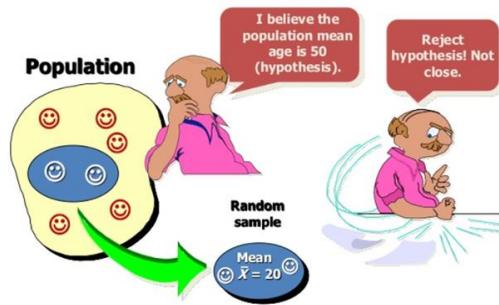


Chapter 14 Statistical Analysis of Quantitative Data

1

Purposes of Statistical Analysis in Quantitative Research

- To **describe** the **data** (e.g., sample characteristics)
- To **test hypotheses**
- To **provide evidence** regarding measurement properties of quantified variables



2

Levels of Measurement

- **Nominal**: lowest level; involves using numbers simply to **categorize** attributes (ex: gender)
- **Ordinal**: **ranks** people on an attribute (ex: educational level)
- **Interval**: **ranks** people on an attribute **and specifies the distance** between them (ex: temperature)
- **Ratio**: highest level; ratio scales, unlike interval scales, have a **meaningful zero** and provide information about the absolute magnitude of the attribute.

ex: pulse

	Nominal	Ordinal	Interval	Ratio
Categories	●	●	●	●
Rank order		●	●	●
Equal spacing			●	●
True zero				●

The 4 levels of measurement

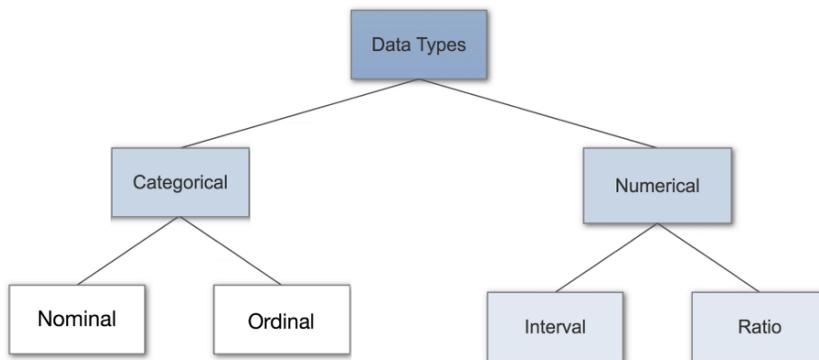
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Measurement



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Measurement - Nominal Data

- Nominal values represent discrete units and are used to label variables, that have no quantitative value.
- Just think of them as "labels".
- Note that nominal data that has **no order**. Therefore, if you would change the order of its values, the meaning would not change.
- Examples of nominal features:

Are you married?

Yes

No

What languages do you speak?

Englisch

French

German

Spanish



5

Measurement - Ordinal Data

- Ordinal values represent discrete and **ordered** units.
- It is therefore nearly the same as nominal data, except that **it's ordering matters**.
- Example:

What Is Your Educational Background?

1 - Elementary

2 - High School

3 - Undegraduate

4 - Graduate



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Measurement - Interval Data

- Interval values represent **ordered units that have the same difference**.
- Therefore we speak of interval data when we have a variable that contains numeric values that are ordered and where **we know the exact differences between the values**.
- An example would be a feature that contains temperature of a given place like you can see below:

Temperature?

- 10
- 5
- 0
- + 5
- + 10
- + 15

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7

Measurement - Ratio Data

- Ratio values are also **ordered units that have the same difference**.
- Ratio values are the same as interval values, with the difference that **they do have an absolute zero**.
- Good examples are height, weight, length etc.

Length (inch)?

- 0
- 5
- 10
- 15

8

Question

A researcher measures the weight of people in a study involving obesity and type II diabetes. What type of measurement is being employed?

- a. Nominal
- b. Ordinal
- c. Interval
- d. Ratio

Answer

- d. Ratio

Rationale:

Many physical measures, such as a person's weight, are ratio measures.

Gender is an example of a nominally measured variable.

A measurement of ability to perform ADLs is an example of ordinal measurement, and

interval measurement occurs when researchers can rank people on an attribute *and* specify the distance between them, e.g., psychological testing.

