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Global sperm counts are falling. This scientist believes she knows why

Shanna Swan has been investigating the impact of chemicals on human fertility for decades

Sarah Neville 14 HOURS AGO

On a rainy evening in Copenhagen last year, a diminutive woman in jeans, ankle boots and a casual shirt waited offstage at the Koncerthuset, a vast venue renowned for its acoustics. She had been invited by Science & Cocktails, a Danish non-profit that pairs lectures with drinks chilled in dry ice. Many in the audience were decades her junior and the mood was more rock concert than lecture as a voice over the loudspeaker announced, “The one and only — Shanna. Fucking. Swan!”

Swan, who turned 87 last month, walked on to the thump of a techno track, whoops and applause. “Wow. I have to say” — she chuckled gamely — “I’ve never had an introduction like that. And it’s wonderful.” As the hall quietened, she began to speak, calmly and without notes, about the animating purpose of her professional life. “I’m going to tell you a mystery story,” she said. “And hopefully, you’ll help me to solve it along the way.”

The mystery is this. Since the late 1930s, sperm counts around the world appear to have dropped significantly. While the decline was initially observed in western countries, there is evidence of the same phenomenon in the developing world, and it seems to be accelerating. Swan, a Berkeley-trained statistician-turned-epidemiologist, believes she knows why.

For more than two decades she has devoted her life to studying the effects of [“endocrine disrupting” chemicals](#) (EDCs), which can interfere with the body’s natural hormones. These include pesticides, [bisphenols](#), which harden plastic so it can be used in food storage containers and baby bottles, and [phthalates](#), which soften plastic for use in packaging and products such as garden hoses. In recent years, traces of EDCs have been found in breast milk, placental tissue, urine, blood and seminal fluid.

In the glare of orange spotlights, Swan led the Copenhagen audience to her conclusion: that the innocuous products in your kitchen cupboard, bathroom cabinet or garden shed may be lowering sperm counts. They could also affect the reproductive systems of your unborn children. The implications of EDCs for human health don’t stop there: they can disrupt thyroid function, trigger cancer and obesity.

Then Swan got to the “ass-ball connector”. A slang term for ano-genital distance (AGD), the span from the anus to the base of the penis, it is “also known as ‘the taint’,

‘the gooch’ and ‘the grundle’”, she told the crowd in Copenhagen. She enunciated the words with an innocence that stripped them of prurience. The audience listened intently as she described one of her pivotal discoveries: that AGD can act as a predictor of a man’s ability, years later, to conceive a child. It has provided evidence for her thesis that inadvertent exposure to EDCs in utero can inflict harm on a developing foetus.

Several weeks later, when I visited Swan at home in New York, she said that speaking to audiences outside her field did not always come naturally: “Sometimes it means saying things like ‘taint’, and sometimes it means talking about erections and other things that don’t trip off my tongue easily.” What has driven her into the public arena is a conviction that the world might be sleepwalking into a fertility crisis. If her hypothesis is correct, we need to overhaul how we cook, eat, produce and package consumer goods, and rethink industrial processes.

Even if average sperm counts have fallen, the reasons why are still disputed by scientists. Some question whether we should worry about it at all. “I would not say with any certainty, of course, that we will be reduced to *The Handmaid’s Tale*,” Swan says, referring to [Margaret Atwood](#)’s novel imagining a world in which pollutants contribute to a reproductive calamity. But a dramatic increase in surrogacies and the use of assisted reproduction are omens for her. As she heads towards her tenth decade, she fears the time for warnings about what she terms “a threat to humanity” is running out.

Rudolph Wittenberg, Swan’s father, was the scion of a cultured Jewish family in Berlin and a writer, who used to read out chapters of his novels on the radio. In the early 1930s, he joined the anti-Nazi underground. One day, he sent the security guard out for cigarettes and used his broadcast to denounce Hitler. As he left the building, the guard came running after him. Wittenberg was terrified but the guard, who had not heard the broadcast, merely wanted to give him his fee. He later escaped to Prague and met a young American, Goldie Ray Polturak. She had been carrying messages for the resistance in her shoes.

