure to environmental pollutants has a significant and multifaceted impact on female reproductive health, affecting essential physiological processes, such as hormone regulation, fertility, and pregnancy

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maintenance. Substances such as endocrine disruptors, heavy metals, pesticides, and particulate matter have been identified as the main harmful agents, with consistent evidence that these exposures can lead to adverse outcomes such as infertility, hormonal changes, gestational complications, and chronic conditions such as endometriosis.

In addition, the results highlight that vulnerable populations, especially low-income women or those living in densely polluted areas, are more exposed to these risks, highlighting environmental inequalities as an aggravating factor.

Although advances have been made in understanding the mechanisms by which pollutants affect reproductive health, there are still significant gaps in the literature, especially regarding the psychological and transgenerational impact of these exposures. The variability in the methodological designs of the studies evaluated also reinforces the need for longitudinal and more robust research that considers contextual factors, such as socioeconomic aspects and access to health care, for a more comprehensive understanding of the problem.

Based on the findings of this review, the urgency of implementing integrated strategies to reduce exposure to environmental pollutants and mitigate their impacts on female reproductive health becomes evident. Public policies that regulate the use of chemical substances, combined with educational programs, can play a crucial role in raising awareness and prevention. In addition, it is essential to invest in sustainable practices and technologies that promote environmental protection, contributing to the reduction of health risks to the population as a whole.

Finally, it is hoped that this review will contribute to the advancement of scientific knowledge on the subject and provide subsidies for the formulation of public policies and health strategies that prioritize women's well-being. Protecting women's reproductive health, especially in a scenario of increasing environmental degradation, is not only an ethical commitment, but also a fundamental step to promote equity and quality of life for present and future generations.

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