HYPOTHESIS TESTING: MAKING IT SIMPLE

Jhuma Sankar
PGIMER, New Delhi
jhumaji@gmail.com

Prologue

Disclaimer:

NOT a statistician

….a mere mortal Clinician!

Structure

- Steps of hypothesis testing
  - 'standard' textbook stuff!
- Demystifying the steps
  - For us (poor clinicians!)
- Examples
  - Making it simple
- Appropriate test
  - For different RQs

Steps of hypothesis testing

Steps of hypothesis testing

Step 0	• State the 'null' hypothesis
Step 1	• Set the significance level
Step 2	• One- or two-sided test
Step 3	• Calculate the test statistic
Step 4	• Find the critical value of distribution of test statistic
Step 5	• Reject (or not!) null hypothesis

Steps...in simple terms!

1. Assume the hypothesis that there is NO DIFFERENCE is TRUE
2. Collect data and observe the difference between 2 groups
3. If null hypothesis is true, HOW LIKELY is the observed RESULT BY CHANCE alone?
4. If results are unlikely due to chance, REJECT the null hypothesis

Demystifying the steps!

Null hypothesis

Why null hypothesis?

Hypothesis:

ALL swans are WHITE!

I see 100 or 100,000 swans –
Still the NEXT swan could be black!!

Null hypothesis

Why null hypothesis?

Null hypothesis:
NONE of the
swans are BLACK!

You can REFUTE an assertion with ONE example but cannot PROVE with many!!

Practical example

A blissfully married couple!

- **Wife – Executive**
- **Husband – Home maker**

Practical example

Wife

- Drives back from office at 6 PM
- Reaches home by 6.40 PM, **USUALLY**
- Reaches by 7 PM, **95%** of the time
- Reaches by 7.20 PM, **99%** of the time

Practical example

Wife

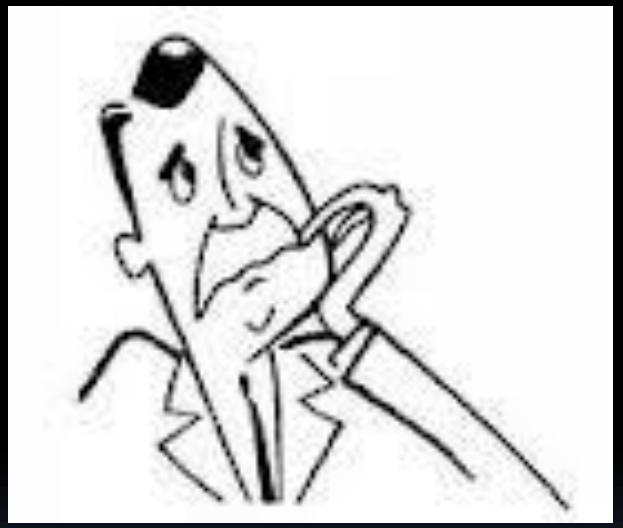
Did not reach home by
6.50 **PM**

Husband fails to reject null hypothesis!
Sits at home…

Practical example

Wife

Did not reach home by
7.05 **PM**



Husband REJECTS null hypothesis!
Gets ready to look for her…

Practical example

Wife

Did not reach home by 7.30 **PM**

Husband REJECTS null hypothesis!
Gets out of his home…

Clarifications

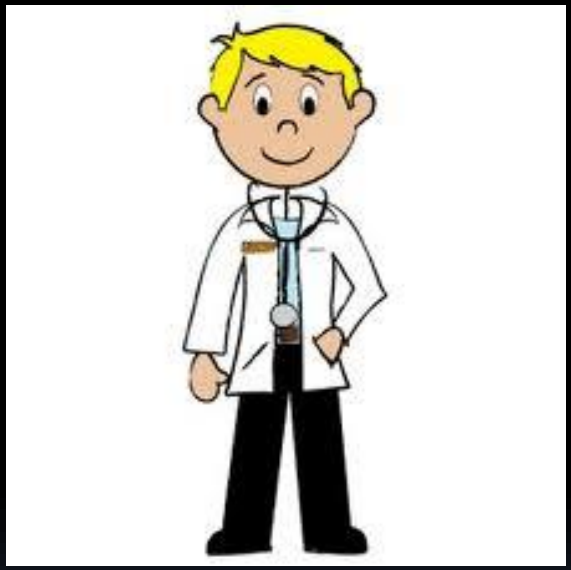
Husband

NO idea about the probability of his wife having an accident

P - probability of delay by CHANCE if there was no accident!

Example 2

Is the IQ of doctors different from general population?



