

# Drug Dose and Response Relationship

Tuesday, October 28, 2025 4:52 AM

## Overview

### Definition

The dose-response relationship explains how the magnitude of a pharmacological effect changes with the amount (dose) of a drug administered.

It helps determine the optimal dose, efficacy, and safety of a drug.

### Relationship Overview

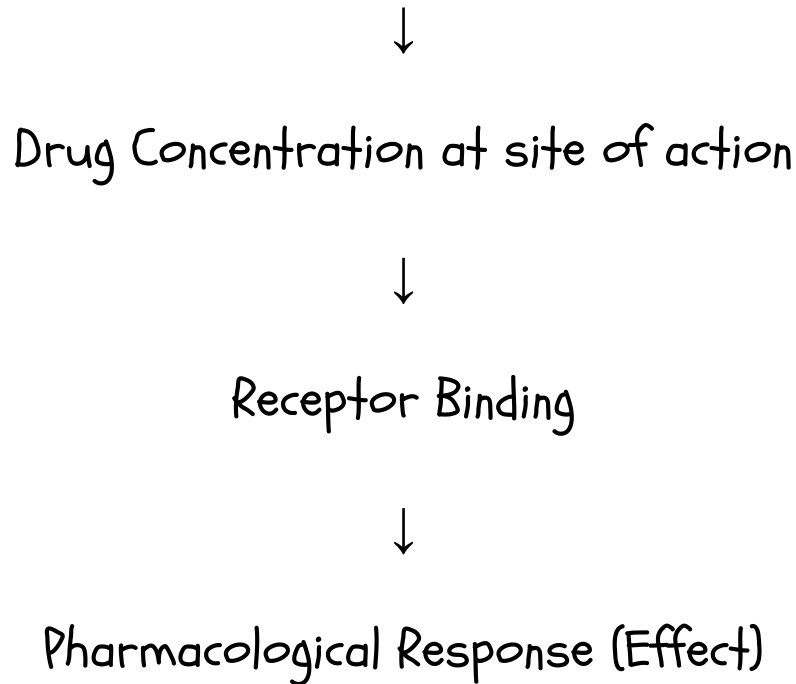
Dose administered → Drug concentration in plasma → Pharmacological effect (response)

Flowchart:

Drug Administration



Absorption & Distribution



## 1 Types of Dose-Response Relationships

### 1. Graded Dose-Response Relationship / Curve

→ Measures the continuous response to increasing doses in a *single individual*.

### 2. Quantal Dose-Response Relationship / Curve

→ Measures the all-or-none (yes/no) response in a *population* (e.g., % of patients showing desired effect).

---

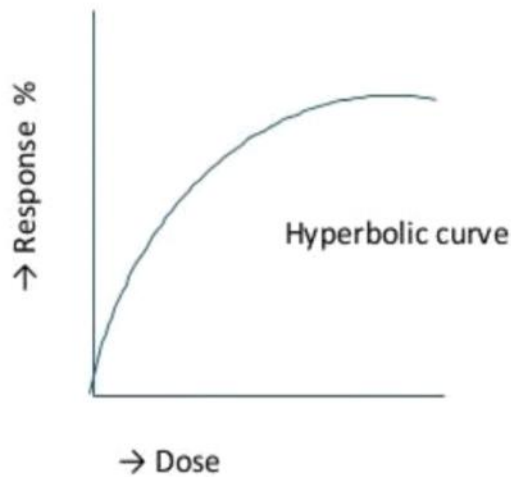
## Graded Dose-Response Relationship

### ◆ Definition

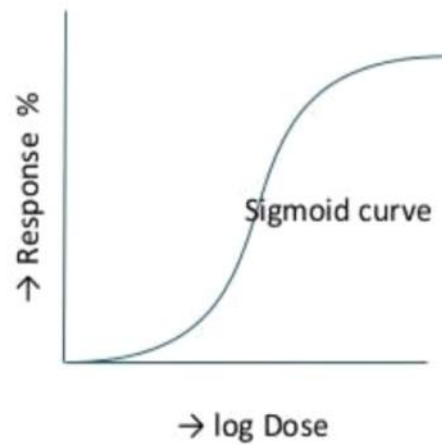
A proportional relationship between dose and the magnitude of response up to a maximum level.

