Applied Statistical Analysis I/Quantitative Methods I
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- Theory
- Lab

Theory

- Population and Sample
- Inferential and Descriptive Statistics
- Distributions and Sampling Distributions
- Confidence Intervals

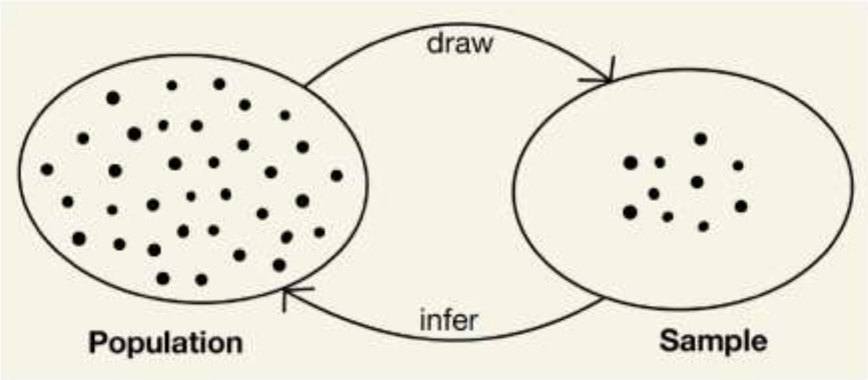
Population, sample, parameter, variable

What is the relationship between population and sample?

Population, sample, parameter, statistic

What is the relationship between population and sample?

- Population: "the total set of subjects of interest in a study" (Agresti and Finlay 2009, 5).
- Parameter: "numerical summary of the population" (Agresti and Finlay 2009, 5).
- Sample: "the subset of the population on which the study collects data" (Agresti and Finlay 2009, 5).
- Statistic: "a numerical summary of the sample data" (Agresti and Finlay 2009, 5).
- Observation: single subject/unit, one row in dataset



Inferential and descriptive statistics

What is the difference between inferential and descriptive statistics?

Inferential and descriptive statistics

What is the difference between inferential and descriptive statistics?

- Descriptive statistics: "summarize the information in a collection of data" (Agresti and Finlay 2009, 4).
- Inferential statistics: "provide predictions about a population, based on data from a sample of that population" (Agresti and Finlay 2009, 4).

Measures of central tendency and variability (dispersion)

How can we describe variables?

Measures of central tendency

How can we describe variables?

- Mean: $\bar{y}$ = Sum of all values divided by the number of observations, $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$

Measures of variability (dispersion)

How can we describe variables?

- Variance: $s^2(y)$ = Sum of squared deviations divided by number of observations (deviation is the difference between observed value and the mean, $y_i - \bar{y}$), $s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}$
- Standard Deviation: Return original units by taking square root, $s = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$

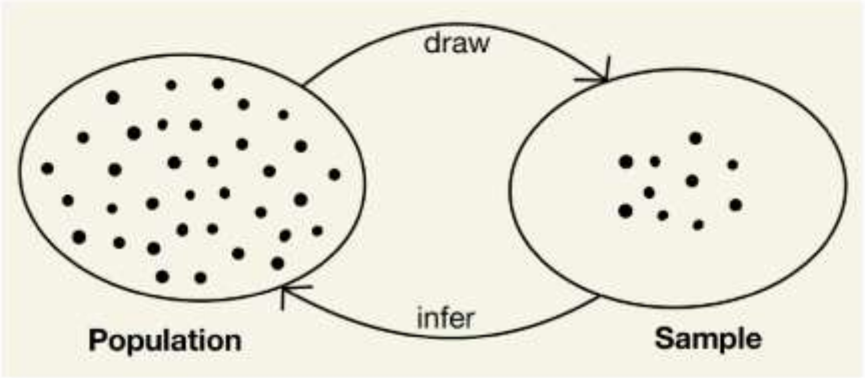
Probability

What is probability? What is a distribution? What is a probability distribution?

Probability

What is probability?

