STATISTICAL ANALYSIS 101

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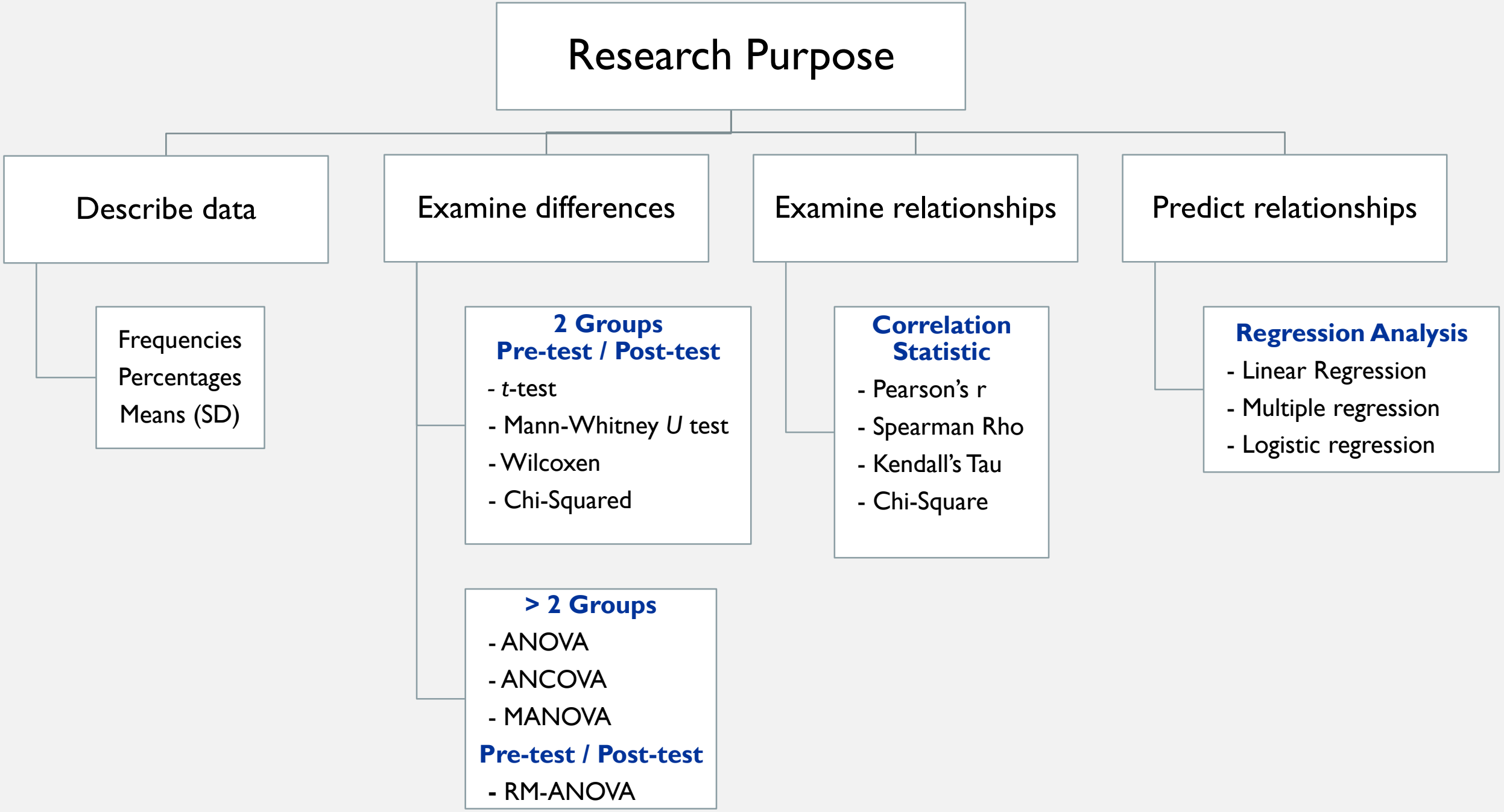
OBJECTIVES

- Distinguish descriptive from inferential statistics
- Apply the decision path in determining statistical tests to use in data analysis
- Determine appropriate parametric or nonparametric statistical tests to use in data analysis