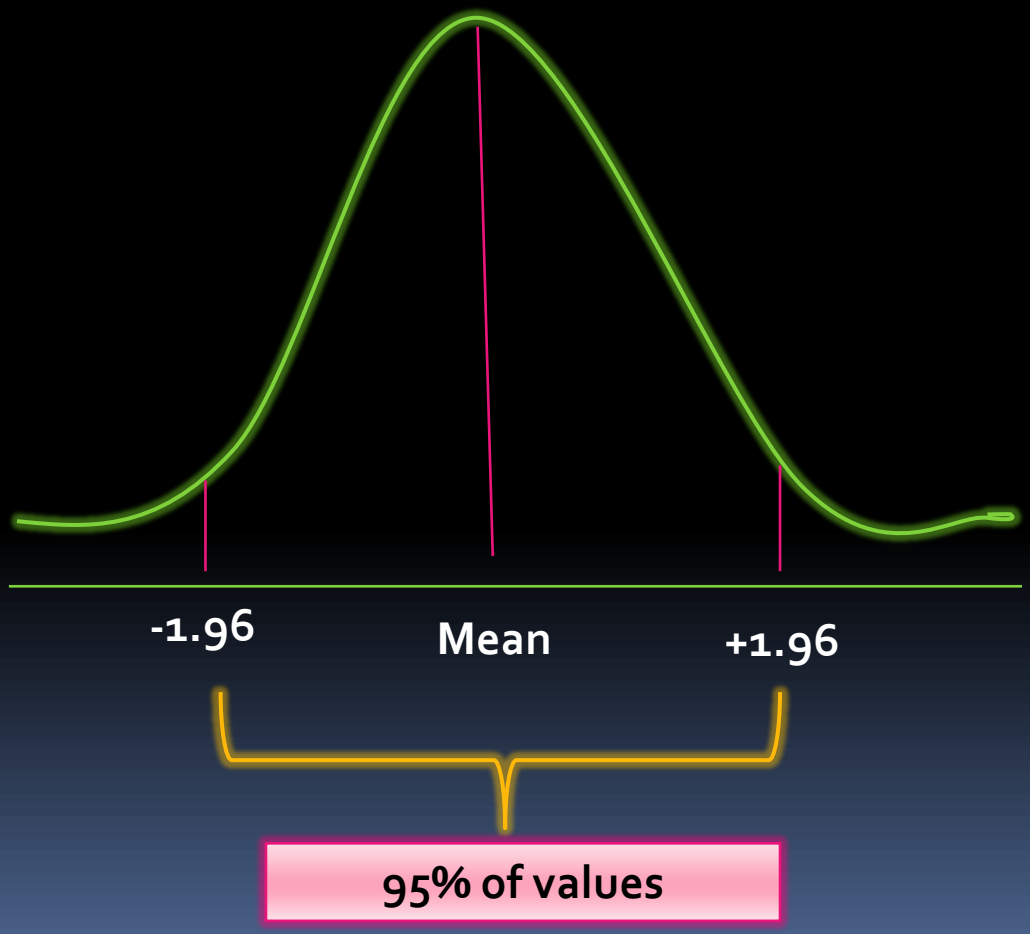
- **Sample – Consultants from PGIMER**

Steps…

1. Assume the hypothesis that there is NO DIFFERENCE is TRUE
2. Collect data and observe the difference between sample and population
3. If null hypothesis is true, HOW LIKELY is the observed RESULT BY CHANCE alone?
   - **Test statistic**
4. If results are unlikely due to chance, REJECT the null hypothesis

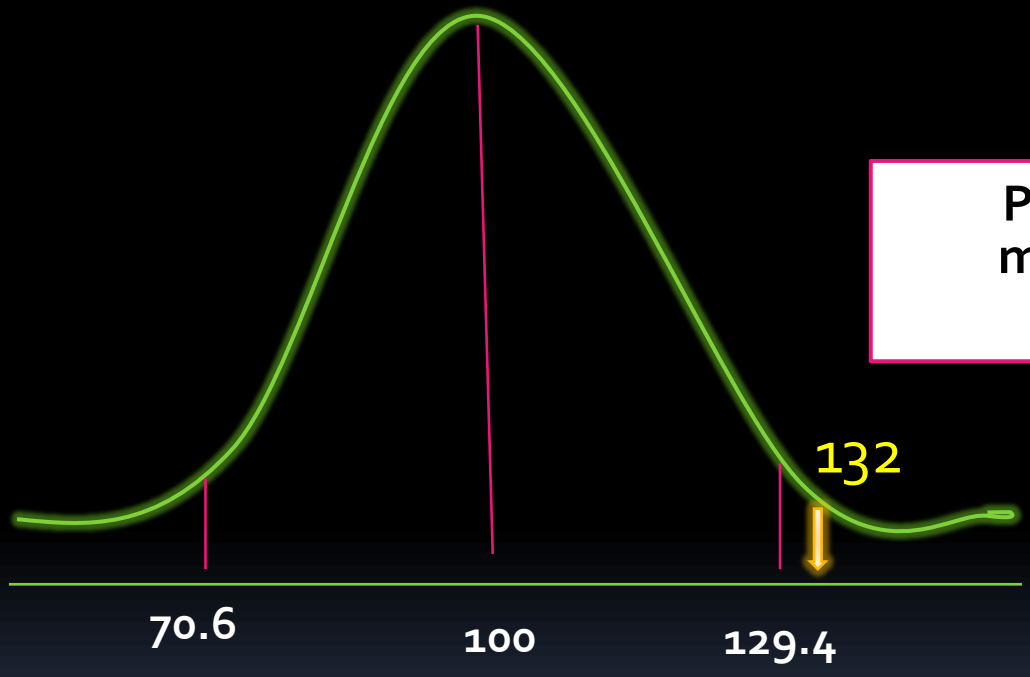
Test statistic – in simple terms

Observed mean = 132



Test statistic – in simple terms

Observed mean = 132



Population
mean = 100
SD=15

REJECT null hypothesis!
Doctors are different!!!