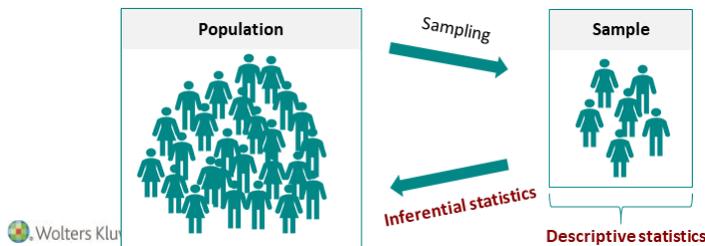
Statistical Analysis

- **Descriptive statistics**

- Used to **describe** and synthesize data
 - Parameters: **descriptor for a population**
 - Statistics: **descriptive index from a sample**

- **Inferential statistics**

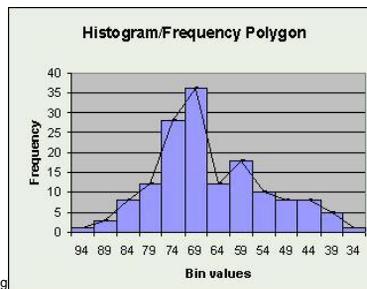
- Used to make **inferences** about the population based on sample data



11

Frequency Distributions

- A **systematic arrangement of numeric values** on a variable from lowest to highest and a count of the number of times (and/or percentage) each value was obtained
- Frequency distributions can be described in terms of:
 - Shape
 - Central tendency
 - Variability
- Can be presented in a table (*N*s and percentages) or graphically (e.g., **frequency polygons**)

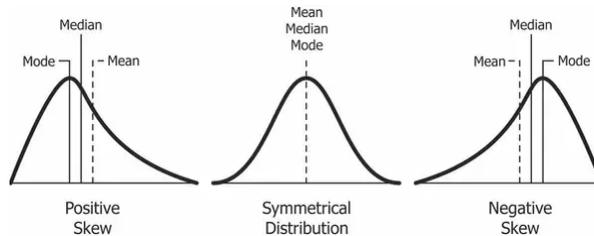


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Shapes of Distributions

- Symmetry
 - a. **Symmetric**
 - b. **Skewed** (asymmetric)
 - **Positive skew** (long tail points to the right)
 - **Negative skew** (long tail points to the left)

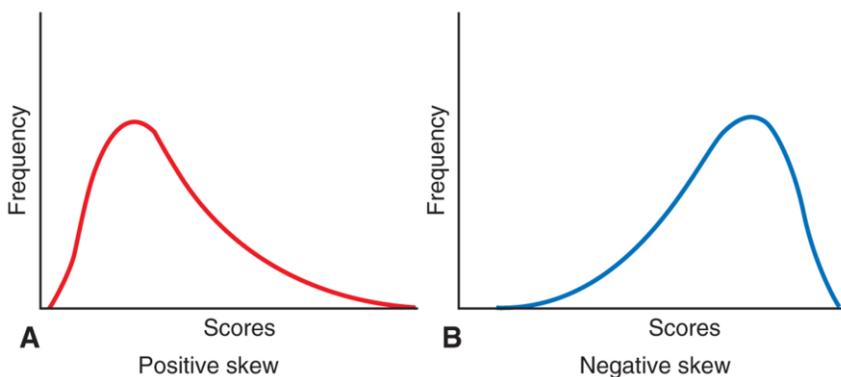


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Examples of Skewed Distribution

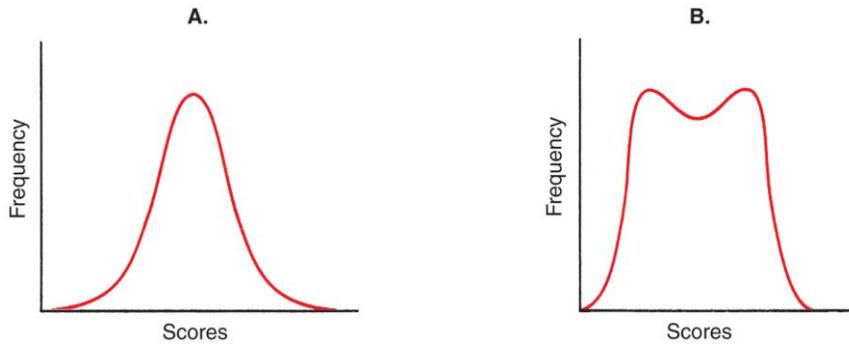


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14

Examples of Symmetric Distributions



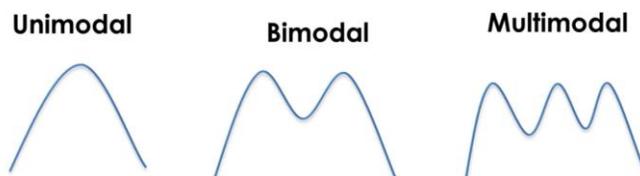
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Shapes of Distributions—(cont.)