### ◆ Curve Characteristics

- Axes:
  - X-axis → *Log Dose*
  - Y-axis → *Response (% of maximum)*
- Shape:
  - Initially rectangular hyperbola, becomes sigmoid (S-shaped) when log dose is plotted.
- Plateau:
  - Represents maximum effect ( $E_{max}$ ) beyond which further dose increase has no additional response.



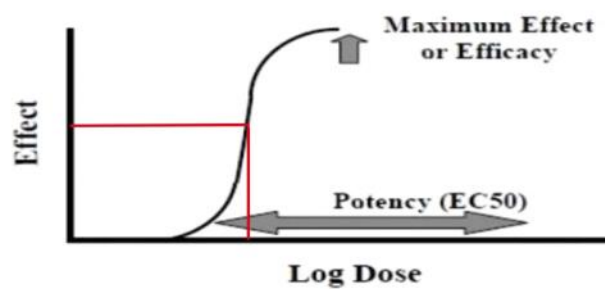
→ Dose- Response curve



→ Log Dose Response curve

## 📌 Implications of the Graded Dose-Response Curve

Parameter	Definition	Interpretation
Potency	Amount of drug needed to produce a given effect	Lower dose → Higher potency
Efficacy (Emax)	Maximum effect achievable by the drug	Indicates <i>ceiling</i> of drug's action



## ◆ Potency

- A measure of how much drug is required to produce 50% of its maximal effect.
- Expressed as:

$EC_{50}$  (Effective Concentration 50%) or  $ED_{50}$  (Effective Dose 50%)

Relationship:

↑ Potency → ↓  $EC_{50}$  (inverse relationship)

Index of potency:

→ Determined by position of the curve on the *dose axis*

- Curve shifted left → More potent drug
- Curve shifted right → Less potent drug

Relative Potency:

→ Comparison of two drugs producing the same effect at different doses.

## ◆ Efficacy (Maximal Efficacy / Emax)

- Refers to the maximum response a drug can produce, regardless of dose.
- Indicates the limit of the dose-response relationship.
- Determines the therapeutic usefulness of a drug.

Example:

Morphine and codeine — both are analgesics, but morphine has greater efficacy even if potency differs.

## ☑ Difference Between Potency and Efficacy

Feature	Potency	Efficacy
Definition	Amount of drug required to produce a given effect	Maximum effect achievable
Measured by	EC <sub>50</sub> / ED <sub>50</sub>	Emax
Curve position	Left = more potent	Height = more efficacious
Clinical importance	Affects dose selection	Affects therapeutic effect

Example

Fentanyl > Morphine (more potent)

Morphine > Codeine (more efficacious)

