

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

Drug Concentration at site of action



Receptor Binding



Pharmacological Response (Effect)

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:

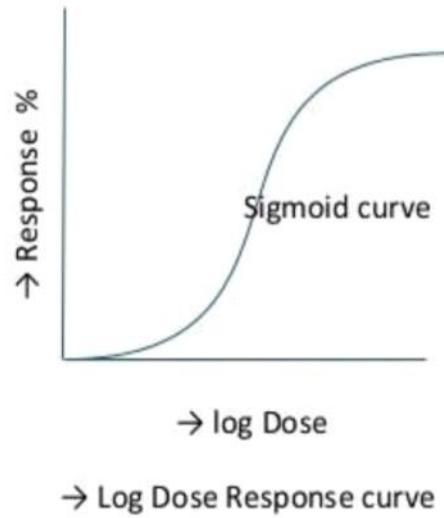
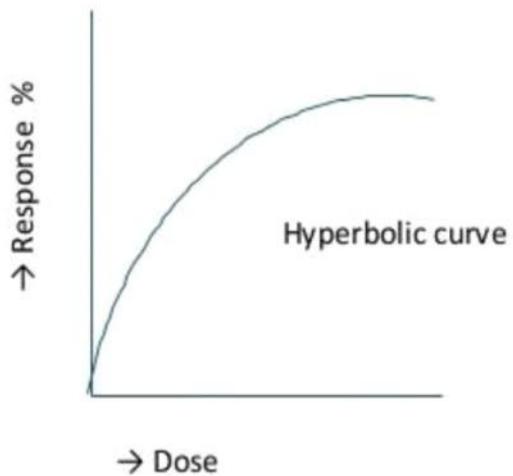
- X-axis → Log Dose
- Y-axis → Response (% of maximum)

- Shape:

- Initially rectangular hyperbola, becomes sigmoid (S-shaped) when log dose is plotted.

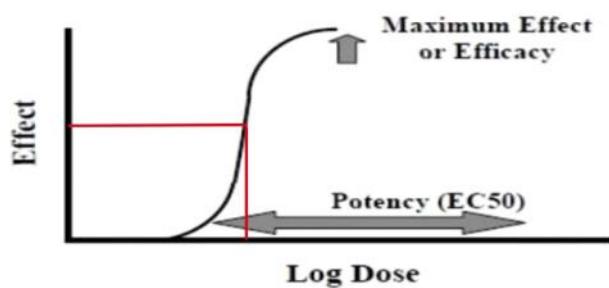
- Plateau:

- Represents maximum effect (Emax) beyond which further dose increase has no additional response.



② 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 ceiling 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 \rightarrow ↓ EC_{50} (inverse relationship)

Index of potency:

\rightarrow Determined by position of the curve on the dose axis

- Curve shifted left \rightarrow More potent drug
- Curve shifted right \rightarrow Less potent drug

Relative Potency:

\rightarrow 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_{50} / ED_{50}	$Emax$
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