Swan’s parents fell in love and left Europe for the US in 1934. She told me this over glasses of filtered water in the kitchen of her roomy mid-century apartment in Manhattan. Ever the rationalist, she was wary of treating the tale’s cinematic elements as unalloyed fact, warning that neither she nor her younger sister had independently verified the details.

Born in Pennsylvania in 1936, Swan was painfully aware of the differences between herself and other children, both because of the family's relative poverty, which eased only after her father qualified as a psychoanalyst, and her parents' membership of the Communist party. "I was always living in some kind of shame about my upbringing," she said. She has a clear memory of riding in a horse-drawn cart with her parents at a May Day parade and praying no one she knew would see her. Bright and independent, Swan used to play in a large cardboard box which, for reasons now obscure to her, she christened Juxey's House, and which was her inviolable domain. She remembers repeating, both out loud and in her head: "I can do it by myself."

She began her education at a public school for gifted children, where she thrived, and later studied maths with a minor in logic at New York's City College, attracted by the "aesthetic beauty" of the discipline. At Columbia, where she undertook a master's degree, she worked with the distinguished Polish biostatistician Agnes Berger, one of the few women then practising in the field. Swan arrived at the University of California at Berkeley's statistics department aged 24, armed only with a letter of introduction from Berger to its head, a fellow Pole, [Jerzy Neyman](#). "He was a very great man, and I don't use that term lightly. He was the father of statistics."

After her PhD, Swan worked for the research arm of the insurer Kaiser Permanente, studying links between the contraceptive pill and conditions including cervical cancer, and later, for the California department of health, where she investigated a spate of unexplained miscarriages in Santa Clara County. In 1995, she was invited to join a [National Academy of Sciences](#) committee examining the impact of "hormonally active agents in the environment" — EDCs. As the group's only statistician, she was asked to review a [Danish study](#), claiming to show a significant drop in sperm counts between 1938 and 1991. "[The committee] said: 'Would you look at this, because it doesn't look very convincing. I don't think we have to pay much attention to it, but just look at it and let us know'," she told me. The study had been carried out after a senior doctor noticed that sperm counts in semen samples in his lab appeared to be falling over time. He'd commissioned an analysis of existing studies, almost half of which originated from the US.

Swan said she was "totally naive" about the internal politics of the committee, which included a representative from a [lobbying firm](#) that had worked for Monsanto and the Chemical Manufacturers Association. It would end up being, she recalled, "an extremely tumultuous experience". Like the rest of the committee, she was initially sceptical that the sharp drop in sperm counts suggested by the Danish study could be real. She looked for "confounders", factors that might skew results. But when Swan

obtained the original 61 studies and analysed how the sperm had been counted, the ages of the men, how many were obese, how they had been recruited, what country they were from, the results astonished her.

“When I put it all together and ran the numbers, they had not changed to the second decimal place . . . I thought wow.” Even then, she did not accept the findings. She wondered if the studies had been selected in a biased way. She added 40 more, published since the initial work. The overall conclusion “almost exactly” matched that of the original team. The process had taken almost five years and turned her from a sceptic into a believer.

Fred vom Saal, a biological sciences professor who had conducted some of the earliest studies on endocrine disruption and also sat on the committee, recalled that when Swan presented her findings, she faced pushback from members who were uncomfortable with her conclusions. The committee’s [final report](#), published in 1999, reflected this tension. Unanimity had been “readily achieved” in some areas, the authors noted, confirming that exposures to EDCs at high concentrations “can affect wildlife and human health” and lead to developmental abnormalities [in wildlife](#). But it had proved “extraordinarily difficult in others”, it said, including on the issue of declining sperm production in humans.

Another scientist might have gone back to working on something less controversial. But Swan felt she was at the start, not the end, of a puzzle. The original Danish study had made no attempt to establish causation, although it raised the possibility that something in the environment might be to blame. What she knew was that there was a trend, and it was rapid — a 50 per cent drop in mean sperm counts in 50 years. “That’s not evolution. That’s too fast,” she thought.

She approached her boss at the California department of health with a proposal to study endocrine disruption. It was returned with a scrawled dismissal: “This does not get my engine going.” As she pondered what to do next, Vom Saal suggested she join him at the University of Missouri. He told her: “We’ll make trouble together.”