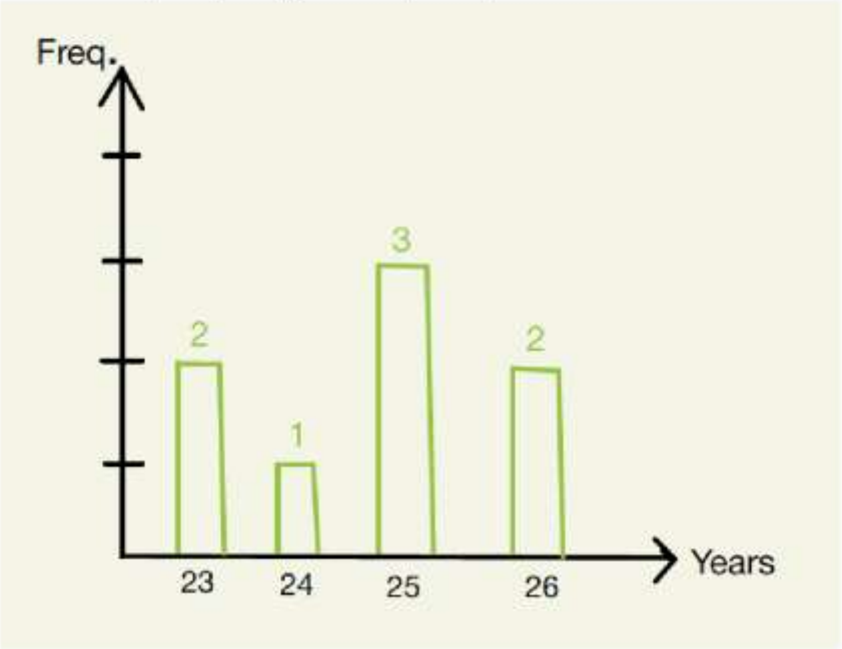
- Probability: "the probability that an observation has a particular outcome is the proportion of times that outcome would occur in a very long sequence of like observations" (Agresti and Finlay 2009, 73). $\rightarrow P(A) = \frac{\textit{Numer of elements in A}}{\textit{Number of all elements}}$
- Why do we need probability?



Distributions and probability distributions

What is a distribution?

Example, Age of people in the room.

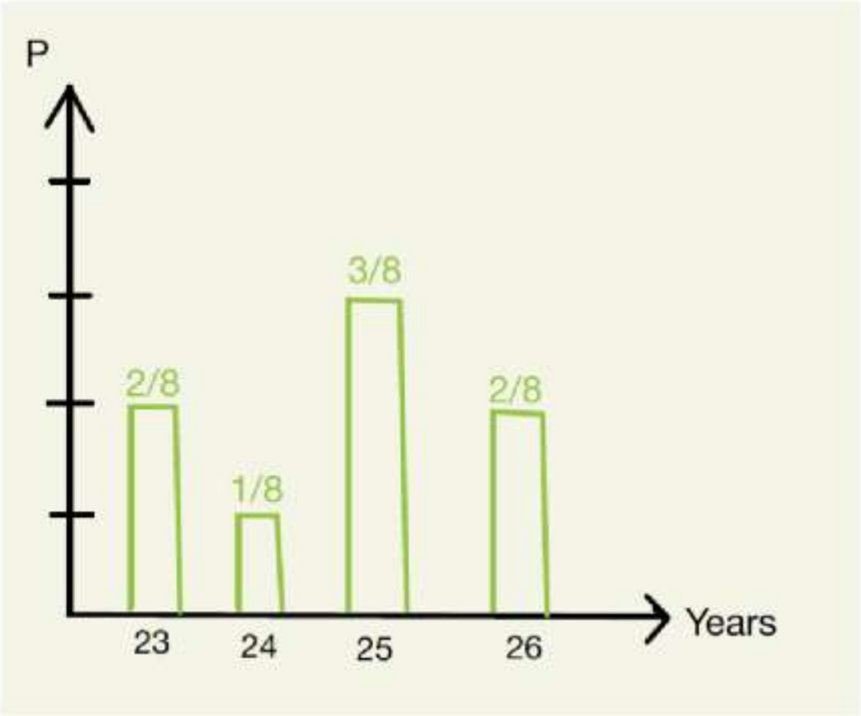


* Different shapes, for example, binomial distribution, normal distribution, t-distribution...