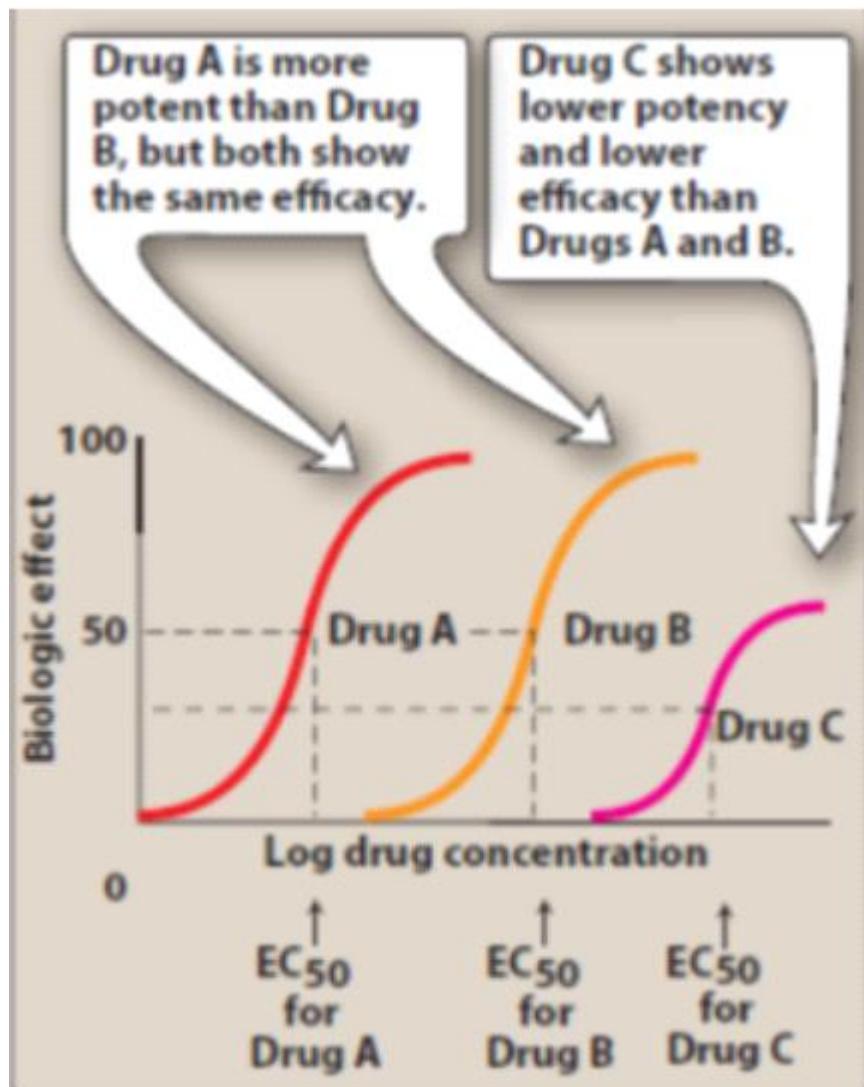
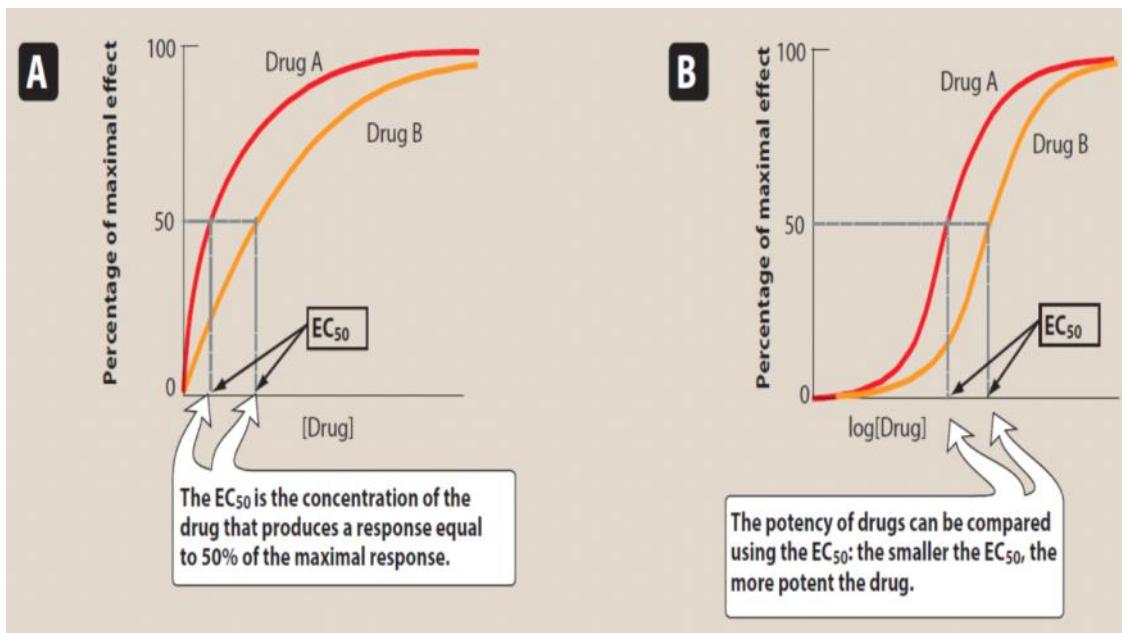


Key Parameters → Potency (EC_{50}) & Efficacy ($Emax$)



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.

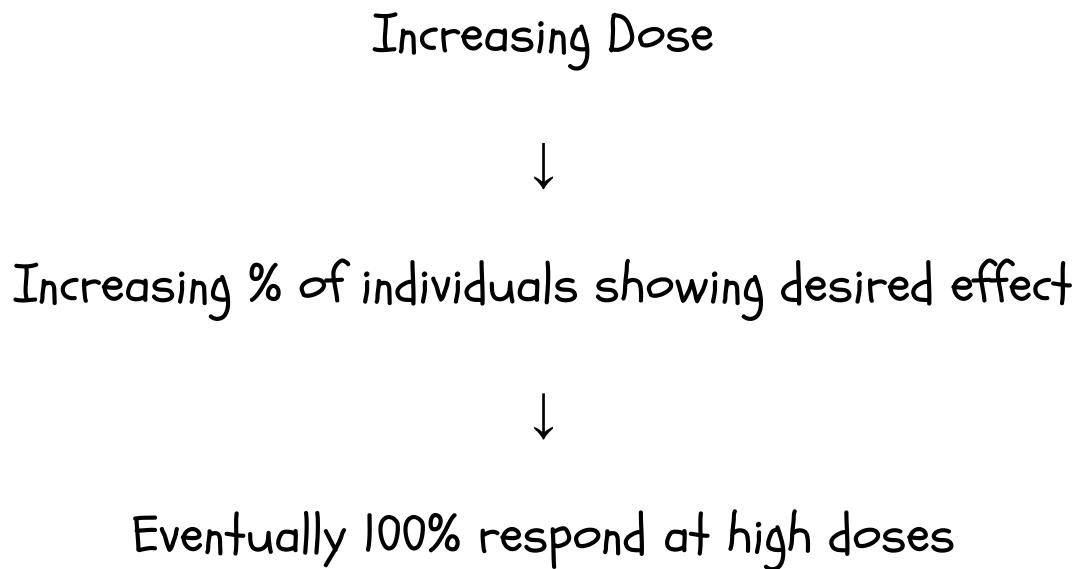
Hence → Quantal Dose-Response Curve is used.

