

Greener Pharmacy

Proper Medicine Disposal Protects the Environment

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What happens to medicines and supplements after they are consumed? Are they utilized in their entirety by our bodies? Or are some portions of them excreted unchanged (and thus still active)? If so, where do unused and expired medicines end up? Do medicinal chemicals affect other organisms living in the environment? If they do, does this affect human health? These are questions the Environmental Sciences Division of the US Environmental Protection Agency (EPA) is currently trying to answer.

This article discusses pharmaceuticals and personal care products (PPCPs) and offers insight into how they enter the environment, how they affect the water supply and aquatic organisms, and, finally, what we as integrative medical professionals can and must do to limit the impact of this emerging pollution problem. For purposes of this discussion, pharmaceutical drugs include all medicines used for diagnosis, treatment, and prevention of disease; illicit or recreational drugs; veterinarian medicines (including those for agricultural livestock); over-the-counter medications; and nutritional supplements or nutraceuticals. Personal care products include fragrances, lotions and creams, cosmetics, sunscreen, soaps, shampoos, and other consumer products, including those containing “inert” ingredients.

The “Ecotoxicology” of Medicine

Three primary human activities change ecosystems: habitat fragmentation, alteration of community structure, and chemical pollution.¹ This article addresses the third problem. During the past 3 decades, attention to the effects of chemical pollution has focused primarily on conventional “priority” pollutants, and rightfully so. These chemicals—referred to as *persistent bioaccumulative toxins* or *persistent organic pollutants*—include lead, mercury, and dioxin. All continue to have highly detrimental effects over long periods of time (ie, they have persistence). They are also generally bioaccumulative, meaning the toxins become concentrated as the chemical is consumed through the succession of a food chain. The good news is that through identification and regulation, the EPA and state and local municipal governments have curbed, to varying degrees, pollution from the most egregious of these chemicals. Experts continue to pay close attention to the ecological consequences.

Comparatively little attention, however, has been directed toward the large group of chemicals contained in PPCPs—yet use of PPCPs continues to grow worldwide, on par with many agrochemicals. Like agrochemicals, PPCPs are disposed or discharged into the environment on a continual basis via industrial and household sewage and waste (many individuals dispose of unwanted and expired drugs directly into the domestic sewage system or garbage). Further complicating the issue—and unique

What Clinicians Can Do to Reduce the Environmental Impacts of Medications

- Do not prescribe more medication than can be used.
- Prescribe smaller quantities such as starter packs and refill packs so there is not so much throwaway waste.
- Review and regularly reassess the patient’s total consumption of medication.
- Consider environmental impacts when prescribing medications.
- Learn about which drugs have large environmental impacts. For more information, go to www.teleosis.org and click on “Green Pharmacy.”
- Educate consumers about the importance of proper disposal of pharmaceutical waste.
- Start a medication take-back program.

to PPCPs—once ingested, pharmaceutical products are subjected to the metabolism of the user, after which excreted metabolites plus some unaltered parent compounds are released into sewage water.

Garbage disposal is a major problem as it leads to wet-weather runoff as a leachate from landfills, sending PPCP compounds into ground and water systems. In addition, landfills accept sewage sludge that can produce leachates carrying high concentrations of drugs. Over a 45-year period, researchers Holm et al found high concentrations of antibiotics and barbiturates in a Danish landfill.²

Through these processes, PPCPs enter the environment, where they are deemed “pseudo-persistent” because their rate of transformation and removal from the environment is overwhelmed by their replacement rate—a direct result both of long-term use of higher quantities of PPCPs by consumers and of improper disposal. A recent take-back event (in which consumers return unused and expired medications) in the San Francisco Bay area found that 45% of unused or expired medicines were flushed down the toilet and 28% were disposed directly into the trash.³ Persistence also arises from the natural resistance of medicines to degradation. One study in Germany showed that barbiturate concentrations were still found in the environment, even though their use had been virtually eliminated 30 years ago.⁴

Since drugs in the environment have not captured as much attention as pesticides, documentation of quantities released and environmental impacts are limited. Studies that quantify PPCPs in the environment originate primarily in Europe. In sharp contrast, pesticide use is clearly documented and controlled in the United States, Canada, and the European Union. And yet, pharmaceuticals may be released directly anywhere

humans exist worldwide—for example, through human excretion in rural or wilderness areas that have limited capacity for sewage treatment.^{5,6} New drugs in development and clinical trials—untested as to long-term effects—also are released directly into the environment through the formerly mentioned means, though in lower concentrations.

Ideally, sewage treatment facilities would capture PPCPs before they enter the environment. However, current waste systems are designed to handle human waste that is primarily biological in origin. Most anthropogenic (human-made) substances suffer an unknown fate in this system. Further complicating matters, new drugs introduced into the marketplace are difficult to monitor. In the case of PPCPs, many compounds resist degradation, and some are too small to be removed through sorption (taken up and held by either adsorption or absorption).¹

Pharmaceuticals also have been detected in domestic drinking water. In the United States, a recent study identified more than 100 kinds of PPCPs in significant concentrations in sampled waterways, the most common being aspirin, statins, hypertension medications, and hormones taken by women.⁷ Drinking-water regulations historically have been designed to protect consumers from threats of pathogens and industrial chemicals. Thus little baseline information for concentrations of PPCPs in drinking water exists. Precaution is necessary to stave off future problems.

