TOPICS TO BE DISCUSSED

- Data types
- Statistical significance – p value, alpha value and confidence interval
- Parametric and non parametric test
- Normality testing
- Chi Square of association
- Student T test
- Correlation – Pearson’s Correlation
- Regression – Linear and logistic
- Mann Witney U test
- Kaplein Meier test
- Kappa estimate

DATA TYPES

QUANTITATIVE
(takes numerical values)

- Discrete (Whole numbers)
  eg. Number of children

- Continuous (takes decimal places)
  eg. Height and weight

QUALITATIVE
(takes coded numerical values)

- Ordinal (ranking order exists)
  eg. Pain severity

- Nominal (no ranking order)
  eg. Race, gender

THE P VALUE

- Null hypothesis (H0) - The observed result is due to chance
- Alternate hypothesis (H1) - The observed result represents the true situation
- P value < 0.05 – Rejects the null hypothesis
- By convention, P is set at 0.05 which means that one accepts a 5% probability of chance

RATIONALE OF STATISTICAL SIGNIFICANCE

- Researchers can never prove any statement as there are infinite alternatives as to why outcome may have occurred
- Only solution is disproving null hypothesis
- Researcher cannot be 100% certain of outcome even when disproving hypothesis
- Significance level/Alpha level – Probability of researcher willing to be incorrect

Tenny et. al. Stat Pearls. Jan 2021

RATIONALE OF STATISTICAL SIGNIFICANCE

- p value – Probability of null hypothesis being true

- Study is statistically significant if p-value is less than pre specified alpha level

Tenny et. al. Stat Pearls. Jan 2021

CONFIDENCE INTERVAL

- 95% CI –95% probability that true population parameter will be within that interval
- If 95% CI describing the difference between two values includes one then obviously P > 0.05

- 1.28 (95% CI, 1.2 to 1.4) P < 0.05

- 1.28 (95% CI, 0.9 to 1.4) P > 0.05

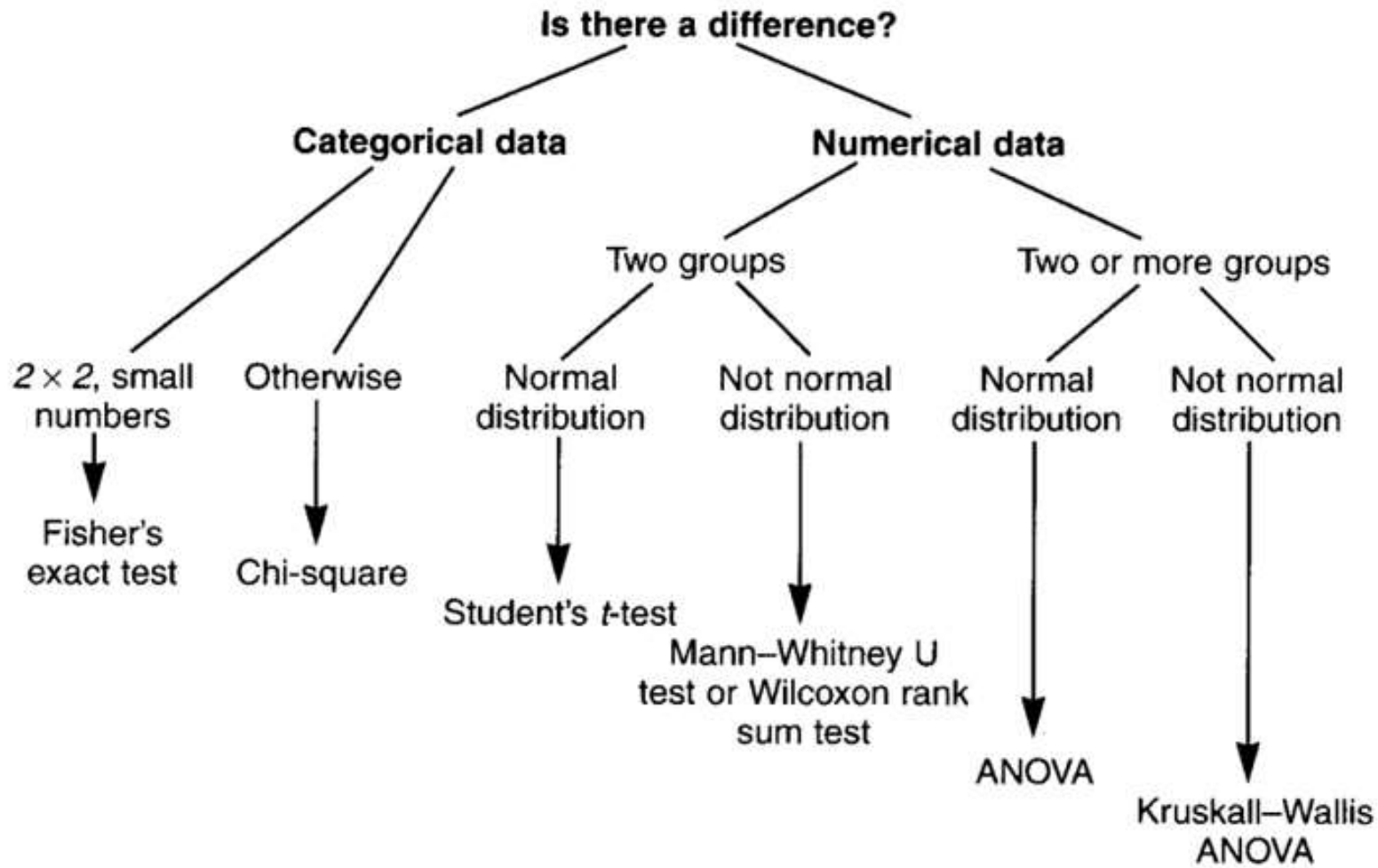
CONFIDENCE INTERVAL

- Trial with positive result - Focus on lower boundary of confidence interval and determine if it is greater than the smallest treatment benefit
- Studies with negative result - Examine upper boundary of confidence interval to determine if this value is lower than the smallest treatment benefit

if confidence interval overlaps smallest treatment benefit that is important to patients, then study is not definitive and larger study is needed

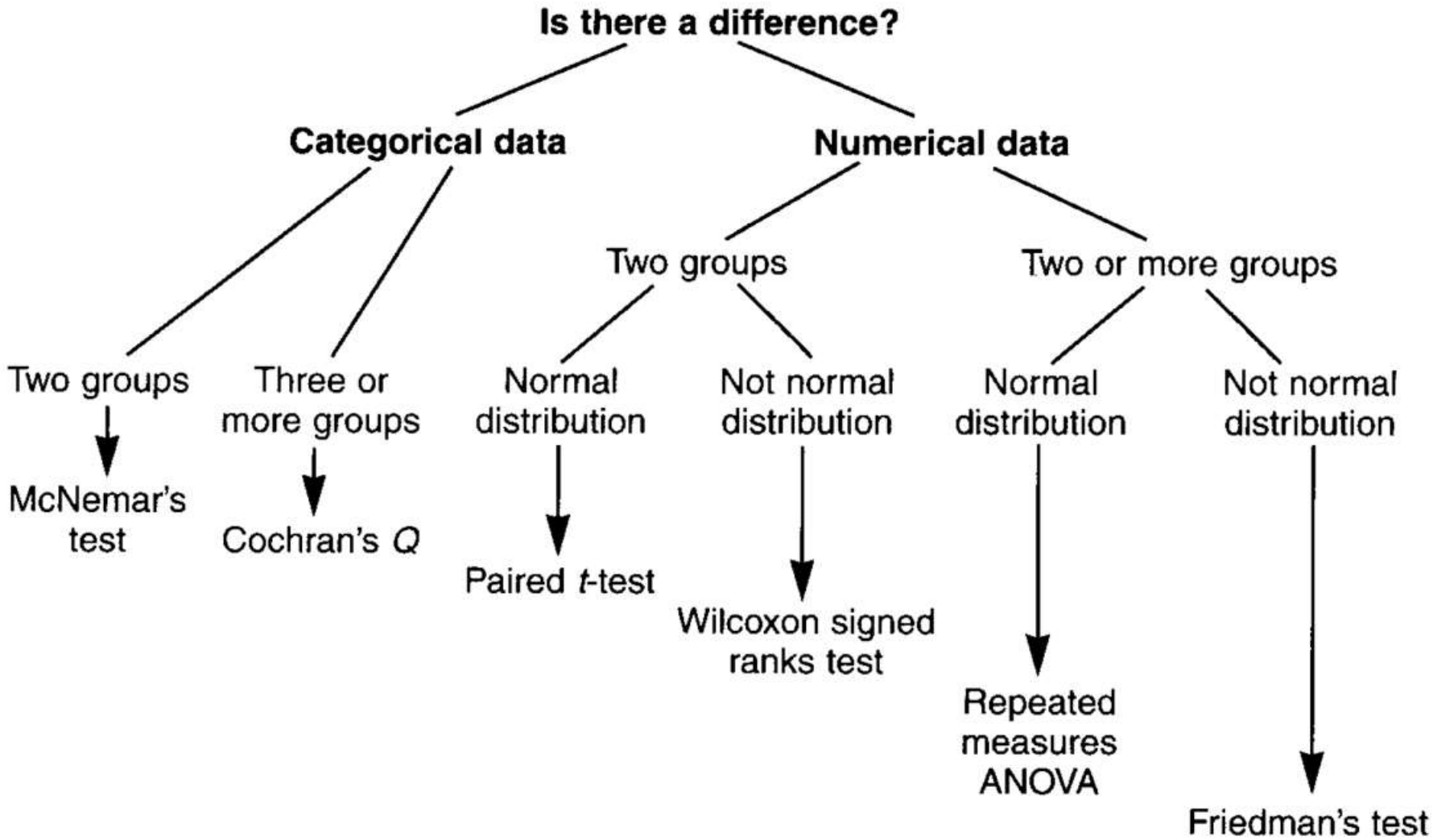
Montori et. al. CMAJ • SEPT. 14, 2004

2 or more independent groups



COURTESY : Prof. RITESH AGARWAL

2 or more dependent groups



COURTESY : Prof. RITESH AGARWAL

PARAMETRIC AND NON-PARAMETRIC TESTS

- Parametric: If normality and homogeneity of variance assumptions satisfied
- Non-Parametric: If above assumptions not satisfied, then equivalent non-parametric test used

PARAMETRIC	NON PARAMETRIC
1 Sample T-test	Sign test/ Wilcoxon Signed Rank test
Paired T-test	Sign test/Wilcoxon Signed Rank test
2 Sample test	Mann Whitney U test/ Wilcoxon Sum Rank test
ANOVA	Kruskal Wallis test

Y H Chan, Singapore Med J 2003 Vol 44(8)

PARAMETRIC TESTS

- 1 Sample T test – Determines whether mean of single variable differs from specified constant
- 2 Sample T-test – Between group comparison
- Paired T test – Within group comparison (before and after)

NON PARAMETRIC TESTS

- Sign test – Magnitude of differences between variable and norm is not taken into consideration. Uses number of positives and negatives of differences. If equal numbers of positives and negatives, then no statistical significance whatever magnitude of positives/negatives
- Wilcoxon Signed Rank test – Uses magnitude of positives/negatives as ranks in calculation of significance

NORMALITY TESTING

- **METHODS FOR CHECKING NORMALITY**

- GRAPHS – Histogram and Q-Q plots

- Q-Q plots compares quantiles of data distribution with quantiles of standardized theoretical distribution from specified family of distributions (in this case normal distribution)

NORMALITY TESTING

- **METHODS FOR CHECKING NORMALITY**

- If distributional shapes differ – points will plot along curve instead of line

- To note central portion of line, severe deviations means non-normality

- Deviations at ends of curve signifies existence of outliers

INTERPRETATION

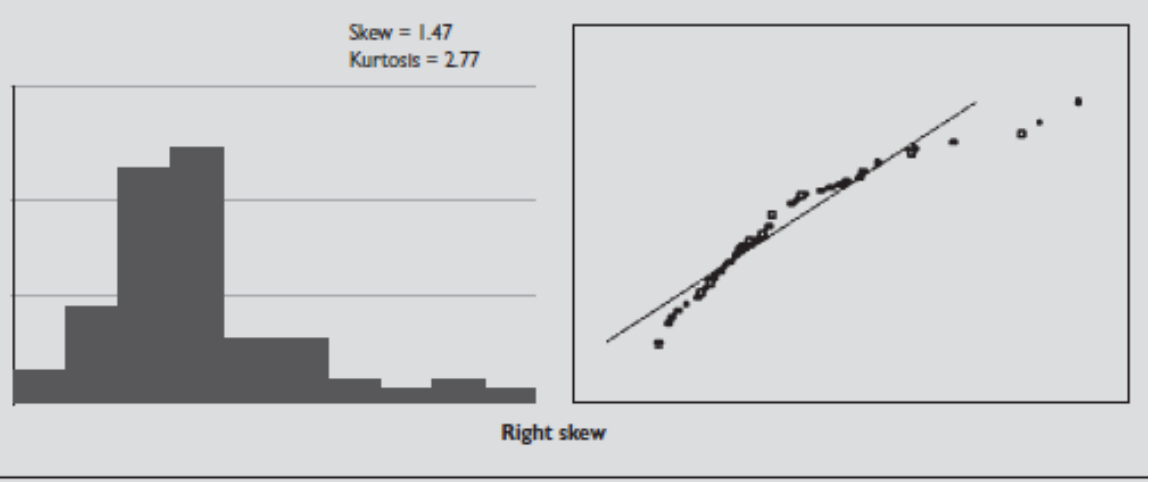
- Three types of Skewness

- Right skew > 0
- Normal skew – 0
- Left skew < 0

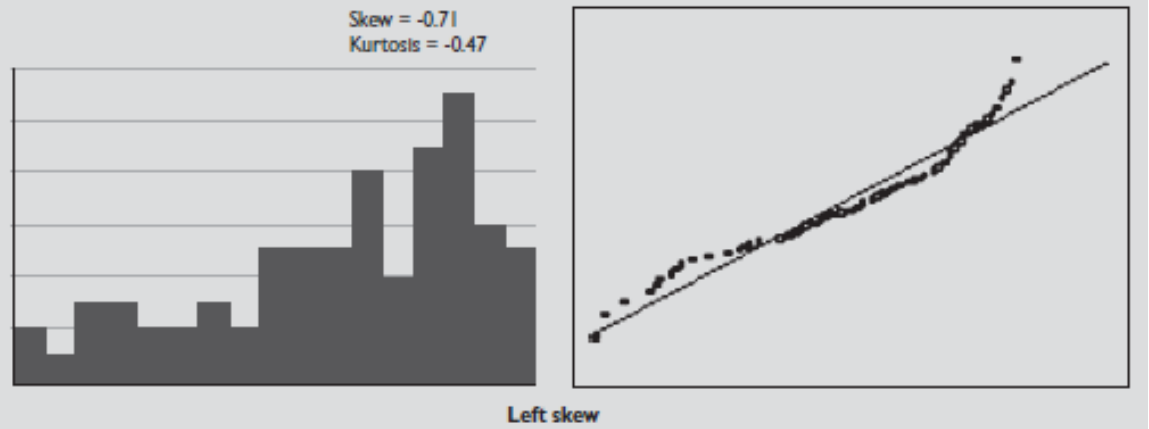
Skewness ranges from -3 to 3. Acceptable range -1 to 1

Kurtosis – measures peakness of bell curve

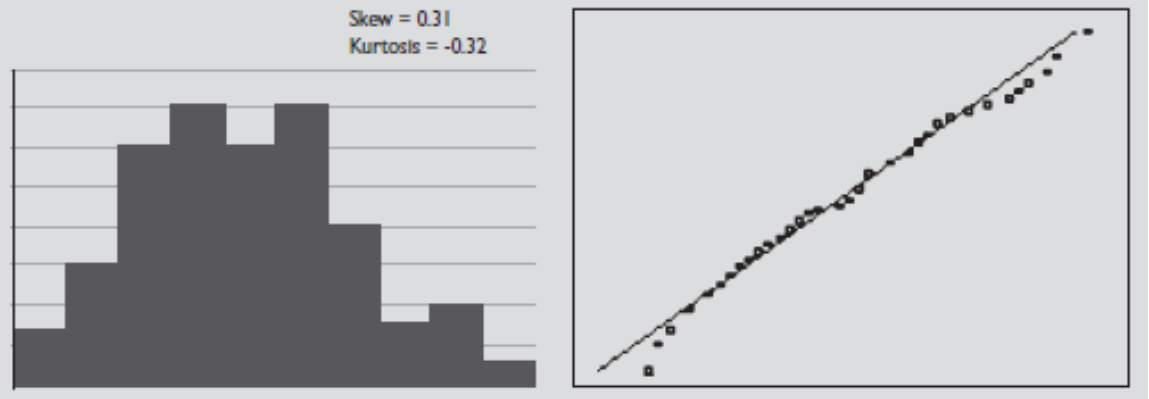
- Acceptable range between -1 to 1

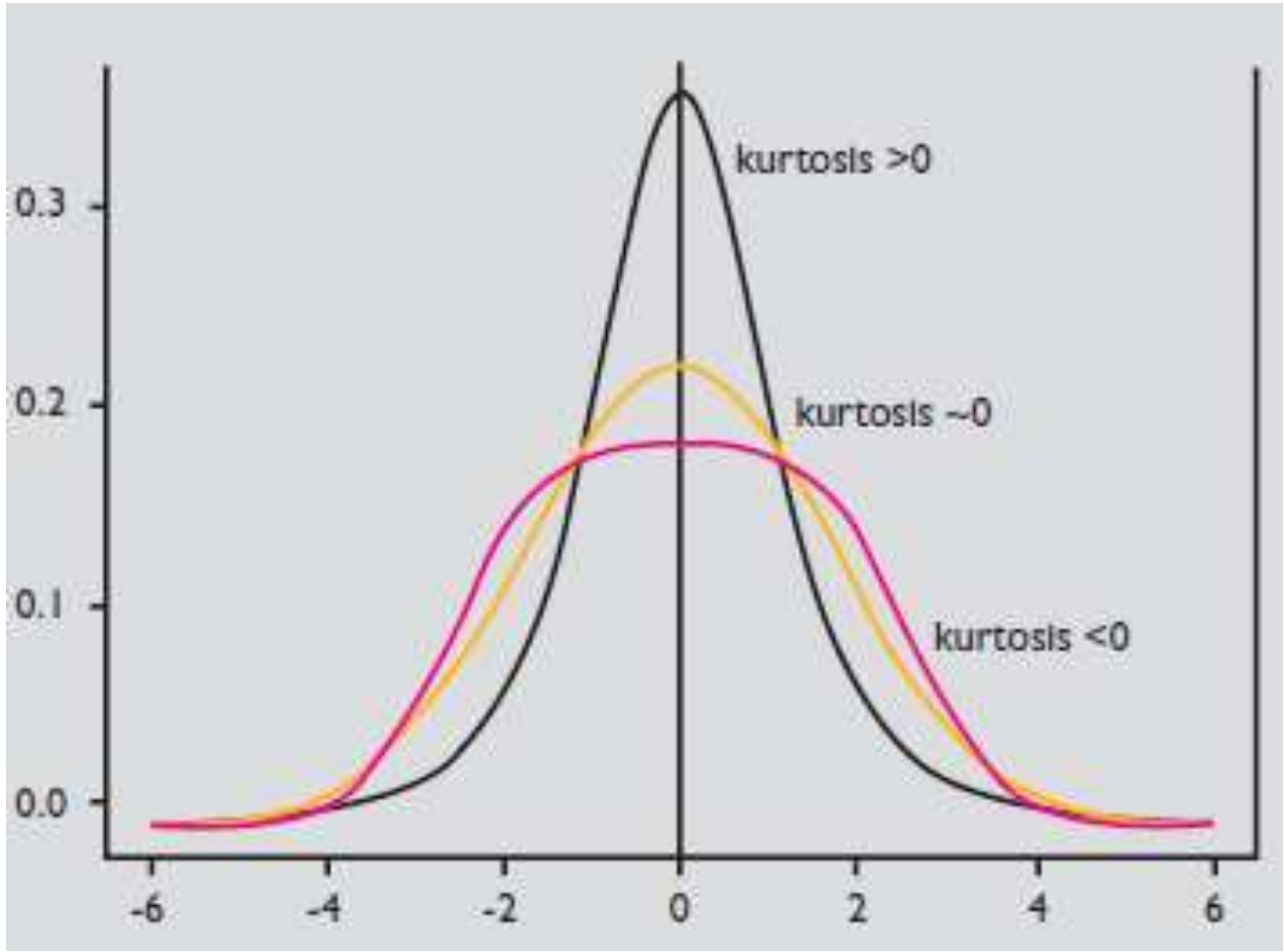


Right skew



Left skew





FORMAL TESTING OF NORMALITY

Tests of Normality

Course		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Time	Beginner	.177	10	.200*	.964	10	.827
	Intermediate	.166	10	.200*	.969	10	.882
	Advanced	.151	10	.200*	.965	10	.837

- Tests of normality - The Kolmogorov-Smirnov Test and The Shapiro-Wilk Test
- The Shapiro-Wilk Test more appropriate for small sample sizes (< 50 samples), but can also handle sample sizes as large as 2000
- If **Sig.** value of the Shapiro-Wilk Test > 0.05 – normally distributed data
- If < 0.05 - significant deviation from normal distribution

FLOWCHART FOR NORMALITY CHECKING

- Small samples (n<30) – always assume not normal

- Moderate samples (30-100)

If formal test significant, accept non-normality otherwise double check using graphs, skewness and kurtosis to confirm normality

- Large sample (n>100)

If formal test is not significant, accept normality otherwise Double-check using graphs, skewness and kurtosis to confirm non normality

Y H Chan Singapore Med J 2003 Vol 44

CHI-SQUARE TEST FOR ASSOCIATION

- Only for categorical data – nominal preferably
- Also known as Chi Square test of Independence
- Tests if 2 categorical variables are associated or statistically independent