Research Purpose
Describe data
Examine differences
Examine relationships
Predict relationships
Frequencies
Percentages
Means (SD)
2 Groups
Pre-test / Post-test
- t-test
- Mann-Whitney U test
- Wilcoxen
- Chi-Squared
> 2 Groups
- ANOVA
- ANCOVA
- MANOVA
Pre-test / Post-test
- RM-ANOVA
Correlation Statistic
- Pearson's r
- Spearman Rho
- Kendall's Tau
- Chi-Square
Regression Analysis
- Linear Regression
- Multiple regression
- Logistic regression

LEVELS OF MEASUREMENT

Nominal	Ordinal	Interval	Ratio
• Gender • Ethnicity • Marital status • Zip code • Religious affiliation • Medical diagnosis • Names of medications	• Pain scale (0-10) • Age groups (18-25, 26-35, etc.) • Grade (A, B, C, D, & F) • Satisfaction scale (poor, acceptable, good) • Performance scale (Below average, average, above average)	• Temperature • IQ • SAT score • Depression score • Time of day • Dates (years)	• Age • Height • Weight • BP • HR • Years of experience • Time to complete a task

CATEGORIES OF STATISTICS

- **Descriptive Statistics**
  - Describe situations and events
    - Summary (numbers, percentages)
    - Central Tendency
  - Charts / Graphs
- **Inferential Statistics**
  - Allows conclusions about variables
  - Statistical tests are performed
    - Comparisons
    - Associations
    - Predictions

DESCRIPTIVE STATISTICS

- Describe, Summarize & Organize data
  - Frequency distributions
    - Graphs/Tables
  - Measures of Central Tendency/Dispersion
    - Mean (*M*)
    - Standard deviation (SD)

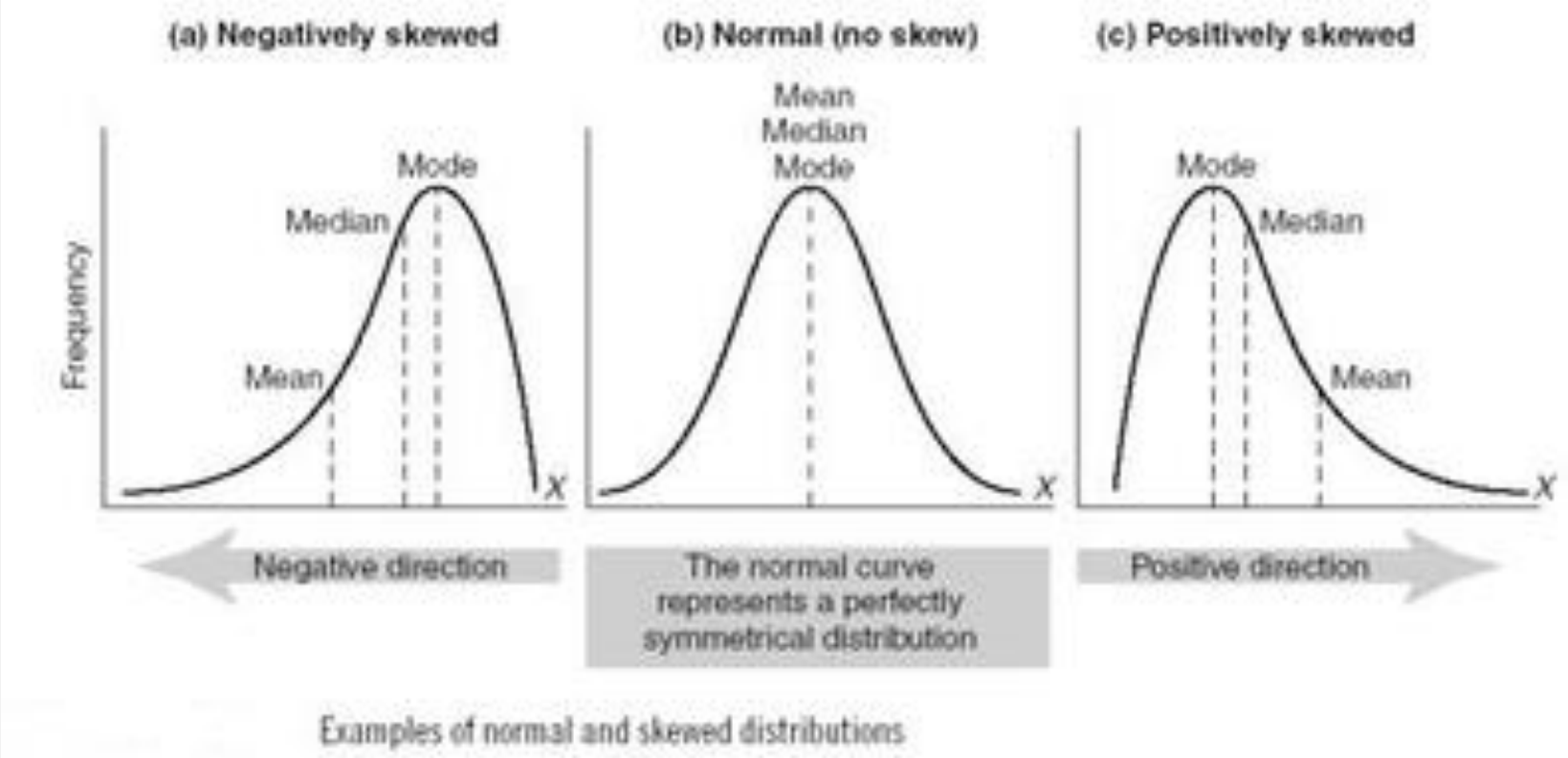
Table 1: Socio-demographic characteristics

