

# Lecture 25 More On Hypothesis Testing

BIO210 Biostatistics

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**LIFE SCIENCES**

# Steps For NHST

1. Specify what you are comparing
2. Formulate hypotheses
3. Check assumptions
4. Determine significance level  $\alpha$
5. Compute the test statistic
6. Check significance
7. Make a decision about whether to reject  $H_0$
8. Interpret findings

6a)



**6b)** Calculate the p-value.

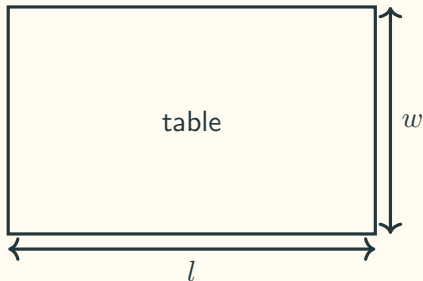
**6c)** Construct  $(1 - \alpha) \times 100\%$  confidence interval to see if it covers the  $H_0$  value.

# The Null And Alternative Hypotheses

	Two-tailed test	One-tailed test	
Hypotheses style #1	$H_0 : \pi = \pi_0$ $H_1 : \pi \neq \pi_0$	$H_0 : \pi \leq \pi_0$ $H_1 : \pi > \pi_0$	$H_0 : \pi \geq \pi_0$ $H_1 : \pi < \pi_0$
Hypotheses style #2	$H_0 : \pi = \pi_0$ $H_1 : \pi \neq \pi_0$	$H_0 : \pi = \pi_0$ $H_1 : \pi > \pi_0$	$H_0 : \pi = \pi_0$ $H_1 : \pi < \pi_0$

Both are okay and used in statistics!

## One-sided/tailed v.s. Two-sided/tailed Tests

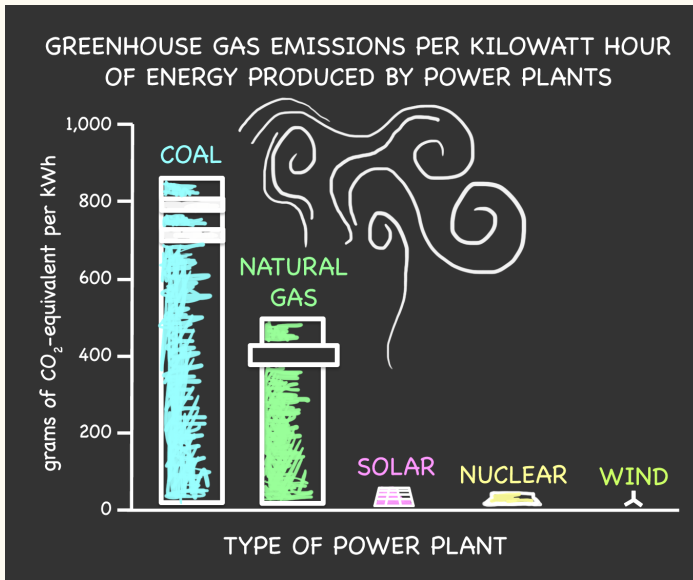


$$l : w = 1.618$$

A sample of 20 tables were taken, and the length-to-width ratio ( $l : w$ ) was measured. The sample mean is 1.7 and the sample variance is  $0.18^2$ . At the significance level of 0.05:

Han Meimei	Li Lei
$H_0: \mu \leq 1.618$	$H_0: \mu = 1.618$
$H_1: \mu > 1.618$	$H_1: \mu \neq 1.618$

