Epidemiology & Biostatistics

MD3

Biostatistics

Learning Objectives

❑❑ Demonstrate understanding of key probability rules

❑❑ Summarize data

❑❑ Solve problems using inferential statistics

❑❑ Use knowledge of nominal, ordinal, interval, and ratio scales

❑❑ Answer questions about statistical tests

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DESCRIPTIVE STATISTICS

Distributions

Statistics deals with the world as *distributions*. These distributions are summarized by a **central tendency** and **variation around that center**. The most important distribution is the **normal** or **Gaussian curve**. This “bell-shaped” curve is **symmetric**, with one side the mirror image of the other.

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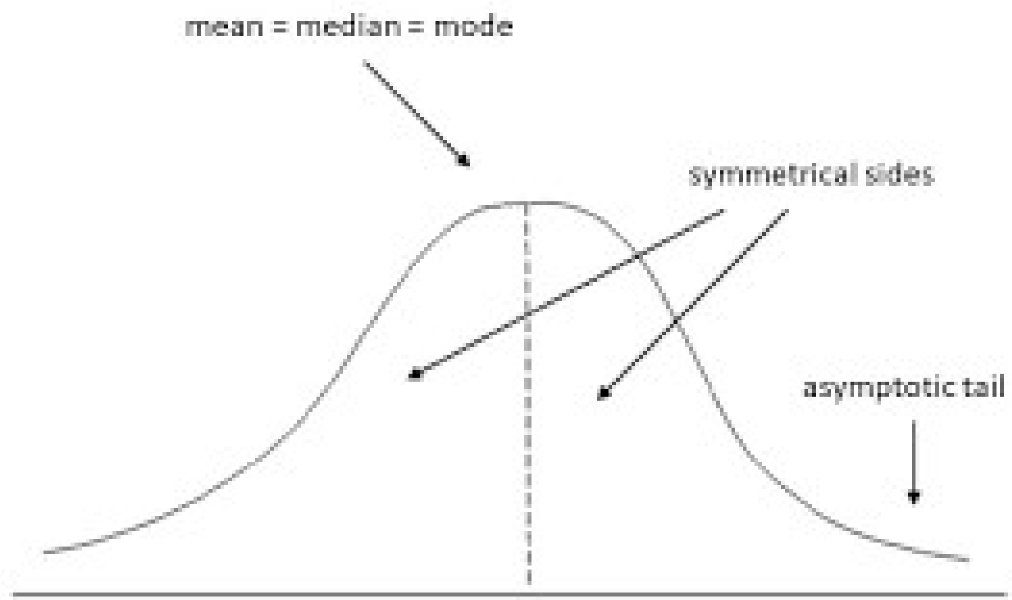
Normal distribution curve



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Measures of central tendency

Central tendency describes a single value which attempts to describe a set of data by identifying the central (or middle) value within that set. (Colloquially, measures of central tendency are often called *averages*.) There are several valid measures:

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M**ean (X)** (or *average*): sum of the values of the observations divided by the numbers of observations

Calculate the mean of 2,4,4,6,2,4,6,8,9

1. Calculate the mean marks of a class where 10 people scored 10 marks and rest 10 scored 15 marks
2. Calculate the average cash each student will have in a class of 10 , where there carried 1,2,3,4,5,6,7,8,9,10 $
3. Calculate the average of 1-100

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Median (Md): point on the scale which divides a group into 2 parts (upper and lower half); the measurement below which half the observations fall is *50th percentile*

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Mode:

Most frequently occurring value in a set of observations

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Given the distribution of numbers: 3, 6, 7, 7, 9, 10, 12, 15, 16, the **mode is 7**, the **median is 9**, and the **mean is 9.4**.

Not all curves are normal; sometimes the curve is **skewed** positively or negatively.

- A **positive skew** has the tail to the right, and the mean greater than the median.
- A **negative skew** has the tail to the left, and the median greater than the mean. For skewed distributions, the **median** is a better representation of central tendency than is the mean.

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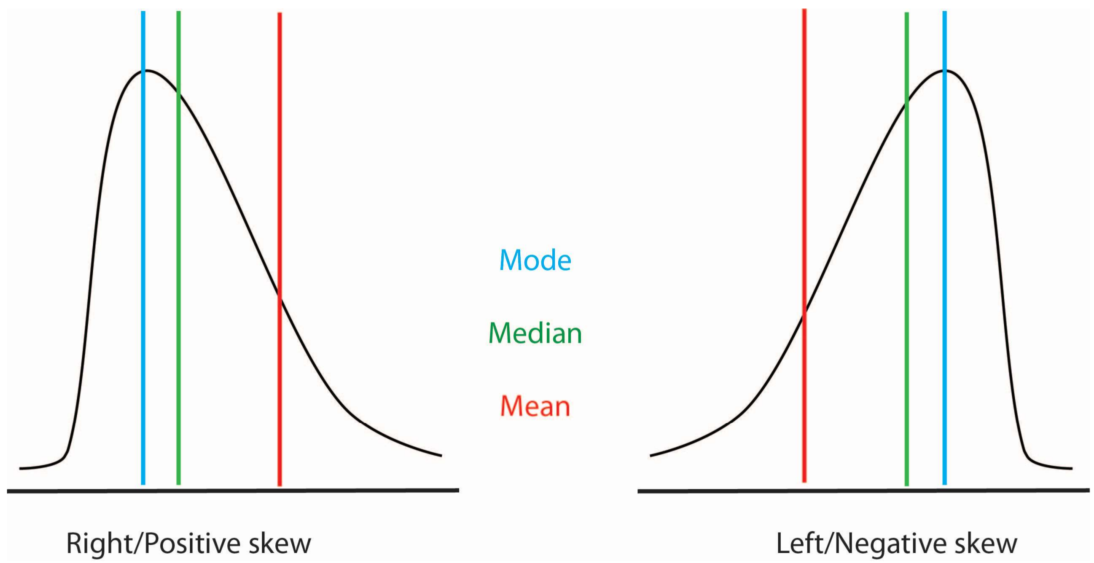
Skewed distribution