Characteristics	(n)	(%)
Gender		
Female	112	30.9
Male	251	69.1
Marital status		
Single	95	26.2
Married	268	73.8
Age (years)		
23–29	148	40.8
30–40	135	37.2
41–50	43	11.8
51 and over	37	10.2
Participation in sports activities		
One day in a week	75	20.6
Two-three days in a week	50	13.8
One day in two weeks	51	14.1
Never	187	51.5

$\bar{x}$ $\bar{x}$

DESCRIPTIVE STATISTICS

- Distribution of data
  - Normal distribution
  - Skewness
    - Negative skew
    - Positive skew



Examples of normal and skewed distributions

INFERENTIAL STATISTICS

- Probability
  - Likelihood an outcome will occur
  - Helps identify risk
  - Confidence Interval (CI)
- Alpha level (α-level) or significance level
  - Defines statistical significance
  - Most common in healthcare: .05 and .01
  - ***p*-value**
- Examine relationships among variables
  - Correlation statistics
- Predict relationships among variables
  - Regression analysis
- Examine / Compare differences between variables
  - *t*-test
  - ANOVA

PARAMETRIC VS NONPARAMETRIC

PARAMETRIC STATISTICAL TESTS

- Assumptions
  - Data must be normally distributed
  - Interval or ratio data
  - Independence of data
- Need sample size >30
- More powerful

