



The Role of Medical Pharmacology Experts in Forensic Science

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Abstract

Medical pharmacology experts possess in-depth knowledge of drug actions, metabolism, and their systemic effects on the human body, providing a critical complement to forensic toxicologists in legal cases. Their extensive training, typically culminating in a PhD from a medical school, includes a detailed understanding of physiology, pathology and the molecular underpinnings of pharmacodynamics and pharmacokinetics.

Consequently, medical pharmacology experts serve an essential function when interpreting complex drug effects, polypharmacy interactions, individualized patient clinical responses, human physiology and disease states, and causality in both criminal and civil proceedings. This article discusses the rigorous training that medical and clinical pharmacologists undergo and highlights how their expertise bolsters legal proceedings, ensuring accurate and scientifically sound conclusions in forensic contexts.

Keywords: Medical Pharmacology; Clinical Pharmacology; Forensic Science; Expert Witness; Toxicology; Legal Medicine

Abbreviations

DUI: Driving Under the Influence; ADRs: Adverse Drug Reactions; NPS: Novel Psychoactive Substances.

Introduction

The legal system increasingly relies on specialized scientific experts to navigate complex questions involving drug actions, poisonings, and adverse medical outcomes. While forensic toxicologists possess expertise in detecting and identifying toxins, the added value of a pharmacology expert lies in their deeper physiological and mechanistic understanding of how pharmaceuticals and toxins interact with the human body [1]. Medical pharmacologists train in human physiology and have a significant understanding

of human disease and disorders. Their field of study focuses on how drugs interact with the body, requiring them to have a deep knowledge of pathology and disease mechanisms to effectively research and develop treatments and novel therapeutics [2]. Such experts are critical in a broad array of legal cases, from homicide and sexual assault to medical malpractice. Their comprehensive training in pharmacological principles, clinical knowledge, and research methodology uniquely positions them to inform case-related inquiries about specific drug dosing, side effects, behavior to include clinical signs and symptoms, drug interactions, and therapeutic standards [3].

This manuscript outlines the core competencies for Pharmacology Experts, detailing how they are distinct from toxicology experts and how they complement and enhance

forensic teams. It further explores the scope and significance of their expert testimony in the legal system.

Training and Expertise in Medical and Clinical Pharmacology

Medical and Clinical Pharmacology Experts often emerge from one principal academic track: a PhD in Pharmacology through a Medical School. Candidates in this field typically complete foundational medical coursework in biochemistry, physiology, anatomy, and molecular biology before concentrating on advanced pharmacology. Research-based dissertations require mastery of experimental design, data analysis, and specific sub-disciplines such as neuropharmacology, cardiovascular pharmacology, or toxicology. Depending upon the program, the combination of medical training—providing clinical exposure to patients, diseases, and treatments—with rigorous laboratory and research experience. The academic background and credentials equip graduates with a translational perspective, bridging bench research to bedside clinical applications.

Beyond classroom instruction, training in medical and clinical pharmacology encompasses an integrative combination of laboratory research, clinical experience, and teaching responsibilities. Trainees engage in multi-year research projects focused on identifying novel drug targets, elucidating mechanisms of action, and assessing toxicological profiles. Concurrently, clinical rotations provide hands-on exposure to the processes of medication prescribing, monitoring, and adjustment within diverse medical settings. Many programs also incorporate teaching components in which trainees instruct medical or undergraduate students, thereby cultivating advanced communication skills essential for professional practice, including expert witness testimony. By the completion of this rigorous training, medical and clinical pharmacology specialists possess a distinctive synthesis of scientific expertise, clinical understanding, and research proficiency that enables a comprehensive grasp of pharmacological mechanisms and physiological interactions in the human body.