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Measures of variability

The simplest measure of variability in statistics is the **range**, the difference between the highest and the lowest score. However, the range is unstable and can change easily.

A more stable and more useful measure of dispersion is the **standard deviation (S** or **SD)**.

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To calculate the SD:

I. First subtract the mean from each score to obtain **deviations from the mean**. This will give us both positive and negative values.

II. Then square the deviations to make them all positive.

III. Add the squared deviations together and divide by the number of cases.Take the square root of this average, and the result is the SD:

$$\textit{Standard Deviation} = \sqrt{\frac{\mathcal{E}(X - x)^2}{n - 1}}$$

Ɛ= Sum

X= Individual values

x= Average of X

n= Number of events

The square of the SD (s2) equals the **variance**.

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On the exam you will not be asked to calculate SD and variance, but you will need to understand how they relate to the normal curve. Also, be able to combine the given SD constants to answer basic questions.

In any normal curve, a constant proportion of the cases fall within 1, 2, and 3 SDs of the mean: within

- 1 SD 68%;
- 2 SDs 95.5%
- 3 SDs 99.7%.

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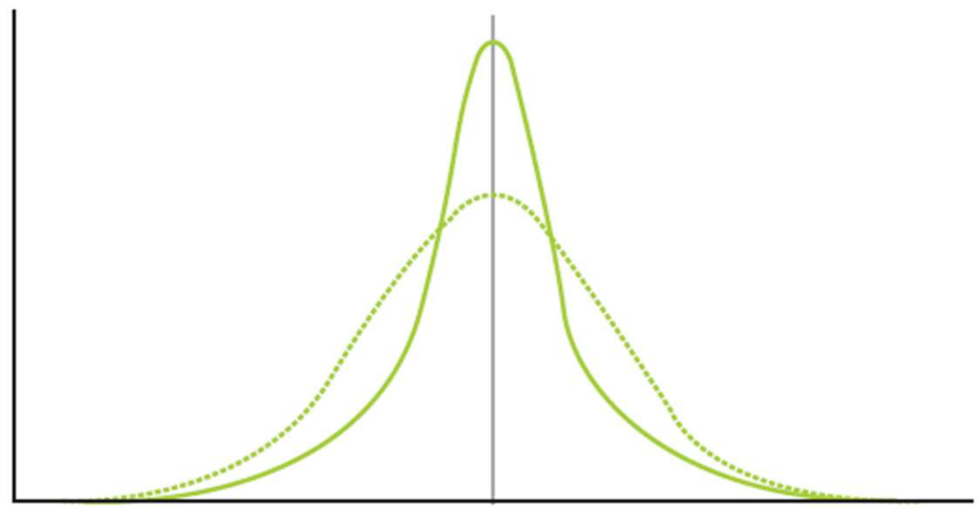
Two normal curves with Same mean Different SD

Average height of male in India vs China



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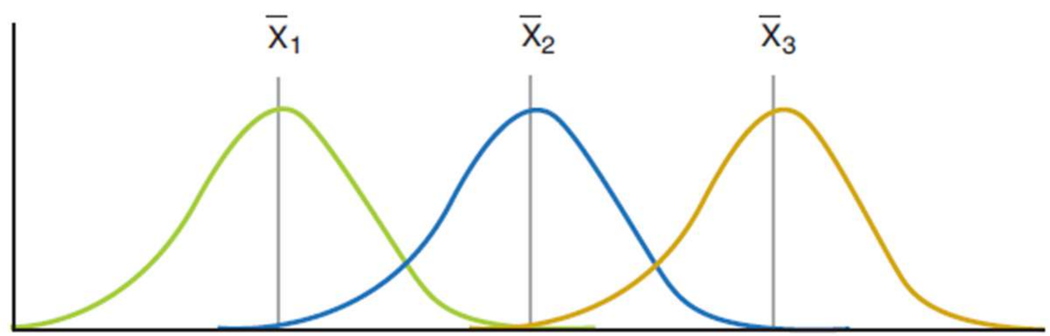
Normal curves with different mean and same SD

