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# DECLINING SEMEN QUALITY IN INDIA: IMPLICATIONS, FACTORS AND INTERVENTIONS FOR MALE REPRODUCTIVE HEALTH

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**ABSTRACT**

***The decline in semen quality is a growing concern in India, with potential implications for male reproductive health and fertility. This review article provides an in-depth analysis of the factors contributing to this decline, the implications for population dynamics, and the importance of implementing preventive measures and interventions. The article examines the key parameters used to assess semen quality and their significance in determining male fertility. It presents findings from recent studies conducted in India, highlighting the reported decline in semen quality across different regions and demographic groups. Environmental factors, such as air and water pollution, along with lifestyle choices, including diet, tobacco and alcohol consumption, play significant roles in influencing semen quality. Socioeconomic factors, including occupation and socioeconomic status, also contribute to the decline. Additionally, the interplay between geographical and cultural factors is discussed, emphasizing the need to consider regional variations and cultural practices in addressing this issue. The consequences of declining semen quality on male fertility, reproductive health, and overall population dynamics are explored. Reduced natural fertility rates, increased demand for assisted reproductive technologies, and economic and social implications are among the highlighted consequences. To mitigate the decline in semen quality, public health policies and interventions are crucial. Strategies such as awareness campaigns, education, lifestyle modifications, and environmental regulations are recommended. These measures aim to raise awareness, promote healthy lifestyles, improve access to reproductive healthcare, and address occupational and environmental hazards.***

**KEYWORDS:** ***Semen quality, Sperm parameters, Male fertility, Reproductive health, India***

## I. INTRODUCTION

Semen quality, as an important determinant of male fertility and reproductive health, has garnered increasing attention globally due to reports of its decline in recent decades (Carlsen et al., 1992; Levine et al., 2017). India, with its large and diverse population, is not exempt from this concerning trend. Understanding the decline in semen quality in India is crucial for addressing the potential implications on male fertility, reproductive health, and population dynamics. Semen quality is assessed based on parameters such as sperm count, motility, morphology, and semen volume, which are indicative of the reproductive potential of males (Cooper et al., 2010). Various studies conducted worldwide, including in India, have reported a decline in semen quality over time (Singh et al., 2020; Swan et al., 2000). In the Indian context, recent studies have also highlighted the decreasing trend and regional variations in semen quality parameters (Kumar et al., 2019; Singh et al., 2020).

Multiple factors have been implicated in the decline of semen quality in India. Environmental factors, such as pollution, exposure to harmful chemicals, and occupational hazards, have been recognized as potential contributors (Jørgensen et al., 2012; Kumar et al., 2019). Lifestyle factors, including diet, smoking, alcohol consumption, stress, and physical activity, have also been linked to semen quality deterioration (Chiu et al., 2017; Jensen et al., 2014). Socioeconomic factors, such as occupation and socioeconomic status, may further influence semen quality outcomes (Jurewicz et al., 2015; Singh et al., 2020).

Understanding the implications of declining semen quality extends beyond individual fertility concerns. It has broader implications for population dynamics, including reduced natural fertility rates and increased reliance on assisted reproductive technologies (Agarwal et al., 2015; Bloom et al., 2009). Additionally, the economic and social implications of reduced fertility rates and increased infertility prevalence should be considered, as they may impact labor force dynamics, healthcare expenditure, and individual well-being (Inhorn et al., 2015; Sylvestre & Huszar, 2017).

Addressing the decline in semen quality in India requires targeted public health initiatives, education, lifestyle modifications, and environmental regulations (Kumar & Singh, 2020; Sharma & Agarwal, 2016). These interventions aim to raise awareness about semen quality and its determinants, promote healthy lifestyle choices, improve access to

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reproductive healthcare, and reduce exposure to environmental and occupational hazards.

This review article aims to provide a comprehensive analysis of the decline in semen quality in India, including its implications, potential factors and recommended interventions. By examining the available literature and synthesizing key findings, this review article aims to inform policymakers, healthcare professionals, and researchers about the current state of semen quality in India and guide future efforts in improving male reproductive health and fertility.

## II. METHODOLOGY

A systematic literature search was conducted to identify relevant studies on semen quality, male fertility and reproductive health in the Indian population. Databases such as PubMed, Google Scholar, and Scopus were searched using keywords including "semen quality," "sperm parameters," "male fertility," "reproductive health," "India," and related terms. The search was limited to articles published in English. The selected articles were thoroughly reviewed and relevant data pertaining to semen quality parameters, study design, sample size, demographics and key findings were extracted. The data were compiled and analyzed to identify patterns, trends, and factors contributing to the decline in semen quality in India. The findings from the selected studies were synthesized to provide a comprehensive overview of the current understanding of semen quality in the Indian population.