Alan Agresti. Categorical Data Analysis, 3rd Edition

CHI-SQUARE TEST OF ASSOCIATION

- Determines association between 2 nominal variables
- Compare observed frequencies in cells to frequencies expected if no association between 2 nominal variables
- Expected frequencies predicted on basis of no association

CHI-SQUARE TEST OF ASSOCIATION

- Greater difference in observed and expected frequencies, greater association between 2 nominal variables
- Tests overall amount of difference between expected and observed frequencies
- Larger difference, greater association and more likely statistically significant result

ASSUMPTIONS

- Assumption 1 - Two categorical variables
- Assumption 2 - Independence of observations means no relationship between observations in groups of categorical variables or between groups themselves
- Assumption 3 - All cells should have expected counts greater than five

EXAMPLE

- Researcher knows that in general population of active individuals, males tend to engage in competitive sports whilst females prefer non-competitive sport/exercise
- Researcher would like to investigate whether this is case for males and females that are currently enrolled in Exercise Science degree course
- They asked 25 males and 25 females whether they predominately participate in competitive sport or non-competitive sport/exercise

			comp		
			yes	no	Total
gender	male	Count	18	7	25
		Expected Count	14.0	11.0	25.0
		% within gender	72.0%	28.0%	100.0%
		% within comp	64.3%	31.8%	50.0%
		% of Total	36.0%	14.0%	50.0%
	female	Count	10	15	25
		Expected Count	14.0	11.0	25.0
		% within gender	40.0%	60.0%	100.0%
		% within comp	35.7%	68.2%	50.0%
		% of Total	20.0%	30.0%	50.0%
Total		Count	28	22	50
		Expected Count	28.0	22.0	50.0
		% within gender	56.0%	44.0%	100.0%
		% within comp	100.0%	100.0%	100.0%
		% of Total	56.0%	44.0%	100.0%

- All expected cells having frequencies greater than 5, Chi Square test can be used
- If any cell having cell frequency less than 5, we need to use Fischer exact test for interpretation

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.195[a]	1	.023		
Continuity Correction[b]	3.977	1	.046		
Likelihood Ratio	5.295	1	.021		
Fisher's Exact Test				.045	.023
Linear-by-Linear Association	5.091	1	.024		
N of Valid Cases	50				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.00.

b. Computed only for a 2x2 table

2 x 2 crosstabulation (i.e., where both variables are dichotomous - only have two categories), can choose to use result of either chi-square test for association ("Pearson Chi-Square" row) or Fisher's Exact test ("Fisher's Exact Test" row)

If one or both of your variables has more than two categories, Fisher's Exact test cannot be used

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.195[a]	1	.023		
Continuity Correction[b]	3.977	1	.046		
Likelihood Ratio	5.295	1	.021		
Fisher's Exact Test				.045	.023
Linear-by-Linear Association	5.091	1	.024		
N of Valid Cases	50				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.00.

b. Computed only for a 2x2 table

When one or more expected cell frequencies less than five, Fisher's Exact test for small sample size

CONCLUSION

- Chi-square test for association conducted between gender and preference for performing competitive sport
- All expected cell frequencies greater than five
- There was statistically significant association between gender and preference for performing competitive sport $p = .023$

STUDENT’S T-TEST

- Also known as Independent t-test, Independent measures t-test, Between-subjects t-test, Unpaired t-test and Student’s t test
- To determine if difference exists between means of two independent groups on continuous dependent variable
- Cases are taken from much larger populations and interest is in these populations

Welch et.al. Biometrika Vol 34

STUDENT’S T-TEST

- Independent-samples t-test determines whether difference exists between two group means in population
- Independent-samples t-test tests whether it is likely that the population means of the groups are different, not just the sample means

ASSUMPTIONS

- Assumption 1 - One dependent variable measured at continuous level
- Assumption 2 - One independent variable consisting of two categorical, independent groups (i.e., dichotomous variable)
- Assumption 3 - Independence of observations

ASSUMPTIONS

- Assumption 4 - No significant outliers in two groups of independent variable in terms of dependent variable
- Assumption 5 - Dependent variable should be approximately normally distributed for each group of independent variable
- Assumption 6 - Homogeneity of variances (i.e., variance of dependent variable is equal in each group of independent variable)

SAMPLE SIZE AND (UN)BALANCED DESIGNS

- Participants in each group ≥ 6
- BALANCED DESIGN - same number of participants in each group
- UNBALANCED DESIGN – unequal number of participants in each group

STUDY DESIGN

Check data meets Assumption 1, 2, 3

SPSS DESIGN

Set up 2 variables using variable view and data in data view

Using SPSS check Assumption 4 (outliers) and 5 (normality) simultaneously. Boxplot to check whether outliers in independent groups

Shapiro – Wilk test if dependent variable normally distributed for each dependent variable

After analyzing boxplot, (a) need to assess whether any outliers (b) remove or alter any of them (c) proceed anyways

Results from Shapiro-Wilk test for dependent variable, if normally distributed for each group of independent variable

If YES – Run Independent Samples T test

If NO – Mann-Whitney U test

EXAMPLE

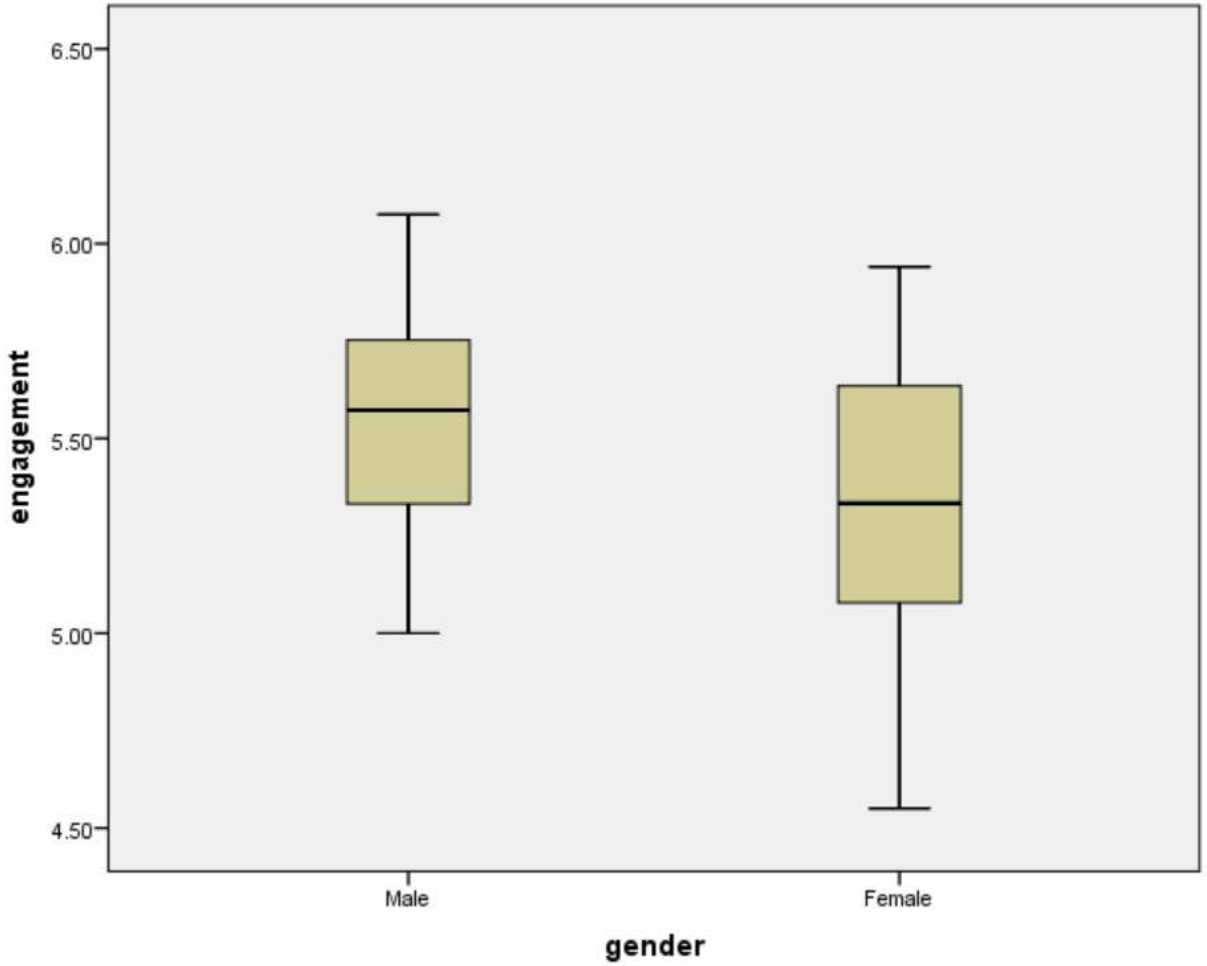
- Advertising Agency commissioned to create TV advert to promote new product
- Company wants to know whether way that men and women engage with TV advert is the same
- TV advert is shown to 20 men and 20 women, who are then asked to fill in questionnaire that measures their engagement with advertisement
- Questionnaire provides overall engagement score

ASSUMPTION 4

- Any data points more than 1.5 box-lengths from edge of their (brown-yellow) box are classified by SPSS Statistics as outliers - circular dots
- Any data points that are more than 3 box-lengths away from the edge of their box are classified as extreme points (i.e., extreme outliers) - asterisk (*)
- Both types of outliers are labelled with their case number – row number in the Data View window – for easy identification

ASSUMPTION 4

- No significant outliers in two groups of independent variable in terms of dependent variable



ASSUMPTION 6

- HOMOGENEITY OF VARIANCES –
- Means two group's variances equal in population
- Failure to adhere to this assumption increase chance of making Type I error

Descriptives

	gender			Statistic	Std. Error
engagement	Male	Mean		5.5589	.06527
		95% Confidence Interval for Mean	Lower Bound	5.4223	
			Upper Bound	5.6955	
		5% Trimmed Mean		5.5613	
		Median		5.5725	
		Variance		.085	
		Std. Deviation		.29190	
		Minimum		5.00	
		Maximum		6.08	
		Range		1.08	
		Interquartile Range		.46	
		Skewness		.028	.512
		Kurtosis		-.619	.992
	Female	Mean		5.2999	.08797
		95% Confidence Interval for Mean	Lower Bound	5.1158	
			Upper Bound	5.4840	
		5% Trimmed Mean		5.3060	
		Median		5.3338	
		Variance		.155	
		Std. Deviation		.39339	
		Minimum		4.55	
		Maximum		5.94	
		Range		1.39	
		Interquartile Range		.59	
		Skewness		-.394	.512
		Kurtosis		-.719	.992

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
engagement	Equal variances assumed	1.922	.174	2.365	38	.023	.25900	.10954	.03726	.48074
	Equal variances not assumed			2.365	35.055	.024	.25900	.10954	.03664	.48136

Use the significance level (*p*-value) of Levene's test to determine if variances are equal in the population

Check "Sig." column located under "Levene's Test for Equality of Variances" column

If population variance of both groups equal, p-value greater than 0.05 (i.e., $p > .05$), indicate that assumption of homogeneity of variances had met

p-value less than 0.05 ($p < .05$), population variances are unequal and assumption of homogeneity of variances violated

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
engagement	Equal variances assumed	5.555	.024	2.282	38	.028	.23438	.10271	.02644	.44231
	Equal variances not assumed			2.282	31.199	.029	.23438	.10271	.02494	.44381

- Levene's test returns statistically significant result (i.e., p = .024, which is p < .05)
- Assumption of homogeneity of variances is violated
- Referred to as heterogeneity of variances
- In this case need to use modified t-test is often referred to as the Unequal variance t-test, separate Variances t-test, or the Welch t-test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
engagement	Equal variances assumed	1.922	.174	2.365	38	.023	.25900	.10954	.03726	.48074
	Equal variances not assumed			2.365	35.055	.024	.25900	.10954	.03664	.48136

Use this row if you have met the assumption of homogeneity of variances

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
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	Equal variances not assumed			2.365	35.055	.024	.25900	.10954	.03664	.48136

Information on the mean difference between your two groups including likely ranges of the mean difference

	Part	Meaning	Column in Table
1	*t*	Indicates that we are comparing to a *t*-distribution (*t*-test).	
2	(38)	Indicates the degrees of freedom, which is *N* - 2	df
3	2.365	Indicates the obtained value of the *t*-statistic (obtained *t*-value)	t
4	*p* = .023	Indicates the probability of obtaining the observed *t*-value if the null hypothesis is correct.	Sig. (2-tailed)

CONCLUSION

- Independent-samples t-test run to determine if there were differences in engagement to an advertisement between males and females
- Advertisement more engaging to male viewers (5.56 ± 0.29) than female viewers (5.30 ± 0.39), statistically significant difference of 0.26 (95% CI, 0.04 to 0.48), p = 0.023
- Advertising company concluded mean difference of 0.26 was of little practical importance

REGRESSION AND CORRELATION

- Correlation and regression are used to describe the relationship between two numerical variables

- Correlation is a measure of association

- Spearman rank order (rho) is a non-parametric version of the Pearson correlation coefficient

- Regression is used for prediction

- $y = a + bx1 + cx2 + \ldots\ldots$

PEARSON'S CORRELATION

- To determine strength and direction of linear relationship between two continuous variables
- Pearson correlation coefficient, denoted as *r*
- High correlation does not give evidence to make cause and effect statement

Laerd Statistics (2018). Statistical tutorials and software guides

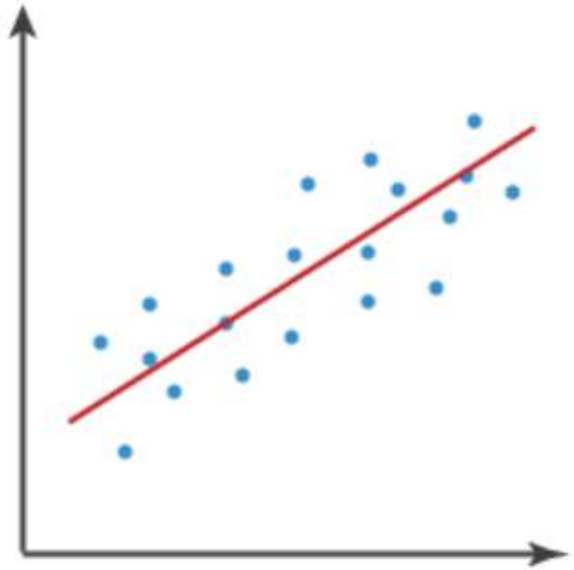
ASSUMPTIONS

- Assumption 1- Two variables should be measured on continuous scale (i.e., measured at interval or ratio level)
- Assumption 2 - Two continuous variables should be paired, each case (e.g., each participant) has two values: one for each variable
- Assumption 3 - Needs to be linear relationship between the two variables

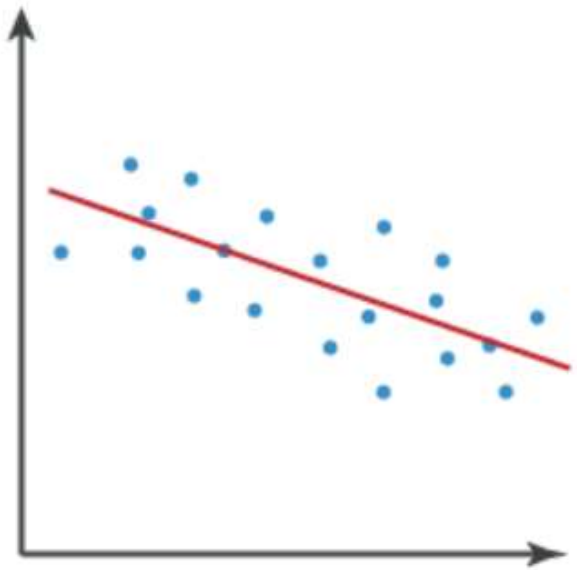
  Plot scatterplot and visually inspect graph
- Assumption 4 - No significant outliers
- Assumption 5 - Assumption of bivariate normality

- Assumption 5 Bivariate Normality required for statistical significance of Pearson's correlation coefficient
- Practically, difficult to assess
- Property of bivariate normality - if bivariate normality exists, both variables will be normally distributed
- Does not work in reverse; two normally distributed variables do not mean you have bivariate normality

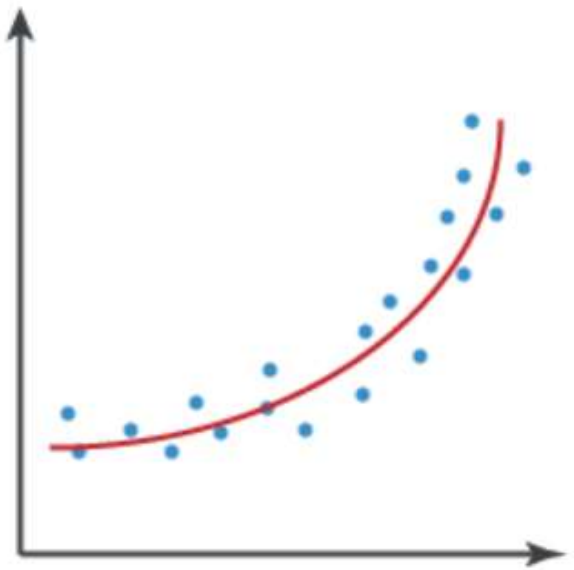
Linear relationship



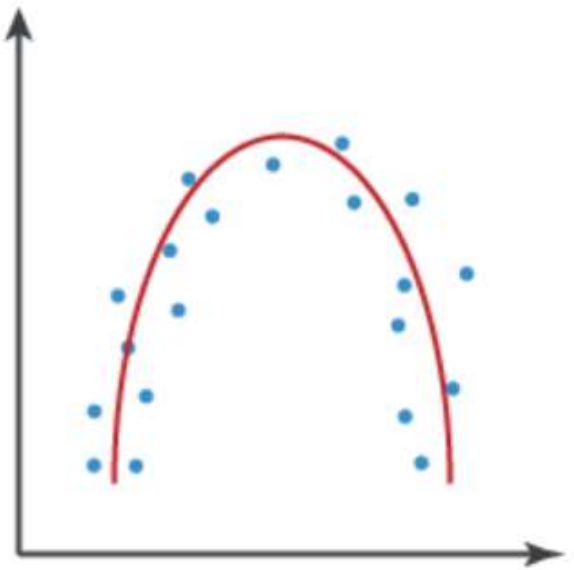
Linear relationship

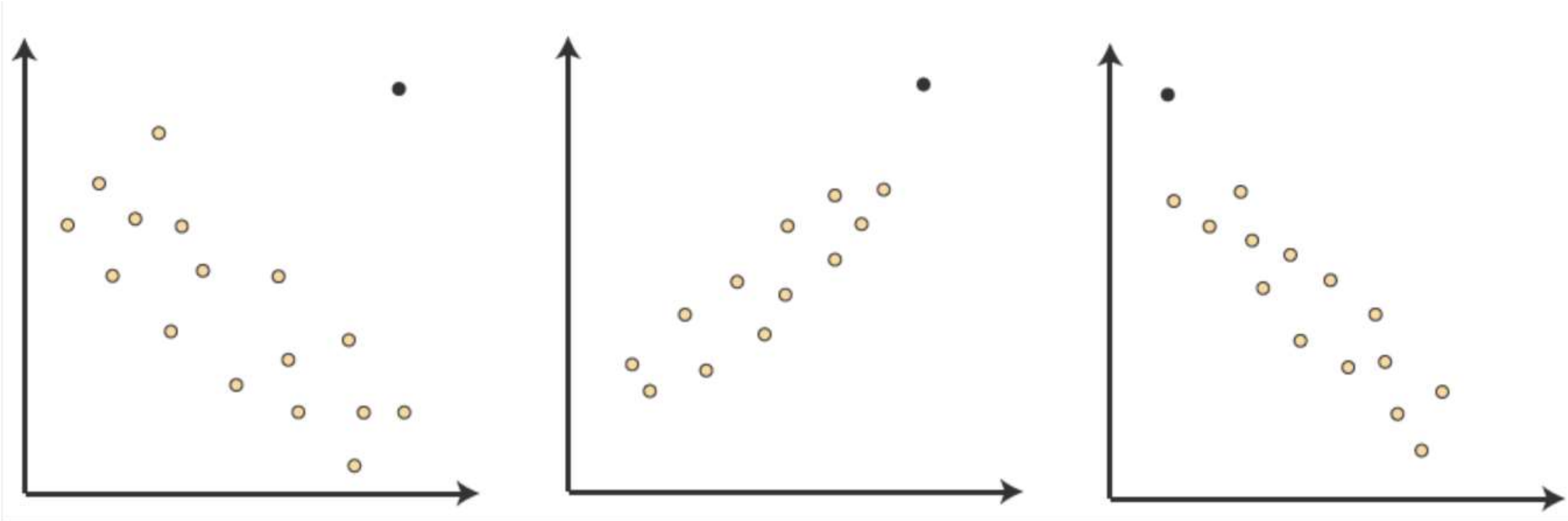


Non-linear relationship



Non-linear relationship





PEARSON'S CORRELATION IS SUSCEPTIBLE TO OUTLIERS

OUTLIERS RESULTS IN VALUE OF PEARSON'S CORRELATION COEFFICIENT BEING UNDULY ALTERED, EXERTING NEGATIVE INFLUENCE ON VALUE OF CORRELATION COEFFICIENT

INTERPRETATION

- Pearson's correlation coefficient value (rs or ρ) - measure of strength and direction of association between variables
- Coefficient of determination - Proportion of variance in one variable that is "explained" by other variable and calculated as square of correlation coefficient (r^2)

INTERPRETATION

- Closer correlation coefficient to zero, weaker the association, and closer the correlation coefficient to +1 or -1, stronger the association
- If $p < .05$ achieving statistically significant Pearson's correlation means less than 5% chance that strength of correlation coefficient happened by chance if null hypothesis were true

Correlations

		time_tv	cholesterol
time_tv	Pearson Correlation	1	.371**
	Sig. (2-tailed)		.000
	N	100	100
cholesterol	Pearson Correlation	.371**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

Row name	Row meaning
Pearson Correlation	Pearson's correlation coefficient, *r*.
Sig. (2-tailed)	Two-tailed significance value (*p*-value) of the correlation coefficient.
N	Number of paired observations (e.g., participants included in correlation). In other words, the sample size.

