

The interplay of diet and environment unraveling their influence on human fertility

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ABSTRACT

As known our environment and our diet have a significant effect on our health. A nutrition rich diet and good environment have a positive effect on our overall health. Any changes in these can gives a negative health effect, even it is become a threat to our reproductive health. The cases of reproductive health issue mostly infertility is increasing worldwide. Infertility is considered when a person failed to achieve pregnancy after 12 months of unprotected sexual intercourse. Our diet includes many different kinds of elements from different kinds of food, which includes micronutrients and minerals which are beneficial for human health but can be dangerous in excess and result in health complications. Hormones involved in reproduction, like gonadotropin, which releases hormone 3, and β luteinizing hormone, are also impacted by rising global temperatures. Endocrine-disrupting compounds (EDCs), such as bisphenol A (BPA) and phthalates, resemble or interfere with natural hormones, changing the hypothalamic-pituitary-gonadal (HPG) axis and that impact ovulation, sperm production, and hormone regulation. Chemicals such as pesticides, heavy metals, industrial solvents, and EDCs are increasingly known to have negative effects on fertility. Stakeholders can try to reduce the burden of infertility and promote a healthier global population by bridging the gap between advances in science and everyday life implementations. A growing global concern, infertility is determined by a combination of environmental influences, physiological conditions, psychological wellbeing, and dietary choices. The significant effects of diet and environmental exposures on reproductive health are highlighted in this study, highlighting the necessity of focused interventions.

Keywords: Intracytoplasmic Sperm Injection, Photoelectrochemical, Polycystic Ovary Syndrome, Antimalaria Hormone, Vascular Endothelial Growth Factor,

INTRODUCTION

As we know our environment and our dietary habits have a significant effect on our life as well as overall health. Everything we eat or do plays a curtail roll in our health including sexual activities. Diet and environmental exposures significantly influence reproductive health poor dietary choices, micronutrients deficiencies and environmental toxins may impair hormonal balance and ovulatory functions contributing infertility. If a person failed to censive baby after having unprotected sexual intercourse for 12 months this condition is considered infertility [1,2]. According to WHO infertility effects more than 48 million people globally [2]. This is the reason uses of Intracytoplasmic sperm injection (ICSI) and In vitro fertilization (IVF) increased in recent years [3,4]. After multiple researches in past, we come to know there are multiple factors that may cause infertility, causes like excessive weight, malnutrition, alcohol consumption, physical activity [5,6]. There are some genetic issues and physiological issues like reproductive organs damaged and stress and anxiety also effect reproductive health [5,6]. There are multiple researches conducted considering nutritional effect on reproductive health mentioning different nutrients and their positive and negative effect on reproductive health [7,8]. Our food contain different types of elements from different food sources and contains variety of micronutrients and minerals which are good for human health but excessive amount of these can cause toxicity and health complication [9]. Rising global temperature also effect on hormones like gonadotropin - releasing hormone 3, β luteinizing hormone which are responsible for reproduction [10]. Exposure to heavy Matels through water, environmental pollution and food initiate decrease semen count and semen motility, feasibility and spermatogenesis [11]. One of six couples facing infertility issues reported environmental and occupational factors responsible for this [12]. Mercury and lead found in water near industrial areas can cause disruption in



normal impaired sperm motility [13]. Women drinking ground water containing tetrachloroethylene (PEC) contamination suffering from spontaneous abortion as well as breast cancer [14]. Chlorination of drinking water is a common practice in developing nations but consuming chlorinated water for a longer period carries a risk of stillbirth [15]. Women living in places where air contain particulate matter PM10 have higher risk of miscarriage [16,17]. Considering this infertility can occurs due to both environmental factors and dietary habits both do impact on fertility in humans. This review we attempt to find how environment and diet effect reproductive health and explore the potential solution of these issues.

Physiological effect on infertility

Infertility is a multifaceted condition which can be impact by various physiological components. Research has shown that several physiological effects can contribute to infertility in both male and female.