Depth of Knowledge in Human Physiology and Pathophysiology

Distinct from forensic toxicologists, whose primary focus is on toxic agents and their detection, while some experts can be trained in both toxicology and pharmacology, medical and clinical pharmacology experts are trained to evaluate how a drug's pharmacokinetics (absorption, distribution, metabolism, and excretion) intersect with individual patient factors—such as organ function, genetic polymorphisms, and comorbidities, which is the underlying physiology and pathologies of the human body [4]. For instance, a drug may

have certain effects on a patient with normotensive blood pressure and a different effect on someone with hypertension [1]. Medical Pharmacologists must be extensively trained in human body and health conditions of the human body. They are equipped to predict drug-drug interactions (DDIs), anticipate variable therapeutic or adverse outcomes in the context of specific pathologies (e.g., kidney or liver disease), assess the chronic effects of long-term medication usage and provide differential diagnoses related to drug-related pathologies or poisonings. Understanding these nuanced factors is essential in forensic investigations, especially in cases of ambiguous drug involvement, atypical overdose presentations, or polypharmacy (more than one drug present).

Collaboration with Forensic Toxicologists

Forensic toxicologists excel in detecting and quantifying chemicals, and are often classically trained in chemistry. In contrast, a medical pharmacologist's academic foundation builds on education in medical physiology and pathology and medical pharmacologists interpret these laboratory findings in the context of human physiology, standard treatment protocols, and known pharmacological profiles [4]. The clinical signs and symptoms of human conditions are fundamental to the training of pharmacologists [1,4]. By collaborating, pharmacologists and toxicologists refine interpretive accuracy in determining cause of death, impairment levels, or liability in medical-legal disputes [3,5]. Underlying human physiology, such as medical conditions or mental health disorders are a critical piece of a pharmacologist's work and interpretation. Certain medical conditions change the clinical signs and symptoms of a drug and alter the overall effects the drug has on the body system [6].

For instance, in a driving under the influence (DUI) case involving prescription medications, a forensic toxicologist may confirm the presence of a benzodiazepine. A Medical Pharmacology Expert elucidates how the pharmacodynamics of that benzodiazepine, perhaps combined with alcohol or another anxiolytic, could potentiate sedation or motor impairment in that specific individual. An underlying disease state can make individuals more susceptible to the effects of the benzodiazepine. The collective input from pharmacology and toxicology forms a robust evidentiary foundation for the court.

Involvement in Civil and Criminal Litigation

Medical and clinical pharmacologists represent an advanced tier of expertise within the biomedical sciences, integrating a depth and breadth of training that extends far beyond the traditional scope of toxicology or pharmacy

practice [7]. While toxicologists focus primarily on the adverse effects and safety profiles of chemical agents, medical and clinical pharmacologists are uniquely trained to investigate, interpret, and optimize the therapeutic use of drugs through the combined lenses of molecular pharmacodynamics, clinical application, and translational research [8-10]. Their preparation demands proficiency in experimental design, statistical analysis, and human physiology, bridging bench science and bedside decision-making.

Medical pharmacology experts play a critical role in diverse legal and forensic settings, where their specialized understanding of physiology and drug mechanisms, therapeutic applications, and toxicological profiles is essential for objective interpretation of complex evidence. In medical malpractice cases, they evaluate whether prescribing practices align with established clinical guidelines and assess the potential contribution of drug administration to patient harm [2]. Their expertise is equally vital in cases involving drug-related assaults or overdose deaths, where interpretation of drug concentrations can distinguish accidental from intentional or homicidal exposure. Additionally, in workers' compensation evaluations, medical pharmacologists assess the role that medication use may have played in occupational performance or injury risk. Collectively, these applications underscore the indispensable interdisciplinary function of medical and clinical pharmacology experts in bridging the domains of medicine, law, and public health through scientifically grounded analysis and testimony.

Subspecialties within the Pharmacology Field

Psychopharmacology is a subspecialty at the interface of psychiatry, psychology, and pharmacology that focuses on the rational use of psychotropic medications to treat mental disorders across the lifespan, integrating pharmacokinetic and pharmacodynamic principles with contemporary neuroscience, pathophysiology, and clinical assessment to guide safe and effective prescribing [11].

