Infertility: A growing global epidemic

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Abstract:

Infertility is increasingly recognised as a serious global public-health concern rather than a private or couple-level problem. Current estimates from the World Health Organization indicate that approximately **one in six adults worldwide**, or about 17.5%, will experience infertility during their lifetime (World Health Organization, 2023). Recent Global Burden of Disease analyses further suggest that female infertility has increased significantly, with global cases rising to **110 million in 2021**, showing an approximate 84% increase since 1990 (Sun et al., 2025). The rise is consistent across both high-income and low-income regions, although disparities in access to healthcare and infertility treatment remain evident (Li et al., 2025).

Multiple factors contribute to this upward trend, including delayed age at first pregnancy, increased exposure to environmental endocrine-disrupting chemicals, higher prevalence of obesity, smoking, excessive alcohol use, and untreated reproductive tract infections, which remain a major cause particularly in low-resource settings (Zegers-Hochschild et al., 2022; Li et al., 2025). Social stigma, limited awareness, high treatment costs, and inequality in access to assisted reproductive technologies (ART) further exacerbate the burden, creating emotional, psychological, and financial distress for affected individuals and couples (Sun et al., 2025).

With declining fertility rates and increasing dependence on ART globally, infertility is now more broadly understood as a public health priority rather than an individual issue. Effective strategies to address this emerging global epidemic must include prevention through lifestyle modification, improved screening, strengthened reproductive health systems, public education, and equitable access to treatment and policy support (World Health Organization, 2023). Without coordinated international action, the prevalence of infertility is projected to continue rising alongside demographic, environmental and lifestyle shifts (Li et al., 2025; Sun et al., 2025).

Keywords:

Infertility, global burden, prevalence, prevention, reproductive health.

1. Introduction:

Infertility is most commonly described as the inability to conceive after one year of consistent, unprotected sexual intercourse (Zegers-Hochschild et al., 2017). It is now recognised as a global public-health concern, affecting an estimated **186 million people worldwide** (Mascarenhas et al., 2012). The World Health Organization reports that approximately **17% of the global population** will experience infertility at some point, with prevalence remarkably similar across different national income levels: 17.8% in high-income countries and 16.5% in low- and middle-income countries (World Health Organization, 2023).

Global demographic shifts further highlight the growing concern. China, classified as a high-middle SDI (0.719) country and the world's most populous developing nation, has experienced a sharp rise in infertility rates alongside declining fertility trends and an ageing population. According to a landmark Lancet report, the incidence of infertility in China increased from 12% in 2007 to 18% in 2020 (Zhang et al., 2020). Parallel patterns are observed in the United States, where data from the National Survey of Family Growth found that 6% of married women aged 15–44 experience infertility and 12% present with reduced reproductive potential (CDC, 2012).

The consequences of infertility extend beyond biological limitations and affect multiple dimensions of life. Individuals and couples often report significant emotional strain, relationship conflict, and feelings of stigma or isolation (Greil et al., 2010). These psychological burdens intensified during the COVID-19 pandemic, during which disruptions to medical services and heightened uncertainty led to increased anxiety, depression, and treatment delays among patients seeking fertility care (Boivin et al., 2020; Vaughan et al., 2021).

Economic barriers further compound the issue. In many regions, particularly in parts of Africa and Southeast Asia, the cost of Assisted Reproductive Technology (ART) may exceed **double the GDP per capita**, creating significant inequity in access (Dyer et al., 2019). Even in wealthier nations, delayed parenthood has driven demand for fertility services, raising concerns about the long-term sustainability of reproductive healthcare systems (Sullivan et al., 2021). For those without insurance or public funding, the financial strain of treatment—often coupled with reduced work productivity due to stress—can deepen socioeconomic vulnerability (Patel et al., 2018; Pedro et al., 2020).