Correlation Coefficient value	Strength of linear relationship
At least 0.8	Very strong
0.6 up to 0.8	Moderately strong
0.3 to 0.5	Fair
Less than 0.3	Poor

PEARSON’S PARTIAL CORRLEATION

- Determine strength and direction of linear relationship between two continuous variables, whilst partialling out one or more continuous variables often called covariates
- Allows us to control for another continuous variable, called covariate, related to other two continuous variables

LINEAR REGRESSION

- Also known as Bivariate linear regression
- Dependent variable - outcome, target or criterion variable
- Independent variable - predictor, explanatory or regressor variable

LINEAR REGRESSION

- Outcome of interest is a continuous variable
- Numerous (continuous and categorical) variables can be included in the equation
- The specific effect on individual variables on outcome can be adjusted according to the presence of other variables
- Simple linear regression assesses linear relationship between two continuous variables to predict value of dependent variable based on value of independent variable

USE OF LINEAR REGRESSION

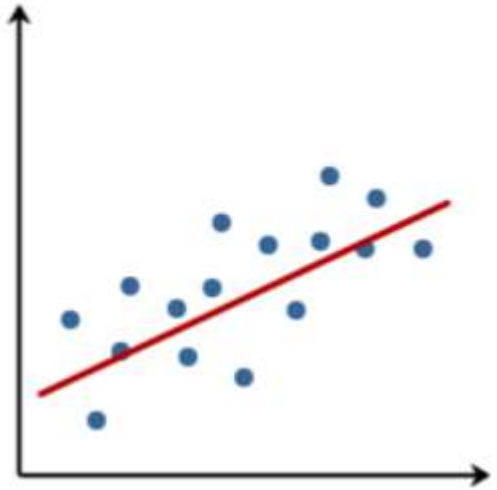
- Determine change in dependent variable for a one unit change in independent variable
- Determine how much of variation in dependent variable is explained by independent variable
- Predict new values for dependent variable given independent variable

LINEAR REGRESSION

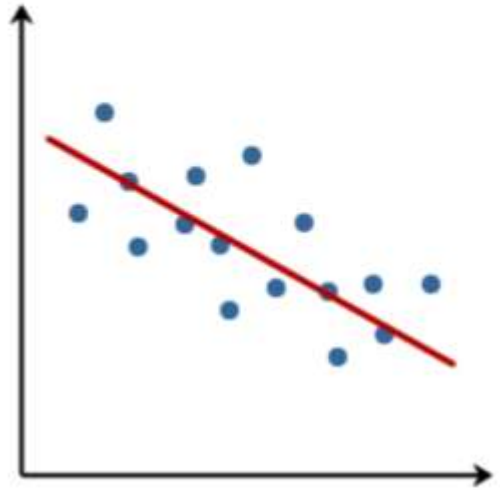
- Assumption 1 - One dependent variable measured at continuous level
- Assumption 2 - One independent variable measured at continuous level
- Assumption 3 – Linearity

  Checked by plotting scatterplot

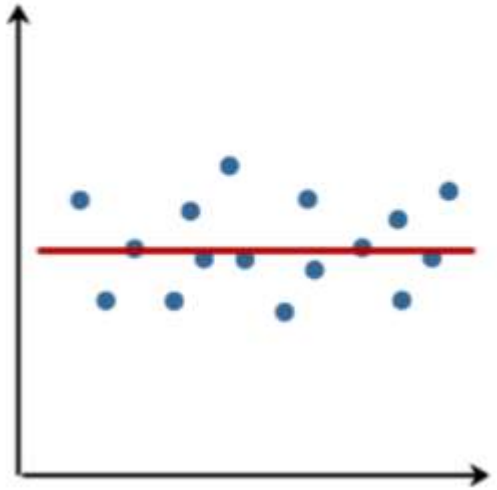
Linear



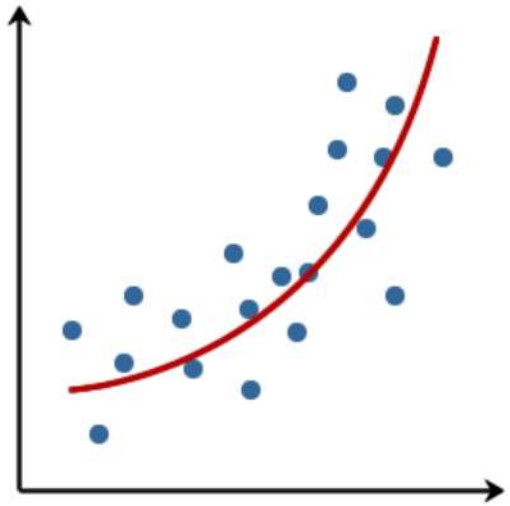
Linear



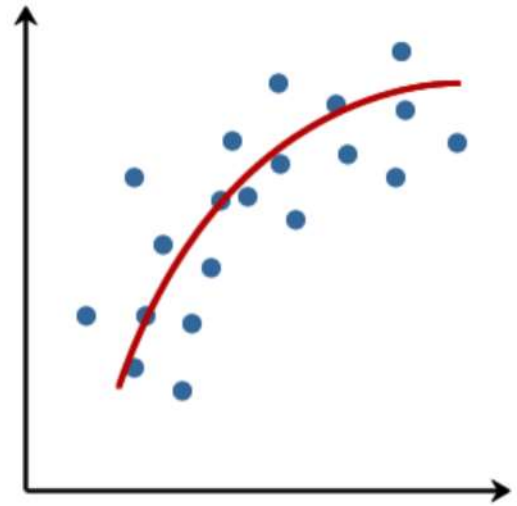
No linear relationship



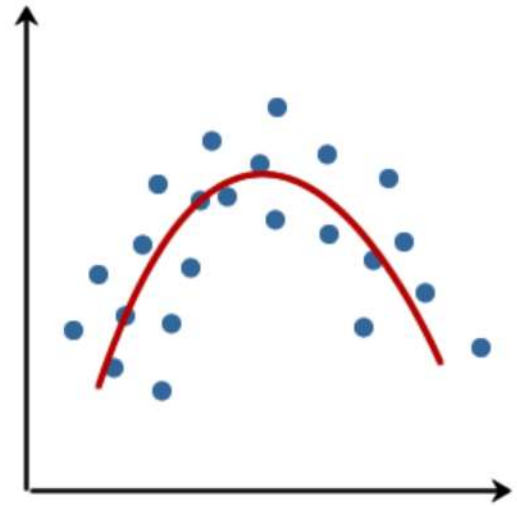
Non-Linear



Non-Linear



Non-Linear



STUDY DESIGN

Check data meets Assumption 1, 2, 3

SPSS DESIGN

Set up 2 variables using variable view and data in data view

Using SPSS check Assumption 3 (linearity)

Assess for Assumption 4 (Independence of observations), Assumption 5 (Outliers), Assumption 6 (Homoscedasticity) Assumption 7 (Normality) (tested with histogram or Normal P-P plot)

Results from case diagnostics for outliers, inspect scatterplot using standardized residuals and assess variances along line of best fit remain similar moving along line – testing assumption of homoscedasticity

If YES – Run analysis

Laerd Statistics (2015). Statistical tutorials and software guides

DEALING WITH OUTLIERS

- OUTLIERS - Observed value of dependent variable is very different to its predicted value

- ISSUES:

- Detrimental effect on regression equation and statistical inferences

- large effect on variability of residuals, leading to problems with normality or homoscedasticity

DEALING WITH OUTLIERS

- Significant effect on line of best fit (regression line)
- **Casewise Diagnostics** table highlights any cases where that case's standardized residual is greater than ±3 standard deviations

Casewise Diagnostics[a]

Case Number	Std. Residual	Cholesterol concentration	Predicted Value	Residual
91	4.059	7.98	5.7977	2.18233

a. Dependent Variable: Cholesterol concentration

TESTING FOR HOMOSCEDASTICITY

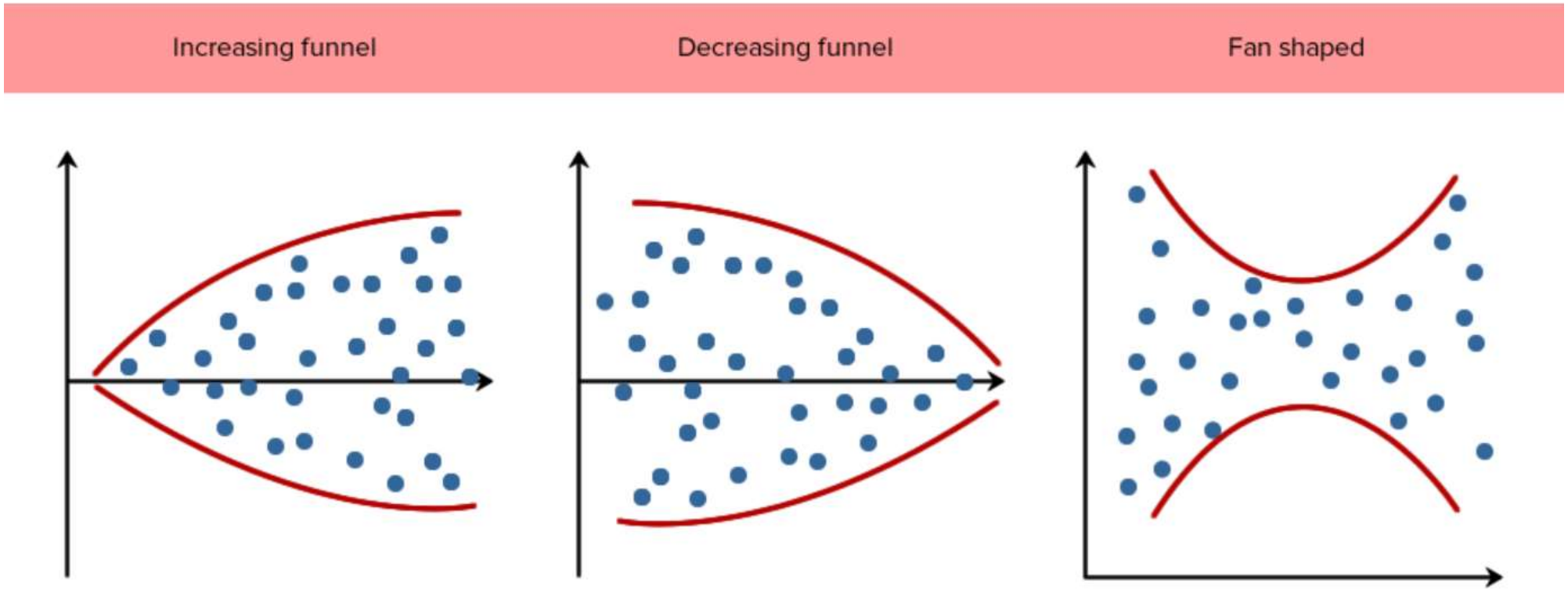
- Variance of errors (residuals) is constant across all values of independent variable
- Homoscedasticity the residuals (errors of prediction) - Equal across standardized predicted (i.e., fitted) values - Points of plot above will exhibit no pattern and will be approximately constantly spread across the fitted values

NORMALITY OF RESIDUALS

Checking for normality of residuals – the Histogram and the Normal P-P Plot

TESTING FOR HOMOSCEDASTICITY

- Heteroscedasticity - if residuals are not evenly spread, but differ in height (e.g., a funnel shape)



DETERMINING HOW WELL THE MODEL FITS

- To determine whether linear regression model is good fit for data

- Percentage (or proportion) of variance explained

- Statistical significance of overall model

- Precision of predictions from regression model

PERCENTAGE OF VARIANCE EXPLAINED

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.359[a]	.129	.120	.49100	1.913

a. Predictors: (Constant), Time in minutes spent watching TV

b. Dependent Variable: Cholesterol concentration

R- Multiple Correlation Coefficient

In simple linear regression – only one independent variable, so R – Pearson's correlation coefficient

Measure of strength of association between two variables

The R^2 value represents proportion of variance in dependent variable that can be explained by independent variable

Adjusted R^2 - Percentage of variation explained by model in population

STATISTICAL SIGNIFICANCE OF MODEL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.470	1	3.470	14.395	.000[b]
	Residual	23.385	97	.241		
	Total	26.856	98			

a. Dependent Variable: Cholesterol concentration

b. Predictors: (Constant), Time in minutes spent watching TV

Regression model is statistically significant, $p < .05$

Indicating statistically significant linear relationship

	Column name	Column meaning
	F	Indicates that we are comparing to an *F*-distribution (*F*-test).
	1 in (1, 97)	Indicates the regression (aka model) degrees of freedom ("df").
	97 in (1, 97)	Indicates the residual (aka error) degrees of freedom ("df").
	14.40	Indicates the obtained value of the *F*-statistic (obtained *F*-value).
	$p < .0005$	Indicates the probability of obtaining the observed *F*-value if the null hypothesis is true.

EXAMPLE

- Researcher decided to determine if cholesterol concentration related to time spent watching TV in otherwise healthy 45 to 65 year old men (at-risk category of people)
- They believed that there would be positive relationship: more time people spent watching TV, greater their cholesterol concentration.
- Researcher also wished to be able to predict cholesterol concentration and to know proportion of cholesterol concentration that time spent watching TV could explain

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.944	1.677		-.563	.575	-4.272	2.383
	Time in minutes spent watching TV	.037	.010	.359	3.794	.000	.018	.056

a. Dependent Variable: Cholesterol concentration

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

β_0 is intercept (also known as intercept or constant), β_1 is slope parameter (also known as the slope coefficient), and ε represents the errors

Value of intercept denoted "**(Constant)**" column under the "**B**" column

Its value of dependent variable when the independent variable is zero

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.944	1.677		-.563	.575	-4.272	2.383
	Time in minutes spent watching TV	.037	.010	.359	3.794	.000	.018	.056

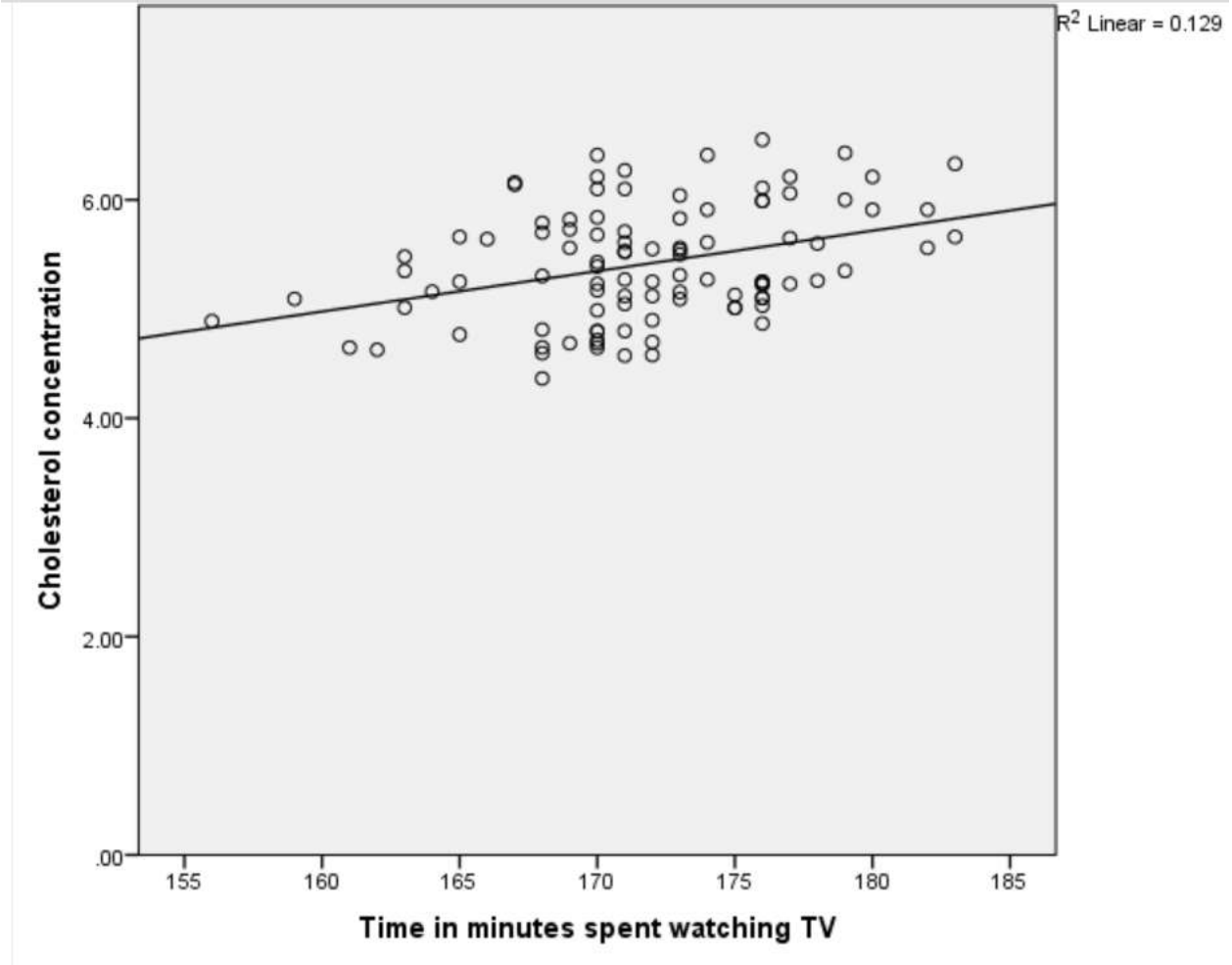
a. Dependent Variable: Cholesterol concentration

Major point of interest - slope coefficient represents the change in the dependent variable for a one unit change in the independent variable

95% confidence intervals reported in "Lower Bound" and "Upper Bound" columns found under "95% Confidence Interval for B" column

If p <. 05, slope coefficient is statistically significant relating to linear relationship in population

- From above table we generate regression equation, by using intercept and slope
- This scatterplot can be used to plot dependent variable against independent variable, as well as fitting "line of best fit"



cholesterol concentration = -0.944 + (0.037 x time_tv)

RESULTS

- Linear regression established that daily time spent watching TV could statistically significantly predict cholesterol concentration, $p < .0005$
- Time spent watching TV accounted for 12.9% of the explained variability in cholesterol concentration
- Regression equation: predicted cholesterol concentration = -0.944 + 0.037 x (time spent watching tv)

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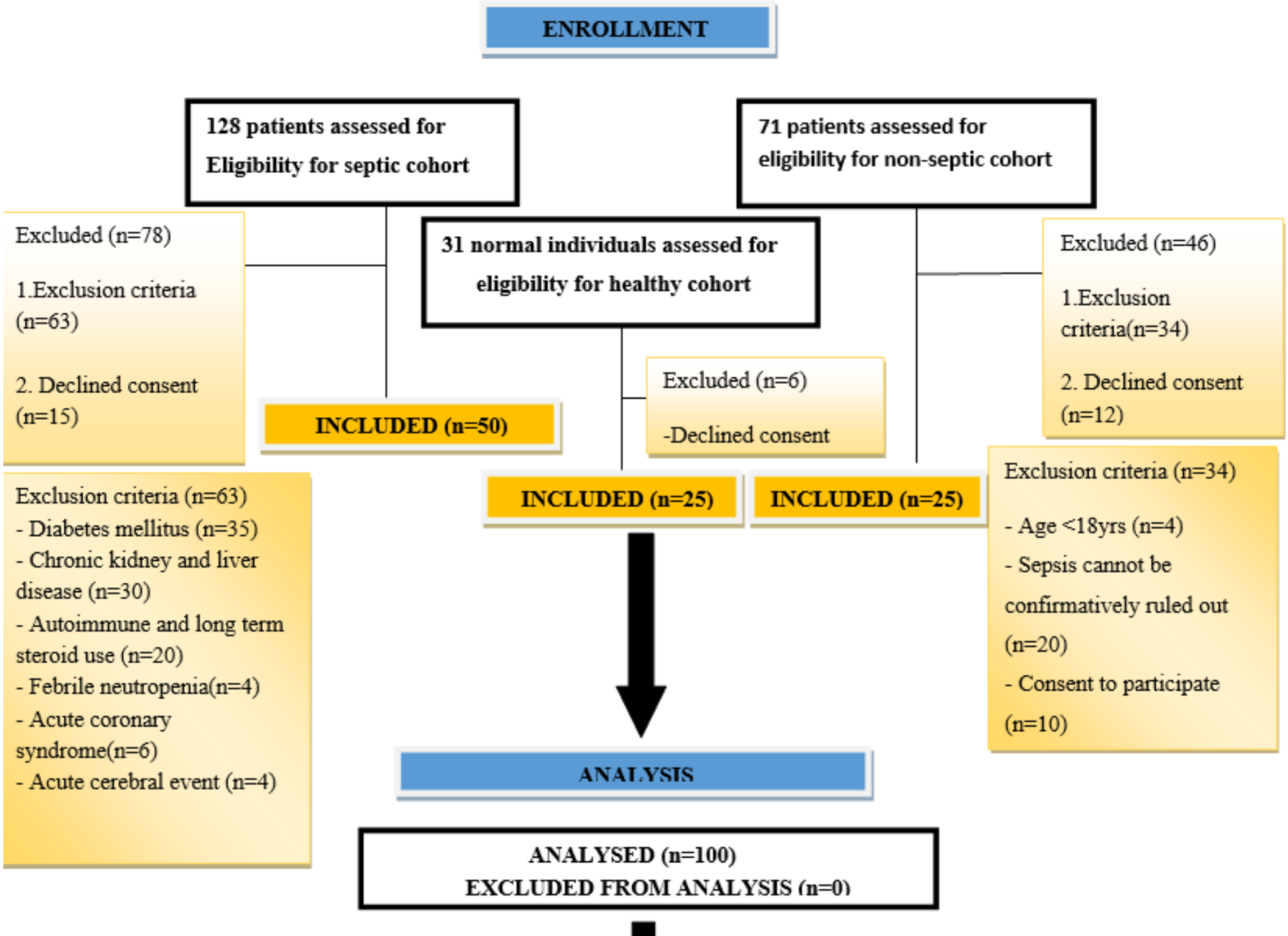
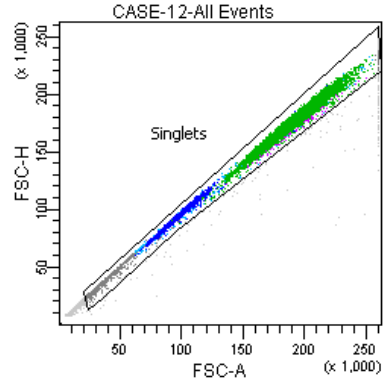
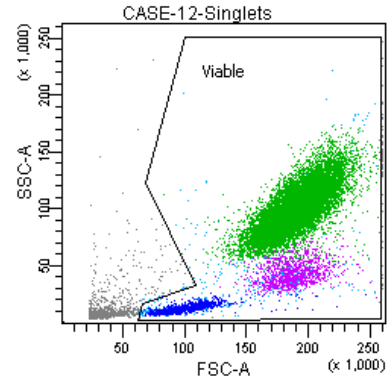
TESTS OF STATISTICAL SIGNIFICANCE

