

# Declining global fertility rates and the implications for family planning and family building: an IFFS consensus document based on a narrative review of the literature

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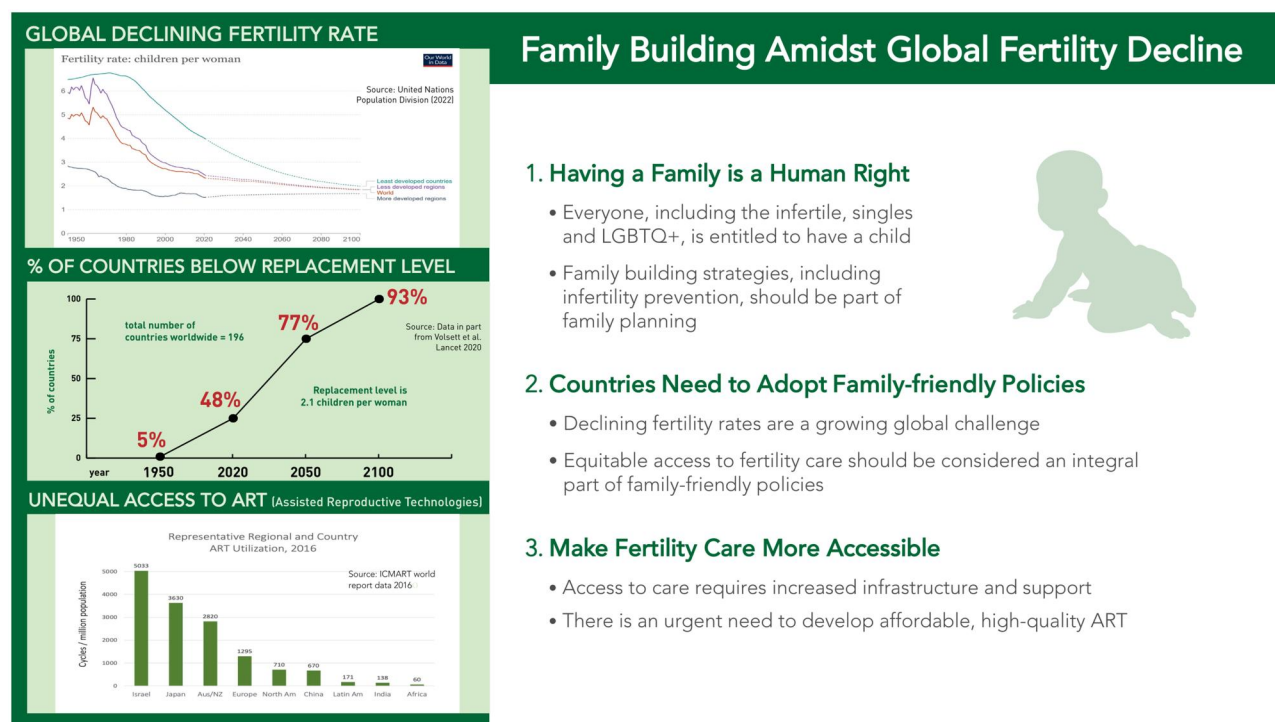
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## GRAPHICAL ABSTRACT



Declining fertility rates globally focus attention on the human right to build a family and the need for family-friendly policies and more accessible fertility care. LBGTQ, lesbian, gay, bisexual, transgender, queer, asexual, questioning.

## ABSTRACT

**BACKGROUND:** Family-planning policies have focused on contraceptive approaches to avoid unintended pregnancies, postpone, or terminate pregnancies and mitigate population growth. These policies have contributed to significantly slowing world population growth. Presently, half the countries worldwide exhibit a fertility rate below replacement level. Not including the effects of migration, many countries are predicted to have a population decline of >50% from 2017 to 2100, causing demographic changes with profound societal implications. Policies that optimize chances to have a child when desired increase fertility rates and are gaining interest as a family-building method. Increasingly, countries have implemented child-friendly policies (mainly financial incentives in addition to public funding of fertility treatment in a limited number of countries) to mitigate decreasing national populations. However, the extent of public spending on child benefits varies greatly from country to country. To our knowledge, this International Federation of Fertility Societies (IFFS) consensus document represents the first attempt to describe major disparities in access to fertility care in the context of the global trend of decreasing growth in the world population, based on a narrative review of the existing literature.

**OBJECTIVE AND RATIONALE:** The concept of *family building*, the process by which individuals or couples create or expand their families, has been largely ignored in family-planning paradigms. Family building encompasses various methods and options for individuals or couples who wish to have children. It can involve biological means, such as natural conception, as well as ART, surrogacy, adoption, and foster care. Family-building acknowledges the diverse ways in which individuals or couples can create their desired family and reflects the understanding that there is no one-size-fits-all approach to building a family. Developing education programs for young adults to increase family-building awareness and prevent infertility is urgently needed. Recommendations are provided and important knowledge gaps identified to provide professionals, the public, and policymakers with a comprehensive understanding of the role of child-friendly policies.

**SEARCH METHODS:** A narrative review of the existing literature was performed by invited global leaders who themselves significantly contributed to this research field. Each section of the review was prepared by two to three experts, each of whom searched the published literature (PubMed) for peer reviewed full papers and reviews. Sections were discussed monthly by all authors and quarterly by the review board. The final document was prepared following discussions among all team members during a hybrid invitational meeting where full consensus was reached.

**OUTCOMES:** Major advances in fertility care have dramatically improved family-building opportunities since the 1990s. Although up to 10% of all children are born as a result of fertility care in some wealthy countries, there is great variation in access to care.

The high cost to patients of infertility treatment renders it unaffordable for most. Preliminary studies point to the increasing contribution of fertility care to the global population and the associated economic benefits for society.

**WIDER IMPLICATIONS:** Fertility care has rarely been discussed in the context of a rapid decrease in world population growth. Soon, most countries will have an average number of children per woman far below the replacement level. While this may have a beneficial impact on the environment, underpopulation is of great concern in many countries. Although governments have implemented child-friendly policies, distinct discrepancies in access to fertility care remain.

**Keywords:** world population growth / total fertility rate / family planning / family building / infertility / fertility care / ART / access to care

## Introduction

For over half a century, *family-planning* policies have focused on contraceptive approaches to avoid unintended pregnancies, postpone desired pregnancies and, in some countries, terminate unwanted pregnancies. Additionally, many policies were driven by the goal to reduce population growth because of concerns that overpopulation would result in overcrowding, poor sanitation, disease epidemics, famine, war, massive migrations, increasing human inequality, and environmental damage that would bring about human apocalypse (Scott, 2022). This approach to family planning has contributed significantly to slowing population growth in many parts of the world. The global population is anticipated to peak at 9.7 billion around the year 2064, followed by a steady decline (Bongaarts, 1994; Vollset et al., 2020). Family planning has also facilitated economic development, increasing levels of education, the empowerment of women to pursue educational and career opportunities and has helped alleviate environmental consequences of an increasing global population. And while most would agree that draconian forced sterilization and other measures that occurred in many countries are no longer necessary, there are still legitimate and compelling arguments that human population growth creates existential risks to humanity (Van Bavel, 2013; Lidicker, 2020; Wilmoth et al., 2022).

Within this context, it is now recognized that the total fertility rate (TFR), defined as the number of children born per woman living to the end of childbearing years (15–49 years), has been decreasing dramatically for decades in many countries. By 2050 and 2100, respectively, 77% of predominantly high-income countries and 93% of all countries will have a TFR below the replacement level of 2.1 children per woman. Not including the effects of migration, many countries are predicted to have a population decline of more than 50% from 2017 to 2100 (Vollset et al., 2020; Dao et al., 2021). This evolution of the world population will cause demographic changes with profound societal implications. The dramatically increasing ratio between elderly people and young adults already affects historical social norms concerning education, marriage, and care of the elderly, with major economic ramifications (Mester, 2018). The ongoing trend of having fewer children may be irreversible and even accelerating (Aitken, 2022).

The decreasing TFR can potentially impact societies in multiple ways, some advantageous, and some disadvantageous (Qiao et al., 2021). Population growth magnifies the harmful impact of economic processes on the environment; yet the rise in per capita income has been more important than population growth in driving increased production and consumption (Götmarm et al., 2018; Dodson et al., 2020; Wilmoth et al., 2022). Increased resources for improving maternal and child health care can be offset by the impact of delayed childbearing on fertility, maternal health, and poorer pregnancy outcomes (Balasch and Gratacos, 2012; Schmidt et al., 2012). Maternal and child health can be improved if each child has access to more resources and parental time, but potentially negatively if many children have no siblings (Fall et al., 2015). Smaller families and delayed parenting will impact

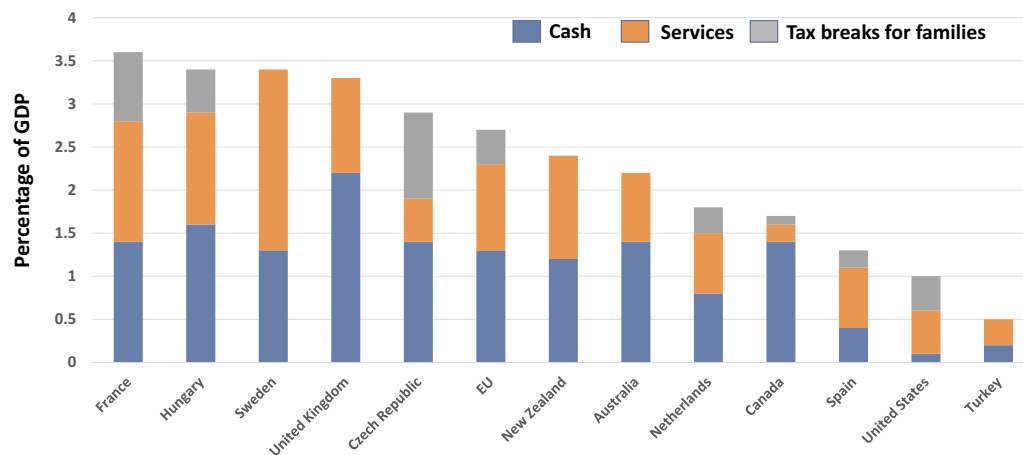
many social norms and activities (Canning and Schultz, 2012; Schmidt et al., 2012). Aging populations will require increased healthcare and pension costs at the same time there are fewer workers producing the wealth to support them, let alone provide the taxes to sustain other social welfare systems—including their own retirement funds—and grow economies. Countries will have to consider policies that address work-life balance, affordable childcare, and parental leave. Different TFRs among countries will promote immigration and emigration with important consequences for all countries, including increased political and social friction (Vollset et al., 2020). All these changes will create changing attitudes and ethical challenges with respect to cultural and societal values and norms of parenthood, gender roles, and gender equality. Different age groups will likely disagree on their proportionate contributions to society. The declining TFR will also raise questions about an individual's reproductive rights relative to the needs of society (Mburu et al., 2023).