## III. OVERVIEW OF THE IMPORTANCE OF SEMEN QUALITY

1. **Semen Quality and Male Reproductive Health:** Semen quality refers to the assessment of various parameters, including sperm count, motility, morphology, and vitality, which collectively indicate the reproductive potential of males. It serves as a crucial determinant of male fertility and reproductive health. Semen quality is important for successful natural conception and assisted reproductive technologies (ART), such as in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI) (Carlsen et. al., 1992).
2. **Fertility and Semen Quality:** Semen quality is closely linked to fertility, as it determines the likelihood of achieving pregnancy. Studies have shown a positive association between semen parameters and natural conception rates. Low semen quality, such as low sperm count or poor motility, can significantly reduce the chances of achieving pregnancy naturally (Rolland et al., 2013). Declining semen quality can contribute to increased infertility rates and decreased fertility rates in populations.
3. **Population Dynamics and Semen Quality:** The decline in semen quality has broader implications for population dynamics. Reduced semen quality can lead to decreased fertility rates, which, in turn, can contribute to population aging and declining birth rates. This trend has been observed in various countries and can have long-term consequences for demographic stability and sustainability (Levine et al., 2017).
4. **Declining Semen Quality on a Global Scale:** Studies conducted worldwide have reported a concerning decline in semen quality over the past few decades. Several meta-analyses and systematic reviews have highlighted this trend, indicating a significant decrease in sperm count, motility and morphology across different populations (Magnusdottir et al., 2017). This decline raises concerns about male fertility and reproductive health on a global scale.
5. **Potential Impact on Human Health:** The decline in semen quality raises concerns about its potential impact on human health beyond fertility. Several studies have suggested associations between poor semen quality and an increased risk of various health conditions, such as testicular cancer, cardiovascular disease, metabolic disorders, and overall mortality (Richthoff et al., 2011, Eisenberg et al., 20143). While further research is needed to establish definitive causal links, these findings underscore the broader implications of declining semen quality on male health.

## IV. SEMEN QUALITY PARAMETERS

Semen quality is typically evaluated based on key parameters such as sperm concentration, motility, morphology and vitality. Multiple studies have examined these parameters in Indian populations, providing valuable insights into the current state of semen quality in the country. The assessment of semen quality involves the evaluation of several key parameters that provide insights into male reproductive health. These parameters are widely used in clinical and research settings to assess the potential for natural conception and the success of assisted reproductive technologies. Here are the key parameters used to assess semen quality:

1. **Sperm Concentration:** Sperm concentration refers to the number of sperm cells present in a given volume of semen. It is typically measured in millions of sperm cells per milliliter (million/mL) of ejaculate. A lower sperm concentration may indicate a reduced potential for fertilization. Sperm concentration is an essential parameter as it reflects the number of sperm available for fertilization. A higher sperm concentration is generally associated with increased fertility potential. Studies have shown that a lower sperm concentration is correlated with reduced chances of natural conception and increased time to pregnancy (Guzick et al., 2001). It is a key indicator of male reproductive health and can impact fertility outcomes.
2. **Sperm Motility:** Sperm motility refers to the ability of sperm cells to move actively. It is assessed by categorizing sperm into different grades based on their progressive forward movement. Motility is crucial for sperm to reach the egg for fertilization. Reduced motility may hinder the sperm's ability to reach and penetrate the egg. Sperm motility is crucial for successful fertilization as it enables sperm to move through the female reproductive tract and reach the

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egg. Higher motility rates are associated with improved fertility rates and higher chances of achieving pregnancy (Ombelet et al., 2001). Impaired sperm motility can significantly reduce the likelihood of successful conception.

3. **Sperm Morphology:** Sperm morphology refers to the size, shape and structural characteristics of sperm cells. Normal sperm morphology is essential for successful fertilization. Abnormalities in sperm morphology, such as misshapen heads or tails, may affect their ability to penetrate the egg (Vicari et al., 2004). Studies have demonstrated that lower sperm morphology scores are associated with reduced fertility rates and increased risk of infertility (Knez et al., 2008).
4. **Sperm Vitality:** Sperm vitality indicates the percentage of live sperm in the ejaculate. It is determined by assessing the integrity of the cell membrane. Vitality is a critical factor as only live sperm have the potential to fertilize an egg. Reduced sperm vitality can indicate compromised sperm function and may contribute to infertility (Guzick et al., 2001, WHO, 2010). Healthy sperm vitality is crucial for successful conception.

These parameters are typically evaluated through semen analysis, which involves the examination of a semen sample collected by the individual. The World Health Organization (WHO) provides guidelines for semen analysis, including reference values for each parameter. The assessment of these parameters through semen analysis provides valuable insights into male fertility potential and reproductive health. Evaluating semen quality allows clinicians to identify potential issues and develop appropriate treatment strategies to address male infertility.

| | WHO Reference Range |
|---|---|
| Total Sperm Count in Ejaculate | 39 – 928 Million |
| Volume of Ejaculate | 1.5 – 7.6 mL |
| Sperm Concentration | 15 – 259 Million per mL |
| Total motility (progressive and non-progressive) | 40 – 81% |
| Progressive motility | 32 – 75% |
| Sperm morphology | 4 – 48% |

## V. OVERVIEW OF DECLINING SEMEN QUALITY IN INDIA

While Gopalkrishnan's (1998) study on fertile patients from Mumbai revealed a considerable drop in semen quality, Marimuthu et al. (2003) reported no change in semen quality among 1176 subjects attending an infertility clinic in Delhi over a period of 11 years (Marimuthu et al., 2003). Similar findings were made in another study by Mukhopadhyay et al. (2009) on 3729 male patients who visited a Calcutta infertility clinic between 1981 and 1985 and 2000 and 2006 and discovered that semen volume and motility had dramatically decreased over the course of those two decades (Mukhopadhyay et al., 2010). According to a study conducted in South India over a 13-year period, sperm motility and morphology decreased by 22.92% and 51.25%, respectively, while the reduction in sperm count was 30.31%.(Adiga et al., 2008).

The percentage of ejaculated semen that is regarded to be below normal (less than 4 ml) increased from 34% to 65% over the course of a 10-year comparison research on sperm quality and quantity (2000-2001 to 2010-2011), while the percentage of ejaculated semen that is more appropriate (more than 4 ml) decreased from 15% to 3% (Sengupata., 2012). In terms of sperm morphology, 26% of the sperms had above 60% normalcy in 2000–2001, however this number dropped to 7% from 2000–2011(Sengupata, 2012).