- **Modality** (number of peaks)
 - Unimodal (1 peak)
 - Bimodal (2 peaks)
 - Multimodal (2+ peaks)



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16

Question

Tell whether the following statement is True or False.
A bell-shaped curve is also called a normal distribution.

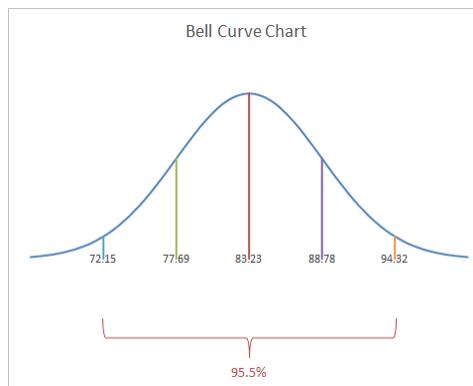
- a. True
- b. False

Answer

- a. True

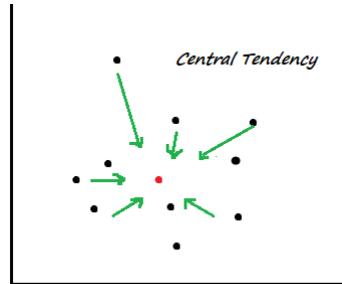
Rationale:

A special distribution called the normal distribution (*a bell-shaped curve*) is symmetric, unimodal, and not very peaked.



Central Tendency

- Index of “typicalness” of a set of scores that comes from center of the distribution
- **Mode**—the most frequently occurring score in a distribution
 - Ex: 2, 3, 3, 3, 4, 5, 6, 7, 8, 9 Mode = 3
- **Median**—the point in a distribution above which and below which 50% of cases fall
 - Ex: 2, 3, 3, 3, 4 | 5, 6, 7, 8, 9 Median = 4.5
- **Mean**—equals the sum of all scores divided by the total number of scores
 - Ex: 2, 3, 3, 3, 4, 5, 6, 7, 8, 9 Mean = 5.0



Central Tendency - Mode

Shows up the most!

5, 13, 9, 7, 1, 9, 2, 9, and 11

Mode = 9

Central Tendency – Median

MEDIAN = Number in the MIDDLE

MEDIAN
The number in the **middle**
3, 3, 3, 6, 7, 7, 13
(Numbers must be in ascending order)

MODE
The number that **appears** the most
3, 3, 3, 6, 7, 7, 13

RANGE
The **difference** between the greatest and least number
3, 3, 3, 6, 7, 7, 13
 $13 - 3 = 10$

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Central Tendency - Mean

mean

The mean is the average or norm.

- Add up all of the values to find a total.
- Divide the total by the number of values you added together.

$2 + 2 + 3 + 5 + 5 + 7 + 8 = 32$
There are 7 values

$32 \div 7 = 4.57$
Divide the total by 7

The mean is 4.57

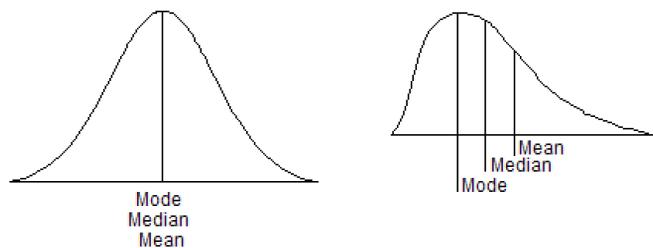
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Comparison of Measures of Central Tendency

- Mode: useful mainly as gross descriptor, especially of nominal measures
- Median: useful mainly as descriptor of typical value when distribution is skewed (e.g., household income)
- Mean: most stable and widely used indicator of central tendency