💡 Concept

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

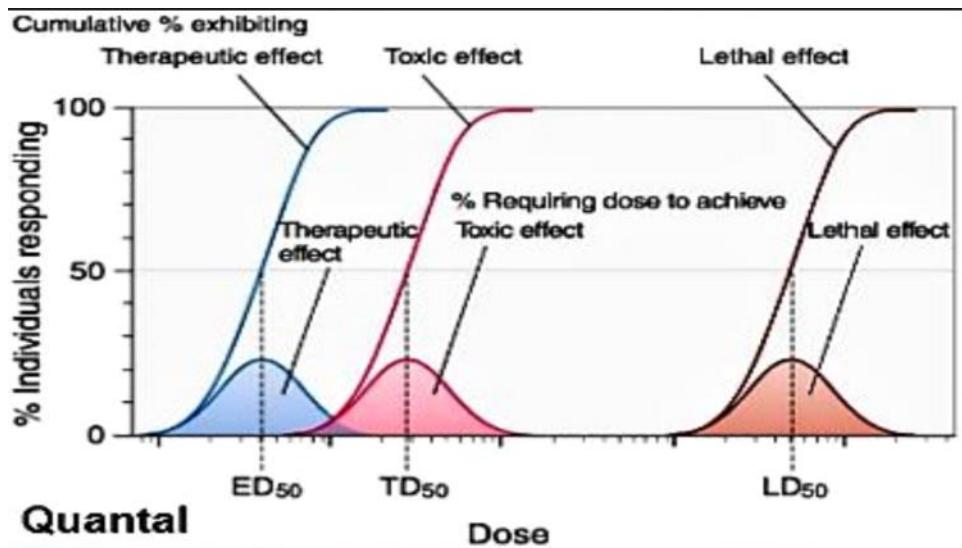
It reflects population variability in drug sensitivity.

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	Median Effective Dose	Dose that produces the desired therapeutic effect in 50% of population	Measures potency
TD ₅₀	Median Toxic Dose	Dose that produces a toxic effect in 50% of population	Indicates toxicity risk
LD ₅₀	Median Lethal Dose	Dose causing death in 50% of test animals	Used only in animal studies
TI	Therapeutic Index	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:

Sub-therapeutic dose → Ineffective



Within Therapeutic Window → Safe & Effective



Above Toxic Dose → Toxic Effects

Hence, TW represents the clinically useful dose range.

Information Derived from Quantal Dose-Response Curves

Feature

Explanation

Example

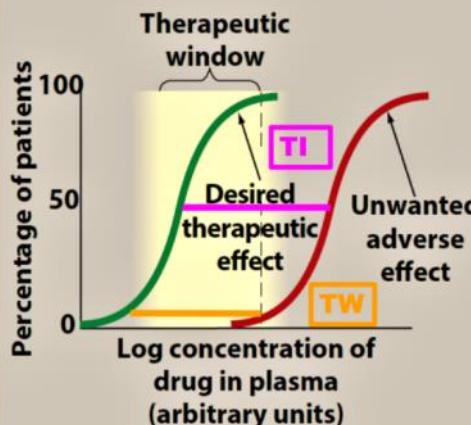
Potency	Derived from ED_{50} of different drugs	Drug A ($ED_{50} = 5 \text{ mg}$) > Drug B (50 mg) > Drug C (500 mg) → A is most potent
Selectivity of Drug Action	Based on ED_{50} for different effects of same drug	A drug may cause Effect 1 at low dose, Effect 2 at higher dose
Margin of Safety	Represented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

☒ Graphical Understanding

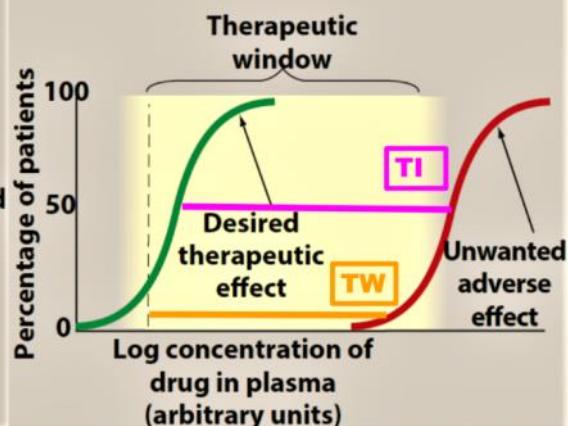
As dose increases →

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

A Warfarin: Small therapeutic index



B Penicillin: Large therapeutic index



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 