Toxicity of PPCPs to Organisms and the Environment

Hormones, specifically estrogen compounds, made the first headlines about medicines adulterating sewage, and since then they have been found in significant concentrations.⁸⁻¹² Synthetic oral contraceptive medications, combined with steroidal estrogens, cause male fish to feminize.¹² Screening for endocrine disruption is complex. Significant numbers of xenoestrogens—estrogen mimics—exist. PPCPs are a subset of these mimics.

A considerable amount of research concerns the environmental effects of antibiotics, due to the extensive use of antibiotics in aquaculture, veterinarian medicine, animal husbandry, and human medicine. Antibiotics enjoy widespread use, but, according to studies, up to 95% of antibiotic compounds are released unaltered into the sewage system.^{13,14} This phenomenon has been shown to accelerate resistance of bacterial pathogens to antibiotics.¹³ High concentrations of antibiotics can produce alterations in microbial community structure and affect entire food chains.¹ Because of its use in cattle in the Indian subcontinent, the anti-inflammatory diclofenac proved fatal to vultures,¹⁵ decimating several species in India before its recent ban.

The most frequently reported PPCPs documented in the public waters of Europe are blood lipid regulators. Buser et al reported concentrations in remote lakes with no apparent atmospheric distribution.¹⁶ The researchers concluded that the route of introduction must be medicinal use and excretion by visitors and local inhabitants. Other substances found in surface water throughout Europe include beta-blockers, antidepressants, antiepileptics, antineoplastics, diagnostic contrast media, synthetic musks, disinfectants, sunscreens, and nutritional supplements.¹

Establishing a Medication Take-Back Program

Proper disposal of unused pharmaceuticals is essential to reducing their environmental impact. As a physician, you have the ability to work directly with your patients. The time when you are prescribing a medication is ideal to educate patients about proper disposal habits. The best and most effective action you can take is to establish a Medication Take-Back Program in your office. Once established, a waste management service licensed to handle medical waste can then dispose of the medications.

For more information on proper medical waste disposal, see: EPA guidelines: www.epa.gov/epaoswer/othermedical/#three
A Guide to Pharmaceutical Waste Disposal: www.medical-wastesolutions.com/pharm_update.pdf

Green Pharmacy and Product Stewardship

Obviously, the increasing amount of PPCPs in the environment is a source of great concern. Equally as obvious, something needs to be done to curb their impact. Fortunately, numerous ways are available to us to limit the potential negative effects of PPCPs on health and the environment.

Proactive Manufacturer Input

Cradle-To-Grave Product Stewardship. The most effective method is to implement “cradle-to-grave product stewardship.” This means that all those involved in production, distribution, sale, and use of any drug, supplement, or personal care product should also be involved with the product’s disposal and waste cycle. Of these constituencies, the manufacturing sector is in the best position to reduce the environmental impact of medicines and supplements, because a product begins with development and manufacturing. If the process begins with cradle-to-grave stewardship, it will be more cost-effective and environmentally sensitive in the long run.

Ecologically Sensitive Drugs. Manufacturers also can design drugs that are more ecologically sensitive, including medicines that biodegrade more quickly and yield less harmful end products. Innovative drug design can improve delivery systems so that lower doses are needed for efficacy.

More Realistic Expiration Dates. With a shift from the current system of averaging, the practice of refining a medication’s expiration date can bring shelf life into closer alignment with real time.

Environmentally Friendly Packaging. Manufacturers can package with recyclable materials, reduce package sizes to minimize unused portions of prescriptions, and add more complete information about proper disposal methods to the packaging. The pharmaceutical industry is in an excellent position to provide more information directly to physicians.

Proactive Physician Input

Patient Information. Individual physicians must also be part of the solution. As the first contact in any healthcare strategy, physicians can inform patients about healthy product stewardship. Right as a doctor is prescribing a medication is an ideal

time to educate patients about proper disposal habits. Imagine a patient receiving a phone call from your medical office reminding her not only about her next appointment, but also to bring along her expired and unused medicines.

Take-Back Programs. Any medical office can create a take-back program. For information on how properly to dispose of returned medications, see sidebar on page 51.

Model solutions already exist for the medical industry. Those involved in hospital medicine are developing methods for proper disposal. Hospitals for a Healthy Environment (H2E, <http://www.h2e-online.org>) is collaborating with many major hospitals in the United States to initiate proper disposal of hospital wastes.

Veterinarians and dentists can take these steps as well. More PPCPs are being used in domestic animals today than ever before. Veterinary offices, too, can participate in proper disposal programs.

Evidence that medicines and supplements are remaining in our waterways and in our drinking water continues to mount. Healthy product stewardship requires everyone's participation. In addition to manufacturer involvement, voluntary recycling fees, more take-back programs, and healthy behaviors that enable us to maintain optimal health can all play a role in keeping PPCPs out of our environment and water supply. Each one of us can contribute to a healthier home for all of us on planet Earth—just by making a better choice. Integrative physicians can provide leadership by taking simple but effective action to reduce the potential impact of this problem on personal and environmental health.

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