

UNIT IV

POPULATION DYNAMICS: MEASUREMENT OF FERTILITY AND MORTALITY- MIGRATION: CAUSES AND CONSEQUENCES-NATIONAL AND INTERNATIONAL PATTERNS-ETHNIC CRISIS

Population dynamics is the type of mathematics used to model and study the size and age composition of populations as dynamical systems.

History

Population dynamics has traditionally been the dominant branch of mathematical biology, which has a history of more than 220 years,^[1] although over the last century the scope of mathematical biology has greatly expanded.

The beginning of population dynamics is widely regarded as the work of Malthus, formulated as the Malthusian growth model. According to Malthus, assuming that the conditions (the environment) remain constant (*ceteris paribus*), a population will grow (or decline) exponentially.^{[2]:18} This principle provided the basis for the subsequent predictive theories, such as the demographic studies such as the work of Benjamin Gompertz^[3] and Pierre François Verhulst in the early 19th century, who refined and adjusted the Malthusian demographic model.^[4]

A more general model formulation was proposed by F. J. Richards in 1959,^[5] further expanded by Simon Hopkins, in which the models of Gompertz, Verhulst and also Ludwig von Bertalanffy are covered as special cases of the general formulation. The Lotka–Volterra predator-prey equations are another famous example,^{[6][7][8][9][10][11][12][13]} as well as the alternative Arditi–Ginzburg equations.^{[14][15]}

Logistic function

Simplified population models usually start with four key variables (four **demographic processes**) including death, birth, immigration, and emigration. Mathematical models used to calculate changes in population demographics and evolution hold the assumption ('null hypothesis') of no external influence. Models can be more mathematically complex where "...several competing hypotheses are simultaneously confronted with the data."^[16] For example, in a closed system where immigration and emigration does not take place, the rate of change in the number of individuals in a population can be described as:

where N is the total number of individuals in the specific experimental population being studied, B is the number of births and D is the number of deaths per individual in a particular experiment or model. The algebraic symbols b , d and r stand for the rates of birth, death, and the rate of change per individual in the general population, the intrinsic rate of increase. This formula can be read as the rate of change in the population (dN/dT) is equal to births minus deaths ($B - D$).^{[2][13][17]}

Using these techniques, Malthus' population principle of growth was later transformed into a mathematical model known as the logistic equation:

where N is the biomass density, a is the maximum per-capita rate of change, and K is the carrying capacity of the population. The formula can be read as follows: the rate of change in the population (dN/dT) is equal to growth (aN) that is limited by carrying capacity ($1-N/K$). From these basic mathematical principles the discipline of population ecology expands into a field of investigation that queries the demographics of real populations and tests these results against the statistical models. The field of population ecology often uses data on life history and matrix algebra to develop projection matrices on fecundity and survivorship. This information is used for managing wildlife stocks and setting harvest quotas.^{[13][17]}

Intrinsic rate of increase

The rate at which a population increases in size if there are no density-dependent forces regulating the population is known as the *intrinsic rate of increase*. It is

where the derivative $\frac{dN}{dt}$ is the rate of increase of the population, N is the population size, and r is the intrinsic rate of increase. Thus r is the maximum theoretical rate of increase of a population per individual – that is, the maximum population growth rate. The concept is commonly used in insect population ecology or management to determine how environmental factors affect the rate at which pest populations increase. See also exponential population growth and logistic population growth.^[18]

Epidemiology

Population dynamics overlap with another active area of research in mathematical biology: mathematical epidemiology, the study of infectious disease affecting populations. Various models of viral spread have been proposed and analysed, and provide important results that may be applied to health policy decisions.

Geometric populations



Operophtera brumata populations are geometric.^[19]

The mathematical formula below can be used to model geometric populations. Geometric populations grow in discrete reproductive periods between intervals of abstinence, as

opposed to populations which grow without designated periods for reproduction. Say that N denotes the number of individuals in each generation of a population that will reproduce.^[20]

Where: N^t is the population size in generation t , and N^{t+1} is the population size in the generation directly after N^t ; B^t is the sum of births in the population between generations t and $t+1$ (i.e. the birth rate); I^t is the sum of immigrants added to the population between generations; D^t is the sum of deaths between generations (death rate); and E^t is the sum of emigrants moving out of the population between generations.