Test statistic

- Observed mean = 132
- Population mean=100
- SD of population=15

$$= \frac{\text{Observed mean} - \text{population (expected) mean}}{\text{SD of population}}$$

$$\frac{132 - 100}{15} = 2.13$$

Test statistic…

Test statistic = 2.13

Probability of getting that result:

<5%

Significance level

Why 5%?

- No special reason
  - By convention
  - Up to 5% could be due to chance alone

You can choose a small number:

<1%

Test statistic

Prototype of any test of significance

$$\frac{\text{What did you get- what did you expect}}{\text{standardized random error}}$$

- Numerator - any difference/deviation from expectation
- Denominator - random error

Test statistic…

$$\frac{\text{What did you get- what did you expect}}{\text{standardized random error}}$$

- Any time you divide a numerator by a denominator , you rescale the numerator into the denominator unit
- Formula rescales the numerator into standardized error units
- How many standardized error units **observed score is away from expected score**

Statistical tests

- z score- hypothesis testing
  - Standard score- score expressed in terms of some standardized unit of measurement
  - Standard score tells the value of a score relative to all other scores – not just the position of the score

Statistical tests

- z score- hypothesis testing

What did you get?	Raw score
What did you expect?	Sample mean
Standardized error/ Expected frequency	Standard deviation

Statistical tests

- z score- hypothesis testing
- Z score= $\frac{X-M}{s}$

Statistical tests

Normal deviate Z test or 1- sample t-test

What did you get?	Observed sample mean
What did you expect?	Population mean
Standardized error	Standard error of mean

Statistical tests

Normal deviate Z test or one sample t-test

$$\text{Z score} = \frac{M - \mu}{\sigma M}$$

- $\sigma M = \frac{\sigma}{\sqrt{n}}$

Statistical tests

Two sample t-test

What did you get?	Difference between two sample means
What did you expect?	Difference between two population means
Standardized random error	Standard error of difference between the means

Statistical tests

Two sample t-test

Difference between sample means- difference between population means

Standard error of difference between the means

- $t_2 \text{ sample} = \frac{(M_1 - M_2) - (\mu_1 - \mu_1)}{\sigma_{M_1 - M_2}}$

Statistical tests

Chi -square test

What did you get?	Observed frequency
What did you expect?	Expected frequency
Expected frequency	Expected frequency

