Does dad matter? New study looks at his environmental exposure in reproductive success

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Richard Pilsner of UMass Amherst is investigating whether phthalate levels in expectant fathers have an effect on the couples' reproductive success, via epigenetic modifications of sperm DNA. Credit: UMass Amherst

A new three-year, $440,000 study led by environmental health scientist Richard Pilsner at the University of Massachusetts Amherst is now underway to investigate whether phthalate levels in expectant fathers have an effect on the couples' reproductive success, via epigenetic modifications of sperm DNA. Phthalates are compounds found in plastics and personal care products that are estimated to be detectable in nearly 100 percent of the U.S. population.

Pilsner and colleagues will examine the possible influence of paternal phthalate exposure on sperm quality and embryo development and whether DNA methylation in sperm cells may be a pathway by which a father's exposure influences these endpoints. The new study is among the first to investigate the influence of phthalate on sperm epigenetics in humans.

Pilsner says, "What we're asking, basically, is whether dad's environmental health contributes to reproductive success, and if so, how is that transmitted to offspring?"

Unlike genetic mutations that affect DNA and the genome, epigenetic markers turn genes on and off to regulate cell processes, which if altered may lead to disease, he explains. If the genome and DNA are like computer hardware, as others have described it, the epigenome is like software, running programs telling genes what to do. Environmental exposures such as smoking, air pollution and metals have been linked to epigenetic changes associated with health risks. DNA methylation is one type of epigenetic mechanism and can be assessed by high-throughput analyses.

Phthalate exposure, known to disrupt endocrines, is associated in human studies with changes in semen quality, androgen levels, birth outcomes and offspring neurodevelopment, but a mechanism has not been clearly identified, Pilsner says.

He adds, "Until now, no one has investigated the sperm epigenome in the context of environmental exposures. Now we know there is this additional layer of information that can be inherited on top of genetic information that could influence the health and development of future generations. Unlike the genetic code, the epigenome is highly dynamic and can be shaped by environmental exposures. We're excited to be among the first to be looking at how paternal environmental exposure might affect sperm epigenetics and subsequent embryo development and other health endpoints in humans."

"There are certain times during development where we are more susceptible to environmental exposures. For example, epigenetic reprogramming, a process of erasing and remodeling epigenetic marks, is essential for sperm maturation and represents a critical window of susceptibility to environmentally-induced epigenetic errors that, in turn, may influence reproductive health."

As sperm mature over several weeks, this epigenetic reprogramming results in a compact nucleus that is essential for fertilization. Pilsner hypothesizes that exposure to certain plastics such as phthalates and other chemicals during this reprogramming event is associated with changes in methylated tags on the sperm's DNA.

Supported by an early career research grant from the National Institutes of Health, Pilsner is collaborating with Dr. Cynthia Sites, director of the in vitro fertilization (IVF) clinic at Baystate Medical Center, Springfield, Mass., to conduct this research. His study is recruiting 250 couples through the clinic, where husbands who hope to become fathers provide routine sperm samples. The researchers will measure phthalates in the men's urine sample, then perform DNA methylation analyses on sperm cells and look for a statistical association between these measures as well as sperm quality and embryo development.

"We plan to measure eight different phthalates to examine the father's environmental health impact on a couple's reproductive success, while future aims will also include their child's health," he adds. "There have been some human studies of how mothers' exposure to various environmental agents affects the couple's success in conceiving a child and on the child's health. But until now, few birth cohorts have investigated the paternal environmental contribution to reproductive success and child's health and development. We want to change that."

Pilsner and Sites' work will also archive samples for future studies of other potential endocrine disrupting chemicals such as Bisphenol A (BPA).

Provided by University of Massachusetts Amherst