Hormonal Imbalances

Hormones play a crucial role in reproductive health. For example, polycystic ovary syndrome is characterized by hormonal imbalances that can lead to irregular ovulation and infertility. A study by Azziz highlights the prevalence of PCOS and its impact on fertility [18]. A comprehensive analysis utilizing data from the Global Burden of Diseases 2019 revealed that the numeral of infertility cases attributable to polycystic ovary syndrome nearly doubled worldwide, rising from 6 million in 1990 to 12.13 million in 2019. The age-standardized occurrence rates enlarged from 223.50 to 308.25 per 100,000 persons during this period. This upward trend was observed across various regions, with the highest rates reported in high-income Asia Pacific countries and Italy [19]. In India, a prospective study conducted at an infertility clinic found that 54.9% of the 102 women seeking infertility treatment were diagnosed with PCOS. Among these women, 59% experienced menstrual irregularities, and 33.9% exhibited hirsutism. Notably, 90- 95% of women attending infertility clinics for anovulation-related issues were found to have PCOS, underscoring its significant role in infertility [20]. Beyond reproductive challenges, PCOS has been related with continuing health risks, including cardiac diseases and metabolic disorders. A novel study painted that females with PCOS face a higher risk of developing cardiac abnormalities, emphasizing the importance of early diagnosis and comprehensive management strategies [21]. Hormonal imbalance in the body from PCOS greatly impacts a woman's reproductive system by making it harder to get pregnant and increasing health problems. Early diagnoses and custom treatment help women with PCOS achieve better results according to research studies [22, 23, 24].

Age-Related Factors

As women grow older their eggs lose both effectiveness and quantity which makes pregnancy difficult. Freeman discusses that the age-related infertility and the physiological changes that go together with aging [26]. As women getting, both the quality and quantity of their oocytes reduce, leading to infertility or low fertility rate. Age-related damages to oocytes specifically stem from different types of genetic, molecular, and biological features. A major National Institutes of Health research discovered that older oocytes receive DNA damage more often and fail at a higher rate because their DNA repair processes weaken with age. Age-related changes happen to oocytes when genes such as BRCA1 that assist DNA repair exhibit decreased functioning [26]. Research shows that a woman builds her maximum number of oocytes before birth then this supply drops slowly until age 32. The decrease in oocyte numbers grows remarkably fast from age 32 to 37 until it drops sharply after 37 years [27]. Changes at the molecular level contribute to reduced fertility rates as a person grows older. A description reviews highlighted changes in intraovarian regulators, including antimalaria hormone (AMH), vascular endothelial growth factor, neurotrophins, mitochondrial function and insulin-like growth factor 1 (IGF1), all of which are essential for healthy cumulus cell and oocyte growth. These factors undergo significant changes with advancing age, impacting overall fertility and ovarian follicle maturation [28]. In summary, the age-related reduced fertility is a complex process involving reduced oocyte quantity, compromised DNA repair mechanisms, and changed intraovarian regulatory issues. Considering these changes is vital for developing interventions to mitigate the impact of aging on female fertility.

Metabolic Factors and Weight

metabolic syndrome and Obesity have been linked to infertility due to their effects on hormonal levels and ovulation. Kauffman examines's systematic review the connection between obesity and reproductive health [29]. Overweightness and metabolic syndrome (MetS) are highly related with infertility due to their harmful effects on hormonal balance and function of ovary. A systematic review by Kauffman highlighted the significant impact of obesity on reproductive health, particularly its contribution to hormonal dysregulation and menstrual irregularities [30]. Obesity often leads to insulin resistance and hyperinsulinemia, which disrupt the hypothalamic-pituitary-gonadal axis, causing anovulation also reduced fertility. Furthermore, Balen and Brewer emphasized that obesity significantly decreases the success rates of assisted reproductive technologies (ART), with studies showing that women with obesity have lower rates of implantation and live births [31]. In men, obesity is associated with hormonal imbalances, including decreased testosterone levels, reduced sperm quality, and impaired spermatogenesis. Campbell conducted a systematic review



demonstrating that paternal obesity negatively affects reproductive outcomes, including reduced sperm concentration and motility [32]. The relationship between obesity, MetS, and infertility is further exacerbated by inflammation and oxidative stress. Adipose tissue in obesity produces inflammatory cytokines that impair ovarian and endometrial function, reducing implantation potential. Moreover, MetS—a cluster of conditions including hypertension, dyslipidemia, and insulin resistance—further compounds these issues, increasing the likelihood of infertility, particularly in women with PCOS [33]. Intervention studies suggest that weight loss through lifestyle modifications significantly improves fertility outcomes. Best found that weight reduction in obese women restores ovulation and enhances live birth rates and pregnancy. Similarly, lifestyle changes in men have been associated with improved sperm parameters and hormonal profiles [34].