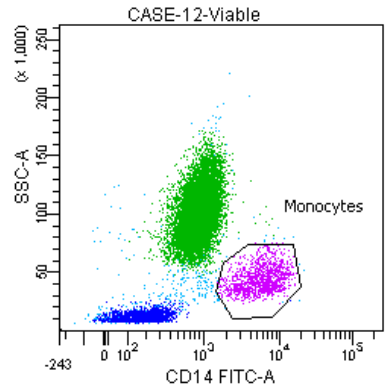
KAJAL ARORA

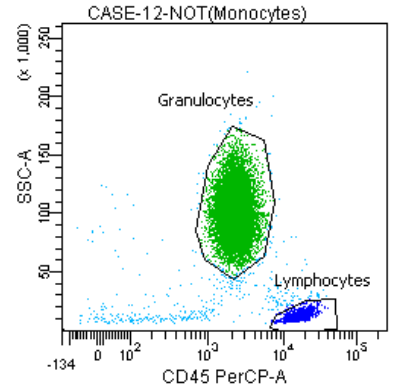
06.08.21

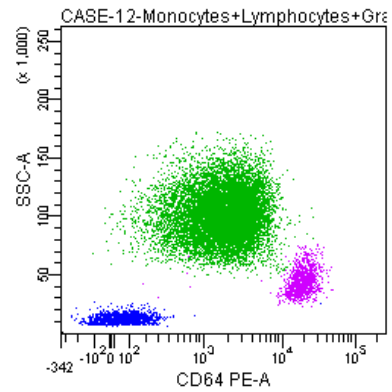

ENROLLMENT
128 patients assessed for Eligibility for septic cohort
71 patients assessed for eligibility for non-septic cohort
31 normal individuals assessed for eligibility for healthy cohort
Excluded (n=78)
1.Exclusion criteria (n=63)
2. Declined consent (n=15)
Excluded (n=46)
1.Exclusion criteria(n=34)
2. Declined consent (n=12)
Excluded (n=6)
-Declined consent
INCLUDED (n=50)
INCLUDED (n=25)
INCLUDED (n=25)
Exclusion criteria (n=63)
- Diabetes mellitus (n=35)
- Chronic kidney and liver disease (n=30)
- Autoimmune and long term steroid use (n=20)
- Febrile neutropenia(n=4)
- Acute coronary syndrome(n=6)
- Acute cerebral event (n=4)
Exclusion criteria (n=34)
- Age <18yrs (n=4)
- Sepsis cannot be confirmatively ruled out (n=20)
- Consent to participate (n=10)
ANALYSIS
ANALYSED (n=100)
EXCLUDED FROM ANALYSIS (n=0)

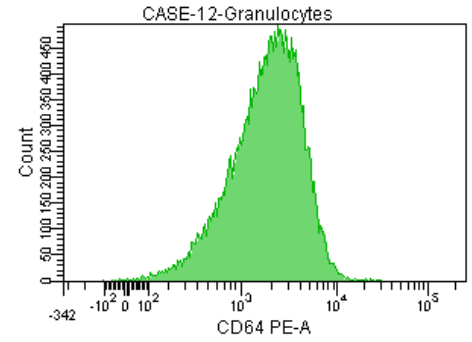












Specimen Name: CASE-12

Population	CD64 PE-A Min	CD64 PE-A Max	CD64 PE-A Mean	CD64 PE-A Median	CD64 PE-A SD	CD64 PE-A %CV
Monocytes	186	53,259	20,477	19,626	6,282	30.7
Lymphocytes	-252	35,330	82	66	676	829.2
Granulocytes	-107	28,549	2,298	1,892	1,757	76.4

Quantibrite curve fitting (1) - Excel (Product Activation Failed)

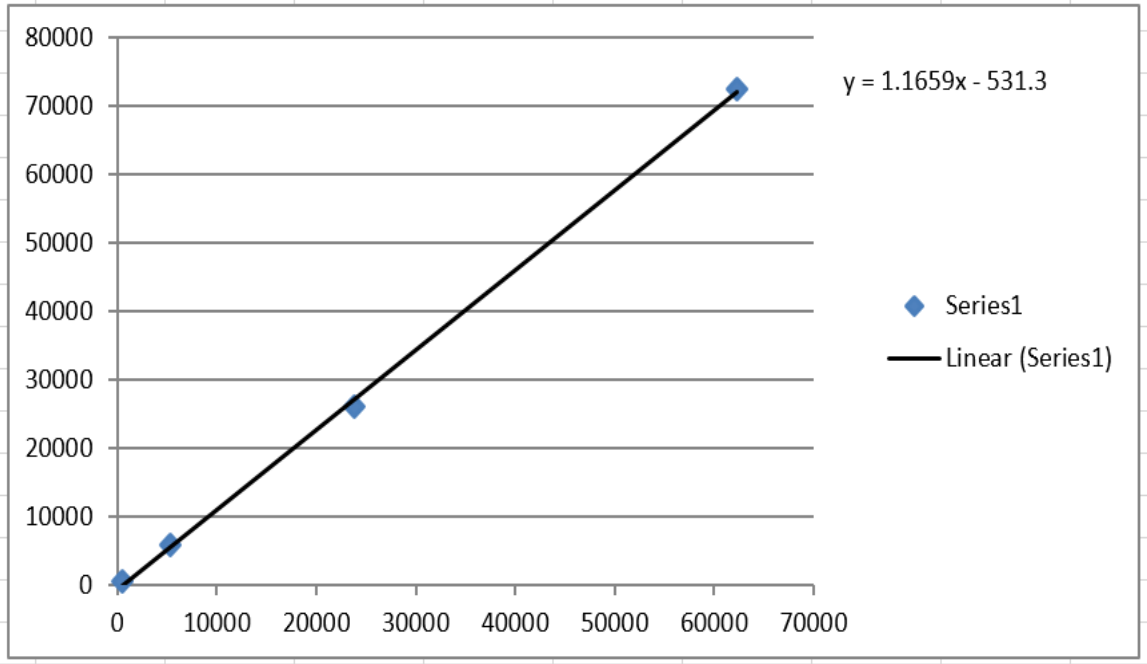
File Home Insert Page Layout Formulas Data Review View Acrobat Tell me what you want to do... Share

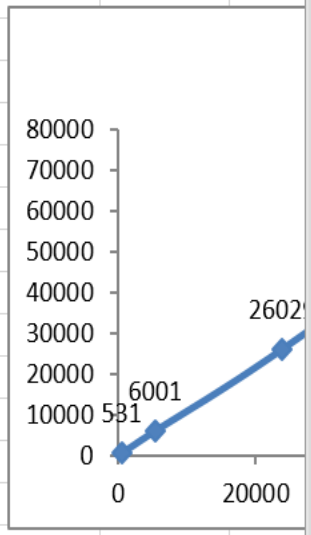
Paste Cut Copy Format Painter | Calibri 11 | Wrap Text | General | Conditional Formatting | Format as Table | Cell Styles | Insert Delete Format | AutoSum Fill Clear | Sort & Filter Find & Select

Clipboard Font Alignment Number Styles Cells Editing

I4

	A	B	C	D
4		Quantibrite Bead	Lot: 60560	Expiry:29/02/2015
5	Date	Bead Type	PE Mol./Bead (X)	PE Median (Y)
6		Low Bead	474	531
7		Low-Mid	5359	6001
8		Mid-High	23843	26029
9		High Bead	62336	72595
11		Date Received from Curve Fitting		
12	m	Slope ('m')	1.167	1.165947949
13	c	Intercept ('c')	-104.14	-531.30067
15	y=m*x+c			





Sheet1 Sheet2 Sheet3

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File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help

1 : mHLADRABC | 27847.66037735849 | Visible: 12 of 12 Variables

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2	52	1	3	SANDEEP	703	30054	68	219	1	1159	30510	.0380		
3	53	1	3	MUNISH	393	35338	70	248	1	849	35794	.0237		
4	54	1	3	GURJEET	506	33650	68	177	1	962	34106	.0282		
5	55	1	3	ANKIT	1678	35485	69	288	1	2134	35941	.0594		
6	56	1	3	ANKUR	722	46648	69	324	1	1178	47104	.0250		
7	57	1	3	GURPREET	383	28452	63	385	1	839	28908	.0290		
8	58	1	3	NARESH	2013	25734	68	380	1	2469	26190	.0943		
9	59	1	3	SUKHVIR	349	47938	75	447	1	805	48394	.0166		
10	60	1	3	DALJEET	243	17731	79	209	1	699	18187	.0384		
11	61	1	3	SIMRAN	462	17705	68	560	1	918	18161	.0505		
12	62	1	3	SONU	354	12629	79	232	1	810	13085	.0619		
13	63	1	3	JATINDER	437	19661	71	177	1	893	20117	.0444		
14	64	1	3	SUNIL	392	14192	78	177	1	848	14648	.0579		
15	65	1	3	SUKHCHAIN	1360	39777	80	178	1	1816	40233	.0451		
16	66	1	3	GURMUKH	150	22006	63	176	1	606	22462	.0270		
17	67	1	3	DILLA	270	22502	60	170	1	726	22958	.0316		
18	68	1	3	AMANPREET	277	27600	70	369	1	733	28056	.0261		
19	69	1	3	ANKIT	655	28335	67	223	1	1111	28791	.0386		
20	70	1	3	GURPREET	194	26959	83	222	1	650	27415	.0237		

Data View | Variable View

IBM SPSS Statistics Processor is ready | Unicode:ON

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3	Group	Numeric	11	0		{1, Septic P...	None	18	Right	Nominal	Input
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5	Patientname	String	10	0	Patient name	None	None	10	Left	Nominal	Input
6	MFInCD64	Numeric	11	0	MFI nCD64	None	None	11	Right	Scale	Input
7	MFImHLADR	Numeric	11	0	MFI mHLA-DR	None	None	11	Right	Scale	Input
8	MFIlyCD64n...	Numeric	11	0	MFI lyCD64(ne...	None	None	11	Right	Scale	Input
9	MFInHLAD...	Numeric	11	0	MFI nHLA-DR (...	None	None	11	Right	Scale	Input
10	Outcome	Numeric	11	0		{1, Recover...	None	9	Right	Nominal	Input
11	nCD64ABC	Numeric	8	0		None	None	10	Right	Scale	Input
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Data View | Variable View

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15 :

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Analyze menu:
- Reports
- Descriptive Statistics
- Custom Tables
- Compare Means
- General Linear Model
- Generalized Linear Models
- Mixed Models
- Correlate
- Regression
- Loglinear
- Neural Networks
- Classify
- Dimension Reduction
- Scale
- Nonparametric Tests
- Forecasting
- Survival
- Multiple Response
- Missing Value Analysis...
- Multiple Imputation
- Complex Samples
- Simulation...
- Quality Control
- ROC Curve...
- Spatial and Temporal Modeling...
- IBM SPSS Amos...

Descriptive Statistics submenu:
- Frequencies...
- Descriptives...
- Explore...
- Crosstabs...
- TURF Analysis
- Ratio...
- P-P Plots...
- Q-Q Plots...

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8	58	1	25734	68	380	1	2469	26190	.0943	
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17	67	1	22502	60	170	1	726	22958	.0316	
18	68	1	27600	70	369	1	733	28056	.0261	
19	69	1	28335	67	223	1	1111	28791	.0386	
20	70	1	26959	83	222	1	650	27415	.0237	

Data View | Variable View

Frequencies...

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2	52									1159	30510	.0380		
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5	55									2134	35941	.0594		
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7	57									839	28908	.0290		
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10	60									699	18187	.0384		
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16	66									606	22462	.0270		
17	67									726	22958	.0316		
18	68									733	28056	.0261		
19	69	1	3	ANKIT	655	28335	67	223	1	1111	28791	.0386		
20	70	1	3	GURPREET	194	26959	83	222	1	650	27415	.0237		

Frequencies

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Group [GRP]
Group
Patient name [Patientname]
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MFI nHLA-DR (neg ctl) [MFInHLADRne...
Outcome

Variable(s):
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MFI mHLA-DR [MFImHLADR]
nCD64ABC
mHLADRABC
SepsisIndex

Statistics...
Charts...
Format...
Style...
Bootstrap...

Display frequency tables

OK Paste Reset Cancel Help

Data View Variable View

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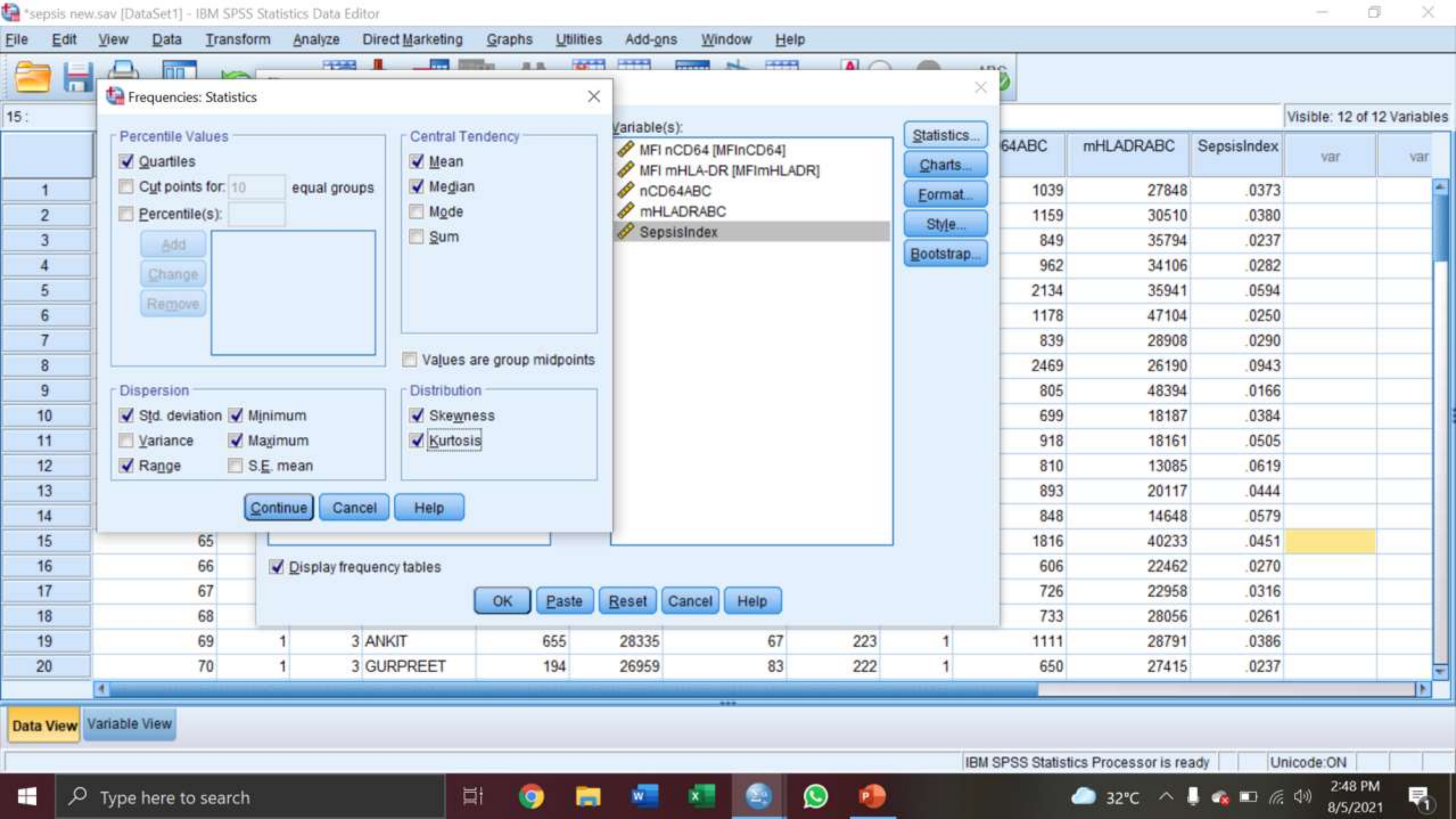
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Frequencies: Statistics
Percentile Values
Quartiles
Cut points for: 10 equal groups
Percentile(s):
Add
Change
Remove
Central Tendency
Mean
Median
Mode
Sum
Values are group midpoints
Dispersion
Std. deviation
Minimum
Variance
Maximum
Range
S.E. mean
Distribution
Skewness
Kurtosis
Continue
Cancel
Help
Variable(s):
MFI nCD64 [MFInCD64]
MFI mHLA-DR [MFImHLADR]
nCD64ABC
mHLADRABC
SepsisIndex
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Charts...
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Style...
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Paste
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Cancel
Help
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64ABC
mHLADRABC
SepsisIndex
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69 1 3 ANKIT 655 28335 67 223 1
70 1 3 GURPREET 194 26959 83 222 1
Data View
Variable View
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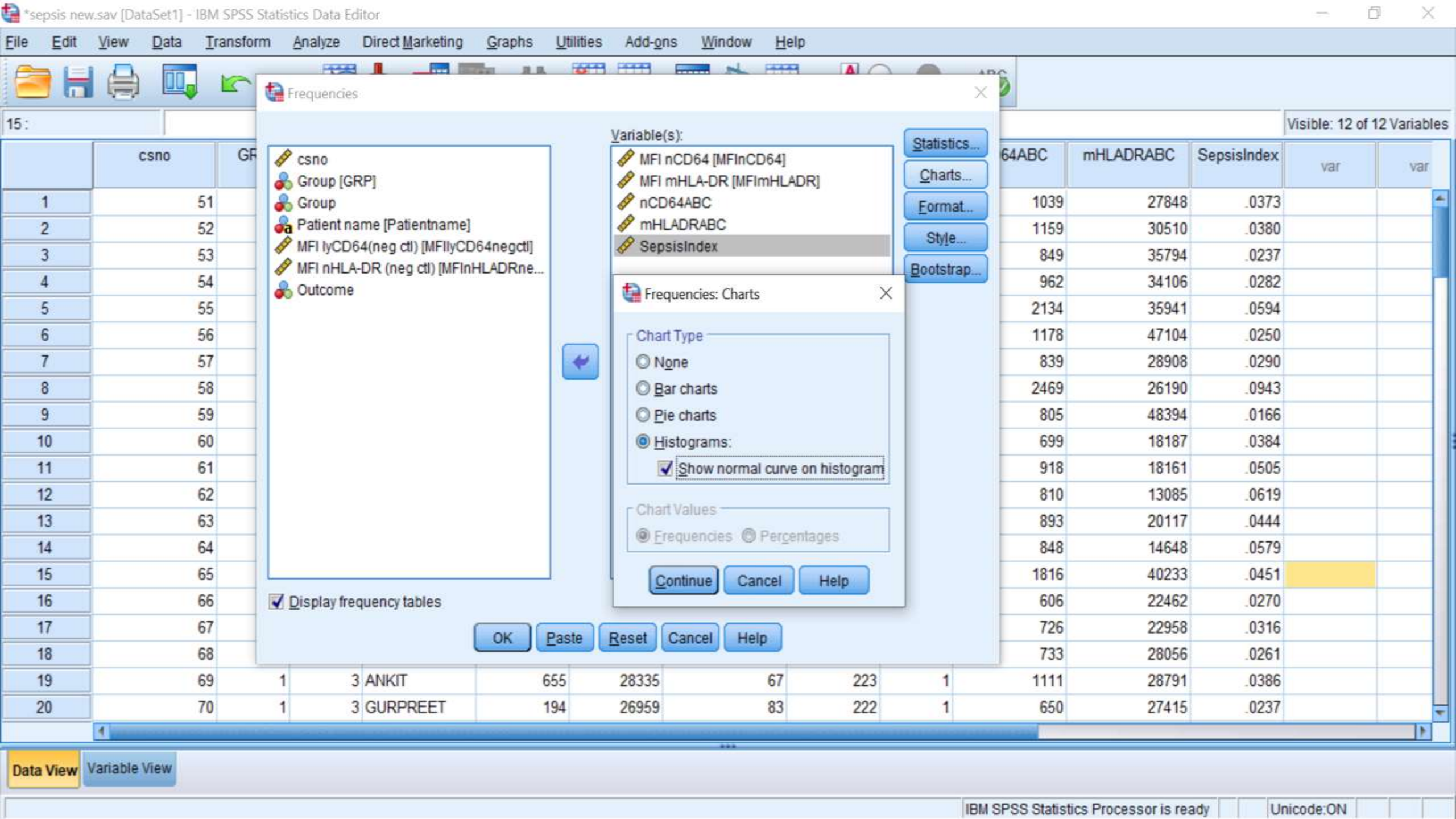
2:48 PM
8/5/2021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15 :
Visible: 12 of 12 Variables
csno GR 64ABC mHLADRABC SepsisIndex var var
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2 52 1159 30510 .0380
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4 54 962 34106 .0282
5 55 2134 35941 .0594
6 56 1178 47104 .0250
7 57 839 28908 .0290
8 58 2469 26190 .0943
9 59 805 48394 .0166
10 60 699 18187 .0384
11 61 918 18161 .0505
12 62 810 13085 .0619
13 63 893 20117 .0444
14 64 848 14648 .0579
15 65 1816 40233 .0451
16 66 606 22462 .0270
17 67 726 22958 .0316
18 68 733 28056 .0261
19 69 1 3 ANKIT 655 28335 67 223 1 1111 28791 .0386
20 70 1 3 GURPREET 194 26959 83 222 1 650 27415 .0237
Frequencies
csno
Group [GRP]
Group
Patient name [Patientname]
MFI lyCD64(neg ctl) [MFIlyCD64negctl]
MFI nHLA-DR (neg ctl) [MFInHLADRne...
Outcome
Variable(s):
MFI nCD64 [MFInCD64]
MFI mHLA-DR [MFImHLADR]
nCD64ABC
mHLADRABC
SepsisIndex
Statistics...
Charts...
Format...
Style...
Bootstrap...
Display frequency tables
OK Paste Reset Cancel Help
Frequencies: Charts
Chart Type
None
Bar charts
Pie charts
Histograms:
Show normal curve on histogram
Chart Values
Frequencies Percentages
Continue Cancel Help
Data View Variable View
IBM SPSS Statistics Processor is ready
Unicode:ON