## 🧠 Quick Revision Summary

### Graded Dose-Response Curve



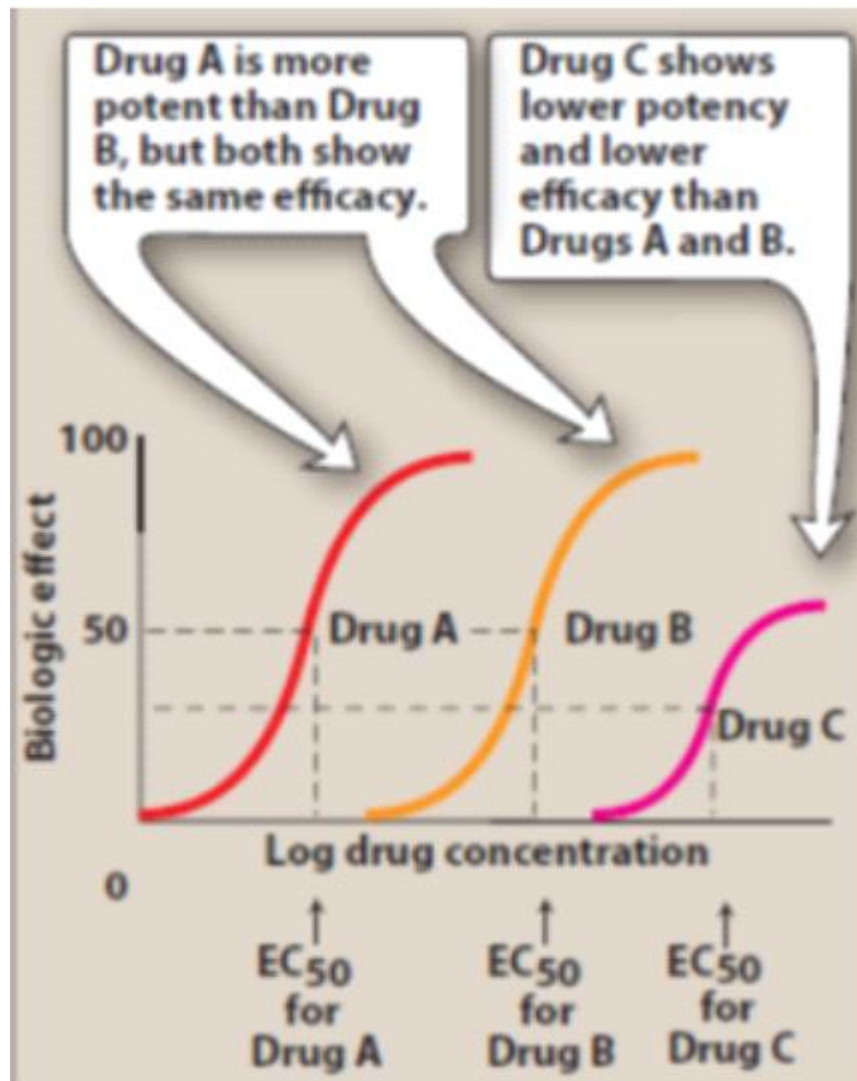
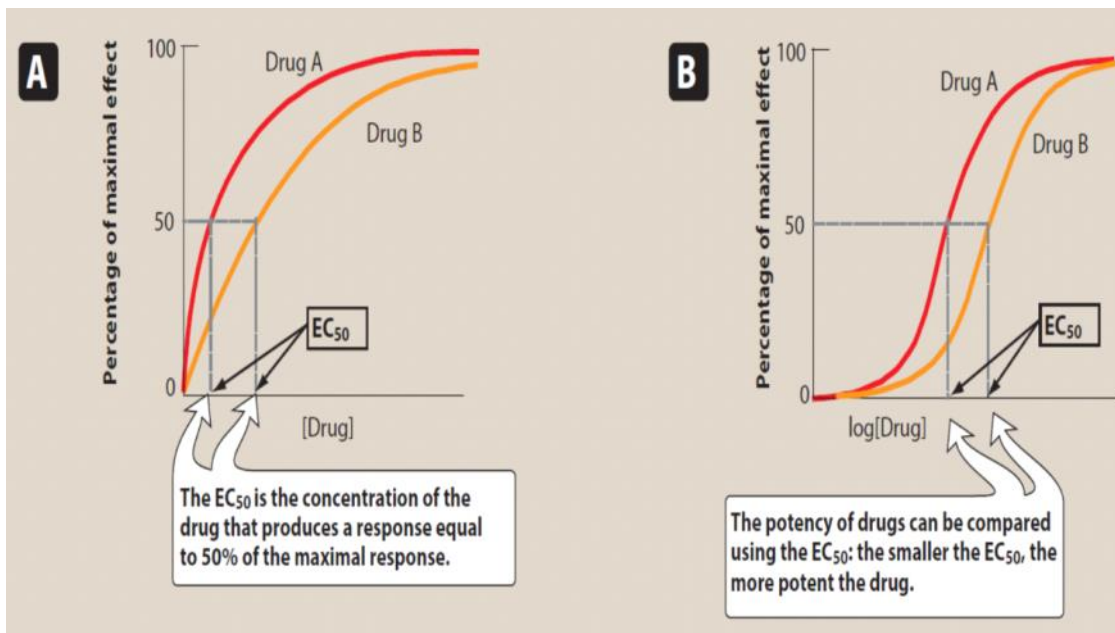
Shows relationship between dose and magnitude of response



Key Parameters → Potency ( $EC_{50}$ ) & Efficacy ( $E_{max}$ )



Potency = "How much drug?"  
Efficacy = "How well does it work?"





