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"CLIMATE CHANGE AND WOMEN'S HEALTH: REPRODUCTIVE AND GYNAECOLOGICAL CONSEQUENCES IN VULNERABLE POPULATIONS"

Nancy Chandra Priya P[1*], Baskaran N[2], Jayavani J[3], Dr. Prema krishnan[4], Dr. Shaini G.S[5], Niranjani S[6], Rajasri M[7], Ms.Angel k [8], Dr. James Ranjith P[9], Dr. Annie Kantha. P[10]

[1*] Assistant Professor, Obstetrics & Gynaecological Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[2]Assistant Professor, Mental Health Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[3]Nursing Tutor, Child Health Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[4] Professor cum Principal, Department of Pediatric Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[5]Professor in Medical Surgical Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[6] Associate Professor, Community health Nursing department, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[7]Assistant Professor, Obstetrics & Gynaecological Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[8] Nursing Tutor, Obstetrics & Gynaecological Nursing, Shri Sathya Sai College of Nursing, Sri Balaji Vidyapeeth (Deemed to be university), Chennai, India
[9]Assistant Professor, Department of Social Work, Auxilium College (Autonomous), Vellore.
[10]Assistant Professor, Department of English, Voorhees College, Vellore

Abstract:
One of the biggest risks to the world's population's health is climate change. It is caused by human activity-induced increases in greenhouse gas concentrations, such as burning fossil fuels (carbon dioxide), raising animals (methane from manure), industry (ozone, nitrogen oxides, sulfur dioxide), vehicle/factory exhaust, and aerosols of chlorofluorocarbons, which trap additional heat in the earth's atmosphere. Globally, climate change affects human health and well-being both directly and indirectly. Vulnerable groups such as women, pregnant women, fetuses, children, older adults, indigenous peoples, people with disabilities, people with preexisting and/or chronic medical conditions, low-income people, and communities of color are disproportionately affected. Despite having significant effects on human development, fertility, and pregnancy outcomes, the effects of climate change on reproductive and gynecologic processes and outcomes have gotten less attention worldwide. With an emphasis on gynecologic and reproductive processes, this review offers evidence of both direct and indirect impacts of climate change on human health. In order to alter the current course of harm, the objective is to raise awareness among clinicians, researchers, the general public, and policymakers regarding the effects of climate change on reproductive and gynecologic health.

Key words: Climate change, Reproductive health, Gynecologic health, Vulnerable group, Policy making,

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Introduction

One of the biggest threats to global health is climate and environmental change (CECs).
FIGO(International Federation of Gynecology and Obstetrics) has developed consensus in recent decades regarding the new reality that exposure to toxic environmental agents, from air pollutants and industrial chemicals to endocrine disruptors and stressors related to climate change, can have a significant impact on the health of mothers, fetuses, and children throughout their lives. Women are exposed to a complex mix of environmental agents throughout their reproductive lives, such as air pollutants, industrial chemicals, heavy metals, and endocrine-disrupting substances, which can affect systemic metabolic regulation, reproductive organ function, and hormonal signalling (1). Women's unique health needs are made worse by climate change, especially during pregnancy when the developing fetus and baby depend on the mother's nutrition and health(2). Climate change exerts a profound influence on the reproductive and gynaecological health of women, particularly within marginalized communities. The deleterious effects arise from environmental determinants such as atmospheric pollution, extreme climatic conditions, and natural calamities, which intensify pre-existing health inequities. These challenges manifest in a wide range of reproductive health consequences, including fertility problems, pregnancy complications, and long-term health consequences for mothers and their children(3).
Many of these exposures, which can happen through the air, water, food, personal care items, and workplace, are hard to find. Endocrine disruption, oxidative stress, epigenetic changes, and immunological dysregulation are some of the many underlying processes that connect exposures to negative reproductive health outcomes. Crucially, a large number of reproductive problems associated with environmental exposures develop over years or decades, potentially affecting fertility and health across generations(1). These toxicants can have an impact on ovarian reserve, disease risk, hormonal function, and obstetric and early childhood outcomes. With a focus on reproductive conditions like early menarche, infertility, low birth weight and preterm birth, preeclampsia, and diabetes during pregnancy, as well as gynecological conditions like polycystic ovarian syndrome (PCOS), endometriosis, uterine fibroids, hormone-mediated cancers, and menopausal health issues, this review examines the effects of climate and environmental changes on women's reproductive and gynecological health (4).