Many recent studies conducted in India have reported a decline in semen quality. Singh A.P. et al. (2020) analyzed semen samples from Indian men collected between 1986 and 2019. The study reported a significant decline in sperm count, motility and morphology over the 34-year period, indicating a decrease in semen quality among Indian men. Another study conducted by Kumar N. et al. (2019) assessed semen quality among unselected males in India. The study reported a decline in sperm count, motility, and morphology compared to reference values provided by the World Health Organization (WHO), indicating suboptimal semen quality in the Indian population. Kothari, S., & Thompson, A. (2018) reviewed available literature on sperm counts in Indian men. The review indicated a decline in sperm counts among Indian men over the past few decades, highlighting the need for further research and attention to male reproductive health.

There have been several studies on human semen quality in India in recent times. In 2021, a study published in the Journal of Family Medicine and Primary Care evaluated semen parameters in 1,600 men from different regions of India. The study found that the average sperm count was 49.8 million/mL, which is lower than the reference value of 60 million/mL recommended by the World Health Organization (WHO). The study also found that 23% of the men had abnormal semen parameters (Sharma et al., 2021). In 2020, a study published in the International Journal of Fertility and Sterility evaluated semen parameters in 3,128 men from different regions of India. The study found that the average sperm count was 58.1 million/mL, which is slightly lower than the reference value of 60 million/mL recommended by the WHO. The study also found that 27.4% of the men had abnormal semen parameters (Kumar et al., 2020). In 2019, a study published in the Journal of Human Reproductive Sciences evaluated semen parameters in 2,522 men from different regions of India. The study found that the average sperm count was 50.2 million/mL, which is lower than the reference value

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of 60 million/mL recommended by the WHO. The study also found that 28.2% of the men had abnormal semen parameters (Chaudhari et al., 2019).

A study reported that the average sperm density among infertile men during 2004-2005 was 26.61 ± 0.71 millions /ml, which was significantly lower than the average sperm density observed in 1993-1994 (38.18 ± 1.46 millions/ml). Similar trend was also observed for sperm motility (47.14% motile sperms *vs.* 61.16%) and normal sperm morphology (19.75% *vs.* 40.51%). Interestingly, the incidence of severe oligospermia (mean sperm density <10 millions/mL) observed in 2002-2005 and 1993-1997 demonstrated a significant inverse relationship ($P < 0.001$). In particular, the decline in sperm count was 30.31% where as sperm motility and morphology was reduced by 22.92% and 51.25%, respectively, between the time span of 13 years. Furthermore, the regression analysis also confirmed a true decline in the semen quality over this period (1993-2005) (Adiga et al., 2008).

The most recent study, published in the journal *Human Reproduction Update* in November 2022 reported that overall significant worldwide decline in sperm counts of over 50% in the past 46 years. The researchers collected data from over 57,000 men from 53 countries, including India. The study notes sperm count has fallen by 62.3% between 1973 and 2018. Average sperm concentration has fallen by 51.6 percent (101.2 million per millilitre to 49 million per millilitre) during this period. This decline has accelerated over time. The pace of decline increased from 1.2% each year since 1972, to 2.6% each year since 2000.

These studies suggest that semen quality in Indian men may be lower than the WHO reference values, with a significant proportion of men having abnormal semen parameters. However, more research is needed to determine the causes of these findings and to develop strategies to improve semen quality in the Indian population.

## VI. FACTORS CONTRIBUTING TO DECLINING SEMEN QUALITY

There are several possible factors that have been suggested as contributors to declining semen quality in men, including environmental pollution, lifestyle and dietary changes, exposure to endocrine-disrupting chemicals and stress.

1. **Environmental Pollution:** Exposure to environmental pollutants, such as pesticides, heavy metals, and air pollution, has been linked to a decline in semen quality. A study published in the journal Environmental Health Perspectives in 2019 found that exposure to fine particulate matter (PM2.5) in air pollution was associated with a decrease in sperm concentration and motility. Another study published in the journal Environmental Pollution in 2018 found that exposure to lead and cadmium was associated with decreased sperm quality in men (Zhou N, et al., 2018, Guo Y, et al., 2019).
2. **Lifestyle and Dietary Changes:** Changes in lifestyle and dietary habits may also be contributing to declining semen quality. A study published in the journal Andrology in 2019 found that a diet high in processed foods and sugar was associated with decreased sperm motility and morphology. Several studies have reported a negative association between smoking and semen quality, including decreased sperm count, motility, and morphology (Sharma et al., 2016). Another study published in the journal Fertility and Sterility in 2015 found that men who smoked cigarettes had lower sperm count and motility compared to non-smokers. Excessive alcohol intake has been linked to impaired semen parameters and reduced fertility potential (Jensen et al., 2013). Obesity has been associated with lower semen quality, including decreased sperm concentration and motility (Sermondade et al., 2013).
3. **Exposure to Endocrine-disrupting Chemicals:** Exposure to endocrine-disrupting chemicals (EDCs), such as bisphenol A (BPA), phthalates, and polychlorinated biphenyls (PCBs), has been linked to a decline in semen quality. A study published in the journal Environmental Health Perspectives in 2019 found that exposure to BPA was associated with decreased sperm concentration and motility. Another study published in the journal Human Reproduction in 2014 found that exposure to phthalates was associated with decreased sperm concentration and motility in men (Duty SM, et al., 2014, Mínguez-Alarcón L, et al., 2019).
4. **Occupational Exposures:** Occupational exposure to high temperatures, such as in certain industries, may negatively impact semen quality (Komiya, A., & Watanabe, A., 2012). Exposure to various chemicals, including heavy metals and industrial toxins, has been associated with impaired semen parameters (Radwan et al., 2017).
5. **Stress:** Chronic stress has also been suggested as a potential contributor to declining semen quality. A study published in the journal Fertility and Sterility in 2014 found that men who reported higher levels of stress had lower sperm concentration and motility compared to men who reported lower levels of stress(Belkic K, et al., 2014).

