Lecture 23 Introduction To Hypothesis Testing

BIO210 Biostatistics

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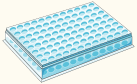
SUSTech · SCHOOL OF
LIFE SCIENCES

Estimation



Population parameters	**Sample**	
Parameters	Point estimate	Interval estimate (95% CI)
μ	$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$	$\bar{x} \pm Z_{\alpha/2}\frac{\sigma}{\sqrt{n}}$ $\quad \bar{x} \pm t_{\alpha/2,n-1}\frac{s}{\sqrt{n}}$
σ^2	$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})^2$	$\left[\frac{(n-1)s^2}{\chi^2_{0.025,n-1}}, \frac{(n-1)s^2}{\chi^2_{0.975,n-1}}\right]$
π	$p = \frac{m}{n}$	$p \pm Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}}$

ABO Blood Type Distribution

Clinical Infectious Diseases

BRIEF REPORT

Relationship Between the ABO Blood Group and the Coronavirus Disease 2019 (COVID-19) Susceptibility

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ABO Blood Type Distribution In COVID-19 Patients

The ABO blood group distribution in 1,775 COVID-19 patients from Wuhan Jinyintan Hospital:

	Total	**A**	**B**	**AB**	**O**
Number	$1,775$	670	469	178	458
Proportion	1	0.38	0.26	0.1	0.26

ABO Blood Type Distribution

- **Question 1:** what is the proportion of blood type AB in the COVID-19 patients ?

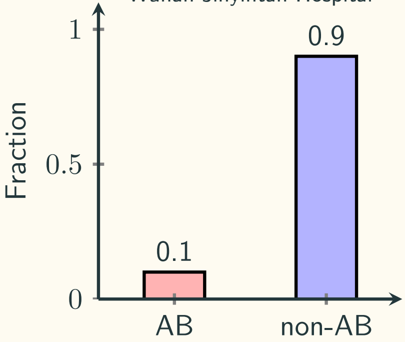
✓ Estimations from the random sample: point (0.1) and interval $(95\%$ CI: $0.083 - 0.117)$.

- **Question 2:** ask questions by incorporating the previous knowledge.

From "ABO blood types distribution in Han Chinese" by Deren Peng in 1992. Data from Hubei:

Total	A	B	AB	O
1	0.32	0.25	0.09	0.34

$1,775$ COVID-19 patients from Wuhan Jinyintan Hospital



Blood Type AB In COVID-19 Patients

- **Question 2:** is the proportion of blood type AB in the COVID-19 patients different from 0.09?

✓ If the proportion of blood type AB in the COVID-19 patients were 0.09, the probability of observing the proportion of blood type AB in $1,775$ COVID-19 patients is 0.1 would be ... ?

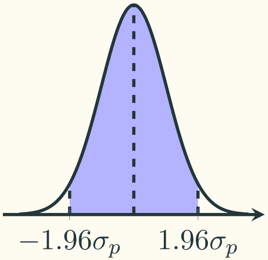
- Using binomial probability $(n = 1775,\ p = 0.09)$:

$$\mathbb{P}\left(\boldsymbol{X} = 178\right) = \binom{1775}{178} 0.09^{178} 0.91^{1597} = 0.01$$

- Using the sampling distribution of the proportion:

$$Z = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}} = \frac{0.1 - 0.09}{\sqrt{\frac{0.09 \times 0.91}{1775}}} = 1.47$$

$\mu_P = 0.09,\ \sigma_P = 0.008$



Correct Answers In Multiple-Choice Questions

Journal of Educational Measurement
Summer 2003, Vol. 40, No. 2, pp. 109–128

Guess Where: The Position of Correct Answers in Multiple-Choice Test Items as a Psychometric Variable

Yigal Attali
Educational Testing Service
Maya Bar-Hillel
The Hebrew University of Jerusalem

In this article, the authors show that test makers and test takers have a strong and systematic tendency for hiding correct answers—or, respectively, for seeking them—in middle positions. In single, isolated questions, both prefer middle positions to extreme ones in a ratio of up to 3 or 4 to 1. Because test makers routinely, deliberately, and excessively balance the answer key of operational tests, middle bias almost, though not quite, disappears in those keys. Examinees taking real tests also produce answer sequences that are more balanced than their single question tendencies but less balanced than the correct key. In a typical four-choice test, about 55% of erroneous answers are in the two central positions. The authors show that this bias is large enough to have real psychometric consequences, as questions with middle correct answers are easier and less discriminating than questions with extreme correct answers, a fact of which some implications are explored.

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Does Correct Answer Distribution Influence Student Choices When Writing Multiple Choice Examinations?