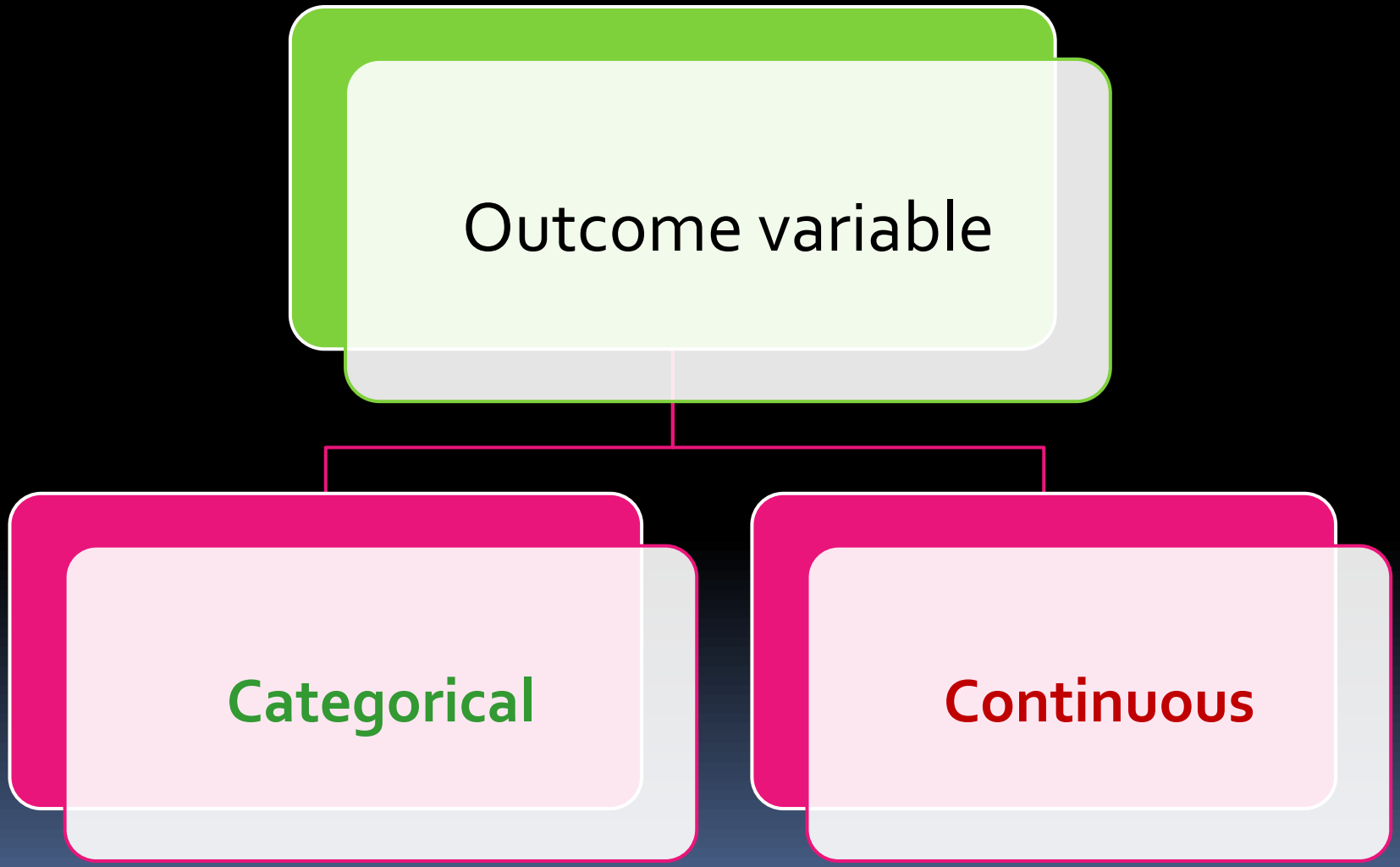
Statistical tests

Chi -square test

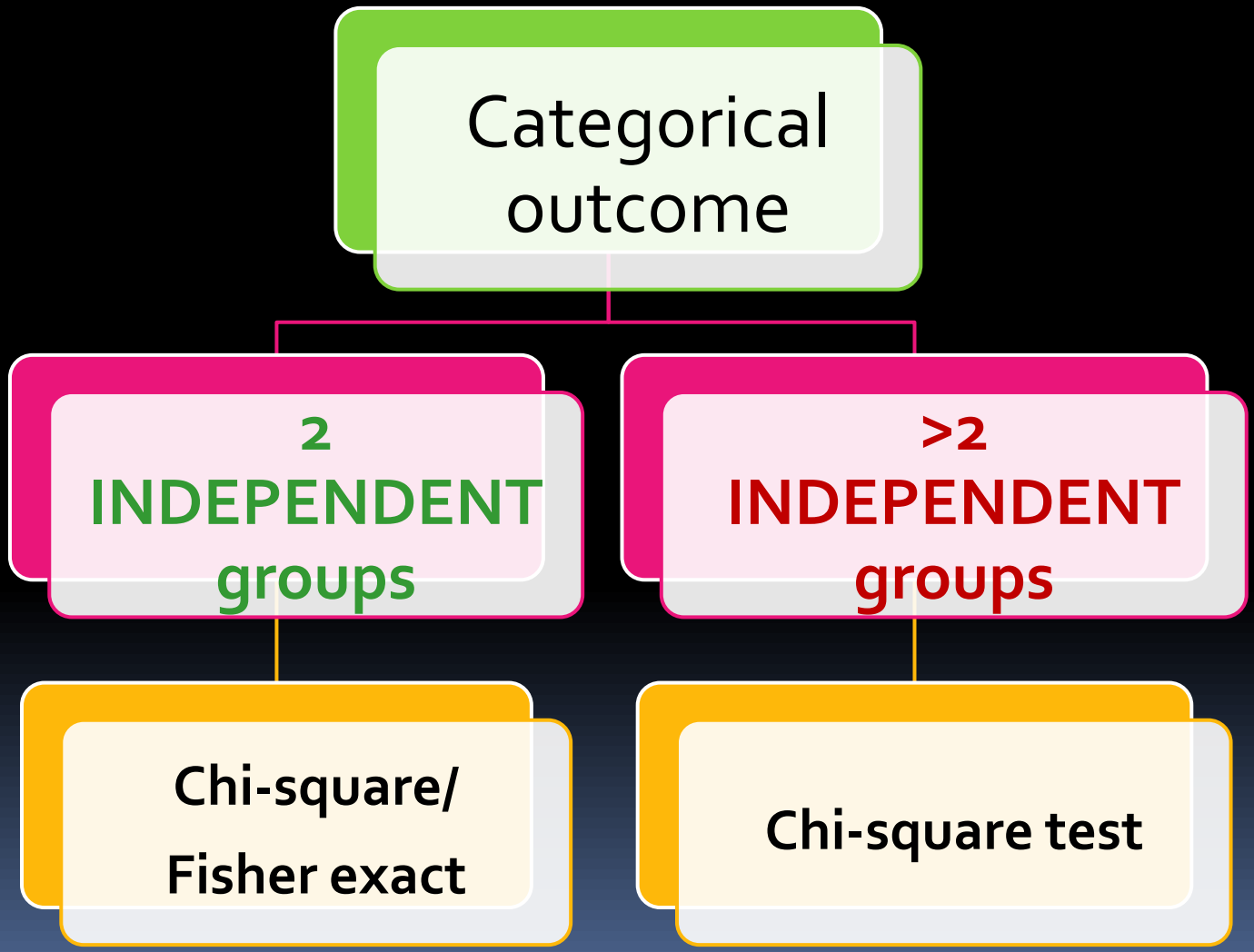