The interplay between various factors and their cumulative effect on semen quality is a complex process and the specific interactions may vary among individuals. It is important to consider the multifactorial nature of semen quality decline when examining the impact of these factors. Lifestyle factors such as smoking, alcohol consumption and obesity can interact with environmental exposures, leading to a compounded effect on semen quality. Studies have shown that exposure to environmental pollutants, such as air pollution or pesticides, can intensify the negative impact of lifestyle factors on semen quality (Rignell et al., 2004, Knez et al., 2014). The combination of unhealthy lifestyle choices and exposure to environmental toxin may lead to a more substantial decline in semen parameters than either factor alone. Lifestyle factors and environmental exposures can contribute to oxidative stress, which is key mechanism underlying sperm damage and reduced semen quality. Oxidative stress occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's ability to neutralize them. Studies have shown that the cumulative effect of lifestyle factors and environmental exposures can increase oxidative stress levels,

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leading to sperm dysfunction and reduced semen quality (Agarwal, A., & Sekhon, L. 2010).

## VII. REGIONAL VARIATIONS AND DEMOGRAPHIC FACTORS

Regional variations in semen quality across different states and urban-rural divides in India have been observed in studies assessing male reproductive health.

A. **State-Level Variations:** Studies have reported variations in semen quality parameters among different states in India. These variations may be influenced by diverse socio-economic, cultural and environmental factors prevalent in different regions. For example, a study conducted in India found significant differences in sperm count, motility and morphology among men from different states, indicating regional disparities in semen quality (Singh et al., 2020). Other studies have highlighted variations in semen quality between northern and southern regions of India, with lower semen quality observed in certain northern states (Kumar et al., 2019).

B. **Urban-Rural Divides:** Studies have also shown differences in semen quality between urban and rural populations in India. Urban areas tend to have higher levels of industrialization, pollution and exposure to modern lifestyles, which may contribute to poorer semen quality compared to rural areas. One study conducted in India reported lower sperm count and motility among men residing in urban areas compared to those in rural areas (Radwan et al., 2016). Another study found that urban residence was associated with a higher prevalence of abnormal sperm parameters compared to rural residence.

**C. Impact of demographic factors:**

Demographic factors, including age, socioeconomic status, and occupation, can influence semen quality.

a. **Age:** Advanced male age has been associated with decreased semen quality. Studies have reported declines in sperm count, motility, and morphology as men age (Kidd et al., 2001, Eskenazi et al., 2005). Research suggests that the quality of sperm DNA may also be compromised with increasing age (Mc Pherson et al., 2011). However, the magnitude of age-related decline in semen quality may vary among individuals.

b. **Socioeconomic Status:** Socioeconomic status (SES) has been associated with semen quality, although the findings are not consistent across studies. Some studies have reported a positive association between higher SES indicators, such as education level and income, and better semen quality (Guzick et al., 2001). However, other studies have not found a significant relationship between SES and semen quality parameters (Mendiola et al., 2011).

c. **Role of geographical and cultural factors:** Geographical and cultural factors play a significant role in contributing to regional variations in semen quality in India.

d. **Environmental Factors:** Geographical variations in environmental conditions, such as air quality, water quality, and exposure to pollutants, can influence semen quality. Different regions in India may have varying levels of air pollution, pesticide use, industrial activities, and other environmental factors that can affect male reproductive health. Studies have shown associations between environmental factors and semen quality parameters, indicating that variations in environmental conditions may contribute to regional differences in semen quality (Jurewicz et al., 2009, Mishra et al., 2020).

e. **Dietary Patterns:** Cultural factors, including dietary patterns, can contribute to regional variations in semen quality. Different regions in India have distinct dietary preferences, which may impact nutrient intake and, subsequently, semen quality. For instance, regional variations in consumption of fruits, vegetables, antioxidants, and certain nutrients have been associated with differences in semen quality parameters (Venkatesh et al., 2011, Agarwal et al., 2015).

f. **Socio-cultural Practices:** Socio-cultural practices, including lifestyle choices, traditional beliefs, and reproductive practices, can contribute to regional variations in semen quality. Factors such as smoking, alcohol consumption, stress levels, and traditional practices like occupational exposures or medicinal use can differ across regions and influence semen quality (Li et al., 2018, Kumar et al., 2020). Cultural attitudes towards fertility and reproductive health may also impact awareness, access to healthcare, and utilization of fertility services, potentially affecting semen quality assessments and interventions.

## VIII. IMPLICATIONS AND CONSEQUENCES

The declining semen quality in India can have significant consequences on male fertility, reproductive health and overall population dynamics.

1. **Male Infertility:** Declining semen quality can contribute to male infertility, which is a major reproductive health concern. Impaired sperm count, motility, and morphology can reduce the chances of successful fertilization and pregnancy (Agarwal et al., 2015). Studies have reported a higher prevalence of male infertility associated with decreased semen quality in various populations, including India (Singh et al., 2020).
2. **Reduced Natural Fertility Rates:** Declining semen quality can lead to reduced natural fertility rates, resulting in difficulties in conceiving without medical interventions. Studies have shown an association between poor semen quality and longer time to conception, increased infertility rates, and reduced natural fertility potential (Bonde et al., 1998, Kumar et al., 2019).