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A hypothetical sample ($n = 374$):

A (74, 0.198), **B** (142, 0.380), **C** (102, 0.273), **D** (56, 0.150)

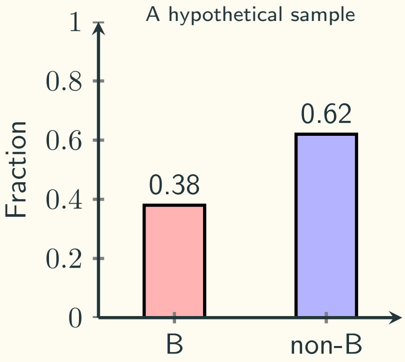
Option B As The Correct Answer

- **Question 1:** what is the proportion of MCQs with B as the correct answer ?

✓ Estimations from the random sample: point (0.380) and interval (95% CI: $0.331 - 0.429$).

- **Question 2:** ask questions by incorporating the previous knowledge.

From senior students and more experienced examinees: "If you do not know which one is the correct answer, choose B!" – $\mathbb{P}(\text{B is the correct answer}) > 0.25$.



Option B As The Correct Answer

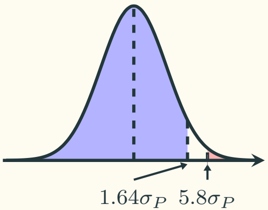
- **Question 2:** is the proportion of MCQs with B as the correct answer higher than 0.25?

✓ If the proportion of MCQs with B as the correct answer were less or equal to 0.25, the probability of observing 38% of 374 MCQs whose correct answer is B would be ... ?

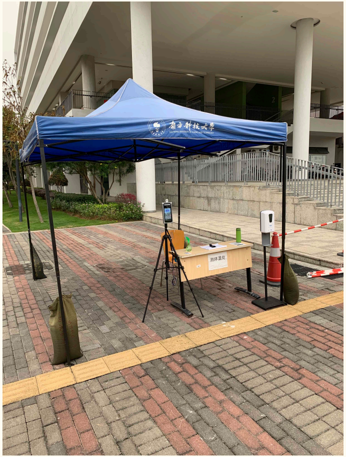
$$\mu_P = 0.25, \ \sigma_P = 0.022$$

- Using the sampling distribution of the proportion:

$$Z = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}} \geqslant \frac{0.38 - 0.25}{\sqrt{\frac{0.25 \times 0.75}{374}}} = 5.8$$



Measuring Body Temperature



Human Body Temperature

In 1868: the German physician Carl Reinhold August Wunderlich concluded that the average body temperature of normal people was 37.0 °C (1 million readings from around $25,000$ people).

- How is the body temperature measured?
- In the rectum (rectal temperature)
- In the mouth (oral temperature)
- Under the arm (axillary temperature)
- In the ear (tympanic temperature)
- On the skin of the forehead over the temporal artery
- In 1992, Mackowiak *et al*. JAMA (36.8 °C).

Human Body Temperature

- **Question 1:** what is the mean body temperature of normal people ?

✓ Estimations from a random sample: point and interval.

- **Question 2:** is the mean body temperature of normal people really 37 °C ?

✓ If the mean body temperature of normal people were 37 °C, then we would expect to see ... with a probability of ...

Human Body Temperature

Brief Report

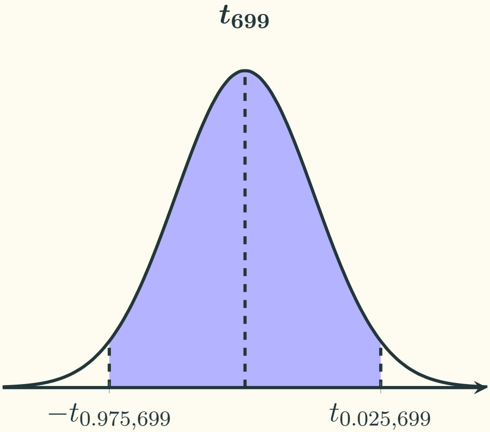
A Critical Appraisal of 98.6°F, the Upper Limit of the Normal Body Temperature, and Other Legacies of Carl Reinhold August Wunderlich

Philip A. Mackowiak, MD; Steven S. Wasserman, PhD; Myron M. Levine, MD

- Mackowiak *et al.* JAMA 268: 1578 - 80.
  - A random sample with 700 temperature readings.
  - Mean: 36.8 °C.
  - Standard deviation: 0.4 °C.

How to assess: If the mean body temperature of normal people were 37 °C (μ), the probability of observing 700 temperature readings with a mean of 36.8 °C ($\bar{x}$) or more extreme is ?

Human Body Temperature



$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} = \frac{36.8 - 37}{\frac{0.4}{\sqrt{700}}} = -12.23$$

Probability vs. Statistics