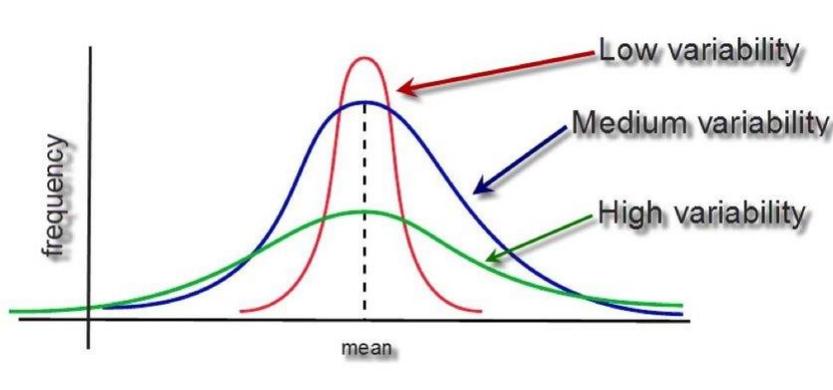
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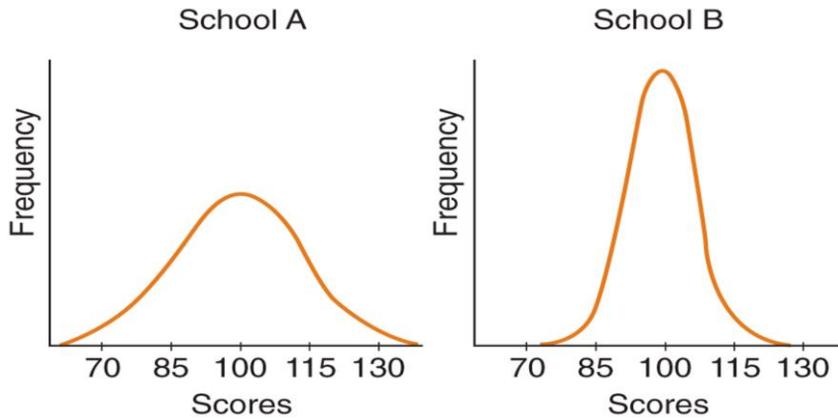
Variability

- The degree to which scores in a distribution are spread out or dispersed
 - **Homogeneity**—little variability
 - **Heterogeneity**—great variability



24

Two Distributions of Different Variability



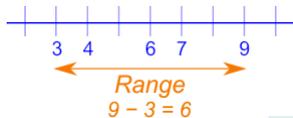
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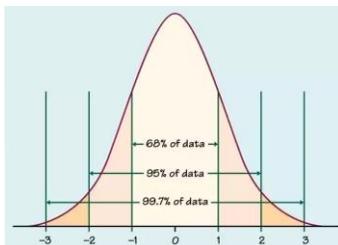
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Indexes of Variability

- **Range**: highest value minus lowest value
- **Standard deviation (SD)**: average deviation of scores in a distribution



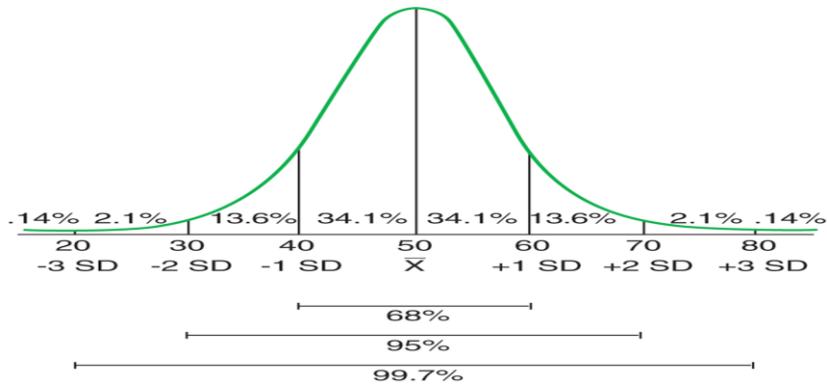
AGES OF STUDENTS
 13,13,14,14,14,15,15,15,15,16,16,16
 Range = highest - lowest
 = 16 - 13
 Range = 3



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26

Standard Deviations in a Normal Distribution



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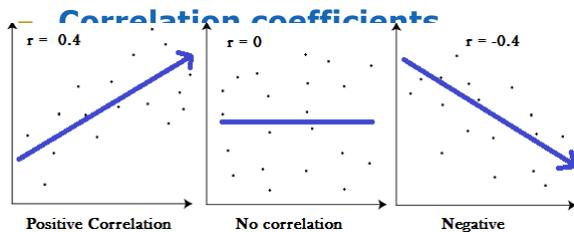
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Bivariate Descriptive Statistics

- Used for **describing** the relationship between two variables

- Two common approaches
 - Crosstabs (contingency tables)**

	Male	Female	Total
Blonde	4	8	12
Brunette	7	9	16
Total	11	17	28



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28

Question

The researcher subtracts the lowest value of data from the highest value of data to obtain:

- a. Mode
- b. Median
- c. Mean
- d. Range

Answer

- d. Range

Rationale:

The range is calculated by subtracting the lowest value of data from the highest value of data.