The optimal number of children per woman may be perceived differently in various countries, depending on cultural norms, economic status, existing TFR, population demographic distribution, and migration (Organization for Economic Cooperation and Development, OECD Family Database, SF2.2, 2016). Regardless of these differences, the overall decreasing fertility rate worldwide is of growing concern. In attempts to address these trends, an increasing number of countries have implemented child-friendly policies: mainly financial incentives, such as compensation for extended pregnancy leave, financial benefits related to childbirth, maternity and paternity leave, child tax deduction or credit strategies, and compensation for childcare.

Despite this entirely changed paradigm of population growth, the concept of *family building* (the process by which individuals or couples create or expand their families) has, until recently, been largely ignored in family-planning paradigms (Ziebe and Devroey, 2008; Seifer et al., 2015; Bakkensen and Goldman, 2022). Not only the general public but also health care professionals could benefit from (inter)national education programs for young adults to increase family-building awareness and improve reproductive life decisions.

While the global decline in fertility rate is due to multiple societal and environmental changes, it is important to emphasize that globally between 48 million couples and 186 million individuals of reproductive age live with infertility (World Health Organization, 2020; Cox et al., 2022). Infertility is a common chronic disease affecting many reproductive-age women and men and represents a major life burden, causing anxiety, depression, relationship dysfunction, and social marginalization (World Health Organization, 2020). Major advances in infertility care, especially through ART, have dramatically improved family-building opportunities for infertile and fertile people over the last three decades in both developed and developing countries. Although up to 10% of all children are born as a result of infertility therapies in some wealthy countries, great variation in access to care can be observed (DeWeerd, 2020; Chiware et al., 2021;

## Overview of child friendly government policies



**Figure 1.** Public spending on child benefits by type of expenditure as percentage of GDP, 2017. GDP, gross domestic product; EU, European Union. Reprinted with permission from Organization for Economic Cooperation and Development. <http://www.oecd.org/social/expenditure.htm>.

Choi et al., 2022). The high cost to patients of infertility treatment renders it unaffordable for most, particularly those in low- and middle-income countries (LMICs) (Karaga et al., 2023). Therefore, access to fertility care remains a major challenge and disproportionately impacts opportunities for family building globally. Currently, the overall contribution of fertility care to the global TFR is relatively small because access to fertility care globally is very limited.

Public funding of fertility treatment has occurred in a limited number of countries with the aim to mitigate decreasing national populations. However, the extent of public spending on child benefits varies greatly from country to country (Fig. 1), and many barriers remain for the inclusion of fertility care in reproductive health policies, especially in LMICs (Organization for Economic Cooperation and Development, OECD Social Expenditure Database; Ethics Committee of the American Society for Reproductive Medicine, 2021; Afferi et al., 2022). Moreover, distinct inconsistencies in regulations, the availability and funding of infertility treatment options and the involvement of patients have recently been described by the patient organization ‘Fertility Europe’ for various European countries (Fig. 2) (Atlas of Fertility Treatment Policies in Europe, 2021).

Infertility has historically been defined as the inability to become pregnant within at least 1 year of regular unprotected intercourse in heterosexual couples who desire to have a child. For the past half-century concerns regarding global overpopulation have frequently led to the contention that infertility treatments should have a low priority because they promote population growth and, as a result, support for fertility care has often been opposed. Such perspectives and actions give rise to inequality, injustice, and discrimination (Pennings, 2008; Gerrits et al., 2017; Ombelet and Goossens, 2017). Such a view requires that couples or individuals who wish to have a child—who already suffer from the distinct burden of the disease—bear a disproportionate responsibility for reducing world population growth. Social policy should be equitable for all members of society, and any approach to population growth that places undue responsibility on people who wish to establish a family contravenes the principle of social justice. The same infertility treatments initially developed to treat infertile heterosexual couples are now also increasingly used to help single persons and lesbian, gay, bisexual, transgender, intersex, queer/questioning (LGBTQ+) persons so they can

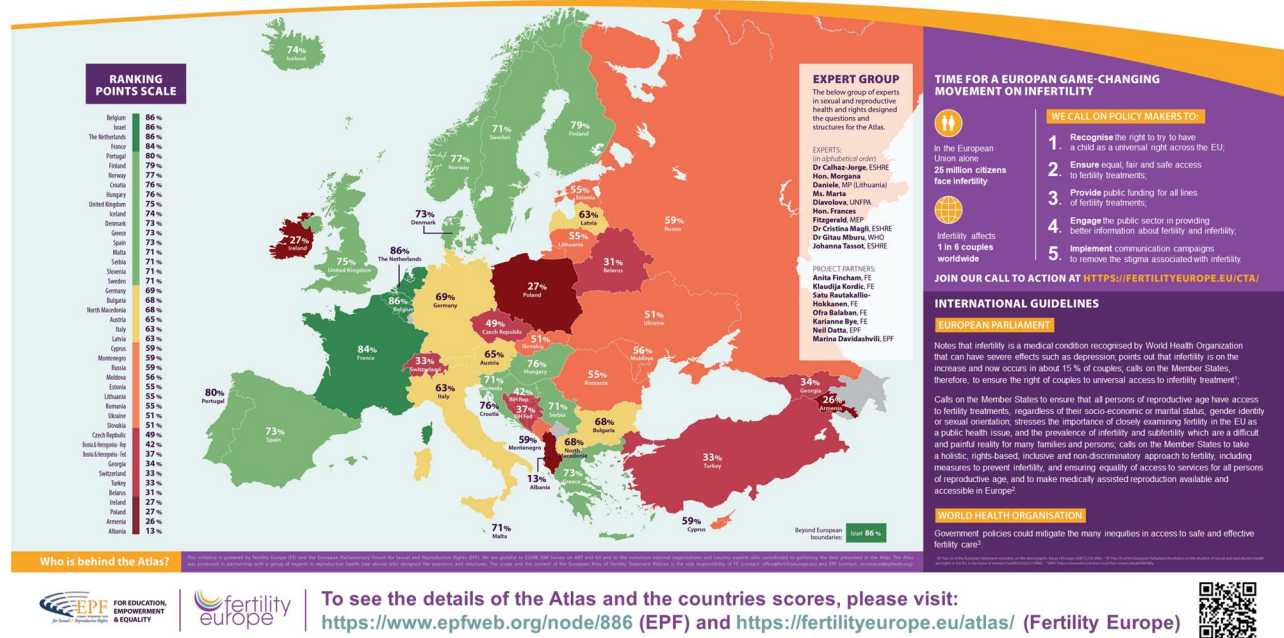
realize their desire to have a child. In this context, these broader scope interventions, which include fertility awareness, support, and fertility management with an intention to assist individuals and couples to realize their desires associated with reproduction and/or to build a family, are defined as fertility care (Zegers-Hochschild et al., 2017). Infertility treatment is a subset of fertility care.

In addition to the need to improve access to fertility care to mitigate the personal burden of this disease, social justice mandates that people wanting to found a family have a right to do so (United Nations (UN), <https://www.ohchr.org/en/human-rights/universal-declaration/translations/english>). This right applies to couples or individuals who wish to have a first or subsequent child. Fertility is an important component of strong societal trends regarding the need to address diversity, equity, inclusion and social determinants of health. The inability to access fertility care disproportionately affects women and minorities (World Health Organization, 2020). Societal trends in many countries encourage access for those in the LGBTQ+ community, single people, and those needing to use third-party reproduction (donor sperm, eggs, embryos, or surrogacy). Thus, providing access to fertility care is important for social justice. Furthermore, preliminary studies point to the increasing contribution of fertility care to the overall population and the economic benefits for society that result from every new person born from fertility care (Connolly et al., 2008, 2009, 2021; Leridon and Slama, 2008; Habbema et al., 2009; Faddy et al., 2018).

This article aims to provide global perspectives that support the need to harmonize family planning with family building: comparing patterns and determinants of TFR, societal and economic implications of a decreasing population, the prevalence and burden of infertility, societal trends impacting fertility care, fertility awareness and infertility prevention, economic and social justice aspects of access to fertility care, and policy recommendations that will benefit both individuals and society. More than ever, today the implementation of public policies needs to balance both the need of the individual and society.

