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Bridget M. Kuehn

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## Traces of Drugs Found in Drinking Water Health Effects Unknown, Safer Disposal Urged

Bridget M. Kuehn

**T**HE US PUBLIC MAY BE CONSUMING trace amounts of such pharmaceuticals as antibiotics, hormones, mood-altering drugs, and pain killers in each glass of water they drink, according to recent reports. Yet little is known about whether these chronic, low-level exposures pose health risks.

An investigative report published by the Associated Press (AP) in March, documenting tiny quantities of various pharmaceuticals in the drinking water of 24 major metropolitan areas has drawn greater public attention to a problem scientists have been probing for several years. So far, researchers have documented ill effects in fish and other aquatic animals. But making an evidence-based determination whether such effects translate to humans will require further research, said George S. Corcoran, PhD, president of the Society of Toxicology.

The attention generated by the AP report may help speed such research, added Corcoran, chair of the Department of Pharmaceutical Sciences at Wayne State University in Detroit, Mich. "The public has a legitimate right to know and the AP story . . . will lead us more quickly to the answers we need to have," he said.

In the meantime, physicians and their patients are being asked to take precautions to help stem the flow of pharmaceuticals into water supplies.

### EMERGING EVIDENCE

In 2002, using newly developed analytical methods that allowed the measurement of previously undetectable concentrations of water contami-

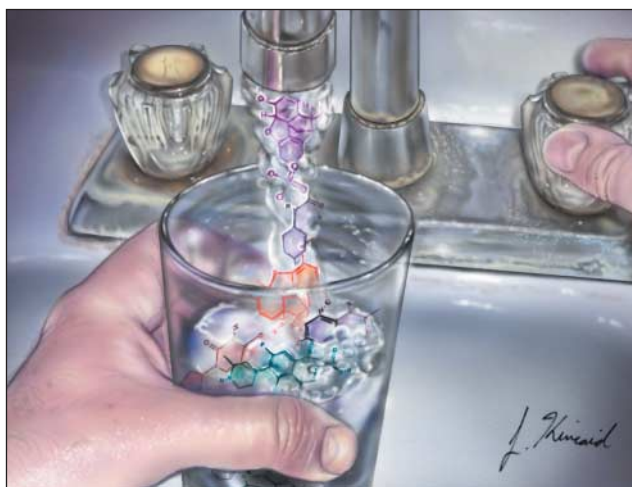
nants, scientists from the US Geological Survey (USGS) documented the presence of pharmaceuticals and metabolites of medications in many of the nation's streams (Kolpin DW et al. *Environ Sci Technol*. 2002;36[6]:1202-1211). Two years later, USGS scientists demonstrated that some of these pharmaceutical contaminants survived the water treatment process and were present in drinking water samples (Stackelberg PE et al. *Sci Total Environ*. 2004;329[1-3]:99-113).

Pharmaceuticals wind up in the water supplies in 1 of 3 ways, explained Christian Daughton, PhD, of the US Environmental Protection Agency's (EPA's) National Exposure Research Laboratory in Las Vegas: they may be excreted unmetabolized by humans or other animals consuming them, topically applied drugs may be washed off, or unwanted drugs may be flushed down the toilet. Some pharmaceuticals are not degraded during waste water treatment and are released back into waterways in concentrations in the

range of parts per billion. From there, they may find their way into drinking water drawn from these sources.

Scientists probing the ecological impact of pharmaceuticals in waterways have identified effects ranging from subtle, such as alterations in the behavior of fish exposed to selective serotonin reuptake inhibitors, to profound, such as feminization of male fish exposed to female hormones in concentrations as low as 5 to 6 parts per trillion, said Daughton. One such study found such minute concentrations of 17 $\alpha$ -ethynylestradiol, a synthetic estrogen used in contraceptives, led to feminization of male fat-head minnows, altered oogenesis in females of the species, and ultimately precipitated the collapse of a population of these fish in a lake in Ontario, Canada (Kidd KA et al. *Proc Natl Acad Sci U S A*. 2007;104[21]:8897-8901).

Dana W. Kolpin, PhD, a research hydrologist at the USGS office in Iowa City, Iowa, said ascertaining the complex effects of trace levels of pharma-



Scientists have discovered trace amounts of an array of pharmaceuticals in US drinking water.



ceuticals in the environment is difficult. For instance, little is known about how exposure to mixtures of pharmaceuticals and other water contaminants may affect animals. Some contaminants may enhance the effects of certain pharmaceuticals, and such interactions may not be detected in traditional tests examining one exposure at a time. Effects of contaminants also may vary based on the developmental stage of an organism.