The mode refers to the most frequently occurring score.

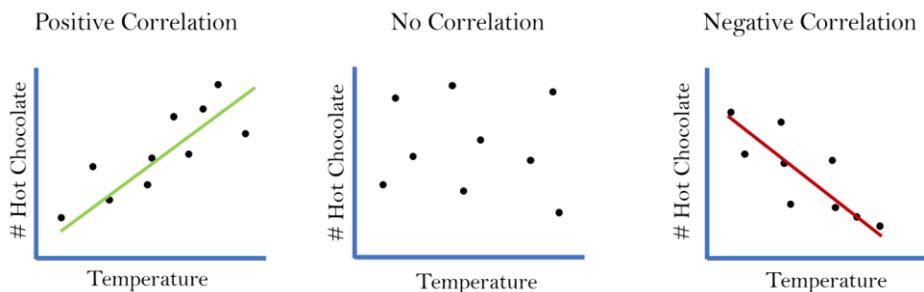
The median refers to the point distribution above which and below which 50% of the cases fall.

The mean is the sum of all the scores divided by the total number of scores.

Correlation Coefficients

Correlation coefficients can range from -1.00 to $+1.00$.

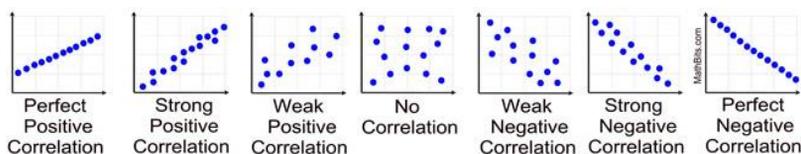
- **Negative relationship** (0.00 to -1.00)—One variable increases in value as the other decreases, e.g., amount of exercise and weight.
- **Positive relationship** (0.00 to $+1.00$)—Both variables increase, e.g., calorie consumption and weight.



31

Correlation Coefficients—(cont.)

- The greater the absolute value of the coefficient, the stronger the relationship:
Ex: $r = -.45$ is stronger than $r = +.40$.
- With multiple variables, a **correlation matrix** can be displayed to show all pairs of correlations.
- **Pearson's r** (the *product-moment correlation coefficient*): computed with continuous measures
- **Spearman's ρ** : used for correlations between variables measured on an ordinal scale



32

Describing Risk

- Clinical decision making for EBP may involve the calculation of risk indexes, so that decisions can be made about relative risks for alternative treatments or exposures.
- Some frequently used indexes
 - **Absolute risk** (proportion of people who experienced an undesirable outcome in each group)
 - **Absolute risk reduction (ARR)** (unexposed group minus exposed group [AR_u - AR_e])
 - **Odds ratio (OR)**
 - **Numbers needed to treat** (estimates how many people would need to receive an intervention to prevent one undesirable outcome)

The Odds Ratio (OR)

- The **odds** = the proportion of people **with** an adverse outcome relative to those **without** it
 - For example, the odds of getting tuberculosis . . .
- The odds ratio is computed to compare the odds of an adverse outcome for two groups being compared (e.g., men vs. women, experimentals vs. controls).

Calculating the Odds Ratio (OR)

	Disease (Case)	No Disease (Control)
Exposed	A	B
Unexposed	C	D

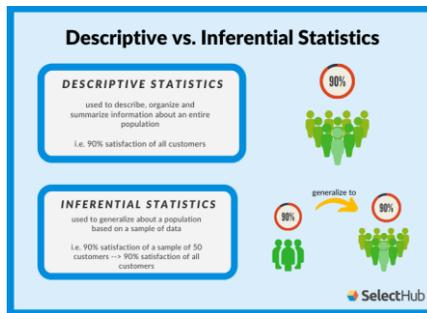
Odds that a case was exposed (A/C)

Odds that a control was exposed (B/D)

$$OR = \frac{A/C}{B/D} = \frac{AD}{BC}$$

Inferential Statistics

- Used to make objective decisions about population parameters using sample data
- Provide a means for drawing inferences about a population, given data from a sample
- Based on laws of probability
- Uses the concept of **theoretical distributions**
 - For example, the **sampling distribution of the mean**

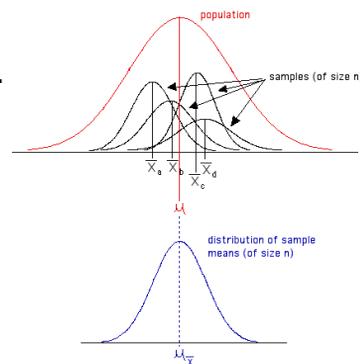


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Sampling Distribution of the Mean

- *Understanding the concept of a sampling distribution is central to understanding statistical inference.*
- A theoretical distribution of means for an infinite number of samples drawn from the same population
- Is always normally distributed
- Its mean equals the population mean.
- Its standard deviation is called the **standard error of the mean (SEM)**.
 - SEM is estimated from a sample SD and the sample size.