Recommendations are provided, and important knowledge gaps identified, to provide professionals, the public, and policy-makers a comprehensive understanding of the role of child friendly policies, including fertility care, in the context of the global trend of decreasing fertility rates. Hopefully, this will

# EUROPEAN ATLAS OF FERTILITY TREATMENT POLICIES



**Figure 2. Infertility friendly treatment policies vary among countries in Europe.** Published online at Atlas of fertility treatment policies in Europe—Fertility Europe. Reprinted with permission, Atlas of Fertility Treatment Policies in Europe. EPF, European Parliament Forum. <https://fertilityeurope.eu/atlas/#:~:text=Infertility%20in%20conjunction%20with%20the%20European%20Parliamentary,The%20Atlas%20describes%20the%20current%20situation%20in%202021.>

facilitate the formulation, now and in the future, of more effective family-building policies that are harmonized with family planning.

## Methods

This article presents the IFFS consensus after a narrative review of the existing literature performed by global leaders who themselves have contributed significantly to the research in this field. These peers were selected by IFFS based on their scholarly publications, academic accomplishments, professional leadership roles, and reputation in respective areas of interest. Each section of the review was prepared by two to three of these experts, each of whom searched the published literature (PubMed), drawing upon decades of professional expertise, and academic accomplishment. Only peer reviewed full papers and reviews were included (if useful, we also refer to website of relevant global organizations), and searches were performed and updated until September 2023. The following keywords were used: world population growth, underpopulation, family planning, family building, fertility, infertility, fertility care, ART, LGBTQ (Introduction and Conclusion sections); world population, TFR, fecundity, fertility, maternal age, childbirth (global population paragraph section); infertility, infertility prevalence, population-based studies, reviews (infertility prevalence section); age-related fertility decline, fertility awareness, education, infertility risk (infertility awareness section); access to care, ART, ART utilization, fertility care (access to fertility care section), fertility care, access to care, affordability, health economics, and gender equality (equitable access section).

Multiple drafts were circulated electronically among each section's team members for comment and editing. All sections were discussed monthly by all authors (January 2021–July 2022) and

quarterly by the review board (July 2021–July 2022). Text was modified and distributed where needed based on these discussions until full agreement was reached by all participants. Repeated discussion also involved the overall scope of the paper, and the order in which the various topics were presented. The final document was prepared following discussions among all team members during a hybrid invitational 2-day meeting organized in Amsterdam, May 2022, where full consensus was reached. The final document was approved by all authors and members of the review board.

## Changes in global population: patterns of fertility

Assuming no net migration and unchanged mortality, a TFR of around 2.1 children per woman is the replacement level often cited for broad population stability (UN, Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2011). Between 1990 and 2021, global TFR dropped from 3.3 to 2.3 (Table 1) (United Nations, 2022). Factors affecting the TFR decline include changes in lifestyle choices, education levels, discrimination against women, and inadequate support of working parents (D'Addio and d'Ercole, 2005). The declining global fertility rate has not been uniformly distributed (United Nations, 2022) (Table 2).

TFR refers to the average number of births per woman. Men's fertility rate has received little attention, yet is similar or lower compared to women's (Schoumaker, 2017). Both similar and dissimilar factors affect the male fertility rate, including the higher male-to-female population, age when pregnancy occurs, registration rate of the father at birth, and biomedical factors (Dudel and Klusener, 2019). Some evidence suggests that decreased male fertility is due to an annual decline of 1.4% in sperm concentration

**Table 1.** Trends in total fertility rate 1975–2021.<sup>a</sup>

World or region	1975	1990	2005	2021
World	4.08	3.31	2.62	2.32
More developed regions <sup>b</sup>	2.01	1.78	1.61	1.52
Less developed regions <sup>c</sup>	4.64	3.43	2.52	2.12
Least developed countries <sup>d</sup>	6.70	5.96	4.86	3.97
Africa	6.69	5.51	5.0	4.31
Northern Africa	6.35	4.58	3.12	3.07
Eastern Africa	7.15	6.61	5.62	4.24
Southern Africa	5.32	3.85	2.62	2.45
Western Africa	6.89	6.70	6.30	4.98
Middle Africa	6.57	6.70	6.30	5.62
Asia	4.43	3.32	2.39	1.94
Eastern Asia	3.34	2.42	1.58	1.17
South-Central Asia	5.47	4.33	3.06	2.25
Western Asia	5.61	4.31	3.12	2.59
Latin America and Caribbean	4.66	3.25	2.35	1.86
Central America	5.81	3.72	2.66	1.94
South America	4.36	3.12	2.23	1.81
Europe	2.07	1.72	1.47	1.48
Northern America	1.78	2.04	2.01	1.64
Australia and New Zealand	2.20	1.95	1.87	1.63
Oceania excluding Australia and New Zealand	5.69	4.69	3.91	3.14

<sup>a</sup> United Nations (2022).<sup>b</sup> More developed regions comprise Europe, Northern America, Australia/New Zealand, and Japan.<sup>c</sup> Less developed regions comprise all regions of Africa, Asia (excluding Japan), Latin America and the Caribbean plus Melanesia, Micronesia, and Polynesia.<sup>d</sup> The least developed countries (n = 48): 33 in Africa, 9 in Asia, 5 in Oceania; 1 in Latin America and the Caribbean. Total fertility rate (TFR) is also negatively correlated with the capacity of women to make their own reproductive decisions. It is difficult to isolate the freedom to exercise reproductive choice from other largely accepted cultural and religious reasons whereby women 'voluntarily' refrain from using contraceptives and place enormous value on having many children. Economic circumstances can modulate the desire to have children in different ways. For example, the TFR in some low- and middle-income countries that are economically restricted (e.g. Cuba) or emerging economies (e.g. Chile, Uruguay) has decreased to around 1.6; in Latin America, TFR decreased from 5.86 in 1950–1955 to 2.04 in 2022. Similar declines have taken place in most African countries. However, in most countries in Eastern, Western, and Central Africa the TFR remains extremely high (> 4.5) (Table 2) (Central Intelligence Agency, The World Factbook: Field Listing—Total Fertility Rate, 2022). Some high-income countries have experienced a slight rebound in their TFR, partly because of childcare friendly policies (Organization for Economic Cooperation and Development, 2009; De Geyter et al., 2020; UNFPA, 2022).**Table 2.** High total fertility rate in selected African countries (estimates, 2022).<sup>a</sup>

Country	Population (millions)	TFR
Nigeria	225	4.6
Congo	108.4	5.6
Tanzania	63.8	4.4
Uganda	46.2	5.4
Angola	34.8	5.8
Mali	20.7	5.5
Mozambique	31.7	4.8

<sup>a</sup> Central Intelligence Agency The World Factbook: Field Listing—Total Fertility Rate 2022.  
TFR, total fertility rate.

and 1.6% in total sperm count, although the impact on TRF is yet unknown (Levine et al., 2017; Jørgensen et al., 2021; Levine et al., 2023). Decreased male fertility has been associated with an increased disease burden including heart disease, cancer, and early death (Kasman et al., 2020). Moreover, both male and female reproductive health is deteriorating, especially in industrialized regions, suggesting important roles of environmental factors, such as endocrine-disrupting chemicals and pesticides, in causing the observed decline in fertility (Le Moal et al., 2016; Skakkebaek et al., 2022).

Fertility decline initially results in more working-age adults relative to children, potentially leading to accelerated economic growth and a temporary 'demographic dividend' (Starrs et al., 2018). However, in countries with fertility rates below the replacement level, a different population pyramid with more elderly people and fewer working adults will eventually occur. An increasing number of countries have implemented policies, including improved access to infertility treatments, aiming to increase their fertility rate, restore the demographic pyramid, and increase the working age group's positive economic impact (De Geyter et al., 2020; Central Intelligence Agency, The World Factbook: Field Listing—Total Fertility Rate, 2022). Nevertheless, globally fertility care currently generates little impact on the fertility rate since most countries, especially LMICs irrespective of their TFR, do not have equitable and universal access to treatments—especially ART (Inhorn and Patrizio, 2015; Chiware et al., 2021; Duffy et al., 2021; Brodeur et al., 2022; Karaga et al., 2023).

Another factor responsible for lowering TFR is that many women in both developed and LMICs are delaying first birth and having children at an older age when there is a natural decline in fecundity (defined as the capacity to have a live birth). Therefore, later marriage and older age when attempting pregnancy increase the risk of infertility. UN statistics demonstrate that the average age of women at first childbirth has increased by ~1 year per decade since 1970 in developed countries (Organization for Economic Cooperation and Development, OECD Family Database SF2.3). Furthermore, there is immense variation in maternal age at first childbirth depending on the country and region. Nineteen countries, mainly in central and west Africa, still have a mean age of women at first childbirth of under 20 years, compared with only one country in the Americas and none in Asia and Europe. On the other hand, the mean age of mothers at first childbirth in 35 countries in Europe and Asia is ≥28 years (Central Intelligence Agency, Field Listing—Mother's Mean Age at First Birth, 2022).

The National Survey of Family Growth reported 1-year infertility rates increased from 6% for women younger than 24 years of age to over 30% at ages 35–44 years (Abma et al., 1997). Mean monthly probability of pregnancy leading to live birth remains optimal until age 31 years. Relative fertility is decreased by about half at age 40 years compared with women in their late 20s and early 30s, the time of peak fertility (Practice Committee of the American Society for Reproductive Medicine and the Practice Committee of the Society for Reproductive Endocrinology and Infertility, 2022). The average age at last childbirth in the general population is 40–41 years (ESHRE Capri Workshop Group, 2010). Postponing childbearing contributes to fertility decline, having fewer children than desired or no children at all, increased need for infertility treatment, and increased morbidity and costs for both mothers and children, delivery, and post-birth (Luke and Brown, 2007).