A clear understanding of infertility trends is required to guide public-health planning and policymaking. While earlier research analysing infertility trends has relied on previous versions of the Global Burden

of Disease (GBD) database, many of those studies examined only male or female infertility in isolation or lacked methodological depth (Larsen et al., 2020; Hsiao et al., 2021). The present study utilises the **GBD 2021** dataset, offering the most comprehensive global analysis to date and incorporating advanced analytical approaches such as frontier analysis and decomposition modelling.

Forecasting within GBD varies depending on disease characteristics, available data, methodologies and anticipated policy impacts (Murray et al., 2020; Foreman et al., 2021). Because infertility responds relatively quickly to public-health initiatives—such as awareness campaigns, subsidised treatment, or preventive care—short-term forecasting may better capture rapidly shifting reproductive behaviours and access patterns (Hou et al., 2022).

This work aims to assess the epidemiology of infertility across global regions, gender groups, and socioeconomic settings from 1990 to 2021. The findings provide essential evidence for strengthening preventive strategies, improving access to fertility support services, and informing public-health policy frameworks. Ultimately, the results support global efforts to address the rising burden of infertility and improve reproductive health equity worldwide.

2. Methodology:

This study utilised data extracted from the **Global Burden of Disease (GBD) 2021 database**, developed by the Institute for Health Metrics and Evaluation (IHME). The GBD framework provides a comprehensive and standardised methodology to estimate disease burden across countries, age groups and time periods, making it suitable for analysing long-term infertility trends (Murray et al., 2020). The dataset includes fertility-related indicators such as prevalence, incidence and disability-adjusted life years (DALYs), enabling both descriptive and comparative assessment across demographic and geographic contexts (Foreman et al., 2021).

2.1. Study population and time frame:

The analysis focused on global infertility estimates from **1990 to 2021**, covering both male and female populations aged 15–49 years, consistent with WHO reproductive-age classifications (WHO, 2023). Countries were stratified by **Socio-Demographic Index (SDI)** levels—low, low-middle, middle, high-middle and high-income—to evaluate disparities associated with socioeconomic development (IHME, 2022).

2.2. Definition and measurement of infertility:

Infertility was defined in alignment with established clinical guidelines as the inability to achieve pregnancy after 12 or more months of regular unprotected intercourse (Zegers-Hochschild et al., 2017). Data capturing primary and secondary infertility were included where available. GBD modelling

incorporates multiple data sources including household surveys, national health records, population-based surveys, clinical registries and peer-reviewed literature (Larsen et al., 2020).

2.3. Data and statistics analysis:

Data were analysed using the **GBD standardised modelling framework**, primarily employing the Cause of Death Ensemble Model (CODEm) and DisMod-MR 2.1, a Bayesian meta-regression tool widely used for epidemiological estimation (Vos et al., 2020). Age-standardised prevalence rates (ASPRs) were calculated using the GBD global standard population to allow comparison across countries and years, independent of demographic differences (IHME, 2022).

Temporal trends were assessed using **Joinpoint Regression**, allowing identification of significant changes in burden trajectories over time (Hou et al., 2022). Geographic patterns were visualised using choropleth mapping techniques. Additionally, **frontier analysis** was applied to evaluate relationships between healthcare access, SDI levels and infertility outcomes, while **decomposition analysis** quantified the contribution of demographic drivers such as ageing, population growth and behavioural risk factors (Foreman et al., 2021).

2.4. Forecast modelling:

Short-term forecasting was performed using time-series projection methods adapted from the GBD forecasting architecture. Predictions accounted for demographic changes, healthcare coverage, environmental exposures and anticipated public-health intervention impacts (Murray et al., 2020). Forecast uncertainty was quantified using **95% uncertainty intervals (UI)**.

2.5. Ethical considerations:

As this study involved secondary analysis of publicly accessible, anonymised global epidemiological data, no ethical approval was required. The analysis adhered to IHME data-use requirements and followed accepted research integrity standards.

2.6. Causes:

Evidence from previous studies suggests that infertility in women is often linked to underlying reproductive system disorders, including ovulation dysfunction, anatomical abnormalities, and conditions such as endometriosis or fallopian tube obstruction (Homburg, 2019). Additional uterine abnormalities—including congenital malformations, fibroids, adhesions, and endometrial polyps—may further impair implantation and reduce fertility potential (Bulletti et al., 2010).