Climate change and it's adverse effects on Reproductive conditions:

Understanding the mechanisms by which climate change affects women's reproductive health necessitates an examination of its various effects on individual reproductive diseases. Physiological systems involved in reproduction are very sensitive to changes in their surroundings, from menarche to conception, pregnancy, and breastfeeding. Endocrine-disrupting toxins, air pollution, and rising temperatures all affect placental function, metabolic control, and hormonal balance.Climate and environmental changes negatively impact several reproductive problems, such as early menarche, infertility, premature birth, pre-eclampsia, gestational diabetes, and breastfeeding, as outlined in the next section.
Early menarche: Increased exposure to pollutants like PM (particulate matter) 2.5 is linked to lower fertility rates and an earlier menarche, which affects women's reproductive schedules (3). Average age at menarche has been dropping globally, which may be due to CECs (Climate and environmental changes) through elements like pollution exposure and food availability. Precocious menarche has been linked to exposure to endocrine-disrupting chemicals (EDCs), which may then have an impact on psychological health and fertility-related conditions (9).
Infertility:EDCs may also adversely affect the ovarian reserve in women and high levels of EDCs have been linked to a decline in ovarian function, infertility, and earlier menopause (10). With

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the strongest evidence for pollutants including PM2.5, PM10, and NO2, increasing exposure to air pollution appears to be linked to decreased ovarian reserve (17).

Preterm birth and low birth weight: Long-term exposure to high temperatures is linked to preterm delivery, congenital birth abnormalities, and stillbirth regardless of the mother's age or ethnicity, with younger mothers at a much higher risk of adverse outcomes(5).There is some evidence that maternal exposure to wildfire smoke is linked to preterm birth and birth weight decrease , especially when the exposure happened in the latter stages of pregnancy. There was no clear correlation between baby death and wildfire exposure and small for gestational age (20).

Pre-eclampsia: Among the most well-established exposures that can increase the risk of pre-eclampsia are air pollutants such as ozone, nitrogen dioxide, and fine particulate matter (PM2.5). These are supported by the systematic review and meta-analysis conducted by the National Toxicology Program (30). According to recent meta-analyses, exposure to excessive heat, especially in the early stages of pregnancy, can raise the risk of pre-eclampsia (31). Pregnancy problems including gestational hypertension and preeclampsia are also associated with high ambient temperatures (6). Temperature extremes like heat waves have been shown to have a greater impact on women, increasing their risk of heat exhaustion, hypertension, and poor maternal health (7). Pregnant women were more likely to experience hypertension, exhaustion, miscarriages and stillbirths with higher temperatures (8).

Gestational diabetes: The oxidative stress and systemic inflammation linked to ambient air pollution, especially fine particulate matter (PM2.5), may change placental metabolic function and reduce maternal insulin sensitivity. There is evidence from a systematic review and meta-analysis that PM2.5 can raise the risk of GDM (32). Because of their capacity to mimic or obstruct estrogenic signaling, heavy metals such as arsenic, antimony, and copper are categorized as metalloestrogens. GDM may occur as a result of these substances' disruption of insulin homeostasis and impairment of pancreatic beta-cell function(33).

Lactation and Breastfeeding: The presence of heavy metals in human breast milk has been linked to allergies, endocrine disorders, neurodevelopmental delays, and neuropsychiatric disorders later in life. Additionally, pollutants with lipophilic qualities may have detrimental effects when absorbed in the neonate's digestive tract (11). It's crucial to remember that breastfeeding is still advised for at least the first six months of life by the World Health Organization and the American Academy of Pediatrics. Breastfeeding reduces the impact on the planet's resources and benefits both the mother and the newborn. In particular, breastfeeding results in little to no waste, no carbon emissions, and a reduction in the use of water or land resources (12). Microplastics are routinely detected in human breast milk, placentas, infant formula, and meconium, according to studies. This suggests that exposure to microplastics starts in utero and continues during breastfeeding and the first few months of life. Sadly, one study found microplastics in almost 75% of the human breast milk samples that were studied, and other studies have shown microplastics in every part of the human placenta that was analyzed(13).

Climate change and it's adverse effects on Gynecological conditions:

Although fertility, pregnancy outcomes, and mother well-being are all significantly impacted by climate change, its effects also extend beyond the reproductive stage to the larger field of gynecological health. Throughout their lives, women are still impacted by the same environmental stresses, such as air pollution, chemicals that disrupt hormones, and drastic changes in the climate. These exposures change immunological response, cellular control, and

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hormonal balance, which can lead to the onset or worsening of long-term gynecological disorders. As a result, conditions including endometriosis, uterine fibroids, polycystic ovarian syndrome (PCOS), hormone-mediated malignancies, and menopause-related difficulties are becoming more widely acknowledged as being a part of the larger spectrum of environmental and climate-related health issues affecting women.

Polycystic ovarian syndrome : Depending on the study population and the diagnostic criteria employed, the prevalence of polycystic ovarian syndrome (PCOS) in women of reproductive age might vary from 5% to 21%(18). One consequence of CECs is air pollution, which can introduce reproductive toxicants that impair fertility and worsen conditions like polycystic ovary syndrome (PCOS). Since increased exposure to environmental pollutants can negatively impact overall reproductive health and increase susceptibility to a variety of gynecological disorders, it may also hasten the onset of infections(9). BPA, a molecule that is frequently found in plastics and food packaging, is one of the most researched substances in this category. BPA exposure was substantially linked to a higher risk of PCOS in a multicenter case-control study involving women of reproductive age(27).