Stress and Psychological Factors:

Chronic stress can lead to hormonal changes that negatively affect fertility. A study by Domar explores the relationship between stress and infertility, emphasizing the physiological effects of stress on reproductive health [35]. Chronic stress is a key factor influencing infertility through its effects on both physiological and psychological processes. Initiation of the hypothalamic-pituitary-adrenal (HPA) axis during stress results in higher levels of cortisol and corticotropin-releasing hormone (CRH). These stress-related hormones can disrupt the hypothalamic-pituitary-gonadal (HPG) axis, leading to hormonal imbalances that impair reproductive function. For women, stress has been linked to irregular menstrual cycles, a lack of ovulation, and reduced ovarian performance [36]. For men, prolonged stress has been linked with inferior testosterone levels, diminished sperm production, also poorer sperm quality, including reduced motility and concentration [37]. The emotional strain of infertility often amplifies stress levels, creating a cycle that further impacts reproductive health. Research has shown that individuals experiencing chronic psychological distress are less likely to conceive, especially those undergoing assisted reproductive technologies (ART). Stress can damage ovary's response, reduce the possibility of successful establishment, and contribute to higher rates of successful fertility issues treatment [38]. If we introduce stress management in fertility care, it will give us batter result and also reduce the infertility issues. Psychological interferences such as mental-behavioral therapy, mindfulness practices, and support groups have been proven to be helpful in reducing stress and improving mental well-being in peoples having fertility issues. Researches show that reduced stress levels with these methods are related with increased chances of pregnancy, highlighting the need for adding psychological support into fertility treatment [39]. Stress for longer period associated with both biological and emotional reasons is a major cause of infertility. Techniques used to control hormonal imbalance and emotional distress is very important in reducing fertility issues and proper planning an effective treatment plan. Implanting these strategies not only control mental health but also reproductive health and hormonal balance which are responsible for a healthy and successful pregnancy.

ENVIRONMENTAL FACTORS

Exposure to environmental toxins can interrupt endocrine function and may cause to infertility.

Meeker discusses in his research about the effect of environment on reproductive health mainly fertility issues [40]. Toxins found in environment have a negative impact on endocrine glands which are responsible for production of hormones, hormones like LH, FSH, Prolactin, Thyroid which have a significant impact on reproduction. end up causing infertility or fertility issues. Chemicals such as heavy metals, pesticides, industrial solvents, and endocrine-disrupting compounds (EDCs) are increasingly recognized for their adverse effects on fertility. EDCs, including bisphenol A (BPA) and phthalates, mimic or interfere with natural hormones, altering the hypothalamic-pituitary-gonadal (HPG) axis and impacting ovulation, semen production, and hormone regulation. Meeker reported that introduction to phthalates and BPA is related with reduced sperm quality, hormonal imbalances, and lower fecundity in couples attempting conception [41]. Meeker further investigated the impact of persistent organic pollutants (POPs) on reproductive health, finding associations between elevated levels of polychlorinated biphenyls (PCBs) and delayed conception in women. POPs are bio accumulative and can interfere with normal ovarian function, leading to prolonged menstrual cycles and decreased ovarian reserve. The adverse effects are not limited to women; researches have also shown that male exposed to elevated levels of POPs experience reduced sperm motility and DNA fragmentation, further impairing fertility [42]. **Dietary effect on infertility**

Dietary habits significantly influence reproductive health, with specific macronutrients and micronutrients playing crucial roles in maintaining optimal fertility. A well-balanced diet can support hormonal regulation, gamete quality, and overall reproductive function, while dietary imbalances can contribute to infertility.



