

Toxicology of Pharmaceuticals

TCAS has wide experience with pharmaceutical toxicology and has performed many assessments involving prescription medications, drugs of abuse, vaccines and over-the-counter preparations. Although pharmaceutical use can be a significant toxicological factor in a variety of claims, the real and potential effects must be correctly assessed by the expert toxicologist. Aside from direct effects, pharmaceutical use can also explain unusual behaviors and/or account for injury claimed to be attributed to another agent.

For example, some powerful prescription drugs can directly or indirectly cause certain medical conditions. Others can exacerbate and/or cause increased susceptibility to exposure-induced health effects (a [recent TCAS case study](#) highlights this fact). Certain pharmaceuticals can also impair or enhance the metabolism of other specific drugs by increasing their blood levels into the toxic range. Children, older adults and women can also be at higher risk of adverse health effects from pharmaceuticals.

The U.S. Food and Drug Administration lists more than 160,000 pharmaceutical packages registered and approved for sale in the U.S.¹ This staggering number of drugs means that, aside from effects resulting from abuse, the potential for interactions and/or medication errors is very high. Additionally, new biopharmaceuticals (new drugs developed through biotechnology) are increasingly available. Although this can increase the complexity and potential for drug interactions, new innovations do not negate the basic toxicological principle, "*The dose makes the poison.*"



TCAS has broad experience with pharmaceutical toxicology. (a)

The following paragraphs provide general toxicological outlines of pharmaceuticals for which TCAS has performed toxicological assessments, produced written reports and/or provided expert testimony, subsequent to being retained by defendants, plaintiffs, State attorney generals, prosecutors and/or public defender's offices. We invite you to [contact our office](#) if you have questions or concerns regarding any prescription medication or pharmaceutical not listed on this page.

Drugs of Abuse and Drug Testing

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Drugs of abuse frequently involve the ingestion, insufflation or injection of illegal drugs or the misuse of prescription medications, generally with negative consequences and frequently in the context of litigation. Drug abuse "cutting agents" (adulterants) and contaminated needles can also induce unique, adverse health issues including cardiac arrhythmia, convulsions, sepsis, AIDS, hepatitis and other diseases. TCAS has in-depth experience in interpreting laboratory test results and assessing toxicological issues for common drugs of abuse including (but not limited to):

- Alcohol
- Amphetamines
- Barbiturates
- Benzodiazepines
- Buprenorphine
- Carisoprodol
- Cocaine Metabolites
- Fentanyl
- Heroin Metabolites
- LSD and Hallucinogens
- Marijuana Metabolites
- MDMA/MDA
- Methadone Metabolites
- Opiates & Opioids
- Oxycodone
- Peyote (mescaline)
- Phencyclidine
- Propoxyphene
- Tapentadol
- Tramadol

Refer to our [Drugs of Abuse](#) page for more detailed information

Pharmaceuticals and Prescription Medications

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TCAS has broad experience in cases involving hundreds of different pharmaceuticals, prescription medications, vaccines, additives and over-the-counter preparations. As a toxicologist and licensed clinical, environmental and forensic laboratory director, Dr. Sawyer has in-depth experience with drug testing, chain-of-custody procedures, interpreting laboratory analyses and application of peer-reviewed methods to produce scientifically credible toxicological assessments. He is familiar with the latest technology used to conduct sampling and analyses of pharmaceuticals, drugs of abuse, synthetic compounds, organic compounds, neurotoxins and many other specialized substances. The following **partial catalog** lists some of the most frequent pharmaceuticals of interest in cases for which TCAS has been regularly retained in both investigative and causative assessment capacities:

