Comparison of Pharmacology and Toxicology
Lecture Notes

This lecture material is based on a presentation delivered by Barbara Sattler,RN,DrPH at Environmental Health Faculty Development Workshops.

Slide 1 (title):
Comparison of Pharmacology and Toxicology

Notations (opening comments):

Slide 2:
Objectives:
By the end of this lecture, students will be able to:

- *Define toxicology*
- *Discuss eight concepts of toxicology that are important in understanding and evaluating environmental health issues*
- *Compare and contrast the key concepts of environmental toxicology with concepts of pharmacology*

Speaker Notes:
You are all familiar with the key principles of pharmacology from (names of courses). Today we're going to talk about a branch of science called toxicology. Toxicology is very important to understanding the effects of environmental pollutants on human health. It is also similar to pharmacology, and we're going to be comparing these two disciplines (toxicology and pharmacology) throughout this lecture.

Additional Notations:

Slide 3:
Definitions
Pharmacology: *the scientific study of the origin, nature, chemistry, effects, and use of drugs.*
Toxicology: *the science that investigates the adverse effects of chemicals on health.*

Additional Notations:

Slide 4:
Dose
Pharmacology: *Dose refers to the amount of a drug absorbed from an administration.*
Toxicology: *Dose refers to the amount of a chemical absorbed into the body from an exposure.*

Additional Notations:

Slide 5:
Key Factors Related to Dose

- *In pharmacology, we have very good control over who receives what dosage of what substance* (as described by the 5 "R"s: you are responsible for giving the right medication, to the right patient, in the right dose, at the right time, by the right route).

- *In environmental health*, though, *it is usually very difficult to control or determine who receives what dose of which toxin(s)*. For environmental exposures, we are often left "reconstructing" a dose based on the best information we can gather.

Additional Notations:

Slide 6:
Administration/Exposure
Pharmacology: *Administration regimen: A drug can be administered one time, short-term or long-term.*
Toxicology: *Exposure is the actual contact that a person has with a chemical. Exposure can be one-time, short-term or long-term.*

Additional Notations:

Slide 7:
Key Factors Related to Administration/Exposure

- *Drugs are taken voluntarily, often under the supervision of a licensed health care provider.*
- *Hazardous chemical exposures are often involuntary.*

- *With both drugs and hazardous chemicals, children's behavior entails special exposure risks.*

Speaker Notes:
Children are at high risk for poisoning from drugs and hazardous chemicals because of their curiosity and hand-to-mouth behavior. With regard to environmental hazards, children are at greater risk because they spend more time on or near the ground, which increases their exposure to residues (including residues from airborne toxicants that settle on the ground). With regard to foodborne toxicants, children have greater food intake per kilogram of body weight than adults, and they eat a smaller range of foods (which leads to increased risk from contaminants on certain foods). With regard to airborne toxicants, children breathe proportionately more air than adults.

Additional Notations:

Slide 8:
Routes of Administration/Exposure
Pharmacology: *Routes of administration: oral, IM, IV, subcutaneous, topical*
Toxicology: *Routes of exposure: ingestion, inhalation, dermal, conjunctival*

Additional Notations:

Slide 9:
Key Factors Related to Routes of Administration/Exposure:

- *In administration of medication, different routes are used based upon the efficacy of absorption of drugs from each route*. For example, the topical route can be used only for medication preparations that are absorbed effectively through the skin. Insulin is administered parenterally because it is broken down in the stomach and, therefore, is not absorbed well via the GI tract.

- *In environmental health, different toxins are absorbed through different routes of exposure, which results in variations in toxicity.* For example, elemental mercury (the silver-grey material in mercury thermometers and sphygmomanometers) is poorly absorbed through the GI tract but well absorbed as a vapor in the respiratory tract. If transformed to methylmercury by the action of bacteria in bodies of water, and later consumed in fish, it is readily absorbed in the GI tract and crosses the placental barrier.