$$X^2 = \Sigma [(fo-fe)2/ fe]$$

Choosing the appropriate test

Choosing a test

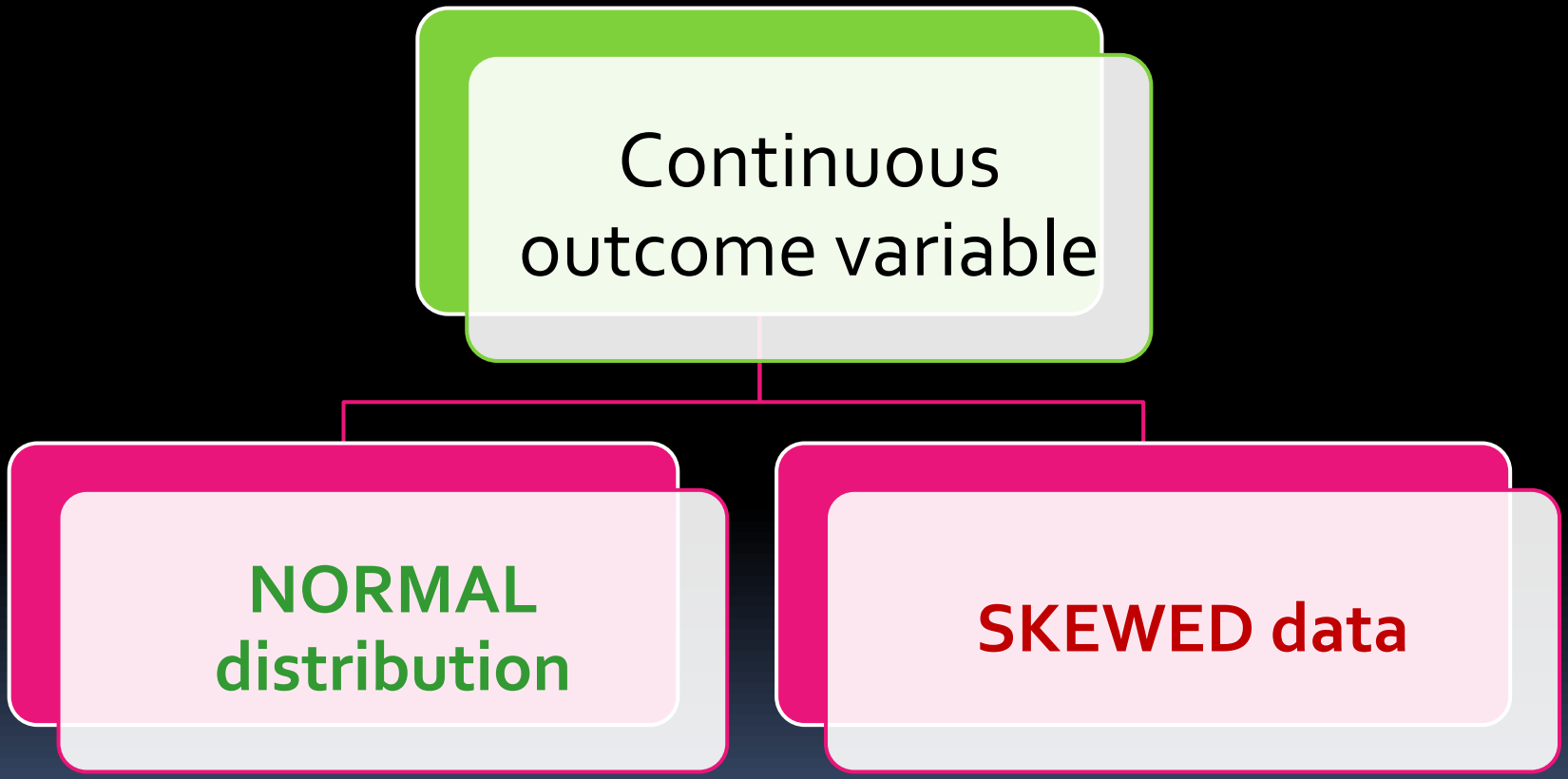