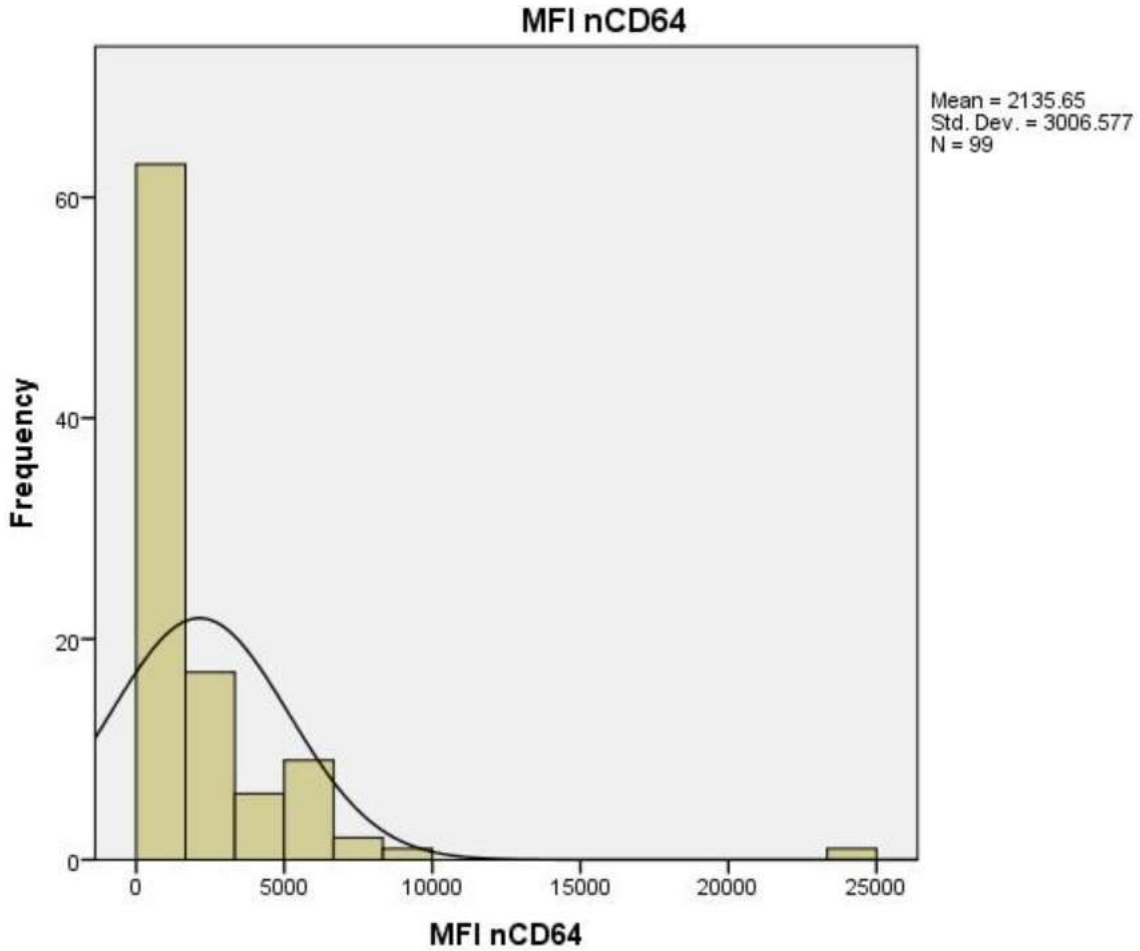
Frequencies

Statistics

		MFI nCD64	MFI mHLA-DR	nCD64ABC	mHLADRABC	SepsisIndex
N	Valid	99	100	100	100	100
	Missing	1	0	0	0	0
Mean		2135.65	16443.41	2580.05	16899.07	.469848
Median		1025.00	13685.00	1473.16	14140.66	.113462
Std. Deviation		3006.577	12128.651	2993.470	12128.651	.9911423
Skewness		4.806	.675	4.830	.675	4.290
Std. Error of Skewness		.243	.241	.241	.241	.241
Kurtosis		33.045	-.518	33.365	-.518	20.993
Std. Error of Kurtosis		.481	.478	.478	.478	.478
Range		24713	47126	24713	47126	6.3824
Minimum		150	812	606	1268	.0166
Maximum		24863	47938	25319	48394	6.3990
Percentiles	25	567.00	5795.25	1025.16	6250.91	.044563
	50	1025.00	13685.00	1473.16	14140.66	.113462
	75	2995.00	25734.00	3368.66	26189.66	.481215

Histogram

MFI nCD64


MFI nCD64
Mean = 2135.65
Std. Dev. = 3006.577
N = 99
Frequency
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40
20
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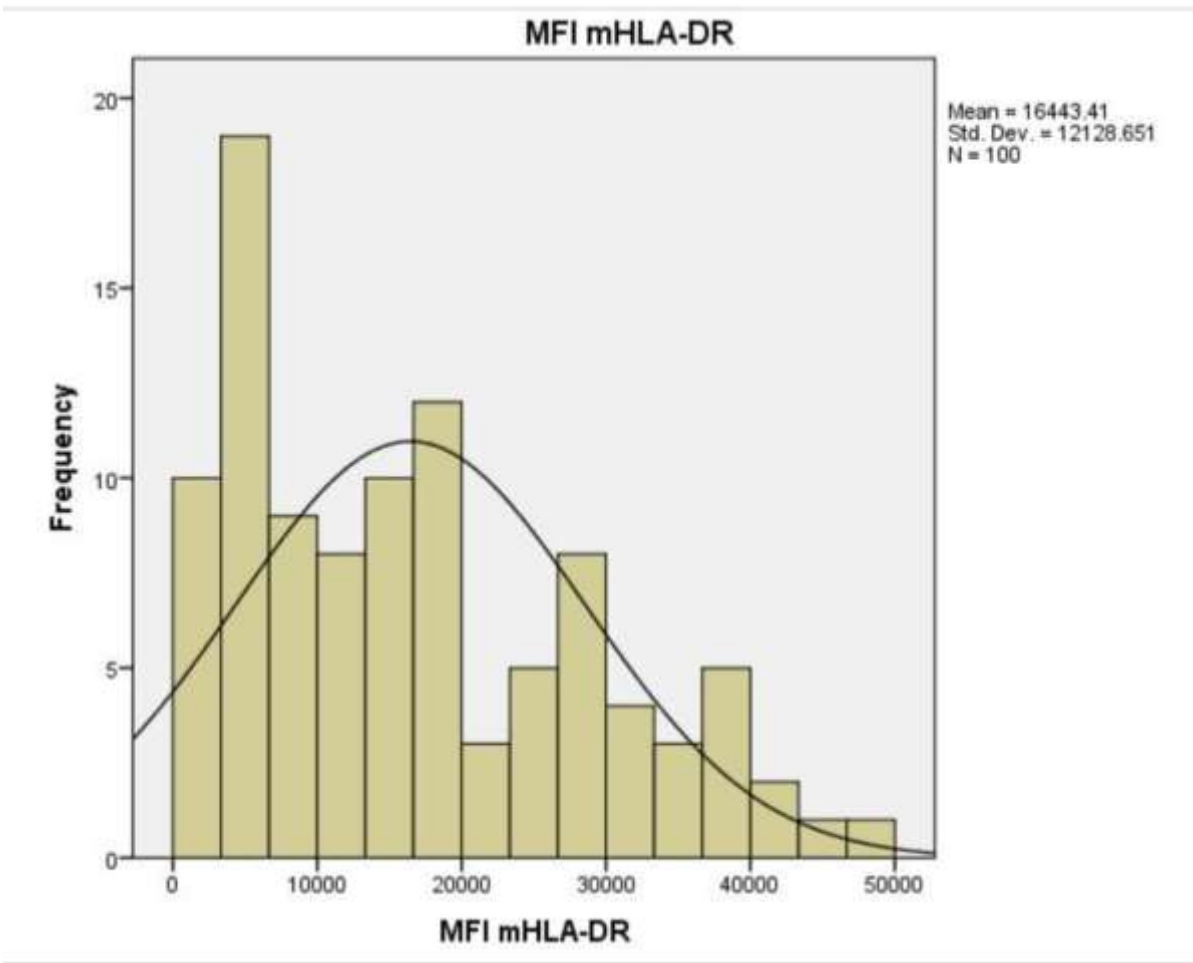
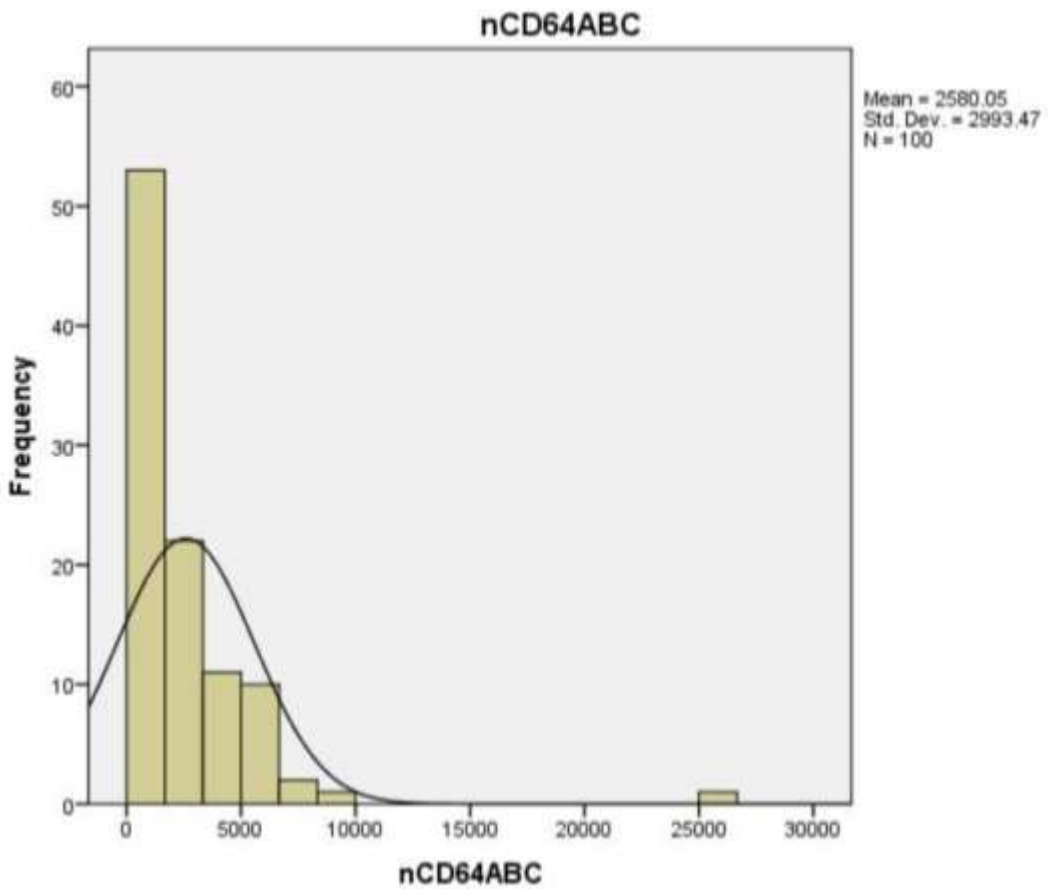
0
5000
10000
15000
20000
25000
MFI nCD64


MFI mHLA-DR
Mean = 16443.41
Std. Dev. = 12128.651
N = 100
Frequency
20
15
10
5
0
0
10000
20000
30000
40000
50000
MFI mHLA-DR


nCD64ABC
Mean = 2580.05
Std. Dev. = 2993.47
N = 100
Frequency
nCD64ABC
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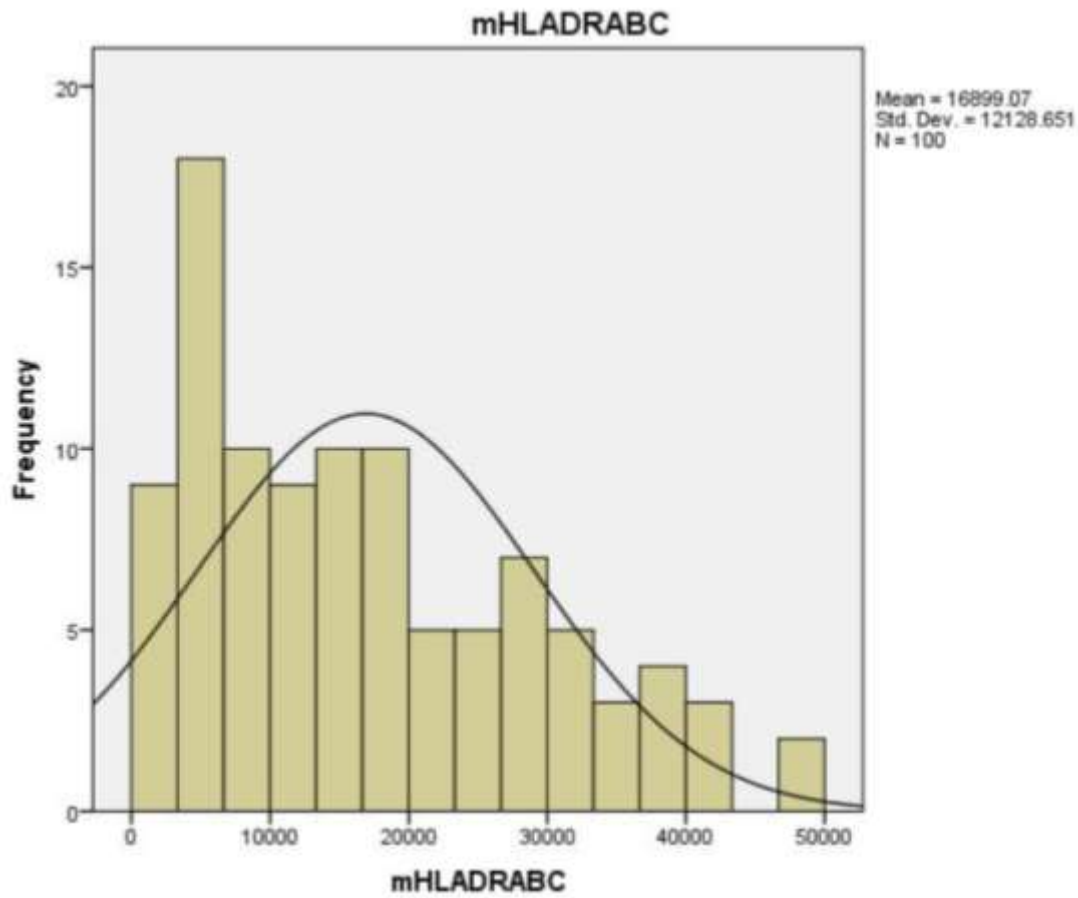
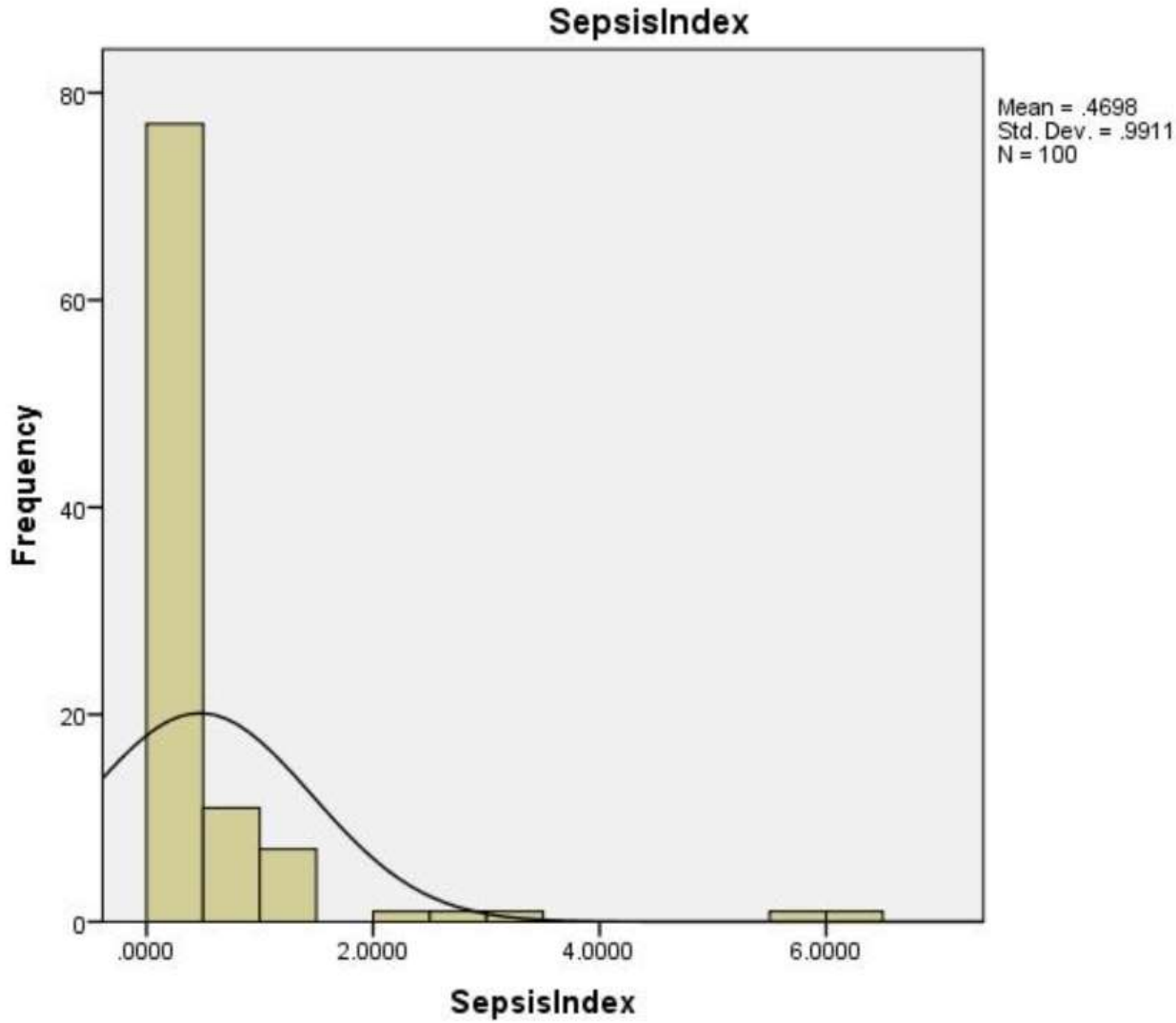
20
30
40
50
60
0
5000
10000
15000
20000
25000
30000


mHLADRABC
Mean = 16899.07
Std. Dev. = 12128.651
N = 100
Frequency
mHLADRABC
0
5
10
15
20
0
10000
20000
30000
40000
50000


SepsisIndex
Mean = .4698
Std. Dev. = .9911
N = 100
Frequency
80
60
40
20
0
.0000
2.0000
4.0000
6.0000
SepsisIndex

Correlations

			MFI nCD64	MFI mHLA-DR	nCD64ABC	mHLADRABC	SepsisIndex
Spearman's rho	MFI nCD64	Correlation Coefficient	1.000	-.516**	1.000**	-.516**	.851**
		Sig. (2-tailed)	.	.000	.	.000	.000
		N	99	99	99	99	99
	MFI mHLA-DR	Correlation Coefficient	-.516**	1.000	-.516**	1.000**	-.879**
		Sig. (2-tailed)	.000	.	.000	.	.000
		N	99	100	100	100	100
	nCD64ABC	Correlation Coefficient	1.000**	-.516**	1.000	-.516**	.850**
		Sig. (2-tailed)	.	.000	.	.000	.000
		N	99	100	100	100	100
	mHLADRABC	Correlation Coefficient	-.516**	1.000**	-.516**	1.000	-.879**
		Sig. (2-tailed)	.000	.	.000	.	.000
		N	99	100	100	100	100
	SepsisIndex	Correlation Coefficient	.851**	-.879**	.850**	-.879**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.
		N	99	100	100	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

RELATIVE RISK

		The Outcome				
		+	-			
The Exposure	+	a	b	a / (a+b) Risk Rate of Developing Outcome in Exposed	Relative Risk (Risk Ratio) =(a / (a+b)) ---------- (c / (c+d))	Relative Risk Reduction = (a/(a+b))-(c/(c+d)) ---------- (c/(c+d))
	-	c	d	c / (c+d) Risk Rate of Developing Outcome in NON-Exposed		

RELATIVE RISK

- ASSUMPTION 1:

- One dichotomous dependent variable and one dichotomous independent variable (i.e., they both have two categorical, independent groups)
- Dichotomous variables can be nominal or ordinal

- ASSUMPTION 2:

- Independence of observations

- ASSUMPTION 3:

- Used for specific study designs (prospective and retrospective cohort designs, randomized controlled trials)

RELATIVE RISK

- Relative risk = 1 i.e. risk of getting disease same in both groups
- Relative risk > 1 i.e. exposed group at greater risk of getting disease
- Relative risk < 1 i.e. exposed group at less risk of getting the disease

ODD RATIO

		The Outcome	
		+	-
The Exposure	+	a	b
	-	c	d
		a/c Odds of Being Exposed in Cases	b/d Odds of Being Exposed in Controls
		Odds Ratio = a/c --- b/d	

LOGISTIC REGRESSION

- Outcome of interest is a dichotomous categorical variable
- Numerous variables (continuous and categorical) can be included in the equation
- The specific effect on individual variables on outcome can be adjusted according to the presence of other variables
- Binomial logistic regression attempts to predict probability that observation falls into one of two categories of dichotomous dependent variable based on one or more independent variables (continuous or categorical)

ASSUMPTIONS

- Assumption 1 - One dependent variable that is dichotomous
- Assumption 2 - One or more independent variables measured on either continuous or nominal scale
- Assumption 3 - Independence of observations and categories of dichotomous dependent variable and all nominal independent variables should be mutually exclusive and exhaustive

ASSUMPTIONS

- ASSUMPTION 4 - Bare minimum of 15 cases per independent variable
- ASSUMPTION 5 - There should be linear relationship between continuous independent variables and logit transformation of dependent variable
- ASSUMPTION 6 - No multicollinearity - two or more independent variables highly correlated with each other

Problems with understanding which independent variable contributes to the variance explained in the dependent variable

- ASSUMPTION 7 - No significant outliers

TESTING FOR LINEARITY

- For every one-unit increase in continuous independent variable, value of log odds (logit) of dependent variable increases by constant amount
- STEP ONE - Create natural log transformations of all continuous independent variables
- Box-Tidwell (1962) procedure on SPSS for determining same

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	age	2.725	1.103	6.100	1	.014	15.258	1.755	132.650
	weight	.144	.783	.034	1	.854	1.155	.249	5.360
	gender(1)	1.854	.922	4.047	1	.044	6.384	1.049	38.857
	VO2max	1.320	1.823	.524	1	.469	3.745	.105	133.452
	age by ln_age	-.543	.227	5.754	1	.016	.581	.373	.905
	ln_weight by weight	-.027	.146	.033	1	.855	.974	.731	1.297
	VO2max by ln_VO2max	-.301	.382	.620	1	.431	.740	.350	1.566
	Constant	-40.585	21.707	3.496	1	.062	.000		

a. Variable(s) entered on step 1: age, weight, gender, VO2max, age * ln_age , ln_weight * weight , VO2max * ln_VO2max .