Average marks in physics chemistry and biology



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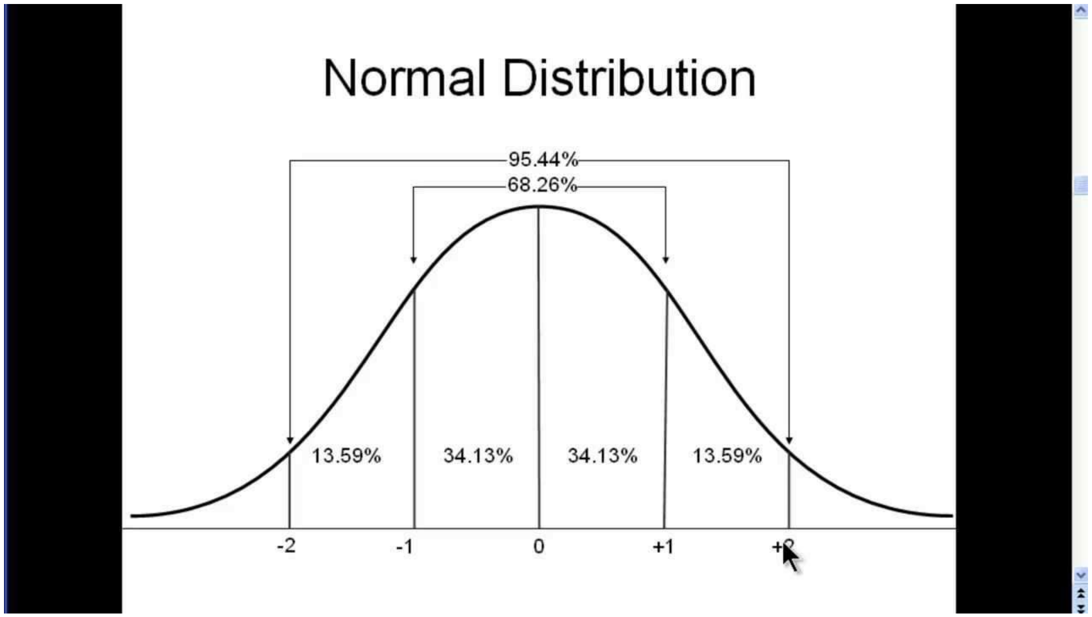
Normal distribution



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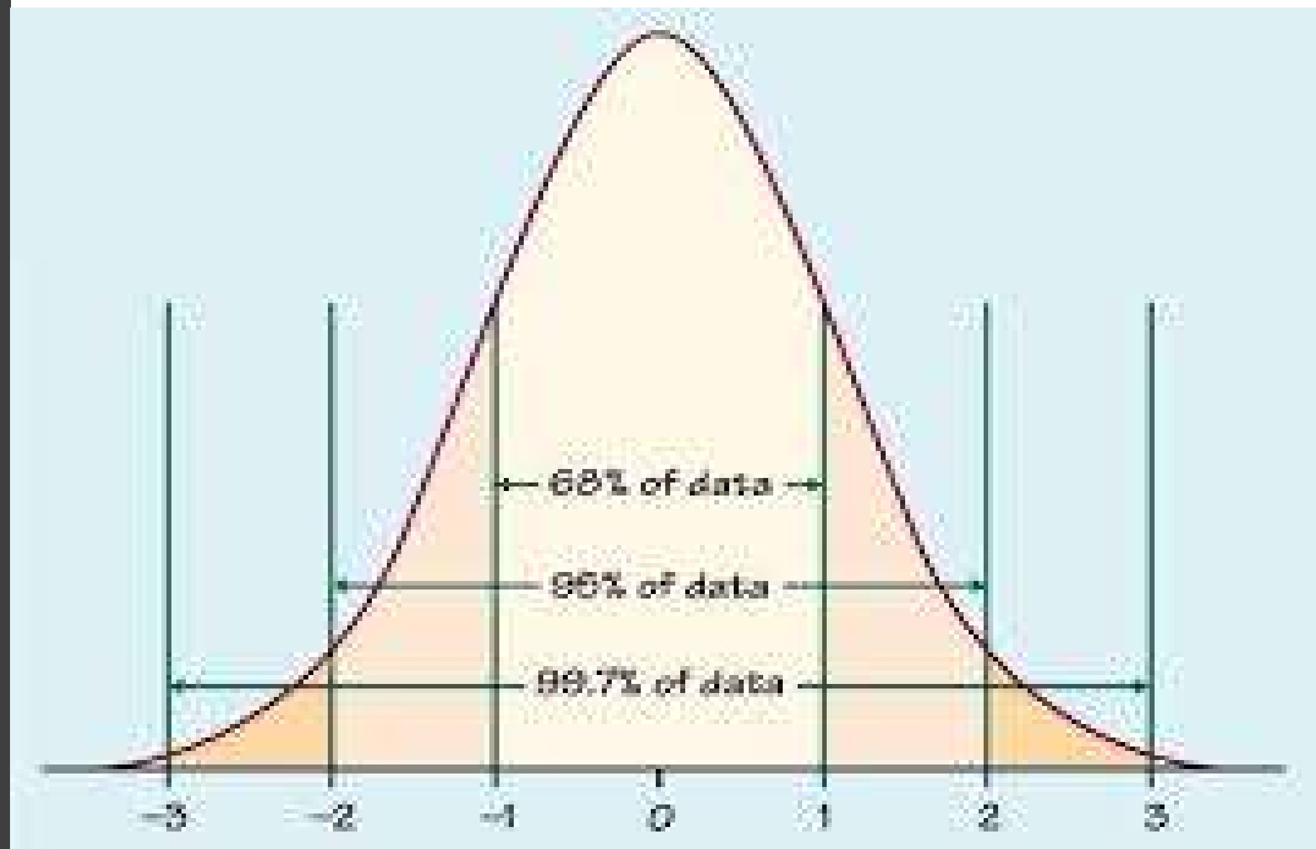
Normal distribution