# Nuclear Power Plant



# Risk of Nuclear Power Plant

- Occupational Health, Cancer

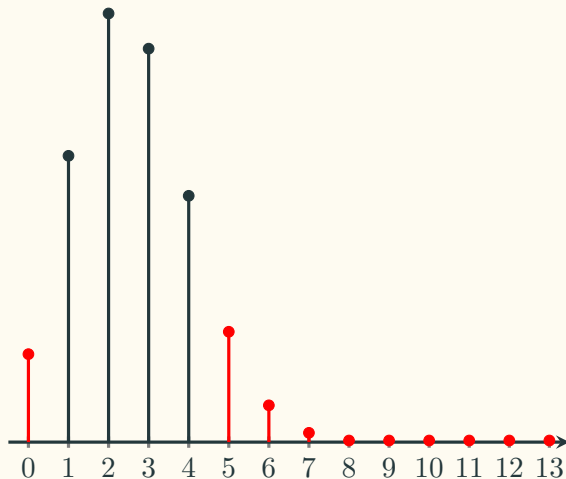
- The safety of people who work at or live close to nuclear-power plants has been the subject of widely publicised debate in recent years. One possible health hazard from radiation exposure is an excess of cancer deaths among those exposed. One problem with studying this question is that because the number of deaths attributable to either cancer in general or specific types of cancer is small, reaching statistically significant conclusions is difficult except after long periods of follow-up. An alternative approach is to perform a **proportional-mortality study**, whereby the proportion of deaths attributed to a specific cause in an exposed group is compared with the corresponding proportion in a large population. Suppose, for example, that **13 deaths** have occurred among 55- to 64-year-old male workers in a nuclear-power plant and that **in 5 of them** the cause of death was cancer. Assume, based on vital-statistics reports, that approximately **20% of all deaths** can be attributed to some form of cancer. Is this result significant different from the reports?

# Conduct The Hypothesis Testing

1.  $p = \frac{x}{n} = \frac{5}{13}$
2.  $H_0 : \pi = \pi_0 = 0.2, H_1 : \pi \neq \pi_0 = 0.2$
3. **Check assumptions:** randomisation, independence,  $n\pi_0 = 2.6$
4.  $\alpha = 0.05$
5. Compute the test statistic ?
6. Check significance ?
7. Make the decision ?
8. Interpret findings ?

$$\begin{aligned} & \mathbb{P}(\text{data or more extreme} \mid H_0 \text{ is true}) \\ &= \mathbb{P}(x \geq 5 \mid \pi = 0.2) \\ &= \mathbb{P}(x = 5 \mid \pi = 0.2) + \\ & \quad \mathbb{P}(x = 6 \mid \pi = 0.2) + \\ & \quad \mathbb{P}(x = 7 \mid \pi = 0.2) + \\ & \quad \vdots \\ & \quad \mathbb{P}(x = 13 \mid \pi = 0.2) \\ &= \sum_{k=5}^{13} \binom{13}{k} 0.2^k 0.8^{13-k} = 0.099 \end{aligned}$$

# Tow-tailed Exact Binomial Test



One tailed p-value :

$$\sum_{k=5}^{13} \binom{13}{k} 0.2^k 0.8^{13-k} = 0.099$$

Two-tailed Exact Binomial  
p-values:

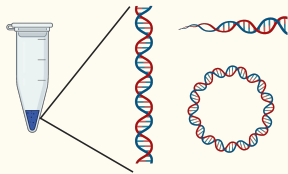
$$\begin{aligned} p &= \sum_{i \in \mathcal{I}} \mathbb{P}(X = i) \\ &= \sum_{i \in \mathcal{I}} \binom{n}{i} p^i (1-p)^{n-i} \end{aligned}$$