- If interaction term is statistically significant, the original continuous independent variable is not linearly related to logit of dependent variable (i.e., it has failed the assumption of linearity)
- To apply Bonferroni correction based on all terms (including intercept) in the model when assessing this linearity assumption

- 8 terms in abovementioned model, divide *p*-value at which statistical significance is accepted – that is, $p < 0.05$ (i.e., *p* is less than .05) – by the number of terms in the model
- New level at which statistical significance would be accepted is when $p < .00625$ (i.e., where *p* is less than .00625 since $.05 \div 8 = .00625$)

BONFERRONI CORRECTION

- Adjusted alpha level = Original alpha level ÷ Number of comparisons

# of contrasts	Original alpha (α) level	New alpha (α) level
1	.05	.05
2	.05	.025
3	.05	.016667
4	.05	.0125
5	.05	.01
6	.05	.008333
7	.05	.007143
8	.05	.00625

Table: Bonferroni-corrected alpha (α) levels

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	age	2.725	1.103	6.100	1	.014	15.258	1.755	132.650
	weight	.144	.783	.034	1	.854	1.155	.249	5.360
	gender(1)	1.854	.922	4.047	1	.044	6.384	1.049	38.857
	VO2max	1.320	1.823	.524	1	.469	3.745	.105	133.452
	age by ln_age	-.543	.227	5.754	1	.016	.581	.373	.905
	ln_weight by weight	-.027	.146	.033	1	.855	.974	.731	1.297
	VO2max by ln_VO2max	-.301	.382	.620	1	.431	.740	.350	1.566
	Constant	-40.585	21.707	3.496	1	.062	.000		

a. Variable(s) entered on step 1: age, weight, gender, VO2max, age * ln_age , ln_weight * weight , VO2max * ln_VO2max .

Linearity of continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell (1962) procedure. Bonferroni correction applied using all eight terms in model resulting in statistical significance being accepted when $p < .00625$. Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable

Casewise List[b]

Case	Selected Status[a]	Observed	Predicted	Predicted Group	Temporary Variable	
		heart_disease			Resid	ZResid
59	S	Y**	.142	N	.858	2.455
70	S	Y**	.082	N	.918	3.349

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

If all cases have standardized residuals less than ±2, this table will not be produced as part of

SPSS Statistics output

INTERPRETING RESULTS

- DATA CODING

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	99	99.0
	Missing Cases	1	1.0
	Total	100	100.0
Unselected Cases		0	.0
Total		100	100.0

a. If weight is in effect, see classification table for the total number of cases.

Table is useful for determining if any cases are missing

INTERPRETING RESULTS

- DATA CODING

Dependent Variable Encoding

Original Value	Internal Value
Recovered	0
Died	1

DEPENDENT VARIABLE CODING - Displays coding that you applied to dependent variable

BASELINE ANALYSIS

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted		
			Outcome		Percentage Correct
			Recovered	Died	
Step 0	Outcome	Recovered	87	0	100.0
		Died	12	0	.0
	Overall Percentage				87.9

a. Constant is included in the model.

b. The cut value is .500

Block 0: Beginning Block“- All relate to situation where no independent variables have been added to model and model just includes constant

Without any independent variables, 'best guess' is to simply assume that all participants did not have heart disease. If you assume this, you will overall correctly classify 88% of cases

MODEL FIT

- "Omnibus Tests of Model Coefficients“ provides overall statistical significance of model

Block 1: Method = Forward Stepwise (Conditional)

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	19.903	1	.000
	Block	19.903	1	.000
	Model	19.903	1	.000

Model is statistically significant ($p < .0005$; "Sig." column)

VARIANCE EXPLAINED

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	53.225[a]	.182	.349

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Methods of calculating explained variation - Cox & Snell R Square and Nagelkerke R Square values

Useful to understand how much variation in dependent variable can be explained by mode

Classification Table[a]

Observed			Predicted		
			Outcome		Percentage Correct
			Recovered	Died	
Step 1	Outcome	Recovered	87	0	100.0
		Died	12	0	.0
	Overall Percentage				87.9

a. The cut value is .500

cut value is .500

YES CATEGORY - Probability of case being classified into "yes" category is greater than .500,

NO CATEGORY - If probability less than 0.5

PERCENTAGE ACCURACY IN CLASSIFICATION (PAC) -

Addition of independent variables improves overall prediction of cases into their observed

categories of dependent variable

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	mHLADRABC	.000	.000	7.962	1	.005	1.000	1.000	1.000
	Constant	.219	.600	.133	1	.716	1.244		

a. Variable(s) entered on step 1: mHLADRABC.

Model if Term Removed[a]

Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 1	mHLADRABC	-40.811	28.397	1	.000

a. Based on conditional parameter estimates

Variables not in the Equation[a]

			Score	df	Sig.
Step 1	Variables	MFInCD64	2.106	1	.147
		nCD64ABC	2.106	1	.147
		SepsisIndex	.077	1	.781

a. Residual Chi-Squares are not computed because of redundancies.

MEASURES IN LOGISTIC REGRESSION

- SENSITIVITY - Percentage of cases that had observed characteristic which were correctly predicted by the model (i.e., TRUE POSITIVES)

- SPECIFICITY - Percentage of cases that did not have observed characteristic and were also correctly predicted as not having observed characteristic (i.e., true negatives)

MEASURES IN LOGISTIC REGRESSION

- POSITIVE PREDICTIVE VALUE - Percentage of correctly predicted cases with observed characteristic compared to total number of cases predicted as having characteristic

- NEGATIVE PREDICTIVE VALUE - Percentage of correctly predicted cases without observed characteristic compared to total number of cases predicted as not having characteristic

ROC – RECEIVER OPERATING CHARACTERISTICS

- Plot of sensitivity versus 1 minus specificity
- Used to calculate overall measure of discrimination
- Ability of binomial logistic regression model to discriminate between those participants with and without event of interest (i.e., to be able to predict who has, or has not, event of interest)

ROC – RECEIVER OPERATING CHARACTERISTICS

Case Processing Summary

Group	Valid N (listwise)
Positive[a]	50
Negative	49
Missing	1

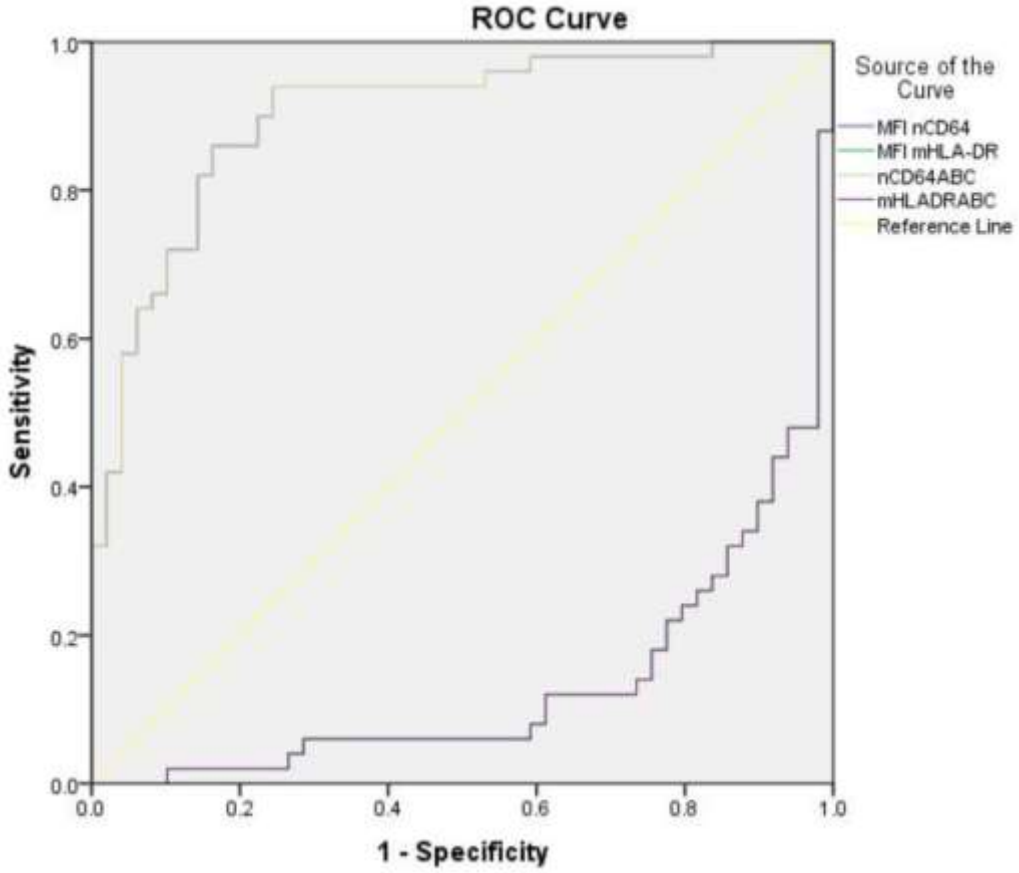
Larger values of the test result variable(s) indicate stronger evidence for a positive actual state.

a. The positive actual state is Septic Patients.

Positive actual state is "1.00 Yes"

Correctly stated event (i.e., event of interest in this example is having septic state, which was coded as "1 = Yes")

ROC – RECEIVER OPERATING CHARACTERISTICS



Further the ROC line is above straight line, better the discrimination

The area under ROC curve is equivalent to concordance probability

ROC – RECEIVER OPERATING CHARACTERISTICS

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MFI nCD64	.901	.031	.000	.840	.962
MFI mHLA-DR	.133	.037	.000	.061	.206
nCD64ABC	.901	.031	.000	.840	.962
mHLADRABC	.133	.037	.000	.061	.206

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

AUC	Classification
0.5	This suggests no discrimination, so we might as well flip a coin.
0.5 < AUC < 0.7	We consider this poor discrimination, not much better than a coin toss.
0.7 ≤ AUC < 0.8	We consider this acceptable discrimination.
0.8 ≤ AUC < 0.9	We consider this excellent discrimination.
AUC ≥ 0.9	We consider this outstanding discrimination.

ROC – RECEIVER OPERATING CHARACTERISTICS

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MFI nCD64	.901	.031	.000	.840	.962
MFI mHLA-DR	.133	.037	.000	.061	.206
nCD64ABC	.901	.031	.000	.840	.962
mHLADRABC	.133	.037	.000	.061	.206

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

95% confidence interval (CI) for area under ROC curve

Presented in "Lower Bound" and "Upper Bound" columns under the "Asymptotic 95%

Confidence Interval" column in "Area Under the Curve"

RESULT INTERPRETATION

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	mHLADRABC	.000	.000	7.962	1	.005	1.000	1.000	1.000
	Constant	.219	.600	.133	1	.716	1.244		

a. Variable(s) entered on step 1: mHLADRABC.

Wald test ("Wald" column) is used to determine statistical significance for each of independent variables

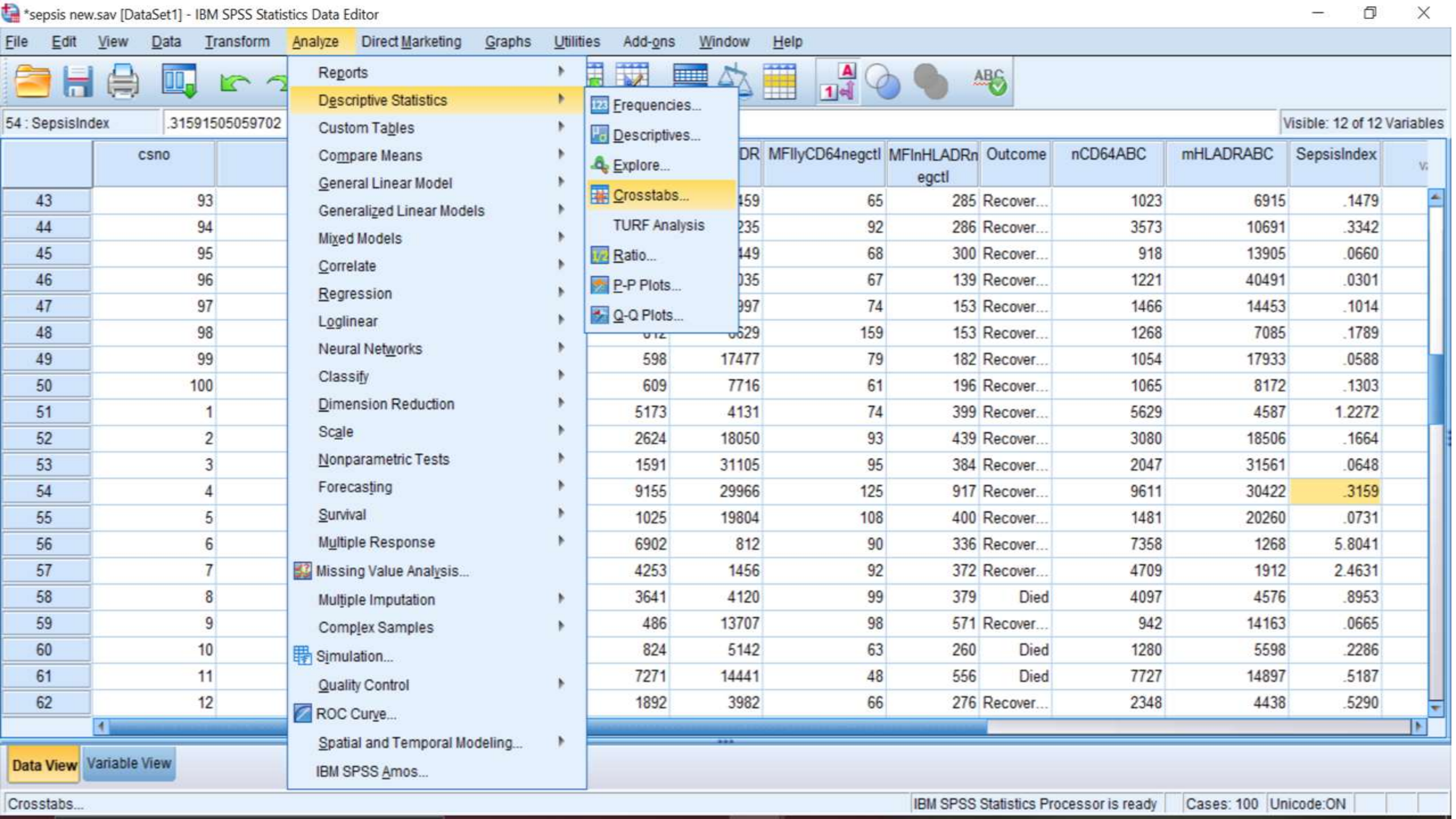
Statistical significance of the test is found in "Sig." column

RESULT INTERPRETATION

- B coefficients ("B" column) - Used in equation to predict probability of event occurring, but
- Coefficients show change in log odds that occur for one-unit change in independent variable when all other independent variables are kept constant