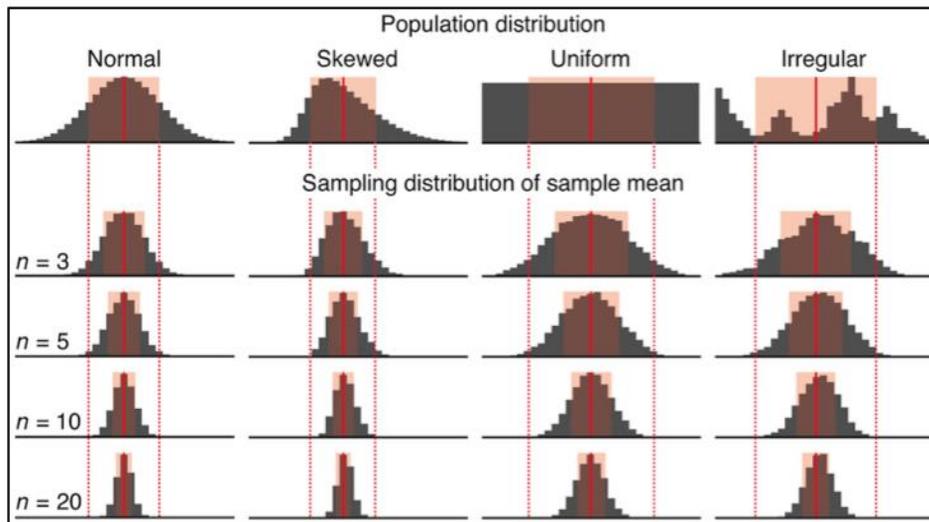


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36

Sampling Distribution of the Mean



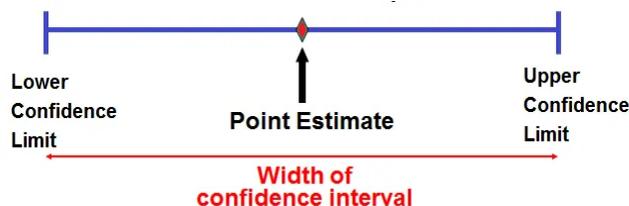
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Estimation of Parameters

- **Point estimation**—a single descriptive statistic that estimates the population value (e.g., a mean, percentage, or OR)
- **Interval estimation**—a range of values within which a population value probably lies
 - Involves computing a **confidence interval (CI)**
 - CIs reflect how much risk of being wrong researchers take.

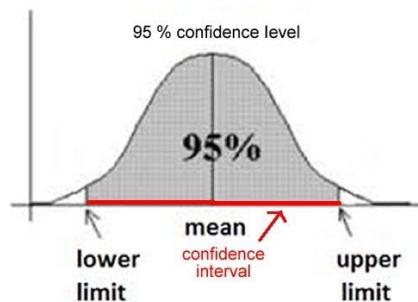


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Confidence Intervals

- CIs indicate the upper and lower **confidence limits** and the probability that the population value is between those limits.
 - For example, a 95% CI of 40 to 50 for a sample mean of 45 indicates there is a 95% probability that the population mean is between 40 and 50.

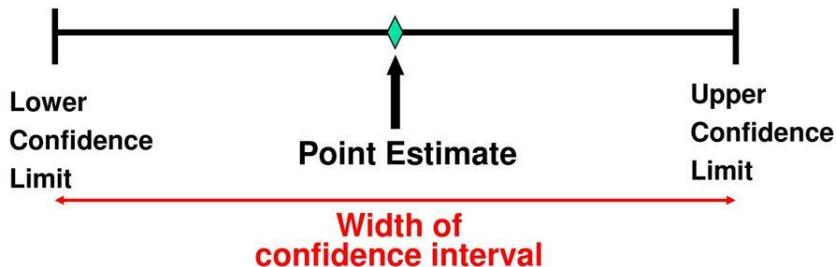


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Point and Interval Estimates