---

## Quantal Dose-Response Relationship & Curve

The Quantal Dose-Response Relationship illustrates how different doses of a drug affect the proportion of a population that exhibits a *specific (quantal)* response — e.g. sleep, pain relief, toxicity, or death.

### Limitation of Graded Dose-Response Curve

The graded curve measures *continuous responses* in an individual, but:

- It cannot show variation among individuals.
- It's unsuitable for *all-or-none* effects like sleep or death.

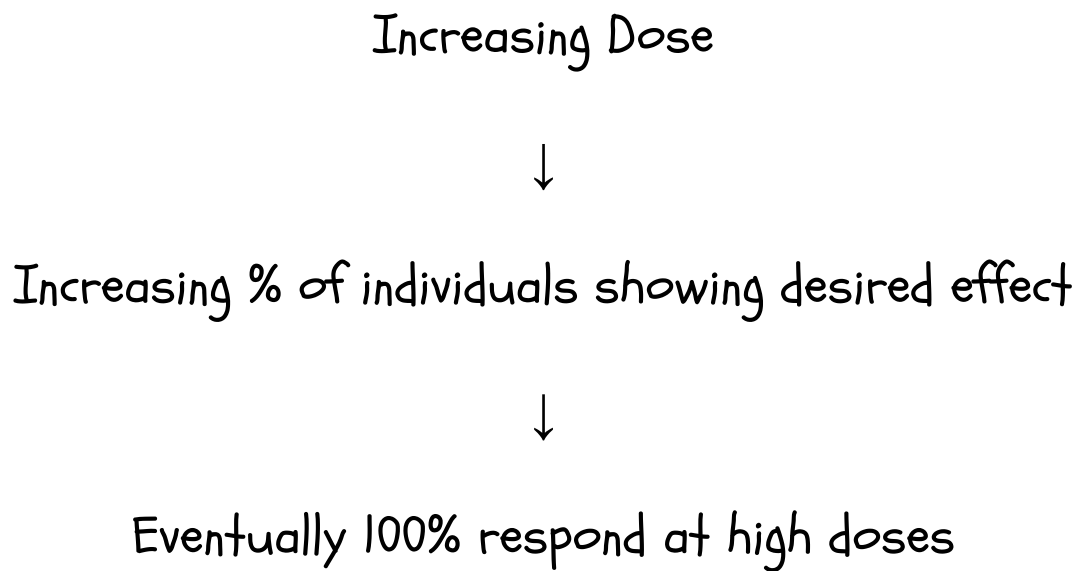
Hence → Quantal Dose-Response Curve is used.

### Concept

Quantal Effect → *All-or-none* response (e.g. "Yes/No", "Asleep/Awake", "Alive/Dead")