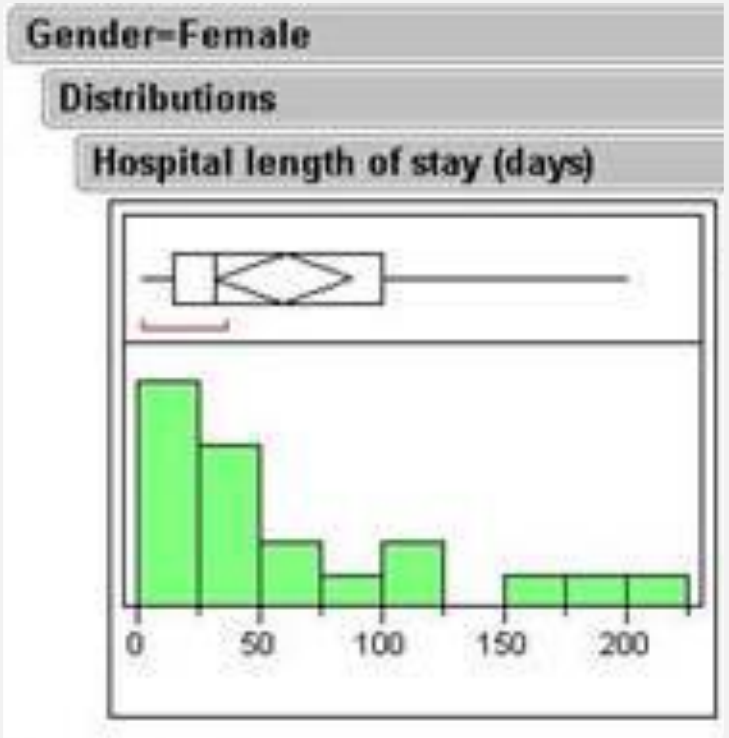
NONPARAMETRIC STATISTICAL TESTS

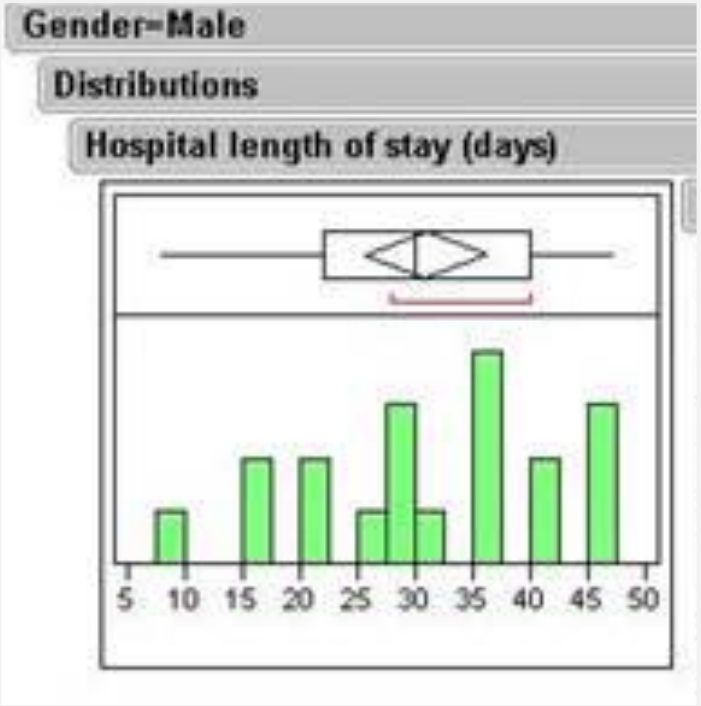
- No assumptions of distribution
- Small sample size
- Level of measurement
  - Nominal or ordinal

WHAT STATISTICAL TEST TO USE? PARAMETRIC OR NONPARAMETRIC

Example:

- Sample of critically ill patients
  - Length of stay
- 20 females
  - Mean = 60
  - Median = 31.5
- 19 males
  - Mean = 30.9
  - Median = 30





EXAMINE RELATIONSHIPS

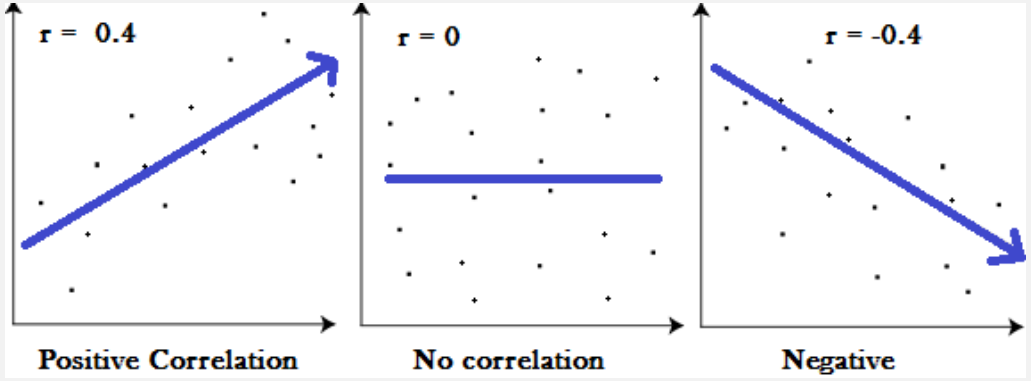
- **Correlation Statistics**
  - Exploratory studies
  - Examines relationship between variables
    - Direction of relationship
    - Doesn't specify IV & DV

EXAMPLES

- Association between overtime hours worked and medication errors in RNs
- Relationship between social support and stress in elderly rural women
- Relationship between time on ventilator and LOS in ICU patients