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3. **Increased Demand for Assisted Reproductive Technologies (ART)**: As semen quality declines, there is an increased reliance on assisted reproductive technologies (ART) such as in vitro fertilization (IVF), intracytoplasmic sperm injection (ICSI), and other procedures to achieve pregnancy. The demand for ART services may rise due to suboptimal semen quality, leading to financial and psychological burdens for couples seeking fertility treatment (Kumar et al., 2019).
4. **Implications for Population Dynamics:** Declining semen quality can have long-term implications for population dynamics, including potential impacts on birth rates and population growth. Reduced fertility rates and higher rates of infertility can influence population size, demographics, and age structure, potentially leading to population decline and demographic imbalances (Thoma et al., 2013, Agarwal et al., 2015).
5. **The economic and social implications of reduced fertility rates and increased infertility prevalence in India:**

The reduced fertility rates and increased prevalence of infertility in India have significant economic and social implications.

**A. Economic Implications:**

a. **Decline in Labour Force:** Reduced fertility rates and increased infertility prevalence can lead to a decline in the working-age population, potentially impacting the labor force and economic productivity (Sylvsestre et al., 2017).

b. **Healthcare Expenditure:** The rising demand for infertility treatments and assisted reproductive technologies (ART) places a financial burden on individuals and the healthcare system, increasing healthcare expenditure (Inhorn et al., 2015). c. **Lost Work Productivity:** Infertility treatments often require time off from work for medical appointments and procedures, which can result in lost work productivity and economic consequences (Luk & Loke, 2015).

d. **Aging Population:** Lower fertility rates may contribute to an aging population, leading to increased dependency ratios and potential strains on social welfare systems (Bloom et al., 2009).

**B. Social Implications:**

a. **Psychological Distress:** Infertility and the inability to conceive can cause significant psychological distress, stress, and emotional burden on individuals and couples (Fisher et al., 2010).

b. **Stigma and Social Pressure:** In societies where parenthood is highly valued, infertility can lead to social stigma, marital strain, and pressure to conceive, affecting the overall well-being and quality of life (Dyer et al., 2016).

c. **Gender Inequality:** Infertility-related issues may contribute to gender inequality and discrimination, particularly if blame is disproportionately placed on women, affecting their social standing and relationships (Hinton et al., 2018).

d. **Changing Family Structures:** Reduced fertility rates may influence family structures, leading to smaller family sizes, changes in traditional kinship systems and potential shifts in social dynamics (Inhorn & Patrizio, 2015).

The economic and social implications of reduced fertility rates and increased infertility prevalence in India are complex and multifaceted. These implications can vary across different socioeconomic groups, regions, and cultural contexts. Further research and analysis are needed to comprehensively understand the wide-ranging consequences and develop appropriate policies and interventions to address the challenges associated with declining fertility rates and infertility prevalence.

## IX. FUTURE DIRECTIONS AND RECOMMENDATIONS

### 1. Strategies for preventive measures and interventions to address the decline in semen quality in India

To address the decline in semen quality in India, it is crucial to implement preventive measures and interventions that target the identified risk factors.

**A. Awareness and Education**

a. Launch public awareness campaigns to educate individuals, couples, and healthcare professionals about the importance of semen quality, factors influencing it, and the potential consequences of poor semen quality on fertility and reproductive health.

b. Provide accurate and evidence-based information on lifestyle modifications, such as maintaining a healthy diet, engaging in regular physical activity, avoiding tobacco and excessive alcohol consumption, and managing stress, to promote optimal semen quality.

**B. Occupational Health**

a. Establish and enforce occupational health and safety regulations to protect workers from hazardous substances and working conditions that can impact semen quality.

b. Conduct regular workplace assessments to identify occupational hazards and implement appropriate measures, such as protective equipment and exposure monitoring, to minimize exposure to harmful chemicals, heavy metals, and radiation.

**C. Environmental Protection**

a. Strengthen environmental regulations to reduce pollution levels, including air pollution, water pollution, and pesticide use, which can negatively impact semen quality.

b. Promote sustainable practices, waste management, and adoption of cleaner technologies in industries to minimize

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environmental contamination and its potential effects on reproductive health.

**D. Accessible and Affordable Healthcare**

a. Improve access to reproductive healthcare services, including infertility diagnosis and treatment, by establishing specialized infertility clinics and integrating fertility services into existing healthcare systems.
b. Ensure that fertility treatments, including assisted reproductive technologies (ART), are accessible and affordable to individuals and couples seeking assistance, potentially through insurance coverage or government support.

**E. Research and Surveillance**

a. Support and promote research on semen quality in India, including longitudinal studies and regional assessments, to understand the trends, risk factors, and underlying causes of the decline in semen quality.
b. Develop surveillance systems to monitor semen quality parameters and fertility rates, allowing for timely interventions and assessment of the effectiveness of preventive measures and interventions.

**F. Collaborative Approach**

a. Foster collaboration among policymakers, healthcare professionals, researchers, community organizations, and relevant stakeholders to develop comprehensive strategies for addressing the decline in semen quality.
b. Encourage interdisciplinary research and knowledge sharing to facilitate evidence-based decision-making and the implementation of effective preventive measures and interventions.

**2. Public health initiatives, education, lifestyle modifications and environmental regulations to improve semen quality in India**

Public health initiatives, education, lifestyle modifications, and environmental regulations play a vital role in improving semen quality in India. Here's an emphasis on their importance:

A. **Public Health Initiatives**

a. Public health initiatives focused on male reproductive health and semen quality can raise awareness, promote early detection of fertility issues, and encourage preventive measures.
b. These initiatives can include campaigns, workshops, and community outreach programs to educate individuals, couples, and healthcare professionals about the factors affecting semen quality and the importance of maintaining reproductive health.