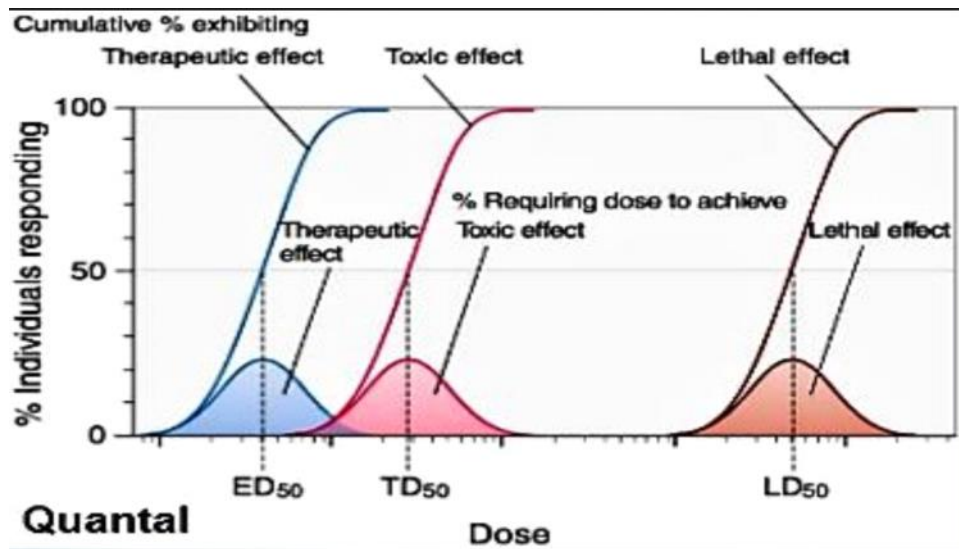
It reflects population variability in drug sensitivity.

Flowchart:



☒ Curve Explanation

- X-axis: Log dose of drug
- Y-axis: % of population responding
- The curve is sigmoidal, showing gradual increase in % responders with increasing dose.



## ⚙ Parameters Derived from the Quantal Curve

Parameter	Full Form	Definition	Significance
$ED_{50}$	<i>Median Effective Dose</i>	Dose that produces the desired therapeutic effect in 50% of population	Measures potency
$TD_{50}$	<i>Median Toxic Dose</i>	Dose that produces a toxic effect in 50% of population	Indicates toxicity risk
$LD_{50}$	<i>Median Lethal Dose</i>	Dose causing death in 50% of test animals	Used only in animal studies
TI	<i>Therapeutic Index</i>	Ratio of toxic dose to effective dose ( $TI = TD_{50} / ED_{50}$ or $LD_{50} / ED_{50}$ )	Indicates margin of safety

## Therapeutic Index (TI)

$$TI = TD_{50} / ED_{50}$$


or

$$TI = LD_{50} / ED_{50}$$

Significance:

- A measure of drug safety
- Higher TI → Safer drug
- Lower TI → Narrow safety margin → Close monitoring required

Example:

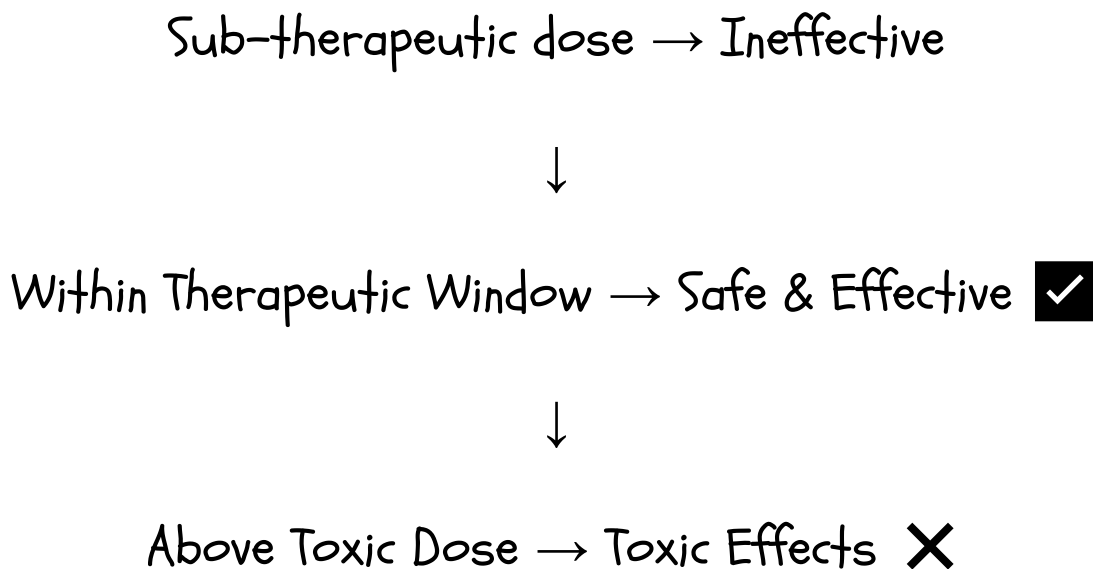
- Penicillin → High TI (very safe)
  - Digoxin, Lithium → Low TI (narrow safety margin )
- 