Distributions and probability distributions

What is a probability distribution?

- Probability distribution "lists the possible outcomes and their probabilities" (Agresti and Finlay 2009, 75).

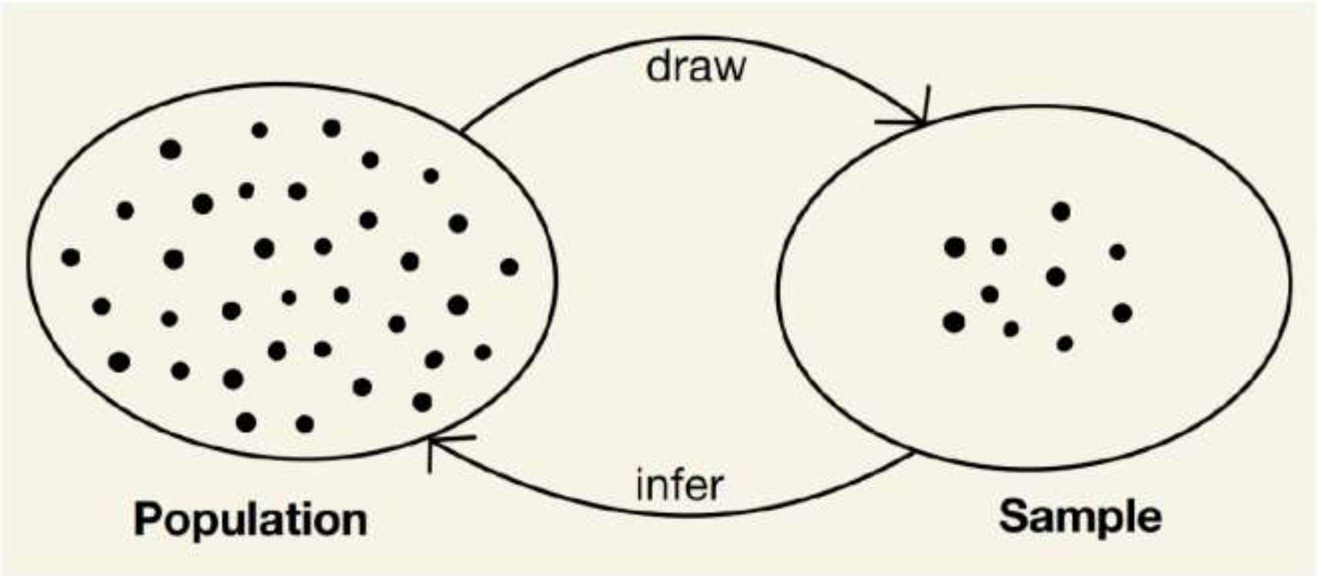


Sampling distribution

What is a sampling distribution? Why is this important?