When she was a child, Swan’s parents nicknamed her “The Victorian Lady” and discouraged participation in sports, apparently equating a petite frame — she is 5ft — with a delicate constitution. In fact, she radiates a quiet indomitability. In the time I spent with her, I came to realise she has a deep, subversive curiosity. “I guess I’m a sleuth,” she told me. “I like to dig around and find out things.”

In Missouri, she set out to examine whether sperm quality varied in different environments. For her “Study for Future Families”, she enrolled expectant parents in four US locations, while Danish colleagues selected another four in Europe. Male participants in a semi-rural Missouri area were found to have half as many moving sperm as those in the urban centres. (Poor sperm motility is a known factor in male infertility.) Hypothesising that some aspect of modern agriculture, particularly pesticides, might be affecting semen quality, Swan launched a pilot study, sending the Missouri men’s urine samples to the Centers for Disease Control and Prevention (CDC). The participants with poor semen quality were found to have significantly higher levels of eight pesticides compared to their counterparts in urban Minneapolis, whose semen quality was above average.

The findings added to a growing consensus that certain pesticides were harmful. Legislators have failed to act sufficiently even now, Swan believes. “To this day, we have very inadequate restrictions on the kinds of pesticides that can be used and the crops they can be used on.” The ability of industry to resist tighter regulation, whether through obfuscation or lobbying, would be a constant frustration for her in the years that have followed.





Shanna Swan with one of the anatomically correct dolls she uses for her research © Brigitte Lacombe

Her next quest began on a flight to Japan for a conference in the late 1990s. She was sitting next to a chemist from the CDC called John Brock, now a professor at the University of North Carolina, who told her that scientists had identified a “phthalate syndrome” in rats. When male fetuses were exposed to di-2-ethylhexyl phthalate (DEHP), one of the worst actors among the phthalates, a normal testosterone surge early in pregnancy failed to take place. The effects on the rats included a smaller penis, sometimes malformed, undescended testicles and a shorter AGD. Swan was fascinated. It was a new puzzle: could something like a phthalate syndrome affect humans?

Her success in working out a way to measure AGD in babies and children to help answer that question has been one of her most crucial contributions to the field. When I visited her in New York, she went to a cupboard and brought out an anatomically correct doll — called Willy, she said, somewhat impishly — and a pair of callipers to demonstrate the simplicity of the procedure, which is painless. AGD, or the length of the perineum, she explained, can reflect how much testosterone or androgen a foetus was exposed to during a very small window of pregnancy. “If there’s too little androgen for a boy, he doesn’t get fully masculinised,” she said. “If there’s too much androgen for a girl, she gets over-masculinised.” A mother with polycystic ovary syndrome, for example, will produce an excess of testosterone, and her daughter might have a longer, more masculine AGD.

Pete Myers was one of the first to alert the world to the dangers of EDCs when, along with two other scientists, he published the 1996 best-seller, *Our Stolen Future*. A longtime collaborator of Swan, he lauds her ability to marry epidemiology with a deep understanding of human biology. “Most epidemiologists are number crunchers, pure

and simple. They don't have a clue about the underlying biology. So they do tests that make no sense." More scientists, he suggests, are now combining these skills, "but Shanna was a real pioneer".

By analysing the urine of mothers from the Future Families project, Swan could determine what level of a particular phthalate they had been exposed to and check for correlation with a shortened AGD in their offspring. She found women in the upper quartile for exposure were 13 times more likely to have a son with a shorter-than-average AGD than those in the lowest quartile. But this begged another question, according to Swan: "Why do we care if AGD is a little shorter in some males? It doesn't look funny. It isn't a deformity."

Determining whether a short AGD was a predictor of later fertility problems meant leaping forward in time to forecast how men would be affected in adulthood. In 2009, while working for the University of Rochester, Swan launched the Rochester Young Men's Study, involving 126 volunteers aged 18-22. It provided the missing link to show that the shorter the AGD, the lower the sperm count. (College students were paid a small fee to undergo the intrusive measurements, said Swan, who recalled one young man telling her: "I'll do anything for \$75.") The research has been backed up by others. Around the same time, Michael Eisenberg, professor of urology at Stanford University School of Medicine, undertook a number of studies involving men in their thirties and forties, and similarly found an association between a shorter AGD and infertility.