Macronutrients	Their Roles in Fertility	References
Proteins	 Plant-Based Proteins: Plant-based proteins are abundant in foods like quinoa, chickpeas, lentils, beans, and tofu. In contrast to animal proteins, which are connected to increased risks of anovulation, higher consumption of these proteins is linked to enhanced ovulatory function. Animal Proteins: Moderate consumption of lean meat, fish, and poultry can be beneficial. On the other hand, consuming too much red and treated meat might raise oxidative stress and harm sperm quality. 	[43]
Fats:	 Healthy Fats: Omega-3 fatty acids, which are present in walnuts, flaxseeds, chia seeds, and fatty fish (mackerel, salmon), are known to enhance sperm motility, lower systemic inflammation, and support egg quality. Unhealthy Fats: Trans and saturated fats, which are frequently included in baked goods, fried foods, and processed snacks, have been connected to impaired ovarian function and worse sperm quality. Monounsaturated Fats: Sources such as olive oil, avocados, and nuts promote hormonal health and may enhance fertility outcomes, especially in women undergoing assisted reproductive technologies. 	[44, 45]
Carbohydrates:	 Low Glycemic Level Carbohydrates: A common cause of infertility, PCOS, can be managed with the support of whole grains, legumes, and vegetables, which help balance insulin and blood sugar levels. Refined Carbohydrates: Insulin resistance, hormonal abnormalities, and impaired ovulation can result from high-glycemic meals such as white bread, pastries, and sugary drinks. 	[46]

Table 1: Macronutrients and Their Roles in Fertility

Table 2: Micronutrients and Their Roles in Fertility

Micronutrients	Their Roles in Fertility	References	
Folate (Vitamin B9):	• Found in beans, citrus fruits, broccoli, leafy greens, and fortified cereals. Folate supports healthy ovulation, lowers the incidence of neural tube abnormalities in the early stages of pregnancy, and is necessary for DNA synthesis and cell division.		
Vitamin D:	• Fatty fish (mackerel, salmon), eggs, and fortified dairy products are some of the sources. The development of ovarian follicles, sperm motility, and embryo implantation are all influenced by vitamin D. Vitamin D deficiency is associated with decreased reproductive rates in both men and women.		
Iron:	• Found in red meat, spinach, lentils, and fortified cereals. Adequate iron intake supports ovulation and prevents anovulatory infertility. Women with iron deficiency are at a higher risk of infertility.	[48]	
Zinc:	• Shellfish, beans, entire grains, and pumpkin seeds all contain it. Spermatogenesis, the synthesis of testosterone, and the general quality of sperm depend on zinc. In developing eggs and embryos, it also aids in DNA synthesis.	[49]	
Selenium:	• Found in Brazil nuts, seafood, and sunflower seeds. Selenium acts as an antioxidant, protecting eggs and sperm from oxidative stress, which can impair fertility.		
Antioxidants:	• Vitamin C, which is present in bell peppers, strawberries, and	[50]	



	 citrus fruits, enhances sperm motility and lessens oxidative stress in the reproductive system. Vitamin E: Found in almonds, sunflower seeds, and spinach, it protects the integrity of sperm and egg cells by neutralizing free radicals. 	
Calcium:	• Found in dairy products, fortified plant-based milk, and leafy greens. Calcium supports healthy sperm function and may play a role in ovarian follicle maturation.	[51]
Magnesium:	• Found in nuts, seeds, whole grains, and dark chocolate. Magnesium aids in regulating hormonal balance and may improve menstrual regularity in women with PCOS.	[52]
Iodine:	• Iodide appears in iodized salt as well as dairy products and shellfish. Because thyroid problems affect ovulation and female reproductive cycle performance iodine aids thyroid system health which impacts fertility.	[53]

Impact of Balanced Nutrient Intake on Fertility

When macronutrients and micronutrients work together they help multiple parts of fertility work properly.

• Egg Quality

Different nutrients found in omega-3 fatty acids, antioxidants and vitamin D help to keep eggs healthier.

• Sperm Health

Zinc, selenium and vitamins C and E help improve the number quality and movement of sperm cells.

• Hormonal Regulation

Low-GI carbs, healthy fats and iodine-sized nutrients maintain hormonal balance to help women ovulate and have regular periods.