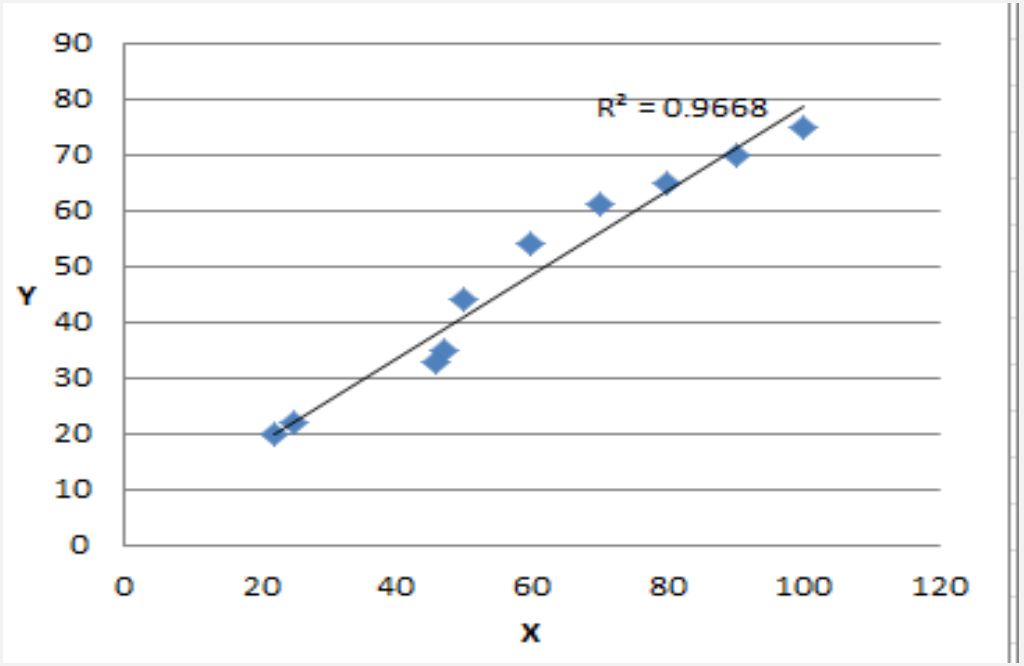
CORRELATION COEFFICIENTS

- Direction of relationship
- Strength of relationship (-1 to +1)
  - ≥ .10 → weak
  - ≥ .30 → moderate
  - ≥ .50 → strong
- Statistical significance



PEARSON'S CORRELATION COEFFICIENT (*r*)

- Parametric test
- Assumptions
  - Normal distribution / Interval or ratio
  - Related pairs / Absence of outliers
  - Linearity / Homoscedasticity
- Interval or ratio data level
- Reported as:
  - $r = .78, p < 0.001$



NONPARAMETRIC TESTS

- **Spearman Rho**
  - Skewed distribution
  - One variable- ordinal level
  - Reported as:
    - $r_s = .82,\ p = .042$
- **Kendall's Tau**
  - Skewed distribution
  - One variable- ordinal level
  - Reported as:
    - $r_t = .82,\ p = .042$

Chi Square test

- One variable- nominal
- No direction or association reported
- Reported as:
- $\chi^2\ (1) = 5.00,\ p = .025$

Good, H., Riley-Doucet, C., & Dunn, K. (2015). The prevalence of uncontrolled pain in long-term care: A pilot study examining outcomes of pain management processes. *Journal of Gerontological Nursing, 41(2)*, 33-41.

Outcome	Gender	Assessment to Physician Contact Time	Assessment to Medication Administration	Pain Score Prior to Schedule II	Sleep Disturbances	Diminished Ability With ADLs	Nonpharma-cological Modalities Used[a]	Lack of Participation in Therapy
Age	–0.27*	0.01	–0.17	0.15	–0.09	0.15	0.08	0.24
Assessment to pain relief time	0.27*	–0.01	0.52**	0.02	0.18	0.17	0.06	–0.09
Pain score prior to schedule II	–0.34*	0.11	0.20	—	0.34*	0.26	–0.07	0.28*
Pain score after schedule II	–0.25	0.22	0.07	0.48**	0.15	0.11	–0.12	0.22
Lack of therapy participation	–0.38*	0.20	0.01	0.28*	0.31*	0.45**	0.03	—
Sleep disturbance	0.02	0.21	0.18	0.34*	—	0.70**	0.09	0.31*
Diminished appetite/ weight loss	–0.24	0.37**	–0.21	0.14	0.07	0.07	–0.20	0.30
Resisting movement with care	–0.09	0.15	0.13	0.45**	0.67**	0.67**	–0.02	0.34*
Diminished psychological well-being	–0.01	0.17	0.11	0.33*	0.52**	0.44**	0.30	0.20

Note. Schedule II = schedule II analgesic medications; ADLs = activities of daily living.