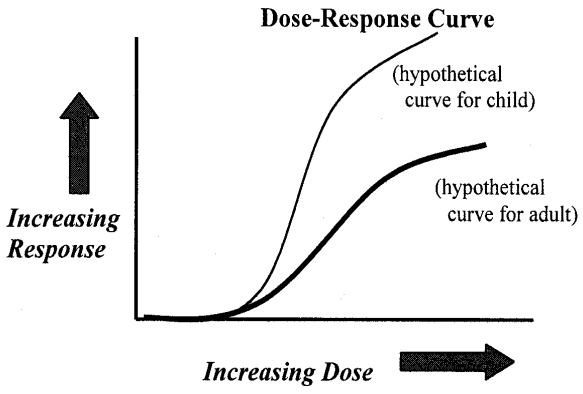
Additional Notations:

Slide 10:
Distribution, Metabolism and Excretion
Pharmacology *and* ***Toxicology:*** *Distribution, metabolism and excretion describe what happens to the drug or toxin in the body.*

- *Distribution* refers to the *organs that are reached* by the drug or toxin.
- *Metabolism* is the *chemical transformation* of the substance that occurs. Metabolism produces products called *metabolites*, which may be more or less toxic than the original substance.
- *Excretion* refers to the *elimination* of the substance, usually by way of the kidneys.

Additional Notations:

Slides 11/12:
Dose-Response Curve



Pharmacology: *A dose-response curve graphically represents the relationship between the dose of a drug and the response elicited.*
Toxicology: *A dose-response curve describes the relationship of the body's response to different amounts of an agent.*

Speaker Notes:
Beyond a certain dose (the threshold), the response increases with increasing dose. At some point, this effect may "level off."

Additional Notations:

Slide 13:
Key Factors Related to Dose Response

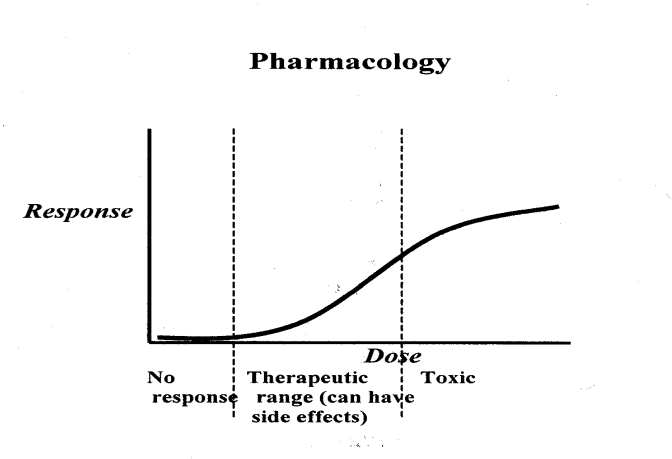
- In pharmacology as well as environmental health, *the dose-response curve may differ for different populations*. Children, for example, are not just little adults. Because of differences in development and function of organs, they may metabolize drugs or toxins differently from adults. Therefore, effects may increase for children at lower (or occasionally higher) doses.

  For example, children absorb lead from the GI tract much more efficiently than adults. With nitrate in drinking water, the higher pH in the digestive system of an infant allows proliferation of bacteria which transform nitrate into toxic nitrite.

- In pharmacology as well as environmental health, *individuals vary with regard to response to drugs or toxins.* This is due to factors such as: age, gender, genetic variations, weight, drug that the person may be taking, pregnancy status.

Additional Notations:

Slide 14:
Responses – Pharmacology

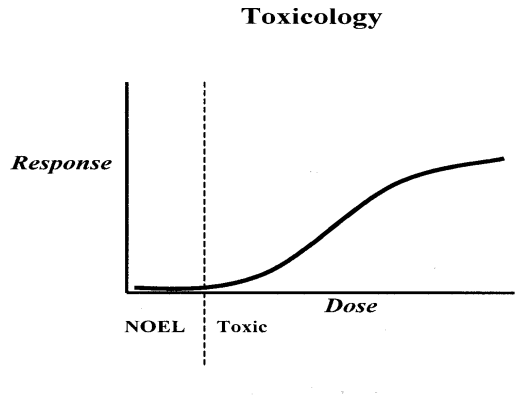


Note: This graph is a "compressed" representation of therapeutic and toxic responses. Actually, there is an S curve for each effect (therapeutic or toxic). Generally, though, toxic effects occur at higher doses—ideally, at doses that exceed those required for maximal therapeutic effect.