## Therapeutic Window (TW)

Range between:

- Minimum effective dose (produces therapeutic effect)
- and
- Minimum toxic dose (produces adverse effect)

Flowchart:



Hence, TW represents the clinically useful dose range.



## Information Derived from Quantal Dose-Response Curves

Feature

Explanation

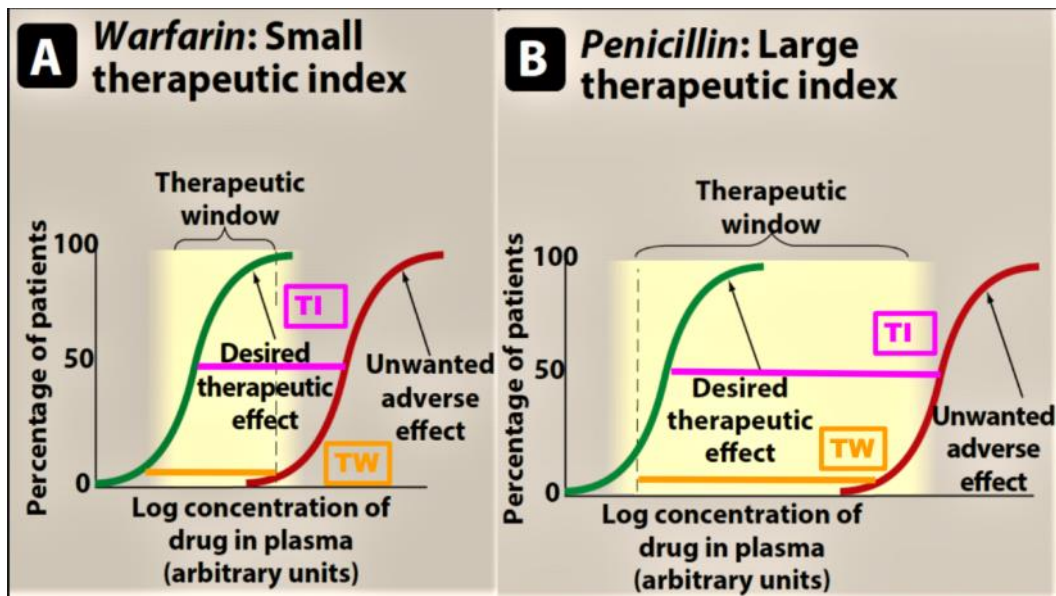
Example

Potency	Derived from $ED_{50}$ of different drugs	Drug A ( $ED_{50} = 5 \text{ mg}$ ) > Drug B (50 mg) > Drug C (500 mg) → A is most potent
Selectivity of Drug Action	Based on $ED_{50}$ for different effects of same drug	A drug may cause Effect 1 at low dose, Effect 2 at higher dose
Margin of Safety	Represented by TI	$TI = TD_{50} / ED_{50}$
Variability of Responsiveness	Assessed from frequency distribution	Reflects individual differences in drug sensitivity

### Graphical Understanding

As dose increases →

- % of population showing therapeutic effect rises first ( $ED_{50}$ )
- % showing toxic effect rises later ( $TD_{50}$ )
- The distance between curves = *Therapeutic Window*



## 📄 Quick Summary

### Quantal Dose-Response Curve



Shows % of population responding to different doses



Gives key parameters:  $ED_{50}$ ,  $TD_{50}$ ,  $LD_{50}$ , TI



TI = safety measure



Wide TI → Safe drug ✓

Narrow TI → Dangerous if overdosed ⚠