When there is no migration to or from the population,

Assuming in this case that the birth and death rates are constants, then the birth rate minus the death rate equals R , the geometric rate of increase.

$$N_{t+1} = N_t + RN_t$$

$$N_{t+1} = (N_t + RN_t)$$

Take the term N_t out of the brackets again.

$$N_{t+1} = (1 + R)N_t$$

$1 + R = \lambda$, where λ is the finite rate of increase.

$$N_{t+1} = \lambda N_t$$

At $t+1$	$N_{t+1} = \lambda N_t$
At $t+2$	$N_{t+2} = \lambda N_{t+1} = \lambda \lambda N_t = \lambda^2 N_t$
At $t+3$	$N_{t+3} = \lambda N_{t+2} = \lambda \lambda N_{t+1} = \lambda \lambda \lambda N_t = \lambda^3 N_t$

Therefore:

$$N_{t+1} = \lambda^t N_t$$

Term	Definition

λ^t	Finite rate of increase raised to the power of the number of generations (e.g. for $t+2$ [two generations] $\rightarrow \lambda^2$, for $t+1$ [one generation] $\rightarrow \lambda^1 = \lambda$, and for t [before any generations - at time zero] $\rightarrow \lambda^0 = 1$)
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Doubling time

***G. stearotherophilus* has a shorter doubling time (td) than *E. coli* and *N. meningitidis*.** Growth rates of 2 bacterial species will differ by unexpected orders of magnitude if the doubling times of the 2 species differ by even as little as 10 minutes. In eukaryotes such as animals, fungi, plants, and protists, doubling times are much longer than in bacteria. This reduces the growth rates of eukaryotes in comparison to Bacteria. *G. stearotherophilus*, *E. coli*, and *N. meningitidis* have 20 minute,^[21] 30 minute,^[22] and 40 minute^[23] doubling times under optimal conditions respectively. If bacterial populations could grow indefinitely (which they do not) then the number of bacteria in each species would approach infinity (∞). However, the percentage of *G. stearotherophilus* bacteria out of all the bacteria would approach **100%** whilst the percentage of *E. coli* and *N. meningitidis* combined out of all the bacteria would approach **0%**. This graph is a simulation of this hypothetical scenario. In reality, bacterial populations do not grow indefinitely in size and the 3 species require different optimal conditions to bring their doubling times to minima.

Time in minutes % that is *G. stearotherophilus*

30	44.4%
60	53.3%
90	64.9%
120	72.7%
$\rightarrow \infty$	100%

Time in minutes % that is *E. coli*

30	29.6%
60	26.7%
90	21.6%
120	18.2%

→∞ 0.00%

Time in minutes % that is *N. meningitidis*

30 25.9%

60 20.0%

90 13.5%

120 9.10%

→∞ 0.00%

Disclaimer: Bacterial populations are logistic instead of geometric. Nevertheless, doubling times are applicable to both types of populations.

The doubling time (t^d) of a population is the time required for the population to grow to twice its size.^[24] We can calculate the doubling time of a geometric population using the equation: $N_{t+1} = \lambda^t N_t$ by exploiting our knowledge of the fact that the population (N) is twice its size (2N) after the doubling time.^[20]

$$2N_{td} = \lambda^{t_d} \times N_t$$

$$\lambda^{t_d} = 2N_{td} / N_t$$

$$\lambda^{t_d} = 2$$

The doubling time can be found by taking logarithms. For instance:

$$t_d \times \log_2(\lambda) = \log_2(2)$$

$$\log_2(2) = 1$$

$$t_d \times \log_2(\lambda) = 1$$

$$t_d = 1 / \log_2(\lambda)$$

Or:

$$t_d \times \ln(\lambda) = \ln(2)$$

$$t_d = \ln(2) / \ln(\lambda)$$

$$t_d = 0.693... / \ln(\lambda)$$

Therefore:

$$t_d = 1 / \log_2(\lambda) = 0.693... / \ln(\lambda)$$

Half-life of geometric populations

The half-life of a population is the time taken for the population to decline to half its size. We can calculate the half-life of a geometric population using the equation: $N_{t+1} = \lambda^t N_t$ by exploiting our knowledge of the fact that the population (N) is half its size (0.5N) after a half-life.^[20]

$$0.5N_{t_{1/2}} = \lambda^{t_{1/2}} \times N_t$$

Term	Definition
$t_{1/2}$	Half-life.

$$\lambda^{t_{1/2}} = 0.5N_{t_{1/2}} / N_t$$

$$\lambda^{t_{1/2}} = 0.5$$

The half-life can be calculated by taking logarithms (see above).