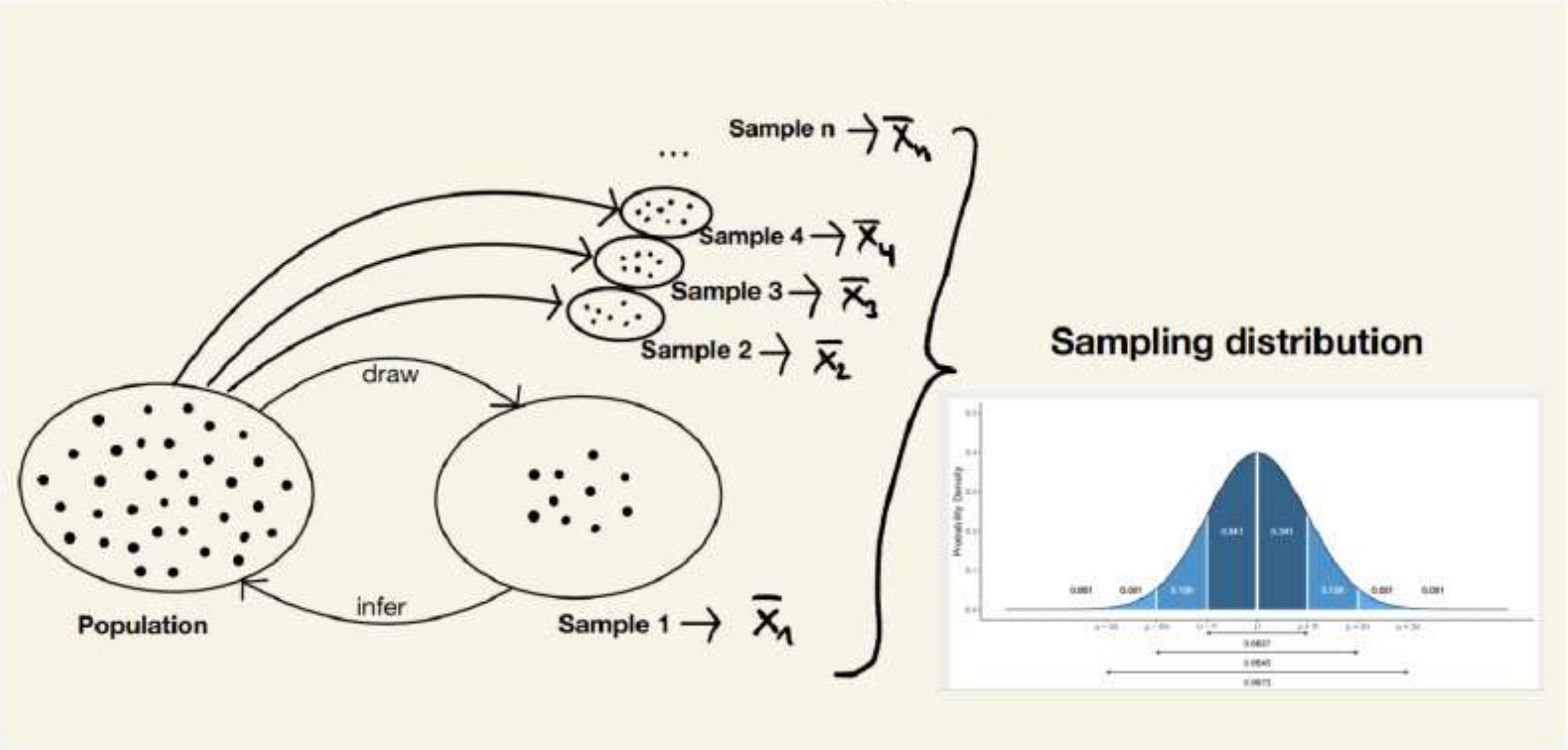
Sampling distribution

Recall the basic idea of empirical research



Sampling distribution

theoretically...



Sampling distribution

What is a sampling distribution?

- Sampling distribution "A sampling distribution of a statistic is the probability distribution that specifies probabilities for the possible values the statistic can take" (Agresti and Finlay 2009, 87).
- In other words, a probability distribution for a statistic rather than values of observations $\rightarrow$ What is the probability of $\bar{Y} = 0.5$, rather than what is the probability of $Y = 3$?

Sampling distribution

Why is this important?

- The corresponding probability theory "helps us predict how close a statistic falls to the parameter it estimates" (Agresti and Finlay 2009, 87). $\rightarrow$ how close is $\bar{y}$ to μ?
- Usually only one sample/one estimate $\rightarrow$ <u>Point estimate</u>: "is a single number that is the best guess for the parameter value" (Agresti and Finlay 2009, 107).

The sampling distribution of the mean, $\bar{y}$

- "If we repeatedly took samples, then in the long run, the mean of the sample means would equal the population mean μ" (Agresti and Finlay 2009, 90). $\rightarrow$ mean of the sampling distribution of $\bar{y}$ equals the population mean, hence, $\mu = \bar{y}$
- "The standard error describes how much $\bar{y}$ varies from sample to sample" (Agresti and Finlay 2009, 90). $\rightarrow$ standard error is estimated based on standard deviation, hence, $\sigma_{\bar{y}} = \frac{\sigma}{\sqrt{n}}$
- *Why does this work?*

Confidence intervals

What are confidence intervals?