Choosing a test

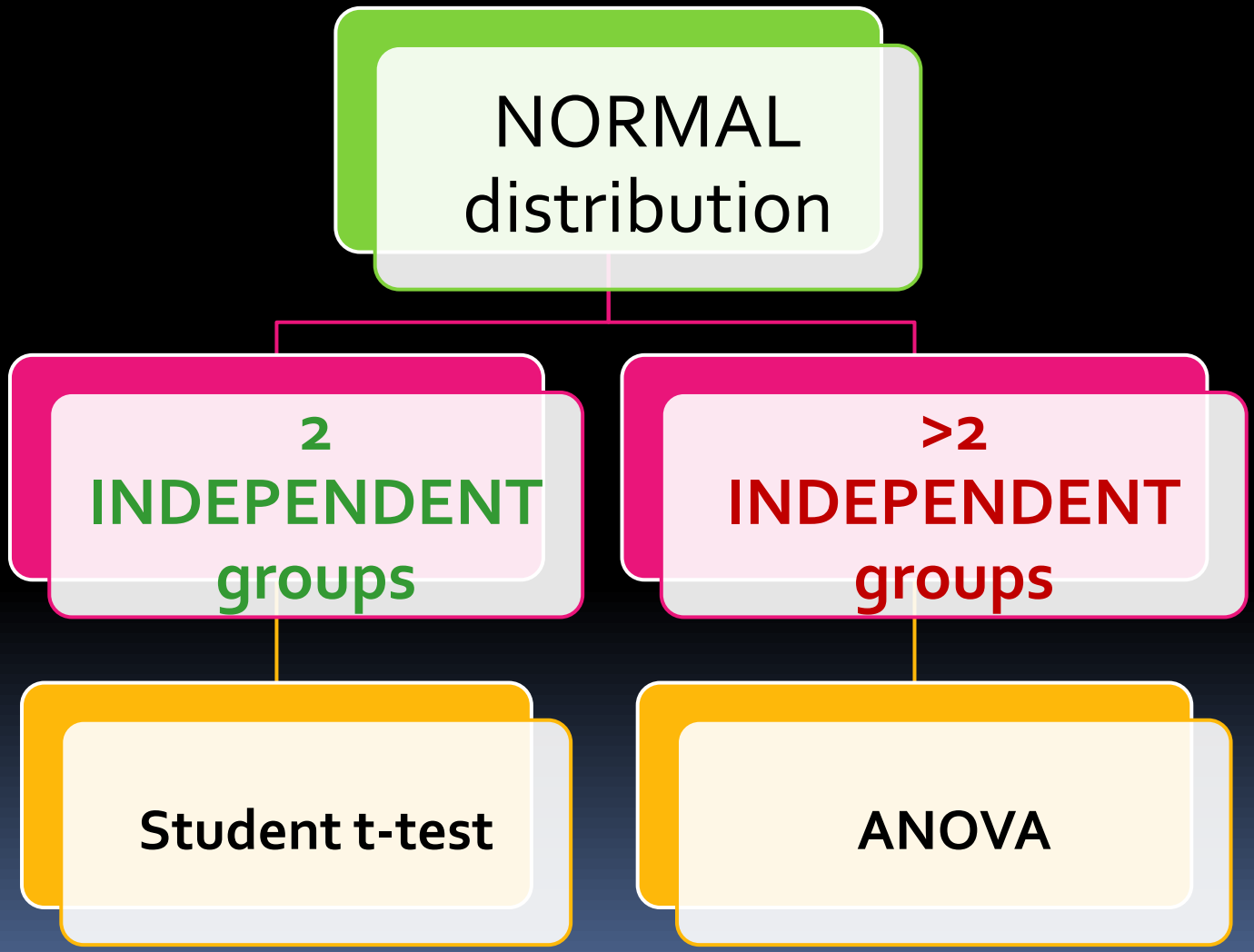


Choosing a test

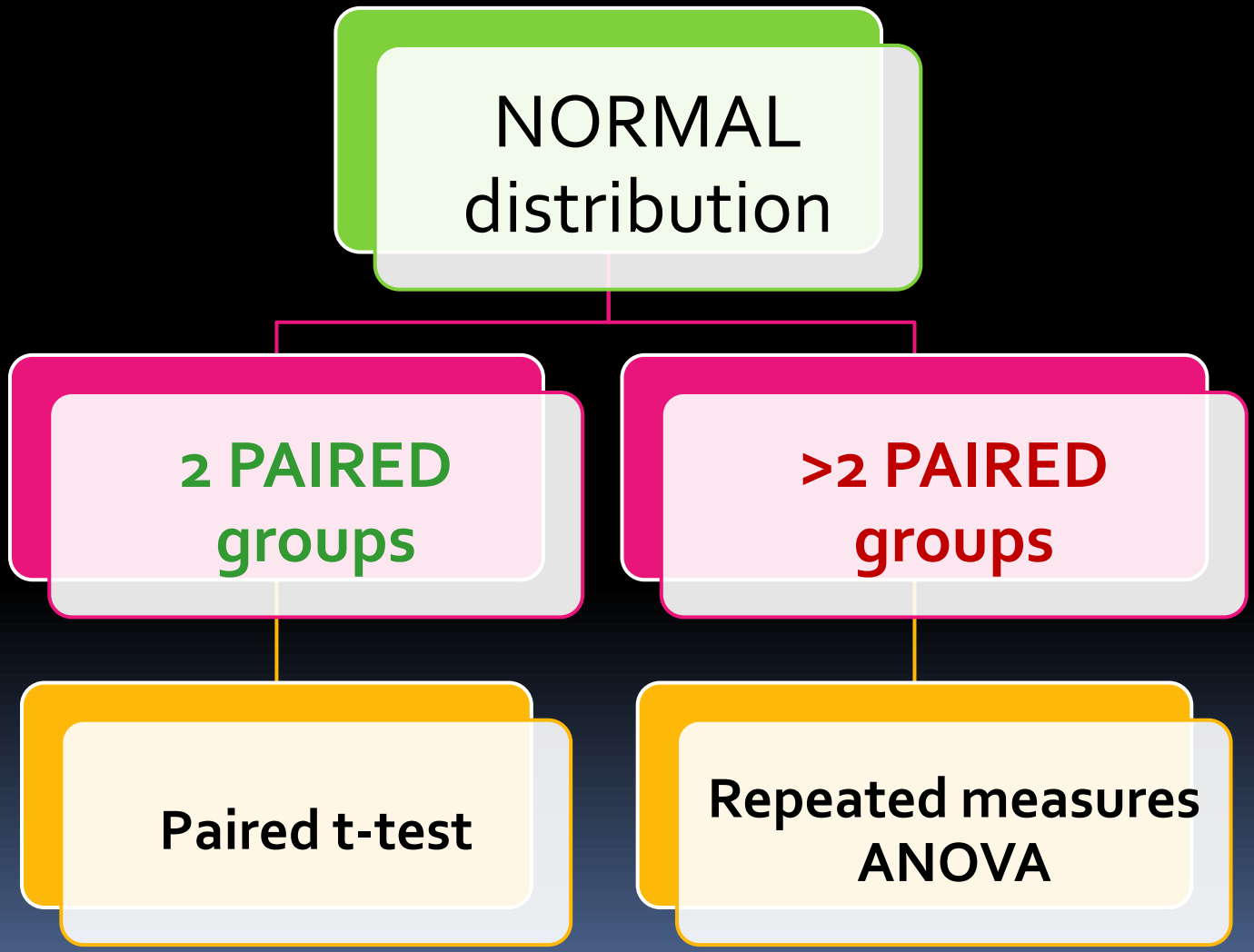