RESULT INTERPRETATION

- Better to comment upon Odds ratios of each of independent variables in "Exp(B)" column along with their confidence intervals ("95% C.I. for EXP(B)" column)
- Change in odds for each increase in one unit of independent variable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Mixed Models
Correlate
Regression
Loglinear
Neural Networks
Classify
Dimension Reduction
Scale
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Survival
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ROC Curve...
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MFInHLADRnegctl
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mHLADRABC
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47 97 74 153 Recover... 1466 14453 .1014
48 98 159 153 Recover... 1268 7085 .1789
49 99 598 17477 79 182 Recover... 1054 17933 .0588
50 100 609 7716 61 196 Recover... 1065 8172 .1303
51 1 5173 4131 74 399 Recover... 5629 4587 1.2272
52 2 2624 18050 93 439 Recover... 3080 18506 .1664
53 3 1591 31105 95 384 Recover... 2047 31561 .0648
54 4 9155 29966 125 917 Recover... 9611 30422 .3159
55 5 1025 19804 108 400 Recover... 1481 20260 .0731
56 6 6902 812 90 336 Recover... 7358 1268 5.8041
57 7 4253 1456 92 372 Recover... 4709 1912 2.4631
58 8 3641 4120 99 379 Died 4097 4576 .8953
59 9 486 13707 98 571 Recover... 942 14163 .0665
60 10 824 5142 63 260 Died 1280 5598 .2286
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Data View
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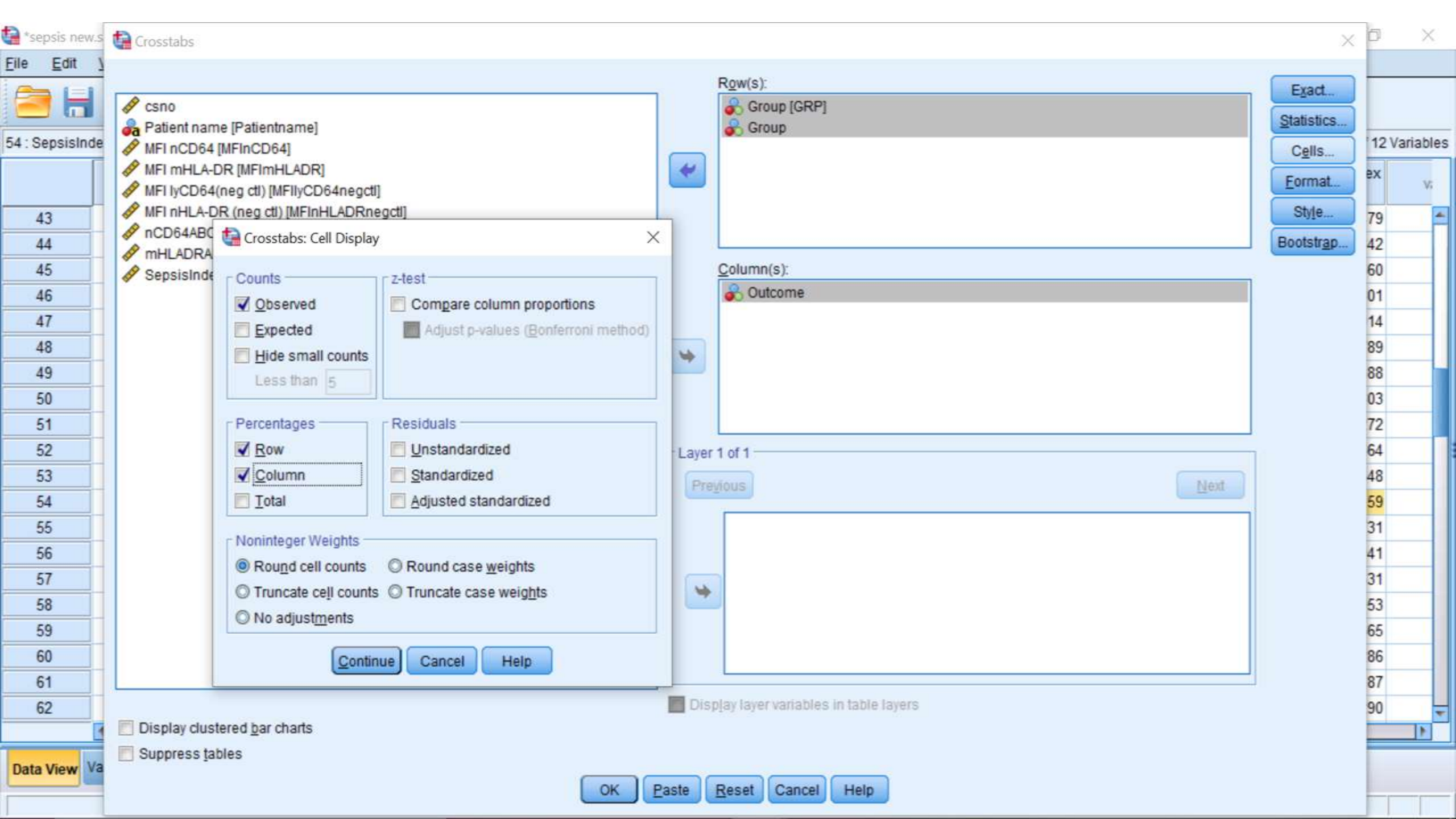
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File
Edit
54 : SepsisInde
12 Variables
Crosstabs
csno
Patient name [Patientname]
MFI nCD64 [MFInCD64]
MFI mHLA-DR [MFImHLADR]
MFI lyCD64(neg ctl) [MFIlyCD64negctl]
MFI nHLA-DR (neg ctl) [MFInHLADRnegctl]
nCD64ABC
mHLADRA
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Row(s):
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Group
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Outcome
Layer 1 of 1
Previous
Next
Display layer variables in table layers
Exact...
Statistics...
Cells...
Format...
Style...
Bootstrap...
Crosstabs: Cell Display
Counts
Observed
Expected
Hide small counts
Less than 5
z-test
Compare column proportions
Adjust p-values (Bonferroni method)
Percentages
Row
Column
Total
Residuals
Unstandardized
Standardized
Adjusted standardized
Noninteger Weights
Round cell counts
Round case weights
Truncate cell counts
Truncate case weights
No adjustments
Continue
Cancel
Help
Display clustered bar charts
Suppress tables
OK
Paste
Reset
Cancel
Help
Data View
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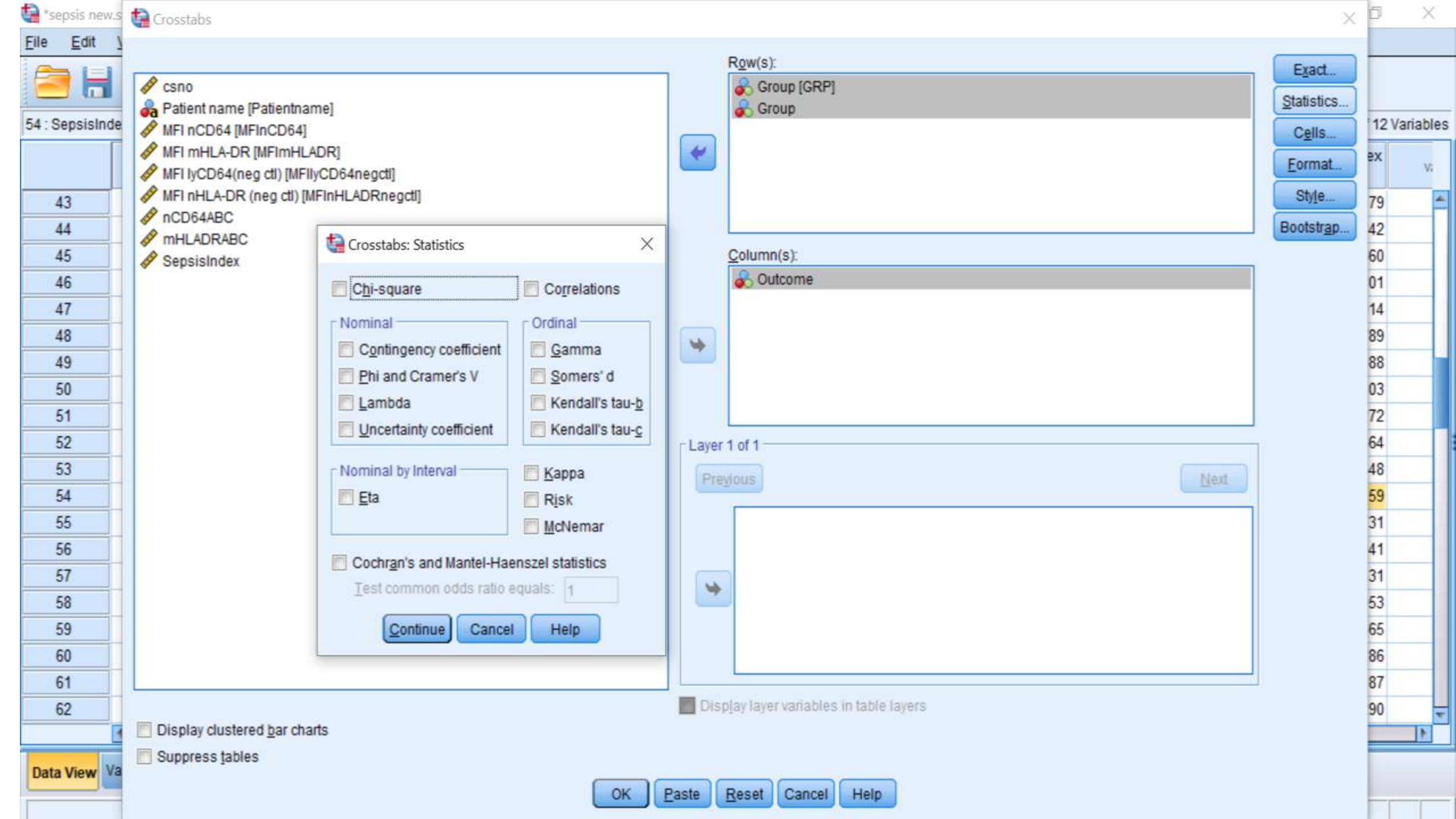

*sepsis new.s
File Edit
54 : SepsisInde
12 Variables
Crosstabs
csno
Patient name [Patientname]
MFI nCD64 [MFInCD64]
MFI mHLA-DR [MFImHLADR]
MFI lyCD64(neg ctl) [MFIlyCD64negctl]
MFI nHLA-DR (neg ctl) [MFInHLADRnegctl]
nCD64ABC
mHLADRABC
SepsisIndex
Row(s):
Group [GRP]
Group
Column(s):
Outcome
Layer 1 of 1
Previous
Next
Exact...
Statistics...
Cells...
Format...
Style...
Bootstrap...
Display layer variables in table layers
Display clustered bar charts
Suppress tables
OK
Paste
Reset
Cancel
Help
Crosstabs: Statistics
Chi-square
Correlations
Nominal
Contingency coefficient
Phi and Cramer's V
Lambda
Uncertainty coefficient
Ordinal
Gamma
Somers' d
Kendall's tau-b
Kendall's tau-c
Nominal by Interval
Eta
Kappa
Risk
McNemar
Cochran's and Mantel-Haenszel statistics
Test common odds ratio equals: 1
Continue
Cancel
Help
Data View

Group * Outcome

Crosstab

			Outcome		Total
			Recovered	Died	
Group	Other Patients	Count	49	1	50
		% within Group	98.0%	2.0%	100.0%
		% within Outcome	55.7%	8.3%	50.0%
	Septic Patients	Count	39	11	50
		% within Group	78.0%	22.0%	100.0%
		% within Outcome	44.3%	91.7%	50.0%
Total		Count	88	12	100
		% within Group	88.0%	12.0%	100.0%
		% within Outcome	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.470[a]	1	.002		
Continuity Correction[b]	7.670	1	.006		
Likelihood Ratio	10.890	1	.001		
Fisher's Exact Test				.004	.002
Linear-by-Linear Association	9.375	1	.002		
N of Valid Cases	100				

CONCLUSION

- Binomial logistic regression was performed to ascertain effect of flowcytometric parameters like MFInCD64, MFImHLA-DR, ABCnCD64, ABCmHLA-DR
- Model explained 35.0% (Nagelkerke R^2) of variance in mortality and correctly classified 88.0% of cases

CONCLUSION

- ROC curves were calculated using Medcal™ software
- Respective cut-off values for MFI nCD64 and nCD64 ABC of >812 and >1152.16 had sensitivity of 94% and specificity of 74% for predicting diagnosis of sepsis
- Value of area under curve was 0.90 (95% CI: 0.824-0.951)

CONCLUSION

- ROC curve for assessing diagnostic utility of MFI mHLA-DR and mHLA-DR ABC yielded respective cut-off values of ≤13765 and ≤ 12262.03
- Both parameters' sensitivity and specificity to detect sepsis were 82 % and 78 %, respectively
- Corresponding value for area under ROC curve was 0.86 (95% CI, 0.783 to 0.926)

MANN-WHITNEY U TEST

- Also known as Wilcoxon-Mann-Whitney test
- Rank-based nonparametric test
- To determine if there are differences between two groups on continuous or ordinal dependent variable
- Nonparametric alternative to independent-samples t-test

ASSUMPTIONS

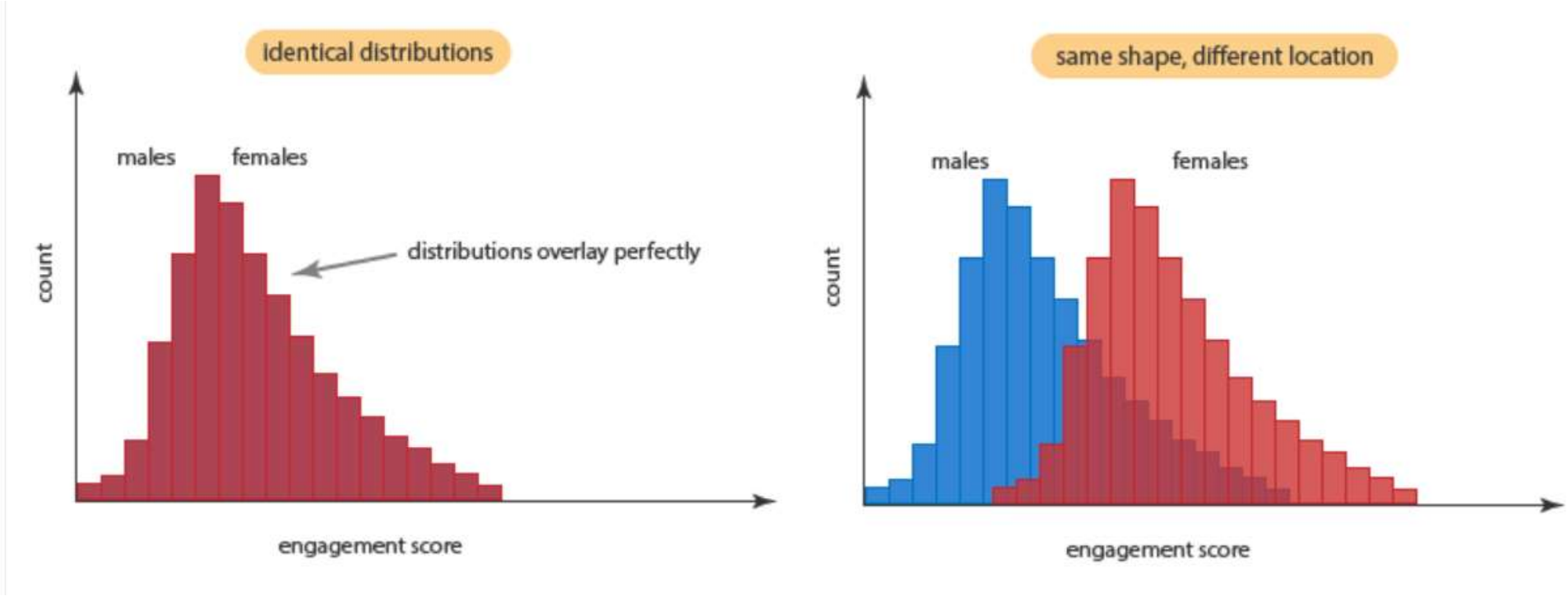
- ASSUMPTION 1 - Dependent variable measured at continuous or ordinal level
- ASSUMPTION 2 - One independent variable that consists of two categorical, independent groups (i.e., dichotomous variable)
- ASSUMPTION 3 - Independence of observations

ASSUMPTIONS

- ASSUMPTION 4 - Distribution of scores for both groups of independent variable have same shape or different shape
- Used to interpret differences in "distributions" of two groups or differences in "medians" of two groups

- Two distributions have a different shape, Mann-Whitney U test is used to determine whether there are differences in the distributions of mean of two groups

- Two distributions are same shape, Mann-Whitney U test is used to determine whether there are differences in medians of two groups

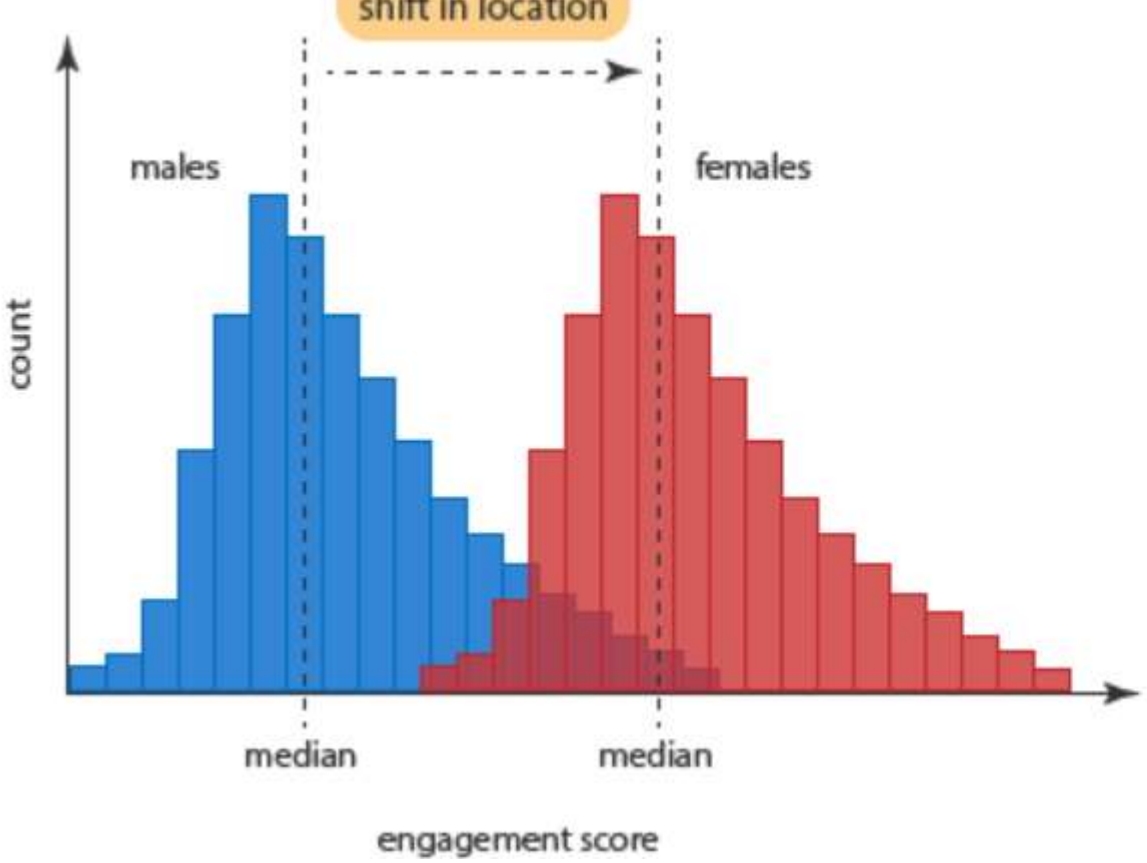


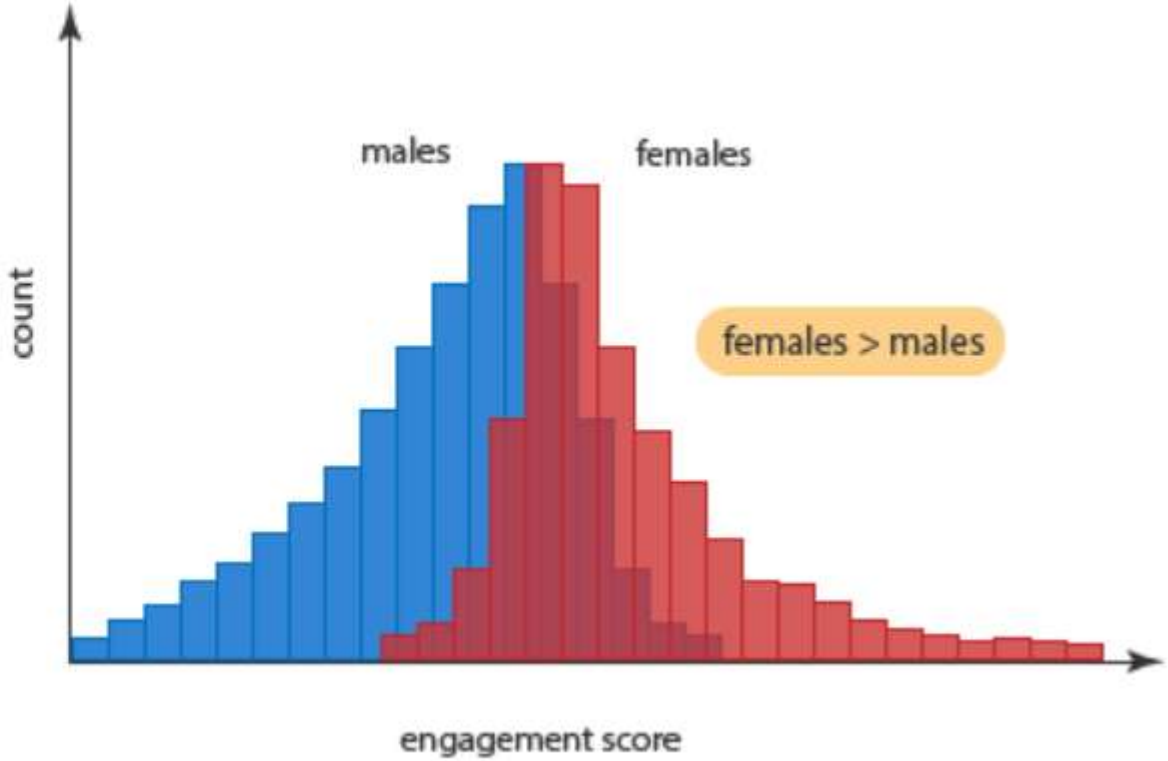
By comparing mean ranks of each distribution of scores using this method one can

determine whether values in one group are lower or higher than values in other group

TECHNIQUE

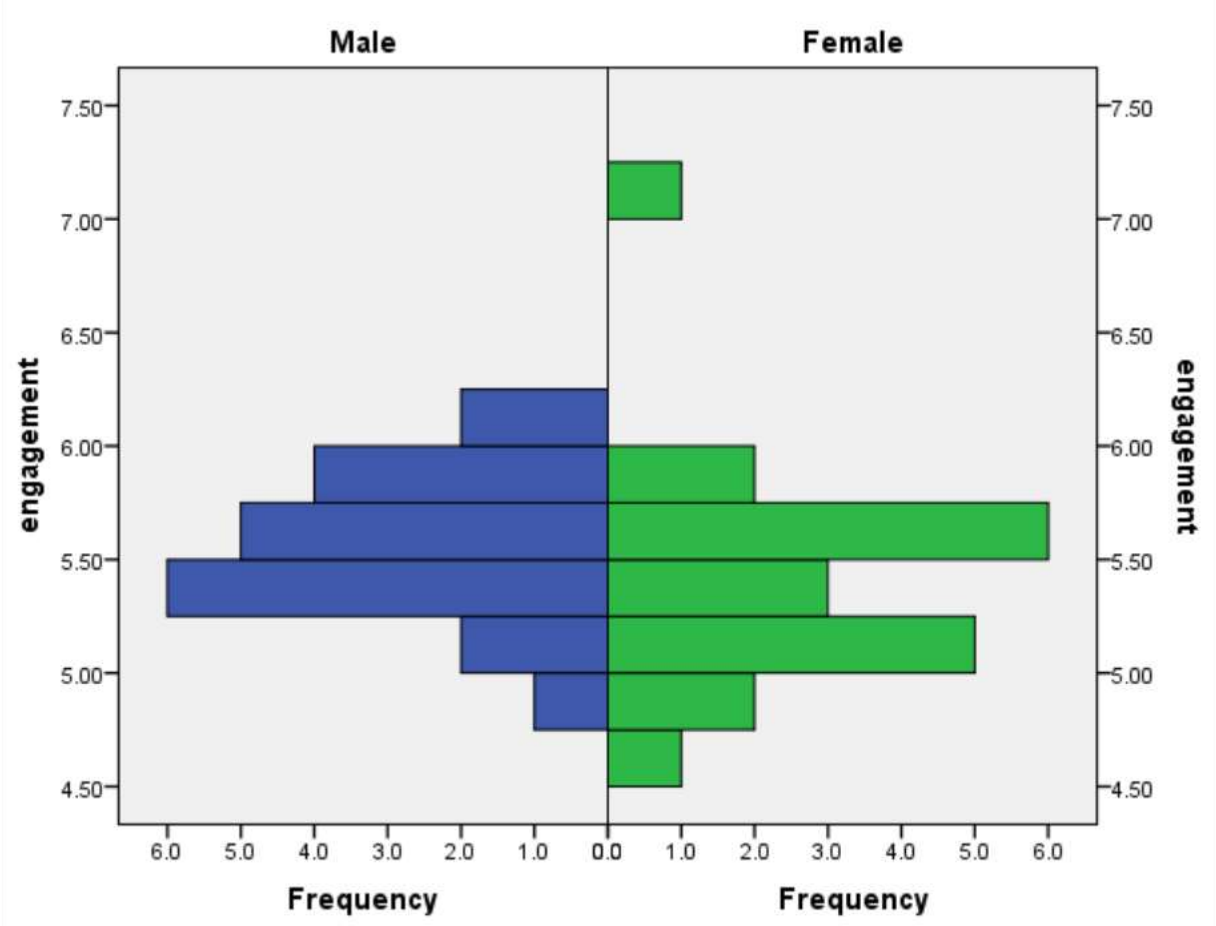
- Firstly, ranking each score of dependent variable, irrespective of group it is in, according to its size, with smallest rank assigned to smallest value
- MEAN RANKS - The ranks obtained for both groups are then averaged
- One group tends to have higher values than other group, that group's scores will have been assigned higher ranks and will have a higher mean rank
- It is this difference in mean rank that is tested by the Mann-Whitney U test for statistical significance