[a] *Nonpharmacological modalities that may have been used include massage, music therapy, pet therapy, social activities, repositioning, and communication and diversion techniques, including family and friend visitation.*

* $p < 0.05$; ** $p < 0.01$.

PREDICT RELATIONSHIPS

- **Regression Analysis**
  - Exploratory & Prediction studies
  - Quantifies a relationships among variables to predict future events
    - Estimates values for DV by known values of IV
      - Dependent variable (DV) – outcome variable
      - Independent variable (IV) – influencing variable
    - Makes inferences or predictions
  - Statistically significant correlations (≥ .50)
    - Measure strength of association

3 TYPES OF REGRESSION ANALYSIS

- **Linear regression**
  - Relationship between a single independent variable and a single interval- or ratio-level variable
  - Predicts the future value of dependent variable based on level of independent variable
  - Results report: R and R^2
- **Multiple regression**
  - Make prediction about how 2 or more independent variables affects the dependent variable
  - Reported as R^2
- **Logistic regression**
  - Used when dependent variable is categorical (nominal or ordinal with 2 categories)
  - Generates an Odds Ratio (OR)

EXAMPLES

Investigate the relationship between gestational age at birth (weeks) & birth weight (lbs.)

- Simple linear regression
  - Significant relationship between gestation and birth weight ($r = .706$, $p < 0.001$).
  - Slope coefficient for gestation was 0.355
    - Weight of baby increases by 0.355 lbs. for each extra week of gestation.

Investigate the effect of age (years) and height (inches) on weight

- Multiple regression
  - Significant relationship between age and weight (r = .476, p = .001); height and weight (r = .672, p = .001)
    - Control for height, every year adds 1.71 lbs.
    - Control for age – every inch adds 10.37 lbs.

EXAMPLE: LOGISTIC REGRESSION

- **Purpose:** Identify factors that can be related to the occurrence of gestational arterial hypertension.
- **Dependent variable**
  - Momentary HTN – yes
  - Momentary HTN – no
- **Independent variables**
  - Anxiety
  - Depression
  - Obesity
  - Demographic variables
    - Age
    - Race
    - Education

		OR	CI	p
Race	White	1		
	Non-white	8.18	1.39-48.10	0.020
Depression	No	1		
	Yes	8.69	1.19-63.42	0.033
Obesity	No	1		
	Yes	6.45	1.40-29.61	0.016
Anxiety	No	1		
	Yes	7.77	1.19-50.45	0.032

Franco, R., Ferrreira, C., Vieira, C., & Silva, R. (2015). Ethnicity, obesity, and emotional factors associated with gestational hypertension. *Journal of Community Health, 40(5)*, 899-904. DOI: 10.1007/s10900-015-0010-8

EXAMINE DIFFERENCES

- **Experimental Designs**
  - Effect of IV on DV
    - 1 or more variables
    - 1 or more groups
  - Comparing results (means)
    - Between subjects
    - Within subjects

- **Statistical test to use depends on**
  - # of groups
  - Level of measurement
  - Type of sample
    - **Independent samples**
    - **Dependent samples**

PARAMETRIC TEST:
Differences between 2 means

- **Students *t*-test**
  - One-sample *t*–test
  - Independent Samples *t*-test
  - Dependent Samples *t*-test

One-sample *t*–test

- Interval or Ratio data
- Compare mean to known value
- Results reported as

  $t\ (99) = 2.224, p = 0.028$

- One-tailed or two-tailed test

PARAMETRIC TEST:
Difference between 2 means

INDEPENDENT SAMPLES

t-test

- Interval or Ratio data
- Independent samples
- Results reported as

  $t\ (18) = 2.86,\ p = 0.011$

DEPENDENT SAMPLES

t–test

- **Paired *t*–test**
- Interval or Ratio data
- Dependent samples
- Results reported as

  $t\ (15) = 4.00,\ p = 0.001$

EXAMPLES

70 patients with leukemia

- Experimental group (*n*=35)
  - 2 follow-up phone calls (IV)
- Control group (*n*=35)
  - Routine care
- Self-care (DV)

70 patients with hypertension

- Stress reduction classes
- SBP (pre & post)