Environmental and lifestyle factors, such as smoking, excessive alcohol intake, obesity, and poor nutrition, can negatively affect both male and female fertility. Exposure to environmental pollutants, such as endocrine-disrupting chemicals, and toxicants, such as pesticides, can be directly deleterious to gametes (oocytes and spermatozoa), resulting in decreased numbers and quality, and subsequent infertility (Gore et al., 2015; Segal and Giudice, 2019; World Health Organization, 2021; Skakkebaek et al., 2022; Giudice et al., 2023). In addition, infertility, especially secondary, is more prevalent in areas with a high incidence of sexually transmitted infection (STI). In 2016 chlamydia, gonorrhea, syphilis, and trichomoniasis accounted for an estimated 376 million new infections worldwide (Rowley et al., 2019). Left

untreated, pelvic inflammatory disease will result in infertility in one-quarter of people (World Health Organization, 2008). Especially in LMICs, tubal disease with ensuing infertility also arises from complications of unsafe abortion, postpartum sepsis, pelvic tuberculosis, bilharzial salpingitis, and iatrogenic tubal obstructions (Serour et al., 1988; Scholes et al., 1996; Tsevat et al., 2017).

Factors associated with decreased TFR in the male and female vary globally. Major factors are socioeconomic, cultural, religious, educational, gender equity, and environmental (Nargund, 2009; Population Reference Bureau, 2021; Skakkebaek et al., 2022; World Economic Forum, 2022). Other factors include infertility prevalence, insufficient fertility knowledge and awareness, and limited access to care (including heterosexual couples, same-sex couples, single women and men, and transgender individuals). The use of donor eggs, sperm, embryos, and surrogacy has made it possible for these persons/couples to access treatment, including ART. The demographic impact of these new family forms, along with fertility preservation to postpone childbearing, is yet unknown.

In the last two decades, there has been a moderate recovery of fertility rates in some developed countries in Europe: e.g. Sweden from 1.54 to 1.67. Trends in other countries can be observed in Table 1 (UNFPA, 2022). This may be due to an increase in births in women who had postponed motherhood, policy measures supporting families and working women, increased access to ART services, and the higher fertility rate among immigrant women (Organization for Economic Cooperation and Development (OECD), 2009; De Geyter et al., 2020). Furthermore, data from 2017 show that medically assisted reproduction (MAR)—defined as ‘reproduction brought about through various interventions, procedures, surgeries, and technologies (including ART) to treat different forms of fertility impairment and infertility’—contributed from 3.2% to almost 10% of births in European countries compared with <1% in Latin America and 2% in the USA (Wyns et al., 2021; Zegers-Hochschild et al., 2017). While it is difficult to isolate the overall effect of ART in raising fertility rates from other behavioral and policy drivers, the impact appears to be approximately a 0.05–0.10 increase in TFR where access to fertility treatment is widely available (Grant et al., 2007; Habbema et al., 2009; Lazzari et al., 2021).

## Conclusion and recommendations

1. TFR is declining globally in women and men, for multiple reasons.
2. While it is difficult to measure the overall impact of ART in raising fertility rates, the potential benefits for the many individuals or couples who wish to have a child are profound.
3. The global trend of delaying parenthood negatively affects TFR.
4. There is an urgent need for more and better data on all aspects of global fertility and associated demographics.

## Identified key knowledge gaps

1. Reliable data on fertility patterns, trends and causes of fertility or infertility are missing in developing countries, especially for male fertility.
2. The impact of infertility treatment, including ART, on fertility patterns is missing in most countries of the world.

## Infertility prevalence and determinants

### Prevalence

It is imperative to identify measurable health indicators in order to quantify disease and measure progress resulting from interventions. Prevalence is the only reproductive health indicator for infertility formally adopted by the World Health Organization (WHO) (World Health Organization, 2008). Infertility prevalence tells us how many lives are affected; both prevalence and measurement of the magnitude of infertility's impact on people's lives inform the burden of disease. The definition of infertility and its prevalence and burden of disease are controversial. Different categories of infertility definitions (clinical, epidemiological, demographic) in conjunction with variations in methodology and study populations give rise to wide-ranging estimates (Gnoth et al., 2005; Barratt et al., 2017; Cox et al., 2022; World Health Organization, 2023). For primary 12-month infertility (never pregnant), the pooled lifetime and period prevalence reported by WHO in 2023 were 9.6% and 9.0%, respectively. For secondary 12-month infertility (prior pregnancy, regardless of outcome), pooled lifetime and period prevalence were 6.5% and 4.9%, respectively: less than primary infertility but still a very large number of people (World Health Organization, 2023). Quantitative burden-of-disease studies lack measurement of the qualitative impact of infertility disease and do not consider how bringing forth new life affects the quality of existing lives. Primary infertility is known generally to have a high burden of disease. Secondary infertility may or may not carry a similar burden for any given person depending on their personal and societal circumstances, including that a child is from a previous relationship. Additionally, secondary infertility applies to many who have become pregnant and/or delivered but subsequently suffered pregnancy loss or death of a child. A rich qualitative narrative describes the often-profound consequences of infertility as a social reality as well as a medical disease (Greil et al., 2010; Inhorn and Patrizio, 2015).

There are two commonly applied clinical definitions of infertility. According to the WHO, infertility is a disease defined by the absence of pregnancy after 12 months of regular unprotected intercourse, which is in line with the definition of male and female infertility in the International Classification of Diseases (ICD-11) (Zegers-Hochschild et al., 2009). The International Glossary on Infertility and Fertility Care, which reflects high-level international consensus, incorporates the WHO definition while being more comprehensive and inclusive by adding, ‘or due to an impairment of a person's capacity to reproduce either as an individual or with his/her partner’ (Zegers-Hochschild et al., 2017). Moreover, by referring to infertility as a disability per se without specifying infertility as disability of the reproductive system, the International Glossary recognizes that fertility and parenthood transcend reproductive organs and affect the entire person, couple, and their social matrix.

Globally, infertility is one of the most frequent chronic diseases among reproductive-aged people. Until publication of the recent WHO document, the most comprehensive systematic review covering infertility studies from 1990 to 2021 gave pooled estimates for period and lifetime infertility prevalence of 12.6% (95% CI 10.7, 14.6) and 17.5% (95% CI 15.0, 20.3), respectively, when estimated among all study participants regardless of risk of pregnancy (Cox et al., 2022; World Health Organization, 2023). However, as most people are unaware of their fertility potential (fecundity) before trying to have children, it is also important to estimate infertility prevalence among those who are trying or have tried to have children. For this group, the range of the

estimated point prevalence of infertility has been reported as 4–34% after 12 months of ‘trying’ and that of cumulative lifetime prevalence as 8–35% (Schmidt and Münster, 1995; Chandra et al., 2013; Zhou et al., 2018; Cox et al., 2022). This seeming paradox can be explained by pro-natal reproductive behaviors that are directly or indirectly associated with risk factors for infertility, including low uptake of contraceptive methods, early sexual debut, early age at first pregnancy, unsafe delivery practices, and high background rates of sexually transmitted diseases.

## Causes and risk factors

Infertility can be caused by female and/or male factors or can be unexplained. Prominent female factors include advanced age and resultant diminished ovarian reserve associated with voluntary or involuntary delay of pregnancy, chronic anovulation, tubal factor infertility (especially secondary to STIs or pregnancy-related sepsis), other pelvic pathology (e.g. endometriosis, adenomyosis, uterine fibroids, adhesions, congenital anomalies), and exposure to environmental contaminants. The extent to which these factors contribute to female infertility varies from country to country. Male infertility—which accounts for or contributes to infertility in approximately one-half of couples—can result from impaired sperm production or sperm ejaculation due to a variety of underlying conditions including hormonal, infectious, and genetic and environmental etiologies (World Health Organization, 2020). In addition, sexual and other factors may impact intercourse. Infertility may be caused by medical interventions, such as cancer therapy or complications of inappropriate care, as well as environmental factors and toxicant exposures during in utero development and/or in adulthood (ASRM Practice Committee, 2019; Skakkebaek et al., 2022; Giudice et al., 2023). Many of these factors are aggravated by increasing age.

Most causes of infertility are acquired, and many are amenable to prevention. Health behaviors, such as smoking, obesity, use of cannabis and anabolic steroids, are risk factors for both women and men (Bala et al., 2021; Carson and Kallen, 2021; Eisenberg et al., 2023). Traditionally, prevention has focused on STI prevention, safe obstetric practices, lifestyle modifications, avoidance of age-related female infertility, and early identification and treatment of male cryptorchidism (one of the most common congenital conditions in male neonates). There is a need for increased education and research on intervention strategies for environmental impacts on male and female infertility (Giudice et al., 2023).

Ultimately, prevention and intervention strategies need to be informed by the social determinants of infertility: the causes of the causes. For example, advanced female age is linked to the social determinants of education and gender equality, since both may delay acting on fertility desires and opportunities for procreation (Broekmans et al., 2009; Fall et al., 2015; Van Roode et al., 2017; Cedars, 2022; Choi et al., 2023). At the same time, lack of gender equality may influence women’s ability to negotiate safe sexual practices or contraception usage, compromise health literacy, and limit women’s ability to access appropriate reproductive health services.

## Conclusions and recommendations

1. Infertility is one of the most common chronic diseases in individuals of reproductive age.
2. Infertility is also common in men, accounting for ~50% of all couples’ infertility.