$$t_{1/2} = 1 / \log_{0.5}(\lambda) = \ln(0.5) / \ln(\lambda)$$

Geometric (R) growth constant[edit]

$$R = b - d$$

$$N_{t+1} = N_t + RN_t$$

$$N_{t+1} - N_t = RN_t$$

$$N_{t+1} - N_t = \Delta N$$

Term	Definition
ΔN	Change in population size between two generations (between generation $t+1$ and t).

$$\Delta N = RN_t$$

$$\Delta N/N_t = R$$

Finite (λ) growth constant

$$1 + R = \lambda$$

$$N_{t+1} = \lambda N_t$$

$$\lambda = N_{t+1} / N_t$$

Mathematical relationship between geometric and logistic populations

In geometric populations, R and λ represent growth constants (see 2 and 2.3). In logistic populations however, the intrinsic growth rate, also known as intrinsic rate of increase (r) is the relevant growth constant. Since generations of reproduction in a geometric population do not overlap (e.g. reproduce once a year) but do in an exponential population, geometric and exponential populations are usually considered to be mutually exclusive.^[25] However, both sets of constants share the mathematical relationship below.^[20]

The growth equation for exponential populations is

$$N_t = N_0 e^{rt}$$

Term	Definition
e	Euler's number - A universal constant often applicable in logistic equations.
r	intrinsic growth rate

Assumption: N_t (of a geometric population) = N_t (of a logistic population).

Therefore:

$$N_0 e^{rt} = N_0 \lambda^t$$

N_0 cancels on both sides.

$$N_0 e^{rt} / N_0 = \lambda^t$$

$$e^{rt} = \lambda^t$$

Take the natural logarithms of the equation. Using natural logarithms instead of base 10 or base 2 logarithms simplifies the final equation as $\ln(e) = 1$.

$$rt \times \ln(e) = t \times \ln(\lambda)$$

Term	Definition
ln	natural logarithm - in other words $\ln(y) = \log_e(y) = x$ = the power (x) that e needs to be raised to (e^x) to give the answer y . In this case, $e^1 = e$ therefore $\ln(e) = 1$.

$$rt \times 1 = t \times \ln(\lambda)$$

$$rt = t \times \ln(\lambda)$$

t cancels on both sides.

$$rt / t = \ln(\lambda)$$

The results:

$$r = \ln(\lambda)$$

and

$$e^r = \lambda$$

Evolutionary game theory

Evolutionary game theory was first developed by Ronald Fisher in his 1930 article *The Genetic Theory of Natural Selection*.^[26] In 1973 John Maynard Smith formalised a central concept, the evolutionarily stable strategy.^[27]

Population dynamics have been used in several control theory applications. Evolutionary game theory can be used in different industrial or other contexts. Industrially, it is mostly used in multiple-input-multiple-output (MIMO) systems, although it can be adapted for use in single-input-single-output (SISO) systems. Some other examples of applications are military campaigns, water distribution, dispatch of distributed generators, lab experiments, transport problems, communication problems, among others.

Trivia

The computer game *SimCity*, *Sim Earth* and the MMORPG *Ultima Online*, among others, tried to simulate some of these population dynamics.

- **Fertility, mortality and migration** are principal determinants of **population** growth. **Population** change depends on the natural increase changes seen in birth rates and the change seen in **migration**. Changes in **population** size can be predicted based on changes in **fertility** (births), **mortality** (deaths) and **migration** rates.
- General **fertility** rate (GFR) - the number of births in a year divided by the number of women aged 15–44, times 1000. ... (That is, because of infant **mortality** some of the births are not included; and because of adult **mortality**, some of the women who gave birth are not counted either.)

Fertility

Fertility is the natural capability to produce offspring. As a measure, fertility rate is the number of offspring born per mating pair, individual or population. Fertility differs from fecundity, which is defined as the *potential* for reproduction (influenced by gamete production, fertilization and carrying a pregnancy to term)^[1] A lack of fertility is infertility while a lack of fecundity would be called sterility.

Human fertility depends on factors of nutrition, sexual behavior, consanguinity, culture, instinct, endocrinology, timing, economics, way of life, and emotions.