In 2011, Swan and a team of andrologists, statisticians, epidemiologists and a reference librarian, began conducting the most complete search of the literature on falling sperm count to date. A total of 185 studies were examined in detail, using meta-analysis methods not available to the Danish academics 30 years before. The conclusion was deeply unsettling. Sperm count appeared to have declined 52 per cent in 38 years, or something over 1 per cent a year. When the study was published in 2017, it made "big, big news", she recalled, eventually leading her to publish *Count Down*, a book aimed at a general audience. It might have felt like a triumph, but Swan's battle to persuade regulators, legislators and industry has advanced at glacial speed.

The plastics era that began in the early 20th century delivered seemingly endless convenience, affordability and hygiene. Amid the bonanza of baby bottles, toys, food containers, medical devices and disposable cutlery, manufacturers propagated a new

narrative: that synthetic polymers were not only safe but essential to a good life. “Plastics: an important part of your healthy diet”, read [a 1990s ad](#) sponsored by the now-defunct American Plastics Council. “You could think of them as the sixth basic food group.”

Ironically, humans have ended up ingesting plastic, as particles and vapour. Chemicals from plastics leach out of containers into food, particularly when heated. Bottle-fed babies are swallowing [millions of microplastic particles](#) a day, a 2020 study showed, the health impacts unknown. An ingredient that was used in Teflon, PFOA, has been [linked to cancer](#), ulcerative colitis and birth deformities. (DuPont, Teflon’s manufacturer, was found to have known about the health risks for decades, but only ceased production of PFOA in 2013.)

As I sat with Swan in her kitchen, she gestured to the non-biological cleaner on her work surface and the cast-iron saucepans on her cooker. She has long since ceased to cook with the chemically coated non-stick variety. We can all take steps to reduce the dangers of phthalates and other chemicals in our lives, she believes. She tries to buy unwrapped, organic fruit and vegetables, and her water is always filtered. She recommends using stainless steel or glass water bottles and microwaving food in glass or ceramic containers — never plastic.

But the situation is too serious to be ameliorated by individual choice alone, she warned. “This is not something we can buy our way out of as consumers,” she said. We need plastic from materials that are not hormonally active, like a fork made from potatoes Swan recently saw. Although its production carried too high a carbon footprint to be sustainable, “I trust brilliant chemists and scientists who were able to give us the [Covid-19] vaccine in a short time, for example, to put their minds to this,” she said.

One difficulty in calculating the impact of chemicals on reproduction is that a host of other factors are affecting worldwide fertility rates. [Richard Sharpe](#), a professor at the University of Edinburgh, believes the [ultra-processed, high-fat western diet](#) is the primary source of exposure to BPA and some phthalates. Diet, stress, obesity, social factors and a trend to start families later in life are all important contributing factors, Swan acknowledges, but that doesn’t mean that EDCs are not playing a substantial role.

Nowhere has the resistance to her field of research been stronger or more consistent than from the chemicals industry, which would suffer a huge financial hit from tougher regulation of its products. From the 1990s onwards, an array of articles by

scientists have cast doubt on Swan and her colleagues' findings. While some of the questions raised are credible — abstinence rates in sperm counting, for instance, can influence the results, and were not reliably accounted for in some early studies — others are less so. Swan was one of the scientists ridiculed as “endocrine disrupter cry babies” by JunkScience.com, a website run by a climate change denier and former tobacco industry advocate [Steve Milloy](#). (Swan and her colleagues inscribed the epithet on T-shirts as a badge of pride.)

The “manufacture of doubt” is a playbook long used by industries resisting regulation, from tobacco to fossil fuels, according to David Michaels, a former regulator who ran the US Occupational Safety and Health Administration under Barack Obama. Now a professor at the Milken Institute School of Public Health in Washington, he told me that research carried out by seemingly independent scientists has often been used to convince regulators, legislators and even the public that there is no consensus about the harms caused by a particular chemical or product.

Andrea Gore, a professor of pharmacology at the University of Texas at Austin, who has led work for the Endocrine Society on EDCs, said that among clinical practitioners in the field there is wide acceptance that chemical exposures in early life can play a part in the development of disease. “I think there was controversy some time ago,” she told me. “And I think there was an effort to keep the controversy alive by the chemical industry. But I don't think it's a controversial field any more. There is just too much knowledge at this point.”

