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Infertility and Assisted Reproductive Technology in India: Trends and Impacts

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The global population has undergone a major change, moving from high fertility and high mortality to low fertility and low mortality. This shift, driven by improvements in health, nutrition, medicine, and social awareness, has led to steady population growth, reaching 8 billion in 2022, while fertility rates have declined from around five children per woman in the 1950s to below replacement level. However, the pace of fertility decline is uneven, with some countries experiencing temporary stalls. A national fertility stall refers to a situation in a country where the decline in fertility rates temporarily stops or slows down significantly, often for several years or even decades, before potentially resuming the downward trend. In India, which accounts for about 17% of the world's population, replacement-level fertility (TFR 2.0) was achieved in 2022 without a national fertility stall. Still, infertility affects 3–14% of couples and carries social stigma and psychological impacts. Assisted reproductive technologies (ART), starting with India's first IVF birth in 1978, have grown rapidly, supported by regulations such as the ART (Regulation) Act, 2021, and the National ART and Surrogacy Registry to ensure safe and fair access.At the same time, declining fertility, later marriages, and better employment opportunities for women have changed women's roles. Marriage and motherhood are no longer central, allowing women to participate more in education, careers, and public life. These shifts challenge traditional gender norms and alter relationships between men and women. In conclusion, India's demographic changes, growth of ART, and changing women's roles show how fertility, reproductive health, and gender equality are connected. Understanding these trends is important for shaping policies, improving access to reproductive health services, and supporting social development in a changing society.

Keywords: Global population transition, Fertility decline, Total fertility rate (TFR), National fertility stall, India, Infertility, Assisted reproductive technologies (ART), ART (Regulation) Act 2021, National ART and Surrogacy Registry, Reproductive health, Women's empowerment, Gender roles, Demographic changes, Social development

Introduction

The global population has undergone a major change, moving from high mortality and high fertility to low mortality and low fertility. On 15 November 2022, the world's population reached 8 billion, marking a significant milestone in human history. Over the past two hundred years, population growth has been driven mainly by longer life expectancy, thanks to improvements in public health, nutrition, medicine, and social awareness. In recent decades, although the population continues to grow, the growth rate has slowed from 2.1% per year in 1965–1970 to 1.1% in 2015–2020. This slowdown is largely due to a decline in global fertility rates, which dropped from about five children per woman in 1950–1955 to below the replacement level by 2022. Projections indicate that this trend will continue, with the world population expected to stabilize around 10 billion by 2100 (Pison, 2022)

The fertility transition has been declining across countries for several decades. However, scholars note that the pace of this decline is not uniform across nations. While some countries have experienced a steady and continuous reduction in fertility rates, others have shown periods of stagnation or even temporary increases during their transition. This phenomenon of halted or reversed fertility decline is known as a fertility stall. A review of various studies reveals that many researchers have observed fertility stalls occurring at an average total fertility rate (TFR) of around 3.2, often persisting for more than 30 years. (Pantelides, E. A.,1996).

From a demographic perspective, India represents a critical area of interest for both researchers and policymakers. According to the 2011 Census, India's population stood at 1.21 billion, accounting for approximately 17% of the global population at that time. Data from the Sample Registration System (SRS) indicate that India's total fertility rate (TFR) has been declining, at a gradual pace, and the country successfully reached replacement-level fertility (TFR 2.0) in 2022. In the global context, fertility stalls have posed significant challenges for several countries attempting to reduce fertility levels. However, evidence suggests that India has not experienced a fertility stall at the national level (Bongaarts, 2006).

Social Stigma and the Evolution of Infertility Treatment in India

In India, the estimated prevalence of infertility ranges from 3% to 14% (Ganguly & Unisa, 2010; Sarkar & Gupta, 2016). The Indian Council of Medical Research (ICMR) has estimated that around 20 million couples in India may be affected by infertility at any given time (ICMR & NAMS, 2005). In Indian society, parenthood holds great importance and is often seen as a key purpose of marriage. Therefore, any delay in conception can lead to social stigma and pressure from families, negatively affecting the couple's mental and emotional well-being (De et al., 2017). Moreover, infertility has been linked to poor quality of life, marital problems, anxiety, depression, sexual difficulties, and other psychosocial issues (Dillu et al., 2013; Jisha & Thomas, 2016; Bose et al., 2021).On 3 October 1978, the world's second and India's first in vitro fertilization (IVF) baby, Kanupriya, was born in Kolkata through the pioneering efforts of Dr. Subhas Mukherjee and his team. Mukherjee used gonadotropins for ovarian stimulation, collected oocytes through a transvaginal colpotomy procedure, and achieved pregnancy using a frozen thawed embryo transfer technique (Kumar, 1997). Following this achievement, IVF and embryo transfer (IVF-ET) and gamete intrafallopian transfer (GIFT) programs were initiated at the Institute for Research in Reproduction and the King Edward Memorial (KEM) Hospital in Mumbai, India (Kumar et al., 1988).

Infertility has often been surrounded by stigma and misunderstanding, especially in conservative societies where having children is strongly linked to social status and family expectations. In India, where traditional beliefs about family and reproduction are deeply rooted, infertility still carries a heavy social burden. Looking at the history of fertility issues in India helps us understand how these problems have been seen and managed over time (Rao, 2004; Sharma et al., 2018). Until the early 2000s, very little attention was given to infertility management, and there was limited scientific information about its causes and effects. In the past, India's family planning programs mainly focused on reducing high fertility rather than dealing with infertility (Sarkar & Gupta, 2016).

