

Fecundity, Fecundability, and Sterility

Microdemography is concerned with the study of fertility and reproduction at the level of individuals and couples.

Unlike macrodemography, which deals with large-scale statistics such as crude birth rates or total fertility rates, microdemography attempts to understand the mechanisms that drive these outcomes:

Why are some women able to conceive easily while others face delays?

What is the natural biological limit of childbearing?

How effective are different contraceptive methods, both in theory and in practice?

Fecundity

Fecundity refers to the **biological capacity of a woman or couple to reproduce**. It is a measure of potential, not actual performance. A woman may be fecund even if she has never had a child — as long as her reproductive system is capable of producing one under normal conditions.

Consider two women, both aged 25. One is married and has two children. The other has never been married and has no children. Both may be equally fecund biologically, even though their fertility outcomes differ. Fertility is the actual number of live births, while fecundity is the underlying capacity.

Types of Fecundity

Natural fecundity is the maximum biological capacity observed in populations without contraception or deliberate fertility control

Controlled fecundity refers to the biological capacity that is observed in populations where social norms, contraceptive practices, or delayed marriage reduce exposure.

Temporary infecundity occurs when women are biologically capable of childbearing but experience a temporary period of reduced capacity, often due to breastfeeding (lactational amenorrhea), illness, or temporary hormonal conditions.

Sterility

Sterility is the permanent inability to conceive or to carry a pregnancy to a live birth. It is the absence of fecundity. Sterility is not the same as childlessness — some women may be childless by choice, or due to social factors, while still biologically capable of reproduction. Sterility specifically refers to biological incapacity.

Types of Sterility:

- **Primary sterility:** A woman is considered primarily sterile if she has never been able to conceive despite prolonged exposure to risk (usually defined as regular intercourse without contraception for at least one year).
- **Secondary sterility:** This applies to women who have previously conceived but are unable to do so again. Secondary sterility is often the result of infections, complications from childbirth, or acquired medical conditions.
- **Absolute sterility:** Caused by permanent and irreversible biological conditions, such as surgical removal of reproductive organs, congenital malformations, or menopause.
- **Relative sterility (subfecundity):** Refers to cases where conception is possible but occurs with great difficulty, or after prolonged waiting. Subfecund couples may eventually conceive, but their fecundability is very low.
- **Social sterility:** Sometimes demographers also use this term to describe couples who are biologically fecund but behave in ways that make them effectively sterile — for example, spouses living apart for long periods due to migration, or couples practicing prolonged abstinence.

Fecundability is one of the most precise measures in microdemography. It is defined as the **probability of conception occurring during a single menstrual cycle**, provided that the couple is exposed to risk (regular intercourse, no contraception, and absence of sterility).

Mathematical Understanding:

If we let f represent fecundability, then the probability of conceiving in the very first cycle of exposure is simply f . If conception does not occur in the first cycle, the probability that it occurs in the second cycle is $(1 - f)f$. More generally, the probability that conception occurs in the x -th cycle is $(1 - f)^{x-1}f$. This follows a geometric distribution.

The average number of cycles required to achieve conception is the reciprocal of fecundability, $E[X] = 1/f$. For instance, if $f = 0.25$, then on average it would take about four cycles for conception to occur.

Fecundability

Types of Fecundability

- **Natural fecundability:** This is the baseline biological probability, under conditions of no fertility regulation. Studies in natural fertility populations show fecundability rates of around 20–25% per cycle.
- **Effective fecundability:** This is what we actually observe in populations, after accounting for factors such as coital frequency, temporary abstinence, breastfeeding, and contraceptive use. Effective fecundability is almost always lower than the natural maximum.
- **Residual fecundability:** This refers to the remaining probability of conception among couples who have not yet conceived after several cycles of trying. Demographers often use survival analysis to estimate residual fecundability, as it reveals the proportion of couples who are subfecund or sterile.

Estimation of Fecundability

Direct Methods:

- *Waiting time to pregnancy (WTP) studies*: Couples are observed or surveyed from the point they begin trying until conception occurs. These provide reliable estimates of fecundability and subfecundity.

Indirect Methods:

- *Retrospective surveys*: Women are asked how long it took to conceive after discontinuing contraception.
- *Demographic and Health Surveys (DHS)*: Information on birth intervals, children ever born, and exposure to risk can be used indirectly to estimate fecundability distributions.

Statistical Models:

- Geometric distribution models assume constant fecundability across cycles.
- Hazard models allow fecundability to vary with age, parity, or duration of exposure.
- Frailty models incorporate unobserved heterogeneity between couples, recognizing that some couples are inherently more fecund than others.

Contraceptive Effectiveness and the Pearl Index

The Pearl Index is the oldest and most widely used measure of contraceptive effectiveness. It expresses the number of accidental pregnancies per 100 woman-years of exposure to a method.

Formula:

$$PI = \frac{\text{Number of pregnancies} \times 1200}{\text{Number of women} \times \text{Months of exposure}}$$

Types of Pearl Index:

- *Gross PI*: Includes all pregnancies, regardless of whether the woman discontinued the method.
- *Net PI*: Excludes pregnancies that occurred after discontinuation of the method.
- *Corrected PI*: Adjusted for incorrect use or discontinuation.

Limitations:

The Pearl Index assumes a constant risk of pregnancy across time, which is unrealistic. In practice, risk often declines as users become more experienced or as subfecund women drop out. This is why life-table methods are now preferred.

Effectiveness vs. Efficacy

- It is very important to distinguish between efficacy (or efficiency) and effectiveness.
- *Efficacy* refers to how well a contraceptive works under ideal, controlled conditions, such as in clinical trials where instructions are followed perfectly.
- *Effectiveness* refers to real-world performance, where people may forget pills, delay injections, or use condoms incorrectly.
- For example, oral contraceptives have an efficacy failure rate of less than 1%, but their real-world effectiveness failure rate is about 7%. Condoms are 98% effective with perfect use but only about 87% effective in typical use.

Comparative Effectiveness of Family Planning Methods

No method leads to pregnancy in about 85% of couples within one year.

Traditional methods like withdrawal have high failure rates (20% in typical use).

Barrier methods like condoms are moderately effective (13% failure in typical use, 2% in perfect use).

Hormonal methods (pills, injectables, implants) and intrauterine devices (IUDs) are highly effective, with failure rates under 1%.

Permanent methods like sterilization have near-zero failure when performed correctly.