Choosing a test



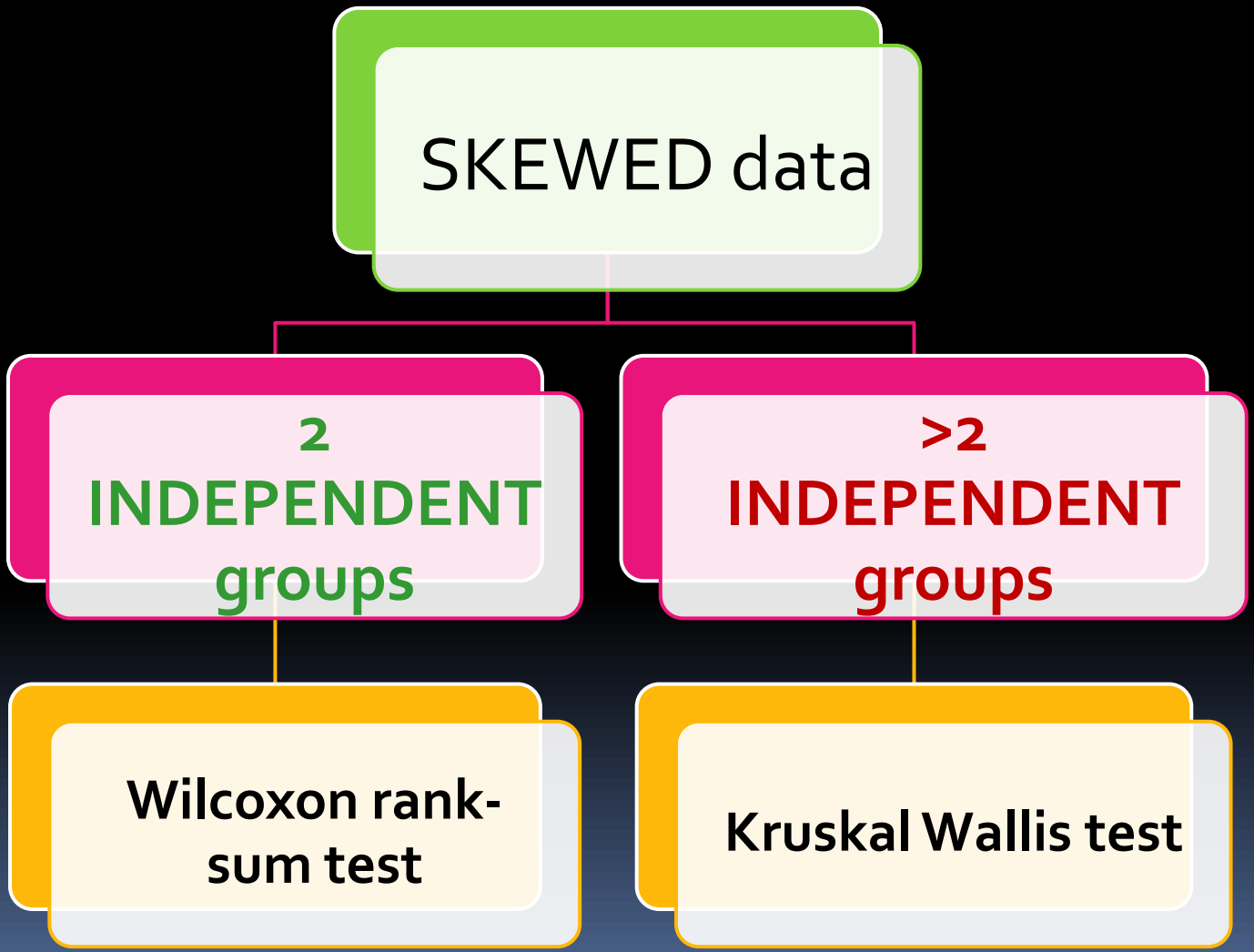
Choosing a test



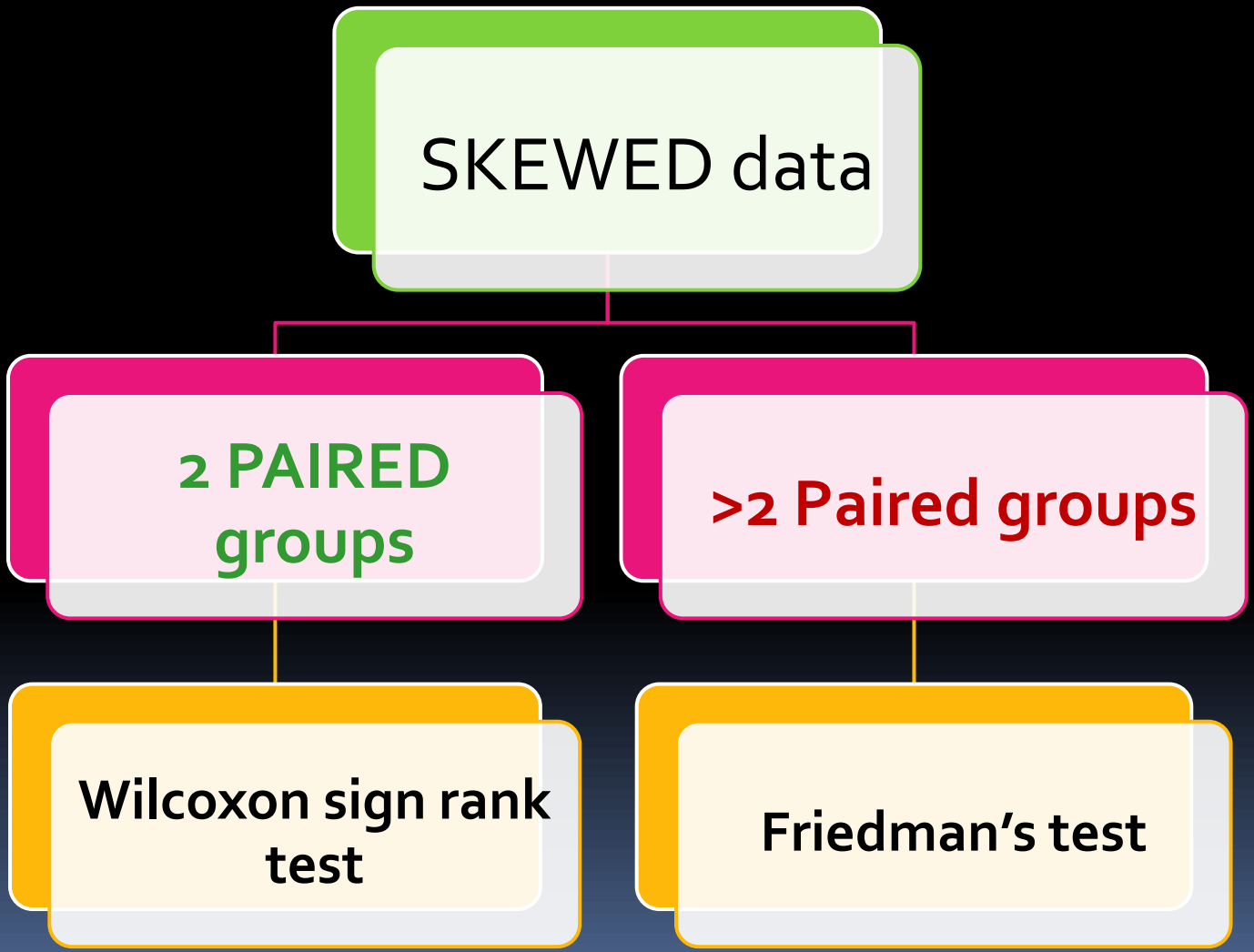
Choosing a test