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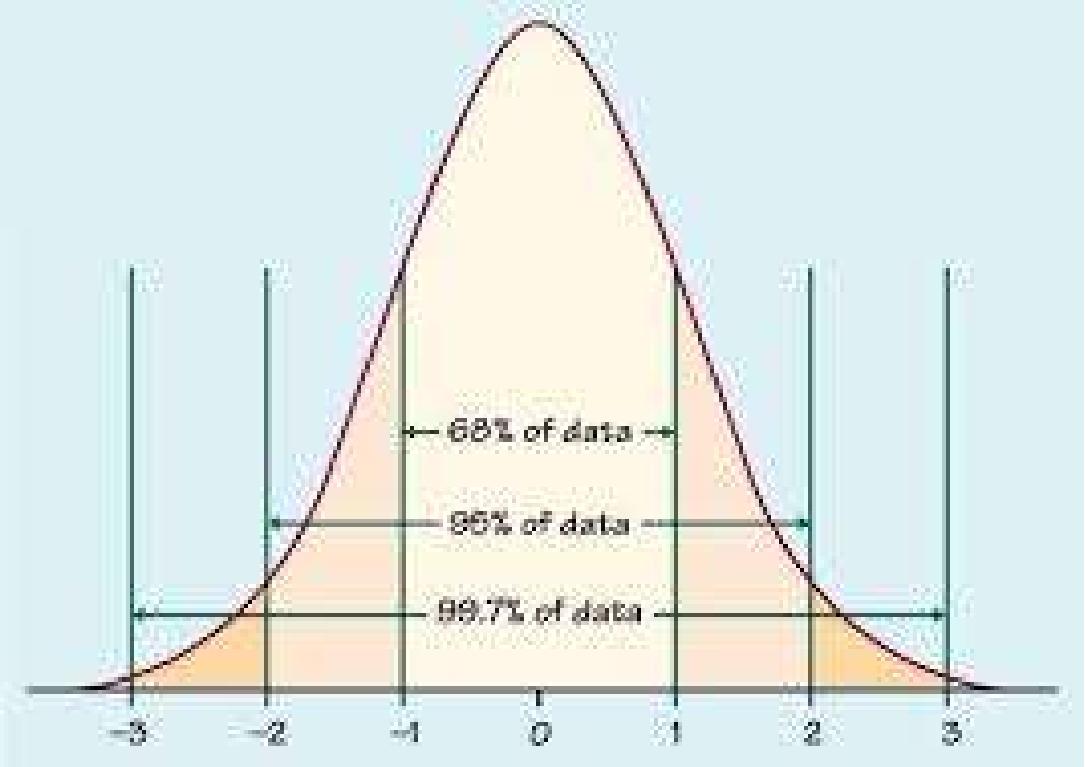
In a normal distribution curve, what percent of the cases are below 2 SDs below the mean?



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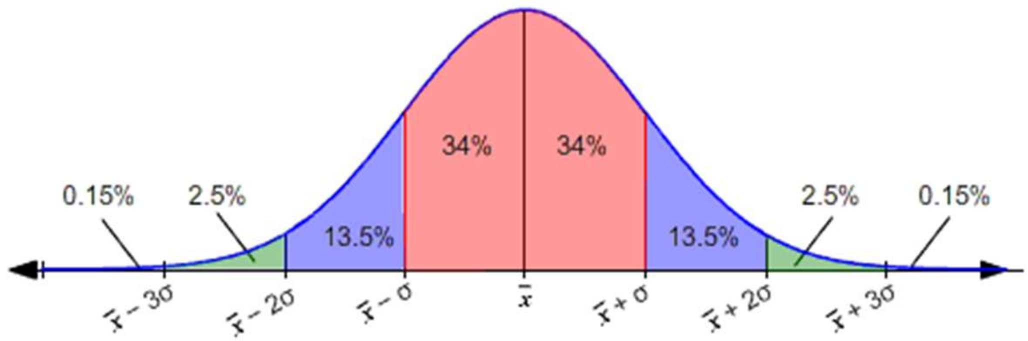
In a normal distribution curve, what percent of the cases are above 1 SD below the mean?



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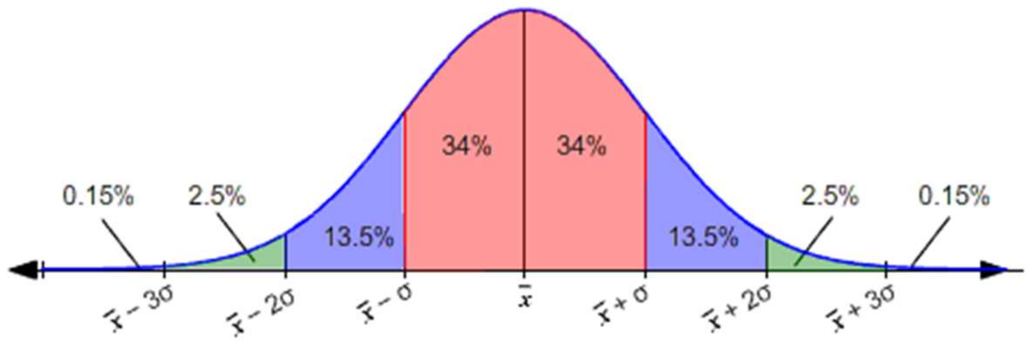
A student who scores at the 97.5 percentile falls where on the curve?



