MUNI
PHARM

Introduction to Statistics

Biophysics

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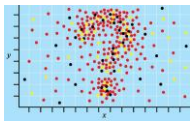
- **Data**
  - Data is a set of values of qualitative or quantitative variables



- **Population**
  - The group we want to find information about

  E.g. the nation, batch produced, people with a certain disease that we want to treat
- **Sample**
  - Part of the population from which we want to find information about the population

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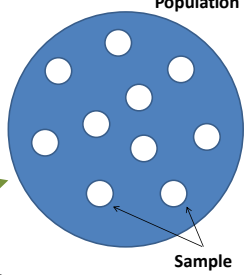
Population/ Sample

Analyze data across population would be expensive – it is not possible tested whole population. Therefore, only a part of the population is analyzed (Sample).

Selection of subjects (Sample) from basic file (Population) should be random.



Example: Determining of voter preferences.
There is the effect of time and place of data collection:
Morning of working day near the supermarket – old age pensioners have impact – estimation of voter preferences will be inaccurate.

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Data

- **Qualitative - categorical data**
  - e.g. eye color, breed of dog, ...
- **Quantitative - continuous data**
  - Continuous data can take any value
  - e.g. temperature, weight, height, time, ...

Level of measurement:

cardinal – numbers with which we can perform mathematical operations
ordinal – order (1st, 2nd, 3rd, etc.) by which data can be sorted
nominal – differentiates between items or subjects based only on their names or categories and other qualitative classifications.
The ordinal and nominal measurement is more suitable for eg. sociological research.

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Quantitative data properties

- **Minimum and maximum**
  - the smallest and the largest value
- **Arithmetic mean (Average)**
  - represents the central tendency in a data set

$$\bar{x} = \frac{(x_1 + x_2 + x_3 + \dots)}{n}$$

- **Median**
  - middle value that divides the data set into two halves
  - simply sort values by size and take a value that is in the middle

● odd number

$$\mathrm{Med}(x) = x_{\frac{n+1}{2}}$$

1, 3, 3, **6**, 7, 8, 9
Median = 6

● even number

$$\mathrm{Med}(x) = \frac{x_{n/2} + x_{(n+2)/2}}{2}$$

1, 2, 3, **4**, **5**, 6, 8, 9
Median = (4 + 5) ÷ 2 = 4.5

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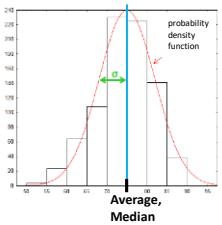
Symmetrical data

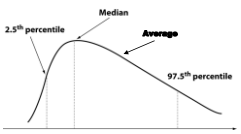
(Gauss normal distribution)

- Average and median correctly describe the data
- Data frequency is the highest around the center



Nonsymmetrical data

- Average can not be used to describe the data
- Often at the medical data, pharmacokinetic studies, etc.
- Verification of normality by tests or graphically (statistical software)



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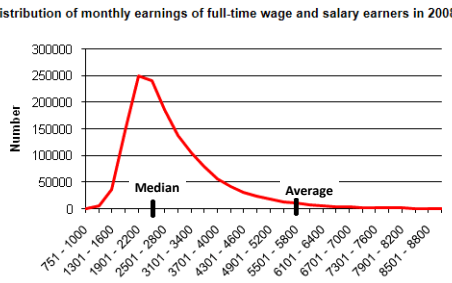

- **The median** is the true indicator of salary size (it is a robust parameter).
- **The average** is shifted to higher values; It is significantly affected by high salaries of a small group of people.

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Quantitative data properties

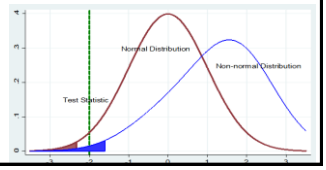
- **Data transformation**

Linear transformation (e.g. multiplication by a constant): **weighting**. The process of weighting involves emphasizing the contribution of some aspects of a set of data to a final effect or result.

Weighted arithmetic mean $\bar{x} = \frac{w_1x_1 + w_2x_2 + w_3x_3 + \ldots + w_nx_n}{w_1 + w_2 + w_3 + \ldots + w_n}$

Non-linear transformation

-changes the structure of the data



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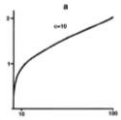
Quantitative data properties

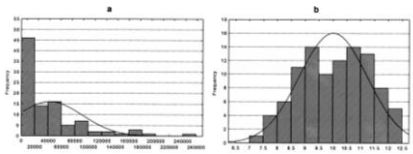
- **Non-linear data transformation**

Logarithmic transformation

Measured values are replaced by their logarithms

$x'_{ij} = \log_e x_{ij}$





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Quantitative data properties

- **Non-linear data transformation**

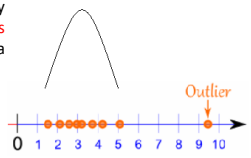
Square root transformation

Exponential transformation

Box-Cox transformation

The reasons for the transformation: data are not normally distributed (nonsymmetrical data) or data contain outliers.

1. Data not normally distributed => Data transformation (or median)
2. Data normally / not normally distributed; data contain outliers which can not be excluded => Data transformation (or median)



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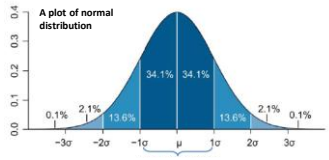
Quantitative data properties

- **Standard deviation (σ)**
  - Represents the variability in the data set
  - For a sample is called the standard deviation of sample, see function in Excel (**STDEV**)

$$\sigma = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + \ldots}{n-1}}$$

Set of random observation tends to be situated around the average value.



68.3% of all measurement

2σ = 95.6% of all measurement
3σ = 99.7% of all measurement

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Quantitative data properties

- **Confidence interval (CI)**
  - The interval which contain the true measured parameter (e.g. mean)
  - CI are constructed using a given confidence level (usually 95%)
  - For a sample is called the **CONFIDENCE.T**, see function in Excel

$$\bar{x} \pm 1.96 \frac{\sigma}{\sqrt{n}}$$

1.96 is valid for 95% confidence interval (n ≥ 30).

Simplified evaluation of CI (for small samples):

$\bar{x} \pm (K_n \times R)$

RANGE (R) = MAXIMUM - MINIMUM

n	K_n (95% confidence level)
2	6.4
3	1.3
4	0.72
5	0.51
6	0.40

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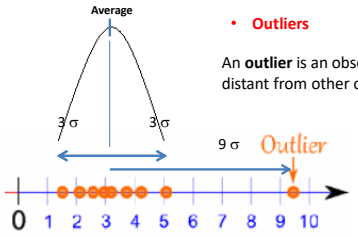
Quantitative data properties



- **Outliers**

An **outlier** is an observation point that is distant from other observations.

An outlier may be due to **variability** in the measurement or it may indicate **experimental error**; the are sometimes excluded from the data set **if they are greater than 3*σ**.

Outliers can not be excluded e.g. for medical data (or other data, where outliers are an integral part of the sample)!

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Outliers

- **Identification of outliers for small samples: Dixon's Q-test**

Tests the first and last value results against neighboring value.

$$Q_n = \frac{x_n - x_{n-1}}{R} \qquad Q_1 = \frac{x_2 - x_1}{R}$$

RANGE (R) = MAXIMUM - MINIMUM

The calculated value is compared with tabulated values. If Q_n or Q_1 > $Q_{tab.}$, than is the extreme result excluded.

n	$Q_{tab.}$ (α = 0.05)
2	-
3	0.941
4	0.765
5	0.642
6	0.560
7	0.507

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