3. Pooled period prevalence of infertility is 12.6% with regional differences when estimated among women/couples regardless of whether they are ‘trying’ to have children or not.
4. Pooled lifetime prevalence of infertility is 17.5% with regional differences when estimated among women/couples regardless of whether they are ‘trying’ or tried to have children or not.
5. Infertility has many causes and risk factors, including genetic and medical disorders, health behavior, age, and exposure to environmental contaminants.
6. We recommend global, regional, and national monitoring of infertility in population-based studies among persons trying or having tried to have children.

## Identified key knowledge gaps

1. Lack of conclusive data pertaining to infertility prevalence.
2. Lack of national and global monitoring of population-based infertility prevalence.

## Infertility awareness and prevention

Infertility is a common chronic disease and a major life burden. But awareness about infertility, its risk factors, and possible treatments vary widely across the globe (Bunting et al., 2013). Personal consequences of infertility can include a profound sense of shame, loss, anxiety, depression, anger, and feelings of failure, both physically and in sexual roles and social responsibilities (van Balen and Bos, 2009). These effects can lead to isolation, ostracism, and violence specifically against women, regardless of the etiology of their infertility. The reasons for these variable effects are complex and include cultural mores, the status of women in each society, the importance of childbearing to the marital relationship, gender power dynamics within the family, and religious, political, and economic factors (van Balen and Bos, 2009; Inhorn and Patrizio, 2015; Stellar et al., 2016; Bayoumi et al., 2018). They may also feel stigma and embarrassment about help-seeking, leading to a reduced chance of pregnancy (International Federation of Gynecology and Obstetrics, <https://fertilitytool.com/tools/basic-tool-1-why-care/>). While recent years have shown an increase in interventions to reduce the stigma of infertility in low-, middle-, and high-income countries, generally poor knowledge about infertility means that most people cannot avoid risks or seek help in a timely fashion when having difficulty achieving pregnancy or fathering a child (Pedro et al., 2018; Gerrits et al., 2023). Thus, awareness about infertility and its prevention and treatment are key to well-being and to global family-building and family-planning efforts. A summary of global strategies and challenges to increase fertility awareness and infertility prevention underscores unmet needs of education and research.

## Awareness

Fertility awareness has been defined as ‘the understanding of reproduction, fecundity, fecundability, and related individual risk factors (e.g. advanced age, sexual health factors, such as STIs, and lifestyle factors such as smoking and obesity) and non-individual risk factors (e.g. environmental and workplace factors)’ including the awareness of societal and cultural factors affecting options to meet reproductive family planning, as well as family-building needs (Zegers-Hochschild et al., 2017). There is a general lack of awareness regarding reproductive health in most societies. Lay populations, especially, have a limited and misconstrued understanding of both the relationship of age to

infertility and the limitations of available reproductive technologies to overcome the effects of age (Bunting *et al.*, 2013; Pedro *et al.*, 2018; Delbaere *et al.*, 2020; Choi *et al.*, 2023). Many women are aware that age impacts fertility, but they lack specific knowledge about when and to what extent fertility declines, making it difficult for them to act on their knowledge in a way that does not undermine parenthood goals (e.g. when to start trying to become pregnant, use of fertility preservation). Due to poor knowledge levels, fertility education initiatives have been suggested to guide people making decisions about fertility (ASRM Practice Committee, 2019; Delbaere *et al.*, 2020).

Qualitative research shows that culturally tailored fertility awareness tools are feasible and acceptable (Bayoumi *et al.*, 2021). This tailoring is needed because evidence is emerging that prevalence of risk factors for infertility varies according to country. Anthropologists have documented infertility campaigns in LMICs led by government, professional societies, patient groups, and activists (Gerrits *et al.*, 2023). For example, in Iran reproductive health authorities have initiated educational campaigns to 'create a culture' of infertility awareness through films, books, and leaflets intended for popular audiences (Tremayne, 2009). Most campaigns in LMICs have not been shown to have major impact because they have lacked visibility and formal evaluation (Ombelet and Campo, 2007; Thevenon and Gauthier, 2011; Tan, 2020).

## Prevention

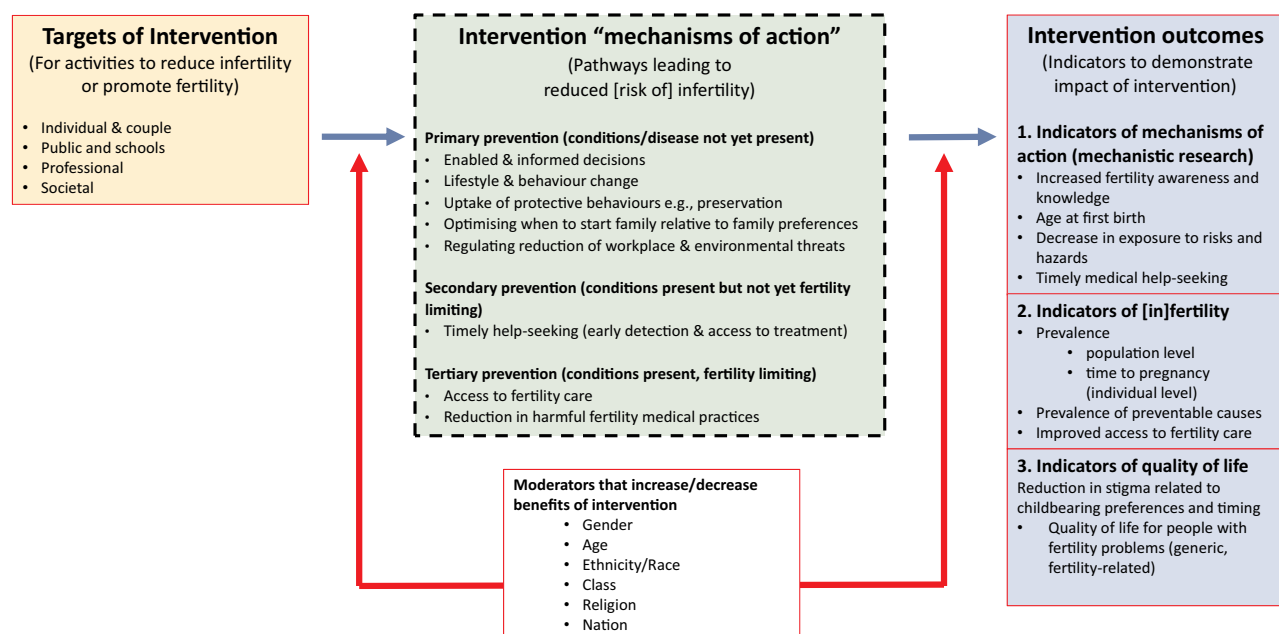
Prevention of infertility has targeted different societal levels and pathways. Figure 3 illustrates a conceptual model of infertility prevention based on theory and extant research (Boivin and Inhorn, 2022). Four aspects of prevention should be considered in evaluating these efforts, namely the target of intervention (individual, couple, society), the proposed mechanism of action (behavior change, early detection), the intervention outcomes (e.g. prevalence of infertility), and any moderators that could impact the effectiveness of interventions (e.g. ethnicity). Figure 3 also

makes clear that prevention efforts could be at primary, secondary, and tertiary care levels. Specifically, prevention efforts can be directed before the disease is present (i.e. primary prevention), for example, delivered opportunistically during contraceptive or smoking cessation programs (Macaluso *et al.*, 2010; Delbaere *et al.*, 2020). Secondary prevention can occur when a health condition is present but not yet fertility limiting (e.g. early detection and treatment of endometriosis or fertility preservation for cancer patients). Tertiary prevention can apply to existing infertility, with prevention aiming to limit impacts of fertility care on health and quality of life (e.g. single embryo transfer to avoid multiple pregnancy).

Research is needed to address the effect of prevention strategies on significant clinical outcomes, which could be behavior change targets (e.g. weight loss) and fertility outcomes (e.g. live births). Prevention research should also examine the moderators of the effects of prevention (e.g. gender, age, ethnicity, education). The effects of prevention at primary, secondary, and tertiary levels on fertility have not been extensively evaluated. Effects of primary prevention strategies targeting behavior changes to eliminate or minimize risk associated with infertility are uncertain due to the paucity of high-quality evidence. One non-randomized trial in India suggested that men willing to stop smoking showed better quality sperm within 3 months of smoking cessation than men unwilling to stop smoking (Kulaksiz *et al.*, 2022). One randomized controlled trial (RCT) showed that in Japan provision of fertility information accelerated the timing of births in partnered women, and that couples tried to achieve pregnancy 15 months earlier, important in Japan where people typically start family building in their mid to late 30s (Maeda *et al.*, 2018). Qualitative research suggests gaps in primary awareness campaigns, for example, not being inclusive across cultures and not targeting men presenting specific risks for male infertility (Berthelsen *et al.*, 2021).

Benefits of secondary and tertiary prevention strategies that target early treatment of STIs and pelvic inflammatory disease,

**Conceptual model for the prevention of infertility through [in]fertility awareness and access to care**



**Figure 3.** Conceptual model of infertility prevention based on theory and existing infertility research. Modified and reprinted with permission from Boivin and Inhorn (2022).

or avoidance of pregnancy or abortion-related infections, are effective in eliminating infection, but subsequent effects on fertility are unknown because fertility outcomes are not being measured in research (Savaris et al., 2020). One public health RCT showed that provision of fertility information in undiagnosed men meeting the definition of infertility was associated with timely medical help-seeking compared to control groups (Maeda et al., 2018). Systematic reviews and prevention campaigns among the diagnosed infertile (e.g. pre-conception, lifestyle advice) are effective in reducing intermediate endpoints (weight loss, biomarkers) but not in markedly increasing fertility outcomes such as live births (Boedt et al., 2021). Often, conclusions are uncertain due to low-quality evidence.