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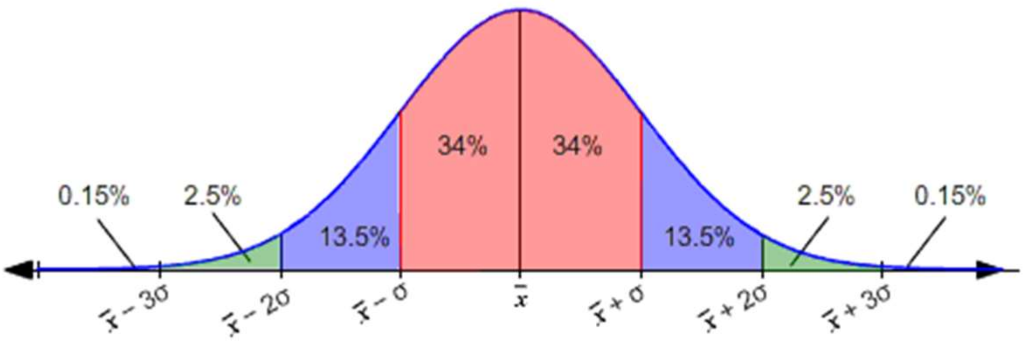
A student took 2 tests: On test A his results were score 45%, mean 30%, and SD 5%. On test B the results were score 60%, mean 40%, and SD 10%. On which test did the student do better, relative to his classmates?



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INFERENTIAL STATISTICS

The purpose of inferential statistics is to designate **how likely it is that a given finding is simply the result of chance**. Inferential statistics would not be necessary if investigators could study all members of a population. However, because that can rarely be done, using select samples that are representative of an entire population allows us to **generalize the results from the sample to the population**.

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Confidence Interval

Confidence interval is a way of admitting that any measurement from a sample is only an **estimate** of the population, i.e., although the estimate given from the sample is likely to be close, the true values for the population may be above or below the sample values. A confidence interval **specifies how far above or below a sample-based value the population value lies** within a given range, from a possible high to a possible low. Reality, therefore, is most likely to be somewhere within the specified range.

To calculate the confidence interval: **study result +/- Z score × standard error**

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Study result might be a mean, a relative risk or any other relevant measure that is the result of the data from the study itself. **Z score** depends on the level of confidence required. In medicine, the requirement is **at least a 95% confidence interval**. So the options are as follows:

- Z score for 95% confidence interval = 1.96 = 2
- Z score for 99% confidence interval = 2.58 = 2.5

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While the SD measures the variability within a single sample, the **standard error** estimates the variability *between* samples. The standard error is usually provided. The smaller the standard error, the better and more precise the study.

The standard error is affected by 2 factors: the SD and the sample size (n). The greater the SD, (high variation in the data), the greater the standard error, and the larger the sample size, the smaller the standard error.

Standard Error: $\frac{SD}{\sqrt{n}}$

Confidence range = Average $\pm$ SE

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Suppose 100 students in the 9th grade have just taken their final exam, and the mean score was 64% with SD 15. The 95% confidence interval of the mean for 9th grade students in the population would be as follows:

- Mean = 65
- Z score for 95% confidence = 2 (rounded up Z score)
- SD = 15
- Sample size = 100
- *SD/n*

Plug in the numbers:

What this means is that we are 95% sure that the mean score of 9th graders in the population will fall somewhere between 62 and 68.

Assuming the graph below presents 95% confidence intervals, which groups, if any, are statistically different from each other?

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When comparing 2 groups, any overlap of confidence intervals means the groups are not significantly different. If the graph represents 95% confidence intervals, drugs B and C are no different in their effects; drug B is no different from drug A and drug A has a better effect than drug C. For the confidence interval for **relative risk and odds ratios**, consider the following:

- **If the given confidence interval contains 1.0, then there is no statistically significant effect of exposure**.
- If **RR** >**1.0**, then subtract 1.0 and read as percent increase. So 1.77 means one group has 77% more cases than the other. If **RR** <**1.0**, then subtract from 1.0 and read as reduction in risk. So 0.78 means one group has a 22% reduction in risk.

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If the given confidence interval contains 1.0, then there is no statistically significant effect of exposure.

Relative Risk	Confidence Interval	Interpretation
1.77	(1.22 – 2.45)	Statistically significant (increased risk)
1.63	(0.85 – 2.46)	NOT statistically significant (risk is the same)
0.78	(0.56 – 0.94)	Statistically significant (decreased risk)

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Statistical Inference

The goal of science is to define reality. Think of statistics as the referee in the game of science. We have all agreed to play the game according to the judgment calls of the referee, even though we know the referee can, and will, be wrong at times. The basic steps of statistical inference are as follows:

1. Define the **research question**: What are you trying to show?

2. Define the **null hypothesis** (generally the opposite of what you hope to show). Null hypothesis says that the **findings are the result of chance or random factors**. If you want to show that a drug works, the null hypothesis will be that the drug does NOT work. The **alternative hypothesis** says what is left after defining the null hypothesis. In this example, that the drug does work.