Demography

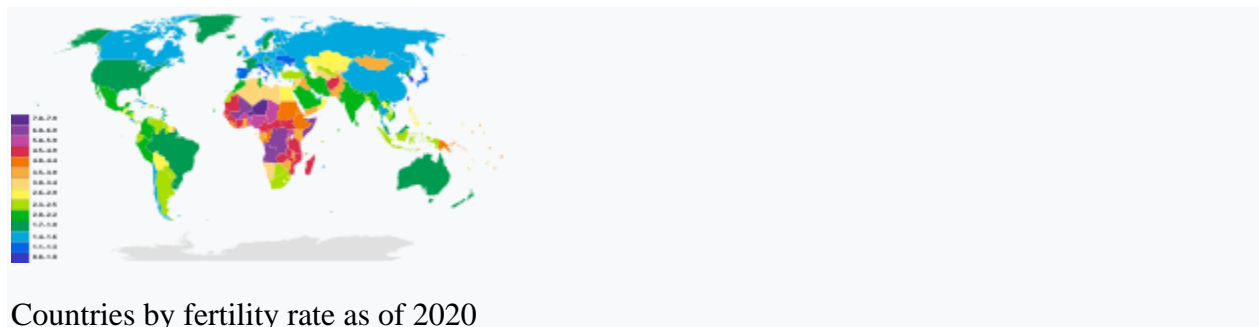
In demographic contexts, fertility refers to the actual production of offspring, rather than the physical capability to produce which is termed fecundity.^{[2][3]} While fertility can be measured, fecundity cannot be. Demographers measure the fertility rate in a variety of ways, which can be

broadly broken into "period" measures and "cohort" measures. "Period" measures refer to a cross-section of the population in one year. "Cohort" data on the other hand, follows the same people over a period of decades. Both period and cohort measures are widely used.^[4]

Period measures

- **Crude birth rate (CBR)** - the number of live births in a given year per 1,000 people alive at the middle of that year. One disadvantage of this indicator is that it is influenced by the age structure of the population.
- **General fertility rate (GFR)** - the number of births in a year divided by the number of women aged 15–44, times 1000. It focuses on the potential mothers only, and takes the age distribution into account.
- **Child-Woman Ratio (CWR)** - the ratio of the number of children under 5 to the number of women 15–49, times 1000. It is especially useful in historical data as it does not require counting births. This measure is actually a hybrid, because it involves deaths as well as births. (That is, because of infant mortality some of the births are not included; and because of adult mortality, some of the women who gave birth are not counted either.)
- **Coale's Index of Fertility** - a special device used in historical research

Cohort measures



Countries by fertility rate as of 2020

- **Total fertility rate (TFR)** - the total number of children a woman would bear during her lifetime if she were to experience the prevailing age-specific fertility rates of women. TFR equals the sum for all age groups of 5 times each ASFR rate.^[5]
- **Gross Reproduction Rate (GRR)** - the number of girl babies a synthetic cohort will have. It assumes that all of the baby girls will grow up and live to at least age 50.
- **Net Reproduction Rate (NRR)** - the NRR starts with the GRR and adds the realistic assumption that some of the women will die before age 49; therefore they will not be alive to bear some of the potential babies that were counted in the GRR. NRR is always lower than GRR, but in countries where mortality is very low, almost all the baby girls grow up to be potential mothers, and the NRR is practically the same as GRR. In countries with high mortality, NRR can be as low as 70% of GRR. When $NRR = 1.0$, each generation of 1000 baby girls grows up and gives birth to exactly 1000 girls. When NRR is less than one, each generation is smaller than the previous one. When NRR is greater than 1 each generation is larger than the one before. NRR is a measure of the long-term future potential for growth, but it usually is different from the current population growth rate.

Social and economic determinants of fertility

A parent's number of children strongly correlates with the number of children that each person in the next generation will eventually have.^[6] Factors generally associated with increased fertility include religiosity,^[7] intention to have children,^[8] and maternal support.^[9] Factors generally associated with decreased fertility include wealth, education,^{[10][11]} female labor participation,^[12] urban residence,^[13] cost of housing,^[14] intelligence, increased female age and (to a lesser degree) increased male age.

The "Three-step Analysis" of the fertility process was introduced by Kingsley Davis and Judith Blake in 1956 and makes use of three proximate determinants:^{[15][16]} The economic analysis of fertility is part of household economics, a field that has grown out of the New Home Economics. Influential economic analyses of fertility include Becker (1960),^[17] Mincer (1963),^[18] and Easterlin (1969).^[19] The latter developed the Easterlin hypothesis to account for the Baby Boom.