Prevention at societal level exists but is incidental rather than targeted. About 60% of countries with below-replacement fertility levels have adopted fertility-friendly policies (e.g. reducing costs of childcare, healthcare, and MAR) or fertility risk-reducing policies (e.g. occupational safety and environmental health) (Bergsvik et al., 2020). However, systematic reviews demonstrate that infertility itself is not integrated into sexual and reproductive health policies or, if it is, prevention is not included (Morshed-Behbahani et al., 2020; Ravindran and Govender, 2020). Major barriers to inclusion are limited political commitment and under-recognition of the burden of infertility, in addition to costs of MAR (Afferri et al., 2022). Other societal level interventions, such as regulation about exposure to occupational and environmental hazards, potentially reduce rates of infertility but are not specifically designed with fertility outcomes in mind despite compelling evidence supporting recent recommendations from ESHRE to collect more surveillance data and initiate public awareness campaigns (Skakkebaek et al., 2022; ESHRE Environment Seminar, 2023). Concern over the impact of endocrine disruptor exposure on reproductive health has led to calls for a multi-country monitoring system (Le Moal et al., 2016).

The significant gaps in knowledge about the efficacy of prevention efforts point to the need for policy and research to implement and evaluate prevention strategies on fertility outcomes and the moderators of these effects. Most prevention efforts continue to target women in high-income countries despite repeated calls for such efforts to also target people in LMICs.

## Conclusions and recommendations

1. The quality of research into effects of prevention campaigns needs to be more rigorous and include fertility outcomes.
2. Advocacy and additional educational efforts, which will require appropriate funding, are needed to increase awareness and acceptance of infertility as a disease with a high burden.
3. Prevention through (in)fertility awareness and access to care should be prioritized in national health and education agendas globally and at all levels (primary, secondary, tertiary).
4. Appropriate conceptual models of prevention of infertility that are culturally informed should be used to guide the design of education and prevention resources and in the selection of fertility indicators.
5. The creation of sustainable multidisciplinary and multi-stakeholder consortia to deliver prevention programs should be supported.

## Identified key knowledge gaps

1. High-quality actionable evidence should be generated to direct policy about the value of prevention efforts.

2. Geographic regions with a high proportion of LMICs are poorly represented in research on prevention.
3. Men, single persons, LGBTQ+ individuals and couples, and people with disabilities or health conditions are largely omitted in research; this needs to change.
4. Attention is needed on causal impacts and assessment of relevant fertility outcomes.
5. Co-production of educational resources with multiple stakeholders (i.e. people with a current or future child wish, policymakers, researchers, healthcare professionals, community groups, schools) is needed, as in other areas of reproductive health.

## Access to fertility care

Infertility treatment and fertility care are increasingly being recognized globally as effective therapies to achieve family-building goals, especially in most high-income countries (HICs). Data on access to non-ART fertility care are minimal globally, so only available data on access to ART can be used. Access to fertility care can only be realized when ART services are present, and the geographical location and activities are known (Markets and Markets, 2021). However, large variations exist in the number of clinics per capita. Reducing these disparities will require the global effort of governments, industry, and non-governmental organizations to provide accessible infrastructure, training, and affordable models (Ombelet, 2011; Chiware et al., 2021).

Access to fertility care, as with healthcare in general, has multiple dimensions (availability, accessibility, acceptability, and quality) and does not comprise a single, measurable entity (Dyer et al., 2020). Access to healthcare is disease-specific and determined by the demand for health services (reflecting individual perceptions of illness, preferences, economic resources, sociocultural, and epidemiological factors), as well as supply (reflecting health system factors such as availability, cost, funding, affordability, regulations, and quality) (Chambers et al., 2009). Distinct disparities in infertility care exist, largely due to barriers to access aligned with race, class, socioeconomic status, gender, sexual orientation, and other forms of difference (ASRM The Ethics Committee, 2021). Evaluation of access to fertility care is complex and includes variable metrics, populations, as well as the absence of data—especially in LMICs (Zegers-Hochschild et al., 2017; Canadian Assisted Reproductive Technologies Register Plus (CARTR Plus), 2018; Dyer et al., 2019; Ishihara et al., 2020; De Geyter et al., 2020; Hu et al., 2020; Lanes et al., 2020; Wyns et al., 2021; Australia and New Zealand Assisted Reproduction Database (ANZARD), 2022; Centers for Disease Control and Prevention (CDC), <https://www.cdc.gov/art/artdata/index.html>). ART utilization is considered to reflect 'realized access' and is a proxy for access. It is calculated based on annually collected global data. The estimated annual demand for ART in 2001 was treatment of 1500 couples (not 1500 cycles) per million population (ESHRE Capri Workshop Group, 2001). Countries with high ART utilization generally have good access to non-ART fertility care, whereas poor access to ART is usually paralleled by poor access to non-ART fertility care (Botha et al., 2018).

## Utilization of ART is multifactorial

Utilization rates require both a numerator and denominator. In ART, there are numerous possible denominators depending on which aspect of the continuum of treatment is being considered. Standardizing global results requires using commonly available metrics such as start of an ART cycle. Arguably, the best metric is the number of couples utilizing services, but such data are

rarely available. It is essential to compare similar metrics when assessing utilization (Adashi and Dean, 2016; Dyer et al., 2020; Kawwass et al., 2021; Beroukhim et al., 2022).

The denominator of utilization rate usually reflects the entire population, millions of women, or females of reproductive age. Different countries have different age and gender distributions, and data are often not available and/or inconsistently defined. Population demographics are usually determined only once every 10 years or more from census counts and often overall age distribution is extrapolated from subgroups of ages. Finally, there are almost no data available regarding men's access to fertility care (Nachtigall, 2006; Tarsi and Tuff, 2012; Rogers, 2017; Dyer et al., 2020).

ART availability, which affects utilization, is affected by the number of clinics and service locations, and geographic locations. Larger clinics are generally more available than smaller ones. High population density countries have more availability than low. Larger countries geographically and those with difficult topography tend to have lower availability. Other population variables include geographic and urban/rural distribution, as well as country development, which affects the ease of transportation (Brodeur et al., 2022).

Accessibility and utilization are affected by physical features of clinics (e.g. access for the disabled, male services available only in female clinics), limitation of reproductive health information, and a regulatory environment that might restrict services and/or discriminate, e.g. LGBTQ+ or single people (ASRM The Ethics Committee, 2021; Oliveira et al., 2021). The acceptability of care influences utilization. This includes the structure of the health system and its ability to provide respectful, culturally appropriate, gender, and life-cycle-sensitive care according to patient preferences (Rich and Domar, 2016; Beroukhim et al., 2022). Finally, the actual and perceived quality of treatment based on a scientific approach, its medically appropriate use, and quality of service impacts utilization (Dyer et al., 2020). Countries with different TFRs, immigration and social policies could perceive utilization rates differently. The variable effectiveness of ART treatments impacts the number of cycles performed, multiple pregnancy rates, and the number of babies born.

The International Committee for Monitoring Assisted Reproductive Technologies (ICMART) collects global data annually from ~80 countries reflecting over 90% of global ART activity (Chambers et al., 2021). China has just begun reporting utilization rates of 657 per million for 2017 (Bai et al., 2020). The global utilization rate is 535/million population with dramatic country differences ranging from 16 to 5203 (Chambers et al., 2021). Country-specific utilization rates have varied only slightly over time. Not all countries collect ART data, in many countries not all clinics report, and data quality and validation are variable (De Geyter et al., 2020; Chambers et al., 2021). A minority of countries collect cycle-by-cycle data; most collect only aggregated clinic data. Very few countries report the number of women or men utilizing treatment as opposed to the number of ART cycles performed. Cross-border care is poorly reported. Few report non-ART treatments, and these are mostly IUI cycles. There are almost no registry data on ovulation induction, empirical ovarian stimulation, female surgical interventions, or other treatments, and essentially no registries or data for men.

Consensus is needed on the optimal way to measure access to care and success of treatment. The numerator and the denominator for calculation need standardization, and confounding variables quantified. The following should be documented: total oocyte aspirations, freeze-all cycles, preimplantation genetic

testing, frozen embryo transfers, third-party cycles, and cross-border care; restrictions on access; number of clinic service locations, population, area, and urbanization index; live birth rate, multiple birth, and complication rates; women, men, and number of treatment cycles for each; number of singletons, twins, and triplets or higher babies; detailed demographic information on gender and age; proportion of the non-fecund population at age 50 years, including those choosing to remain child-free, IUI, non-traditional family-building services for LGBTQ+ and singles; number of children per couple/person; and age of childbearing.

In most countries ART is under-utilized. High costs related to ART and/or insufficient reimbursement making ART unaffordable to many or most people result in reduced access, whereas uncontrolled reimbursement or consumer behavior in a commercial environment may provoke over-utilization (Bai et al., 2020). More complete and robust data would help health authorities develop appropriate ART policies.

## Conclusions and recommendations

Understanding the status of access to fertility care is essential to ensure individual reproductive rights and promote societal population goals.

1. Current data have identified the need for significantly increased access to quality fertility care in almost all global jurisdictions.
2. Many complexities, deficiencies, and challenges remain to improve available data so that individual rights and societal reproductive goals can be optimized through public health policies.
3. Identified key knowledge gaps can only be rectified by significantly increased and more detailed surveillance.
4. Unrestricted access to fertility care may result in over utilization.