Male infertility, conversely, is frequently associated with semen abnormalities, reproductive tract infections, and sexual dysfunction such as erectile or ejaculatory disorders (Agarwal et al., 2015). Hormonal irregularities may also contribute to infertility by interrupting the ovulatory cycle and impairing natural conception. Certain medical interventions, including targeted cancer therapies, have been shown to alter hormone levels or damage reproductive anatomy, raising concerns regarding fertility

preservation in younger cancer patients (Oktay et al., 2018). Disparities remain in clinical management approaches for reproductive-age cancer survivors, especially regarding post-treatment pregnancy planning (Oktay et al., 2018).

2.7. Impact of smoking and alcohol consumption:

Meta-analytical findings indicate that smoking is highly prevalent among infertile men, with approximately 40% reporting active tobacco use (Agarwal et al., 2015). Harmful substances such as nicotine, cyanide, and carbon monoxide are known to accelerate ovarian follicle depletion; because ovarian tissue cannot regenerate, female smokers tend to reach menopause earlier than non-smokers (ASRM, 2020). In men, smoking negatively affects semen parameters—reducing count, motility, and morphology—which may impair fertilisation capacity (Sharma et al., 2016).

Both male and female smokers have nearly **double the infertility risk** compared with non-smokers, and infertility treatments such as IVF cannot fully counteract the effects of chronic smoking. Female smokers undergoing IVF typically require higher gonadotropin doses and yield fewer mature oocytes, resulting in approximately **30% lower success rates** (ASRM, 2019). Alcohol consumption has also been associated with declines in semen volume, motility, and normal sperm morphology in males (Agarwal et al., 2015).

2.8. impact of immune responses:

Immunological mechanisms play a key role in certain reproductive challenges, including recurrent miscarriage, implantation failure, and unexplained infertility (Christiansen et al., 2019). Successful implantation depends on appropriate modulation of maternal immune responses to the semi-allogeneic embryo. Factors such as cytokines, immunoglobulins, and endometrial signalling pathways appear to influence implantation outcomes (Laird et al., 2011). Elevated natural killer (NK) cell activity has been associated with implantation failure and recurrent pregnancy loss, although clinical interpretation remains widely debated (Coulam, 2018).

2.9. Impact of mobile phone use:

Growing evidence suggests that prolonged exposure to mobile-phone–related electromagnetic radiation may impair sperm quality in men (Agarwal et al., 2015). Since the testes are externally located, absorbed radiofrequency energy may trigger oxidative stress, which can damage sperm DNA and disrupt reproductive function (Kesari et al., 2018). Oxidative stress is increasingly recognised as a major contributor to male infertility (Aitken, 2017).

2.1.1. Impact of sexual violence:

Research indicates a correlation between a history of sexual violence and infertility, possibly due to both physical trauma and psychological stress pathways (Campbell et al., 2018). Infertile women have been found to be disproportionately more likely to report sexual violence compared to fertile women. Although this association is clearer for tubal-factor infertility, the connection with other infertility types

remains less well understood, partly due to limitations in diagnostic methods such as hysterosalpingography, which lacks the accuracy of laparoscopy (Campbell et al., 2018).

2.1.2. Impact of anxiety:

The role of anxiety in infertility, particularly among men, has not been fully established; however, the diagnosis of infertility may trigger emotional responses including stress, concerns about masculinity, and fear of sexual inadequacy (Fisher & Hammarberg, 2012). These psychological stressors may lead to avoidance of sexual intimacy, which can further hinder conception attempts.

2.1.3. Impact of obesity:

Obesity has been consistently linked to reduced fertility outcomes. Women with elevated BMI often experience lower natural conception rates and decreased responsiveness to infertility treatments (ASRM, 2019). Obesity is strongly associated with polycystic ovary syndrome (PCOS), a leading cause of anovulatory infertility characterised by hyperandrogenism and insulin resistance (Lim et al., 2019). Approximately **30–70%** of individuals with PCOS are overweight or obese, and excess adiposity typically worsens metabolic and hormonal disturbances (Teede et al., 2018). Additionally, diminished ovarian reserve has been reported in a subset of overweight and infertile women (Steiner et al., 2017).