Bongaarts' model of components of fertility

Bongaarts proposed a model where the total fertility rate of a population can be calculated from four proximate determinants and the total fecundity (TF). The index of marriage (Cm), the index of contraception (Cc), the index of induced abortion (Ca) and the index of postpartum infecundability (Ci). These indices range from 0 to 1. The higher the index, the higher it will make the TFR, for example a population where there are no induced abortions would have a Ca of 1, but a country where everybody used infallible contraception would have a Cc of 0.

$$\text{TFR} = \text{TF} \times \text{Cm} \times \text{Ci} \times \text{Ca} \times \text{Cc}$$

These four indices can also be used to calculate the total marital fertility (TMFR) and the total natural fertility (TN).

$$\text{TFR} = \text{TMFR} \times \text{Cm}$$

$$\text{TMFR} = \text{TN} \times \text{Cc} \times \text{Ca}$$

$$\text{TN} = \text{TF} \times \text{Ci}$$

Intercourse

The first step is sexual intercourse, and an examination of the average age at first intercourse, the average frequency outside marriage, and the average frequency inside.

Conception

Certain physical conditions may make it impossible for a woman to conceive. This is called "involuntary infecundity." If the woman has a condition making it possible, but unlikely to conceive, this is termed "subfecundity." Venereal diseases (especially gonorrhea, syphilis, and chlamydia) are common causes. Nutrition is a factor as well: women with less than 20% body fat may be subfecund, a factor of concern for athletes and people susceptible to anorexia. Demographer Ruth Frisch has argued that "It takes 50,000 calories to make a baby". There is also subfecundity in the weeks following childbirth, and this can be prolonged for a year or more through breastfeeding. A furious political debate raged in the 1980s over the ethics of baby food companies marketing infant formula in developing countries. A large industry has developed to deal with subfecundity in women and men. An equally large industry has emerged to provide contraceptive devices designed to

prevent conception. Their effectiveness in use varies. On average, 85% of married couples using no contraception will have a pregnancy in one year. The rate drops to the 20% range when using withdrawal, vaginal sponges, or spermicides. (This assumes the partners never forget to use the contraceptive.) The rate drops to only 2 or 3% when using the pill or an IUD, and drops to near 0% for implants and 0% for tubal ligation (sterilization) of the woman, or a vasectomy for the man.

Gestation

After a fetus is conceived, it may or may not survive to birth. "Involuntary fetal mortality" involves natural abortion, miscarriages and stillbirth (a fetus born dead). Human intervention intentionally causing abortion of the fetus is called "therapeutic abortion".

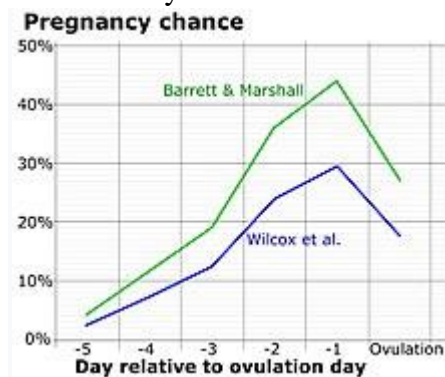
Fertility biology

Women have hormonal cycles which determine when they can achieve pregnancy. The cycle is approximately twenty-eight days long, with a fertile period of five days per cycle, but can deviate greatly from this norm. Men are fertile continuously, but their sperm quality is affected by their health, frequency of ejaculation, and environmental factors.

Fertility declines with age in both sexes. In women the decline is more rapid, with complete infertility normally occurring around the age of 50.

Pregnancy rates for sexual intercourse are highest when it is done every 1 or 2 days,^[20] or every 2 or 3 days.^[21] Studies have shown no significant difference between different sex positions and pregnancy rate, as long as it results in ejaculation into the vagina.^[22]

Menstrual cycle



Chance of fertilization by menstrual cycle day relative to ovulation.^[23]

Main article: Menstrual cycle

A woman's menstrual cycle begins, as it has been arbitrarily assigned, with menses. Next is the follicular phase where estrogen levels build as an ovum matures (due to the follicular stimulating hormone, or FSH) within the ovary. When estrogen levels peak, it spurs a surge of luteinizing hormone (LH) which finishes the ovum and enables it to break through the ovary wall.^[24] This is ovulation. During the luteal phase, which

follows ovulation LH and FSH cause the post-ovulation ovary to develop into the corpus luteum which produces progesterone. The production of progesterone inhibits the LH and FSH hormones which (in a cycle without pregnancy) causes the corpus luteum to atrophy, and menses to begin the cycle again.

Peak fertility occurs during just a few days of the cycle: usually two days before and two days after the ovulation date.^[25] This fertile window varies from woman to woman, just as the ovulation date often varies from cycle to cycle for the same woman.^[26] The ovule is usually capable of being fertilized for up to 48 hours after it is released from the ovary. Sperm survive inside the uterus between 48 and 72 hours on average, with the maximum being 120 hours (5 days).