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There are 2 types of null hypothesis:

- **One-tailed**, i.e., directional or “one-sided,” such that one group is greater than or less than the other (Group A is not less than Group B, or Group A is not greater than Group B)
- **Two-tailed**, i.e., nondirectional or “two-sided,” such that 2 groups are not the same (Group A ≠ Group B)

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Once the data are collected and analysed by the appropriate statistical test, the **hypothesis testing** is begun. How to run these tests is not tested on the exam, but you may need to be able to interpret results of statistical tests with which you are presented.

- To interpret output from a statistical test, focus on the ***p*-value**. The term *p*-value refers to 2 things. In its first sense, the *p*-value is a standard against which we compare our results. In the second sense, the *p*-value is a result of computation.

The **computed *p*-value is compared with the *p*-value criterion to test statistical significance**. If the computed value is less than the criterion, we have achieved statistical significance. In general, the smaller the *p* the better.

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- The *p*-value criterion is traditionally set at $p \leq 0.05$. (Assume these are the criteria if no other value is explicitly specified.) Using this standard:

- If $p \leq 0.05$, reject the null hypothesis (reached statistical significance).

- If $p > 0.05$, do not reject the null hypothesis (has not reached statistical significance).

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Types of error

- If we do reject the null hypothesis, we are still not certain we are correct, i.e., the results given by the sample may be inconsistent with the full population. If that is true, any decision made based on the sample could be in error.
- Two types of errors can be made:

Type I error (α error): rejecting the null hypothesis when it is really true

— This type of error assumes a statistically significant effect on the basis of the sample when there is none in the population, e.g., asserting that the drug works when it doesn't.

— The chance of type I error is given by the *p*-value; if $p = 0.05$, then the chance of a type I error is 5 in 100, or 1 in 20 if we reject the null hypothesis based on the evidence of the data.

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Type II error (β error): Failing to reject the null hypothesis when it is false

— This type of error declares no significant effect based on the sample when there really is one in the population, e.g., asserting the drug does not work when it really does.

— The chance of a type II error cannot be directly estimated from the *p*-value.

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The ***p*-value** here does a few things:

- Provides criterion for making decisions about the null hypothesis
- Quantifies the chance that a decision to reject the null hypothesis will be wrong
- Tells statistical significance, not clinical significance or likelihood of benefit
- Note

A **type I error (error of commission)** is generally considered **worse** than a type II error (error of omission). If the null hypothesis is rejected, there is no chance of a type II error.

- If the null hypothesis is not rejected, there is no chance of a type I error.

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The *p*-value **does not** tell us the following:

- Chance that an individual patient will benefit
- Percentage of patients who will benefit
- Degree of benefit expected for a given patient

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Statistical power

- In statistics, **power** is the capacity to detect a difference if there is one. Just as increasing the power of a microscope makes it easier to see what is going on in histology, increasing statistical power allows us to detect what is happening in the data.

Power is directly related to type II error.

Power = **1** - **β**

There are several ways to increase statistical power. The most common is to increase sample size.

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STATISTICAL TESTS

Selecting the correct statistical test for a research project will depend on the nature of the variables being studied.

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Statistical tests

		Variables	
Name of Statistical Test	**Interval**	**Nominal**	**Comment**
Pearson correlation	2	0	Is there a linear relationship?
Chi-square	0	2	Any # of groups
t-test	1	1	2 groups only
One-way ANOVA	1	1	2 or more groups
Matched pairs *t*-test	1	1	2 groups, linked data pairs, before and after
Repeated measures ANOVA	1	1	More than 2 groups, linked data

ANOVA = Analysis of Variance

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Correlation (*r*, -1.0 to +1.0)

Correlation, by itself, does not mean causation. A correlation coefficient indicates the degree to which 2 measures are related, not *why* they are related. In other words, it does not mean that one variable necessarily causes the other.

There are 2 types of correlation:

- **Pearson correlation** compares 2 interval level variables
- **Spearman correlation**: compares 2 ordinal level variables

A **positive value** means that **2 variables go together in the same direction,** e.g., MCAT scores have a positive correlation with medical school grades. A **negative value** means that the **presence of one variable is associated with the absence of another variable,** e.g., there is a negative correlation between age and quickness of reflexes.

- The further from zero, the stronger the relationship ($r = 0$). A **zero correlation** means that **2 variables have no linear relation to one another,** e.g., height and success in medical school.
- Correlation can be graphed using a scatterplot, which shows points that approximate a line.

