Do Pharmaceuticals in Drinking Water Pose a Health Risk?

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Seven human health risk assessments of pharmaceuticals in drinking water in the U.S. and Canada were reviewed. And good news: None of these studies reported a potential health risk from exposure to pharmaceuticals in drinking water.

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In March, 2008, the Associated Press published a three-part series reporting pharmaceuticals detected in the drinking water of 24 U.S. metropolitan areas serving approximately 41 million people. This story was carried on the front page of many newspapers and was the leading story on the network news that night.

“The concentration of these pharmaceuticals are tiny, measured in quantities of parts per billion or trillion, far below the levels of a medical dose. And utilities insist that their water is safe. But the presence of so many prescription drugs – and over-the-counter medicines like acetaminophen or ibuprofen – in so much of our drinking water is heightening worries among scientists of long-term consequences to human health.”

Since that time, little information has been published in the popular press about this issue. In fact, one would be hard pressed to find a follow-up article discussing this subject. However, there have
been a number of scientific articles that have examined the human health risk of pharmaceuticals in drinking water.

The purpose of this article is to present basic information on pharmaceuticals in drinking water and to discuss the research that has been done since that time.

**Background**

Pharmaceuticals have been detected in surface water, ground water and drinking water across the U.S. The sources of these pharmaceuticals are discharges from wastewater treatment plants and septic systems, leaking sewer lines, landfills, animal feeding operations, and cropland where biosolids have been applied.

**What Pharmaceuticals Have Been Found?**

The U.S. Geological Survey (USGS) first reported the presence of pharmaceuticals in streams across the U.S. in 1999-2000. In the largest study to date, from 2007-2012, the USGS and the EPA examined the presence of pharmaceuticals in source water and treated drinking water across the U.S. (Furlong et al., 2017). In phase II of the study, samples were analyzed for 118 pharmaceuticals, with 47 pharmaceuticals detected in all source water samples at a median concentration of 14.2 nanograms/liter (ng/L = parts per trillion). The most frequently identified pharmaceuticals in source water were lithium, sulfamethoxazole, metoprolol, carbamazepine, estrone, and hydrochlorothiazide. In treated water, 25 pharmaceuticals were detected, with lithium, bupropion, metoprolol, carbamazepine, and cotinine most frequently detected at a median concentration of 10.6 ng/L. Treatment processes appeared to be effective in reducing concentrations of most pharmaceuticals.

**How is Risk Assessed?**

A number of scientists have carried out studies attempting to characterize the risk from drinking water containing pharmaceuticals detected at the levels reported in occurrence studies. The most commonly used approach for carrying out these studies consists of comparing the concentration of a pharmaceutical detected in water with an “acceptable” level of the pharmaceutical. If the concentration of the detected pharmaceutical is less than the “acceptable” level, then it signifies that there is little risk; conversely, a concentration above the “acceptable” level signifies potential risk.

Terms used in the scientific literature for “acceptable” levels include: (there is no consistent terminology in this type of risk assessment, however, essentially all of these terms mean the same thing)

- Human Health Benchmarks (HHBs); Acceptable Daily Intakes (ADIs), Drinking Water Equivalent Levels (DWELs), Predicted No-Effect Concentrations (PNECs), or Acceptable Daily Exposures (ADEs).

How are “acceptable” levels of pharmaceuticals in water calculated? This is the method used by the Minnesota Dept. of Health (2018):

- Identify the lowest therapeutic dose (LTD) of a pharmaceutical from the FDA label. The LTD
is the dose of a pharmaceutical that is needed to produce a clinically effective outcome.

- The LTD is then divided by an appropriate uncertainty factor, which is based on the severity of the effects noted in the FDA label. In most cases, a series of individual factors are multiplied together to get a total uncertainty factor ranging from 100-10,000.
- This value is then converted to a water screening value by multiplying it by a water intake rate, i.e., the average amount of water consumed for an individual.

The comparison of the “acceptable” level of the pharmaceutical to the concentration of the pharmaceutical detected in water is termed the margin of exposure (MOE), and is calculated as follows:

\[
\text{MOE} = \frac{\text{“Acceptable” Level}}{\text{Exposure concentration}}
\]

Using this approach, the lower the magnitude of the MOE, the higher the risk is to human health. Generally, an MOE of less than 1.0 is considered to represent a possible risk to human health.

Alternatively, a comparison of the concentration of the pharmaceutical in water to the “Acceptable” Level is termed the hazard index (HI), and is the same as the MOE equation, except the denominator and numerator are reversed, as follows:

\[
\text{HI} = \frac{\text{Exposure concentration}}{\text{“Acceptable” Level}}
\]

In this method, the higher the magnitude of the HI, the higher the risk is to human health. Using this approach, a HI less than 1 is not considered a risk to human health.

**What are the Results of Risk Assessments?**

Seven human health risk assessments of pharmaceuticals in drinking water in the U.S. and Canada were reviewed. None of these studies reported a potential health risk from exposure to pharmaceuticals in drinking water, as follows:

- Schwab et al. (2005): No human health risk (low HIs, measured surface water across the U.S.)
- Illinois EPA (2008): No human health risk (HIs ranging from <0.00000001 - 0.003, measured raw and treated drinking water in Chicago, IL)
- Cunningham (2009): No human health risk (all HIs < 1, measured treated drinking water across the U.S.)
- Bull et al. (2022): No human health risk (all MOEs > 10, measured wastewater and treated drinking water across the U.S.)
- Khan and Nicell (2015): Negligible human health risk (MOEs ranged from 4-137,500, measured treated drinking water across Canada)
- Roden et al. (2015): No human health risk (HIs ranging from <0.00001 - 0.01, measured surface water in New Jersey)
- Bexfield et al. (2019): No human health risk (no detections > “acceptable” levels, measured ground water across the U.S.)

**Conclusions**

The uniformity of these results is reassuring news for public health. The fact that none of these
studies have reported a human health risk means that this issue should be moved down the list of priorities for our public health community. With so many urgent issues facing us today, it is good news that one issue may not be as pressing as originally thought.

Another conclusion is that the media loves to publish a good scare story, such as the original AP articles from 2008, but rarely do they report reassuring follow-up stories that could calm the fears of the public.

References