These periods and intervals are important factors for couples using the rhythm method of contraception.

Female fertility

The average age of menarche in the United States is about 12.5 years.^[27] In postmenarchal girls, about 80% of the cycles are anovulatory (ovulation does not actually take place) in the first year after menarche, 50% in the third and 10% in the sixth year.^[28]

Menopause occurs during a woman's midlife (between ages 48 and 55).^{[29][30]} During menopause, hormonal production by the ovaries is reduced, eventually causing a permanent cessation of the primary function of the ovaries, particularly the creation of the uterine lining (period). This is considered the end of the fertile phase of a woman's life.

The following effects of age and female fertility have been found in women trying to get pregnant, without using fertility drugs or in vitro fertilization (data from 1670 to 1830):^[31]

- At age 30
 - 75% will have a conception ending in a live birth within one year
 - 91% will have a conception ending in a live birth within four years.
- At age 35
 - 66% will have a conception ending in a live birth within one year
 - 84% will have a conception ending in a live birth within four years.
- At age 40
 - 44% will have a conception ending in a live birth within one year
 - 64% will have a conception ending in a live birth within four years.

[31]

Studies of actual couples trying to conceive have come up with higher results: one 2004 study of 770 European women found that 82% of 35- to 39-year-old women conceived within a year,^[32] while another in 2013 of 2,820 Danish women saw 78% of 35- to 40-year-olds conceive within a year.^[33]

According to a report, approved by The Practice Committees and the Board of Directors of the American Society for Reproductive Medicine, specific coital timing or position and resting supine after intercourse have no significant impact on fertility. Sperm can be found in the cervical canal seconds after ejaculation, regardless of coital position.^[34]

The use of fertility drugs and/or invitro fertilization can increase the chances of becoming pregnant at a later age.^[35] Successful pregnancies facilitated by fertility treatment have been documented in women as old as 67.^[36] Studies since 2004 now show that mammals may continue to produce new eggs throughout their lives, rather than being born with a finite number as previously thought. Researchers at the Massachusetts General Hospital in Boston, US, say that if eggs are newly created each month in humans as well, all current theories about the aging of the female reproductive system will have to be overhauled, although at this time this is simply conjecture.^{[37][38]}

According to the March of Dimes, "about 9 percent of recognized pregnancies for women aged 20 to 24 ended in miscarriage. The risk rose to about 20 percent at age 35 to 39, and more than 50 percent by age 42".^[39] Birth defects, especially those involving chromosome number and arrangement, also increase with the age of the mother. According to the March of Dimes, "At age 25, your risk of having a baby with Down syndrome is 1 in 1,340. At age 30, your risk is 1 in 940. At age 35, your risk is 1 in 353. At age 40, your risk is 1 in 85. At age 45, your risk is 1 in 35."^[40]

Male fertility

Some research suggest that increased male age is associated with a decline in semen volume, sperm motility, and sperm morphology.^[41] In studies that controlled for female age, comparisons between men under 30 and men over 50 found relative decreases in pregnancy rates between 23% and 38%.^[41] It is suggested that sperm count declines with age, with men aged 50–80 years producing sperm at an average rate of 75% compared with men aged 20–50 years and that larger differences are seen in how many of the seminiferous tubules in the testes contain mature sperm.^[41]

- In males 20–39 years old, 90% of the seminiferous tubules contain mature sperm.
- In males 40–69 years old, 50% of the seminiferous tubules contain mature sperm.
- In males 80 years old and older, 10% of the seminiferous tubules contain mature sperm.^[42]

Decline in male fertility is influenced by many factors, including lifestyle, environment and psychological factors.^[43]

Some research also suggests increased risks for health problems for children of older fathers, but no clear association has been proven.^[44] A large scale in Israel study suggested that the children of men 40 or older were 5.75 times more likely than children of men under 30 to have an autism spectrum disorder, controlling for year of birth, socioeconomic status, and maternal age.^[45] Increased paternal age is suggested by some to directly correlate to schizophrenia but it is not proven.^{[46][47][48][49][50]}

Australian researchers have found evidence to suggest overweight obesity may cause subtle damage to sperm and prevent a healthy pregnancy. They say fertilization was 40% less likely to succeed when the father was overweight.^[51]

The American Fertility Society recommends an age limit for sperm donors of 50 years or less,^[52] and many fertility clinics in the United Kingdom will not accept donations from men over 40 or 45 years of age.^[53]