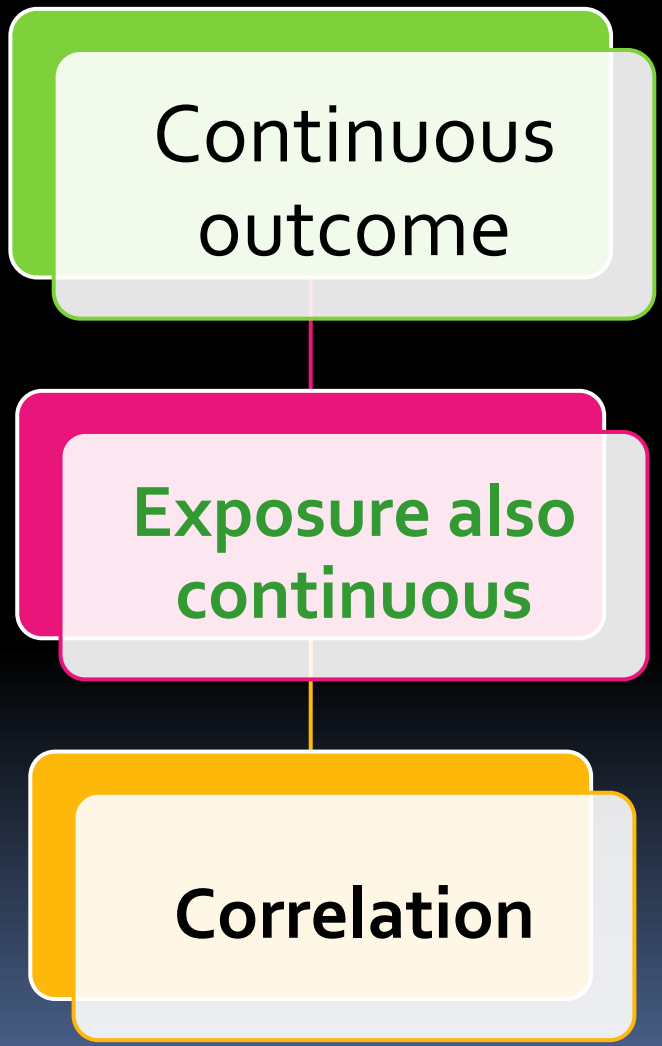
Choosing a test



Choosing a test



Choosing a test



Practical examples