- A **point estimate** is a single number,
- a **confidence interval** provides additional information about variability



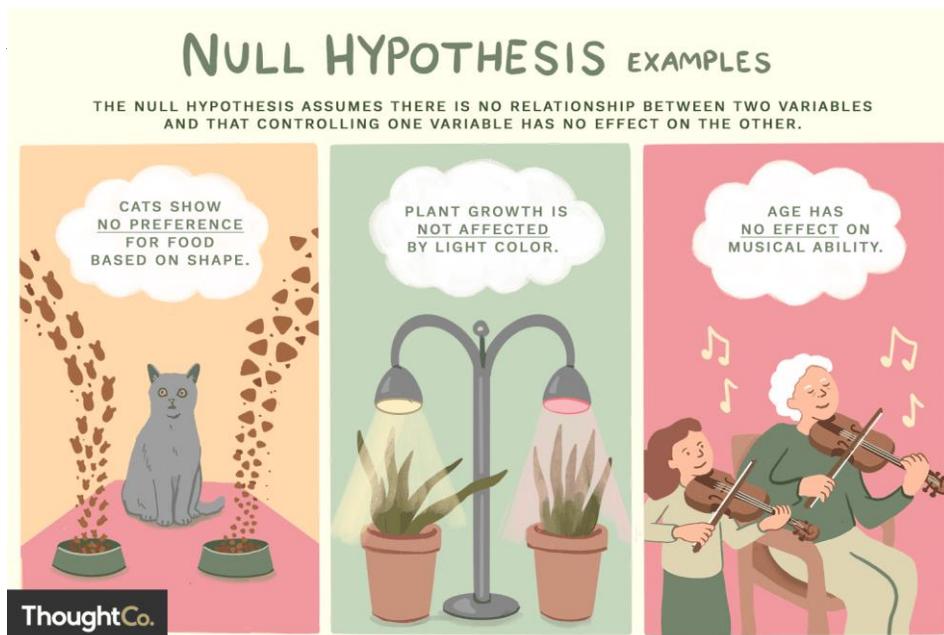
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Chap 7-4

40

Hypothesis Testing

- Based on rules of negative inference:
 - **Research hypotheses** are supported if **null hypotheses** can be rejected.
- Involves statistical decision making to either:
 - **Accept** the **null** hypothesis *or*
 - **Reject** the **null** hypothesis



Hypothesis Testing—(cont.)

- If the value of the test statistic indicates that the null hypothesis is **improbable**, then the result is **statistically significant**.
- A **nonsignificant result** means that any observed difference or relationship could have happened by chance.
- Statistical decisions are either correct or incorrect.

Errors in Statistical Decisions

- **Type I error**: rejection of a null hypothesis when it should not be rejected; a false-positive result
 - Risk of error is controlled by the **level of significance** (alpha), e.g., $\alpha = .05$ or $.01$.
- **Type II error**: failure to reject a null hypothesis when it should be rejected; a false-negative result
 - The risk of this error is beta (β).
- **Power** is the ability of a test to detect true relationships; power = $1 - \beta$.
 - By convention, power should be at least $.80$.
 - Larger samples = greater power

Outcomes of Statistical Decision Making

The researcher calculates a test statistic and decides that the null hypothesis is:

		The actual situation is that the null hypothesis is:	
		True	False
The researcher calculates a test statistic and decides that the null hypothesis is:	True (Null accepted)	Correct decision	Type II error
	False (Null rejected)	Type I error	Correct decision

Overview of Hypothesis Testing Procedures

- Select an appropriate test statistic.
- Establish significance criterion (e.g., $\alpha = .05$).
- Compute test statistic with actual data.
- Determine **degrees of freedom (df)** for the test statistic.
- *In statistics, the number of degrees of freedom is the number of values in the final calculation of a statistic that are free to vary. The number of independent ways by which a dynamic system can move, without violating any constraint imposed on it, is called number of degrees of freedom*
- Compare the computed test statistic to a theoretical value.
- Make decision to accept or reject null hypothesis.