## Identified key knowledge gaps

1. The underlying population need for ART remains largely unknown.
2. The association between ART utilization and access to non-ART fertility care is uncertain.
3. Almost no data exist on non-ART fertility treatments.
4. The major deficiency regarding access is its complexity and lack of a standardized quantifiable approach.
5. The major deficiency regarding measurement of utilization of infertility care is that data are limited or absent for all populations, especially LGBTQ+, singles, minorities, and males.
6. Policymakers have insufficient knowledge and lack awareness of the true demand for infertility treatment in high-, middle-, and low-income countries.

## Working toward equitable access to fertility care

### A human right

Article 16.1 of the UN Declaration of Human Rights states that 'men and women of full age, without any limitation due to race, nationality or religion, have the right to marry and to found a family': United Nations Charter Article 16 (United Nations, <https://www.ohchr.org/en/human-rights/universal-declaration/translations/english>). The human right of persons to access infertility treatment is consistent with the 1948 UN Declaration of Human Rights and the ICPD plan of action Cairo 1994 (United Nations, <http://www.ohchr.org>; International Conference on

Population and Development, [https://partners-popdev.org/icpd/ICPD\\_POA\\_summary.pdf](https://partners-popdev.org/icpd/ICPD_POA_summary.pdf)). Therefore, addressing infertility is fundamental to realizing the right of individuals and couples to found a family (Zegers-Hochschild et al., 2013; Mburu et al., 2023). Infertility treatments must not be limited to the affluent. Although both male and female factors can be the cause of infertility, women bear the most severe consequences and burdens even if they are not the cause of infertility (Starrs et al., 2018; Vollset et al., 2020).

Ways to improve access to care include reducing cost and other structural barriers to access, addressing diversity, equity, inclusion, and belonging, providing culturally appropriate care, increasing availability in low resource settings, and demonstrating the economic burden of infertility (Ombelet, 2011; Chiware et al., 2021; Afferri et al., 2022; International Federation of Gynecology and Obstetrics, <https://fertilitytool.com/tools/basic-tool-1-why-care/>).

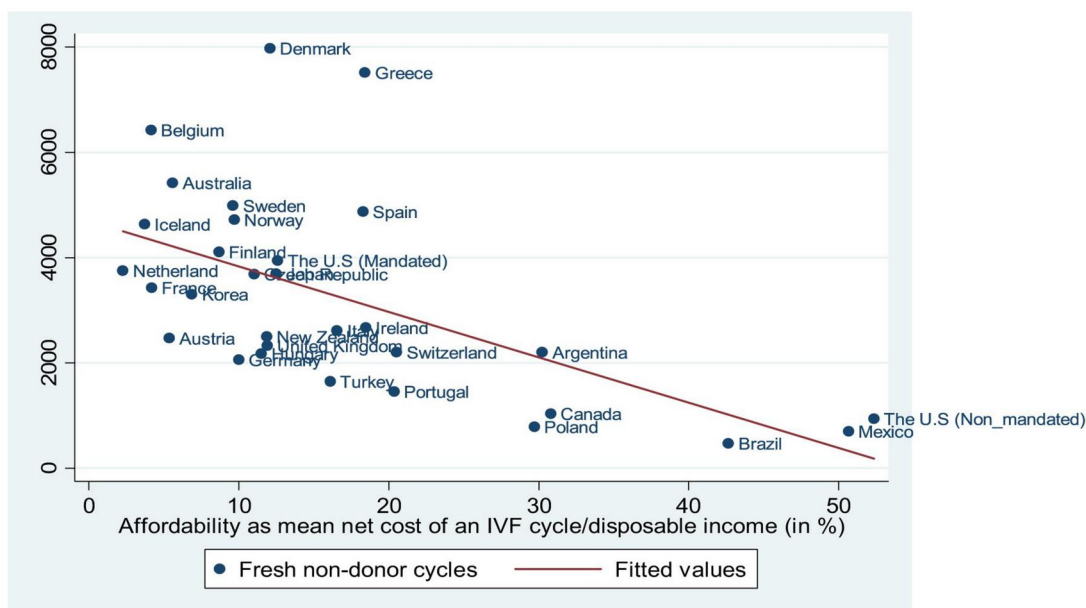
### Affordability

Consumer affordability is clearly a strong driver of access (Fig. 4) and is defined as the consumer out-of-pocket cost relative to average disposable income. Affordability can be increased by reducing the cost and complexity of infertility interventions, increasing reimbursement, and increasing individuals' disposable income (Chambers et al., 2014). However, only treatment cost and reimbursement arrangements are amenable to policy interventions. Since ART is a widely practiced, mature technology, its cost should be decreasing. However, the primary focus on maximizing pregnancy rates per cycle—especially in HICs—has often created very complex and expensive ART. Often such efforts do not result in increased success rates proportionate to the cost, especially from a cumulative (multiple cycles) live birth rate perspective compared to non-ART treatments such as ovulation induction, ovarian stimulation with IUI or surgery in selected patients. Furthermore, ART is usually offered in a free-market economy where providers, and often commercial owners of clinics, are incentivized to make a profit.

Reducing the societal cost of infertility treatment also includes reducing pregnancy, neonatal, and long-term costs associated with multiple pregnancies resulting from ART. By improving affordability, the incentive to transfer more than one embryo is minimized and promotes this goal (Chambers et al., 2014). The Belgian reimbursement policy in which reimbursement of ART-related laboratory activities is linked to a transfer policy aiming at substantial multiple pregnancy reduction, turned out to become a good example of cost-efficient health care through responsible, well considered clinical practice (Ombelet et al., 2005). The cost of multiple births that have been associated with fertility treatment is a legitimate concern of policymakers, providers, and patients. Fertility providers have responded by decreasing substantially the percentage of multiple pregnancies. In 2022, the percentage of twins globally is approaching 10% and in some countries is only slightly higher than naturally occurring twin rates. There are strong trends in technology advances and clinical practice that should ensure continued reduction in multiple births from fertility care. Due to high cost and/or unaffordability, ART remains out of reach for many, even in resource-rich countries (Dyer et al., 2020; ASRM The Ethics Committee, 2021; Njagi et al., 2023). There is wide variation in regulatory and funding arrangements by governments and third parties. Less than half of reporting countries provide any financial support for ART, and only 20% offer full reimbursement (International Federation of Fertility Societies' Surveillance (IFFS), 2022).

### Societal economic benefit

Fertility care is often not affordable for individuals who have to pay out of pocket for such treatments (Dyer, 2002; Ombelet et al., 2008; Chambers et al., 2013; Bahamondes and Makuch, 2014; Koniarens et al., 2022). In contrast, fertility care is very affordable from a societal perspective (Chambers et al., 2009; Connolly et al., 2010; Vélez et al., 2014). Indeed, fertility care is cost-effective and represents a positive return on public investment through the future economic value of babies resulting from fertility treatments (ESHRE Capri Workshop Group, 2015). Identifying the optimal



**Figure 4.** Correlation between affordability (mean cost of a fresh IVF cycle as a percentage of average disposable income) and the utilization (number of fresh non-donor cycles per million women of reproductive age (15–49 years)). Correlation co-efficient =  $-0.35$ . Reprinted with permission from Chambers et al. (2014).

economic framework to assess the cost and benefits of fertility care remains challenging because infertility and its treatment are unique in the health care system because its goal is the creation of a new life (Martins and Connolly, 2022). Compelling economic reasons to support increased access to fertility care in most countries include the relatively low societal cost to obtain a live birth, future economic productivity of the resulting individuals, and the high net present value of future tax payments from those individuals (Connolly et al., 2008; Martins and Connolly, 2022). For instance, lifetime revenue from tax-paying citizens, calculated in the UK, was eight times the return on investment from the total cost of fertility care (Connolly et al., 2009). Comparable benefits have been reported for other countries such as Canada, USA, Denmark, Sweden, and South Africa (Connolly et al., 2008; Svensson et al., 2008). IVF and naturally conceived individuals in the Netherlands have negative yet similar discounted net tax revenue at the end of life in an analytic framework that undervalues the incremental value of an additional birth because it only considers the fiscal consequences of life and does not take into consideration broader macroeconomic benefits (Moolenaar et al., 2014). Another way to conceptualize the importance of fertility care is to assess the statistical value of a human life (estimated to be US\$5.7 million), which far exceeds the cost of creating a life through fertility treatment (Keller et al., 2021). This median value ranged from \$858 599 in developing countries to \$8 342 027 in developed countries. Estimates of the statistical value of a human life were up to 4.66 times higher when parents were asked to value their children's rather than their own lives (Keller et al., 2021). In addition to improving the quality of life of individuals and couples, by any measure, the net economic impact of fertility care is highly positive for all societies.

### Socio-cultural factors

Religion and cultural beliefs about fertility reflect the level of acceptability of ART and thus influence access to fertility care. Indeed, the moral status of the embryo, use of frozen gametes, and third-party reproduction have been central to many religious debates, particularly in the Middle East, Latin America, parts of Europe (where there is reduced acceptability of ART), and the USA (Serour and Serour, 2021). Although most world religions support the use of ART, fostering culturally appropriate care (e.g. accommodating language barriers, respecting gender, and privacy norms), and removing structural barriers would ameliorate many of the disparities in access to infertility care (International Federation of Gynecology and Obstetrics, <https://fertilitytool.com>).