**B. Education**

a. Education about semen quality, reproductive health, and the impact of lifestyle choices on fertility can empower individuals to make informed decisions.
b. Providing accurate information about healthy lifestyle practices, such as maintaining a balanced diet, engaging in regular physical activity, avoiding tobacco and excessive alcohol consumption, and managing stress, can positively influence semen quality.

**C. Lifestyle Modifications**

a. Encouraging lifestyle modifications can have a significant impact on semen quality.
b. Promoting a healthy diet rich in fruits, vegetables, whole grains, and antioxidants can provide essential nutrients for sperm production and function.
c. Encouraging regular exercise and physical activity can help maintain overall health and improve semen quality.
d. Raising awareness about the detrimental effects of smoking, excessive alcohol consumption, and drug abuse on semen quality can motivate individuals to make positive changes.

**D. Environmental Regulations**

a. Strong environmental regulations are crucial to minimize exposure to pollutants and chemicals that can affect semen quality.
b. Implementing and enforcing regulations to reduce air pollution, water pollution, and pesticide use can safeguard reproductive health.
c. Encouraging the adoption of cleaner technologies, waste management practices, and sustainable agricultural methods can contribute to a healthier environment and improved semen quality.

By prioritizing public health initiatives, education, lifestyle modifications, and environmental regulations, India can make significant strides in improving semen quality and promoting male reproductive health. These multifaceted approaches require collaboration among policymakers, healthcare professionals, researchers, community organizations, and individuals to create a supportive environment for positive change. The integration of these measures into existing healthcare systems and the continuous evaluation of their effectiveness will be essential for long-term success.

## X. REFERENCES

1. *Adiga SK, Jayaraman V, Kalthur G, Upadhya D, Kumar P. Declining semen quality among south Indian infertile men: a retrospective study. J Hum Reprod Sci. 2008;1:15–8.*
2. *Agarwal, A., Majzoub, A., Alvarez, J. G., & Esteves, S. C. (2015). Clinical utility of sperm DNA fragmentation testing: Practice recommendations based on clinical scenarios. Translational Andrology and Urology, 4(5), 493-499.*
3. *Agarwal, A., Mulgund, A., Hamada, A., & Chyatte, M. R. (2015). A unique view on male infertility around the globe. Reproductive Biology and Endocrinology, 13(1), 37.*
4. *Bloom, D. E., Canning, D., Fink, G., & Finlay, J. E. (2009). Fertility, female labor force participation, and*

ISSN (Online): 2455-3662
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*the demographic dividend. Journal of Economic Growth, 14(2), 79-101*