Bivariate Statistical Tests

- [t-Tests](#)
- [Analysis of variance \(ANOVA\)](#)
- [Chi-squared test](#)
- [Correlation coefficients](#)
- [Effect size indexes](#)

t-Test

- Tests the **difference between two means**
- t-Test for independent groups: between-subjects test
 - For example, means for men vs. women
- t-Test for dependent (paired) groups: within-subjects test
 - For example, means for patients before and after surgery

Analysis of Variance (ANOVA)

- Tests the **difference between more than two means**
- Sorts out the variability of an outcome variable into two components: variability due to the independent variable and variability due to all other sources
- Variation *between* groups is contrasted with variation *within* groups to yield an **F ratio** statistic.
 - One-way ANOVA (e.g., three groups)
 - Multifactor (e.g., two-way) ANOVA
 - Repeated measures ANOVA (RM-ANOVA): within subjects

Chi-Squared Test

- Tests the **difference in proportions in categories** within a contingency table
- Compares **observed frequencies** in each cell with **expected frequencies**—the frequencies expected if there was no relationship

Correlation Coefficients

- Pearson's r is both a descriptive and an inferential statistic.
- Tests that the relationship between two variables is not zero

Question

Tell whether the following statement is True or False.

A correlation coefficient of $-.38$ is stronger than a correlation coefficient of $+.32$.

- True
- False

Answer

a. True

Rationale:

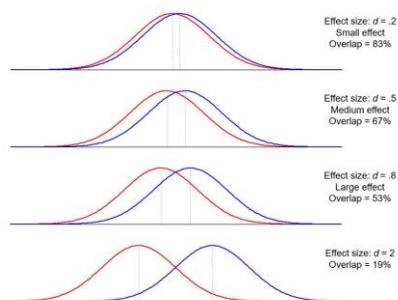
For a correlation coefficient, the greater the absolute value of the coefficient, the stronger the relationship.

So, the absolute value of $-.38$ is greater than the absolute value of $+.32$ and thus is stronger.

Effect Size

- **Effect size** is an important concept in **power analysis**.
- Effect size indexes summarize the **magnitude of the effect** of the independent variable on the dependent variable.
- In a comparison of two group means (i.e., in a t -test situation), the effect size index is d .
- By convention:
 - $d \leq .20$, small effect
 - $d = .50$, moderate effect
 - $d \geq .80$, large effect

Understanding Effect Sizes



Multivariate Statistical Analysis

- Statistical procedures for analyzing **relationships among three or more variables** simultaneously
- Commonly used procedures in nursing research:
 - **Multiple regression**
 - **Analysis of covariance (ANCOVA)**
 - **Logistic regression**
 - **Multivariate analysis of variance (MANOVA)**

Multiple Regression

- Used to predict a dependent variable based on two or more independent (**predictor**) **variables**
- The statistic used in multiple regression is the **multiple correlation coefficient**, symbolized as **R**.
- Dependent variable is continuous (interval or ratio-level data).
- Predictor variables are continuous (interval or ratio) or dichotomous.

Multiple Regression—(cont.)

Multiple Correlation Coefficient (R)

- The correlation index for a dependent variable and more than two independent (predictor) variables: R
- Does not have negative values: shows strength of relationships, not direction
- R^2 is an estimate of the proportion of variability in the dependent variable accounted for by all predictors.

Analysis of Covariance (ANCOVA)

- Extends ANOVA by removing the effect of confounding variables (covariates) before testing whether mean group differences are statistically significant
- Levels of measurement of variables
 - Dependent variable is continuous—ratio or interval level.
 - Independent variable is nominal (group status).
 - Covariates are continuous or dichotomous.

Question

Which test would be used to compare the observed frequencies with expected frequencies within a contingency table?

- a. Pearson's r
- b. Chi-squared test
- c. t -Test
- d. ANOVA

Answer

- b. Chi-squared test

Rationale:

The chi-squared test evaluates the difference in proportions in categories within a contingency table, comparing the observed frequencies with the expected frequencies.

Pearson's r tests that the relationship between two variables is not zero.

The t -test evaluates the difference between two means.

The ANOVA tests the difference between more than two means.

Logistic Regression

- Analyzes relationships between a nominal-level dependent variable and more than two independent variables
- Yields an odds ratio—the risk of an outcome occurring given one condition versus the risk of it occurring given a different condition
- The OR is calculated after first removing (statistically controlling) the effects of confounding variables.

Measurement Statistics

- **Reliability assessment**

- Test–retest reliability
- Interrater reliability
- Internal consistency

- **Validity assessment**

- Content validity
 - The test assesses all aspects of the construct?
- Construct validity
 - The method matches the construct?
- Criterion validity
 - How much the test agrees with a gold standard?



Unreliable & Invalid



Unreliable, But Valid



Reliable, Not Valid



Both Reliable & Valid

Research Article Information: Hypothesis Testing

- The test used
- The value of the calculated statistic
- Degrees of freedom
- Level of statistical significance