Additional assumption - to compare medians the distribution of engagement scores for males and females must have the same shape (including dispersion)

SHIFT LOCATION - All scores being shifted to right



If distributions are similarly shaped, use Mann-Whitney U test to make inferences about differences in medians between two groups

If they look dissimilar, better to use mean ranks

Ranks

	Outcome	N	Mean Rank	Sum of Ranks
MFI nCD64	Recovered	87	46.95	4085.00
	Died	12	72.08	865.00
	Total	99		
MFI mHLA-DR	Recovered	88	54.69	4813.00
	Died	12	19.75	237.00
	Total	100		
nCD64ABC	Recovered	88	47.45	4176.00
	Died	12	72.83	874.00
	Total	100		
mHLADRABC	Recovered	88	54.69	4813.00
	Died	12	19.75	237.00
	Total	100		
SepsisIndex	Recovered	88	46.22	4067.00
	Died	12	81.92	983.00
	Total	100		

Test Statistics[a]

	MFI nCD64	MFI mHLA-DR	nCD64ABC	mHLADRABC	SepsisIndex
Mann-Whitney U	257.000	159.000	260.000	159.000	151.000
Wilcoxon W	4085.000	237.000	4176.000	237.000	4067.000
Z	-2.841	-3.914	-2.843	-3.914	-3.999
Asymp. Sig. (2-tailed)	.004	.000	.004	.000	.000

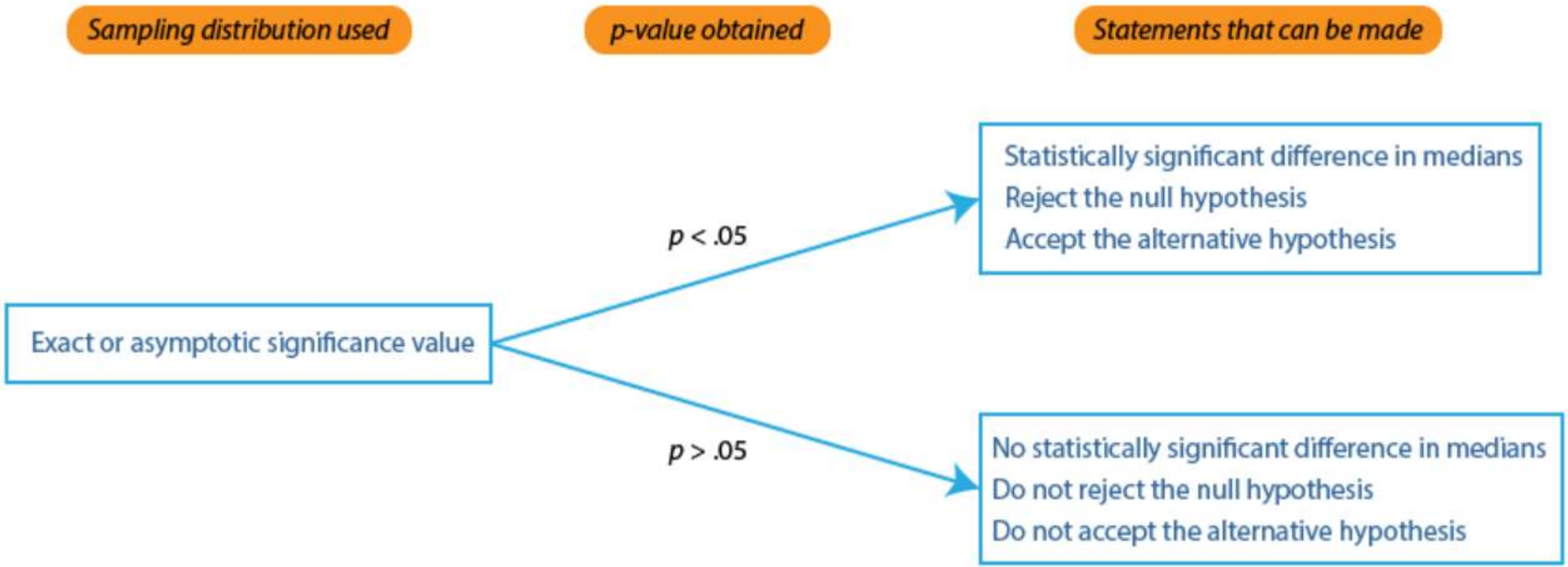
a. Grouping Variable: Outcome

"Asymp. Sig. (2-tailed)" and "Exact Sig. [2*(1-tailed Sig.)]" rows representing asymptotic p-value and exact p-value

"Asymptotic" - *p*-value approaches real value as sample size increases

For smaller sample sizes *p*-value calculated from this method is only approximation to true *p*-value

For smaller sample sizes, exact *p*-value ("Exact Sig. [2*(1-tailed Sig.)]")


Sampling distribution used
p-value obtained
Statements that can be made
Exact or asymptotic significance value
p < .05
Statistically significant difference in medians
Reject the null hypothesis
Accept the alternative hypothesis
p > .05
No statistically significant difference in medians
Do not reject the null hypothesis
Do not accept the alternative hypothesis

CONCLUSION

- Mann-Whitney U test was run to determine if there were differences in flowcytometric parameters between patients who succumbed to illness and those who survived
- Flowcytometric parameters were statistically significant between survivors and non survivors

KAPLEIN MEIER METHOD

- Nonparametric method
- Used to estimate probability of survival past given time points
- ADVANTAGES:
- CENSORED CASES - Some of cases observing do not experience event (e.g., death) before end of study (i.e., end of observation period)

KAPLEIN MEIER METHOD

- For every time point, Kaplan-Meier method will estimate probability of surviving (i.e., not experiencing event) past that particular time point taking into consideration the presence of censored cases

- Kaplan-Meier method estimates "experience" of survival over period of time

ASSUMPTIONS

- ASSUMPTION 1 - Event status should consist of two mutually exclusive and collectively exhaustive states: "censored" or "event“
- ASSUMPTION 2 - Time to event or censorship (known as "survival time") should be clearly defined and precisely measured

  Survival time should be clearly defined (measured in days, weeks, months, years)

ASSUMPTIONS

- ASSUMPTION 3 - Left-censoring should be minimized or avoided

- Time between participant developing disease and diagnosis is unknown and not included in Kaplan-Meier analysis

- Left censored data - Does not reflect observed survival time

- Survival time recorded will be less than (or equal to) observed survival time

ASSUMPTIONS

- ASSUMPTION 4 - Independence of censoring and the event

Censored data does relate to event, this introduces serious bias to results

- ASSUMPTION 5 - There should be no secular trends (also known as secular changes)

If over follow up period of time, factors have changed that affect likelihood of event then it may introduce bias

ASSUMPTIONS

- ASSUMPTION 6 - There should be similar amount and pattern of censorship per group

- To detect censoring

(a) Percentage of censored cases per intervention group

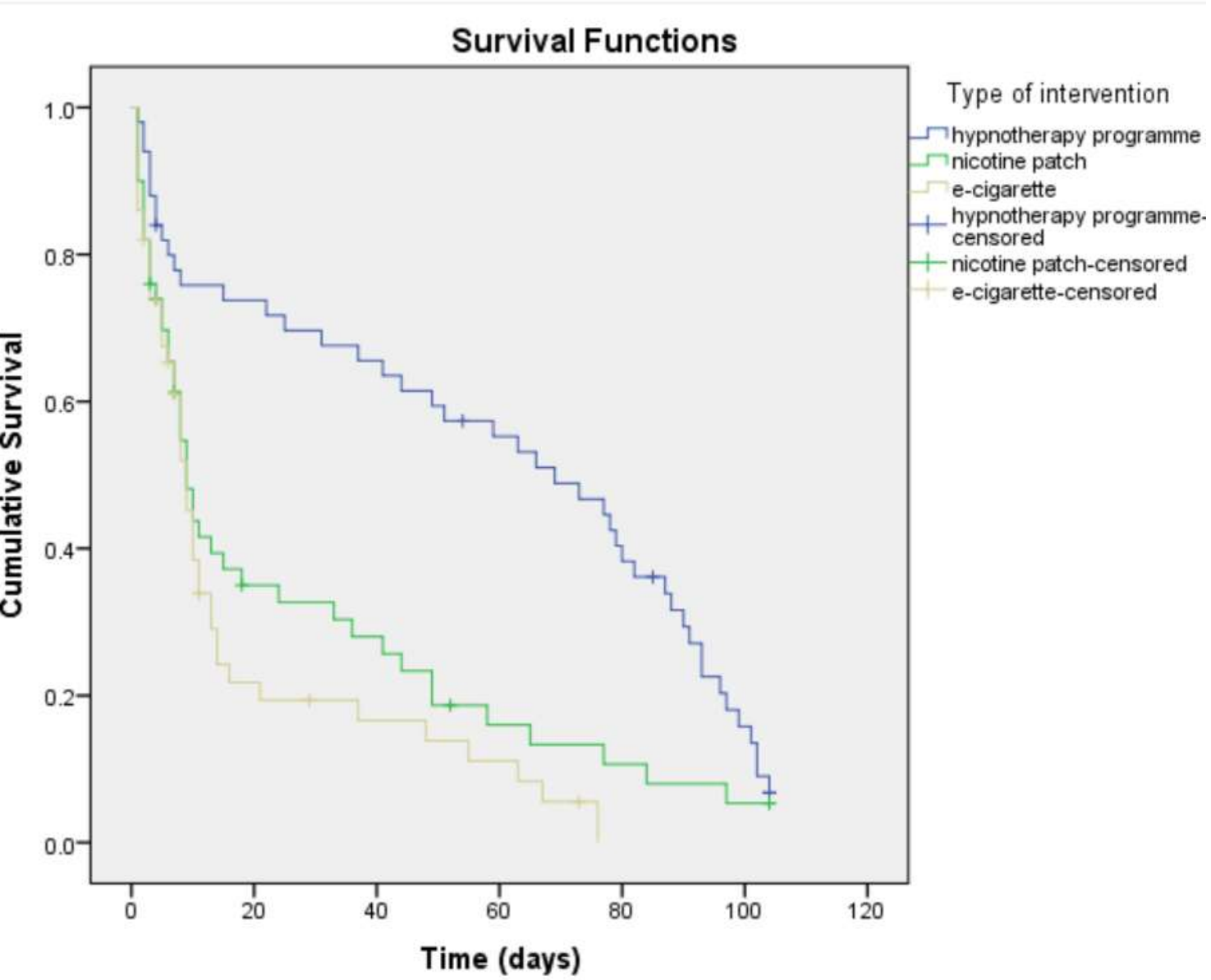
(b) Pattern of censoring using a scatterplot.

Censoring should not related to time and pattern of censoring is same in all groups

EXAMPLE

- Researcher wanted to determine relative effectiveness of three types of intervention designed to help long-term smokers quit: "hypnotherapy programme", wearing "nicotine patches" and use of "e-cigarettes" (electronic cigarettes)
- A successful result would be where smokers did not start smoking again
- Also, longer the length of time it took before participants started smoking again, more effective the intervention

KAPLAN-MEIER SURVIVAL CURVES



Lower cumulative survival proportion and lower (i.e., on the y-axis) survival curve on graph

Means and Medians for Survival Time

intervention	Mean[a]				Median			
			95% Confidence Interval				95% Confidence Interval	
	Estimate	Std. Error	Lower Bound	Upper Bound	Estimate	Std. Error	Lower Bound	Upper Bound
hypnotherapy programme	57.955	5.504	47.167	68.742	69.000	12.162	45.163	92.837
nicotine patch	26.237	4.666	17.092	35.383	9.000	1.243	6.563	11.437
e-cigarette	17.601	3.403	10.931	24.271	9.000	.971	7.097	10.903
Overall	34.947	3.100	28.871	41.024	13.000	3.064	6.995	19.005

a. Estimation is limited to the largest survival time if it is censored.

Kaplan-Meier survival analysis, mean survival time has far less importance than median

Median values for each group are found under "Estimate" column and 95% confidence intervals for median under "Lower Bound" and "Upper Bound" columns under "95% Confidence Interval" column

RESULTS

- Three statistical tests determine whether survival functions are equal - the log rank test, Breslow test and the Tarone-Ware test

Overall Comparisons

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	**25.818**	**2**	**.000**
Breslow (Generalized Wilcoxon)	20.447	2	.000
Tarone-Ware	24.456	2	.000

Test of equality of survival distributions for the different levels of intervention.

RESULTS

- THE LOG RANK TEST - Weights difference at each time point equally (i.e., all weights are equal to 1)

- Greater emphasis on differences at later rather than earlier time points

RESULTS

- Log rank test - Testing null hypothesis that there is no difference in overall survival distributions between the groups (e.g., intervention groups) in population
- Calculates $\chi 2$-statistic (the "Chi-Square" column), which is compared to $\chi 2$-distribution with two degrees of freedom (the "df" column)

RESULTS

- $p < .05$ - Statistically significant result

  Survival distributions of different types of intervention are not equal in population

- $p > .05$ - Statistically insignificant result

  Cannot conclude Survival distributions are different in population

PAIRWISE COMPARISONS

	intervention	hypnotherapy programme		**nicotine patch**		e-cigarette	
		Chi-Square	Sig.	Chi-Square	Sig.	Chi-Square	Sig.
Log Rank (Mantel-Cox)	**hypnotherapy programme**			**11.035**	**.001**	29.003	.000
	nicotine patch	11.035	.001			1.541	.214
	e-cigarette	29.003	.000	1.541	.214		

Pairwise Comparisons

	intervention	hypnotherapy programme		**nicotine patch**		e-cigarette	
		Chi-Square	Sig.	Chi-Square	Sig.	Chi-Square	Sig.
Log Rank (Mantel-Cox)	hypnotherapy programme			11.035	.001	29.003	.000
	nicotine patch	11.035	.001			1.541	.214
	e-cigarette	29.003	.000	**1.541**	**.214**		

Pairwise log rank comparisons conducted to determine which intervention groups had different survival distributions

CONCLUSION

- Participants randomly assigned to three different interventions in order to quit smoking: hypnotherapy programme (n = 50), wearing nicotine patches (n = 50) and using e-cigarettes (n = 50)
- Kaplan-Meier survival analysis conducted to compare three different interventions for their effectiveness in preventing smoking resumption

CONCLUSION

- Participants that underwent hypnotherapy programme had median time to smoking resumption of 69.0 (95% CI, 45.2 to 92.8) days
- This was longer than groups receiving nicotine patches or e-cigarettes, which had identical median times to smoking resumption of 9.0 (95% CI, 6.6 to 11.4) days and 9.0 (95% CI, 7.1 to 10.9) days, respectively

CONCLUSION

- A log rank test was conducted to determine if there were differences in the survival distributions for the different types of intervention. The survival distributions for the three interventions were statistically significantly different, $p < .0005$
- Pairwise log rank comparisons were conducted to determine which intervention groups had different survival distributions

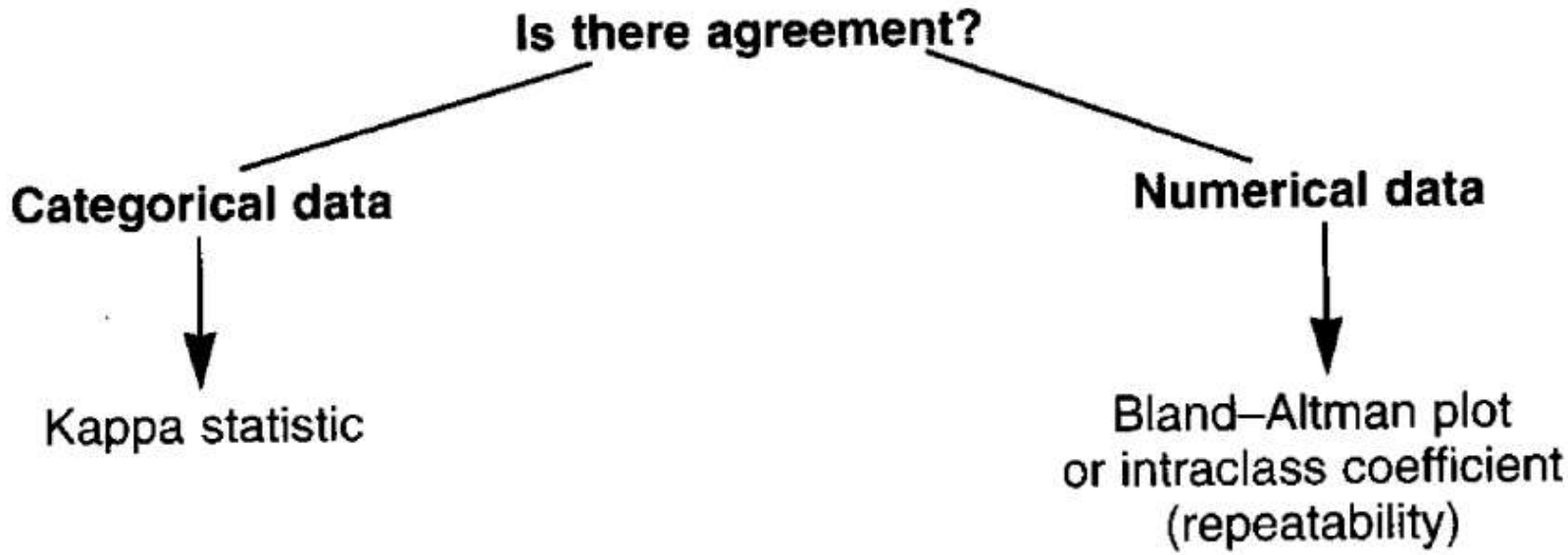
CONCLUSION

- Bonferroni correction made with statistical significance accepted at the $p < .0167$ level
- There was statistically significant difference in survival distributions for hypnotherapy vs nicotine patch intervention $p = .001$, and hypnotherapy vs e-cigarette intervention,
- $p < .0005$
- Survival distributions for e-cigarette and nicotine patch interventions were not statistically significantly different, $p = .214$

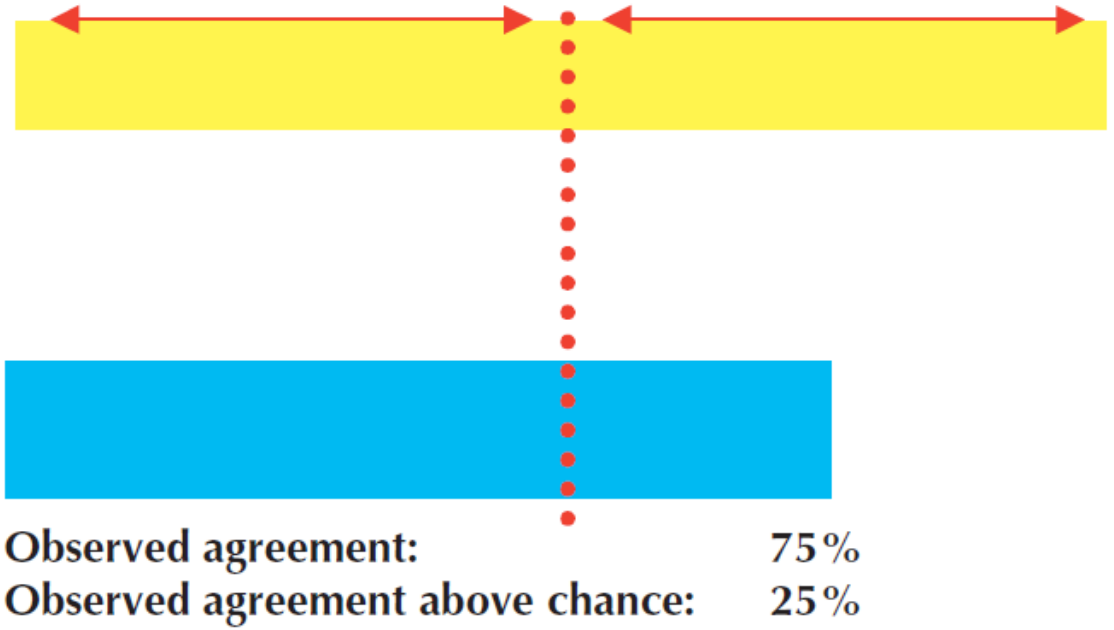
ANOVA

- ONE-WAY ANALYSIS OF VARIANCE (ANOVA) - To determine whether there are any statistically significant differences between means of two or more independent groups
- TWO-WAY ANOVA - To determine whether there is interaction effect between two independent variables on continuous dependent variable
- THREE-WAY ANOVA - To determine if there is interaction effect between three independent variables on continuous dependent variable

To study agreement



- Kappa statistic corrects for chance agreement and tells us how much of possible agreement over and above chance the reviewers have achieved



Calculation of kappa –

$$\frac{\text{observed agreement – agreement expected by chance}}{\text{100\% - agreement expected by chance}}$$

QUANTITATIVE CLASSIFICATION OF KAPPA VALUES AS DEGREE OF AGREEMENT BEYOND CHANCE	
KAPPA VALUE	DEGREE OF AGREEMENT BEYOND CHANCE
0	NONE
0-0.2	SLIGHT
0.2-0.4	FAIR
0.4-0.6	MODERATE
0.6-0.8	SUBSTANTIAL
0.8-1	ALMOST PERFECT

KAPPA values - range from -1 to +1

NEGATIVE value for weighted kappa (κ_w) - Agreement between two raters was less than the agreement expected by chance, with -1 indicating that there was no observed agreement

Zero - agreement no better than chance

TAKE HOME MESSAGE

- In terms of selecting statistical test, most important question is “ what is the main study hypothesis?”
- Important to decide a priori which hypotheses are confirmatory (testing some presumed relationship) and which are exploratory (are suggested by data)
- Need to determine independency of data