

Logical Principles of Reserch in Medicine with Most Common Errors

From Idea to Publication

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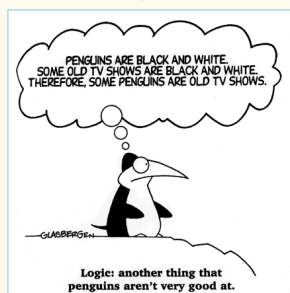
1. Typing error

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2. Logic, reasoning



www.glasbergen.com/



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Logic of scientific work

1. **rules of logic** and logic itself as a way of valid thinking is more expressed in science and philosophy compared to other human activities...
2. science is recognized by utilizing empirical methods and therefore **logic** is prerequisite in scientific methodology...

Mirko Jakić. Logika. Školska knjiga, Zagreb 2003.



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Logic of scientific work

3. use of is logic evident in using logical reasoning, by using terms such as **rules, conclusions, definitions, distributions, proves**, etc.
4. logic – how our thinking is valid in our mission to find the **truth**...



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3. Nonscientific procedures

- ~~• diligence
(habit, attitude, manner, believe, momentum)~~
- authority
- intuition



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4. Argument, proof



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5. Logic in science

- system
- models of the system
 - deterministic
 - probabilistic
- event probability $\rightarrow P(E)$

$$0 \leq P(E) \leq 1$$



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6. Probability

- mathematical calculation that something, event, will occur
- mathematic \Rightarrow probability theory
 - statistics
 - mathematics
 - scientific methodology
 - logic, philosophy
- reasoning about event feasibility



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Probability, calculation

- symbol – P
- $$P = \frac{\text{No. of expected events}}{\text{No. of all events}}$$
- values range 0 – 1:
 - 0 – impossible event
 - 1 – certain event



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Probability, the term

- probability
 - *vjerojatnost, mogućnost*
- possibility
 - *mogućnost, vjerojatnost, izvedivost*
- likelihood
 - *vjerojatnost, mogućnost*
- chance
 - *mogućnost, prigoda, slučaj, slučajnost, vjerojatnost, sreća, povoljna prilika*
- odds
 - *izgled, prednost, vjerojatnost, slučajnost*

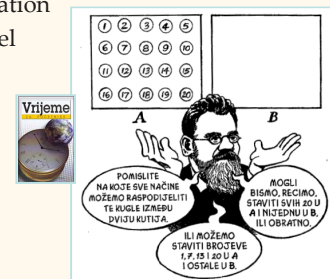


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7. Statistics

- probability calculation
- probabilistic model of the system



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Statistical mechanics

- Lord Kelvin (1824.-1907.)
- James C. Maxwell (1831.-79.)
- Ludwig Boltzmann (1844.-1906.)
- Willard Gibbs (1839.-1903.)



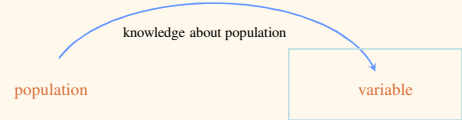
$p = ?$



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8. Measuring & 9. Research



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10. Variable

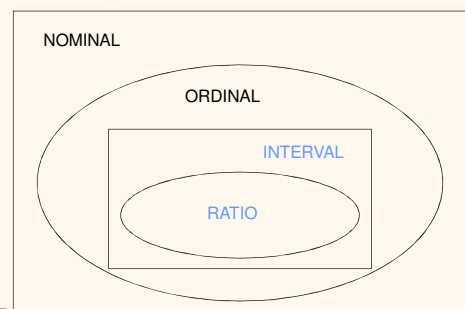
- all variables in research
- as many of them
- the end of research
- simple → complex (data)
- accuracy (numbers)
- measuring scales



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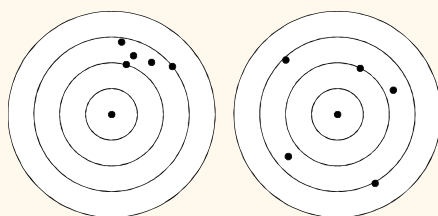
11. Measuring scales



