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

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

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

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:** $\sum(x_i - \mu_x)^2$ 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:** $\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2$

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

- **Variances for grouped data:**

- **Population:** $\sigma^2 = \frac{1}{N}\sum_{i=1}^{k} f_i(m_i - \mu)^2$

- **Sample:** $s^2 = \frac{1}{n-1}\sum_{i=1}^{k} f_i(m_i - \bar{x})^2$

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.: $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$

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)

NORMAL CURVE

SKEWED CURVE — LEFT

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