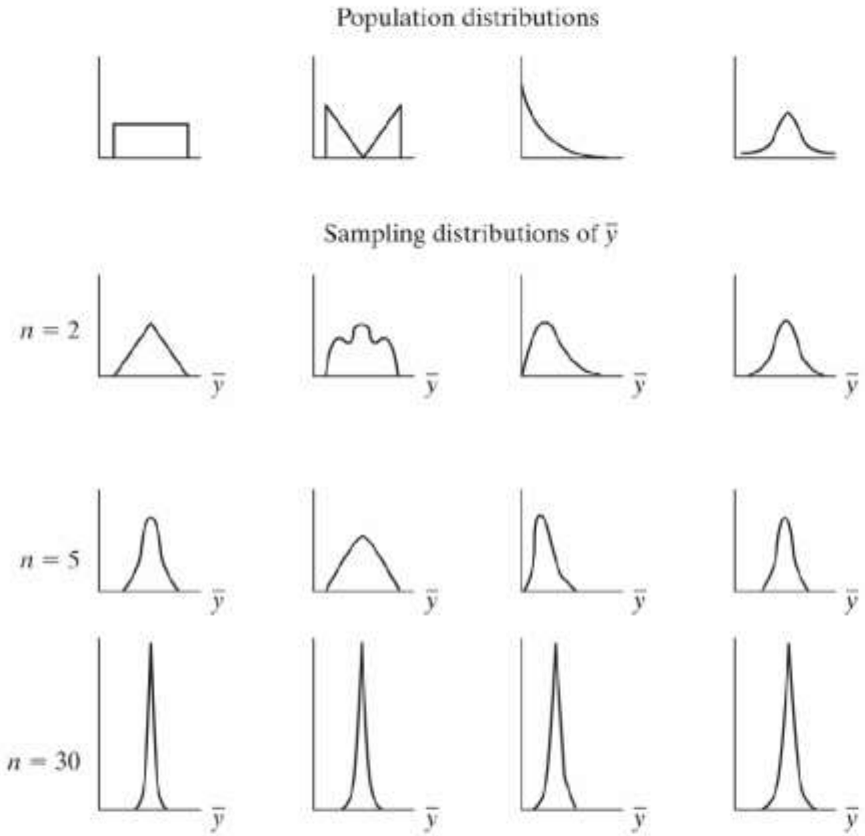
Confidence intervals

What are confidence intervals?

- Confidence interval: "an interval of numbers around the point estimate that we believe contains the parameter value" (Agresti and Finlay 2009, 110). $\rightarrow$ Point estimate $\pm$ Margin of error
- Confidence level: "The probability that this method produces an interval that contains the parameter" (usually 0.95, 0.99) (Agresti and Finlay 2009, 110).
- Margin of error $=$ multiple of the standard error, $\sigma_{\bar{y}} = \frac{\sigma}{\sqrt{n}}$ (Agresti and Finlay 2009, 117).
- For example, for 95% confidence level, the margin of error is $\pm 1.96\sigma_{\bar{y}}$ (have a look at the normal distribution).