Element/Factor	Туре	Effect on Fertility	References
Pesticides	Environmental	 May disrupt endocrine function, leading to infertility 	[54, 55]
Heavy Metals	Environmental	• Associated with reduced sperm quality and hormonal imbalance	[56, 57]
Endocrine Disruptors	Environmental	• Can interfere with reproductive hormone levels	[58, 59]
Alcohol	Dietary	 Excessive consumption linked to decreased fertility 	[60, 61]
Caffeine	Dietary	 High intake may affect ovulation and sperm quality 	[62, 63]
Obesity	Dietary	 Linked to hormonal imbalances affecting fertility 	[64, 65]
Omega-3 Fatty Acids	Dietary	May improve reproductive health and fertility outcomes	[66, 67]
Folate	Dietary	• Important for DNA synthesis and may enhance fertility	[68, 69]

Table 3: Environmental and Dietary Elements Affecting Fertility Issues



DISCUSSION

These results confirm that environmental elements and eating habits influence reproduction. Total well-being depends strongly on reproductive health and it experiences effects from both changeable and unchangeable conditions. To handle rising infertility globally we need to grasp all its affecting elements thoroughly. Macronutrients and Micronutrients have a strong effect on reproductive results and dietary selection is a necessary part to maintain hormonal balance and gamete quality. On the other hand, increased intake in saturated fats and refined carbs has been associated to increased insulin resistance and disruption in hormone balance, while food rich in plant based proteins and omega-3 fatty acids are active to uphold ovulatory and sperm health Numerous micronutrients, including zinc, folate, and vitamin D, have been shown to be required for gamete and embryo development, thus they may provide potential benefits of focused nutritional treatments in reproductive care [70]. But, exposures to the environment are becoming a developing problem. All abnormalities in the hypothalamic-pituitary-gonadal axis are related to particulate matter from air pollution, endocrine effecting substances and heavy metals. Some of the symptoms of these disturbances are reduced sperm quality, irregular menstrual periods, and reduced ovarian reserve. Furthermore, exposure to environmental contaminants including phthalates and bisphenol A indicates lines with reproductive health concerns and industrialization [71]. Physiological factors such as age related declines in fertility and polycystic ovarian syndrome (PCOS) are some of the conditions that make things just a little bit more challenging. It is because the oocyte quality and quantity decline with age that we emphasize the importance of fast fertility preservation measures. Similarly, like PCOS has far reaching effects on reproductive health, treating PCOS with a combination of medical treatments and lifestyle changes will go a long way to minimizing those effects [72]. Furthermore, psychological and stress factors play a large part in infertility. The series of events that lead to this becoming is as a result of mental strain and stress induced hormone imbalances [73]. Until now it's been shown that methods such as stress reduction and psychological support can break that pattern and improve fertility results [74]. This is a review which emphasizes on the concept of the need for multidisciplinary approach in infertility treatment. Mental health should be promoted using public health campaigns so that individuals will abstain from environmental exposures, spread awareness about healthy eating habits, etc. To reduce the influence of environmental and dietary factors on fertility, more research is needed on groundbreaking therapies such as bio fortified food and high level of detoxification procedures. By closing this gap, organizations may want to reduce the impact of infertility and make the world a healthier world population.

CONCLUSION

Being infertile is a growing global issue that involves a mixture of diet, environmental factors, physiological condition and psychological status. This review discusses the critical role of nutrition and environmental exposures in reproductive health, implying the special requirement for what kind of intervention. Essential macronutrients and micronutrients in proper dietary choices can help in hormonal regulation, gamete quality as well as in reproductive outcomes. On the contrary, environmental toxins and pollutants continue weakening fertility, and therefore making regulatory measures and public health more stringent. Infertility is both a social and a physiological condition underscored by early detection and tailored treatments due to physiological factors including age related decline in fertility, polycystic ovary syndrome, among other conditions. Chronic stress further adds to problems with hormonal imbalances and reduces fertility potential while stress management and psychological support also play an important part. For managing the multichallenger problem of infertility a multidisciplinary treatment is required. Through joint efforts amongst healthcare providers, academics, research and policymakers, strategies for tackling communicable diseases from the nutritional side, environmental risk mitigation, and stress reduction techniques can be created. Improving reproductive health outcomes should be the goal of future research. Potential creative solutions include bio fortification, enhanced detoxification technologies, and individualized fertility treatments.

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