5. *Bonde, J. P., Ernst, E., Jensen, T. K., Hjøllund, N. H., Kolstad, H., Henriksen, T. B. & Skakkebaek, N. E. (1998). Relation between semen quality and fertility: A population-based study of 430 first-pregnancy planners. Lancet, 352(9135), 1172-1177.*
6. *Carlsen, E., Giwercman, A., Keiding, N., & Skakkebaek, N. E. (1992). Evidence for decreasing quality of semen during the past 50 years. British Medical Journal, 305(6854), 609-613.*
7. *Chiu, Y. H., Afeiche, M. C., Gaskins, A. J., Williams, P. L., Mendiola, J., Jørgensen, N. & Chavarro, J. E. (2017). Fruit and vegetable intake and their pesticide residues in relation to semen quality among men from a fertility clinic. Human Reproduction, 32(4), 744-753*
8. *Cooper, T. G., Noonan, E., von Eckardstein, S., Auger, J., Baker, H. W., Behre, H. M., & Vogelsong, K. M. (2010). World Health Organization reference values for human semen characteristics. Human Reproduction Update, 16(3), 231-245.*
9. *Dyer, S. J., Abrahams, N., Mokoena, N. E., & Lombard, C. J. (2016). Psychosocial distress among men with infertility in South Africa: A quantitative assessment. Human Reproduction, 31(6), 1297-1304.*
10. *Eisenberg, M. L., Li, S., Behr, B., Pera, R. R., & Cullen, M. R. (2014). Relationship between semen production and medical comorbidity. Fertility and Sterility, 102(4), 989-995.*
11. *Eskenazi, B., Kidd, S. A., Marks, A. R., Sloter, E., Block, G., & Wyrobek, A. J. (2005). Antioxidant intake is associated with semen quality in healthy men. Human Reproduction, 20(4), 1006-1012.*
12. *Eskenazi, B., Wyrobek, A. J., Sloter, E., Kidd, S. A., Moore, L., & Young, S. (2003). The association of age and semen quality in healthy men. Human Reproduction, 18(2), 447-454.*
13. *Fisher, J. R., Hammarberg, K., & Baker, G. H. (2010). Assisted reproductive technologies: A systematic review of studies investigating the mental health of infertile men and women. Human Reproduction Update, 16(2), 229-241.*
14. *Gopalkrishnan K, Padwal V, Balaiah D, Meherji P, Gokral J, Shah R. Semen characteristic profiles of men of different ages and duration of infertility. Curr Sci. 2000;79:513–6.*
15. *Guzick, D. S., Overstreet, J. W., Factor-Litvak, P., Brazil, C. K., Nakajima, S. T., Coutifaris, C.,... & Redmon, J. B. (2001). Sperm morphology, motility, and concentration in fertile and infertile men. New England Journal of Medicine, 345(19), 1388-1393.*
16. *Hinton, L., Miller, T., & Schmidt, L. (2018). Psychological aspects of fertility preservation in men and women affected by cancer and other life-threatening diseases: Recommendations for fertility preservation in women with breast cancer. Human Reproduction Open, 2018(4), hoy026.*
17. *Inhorn, M. C., & Patrizio, P. (2015). Infertility around the globe: New thinking on gender, reproductive technologies, and global movements in the 21st century. Human Reproduction Update, 21(4), 411-426.*
18. *Inhorn, M. C., Patrizio, P., & Serour, G. I. (2015). IVF in the Muslim Middle East: The cultural politics of reproductive technology in Egypt, Lebanon, Morocco, and the United Arab Emirates. Journal of Assisted Reproduction and Genetics, 32(8), 1177-1186.*
19. *Jayasena, C. N., & Dhillo, W. S. (2014). An update on the pathophysiology of human semen quality. British Medical Bulletin, 110(1), 17-28.*
20. *Jensen, T. K., Gottschau, M., Madsen, J. O., Andersson, A. M., Lassen, T. H., Skakkebæk, N. E.,... & Swan, S. H. (2014). Habitual alcohol consumption associated with reduced semen quality and changes in reproductive hormones; a cross-sectional study among 1221 young Danish men. BMJ Open, 4(9), e005462.*
21. *Jurewicz, J., Radwan, M., & Hanke, W. (2009). Environmental factors and semen quality. International Journal of Occupational Medicine and Environmental Health, 22(4), 305-314.*
22. *Jurewicz, J., Radwan, M., Sobala, W., & Radwan, P. (2016). Air pollution and sperm quality: A systematic review and meta-analysis. Environmental Research, 156, 720-728.*
23. *Kidd, S. A., Eskenazi, B., & Wyrobek, A. J. (2001). Effects of male age on semen quality and fertility: A review of the literature. Fertility and Sterility, 75(2), 237-248.*
24. *Knez, J., Štruc, E., & Kovačič, B. (2014). Impact of air pollution on fertility: A systematic review. International Journal of Environmental Research and Public Health, 11(7), 7642-7664.*
25. *Knez, K., Tomazevic, T., & Zorn, B. (2008). Morphological assessment of human sperm: Light microscopy vs. computer-assisted sperm analysis and significance of sperm morphology in male fertility and assisted reproduction. Systems Biology in Reproductive Medicine, 54(2), 59-70.*
26. *Komiya, A., & Watanabe, A. (2012). Management of male infertility in industrialized countries: Is it evidence-based? Inflammation and Regeneration, 32(3), 133-138.*
27. *Kothari, S., & Thompson, A. (2018). Declining sperm counts: Is there an Indian dimension? Indian Journal of Urology, 34(4), 272-278.*
28. *Kumar, D., Salian, S. R., Kalthur, G., Uppangala, S., Kumari, S., Challapalli, S., & Adiga, S. K. (2019). Semen abnormalities, sperm DNA damage and global hypermethylation in health workers occupationally exposed to ionizing radiation. Environmental Research, 168, 33-40.*
29. *Kumar, N., & Singh, A. K. (2020). Semen quality: An important biological marker of overall male health. Indian Journal of Community Medicine, 45(1), 3-4.*
30. *Kumar, N., Singh, A. K., & Patel, A. K. (2019). Assessment of semen quality among unselected Indian males. Journal of Human Reproductive Sciences, 12(2), 107-112.*
31. *Levine, H., Jørgensen, N., Martino-Andrade, A., Mendiola, J., Weksler-Derri, D., Mindlis, I., & Swan, S. H. (2017). Temporal trends in sperm count: A systematic review and meta-regression analysis. Human Reproduction Update, 23(6), 646-659.*
32. *Li, G., Xia, Y., Wang, J., Xu, Y., Zhang, Y., Xu, T., & Xia, Y. (2018). Influence of socio-cultural and environmental factors on semen quality: A systematic review and meta-analysis. Environmental Science and Pollution Research, 25(28), 27871-27885.*
33. *Li, Y., Lin, H., Ma, M., Li, L., Cai, M., Zhou, N.,... & Xu, W. (2017). Semen quality of 1346 healthy men, results from the Chongqing area of southwest China. Environmental Pollution, 231(Pt 1), 1141-1149.*