	Experimental Group (n=35)		Control Group (n=35)		
	m	SD	m	SD	t
Self-care	2.67	.036	1.78	0.38	10.347*
*p<.001					

	Pre- class		Post- class		
	m	SD	m	SD	t
SBP	178.92	24.6	131.47	6.38	4.467*
*p<.001					

NONPARAMETRIC TESTS: Differences between 2 medians

MANN-WHITNEY *U*-TEST

- Looks at differences in distribution of a variable
- Assumptions
  - Random samples
  - Independent samples
  - Level of measurement: Ordinal +
- Results of test are reported as
  - $U = 67.5, p = .034$
- Wilcoxon Rank-Sum test
  - $W_s = 109.50, p = .008$

WILCOXON RANKED-SIGN TEST

- Looks at differences in distribution of a variable
- Assumptions
  - Random samples
  - Dependent samples
  - Level of measurement: Ordinal +
- Results of test are reported as
  - $(Mdn = 21.00), Z = -1.807, p = 0.071, r = -.84$
- Wilcoxon Matched-Pairs test

NONPARAMETRIC TESTS:
Differences between 2 frequencies

CHI-SQUARE ($\mathcal{X}^2$) STATISTIC

- Looks at differences in distribution of frequencies
- Level of Measurement: nominal or ordinal
- Independent groups
- Observed frequencies vs. Expected frequencies
- Results reported as
  - $\mathcal{X}^2\,(2, N = 218) = 14.14, p < 0.01$

	Do not use Antihistamines	Use Antihistamines	Total
< 30	105	32	137
> 30	72	9	81
Total	177	41	218

ANALYSIS OF VARIANCE (ANOVA)

- **Parametric Test**
  - Differences in means between >2 Groups
- **Post hoc tests**
  - Bonferroni
  - Tukey's
  - Scheffé's
- Reported as an *F* ratio
  - $F(59, 56) = 7.77, p = .042$

Types of ANOVAs

- One-way ANOVA
- ANCOVA
- Two-way ANOVA
- N-way (Factorial) ANOVA
- RM-ANOVA
- MANOVA

ONE-WAY ANOVA

- 3 or more Independent Groups
  - Comparing 3 or more means
- 1 independent variable (1 factor)
- 1 dependent variable
- Results reported as
  - $F(2, 27) = 4.98, p = 0.01$

- Assumptions
  - Normal distribution
  - DV at least Interval level
  - Variances in groups are same
  - Independent samples

EXAMPLE using ONE-WAY ANOVA

Smokers

- IV- methods to quit smoking
- DV- # cigarettes/day

Group A Counseling	Group B Nicotine Patch	Group C Chantix
16.6	19.2	34.0
n = 8	n = 10	n = 9
F (2, 27) = 4.98, p = 0.01		

- Ho: *There is no significant difference in number of cigarettes per day between smokers who had counseling, used a nicotine patch, or used Chantix.*
- Ha: *There is a significant difference in number of cigarettes per day between smokers who had counseling, used a nicotine patch, or used Chantix.*

ANCOVA (Analysis of Covariance)

- 3 or more Groups
  - Comparing 3 or more means
- 1 Independent Variable (factors)
- 1 Dependent Variable
- **Adjusts scores on dependent variable**
  - Removes effect of confounding variables (covariates)

- Assumptions
  - Normal distribution
  - DV at least Interval level
  - Variances in groups are same
  - Independent samples
  - Independence between covariate & IV
  - Relationship between covariate & DV stays the same

EXAMPLE using ANCOVA

EXERCISE STUDY

- IV- Exercise
  - No exercise
  - Exercise 1x / week
  - Exercise 3x's / week
  - Exercise 5x's / week
- DV- Health Problem Index
- Confounding variable: weight

EXAMPLE USING TWO-WAY ANOVA

- Smokers study
  - IV #1- Methods to quit smoking (Factor A)
  - IV #2- Gender (Factor B)
  - DV- # cigarettes/day

H_{01}: *There is no significant difference in the mean # cigarettes/day among participants getting counselling or the nicotine patch.*

H_{02}: *There is no significant difference in the mean # cigarettes/day among male or female participants.*

H_{03}: *There is no significant interaction effect between gender and method used..*