Infertility

Infertility primarily refers to the biological inability of a person to contribute to conception. Infertility may also refer to the state of a woman who is unable to carry a pregnancy to full term. There are many biological causes of infertility, including some that medical intervention can treat.^[58]

Mortality rate



Colour-coded map of the *crude death rates* of countries, globally, based on WHO data for 2000–2005, presented per thousand persons in the population, per year.^{[1][verification needed]}

Mortality rate, or **death rate**,^{[2]:189,69} is a measure of the number of deaths (in general, or due to a specific cause) in a particular population, scaled to the size of that population, per unit of time. Mortality rate is typically expressed in units of deaths per 1,000 individuals per year; thus, a mortality rate of 9.5 (out of 1,000) in a population of 1,000 would mean 9.5 deaths per year in that entire population, or 0.95% out of the total. It is distinct from "morbidity", which is either the prevalence or incidence of a disease, and also from the incidence rate (the number of newly appearing cases of the disease per unit of time).^{[2]:189[verification needed]}

An important specific mortality rate measure is the **crude death rate**, which looks at mortality from all causes in a given time interval for a given population. As of 2020, for instance, the CIA estimates that the crude death rate globally will be 7.7 deaths per 1,000 persons in a

population per year.^[3] In a generic form,^{[2]:189} mortality rates can be seen as calculated using
$$M = \frac{d}{p} \times 1000$$
, where d represents the deaths from whatever cause of interest is specified that occur within a given time period, p represents the size of the population in which the deaths occur (however this

population is defined or limited), and k is the conversion factor from the resulting fraction to another unit (e.g., multiplying by k to get mortality rate per 1,000 individuals).^{[2]:189}

Crude death rate, globally

The crude death rate is defined as "the mortality rate from all causes of death for a population," calculated as the "[t]otal number of deaths during a given time interval" divided by the "[m]id-interval population", per 1,000 or 100,000; for instance, the population of the U.S. was ca. 290,810,000 in 2003, and in that year, approximately 2,419,900 deaths occurred in total, giving a crude death (mortality) rate of 832 deaths per 100,000.^{[4]:3–20f} As of 2020, the CIA estimates the U.S. crude death rate will be 8.3 per 1,000, while it estimates that the global rate will be 7.7 per 1,000.^[3]

According to the World Health Organization, the ten leading causes of death, globally, in 2016, for both sexes and all ages, were as presented in the table below.^[5]

Crude death rate, per 100,000 population

1. Ischaemic heart disease, **126**
2. Stroke, **77**
3. Chronic obstructive pulmonary disease, **41**
4. Lower respiratory infections, **40**
5. Alzheimer's disease and other dementias, **27**
6. Trachea, bronchus, lung cancers, **23**
7. Diabetes mellitus, **21**
8. Road injury, **19**
9. Diarrhoeal diseases, **19**
10. Tuberculosis, **17**

Mortality rate is also measured per thousand. It is determined by how many people of a certain age die per thousand people. Decrease of mortality rate is one of the reasons for increase of population. Development of medical science and other technologies has resulted in the decrease of mortality rate in all the countries of the world for some decades. In 1990, the mortality rate of children under 5 years of age was 144 per thousand, but in 2015 the child mortality rate was 38 per thousand.

Related measures of mortality

Other specific measures of mortality include:^[4]

Measures of mortality	
Name	Typical definition
Perinatal mortality rate	The sum of fetal deaths (stillbirths) past 22 (or 28) completed weeks of pregnancy plus the number of deaths among live-born children up to 7 completed days of life, divided by number of births. ^[6]

<p>Maternal mortality rate</p>	<p>Number of deaths of mothers assigned to pregnancy-related causes during a given time interval, divided by the number of live births during the same time interval.^{[4]:3–20}</p>
<p>Infant mortality rate</p>	<p>Number of deaths among children <1 year of age during a given time interval divided by the number of live births during the same time interval.^{[4]:3–20}</p>
<p>Child mortality rate (also known as 'Under-five mortality rate')</p>	<p>Number of deaths of children less than 5 years old, divided by number of live births.^[7]</p>
<p>Standardized mortality ratio (SMR)</p>	<p>The ratio of the number of deaths in a given (index) population to the number of deaths expected, a form of indirectly (as opposed to directly) standardized rates, where the categories are usually "defined by age, gender and race or ethnicity".^[8] The numerator is calculated as $\sum_i n_i \cdot r_i$, where "n_i" is the number of persons in category i of the index population and "r_i" is the corresponding category-specific event rate in a standard population."^[8] It has also been described as a proportional comparison to the numbers of deaths that would have been expected if the population had been of a standard composition in terms of age, gender, etc.^[9]<i>[full citation needed]</i><i>[verification needed]</i></p>
<p>Age-specific mortality rate (ASMR)</p>	<p>The total number of deaths per year at a specific age, divided by the number of living persons at that age (e.g. age 62 at last birthday)^{[4]:3–21}</p>
<p>Cause-specific death rate</p>	<p>Number of deaths assigned to a specific cause during a given time interval divided by the mid-interval population^{[4]:3–21}</p>