### Gender equity

The increasing understanding of how gender norms and disparities affect pathways to health outcomes helps explain why there are such inequalities in access to fertility care. Countries with high ART utilization rates (a proxy for access) generally have high levels of gender equality, particularly reflected in education, labor force participation, empowerment, and reproductive rights (Fig. 5) (Chambers and Fauser, 2021). Infertility and its treatment are particularly sensitive to gender inequalities because it largely remains a gendered problem, with women carrying much of the stigma and burden (Greil et al., 2010). Emphasizing the importance of a life-course approach to the integration of fertility care in women's social and physical health, both the WHO and the UN recently included fertility care under the definitions of sexual and reproductive health and rights (United Nations, 2019).

### Diversity, equity, inclusion, and belonging

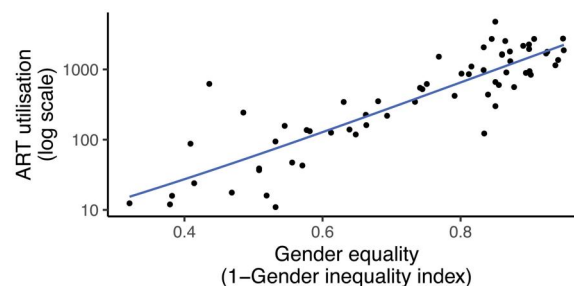
Infertility can negate the realization of the right of every person to found a family. Inequities in access to fertility care adversely affect all minorities, whether racial, religious, gender-based, or other. Such disparities in access often arise from restrictive legislation, government policies, and inappropriate care pathways (Seifer et al., 2022). Embracing the principles of diversity, equity, and inclusion while addressing infertility and fertility care improves emotional health and well-being, promotes gender equity, advances diversity, equity, inclusion, and belonging goals, and enhances social justice.

### Context

ART has predominantly been developed in HICs. Approximately three-quarters of all global ART cycles are performed in just 10 countries. Complex and expensive ART protocols are less applicable in low-resource settings because the context is significantly different (Macklon and Fauser, 2020). Comparing ART from many parts of the world in a useful manner remains challenging because standardized outcome measures, involving success rates along with the burden of treatment, risks and cost, are not yet available (Fauser 2019). Simplified, lower cost, high-quality ART procedures are urgently needed to establish affordable ART, especially in LMICs (Ombelet 2011; Chiware et al., 2021).

### Conclusions and recommendations

1. Cost, affordability, socio-cultural and diversity factors, and gender inequality represent the most important drivers in unequal access to fertility care.
2. Fertility care is not affordable for many people around the world, especially in low-resource settings.
3. The child who results from fertility care represents a strong economic benefit for society.



**Figure 5.** Relation between ART utilization (cycles per million population) and the degree of gender equality in countries reporting to the United Nation's Development Program Gender Inequality Index. Each black dot represents a country. Utilization from the ICMART 2012 World Registry. Reprinted with permission from Chambers and Fauser (2021).

4. Policies and practices need to be developed to reduce disparities in fertility care based on class, gender, sexual orientation, and other differences.
5. Striving for gender equality and universal reproductive rights will foster more equitable, culturally appropriate access to fertility care.
6. There is an urgent need to develop simpler, less expensive ART.
7. Infrastructure and training support are needed to increase access to care, especially in low-resource countries.

## Identified key knowledge gaps

1. The development and evaluation of simplified fertility treatments, especially ART.
2. Effective ways to reduce disparities in access to fertility care for single women and men, and LGBTQ+ people.
3. Quantification of economic benefits of infertility care in different settings.

## Conclusions

Economic development, urbanization, improved education, secularization, gender equity, and family-planning policies have all contributed to slowing world population growth. Global TFR is decreasing, which will eventually result in a declining global population and radically changed demographics in most countries worldwide during this century. Although all declining, major regional differences in absolute TFR numbers remain. While a beneficial impact on the environment is anticipated, these drastic changes will have major societal and economic implications that will severely challenge nations and the global community. Policies will need to be developed to optimize the management of these changes. More focus on developing effective family-building policies should represent an important component of such strategies.

Globally, infertility is one of the most frequent chronic diseases among women and men of reproductive age, with several well-known risk factors and a high burden globally. Both success and safety of infertility treatments have improved significantly in recent decades. More recently, these technologies are also increasingly applied in other populations of individuals and the LGBTQ+ community in need of fertility care to form a family. Since the right to found a family is fundamental to every person, appropriate funding should be provided for fertility care, evaluation, and treatment. Because of a lack of awareness and appreciation of the prevalence and burden of infertility, however, only a few countries globally meet these needs. Fertility care, including infertility treatment, should be considered a principal component of family building and family planning.

Fertility care is now successful enough to justify its widespread global availability for those in need of reproductive assistance to realize their family goals and improve their personal well-being. Doing so will also help mitigate the declining TFR. This mitigation can be achieved in harmony with goals related to climate change, since it is human activity—linked to rising gross domestic product per capita and resultant consumption—rather than human numbers per se that does the greatest damage to the environment (United Nations, 2021).

The economic benefits to society of providing fertility care clearly exceed the cost of treatment, and these benefits will only increase as populations become more aged. The medical profession, policymakers, other stakeholders, and the public can use

the information provided to increase their understanding of fertility care. Such increased understanding will enable the development of integrative family-planning policies that meet the needs of those needing fertility care to establish their family, while also helping societies manage the decreasing TFR and resulting demographic and societal challenges.

## Call to action Concerning awareness

1. Increase awareness that family building should become an integral part of global family-planning policies.
2. Increase awareness of stakeholders, policymakers, and the public regarding the distinct societal implications of decreasing TFR.
3. Focus more on family building and the prevention of infertility in educational programs for young adults.
4. Promote research that provides answers to critical gaps in the knowledge of family building.
5. Recognize the distinct global need for nations to develop and implement effective strategies to prevent infertility.
6. Educate stakeholders, policymakers, and the public regarding the ability of fertility care to help mitigate the consequences of a reducing TFR.
7. Promote research on the diagnosis and treatment of male infertility.

## Concerning human rights

Recognize and promote the right of all individuals to have children if desired.

## Concerning access to care

1. Recognize the global need to improve access to fertility care, especially in LMICs, by developing less complex and more affordable, high quality fertility care (both diagnosis and treatment).
2. Reduce complications of fertility care, especially multiple pregnancies, to diminish the societal cost of fertility care.
3. Realize more equitable access by increasing public and insurance funding of fertility care and expanding coverage to individuals and same-sex couples.

## Data availability

All data are incorporated into the article. The data underlying this article are available in the article and in the source references listed at the end of the article.

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## Key terminology used in current document

(No consensus concerning definitions exists in this complex field, and alternative explanations (clinical, epidemiological, or demographic) may exist.)

<b>Access to health care</b>	Timely use of health services to achieve the best health outcomes. This is disease-specific and determined by the demand for and supply of health services.
<b>ART</b>	Assisted reproductive technologies
<b>Child-friendly policies</b>	Measures and initiatives aimed at creating a supportive and nurturing environment for children. These policies are designed to safeguard children's rights, enhance their well-being, and provide them with opportunities for healthy development. Child-friendly policies typically cover various areas, including education, healthcare, social welfare, protection, and participation.
<b>Family building</b>	The process by which individuals or couples create or expand their families. It encompasses various methods and options available to individuals or couples who wish to have children. Family building can involve biological means, such as natural conception, as well as assisted reproductive technologies (ART) like in vitro fertilization (IVF), intrauterine insemination (IUI), donor sperm, eggs and embryos, and surrogacy. Adoption and foster care are also considered forms of family building. Additionally, some individuals or couples may choose to build their families through step-parenting or other non-biological means. The term 'family building' acknowledges the diverse ways in which individuals or couples can create their desired family structure and reflects the understanding that there is no one-size-fits-all approach to building a family.
<b>Family-friendly policies</b>	Pro-natalist, family-building, and child-friendly policies that aim to support and enhance the well-being of families and recognize reproductive rights.
<b>Family-planning policies</b>	Measures and initiatives with the purpose to reduce the number of children born and mitigate world population growth by approaches that avoid unintended pregnancies and postpone or terminate pregnancies.
<b>Fecundity</b>	Capacity to have a live birth (i.e. fertility potential).
<b>Fertility awareness</b>	The understanding of reproduction, fecundity, and related risk factors, including the awareness of societal and cultural factors affecting options to meet reproductive family-planning and family-building needs.
<b>Fertility care</b>	Interventions that include fertility awareness, support, and fertility management with an intention to assist individuals and couples to realize their desires associated with reproduction and/or to build a family.
<b>GDP</b>	Gross domestic product. The value of all goods and service products by an economy in a given year.
<b>HIC</b>	High-income countries
<b>Infertility</b>	A disease characterized by the failure to establish a clinical pregnancy after 12 months of regular, unprotected sexual intercourse. Different definitions exist that address clinical, epidemiological, demographic, and sociologic aspects, including due to an impairment of a person's capacity to reproduce either as an individual or with his/her partner. Infertility is a disease, which generates disability as an impairment of function.
<b>LGBTQ+ community</b>	Abbreviation for lesbian, gay, bisexual, transgender, queer, asexual, questioning, and intersex individuals
<b>LMIC</b>	Low- and middle-income countries
<b>MAR</b>	Medically assisted reproduction
<b>NGOs</b>	Nongovernmental organizations
<b>Pro-natalist policies</b>	Policies implemented to address concerns related to declining birth rates, aging populations, and potential labor shortages. Pro-natalist policies often include a range of measures and incentives designed to encourage individuals or couples to have more children.
<b>Replacement level</b>	A TFR of 2.1 needed for population stability
<b>Total fertility rate (TFR)</b>	Average number of children born per woman (living to the end of childbearing age)