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12. Error



systematic

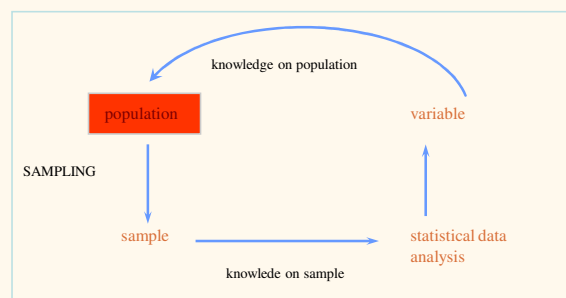
incidental



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13. Population



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14. Sample

- part of population
 - what? who?
 - when?
 - where?
 - size

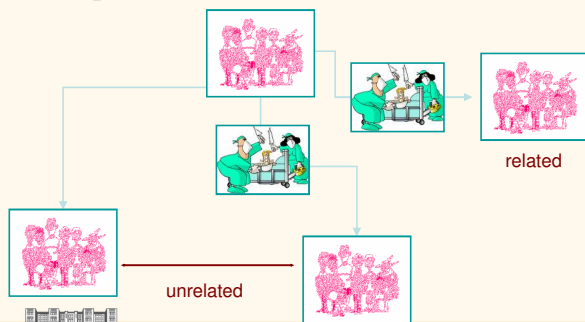


Sample

- representative
- measurable
- probabilistic
 - simple
 - system
 - stratified
 - cluster



Sample



15. Sampling



Sampling

MedCalc

The screenshot shows the MedCalc software interface. A dialog box titled "Sampling: comparison of means" is open, showing options for Type I error (Alpha) and Type II error (Beta). Below it, a table is visible with columns labeled F, G, H, and I, and rows containing data like "i18h6", "dob", "spolm1", "sluca", and "65". Another dialog box titled "Sampling: simple mean" is also visible.

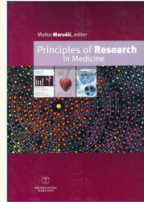


16. Bias (sampling)



Bias (sampling)

- Bias – systemic sampling error
- prevalence bias (Neyman)
- admittance rate bias (Berkson)
- answering rate bias
- etc.



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17. Blinding

- single-blind
- double-blind
- triple-blind
- quadruple-blind



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18. Control group

- must have
- to be compared with experimental group
- Hawthorn effect
 - research with no control group
 - subject changes behavior with a knowledge that is a part of experiment
 - subject feels better with knowledge to be a part of experiment



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19. Hypothesis

<http://biology.ucf.edu/~pascencio/images/Hypothesis.jpg>



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20. Statistical hypothesis

- ◆ elemental statement
- ◆ truth or not (false, lie)
- ◆ hypothesis testing → **finding the truth**



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Statistical hypothesis

- ◆ truth \Leftrightarrow real object state
probabilistic system:
truth \rightarrow **probability**
- ◆ significant \Leftrightarrow any occasion other than
accidentally:
probability \rightarrow **level of significance**



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21. Null-hypothesis



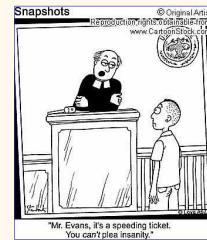
No difference



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Null-hypothesis



No difference \approx Not guilty



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22. Testing the hypothesis

- A. null-hypothesis
- B. statistical test
- C. level of significance
- D. statistics calculation
- E. conclusion



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A. Hypothesis

- null – H_0 – no difference
- alternate – H_1 – difference exists
- only one can be **truthful**
- only one can be **accepted**, other will be **rejected**



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B. Choosing the test

- measuring scales
- sample
 - size
 - related on unrelated samples
- data distribution
 - parametric
 - nonparametric
- no. of variables
- etc.



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23. Statistical tests

Scale	One sample	Two		Three or more	
		related	unrelated	related	unrelated
Nominal	binomial chi-square	McNemar	Fisher chi-square/	Cohran	chi-sqr.
Ordinal	Kol.-Smirn.	Wilcoxon MW Moses		Friedman	p/median KW
Interval	...				
Ratio	...				



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C. Level of significance

- P
 - α if defined before statistics
 - α – probability of rejecting H_0 when $H_0 = \text{truth}$
- error α (type I error or false positive error)
- as less as possible
- default values, e.g. $P < 0,05$



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24. Statistical errors

Table 3-1. Making the conclusions – correct and incorrect concluding

True situation	Conclusion from statistical hypothesis test	
	No difference (accept H_0)	Difference exist (reject H_0)
No difference (H_0)	Correct conclusion (no error)	Incorrect conclusion (α error or type I error)
Difference exist (H_1)	Incorrect conclusion (β error or type II error)	Correct conclusion (no error)

Deducting presupposes the comparison of two systems. Systems may be, in theory, equal (the same) or they may differ in any aspect. We do not know the actual state and therefore we investigate. Assumption is presented in a statistical hypothesis, in two ways; null (H_0 : no difference) and alternative (H_1 : difference exists). From the testing we draw a conclusion with which we prove that the difference exists or that it does not exist. Correct conclusions are when there is no actual difference of systems and we do not find it, or when there is actual difference and we find it. Incorrect conclusions are when the difference actually does not exist but we find it, as well as when the difference actually does exist but we do not find it. Types of errors are indicated next to incorrect conclusions.