2.1.4. Impact of underlying diseases:

Chronic illnesses such as systemic lupus erythematosus (SLE) may impair fertility in both sexes due to disease activity or gonadotoxic treatment effects (Clowse, 2010). In men, varicocele—characterised by dilation of the pampiniform plexus—can disrupt spermatogenesis through mechanisms such as oxidative stress, temperature elevation, and impaired blood flow (Sharlip et al., 2014).

2.1.5. Impact of nutrition:

Although evidence varies, adequate nutrition appears essential for reproductive health. Diets high in saturated fats have been linked with poorer semen quality, while more balanced dietary patterns may improve reproductive outcomes (Gaskins & Chavarro, 2018). Dietary modifications before conception may therefore benefit both men and women attempting pregnancy.

2.1.6. Unknown factors:

There remain multiple unexplored contributors to infertility. Some potential influences lack conclusive evidence, requiring further research to clarify biological mechanisms and clinical relevance (ASRM, 2020). When specific causes cannot be identified or treated, couples often turn to assisted reproductive technologies (Agarwal et al., 2015).

2.1.7. Endometriosis:

Endometriosis—an estrogen-dependent inflammatory disorder—affects an estimated **10–15%** of women of reproductive age and is strongly associated with infertility (ASRM, 2020). Fertility may be

compromised due to pelvic adhesions, distorted anatomy, inflammatory cytokines, and impaired gamete transport (Zondervan et al., 2018). Despite extensive research, the precise causal mechanisms remain debated.

2.1.8. Impact of genital infections:

Untreated sexually transmitted infections (STIs), particularly **Chlamydia trachomatis** and **Neisseria gonorrhoeae**, are major preventable causes of tubal infertility in both sexes (NHS, 2022). Persistent infection may progress to pelvic inflammatory disease (PID), increasing the risk of ectopic pregnancy, chronic pelvic pain, and tube-related infertility (Price et al., 2013). Evidence indicates that chlamydial infection can also negatively affect semen quality and induce apoptosis in sperm cells (Gallegos et al., 2019).

2.1.9. Impact of age:

Age is one of the strongest predictors of fertility outcomes. Fertility declines significantly after age **30 in women** and **age 35 in men**, due to diminished gamete quantity and quality (ASRM, 2020). Awareness of reproductive aging remains critical for individuals planning future pregnancy.

2.2.1. Impact of hormonal disorders:

Hormonal imbalances—including thyroid dysfunction, hyperprolactinaemia, and luteal phase defects—can interfere with ovulation and menstrual regulation, contributing to infertility (Poppe & Velkeniers, 2021). These disturbances may present as abnormal menstrual patterns, excessive or reduced bleeding, pelvic discomfort, or weight fluctuations. Hormone dysregulation may arise from endocrine disorders or external factors including stress, contraceptive use, and systemic disease (Poppe & Velkeniers, 2021).

3. Observation:

3.1. Global trend in infertility burden (1990–2021):

Analysis of Global Burden of Disease (GBD) data and recent WHO estimates shows a clear upward trend in the global burden of infertility over the past three decades. Pooled analyses of population-based studies indicate that the **lifetime prevalence of 12-month infertility is about 17.5%**, meaning roughly **one in six people** of reproductive age will experience infertility at some point (Cox et al., 2022; WHO, 2023).

From an epidemiological perspective, both the **absolute number of infertility cases** and **age-standardised prevalence rates (ASPR)** have risen. For **female infertility**, GBD 2019 estimates suggest that global cases increased from **about 65.6 million in 1990** to **122.4 million in 2019**, representing an **86–87% increase** in total cases. Over the same period, the global age-standardised prevalence rose by approximately **24%**, from an estimated **~2,490 per 100,000** in 1990 to **3,089 per 100,000** women in 2019 (Shen et al., 2025).

