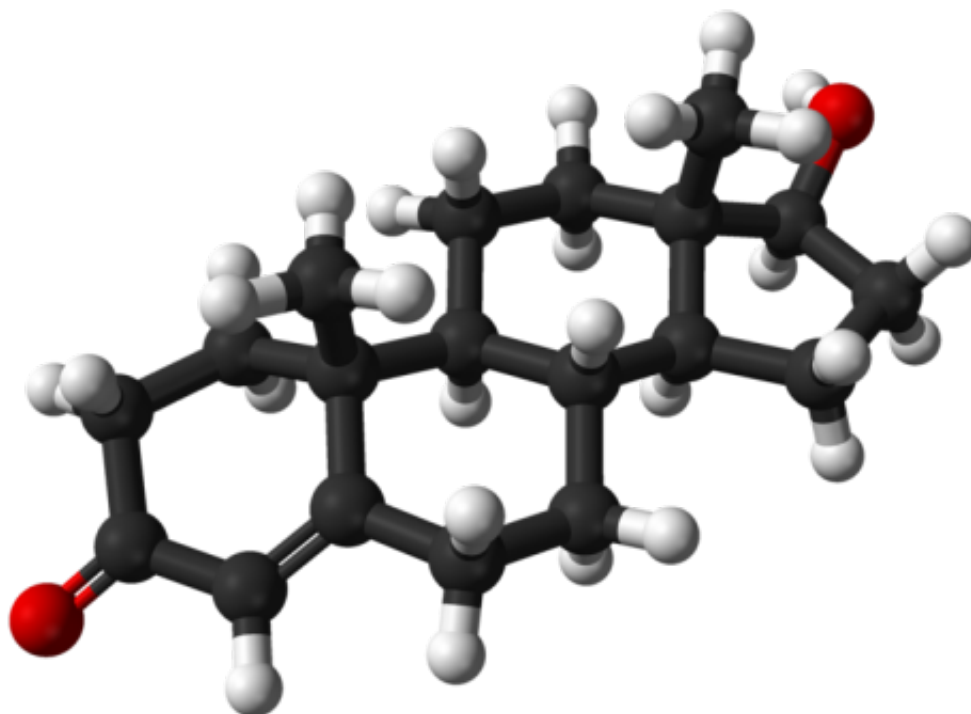


# Prenatal testosterone linked to long-term effects in females who share womb with male twin

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Ball-and-stick model of the testosterone molecule,  $C_{19}H_{28}O_2$ , as found in the crystal structure of testosterone monohydrate. Credit: Ben Mills/Wikipedia

Women who shared their mother's womb with a male twin are less likely to graduate from high school or college, have earned less by their early

30s, and have lower fertility and marriage rates when compared with twins who are both female, according to new Northwestern University research.

In the largest and most rigorous study of its kind, Northwestern University and Norwegian School of Economics researchers examined data on all twin births in Norway over a 12-year period to find that females exposed in utero to a male twin experienced adverse educational and labor outcomes along with altered patterns of marriage and fertility as adults.

"Nobody has been able to study how male twins impact their twin sisters at such a large scale," said study corresponding author Krzysztof Karbownik, an economist and research associate at Northwestern University's Institute for Policy Research (IPR). "This is the first study to track people for more than 30 years, from birth through schooling and adulthood, to show that being exposed in utero to a male twin influences important outcomes in their twin sister, including school graduation, wages and fertility rates."

The study, "Evidence that prenatal testosterone transfer from male twins reduces the fertility and socioeconomic success of their female co-twins," will be published the week of March 18 in the *Proceedings of the National Academy of Sciences (PNAS)*.

The researchers used data on 13,800 twin births between 1967 and 1978 to show that females exposed in utero to a male twin are less likely to graduate from high school (-15.2 percent), to complete college (-3.9 percent) or to get married (-11.7 percent). They also have lower fertility rates (-5.8 percent) and life-cycle earnings (-8.6 percent.)

The study supports the "twin testosterone-transfer hypothesis," which posits that females in male-female twin pairs are exposed to more

testosterone in utero via the amniotic fluid or through the mother's bloodstream that they share with their twin brother. One explanation for the long-term effects the researchers discovered is changes in behavior, which have previously been demonstrated in girls with male twins. Unlike the females, the researchers found that male twins do not experience long-term consequences of being exposed to a female twin in utero.

"This is a story about the biology of sex differences," said co-author David Figlio, Dean of Northwestern's School of Education and Social Policy and IPR fellow. "We are not showing that exposed females are necessarily more 'male-like,' but our findings are consistent with the idea that passive exposure to prenatal testosterone changes women's education, labor market, and fertility outcomes."

During sensitive developmental periods in utero, steroids produced by the ovaries and testes, including testosterone, help establish biological differences between males and females. Previous, smaller studies have suggested that such exposure to opposite-sex hormones can lead to lasting changes in behavior and other traits. On the other hand, it has also been noted that socialization effects—or being a female raised alongside a twin brother—could likewise explain the different behaviors and outcomes shown by past studies.

To separate the effects of fetal testosterone from postnatal socialization, the research team repeated their analyses focusing only on female twins whose twin sibling—either twin sister or twin brother—died shortly after birth, and thus they were raised as singletons. The results were unchanged in this sample, providing strong evidence that the long-term effects that the study documents are due to prenatal exposure, rather than postnatal socialization.

The near-doubling of twinning rates in many countries since 1980—a

result of women conceiving later in life and increased reliance on in vitro fertilization (IVF)—means that an increasing number of females worldwide are exposed to prenatal testosterone from their male twin.

The researchers caution that they lack information on all possible outcomes, and it is possible that some positive effects from testosterone exposure also exist. Moreover, the long-term impacts of prenatal testosterone exposure, which likely involve behavioral changes, may shift as societal norms surrounding gender change.

"It is important to emphasize that our findings apply to Norwegian society during the timeframe of the study, but may not apply equally across other societies or cultural settings. For instance, if gender norms change within a society, acceptance of a wider array of behaviors could minimize later effects on outcomes like school completion or entering a marriage" said study co-author Christopher Kuzawa, professor of anthropology and an IPR fellow, whose research focuses on the roles that the intrauterine and early postnatal environments have on development and long-term health.

"Basically we find that there are some very interesting long-term biological effects of being a sister to a twin brother," Kuzawa said. "But whether we view those effects as 'positive' or 'negative' may be culturally dependent."

"While we found moderate effects at the national level, these results reflect mean differences," Karbownik said. "Not everyone will be affected in the same way, and some female twins may not be affected at all. And, these effects are highly unlikely to result from any individual fertility decision made by a woman or couple, given that twins are a small subset of births and male-female twin pairs even rarer yet."

"We certainly do not advocate against delayed reproduction or the use of

IVF, which are complex decisions made by individuals balancing a range of personal factors," Karbownik said.

Caveats aside, "our results suggest that in utero [testosterone](#) transfer could present a hidden impact of practices that increase multiple zygote implantation, and provide long-term perspectives concerning the risks and returns of these fertility decisions," the researchers wrote.

**More information:** Aline Bütikofer et al., "Evidence that prenatal testosterone transfer from male twins reduces the fertility and socioeconomic success of their female co-twins," *PNAS* (2019).

[www.pnas.org/cgi/doi/10.1073/pnas.1812786116](http://www.pnas.org/cgi/doi/10.1073/pnas.1812786116)

Provided by Northwestern University

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