Psychopharmacologists are trained to conduct detailed medication evaluations, determine when psychotropic agents should be initiated, titrated, combined, or discontinued, and manage complex polypharmacy in conditions such as mood, anxiety, psychotic, substance use, and neurocognitive disorders, while systematically monitoring efficacy, tolerability, and adherence [12]. In forensic and legal settings, this expertise is applied to questions about how specific psychotropic regimens may influence cognition, judgment, and behavior, whether treatment decisions are consistent with accepted standards of care, and how medication exposure, blood levels, or adverse effects may relate to claimed impairment or risk at a given time.

The scope of opinion offered by a clinical psychopharmacologist in these contexts is necessarily constrained by both scientific uncertainty and legal doctrine, and does not substitute for the fact-finding role of the court or jury. Within these boundaries, the expert's task is to clarify the state of the science, explain the range and limits of reasonable clinical judgment, and articulate evidence-based, transparent reasoning, explicitly acknowledging diagnostic ambiguity, interindividual variability in drug response, and limitations in the empirical literature, rather than to advocate for a specific legal outcome.

Accordingly, a clinical psychopharmacologist may opine on issues such as whether a prescribed regimen is congruent with prevailing practice standards, whether measured serum concentrations are compatible with therapeutic versus toxic exposure, or whether a drug's known profile could plausibly contribute to reported symptoms, but should refrain from asserting ultimate legal conclusions on criminal responsibility, competence, or causation in the legal sense, which remain reserved to the trier of fact.

Some experts, particularly pharmacologists with a subspecialty of psychopharmacology who work in clinical settings such as a psychology clinic, within a psychiatric mental health setting, or in other various clinical settings (emergency department, medical schools, nursing schools, etc.) have in depth training in mental health disorders [11,12]. While diagnosing mental health conditions should be restricted to individuals holding a medical license, a clinical pharmacologist is well versed in the mechanisms and clinical signs and symptoms.

Personalized Medicine and Pharmacogenomics

Advances in pharmacogenomics have underscored that genetic variants can drastically alter drug metabolism, efficacy, and toxicity. Within forensic investigations, such variability can explain differential responses to "standard" doses or unanticipated adverse drug reactions (ADRs). Medical Pharmacology Experts, with their grounding in molecular pharmacology and human genetics, can interpret emerging genomic data to contextualize atypical or idiosyncratic drug effects; acknowledging the often-ignored human variability in drug reactions [1,4].

The continuous influx of novel psychoactive substances (NPS) and designer drugs poses a challenge for standard toxicological assays. Medical Pharmacology Experts, staying abreast of pharmaceutical developments, can offer mechanistic insights, potential antidotes, and anticipated toxicities for substances that have not yet been fully characterized in routine forensic toxicology panels [2]. Medical pharmacologists must have a deep understanding

of metabolic pathways and a strong integration of chemistry. The metabolic pathways of the human body can be utilized to understand how novel designer drugs are processed by the body. Metabolites of metabolism are often similar between drug classes and can be used to evaluate the impact of designer drugs on the body.

Conclusions

Medical Pharmacology Experts fulfill a vital niche in forensic science, bridging the detection of substances by forensic toxicologists with a nuanced comprehension of drug mechanisms and clinical realities. Their advanced training, typically a PhD grounded in medical and biological disciplines, confers a detailed knowledge of pharmacokinetics, pharmacodynamics, and pathophysiology, which is essential for informed legal judgments. In an era when personalized medicine and complex polypharmacy are increasingly common, the value of these experts will only grow—enhancing the accuracy of causation analyses, clarifying liability in medical or product-based litigation, and improving the overall reliability of forensic conclusions.

Conflicts of Interest

Dr. Korin Leffler reports expert witness work in forensic pharmacology and toxicology litigation. No other conflicts to disclose.

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