Legal and Ethical Frameworks Governing ART and Surrogacy in India

India's Pre-Conception and Pre-Natal Diagnostic Techniques (PCPNDT) Act prohibits ART clinics from selecting or providing a child of a predetermined sex, except in cases where such selection is required to prevent or treat sex-linked genetic disorders. Furthermore, the ART (Regulation) Act, 2021 bans commercial surrogacy, allowing only altruistic surrogacy for Indian citizens (Gazette of India, 2021).

The significant disparity in access to assisted reproductive technology (ART) services across the world reflects broader global inequalities in reproductive health and highlights differences in the social position of women (Jain, 2006; Marmot et al., 2010; Chambers et al.,

2013). The use of donor gametes is permitted in cases with medical indications; however, embryo sharing between couples undergoing treatment is not allowed.

The rising rates of infertility in India have been accompanied by a corresponding increase in the number of ART clinics, both in the public and private sectors. Over the past two decades, the country has witnessed rapid growth in the availability of ART services. To ensure transparency and oversight, the National ART and Surrogacy Registry has been established as an online public record system that maintains information on registered ART clinics, banks, and surrogacy centers across India (National ART and Surrogacy Registry, http://registry.artsurrogacy.gov.in).

The National ART and Surrogacy Registry serves as a centralized database of all ART clinics, banks, and surrogacy centers in India. It provides detailed information on the services offered, types of procedures performed, treatment outcomes, and other relevant data. This information is used to inform policy decisions, develop regulatory guidelines, and identify potential research areas in the field of assisted reproduction.

Institutional Framework for ART Governance in India

India has seen a significant increase in ART facilities over the past decade. In 2010, there were approximately 500 ART centers, which grew to 1,500 centers by 2019 (IFFS Surveillance, 2019).

The National ART and Surrogacy Board was established on 4 May 2022 (Government of India Notification No. CG-DL-E-04052022-235539, 2022) as a central advisory body for the Government of India on matters related to assisted reproductive technology. The Board is tasked with reviewing and monitoring the implementation of ART rules and regulations, formulating a code of conduct for personnel working in ART facilities, and setting minimum standards for laboratories, physical infrastructure, and diagnostic equipment. Additionally, it performs other functions as prescribed under the relevant legislation. Indian ART clinics are allowed to provide services to women above 21 years and below 50 years of age and men above 21 years and <55 years of age.

In India, a growing number of assisted reproductive technology (ART) clinics have integrated advanced techniques such as preimplantation genetic testing, artificial intelligence, endometrial receptivity assays, and microfluidics into their clinical programs. Despite their increasing use, the scientific evidence supporting the clinical efficacy and safety of many of these in vitro fertilization (IVF) add-on procedures remains limited (Mahajan, 2015; Selvaraj et al., 2016; Kotdawala et al., 2019). In response to these concerns, professional bodies have developed guidelines to promote the judicious and evidence-based application of add-on technologies in ART cycles (Malhotra et al., 2021).

Technological Progress and Economic Challenges in ART

Access to advanced fertility preservation techniques, such as ovarian tissue cryopreservation, remains confined to a limited number of specialized centers across the country (Salama et al., 2020). Furthermore, emerging methods including non-invasive metabolomic screening of embryos (Jijo et al., 2022) and immature testicular tissue cryopreservation for pediatric oncology patients are currently being investigated within research settings (Tholeti et al., 2024). These developments highlight the rapid technological evolution of ART practices in India while emphasizing the necessity for ongoing evaluation of their clinical utility, ethical considerations, and regulatory oversight.

The financial burden associated with assisted reproductive technology (ART) remains a major barrier to access in India. The cost of undergoing a single ART cycle is estimated to exceed the average annual income of a patient by approximately 166.4% (Njagi et al., 2023). Despite these financial constraints, many couples who begin treatment are unable to continue after the first in vitro fertilization (IVF) cycle when multiple attempts are medically indicated (Kulkarni et al., 2014). Recognizing this challenge, a few centers have undertaken initiatives to make ART services more affordable by reducing the costs associated with ovarian

stimulation, diagnostic testing, and IVF procedures, while maintaining clinical quality and standards of care (Aleyamma et al., 2011).

Conclusion

India's demographic and reproductive health landscape has evolved remarkably over the past decades, reflecting broader global transitions from high to low fertility and mortality. The nation's achievement of replacement-level fertility without experiencing a national fertility stall signifies substantial progress in population stabilization. However, this demographic success coexists with rising infertility rates, which continue to carry deep social and psychological implications, particularly in a cultural context where parenthood remains central to social identity.

The introduction and expansion of assisted reproductive technologies (ART) have revolutionized infertility treatment in India, offering new hope to affected couples. Legislative measures such as the **ART (Regulation) Act, 2021**, the **Surrogacy (Regulation) Act**, and the **PCPNDT Act** represent significant steps toward ensuring ethical, safe, and transparent practices in reproductive medicine. The establishment of the **National ART and Surrogacy Board** and the **National ART and Surrogacy Registry** further strengthens institutional governance, facilitating accountability and evidence-based policymaking.

Technological innovation in ART, including preimplantation genetic testing, artificial intelligence applications, and fertility preservation techniques, marks a new phase in India's reproductive health system. Nevertheless, these advancements raise critical ethical and regulatory considerations and highlight ongoing inequalities in access to care. The high cost of ART procedures, which often exceeds the average annual income of patients, remains a formidable barrier, underscoring the urgent need for affordable and inclusive reproductive healthcare models.

In conclusion, India stands at a pivotal juncture where demographic stability, technological advancement, and social transformation intersect. Future efforts should focus on **balancing innovation with accessibility**, **strengthening ethical and regulatory oversight**, and **addressing socioeconomic disparities** in ART services. A holistic approach integrating policy, technology, and public health perspectives will be vital to ensuring that reproductive technologies contribute not only to individual well-being but also to the broader goals of gender equality, social justice, and sustainable population development.

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