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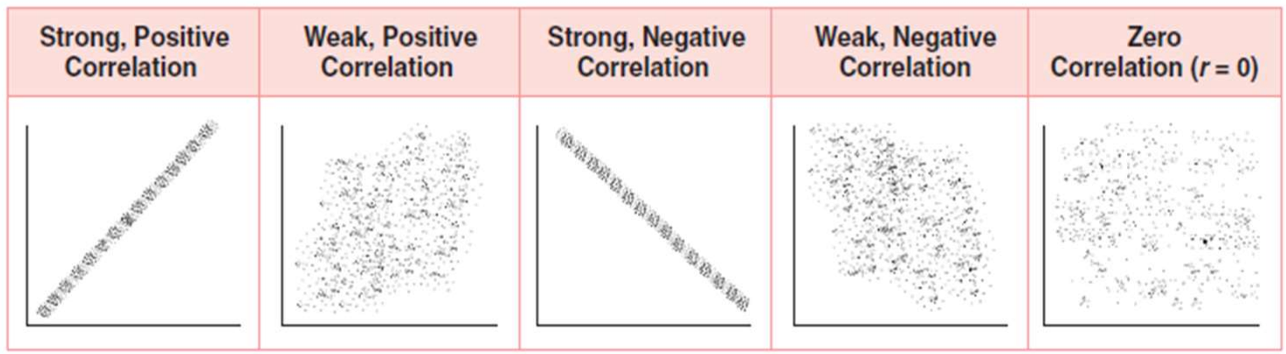
- NoteOn the exam you will not be asked to compute statistical tests but do recognize how and when they shouldbe used.

You should, however, be able to interpret **scatterplots of data:** positive slope, negative slope, and which of asset of scatterplots indicates a strongercorrelation.



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***t*-test**

A *t*-test **compares the means of 2 groups** from a single nominal variable, using means from an interval variable to see whether the groups are different.

The output of a *t*-test is a "*t*" statistic. It is used for 2 groups only, i.e., compares 2 means. For example, do patients with MI who are in psychotherapy have a reduced length of convalescence compared with those who are not in therapy?

- **Pooled** *t*-test is a regular *t*-test, assuming the variances of the 2 groups are the same
- **Matched pairs** *t*-test involves matching each person in one group with a person in a second group; applies to before-and-after measures and linked data

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Analysis of Variance (ANOVA)

Output from an ANOVA is ≥1 F-statistics.

- **One-way ANOVA** compares means of many groups (≥2) of a single nominal variable using an interval variable. A significant *p*-value means that at least 2 of the tested groups are different.
- **Two-way ANOVA** compares means of groups generated by 2 nominal variables using an interval variable. It can test the effects of several variables at the same time.
- **Repeated measures ANOVA** features multiple measurements of the same people over time.

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***Chi*-square**

A *chi*-square tests to see whether 2 nominal variables are independent, i.e., in order to test the efficacy of a new drug, compare the number of recovered patients given the drug with those who were not. *Chi*-square features nominal data only, and any number of groups (2 × 2, 2 × 3, 3 × 3, etc.).

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A recent study finds a higher incidence of SIDS for children of mothers who smoke. If the rate for smoking mothers is 230/100,000 and the rate for non smoking mothers is 71/100,000, what is the relative risk for children of mothers who smoke?

A. 159

B. 32

C. 230

D. 3.2

E. 8.4

Biostatistics

A researcher wishing to demonstrate the efficacy of a new treatment for hypertension compares the effects of the new treatment versus a placebo. This study provides a test of the null hypothesis that the new treatment has no effect on hypertension. In this case, the null hypothesis should be considered as

A. positive proof that the stated premise is correct.

B. the assertion of a statistically significant relationship.

C. the assumption that the study design is adequate.

D. the probability that the relationship being studied is the result of random factors.

E. the result the experimenter hopes to achieve.

Biostatistics

A standardized test was used to assess the level of depression in a group of patients on a cardiac care unit. The results yielded a mean of 14.60 with confidence interval of 14.55 and 14.65. This presented confidence interval is

- A. less precise but has a higher confidence than 14.20 and 15.00.
- B. more precise but has a lower confidence than 14.20 and 15.00.
- C. less precise but has a lower confidence than 14.20 and 15.00.
- D. more precise, but has a higher confidence than 14.20 and 15.00.
- E. indeterminate, because the degree of confidence is not specified.

Biostatistics

12. A recently published report explored the relationship between height and subjects' self-reported cholesterol levels in a sample of 44- to 65-yearold males. The report included a correlation of +0.02, computed for the relationship between height and cholesterol level. One of the possible interpretations of this correlation is:

A. The statistic proves that there is no definable relationship between the two specified variables.

B. There is a limited causal relationship between the two specified variables.

C. A real-life relationship may exist, but the measurement error is too large.

D. A scatterplot of the data will show a clear linear slope.

E. The correlation is significant at the 0.02 level.

Biostatistics

The Collaborative Depression study examined several factors impacting the detection and treatment of depression. One primary focus was to develop a biochemical test for diagnosing depression. For this research, a subpopulation of 300 persons was selected and subjected to the dexamethasone suppression test (DST). The results of the study are as follows:

13. Which of these ratios' measures specificity?

A. 102:150

B. 102:189

C. 63:150

D. 87:150

E. 63:111

	Actual Depression	
	NO	YES
DST Results		
Depressed	87	102
Nondepressed	63	48

Biostatistics

A 56-year-old female comes to the emergency department because of chest pain and shortness of breath. You use test X to rule out the possibility of a pulmonary embolus. Her result is negative. Test X has a specificity of 80% and a sensitivity of 90% when tested in 100 subjects with pulmonary embolus and 100 subjects without pulmonary embolus. Assume that this patient's pretest probability for having a pulmonary embolus is equivalent to the disease prevalence in the study population What is the probability that this patient truly does not have a pulmonary embolus?