***Pharmacology*:** At *low doses* or concentrations, there is *no observable response* (dose is *subtherapeutic*). With *increased dosage*, there are *therapeutic responses (*which are desirable*) and side effects (*which are generally undesirable*). Beyond the therapeutic dose*, a drug may become toxic.

Additional Notations:

Slide 15:
Responses – Toxicology
Toxicology*: Only the toxic effects are of concern.* At *low doses,* there may be no effect (called *NOEL – no observable effect level*). *At levels greater than NOEL, toxicity* occurs.



Additional Notations:

Slide 16:
Toxicity
Toxicity is the ability of a chemical to damage an organ system, to disrupt a biochemical process, or to disturb an enzyme system.

Additional Notations:

Slide 17:

Key Factors Related to Toxicity

- *With medications, side effects sometimes result from long-term use of the drug* (for example, gastric ulcers from non-steroidal anti-inflammatory drugs [NSAID's]).

- *In environmental health, chronic exposure may result in effects that are quite different from the effects of single larger exposures* that result in acute symptoms. These chronic exposures often result in neurological effects or cancer.

Additional Notations:

Slide 18:

Interactions

Pharmacology: *Drug interactions define the effect one drug has on another.*

Toxicology: *Toxicological interactions define the effect one chemical has on another*

Speaker notes:

Toxicological interactions include interactions between drugs and environmental pollutants)

Slide 19:

Interactions, continued

These effects may be *additive* (*the sum* of the effects = *whole,* or the total toxicity of the two), *synergistic* or *potentiated* (*one enhances the other's effect*), or *antagonistic* (*one reduces the effect of the other*).

Additional Notations:

Slide 20:

Potency

Pharmacology: *Potency refers to the relative amount of drug required to produce the desired response.*

Toxicology: *The potency of a toxic chemical refers to the relative amount it takes to elicit a toxic effect compared with other chemicals.*

Additional Notations:

Slide 21:
Biological Monitoring
Pharmacology: *Biological monitoring is done for some drugs.*
Toxicology: *Biological monitoring is done for some toxic exposures.*

Speaker Notes:
In pharmacology, clotting time is monitored in patients on anticoagulants like coumadin. Actual drug levels are measured for some drugs like digoxin.

In environmental health, blood lead levels, or metabolites of chemicals such as cotines for environmental tobacco smoke, may be monitored.

Additional Notations:

Slide 22:
The Regulatory Process

- *The regulatory process for approval to sell a medication includes several stages of testing on animals and humans*
- *The regulatory process for hazardous chemicals that are not food, drug, cosmetic, or pesticide in nature does not require any original testing for human health risks*

Speaker Notes:
When testing is done, it tends to be focused on the effects on middle-aged white males. In recent years (notably with the Food Quality Protection Act of 1996), the effects on children have begun to be taken into consideration.

Additional Notations:

Slides 23, 24, 25:
Resources for further information:
General environmental health (with links): www.enviRN.umaryland.edu
Toxicology: www.sis.nlm.nih.gov ("toxicology tutor")
Mercury: www.epa.gov/mercury, www.atsdr.cdc.gov(→ toxicological profiles), www.hcwh.org
Effects in children: www.cehn.org
Lead: www.aeclp.org, www.atsdr.cdc.gov (→ toxicological profiles)
Nitrate/nitrite: www.epa.gov/safewater, www.ianr.unl.edu (search: "nitrate and drinking water")

Cancer: www.niehs.nih.gov (→ National Toxicology Program → Report on Carcinogens), www.epa.gov/children (→ childhood cancer), S. Steingraber: Living Downstream

Neurological effects: www.igc.org/psr (In Harm's Way), www.epa.gov/children (→ developmental and neurological problems)

Interactions: www.sis.nlm.nih.gov (" toxicology tutor "); McCauley, L.A. 1998. Chemical Mixtures in the Workplace. AAOHN Journal 46(1): 29-40.

This material was developed at the Environmental Health Education Center of the University of Maryland School of Nursing. For more information, see envirn.umaryland.edu