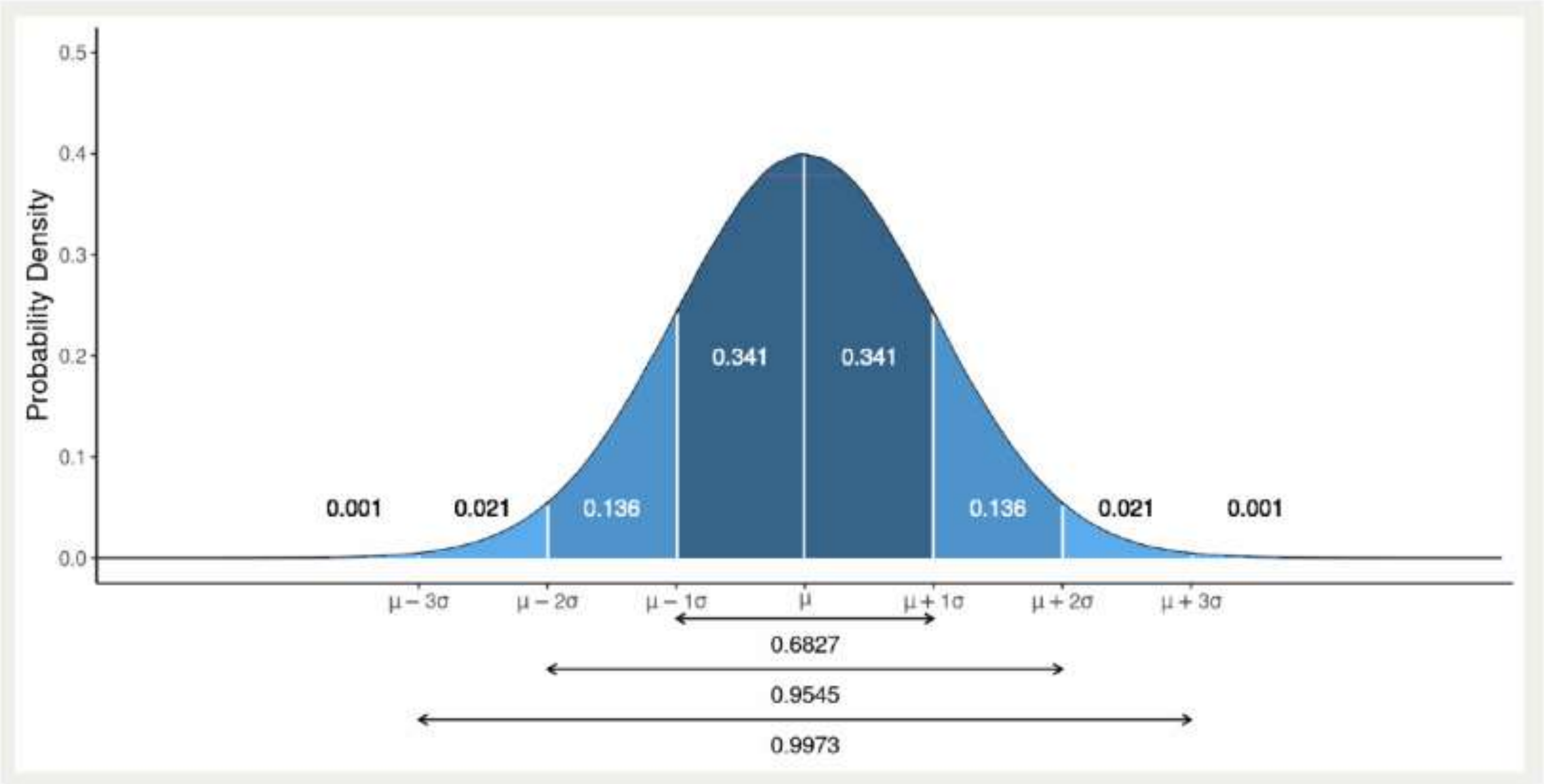
What is the Central Limit Theorem?

- "For random sampling with a large sample size n, the sampling distribution of the sample mean $\bar{y}$ is approximately a normal distribution" (Agresti and Finlay 2009, 93). $\rightarrow$ regardless of the population distribution



What is the Central Limit Theorem?

- "Knowing that the sampling distribution of $\bar{y}$ can be approximated by a normal distribution helps us to find probabilities for possible values of $\bar{y}$ (Agresti and Finlay 2009, 94). $\rightarrow$ key in inferential statistics



References

Agresti, Alan, and Barbara Finlay. 2009. *Statistical methods for the social sciences.* Essex: Pearson Prentice Hall.

Kellstedt, Paul M., and Guy D. Whitten. 2018. *The fundamentals of political science research.* Cambridge: Cambridge University Press.

Software Check

- R and LaTeX
- Rstudio and TexStudio
- GitHub desktop

Lab

- Sampling & measurement
- Descriptive statistics
- Probability distributions
- Confidence intervals

Acknowledgements

- Jeffrey Ziegler
- Trajche Panov
- Hannah Frank