UN estimates

United Nations, World Population Prospects: The 2019 revision – India^[87]

Period	Births per year	Deaths per year	Natural change per year	CBR₁	CDR₁	NC₁	TFR₁	IMR₁
1950–1955	16,832,000	9,928,000	6,904,000	43.3	25.5	17.7	5.90	165.0
1955–1960	17,981,000	9,686,000	8,295,000	42.1	22.7	19.4	5.90	153.1
1960–1965	19,086,000	9,358,000	9,728,000	40.4	19.8	20.6	5.82	140.1
1965–1970	20,611,000	9,057,000	11,554,000	39.2	17.2	22.0	5.69	128.5
1970–1975	22,022,000	8,821,000	13,201,000	37.5	15.0	22.5	5.26	118.0
1975–1980	24,003,000	8,584,000	15,419,000	36.3	13.0	23.3	4.89	106.4
1980–1985	25,577,000	8,763,000	16,814,000	34.5	11.8	22.7	4.47	95.0
1985–1990	26,935,000	9,073,000	17,862,000	32.5	10.9	21.5	4.11	85.1

United Nations, World Population Prospects: The 2019 revision – India^[87]

Period	Births per year	Deaths per year	Natural change per year	CBR₁	CDR₁	NC₁	TFR₁	IMR₁
1990–1995	27,566,000	9,400,000	18,166,000	30.0	10.2	19.8	3.72	76.4
1995–2000	27,443,000	9,458,000	17,985,000	27.2	9.4	17.8	3.31	68.9
2000–2005	27,158,000	9,545,000	17,614,000	25.2	8.4	16.9	3.14	–
2005–2010	27,271,000	9,757,000	17,514,000	22.8	7.8	15.0	2.80	–

MIGRATION TYPES CAUSES AND CONSEQUENCES

Migration is a **consequence** of the uneven – distribution of opportunities over space. People : tends to move from place of low opportunity and low safety to the place of higher opportunity and ; better safety. Results can be observed in i economic, social, cultural, political and, demographic terms.

- internal migration: moving within a state, country, or continent
- external migration: moving to a different state, country, or continent
- emigration: leaving one country to move to another
- immigration: moving into a new country
- return migration: moving back to where you came from
- seasonal migration: moving with each season or in response to labor or climate conditions

- An *emigrant* is a person who is leaving one country to live in another.
- An *immigrant* is a person who is entering a country from another to make a new home.
- A *refugee* is a person who has moved to a new country because of a problem in people move for many reasons and that those reasons are called push factors and pull factors. Tell students that push factors include leaving a place because of a problem, such as a food shortage, war, or flood. Tell students that pull factors include moving to a place because of something good, such as a nicer climate, more job opportunities, or a better food supply. Ask: *What effect does a region's economy, climate, politics, and culture have on migration to and from the area?* Have students brainstorm additional reasons for migrating, such as displacement by a natural disaster, lack of natural resources, the state of an economy, and more.their former home.

ETHNIC CRISIS

- An **ethnic conflict** is a **conflict** between two or more contending **ethnic** groups. While the source **of** the **conflict** may be political, social, economic or religious, the individuals in **conflict** must expressly fight for their **ethnic** group's position within society.
- An **ethnic conflict** is a conflict between two or more contending ethnic groups. While the source of the conflict may be political, social, economic or religious, the individuals in conflict must expressly fight for their ethnic group's position within society. This final criterion differentiates ethnic conflict from other forms of struggle.^{[1][2]}
- Academic explanations of ethnic conflict generally fall into one of three schools of thought: primordialist, instrumentalist or constructivist. Recently, several political scientists have argued for either top-down or bottom-up explanations for ethnic conflict. Intellectual debate has also focused on whether ethnic conflict has become more prevalent since the end of the Cold War, and on devising ways of managing conflicts, through instruments such as consociationalism and federalisation.