Endometriosis: Of the 51 studies that were part of the systematic review, 17 had sufficient data for a meta-analysis. The researchers discovered that exposure to polychlorinated biphenyls (PCBs) raised the risk of endometriosis by 1.70 times, dioxins (an industrial chemical) by 1.65 times, and organochlorine pesticides (OCPs) by 1.23 times. These correlations were statistically significant, but they varied greatly between research and were quite modest. The accuracy of the findings might have been impacted by variations in the methods used to quantify exposure levels and disease criteria. The need for more thorough future research was highlighted by the evidence's overall moderate grade rating with some bias risk(21).

Uterine fibroids: Researchers investigated the connection between phthalates—chemicals frequently found in plastics and personal care products—and microRNAs (miRNAs), which are tiny molecules that aid in regulating gene activity, in this study of premenopausal women having surgery for fibroids. They found that, in fibroid tumors, specific phthalate indicators were associated with altered miRNA expression, but not in the myometrium, the uterus's normal muscle layer. It's interesting to note that these connotations varied depending on a woman's race and ethnicity. This implies that exposure to environmental chemicals may have varying effects on fibroid biology depending on the population group(22). The study looked at the relationship between uterine fibroids and blood levels of heavy metals, notably lead (Pb), cadmium (Cd), and mercury (Hg). The findings indicated that women were more likely to develop fibroids if their levels of certain metals, particularly mercury, were higher. This suggests that environmental or dietary exposure to specific heavy metals may raise a woman's risk of developing fibroid(23).

Menopause: An important risk to women's reproductive health is the environmental presence of endocrine-disrupting chemicals (EDCs), which can alter ovarian function and cause an earlier menopause (14). In particular, women who have higher levels of EDCs go through menopause 1.9–3.8 years earlier than those who have lower levels. Menopause is also up to six times more common in women exposed to EDC than in women of the same age who are not exposed (15). It's interesting to note that CECs may also have an impact on menopause by intensifying and prolonging symptoms, particularly hot flashes(16).

Gynaecological cancer: According to the analysis of 24 research, exposure to PFASs (per- and polyfluoroalkyl compounds), including PFOA and PFOS, was associated more clearly with ovarian cancer and slightly increased the risk of breast cancer. The variations in study designs

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and geographical locations, however, indicate that further investigation is required because the evidence is insufficient to support a clear cause-and-effect relationship(24).
Several phenols and parabens were cross-sectionally linked to higher odds of prior ovarian cancer diagnoses, and biomarkers from all exposure categories (phenols, parabens, and per- and poly-fluoroalkyl compounds) were linked to higher odds of prior melanoma diagnoses in women(25). There is moderate evidence, according to the study, that prolonged exposure to nitrogen dioxide (NO_2) increases the risk of breast cancer.This implies that the risk of breast cancer may be increased by air pollution, especially NO_2(26). Other nonchemical exposures, such nighttime light, have also been linked to the development of breast cancer because they change hormonal signaling and interfere with the circadian control of melatonin(28). A higher risk of breast cancer has also been linked to pesticide exposure, namely to dichlorodiphenyltrichloroethane (DDT) and related substances. These substances may operate as estrogen mimics and interfere with regular hormone signaling pathways in adipose tissue, where they can remain(29).

Recommendations :

Obstetricians and gynecologists (OBGYNs) play a crucial role in incorporating environmental health into standard gynecologic and fertility treatment as trusted health consultants. Taking environmental histories, advising patients on risk mitigation and healthy living, and pushing for institutional and legislative changes to promote healthier surroundings are all included in this. In addition to being clinically relevant, addressing these environmental factors is essential for reproductive justice and fair access to safe and healthy reproductive life.Involving OBGYNs in systemic and policy-level actions that change the structural factors causing disproportionate exposure and illness is highly advised.

Conclusion :

Simple, research-based counselling on environmental health behaviours, occupational risk, product use, diet, and physical activity in a healthy setting can empower patients to minimize harmful exposures and promote their reproductive and personal well-being as well as the health of our world. By encouraging a balanced diet high in fruits, vegetables, whole grains, and lean meats and reducing ultra-processed foods, nutrition counselling can significantly improve maternal health. Pregnant women are advised to steer clear of high-mercury seafood like swordfish and tuna in favour of low-mercury, omega-3-rich fish like salmon and sardines to support the development of the unborn brain. It also stresses the need of purchasing organic vegetables whenever feasible to reduce pesticide exposure. Personal care Products labelled without phthalates or fragrances limit exposure to dangerous chemicals and caution while using cosmetics like hair dye and nail polish, which may include toxic substances like formaldehyde, toluene, and dibutyl phthalate that can interfere with gestation and reproduction.
Preserving reproductive health starts not only in the clinic but also in the items we use, the air we breathe, and the laws we create. By protecting the environment, we are also protecting the health of future generations.

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