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D. Statistics

- computation...

- P = exact value
- three decimals

~~$P > 0,05$~~



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Table 1. Participants' demographic and clinical characteristics

Variable*	Participants		p†
	PTSD patients (n=38)	healthy volunteers (n=26)	
Age (mean±SD)	44.3±9.4	39.5±8.4	0.028
Tobacco use	24	13	0.330
Marital status:			0.443
married	21	12	
unmarried/divorced/widowed	17	12	
Lives with the family‡	32	22	0.339
Education:			0.006
elementary school	5	0	
high school	28	13	
university education	5	11	
Work status:			0.012
employed	22	21	
retired	11	0	
unemployed	5	3	
CAPS (mean±SD)	16.6±2.2	0	
misopagny	28.1±3.1	0	
hyperarousal	15.7±3.3	0.5±1.1	
total	58.3±7.0	0.5±1.1	<0.001
Delayed	2038		
Years from trauma (median, range)	10 (0-13)		

abuse for from any der. The chronic i The s mittee of sent was Blood sa Heparin (10 mL between 8 Dickins (France), (50 µL.p manoph express ripheral separate (Pharma dient an ty deteri outed.

*at least 2 "hyperarousal symptoms" within the 12 months after the first six months of traumatic incident.

†Two-tailed t-test for continuous variables; Fisher's exact test for 2x2 tables; Pearson's chi-square test for 3x2 tables, and Fisher's exact test for categorical variables.

‡Does not include the family.

25. Software

26. Conclusion (E)

- low P \Rightarrow low possibility to reject the truth
- conclusion:
 - $P < \alpha$
 - low probability that H_0 is true
 - reject (not accept) null hypothesis
 - accept alternate hypothesis
 - statement "... " is truth with $P = \dots$



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27. Yes & No in statistics

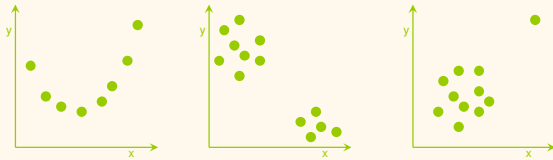
- hypothesis = ?
- calculation = ?
- correct data = ?
- all conditions for statistic valid = ?
- no limitations = ?



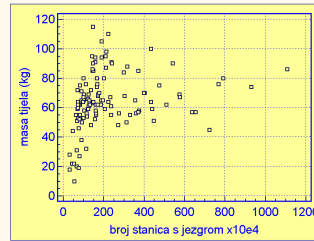
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Example 1: "Not" in correlation



(cont.)



	N	r	p
linear	118	0,25	0,006
logarithm	118	0,43	<0,001

Example 2: "Not" with χ^2 -test

lectures quality	students Zagreb	students other
well	10	31
bad	0	19
total	10	50

Example 3: Another "not"

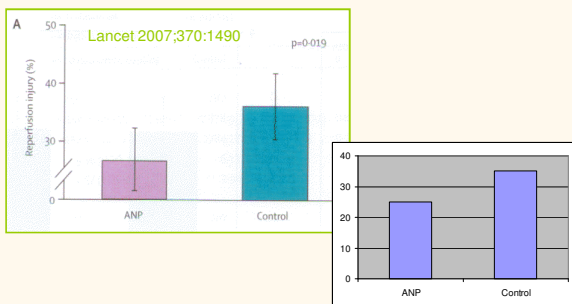
a predictor. All statistical tests were performed using the SAS software system and significance was determined when P-values were less than 0.05.

in Group I-II versus Group III was marginally significant ($P = 0.07$). However, when tests were

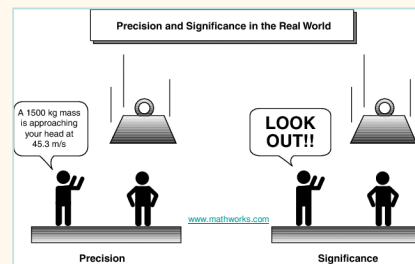
Lupus 2004;14:426

($P = 0.0007$) and a marginally significant increase in creatinine clearance ($P = 0.096$). There was no statistically significant longitudinal effect in serum creatinine levels.

Example 4: "Not" in graphs



28. Significance vs. 29. Accuracy



30. The truth



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