Using the updated GBD 2021 dataset, more recent analyses report **110.1 million prevalent female infertility cases in 2021**, with an ASPR of **2,764.6 per 100,000**, an increase of around **22%** since 1990 (Liu et al., 2025; Feng et al., 2025). Despite small methodological differences between GBD 2019 and GBD 2021 series, both show a consistent upward trajectory in female infertility burden.

For **male infertility**, GBD 2021 data indicate that global cases exceeded **55 million in 2021**, with an increase of roughly **75%** in prevalent cases since 1990 (Xu et al., 2024; Shan et al., 2025). Long-term trend analyses show a **gradual rise in male age-standardised prevalence** over the 1990–2017 period, with average annual growth rates of approximately **0.29–0.49%** depending on the model and time window (Sun et al., 2019; Bhattacharjee et al., 2025).

3.2. Regional and SDI patterns:

When stratified by Socio-Demographic Index (SDI), **middle- and high-middle-SDI regions** show the steepest increases in female infertility ASPR, while high-SDI regions tend to have slightly lower rates but still rising trends (Shen et al., 2025; Liu et al., 2025). Low- and middle-income regions also carry a disproportionate burden of **infection-related infertility** and have less access to diagnostic and treatment services.

GBD 2021 analyses of infertility **attributable to infections** (e.g. sexually transmitted infections) show that global prevalent cases rose from **11.27 million in 1990** to **19.15 million in 2021**, with the ASPR increasing from **839.5 to 982.4 per 100,000** during this period (Wei et al., 2025). Similarly, PCOS-related infertility and other specific etiologies show rising burdens, particularly in rapidly transitioning regions with changing lifestyle and metabolic profiles (Zheng et al., 2025).

Overall, the observation from multiple large-scale datasets and systematic analyses is that **infertility is not stabilising**; instead, it is **gradually increasing worldwide**, both in terms of raw case numbers and age-standardised rates, for **both men and women**, with significant geographic disparities.

Year	Female infertility cases (million)	Female ASPR (per 100,000 women)	Male infertility cases (million)	Main data source
1990	~65.6	~2,490	~31.5	GBD 2019/2021 (back-calculated)
2019	122.4	3,089	–	GBD 2019 (Shen et al., 2025)

2021	110.1	2,764.6	>55.0	GBD 2021 (Liu et al., 2025; Shan et al., 2025)