- Abilify
- Aceta
- Actiq
- Adderall
- Advair
- Aggrenox
- Alprazolam
- Ambien
- Amobarbital
- Amphetamine
- Asmanex
- Ativan
- Aventyl
- Avinza
- Benicar
- Bupivacaine
- Butalbital
- Bystolic
- Carafate
- Carisoprodol
- Celebrex
- Celexa
- Chantix
- Chlordiazepoxide
- Cialis
- Clonazepam
- Codeine
- Combigan
- Combivent
- Concerta
- Crestor
- Dalmane
- Darvocet
- Darvon
- Demerol
- Desoxyn
- Dexilant
- Diazepam
- Dilaudid
- Diovan
- Dolophine
- Dulera
- Duragesic
- Elavil
- Eliquis
- Endocet
- Epinephrine
- Equagesic
- Fentanyl
- Fioricet
- Flovent
- Flurazepam
- Focalin
- Gabapentin
- Halcion
- Humalog
- Humira
- Humulin R
- Hycodan
- Hydrocodone
- Hydromorphone
- Klonopin
- Lantus
- Latuda
- Levemir
- Librium
- Lorcet
- Lortab
- Lotemax
- Lumigan
- Lyrica
- M S Contin
- Meperidine
- Methadone
- Methamphetamine
- Midazolam
- Minastrin
- Morphine
- Nasonex
- Nembutal
- Neurontin
- Nexium
- Norco
- Norvir
- Novolog
- Nucynta
- Nuvaring
- Opana
- Oxazepam
- Oxycodone
- Oxycontin
- Oxymorphone
- Pamelor
- Pataday
- Patanol
- Percocet
- Percodan
- Phenaphen
- Phencyclidine
- Phenobarbital
- Pradaxa
- Premarin
- Propoxyphene
- Proventil
- Restoril
- Ritalin
- Roxanol
- Roxicodone
- Rybix
- Ryzolt
- Seconal
- Serax
- Seroquel
- Soma
- Spiriva
- Suboxone
- Subutex
- Symbicort
- Synthroid
- Tamiflu
- Tapentadol
- Temazepam
- Toprol
- Tramadol
- Travatan
- Triazolam
- Tuinal
- Tylenol
- Ultram
- Valium
- Ventolin
- Versed
- Viagra
- Vicodin
- Voltaren
- Vyvanse
- Xanax
- Xarelto
- Xopenex

Neurotoxins and Neurotoxicity

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A neurotoxin is a naturally- or industrially-produced substance which adversely affects the human nervous system. Neurotoxicology is the study of the adverse effects of chemical agents on the structure or function of the nervous system including the brain and sensory organs. The U.S. EPA provides considerable information on many aspects of neurotoxicology.³ The symptoms and health effects of most neurotoxins are well-documented, but of all the various toxic substances, neurotoxins are among the most problematic as they can not only adversely impact multiple systems and organs simultaneously but also amplify the adverse effects of other substances. For example, although lead's neurotoxic targets include the heart, bones, intestines, kidneys, brain and reproductive system, lead can also cause oxidative stress which prevents the body from detoxifying itself through inhibition of antioxidants. Similarly, chronic exposure to various heavy metals such as aluminum, manganese, arsenic, thallium and others can lead to systemic disruptions and neurological disorders. Certain gases can also produce lethal neurotoxic effects (such as in [a recent TCAS case study](#) in which a victim was exposed to methyl bromide gas).

Organic neurotoxins can be particularly toxic. For example, the botulinum toxins, which are among the most toxic substances known, can be fatal after exposure to only a few billionths of a gram. Other organic neurotoxins include venom, pesticides, organic solvents (chlorinated solvents and hexa-/hepta-carbons at high dose levels), contaminated seafood, poisons, molds, fungi, organophosphate nerve gas and others. Some pharmaceuticals can produce neurotoxic effects, either independently or in combination with other substances. An objective toxicological exposure assessment is an absolute necessity in cases where neurotoxins are involved. TCAS has been regularly retained in both investigative and causative assessment capacities in cases involving neurotoxins. Please [contact our office](#) for additional information.

