



# STATISTICS

Parameters, Variables, Intervals, Proportions

## THE BASIC PRINCIPLES OF STATISTICS FOR INTRODUCTORY COURSES

### BASIC DEFINITIONS

**STATISTICS:** The study of methods for collecting, organizing, and analyzing data

- **Descriptive Statistics:** Procedures used to organize and present data in a convenient and communicable form.
- **Inferential Statistics:** Procedures employed to arrive at broader conclusions or inferences about populations on the basis of samples

**POPULATION:** The complete set of actual or potential elements about which inferences are made

**SAMPLE:** A subset of the population selected using some sampling method

• **Sampling methods**

- **Cluster sample:** A population is divided into groups called clusters; some clusters are randomly selected, and every member in them is observed
- **Stratified sample:** The population is divided into strata, and a fixed number of elements of each stratum are selected for the sample
- **Simple random sample:** A sample selected so that each possible sample of the same size has an equal probability of being selected; used for most elementary inference

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**VARIABLE:** An attribute of elements of a population or sample that can be measured; ex: height, weight, IQ, hair color and pulse rate are some of the many variables that can be measured for people

**DATA:** Values of variables that have been observed

• **Types of data**

- **Qualitative (or "categorical") data** are descriptive but not numeric; ex: your gender, your birthplace, the color of an automobile
- **Quantitative data** take numeric values
- **Discrete data** take counting numbers (0, 1, 2, ...) as values, usually representing things that can be counted; ex: the number of fleas on a dog, the number of times a professor is late in a semester
- **Continuous data** can take a range of numeric values, not just counting numbers; ex: the height of a child, the weight of a bag of beans, the amount of time a professor is late

• **Levels of measurement**

- **Qualitative data** can be measured at the:
  - **Nominal level:** Values are just names, without any order; ex: color of a car, major in college
  - **Ordinal level:** Values have some natural order; ex: high school class (freshman / sophomore / junior / senior), military rank
- **Quantitative data** can be measured at the:
  - **Interval level:** Numeric data with no natural zero point; intervals (differences) are meaningful, but ratios are not; ex: temperature in Fahrenheit degrees; 80°F is 20°F hotter than 60°F, but it is not 150% as hot
  - **Ratio level:** Numeric data for which there is a true zero; both intervals and ratios are meaningful; ex: weight, length, duration, most physical properties

**STATISTIC:** A numeric measure computed from sample data, used to describe the sample and to estimate the corresponding population parameter

**PARAMETER:** A numeric measure that describes a population; parameters are usually not computed, but are inferred from sample statistics

### FREQUENCY DISTRIBUTION

Provides the frequency (number of times observed) of each value of a variable

**Table #1:** Students in a driving class are polled regarding number of accidents they've had:

(# of accidents) (frequency) (relative frequency)

$x$	$f$	$RF$
5	3	0.0526
4	2	0.0351
3	9	0.1579
2	15	0.2632
1	16	0.2807
0	12	0.2105

**GROUPED FREQUENCY DISTRIBUTION:** Values of the variable are grouped into classes

**Table #2:** The scores on a midterm exam are grouped into classes:

class	$f$	cumulative freq.
90-99	4	80
80-89	18	76
70-79	31	58
60-69	19	27
50-59	7	8
40-49	1	1

**RELATIVE FREQUENCY DISTRIBUTION:** Each frequency is divided by the total number of observations to produce the proportion or percentage of the data set having that value; ex: third column of Table 1

**CUMULATIVE FREQUENCY DISTRIBUTION:** Frequencies count all observations at a particular value or class and all those less. Ex: third column of Table 2

### MEASURES OF CENTRAL TENDENCY

**MEAN:** Most commonly used measure of central tendency, usually meant by "average"; sensitive to extreme values

**POPULATION MEAN**

$$\mu = \frac{1}{N} \sum_{i=1}^N x_i$$

**SAMPLE MEAN**

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

• **Trimmed mean:** Computed discarding some number of the highest and lowest values; less sensitive than ordinary mean

• **Weighted mean:** Computed with a weight multiplied to each value, making some values influence the mean more heavily than others

**MEDIAN:** Value that divides the set so the same number of observations lie on each side of it; less sensitive to extreme values; for an odd number of values, it is the middle value; for an even number, it is the average of the middle two; ex: in Table 1, the median is the average of the 28th and 29th observations, or 1.5

**MODE:** Observation that occurs with the greatest frequency; ex: in Table 1, the mode is 1

### MEASURES OF DISPERSION

**SUM OF SQUARES (SS):** The sum of squared deviations from the mean

• **Population SS:**  $\sum (x_i - \mu)^2$  or  $\sum x_i^2 - \frac{(\sum x_i)^2}{N}$

• **Sample SS:**  $\sum (x_i - \bar{x})^2$  or  $\sum x_i^2 - \frac{(\sum x_i)^2}{n}$

**VARIANCE:** The average of square differences between observations and their mean

• **Population variance:**  $\sigma^2 = \frac{1}{N} \sum (x_i - \mu)^2$

• **Sample variance:**  $s^2 = \frac{1}{n-1} \sum (x_i - \bar{x})^2$

• **Variances for grouped data:**

- **Population:**  $\sigma^2 = \frac{1}{N} \sum f_j (m_j - \mu)^2$

- **Sample:**  $s^2 = \frac{1}{n-1} \sum f_j (m_j - \bar{x})^2$

**STANDARD DEVIATION:** The square root of the variance; unlike variance, it has the same units as the original data and is more commonly used:

ex: Pop. S.D.:  $\sigma = \sqrt{\frac{1}{N} \sum (x_i - \mu)^2}$

**STANDARD SCORES:** Also known as **Z-scores**; the standard score of a value is the directed number of standard deviations from the mean at which the value is found; that is,  $z = \frac{x - \mu}{\sigma}$

• A positive z-score indicates a value greater than the mean; a negative z-score indicates a value less than the mean; a z-score of zero indicates the mean value

• **Converting every value in a data set or distribution to a z-score** is called **standardization**; once a data set or distribution has been standardized, it has a new mean  $\mu = 0$ , and a new standard deviation  $\sigma = 1$

### GRAPHING TECHNIQUES

**BAR GRAPH:** A graph that uses bars to indicate the frequency of occurrence of observations

• **Histogram:** A bar graph used with quantitative, continuous variables

**FREQUENCY CURVE:** A graph representing a frequency distribution in the form of a continuous line that traces a histogram

• **Cumulative frequency curve:** A continuous line that traces a histogram where bars in all the lower classes are stacked up in the adjacent higher class; cannot have a negative slope

• **Symmetric curve:** The frequency curve is unchanged if rotated around its center; median = mean

• **Normal curve:** Bell-shaped curve; symmetric

• **Skewed curve:** Deviates from symmetry; frequency curve is shifted with a longer "tail" to the left (mean < median) or to the right (mean > median)



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