In the 1980s and 90s, Swan was an expert witness in a series of court cases about [DES, an endocrine-disrupting drug](#) widely prescribed until the 1970s to lower the risk of miscarriages. It went on to cause devastating cancers in the daughters of some of the women who had taken it. One night, after honing her arguments for the following day's court appearance, she threw some of her notes into a hotel waste basket. The next day, while being quizzed by the counsel for a pharmaceutical company, she saw her discarded notes in front of him. “And the only way he could get those was to rifle through the garbage in my hotel room,” she told me. “Just think about what that takes.” She recalls, with a touch of satisfaction, discovering that the opposing legal team referred to her as “that bitch from California”.

Not all scientists accept the premise that sperm counts have fallen, although independent studies covering China, France, Brazil and southern India have come to similar conclusions. Some critics argue that even if the drop is real, the impact on a man's prospects of fathering a child has been overstated. A [2021 study](#) by Harvard researchers — several of whom had backgrounds in philosophy and history —

suggested that, “above a critical threshold”, more sperm is not necessarily an indicator of health or fertility. Sperm count varies “across bodies, ecologies, and time periods”, they said. They imputed a racist and sexist tinge to Swan and her colleagues’ work, noting that it “situates men’s bodies and environments labelled ‘Western’ as exemplary, natural, and now imperilled”.

Swan rebuts this, pointing out that her most recent work, published last November, suggests [sperm counts are falling worldwide](#). Climate change scientists faced similar scepticism, she noted. “People said, ‘Oh, well, it’s warm right now. But [temperatures will] go down. And that’s the way climate is.’ Well, in fact, that’s not the case.” While she accepts that a lower-than-average sperm count does not necessarily doom a man to childlessness, there is a consensus that once sperm counts hit a particular level — below about 40 million sperm cells per millilitre of semen — fertility can be impaired.

The chemicals she has been able to link most directly to reproductive health are phthalates and pesticides, where she and others have found convincing evidence of a causal link between reproductive disorders and the “triazine” category of herbicides. Other researchers, she says, have found equally incontrovertible evidence of harm to reproductive health from other classes of EDCs such as the bisphenols. “When we began this work, we were in the medical and scientific wilderness because no one believed us,” Myers, who wrote the 1996 best-seller, told me. “And then gradually we built up the science.” But the regulatory climate remains heavily weighted towards industry. Some companies have proudly declared their plastic bottles and baby products “BPA free”, referring to Bisphenol-A, a chemical that can seep into food and beverages and, some researchers believe, harm human health — only for it later to emerge that the substituted product amounted to “slightly tweaked molecules”, Swan said.

Some nights Swan lies awake worrying. “The alarm I feel is a global alarm,” she said. “I feel it equally for human and non-human species.” She and her fellow campaigners have notched some successes. In 2008, for example, children’s toys and childcare items containing more than 0.1 per cent of three types of phthalates were permanently banned in the US. This year, the European Food Safety Authority recommended lowering the “tolerable daily intake” for BPA by a factor of about 20,000. (The European Medicines Agency is opposing the change.)

In April, G7 climate, energy and environment ministers issued a [communiqué](#) committing to “actively preventing chemical pollution, or . . . minimising its

committing to actively preventing chemical pollution, or ... minimising its associated risks, including when caused by releases of endocrine disrupting chemicals". Swan characterised this as a "very, very big" moment in her long-running battle to wake up governments and regulators to the dangers from EDCs.

As I spent time with her, I sensed that what keeps her going, above all else, is a lifetime habit of curiosity. Now based in San Francisco, she continues to pursue research breakthroughs in her field. While studying maths in her youth, she won an award after conceiving the notion that logic need not be binary, with true or false the only options, and developing a system of "three value" logic. She resists the security of the status quo, and while she revels in collaboration, she has also stayed true to the independent little girl, determined to navigate the world on her own terms, that found sanctuary in Juxey's House.

Her overriding preoccupation remains how to alert a still largely oblivious world to the threat from EDCs. "You and I, and everyone on this planet, are really serving as guinea pigs," she says. "And nobody asked us."

Sarah Neville is the FT's global health editor

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