Factor B- Gender	Factor A- Treatment		
	Counseling (1)	Patch (2)	
Female (1)	$X_{a1b1} = 22.0$	$X_{a2b1} = 20.0$	$X_{b1} = 21.0$ (female)
Male(2)	$X_{a2b2} = 16.0$	$X_{a2b2} = 30.0$	$X_{b2} = 21.0$ (male)
	$X_{a1} = 21.0$ (treatment)	$X_{a2} = 21.0$ (treatment)	

RM-ANOVA (Repeated Measures ANOVA)

- Dependent Sample
  - Comparing 3 or more means
    - DV measured at different times
    - >2 IV to same group
- 1 or more Independent Variables
- 1 or more Dependent Variable
- Results reported as
  - $F(1, 108) = 3.93, p < 0.001$

Assumptions

- Normal distribution
- DV at least Interval level
- Variances in groups are same
- Sphericity

RM-ANOVA EXAMPLES

Example 1

n = 100		
Baseline *m*(SD)	Time 1 *m*(SD)	Time 2 *m*(SD)
16.6 (2.78)	19.2 (1.51)	34.0 (2.13)
DV: Quality of sleep		

Example 2

n = 100		
Video Game (Weeks 1-4)	Music (Weeks 5-8)	Television (Weeks 9-12)
9.4(1.96)	16.9(3.05)	13.8 (2.63)
DV: Quality of sleep		

Example 3

n = 100			
	Video Game (Weeks 1-4)	Music (Weeks 5-8)	Television (Weeks 9-12)
Male	12.4(2.16)	16.9(3.05)	13.8 (2.63)
Female	14.9 (3.21)	18.3(2.78)	15.5 (1.45)
DV: Quality of sleep			

NONPARAMETRIC TESTS: Kruskal-Wallis

- **Compares medians**
  - Any assumption of ANOVA testing is violated
  - Small sample size
- Assumptions
  - Random samples
  - Independent samples
  - Level of measurement: Ordinal, Interval, or Ratio
- Only tells that measurements differ
  - Mann-Whitney test provides which differ significantly

NONPARAMETRIC TESTS: Friedman's ANOVA

- Nonparametric equivalent for **RM-ANOVA**
  - Uses ranked data
  - Any assumption of ANOVA testing is violated
  - Small sample size
- Assumptions
  - Independent measurements
  - Level of measurement: Ordinal, Interval, or Ratio
- Only tells that measurements differ
  - Wilcoxon Signed-rank test provides which differ significantly

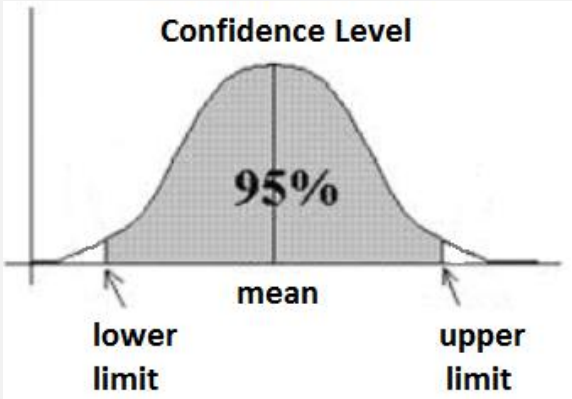
STATISTICAL SIGNIFICANCE vs. CLINICAL SIGNIFICANCE

Statistical Significance

- Results unlikely to caused by chance
- Dependent upon Power and # of subjects in a study
- The larger the sample the greater the power & probability of detecting significant results between variables

Clinical Significance

- Magnitude of risk reduction
- Precision of the treatment effect
  - Effect Size (ES)
    - Cohen's *d* calculation
  - Confidence Interval (CI)



EFFECT SIZE CALCULATION- COHEN'S *d*

$$\frac{\text{mean}^1 - \text{mean}^2}{SD^1 + SD^2 / 2}$$

- Small ES ≥ .20
- Medium ES ≥ .50
- Large ES ≥ .80

EXAMPLE OF CLINICAL SIGNIFICANCE

- Research Question: "In teens, what is the effect of imagery on anxiety level"
- 20 teens in Control Group, 20 teens in Experimental Group
  - Control group $\mu = 40\ (25)$
  - Experimental group $\mu = 50\ (15)$
  - $p = 0.15$
- Cohen's d $\frac{50-40}{25+15/2} \rightarrow \frac{10}{20} \rightarrow$ 0.5 or Medium Effect size