where  $\mathcal{I} = \{i \mid \mathbb{P}(X = i) \leq \mathbb{P}(X = k)\}$

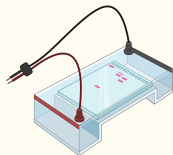


# Gel Extraction

Target DNA preparation



DNA separation



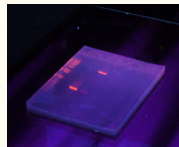
Transilluminator



Cut the band



Check bands



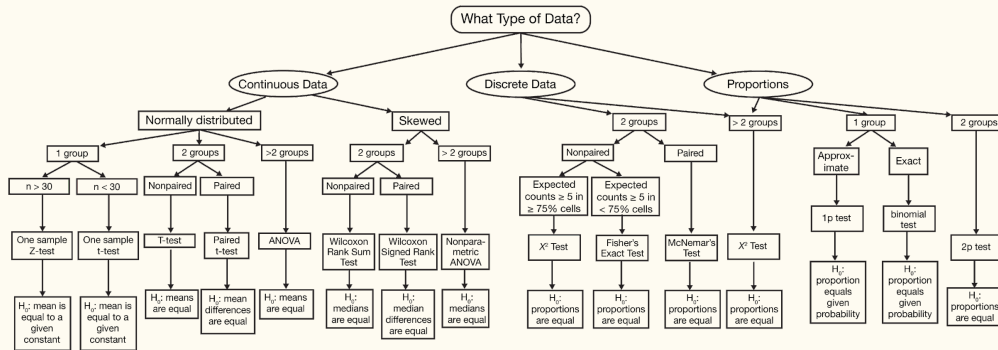
# UV Safety Visor



- Suppose you have a production line to make UV safe visors for scientists in the lab. Their quality is measured by a score indicating the percentage of UV they can block. Based on your past experience, you know their scores follow a normal distribution with a mean of 950 and a variance of 1,600. To check the quality of visors from a particular batch, tests were run on a random sample of  $n = 40$  visors, and the sample mean and sample variance were found to be 945 and 2,352.25, respectively.
- Do the data provide sufficient evidence, at the  $\alpha = 0.05$  level, to conclude that the population variance exceeds 1,600 ?

# What Tests Should We Choose?

## Flow chart: which test statistic should you use?

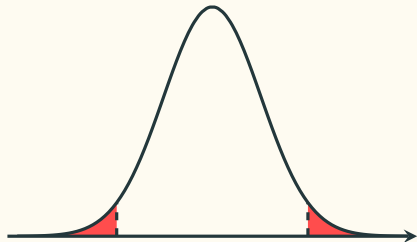


<https://onishlab.colostate.edu/summer-statistics-workshop-2019/>

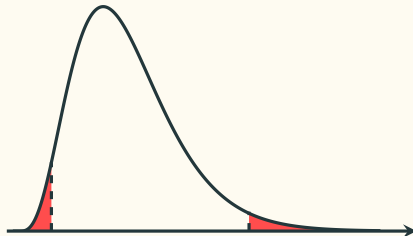
**We do not really need this!**

# One-sample Hypothesis Testing For Variance

Sampling distribution of the sample mean/proportion



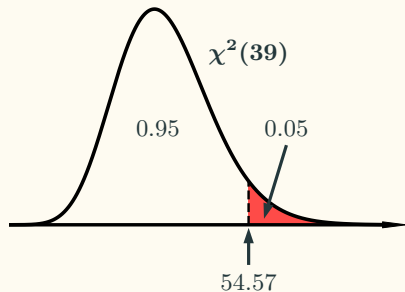
Sampling distribution of the sample variance



# One-sample Hypothesis Testing For Variance

1.  $s^2 = 2352.25$
2.  $H_0 : \sigma^2 \leq \sigma_0^2 = 1600, H_1 : \sigma^2 > \sigma_0^2 = 1600$
3. **Check assumptions:** Randomisation, independence, population normally distributed
4.  $\alpha = 0.05$
5.  $\chi^2 = \frac{(n-1)s^2}{\sigma_0^2} \geq \frac{39 \times 2352.25}{1600} = 57.34$
6. **Check significance**
7. Reject  $H_0$ .
8. The data suggest the population variance do not exceed 1,600.

**6a) Rejection/critical region:**



**6b) P-value:**  $\mathbb{P}(\chi^2 \geq 57.34) = 0.029$

**6c) Construct  $(1 - \alpha) \times 100\%$  CI:**

$$\left[ \frac{39 \times 2352.25}{54.57}, +\infty \right)$$