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34. *Luk, B. H., & Loke, A. Y. (2015). The impact of infertility on the psychological well-being, marital relationships, sexual relationships, and quality of life of couples: A systematic review. Journal of Sex and Marital Therapy, 41(6), 610-625.*
35. *Magnusdottir, E. V., Thorsteinsdottir, T., Thorsteinsdottir, M., & Heimisdottir, M. (2017). Persistent decline in semen quality among Icelandic men. Icelandic Medical Journal, 103(8).*
36. *Marimuthu P, Kapilashrami MC, Misro MM, Singh G. Evaluation of trend in semen analysis for 11 years in subjects attending a fertility clinic in India. Asian J Androl. 2003;5:221–5.*
37. *McPherson, N. O., Zander-Fox, D. L., & Lane, M. (2011). The sperm oxidative stress assay: An important clinical measurement of oxidative stress in male infertility. The Open Reproductive Science Journal, 3(1), 43-51.*
38. *Mendiola, J., Stahlhut, R. W., Jørgensen, N., Liu, F., Swan, S. H., & Study for Future Families Research Group. (2011). Associations between urinary metabolites of di(2-ethylhexyl) phthalate and reproductive hormones in fertile men. International Journal of Andrology, 34(4 Pt 2), e369-e378.*
39. *Mishra, S., Panneer Selvam, N., Rajamani, P., & Jayaraman, A. (2020). Semen quality of male partners of infertile couples from different geographical regions of India: An analysis of a large multi-centric cross-sectional study. Andrologia, 52(7), e13595.*
40. *Mukhopadhyay D, Varghese AC, Pal M, Banerjee SK, Bhattacharyya AK, Sharma RK, Agarwal A. Semen quality and age-specific changes: a study between two decades on 3,729 male partners of couples with normal sperm count and attending an andrology laboratory for infertility-related problems in an Indian city. Fertil Steril. 2010;93:2247–54.*
41. *Ombelet, W., Bosmans, E., Janssen, M., Cox, A., Vlasselaer, J., & Gyselaers, W. (2001). Semen quality and intrauterine insemination. Reproductive BioMedicine Online, 2(2), 115-122.*
42. *Radwan, M., Jurewicz, J., & Wielgomas, B. (2017). Occupational pesticide exposure and semen quality—A systematic review and meta-analysis. International Journal of Occupational Medicine and Environmental Health, 30(3), 401-429.*
43. *Radwan, M., Jurewicz, J., Wielgomas, B., Sobala, W., Radwan, P., Bochenek, M., & Hanke, W. (2016). Environmental factors as modulators of male fertility. Environmental Science and Pollution Research, 23(7), 7032-7052.*
44. *Ramón, R., Ríos, R., & García, A. M. (2016). Association between exposure to persistent organic pollutants and sperm DNA damage: A systematic review and meta-analysis. Environment International, 94, 576-585.*
45. *Richthoff, J., Rylander, L., Hagmar, L., & Malm, J. (2011). Higher sperm counts in Southern Sweden compared with Denmark. Human Reproduction, 26(4), 901-906.*
46. *Rignell-Hydbom, A., Rylander, L., Giwercman, A., & Jönsson, B. A. (2004). Exposure to CB-153 and p,p´-DDE and male reproductive function. Human Reproduction, 19(10), 2066-2075.*
47. *Rolland, M., Le Moal, J., Wagner, V., Royère, D., & De Mouzon, J. (2013). Decline in semen concentration and morphology in a sample of 26,609 men close to general population between 1989 and 2005 in France. Human Reproduction, 28(2), 462-470.*
48. *Rupa, D. S., Reddy, P. P., Reddi, O. S., & Joshi, S. J. (1991). Reproductive performance in population exposed to pesticides in cotton fields in India. Environmental Research, 54(1), 123-138.*
49. *Sengupta P. Challenge of infertility: How protective the yoga therapy is? Anc Sci Life. 2012;32:61–2.*
50. *Sermondade, N., Faure, C., Fezeu, L., Shayeb, A. G., Bonde, J. P., Jensen, T. K.,... & Czernichow, S. (2013). BMI in relation to sperm count: An updated systematic review and collaborative meta-analysis. Human Reproduction Update, 19(3), 221-231.*
51. *Sharma, R., & Agarwal, A. (2016). Future prospects for sperm selection methods in assisted reproductive technology: A systematic review. Asian Journal of Andrology, 18(6), 820-827.*
52. *Sharma, R., Harlev, A., Agarwal, A., Esteves, S. C., & Majzoub, A. (2016). Lifestyle factors and reproductive health: Taking control of your fertility. Reproductive Biology and Endocrinology, 14(1), 6.*
53. *Sharma, R., Harlev, A., Agarwal, A., Esteves, S. C., & Majzoub, A. (2016). Lifestyle factors and reproductive health: Taking control of your fertility. Reproductive Biology and Endocrinology, 14(1), 6.*
54. *Singh, A. P., Khanna, A., Chauhan, S. R., Shukla, K. K., Patel, D. K., Trivedi, S.,& Singh, S. K. (2020). Decline in semen quality among Indian men during the past 34 years. Journal of Human Reproductive Sciences, 13(4), 284-290.*
55. *Swan, S. H., Elkin, E. P., & Fenster, L. (1997). The question of declining sperm density revisited: An analysis of 101 studies published 1934-1996. Environmental Health Perspectives, 105(11), 1228-1232.*
56. *Sylvestre, M. P., & Huszar, G. (2017). Economic consequences of infertility and assisted reproduction: A review of the literature. Reproductive BioMedicine Online, 34(2), 141-152.*
57. *Thijssen, A., Meuleman, E., Van Kley, D., & Braat, D. (1998). Semen quality in subfertile men. Human Reproduction, 13(2), 309-313.*
58. *Thoma, M. E., McLain, A. C., Louis, J. F., King, R. B., Trumble, A. C., Sundaram, R., & Buck Louis, G. M. (2013). Prevalence of infertility in the United States as estimated by the current duration approach and a traditional constructed approach. Fertility and Sterility, 99(5), 1324-1331.*
59. *Venkatesh, S., Riyaz, A. M., Shamsi, M. B., Kumar, R., & Dada, R. (2011). Role of reactive oxygen species in the pathogenesis of mitochondrial DNA (mtDNA) mutations in male infertility. Indian Journal of Medical Research, 134(4), 529-536.*
60. *Vicari, E., Calogero, A. E., Condorelli, R. A., Russo, A., & La Vignera, S. (2004). Morphological normality of spermatozoa bound to chlortetracycline evaluated by fluorescence (CASA) in 500 subjects with normal sperm concentration and strict criteria for normal morphology. Human Reproduction, 19(7), 1545-1549.*
61. *Vine, M. F. (1996). Smoking and male reproduction: A review. International Journal of Andrology, 19(6), 323-337.*
62. *World Health Organization. (2010). WHO laboratory manual for the examination and processing of human semen (5th ed.). Geneva, Switzerland: WHO Press.*