Additionally, some classes of chemicals found in waterways may have additive effects, such as synthetic estrogens from birth control pills, natural estrogens from plants and animals, and chemical contaminants that may mimic estrogens. Alone, each of these substances may be in concentrations too low to affect animals, but when found together may be enough to cause problems, Kolpin explained.

Although more studies are needed to determine the potential effects of these contaminants on human health, Kolpin said, "so far, there are no studies linking human health effects to trace levels in water."

#### RISKS LIKELY LOW

While the health risks of exposure to pharmaceutical residues in water are unknown, some factors suggest the risks may be low, explained Corcoran. For instance, the concentrations of pharmaceuticals being detected are far below therapeutic doses. "It's truly a question of whether the dose is high enough to present a real risk," he said.

Additionally, unlike some industrial chemicals found in water, pharmaceuticals are designed to be safe for humans and are unlikely to accumulate in tissues because most are rapidly eliminated from the body, Corcoran said.

But there are other factors that make exposures to traces of pharmaceuticals in drinking water unique. In some municipalities, individuals are exposed to many different medications and/or to metabolites of those drugs. For example, in Philadelphia, 56 pharmaceuticals or metabolites of drugs

were detected in drinking water, according to the AP report. In this kind of setting, individuals could be exposed to unusual combinations of drugs, and the exposures are chronic, noted Corcoran. "This exposure scenario has not been studied," he said.

Daughton also agreed that the risk to humans is likely low. "At a part per trillion concentration, no one thinks there are ramifications—but we can't rule it out," he said.

However, there is concern about populations that may be particularly vulnerable to pharmaceutical contaminants. In particular, fetuses are exquisitely sensitive to the effects of some chemicals and scientists worry that exposure to powerful pharmaceuticals like estrogen could affect them, Daughton said. He said the EPA is examining the potential for such health issues.

"We are definitely looking at it more closely," he said.

Currently, the only technology capable of removing pharmaceuticals and their metabolites from drinking water is reverse osmosis. However, this process is not widely available and is expensive. Until more research is conducted to assess potential human health risks it is not clear whether this costly measure should be implemented in the interest of public health.

But all of the experts interviewed agreed that greater care in the disposal of medications is warranted and may help reduce such contamination in the future.

"To get at the sources and try to control those is probably the best bet," said Barbara S. Minsker, PhD, professor in the department of civil and environmental engineering at the University of Illinois in Urbana. She noted that physicians are well positioned to remind their patients not to flush expired or excess medications.

Guidelines for disposing of prescription drug products were issued in February 2007 by the White House Office of National Drug Control Policy (ONDCP) ([http://www.whitehousedrugpolicy.gov/drugfact/factsht/proper\\_disposal.html](http://www.whitehousedrugpolicy.gov/drugfact/factsht/proper_disposal.html)). The

guidelines suggest that only certain drugs should be flushed down the toilet, including Actiq (fentanyl citrate), Daytrana transdermal patch (methylphenidate), Duragesic transdermal system (fentanyl), OxyContin tablets (oxycodone), Avinza capsules (morphine sulfate), Baraclude tablets (entecavir), Reyataz capsules (atazanavir sulfate), Tequin tablets (gatifloxacin), Zerit for oral solution (stavudine), Meperidine HCl tablets, Percocet (oxycodone plus acetaminophen), Xyrem (sodium oxybate), and Fentora (fentanyl buccal tablet), and any other medication that has explicit instructions to do so on its label or in the accompanying patient information.

"There is a range of narcotics that should still be flushed, especially if the package says they should be flushed," stressed Daughton. He explained that such products have been linked to deaths when children or other individuals accidentally consume them, or when they are purposefully abused.

In other cases, however, the guidelines suggest removing the products from their labeled containers, mixing them with "undesirable" substances such as coffee grounds or kitty litter, sealing them in an empty can or plastic bag, and throwing them in the trash. Another option is to take unused medications to a designated pharmaceutical take-back program.

#### DISPOSAL DRAWBACKS

However, there are drawbacks to disposing pills in the trash, Kolpin noted. He explained that some of the drugs disposed in this way may eventually find their ways into waterways. For example, some landfill operators collect the water in their landfills and send it to water treatment plants.

Daughton acknowledged that these recommendations are an interim solution and have disadvantages. He said the EPA is currently examining other alternatives, such as a statewide medication take-back program in Maine in which patients may mail unused drugs to the Drug Enforcement Agency for incineration.