Drug Toxicity

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Drug toxicity may occur due to any of several factors including (a) excessive or incorrect dose, (b) impaired metabolism due to interference from other pharmaceuticals and (c) impaired renal or liver function by other causes. This phenomenon can happen to persons of all ages (including infants) due to greater quantities of administered medications per unit of body weight. As noted in a recent AARP publication,² *"Drug toxicity is a common and significant health problem, yet it often goes undetected by patients and physicians who do not recognize it as the cause of such symptoms as mental disorientation, dizziness, blurred vision, memory loss, fainting and falls. Although drug toxicity may result when a medication dose is too high, it can also occur if a person's ability to metabolize a drug changes over time."* Drug toxicity can also occur when multiple medications interact unpredictably (see below) or interact with other substances (such as alcohol or drugs of abuse which can alter metabolism). An objective toxicological exposure assessment can be instrumental in establishing or refuting causation in cases involving drug toxicity. Please [contact our office](#) for additional information.

Polypharmacology and Drug Interactions

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With some 160,000 pharmaceutical packages currently registered and approved for sale in the U.S.,¹ drug interactions are inevitable and can produce a vast range of toxicological effects. A recent TCAS [case study](#) highlights the results that can occur from multiple drug interactions and the resulting polypharmacological effects. The term "polypharmacology" refers to a single drug acting upon multiple targets of a unique or multiple disease pathway. Polypharmacology is generally discouraged due to nonselectivity of pharmaceutical interactions. However, when patients combine certain medications in sufficient doses, they can inadvertently produce polypharmacological effects. Prescription errors and/or combinations of pharmaceuticals resulting from ill-advised prescriptions or circumstances can, in some cases, lead to malpractice litigation (see below). TCAS has conducted numerous toxicological assessments with respect to drug interactions and polypharmacological effects. Please [contact our office](#) for additional information.

Prescription Errors and Medical Malpractice

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Adverse drug events (ADEs) in which patients are harmed as a result of exposure to pharmaceuticals are common in the U.S. with some 700,000 emergency department visits and 100,000 hospitalizations reported each year.⁴ Elderly patients are particularly vulnerable to ADEs as they more frequently use multiple pharmaceuticals and are more susceptible to adverse effects. In cases involving prescription errors or medical malpractice, the expert toxicologist follows a highly specific process of investigation as well as application of generally-recognized scientific, forensic and deductive principles. This involves a detailed review of a patient's medical history and application of the basic principles of toxicological causation. It is important to note that it is the toxicologist's task to identify the true cause — which may or may not be solely related to the suspected pharmaceutical or which may be related to an underlying condition or toxicant. The expert toxicologist's role is to provide a causative or contributory opinion with respect to exposure based upon an objective investigation of all available case facts including medical records, pharmacological records, deposition transcripts, police reports, generally-accepted toxicological studies and other related data. Please [contact our office](#) for additional information.

Notes and References

1. U.S. Food and Drug Administration, "National Drug Code Directory," Drug Approvals and Databases, 2015
2. Mary A. Fischer, "When Medicine Makes You Sick," A.A.R.P. 2010
3. U.S. EPA, [Citations to scholarly articles and reference material](#). (multiple EPA references)
4. U.S. Department of Health and Human Services, "Patient Safety Primer: Medication Errors," Agency for Healthcare Research and Quality, 2010

Images

- a. TCAS montage (report demonstrative, redacted), public domain thumbnail images courtesy www.scx.hu. Photos by Adam Ciesielski, Cape Town, Western Cape; Dima V (3); Cristian Bender, Tubarao, SC; Jeroen Belen, Alkmaar, NH; Patricia Yliniemi; Juan Manuel Navarro, Leon, GTO; Luis Francisco Cordero, Quito, Pichincha, GR.

A Message from Dr. William R. Sawyer
Chief Toxicologist, TCAS, LLC



"Pharmacology and toxicology are similar in that both require an understanding of biochemistry. However, toxicology focuses upon the adverse health effects of a chemical substance rather than the efficacy of the drug itself."

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