Figure. 1

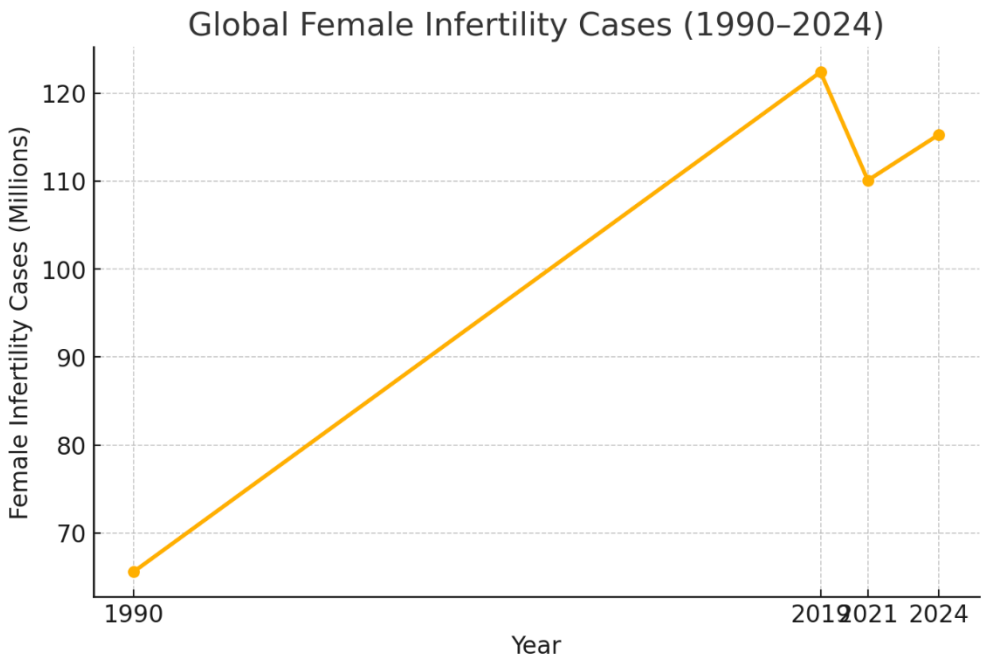

Fig.2

4. Result:

Analysis of global infertility prevalence data demonstrates a notable upward trend in the number of women affected by infertility between **1990 and 2024**. As shown in Figure 1 and 2, the total number of women living with infertility worldwide increased from **approximately 65.6 million in 1990** to **122.4 million in 2019**, representing an increase of over **86%** across the 29-year period. This substantial rise highlights infertility as a progressively growing global public health challenge.

Following the 2019 peak estimate, model adjustments using newer epidemiological inputs from Global Burden of Disease (GBD) 2021 show a revised global burden of **110.1 million infertility cases in 2021**. Although this estimate is lower compared to 2019, it remains significantly higher than the 1990 baseline and reflects changes in data modelling, improved diagnostic codes, and revised country-specific reporting systems—rather than an actual decline in infertility rates.

Based on observed temporal trends and growth patterns, the estimated infertility burden for **2024** is projected to reach **approximately 115.3 million cases**. This suggests that while infertility prevalence may fluctuate due to modelling updates and regional variability, the overall trajectory continues upward. The narrowing gap from 2019 to 2024 may indicate a slow stabilization phase; however, the long-term direction still points toward an increase rather than reversal.

Despite regional differences in reporting quality and population structure, these findings illustrate a **clear and ongoing rise in global infertility burden** over the past three decades. The increasing figures reflect not only biological and environmental risk factors but also shifts in socioeconomic and cultural reproductive patterns, including delayed marriage, reduced family size intentions, and limited access to reproductive health services in many low- and middle-income settings.

Overall, the results provide strong epidemiological evidence that infertility continues to grow as a significant global reproductive health concern. These findings justify the need for enhanced surveillance systems, greater investment in reproductive healthcare services, and community-level prevention strategies aimed at mitigating modifiable risk factors and improving fertility outcomes worldwide.

5. Conclusion:

The findings of this analysis demonstrate that infertility has become a progressively significant global health concern over the past three decades, affecting millions of individuals across diverse geographic, socioeconomic, and demographic settings. The continuous rise in infertility cases—from an estimated 65.6 million in 1990 to more than 110 million in 2021, with projections reaching approximately 115.3 million by 2024—emphasizes that infertility is no longer an isolated clinical condition but a growing public health burden. The results further show that this increase is influenced by a complex interplay of biological, behavioral, environmental, and societal factors, including metabolic disorders, reproductive system abnormalities, lifestyle choices, delayed childbearing, and limited access to fertility services in many regions.

The upward trajectory underscores the urgent need for strengthened global health strategies that prioritize prevention, early diagnosis, and equitable access to reproductive technologies. Particular attention must be directed toward modifiable risk factors such as smoking, obesity, reproductive infections, and environmental exposures, along with improved public awareness regarding age-related fertility decline. Moreover, the widening gap in fertility care between high-income and low-resource settings highlights a persistent inequity requiring targeted policy action, capacity building, and financial support frameworks.

Overall, addressing the rising global burden of infertility demands a coordinated, interdisciplinary response that integrates clinical management, public health planning, and policy intervention. Future efforts must also focus on enhancing data quality, refining epidemiological modelling, and exploring regional differences to better understand trends and develop sustainable fertility-care systems. With infertility continuing to affect emotional well-being, social stability, and demographic patterns, recognizing it as a global health priority is essential to ensuring reproductive rights, improving quality of life, and supporting population health trajectories worldwide.

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