Daughton also recommends that the health care industry work to reduce the number of leftover medications (Daughton CG. *Environ Health Perspect.* 2003;111[5]:757-774; Daughton CG. *Environ Health Perspect.* 2003; 111[5]:775-785). He suggested steps to reduce overprescribing, such as using small trial prescriptions for patients starting a new drug that might not prove

to be helpful for the patient. Also, pharmacies and insurance companies may want to reconsider policies that encourage patients to have a 3-month supply of their medications. Automatic refill of mail order drugs might also be examined.

Although reducing overprescribing is something the health care industry would have to work toward over time,

there may be collateral improvements in health care outcomes and cost savings from such an effort, Daughton said. Physicians may become more aware of whether patients are adhering to their prescriptions, and there may be fewer accidental or intentional poisonings.

"Everyone needs to communicate on this to devise an optimal solution," Daughton said. □

## Abstinence-Only Programs Under Fire

Tracy Hampton, PhD

CHICAGO—Over the past decade, the US federal government has heavily promoted programs that advocate sexual abstinence as the key strategy for dealing with adolescent sexuality, but studies are demonstrating that the approach has little impact on teen sexual behavior or in preventing pregnancy or sexually transmitted diseases (STDs). As a result, health professionals and government officials are working to end the programs and to expand funding for other types of sexual education initiatives, and many states have refused federal funding for abstinence-only programs.

"By 2005, there were more than 800 programs that had been funded with over \$1.5 billion, and increasingly, professionals, parents, policy makers, and adolescents have been raising concerns," said John Santelli, MD, MPH, of the Columbia University Mailman School of Public Health in New York City. The mounting pressure to revamp sex education programs was a topic of discussion at the 2008 National STD Prevention Conference held here in March.

### ABSTINENCE-ONLY PROGRAMS

Abstinence-only education programs for adolescents received only a small amount of federal money starting in 1982, but funding has increased each year since then. In 1996, the federal government attached a provision to a major welfare reform law establishing

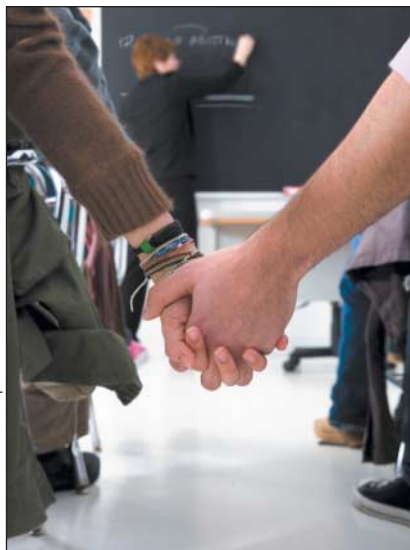
a program called Title V that provides up to \$50 million annually in grants to states for abstinence-only programs.

President Bush's 2009 budget, which cuts funding for HIV/AIDS and STD prevention efforts, designates \$204 million for abstinence-only programs. Such

likely to have harmful psychological and physical adverse effects. In total, there are 8 such components of the federal definition of abstinence-only programs.

Today, much of the federal funding for abstinence-only initiatives goes toward the Community-Based Abstinence Education program, which targets adolescents aged 12 to 18 years. Fund recipients cannot also provide more comprehensive information on contraception or safer sex practices to prevent STDs, even if nonfederal funds are used for that purpose.

Despite the allocation of hundreds of millions of dollars of federal funds for abstinence-only programs over the past decade, at the time Title V was enacted there was little, if any, evidence that such efforts prevented sexual intercourse in adolescence or provided accurate information about reproductive health. Mathematica Policy Inc, a nonpartisan firm that conducts policy research and surveys, was authorized by Congress in 1997 to conduct an evaluation of abstinence-only education programs. Three reports were released, with a final evaluation published in 2007 (<http://aspe.hhs.gov/hsp/abstinence07/report.pdf>). The firm surveyed more than 2000 elementary and middle school students who were followed up into high school. Approximately 60% of the students were in programs identified by abstinence-only proponents as ideal programs and 40% were controls.



Studies reveal that abstinence-only programs have little influence on teen sexual behavior.

programs are required to teach that abstinence from sexual activity is the only certain way to avoid out-of-wedlock pregnancy, sexually transmitted infections, and other associated health problems; that a mutually faithful monogamous relationship in the context of marriage is the expected standard of sexual activity; and that sexual activity outside the context of marriage is