A. 80%
B. 90%
C. 89%
D. 20%
E. 66%
F. 10%

Biostatistics

A large study of serum folate levels in a sample of women age 16-45 reveals that this parameter is normally distributed with a mean of 5.0 ng/ml and a standard deviation of 0.5 ng/mL According to the study results, 95% of serum folate observations in these patients will lie approximately between which of the following limits?

A.

Biostatistics

A study investigating a new test for diagnosing acute myocardial infarction (AMI) has just been released. The sensitivity of the test is 75% and the specificity is 80%. The St Jude contains 200 patients who actually had an AMI and 400 who actually did not, as determined by the diagnostic gold standard. How many false negatives are in the St Jude?

A. 50

B. 80

C. 120

D. 150

E. 320

Biostatistics

The graph below shows the yearly incidence of viral hepatitis per 100,000 population from 1982-2012 in the United States (US). During this period, the total population in the US continued to increase, as shown in the table below:

At any given time point, the number of individuals at risk for hepatitis infection is assumed to be equal to the total US population. Based on these data, which of the following is most likely to be true?

A. After 2006, hepatitis B prevalence surpassed hepatitis A and hepatitis C prevalence

B. In 1987, there were as many individuals with hepatitis A as with hepatitis B

C. In 1989, there were more individuals with hepatitis A than with hepatitis B in the US

D. In 1997, there were more new cases of hepatitis A than of hepatitis B and C combined

E. The number of new cases of hepatitis A diagnosed in 1982 and 1998 were the same

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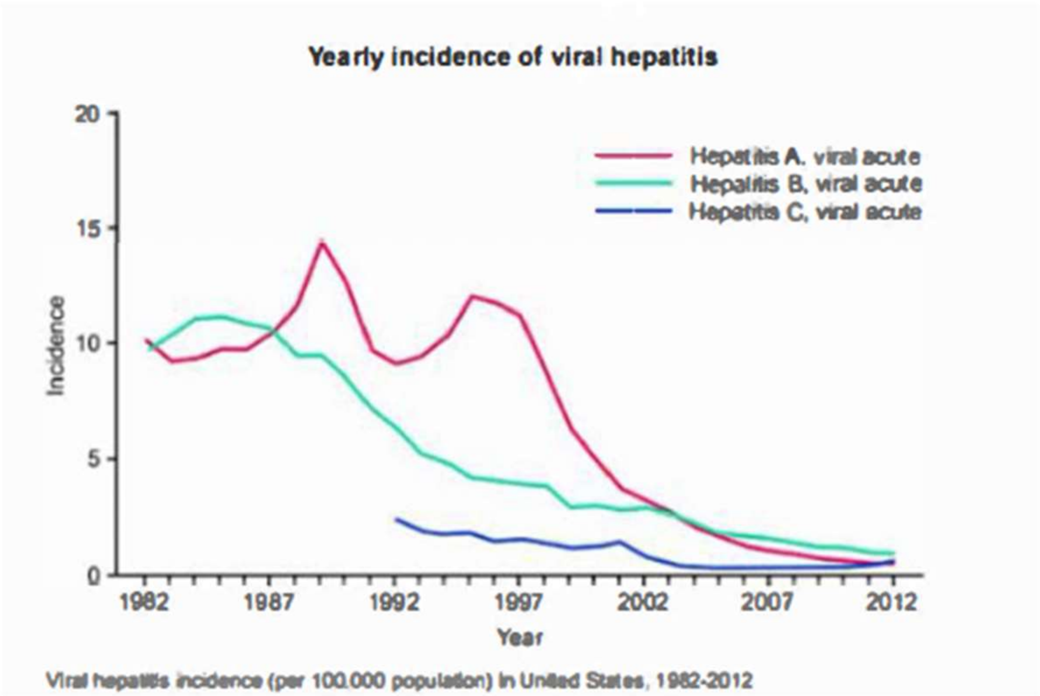
- A. After 2006, hepatitis B prevalence surpassed hepatitis A and hepatitis C prevalence
- B. In 1987, there were as many individuals with hepatitis A as with hepatitis B
- C. In 1989, there were more individuals with hepatitis A than with hepatitis B in the US
- D. In 1997, there were more new cases of hepatitis A than of hepatitis B and C combined
- E. The number of new cases of hepatitis A diagnosed in 1982 and 1998 were exactly the same



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A study was conducted to assess the impact of cholesterol levels on all-cause mortality on 400 patients hospitalized with diabetes mellitus-related cardiovascular complications. Serum cholesterol levels were found to be normally distributed among the patients with a mean of 220 mg/dl and standard deviation of 10 mg/dl. Based on the study results, how many patients are expected to have serum cholesterol >240 mg/dl in this study?

A. 2

B. 10

C. 20

D. 64

E. 128

Biostatistics

A 62-year-old man with diabetes, hypertension, and hyperlipidaemia comes to the emergency department of an academic medical centre with chest pain, nausea, vomiting, and diaphoresis. An electrocardiogram demonstrates ST elevation in the anterior leads, and cardiac enzymes are markedly elevated. Investigators at the centre are designing a randomized control trial to test the hypothesis that drug B will decrease the mortality associated with acute ST-elevation myocardial infarction compared to standard of care. To ensure that investigators will not miss a difference between drug Band standard of care (if a difference truly exists), which of the following would they want to maximize?

A. alpha

B. beta

C. Type I error

D. Type II error

E. 1-beta

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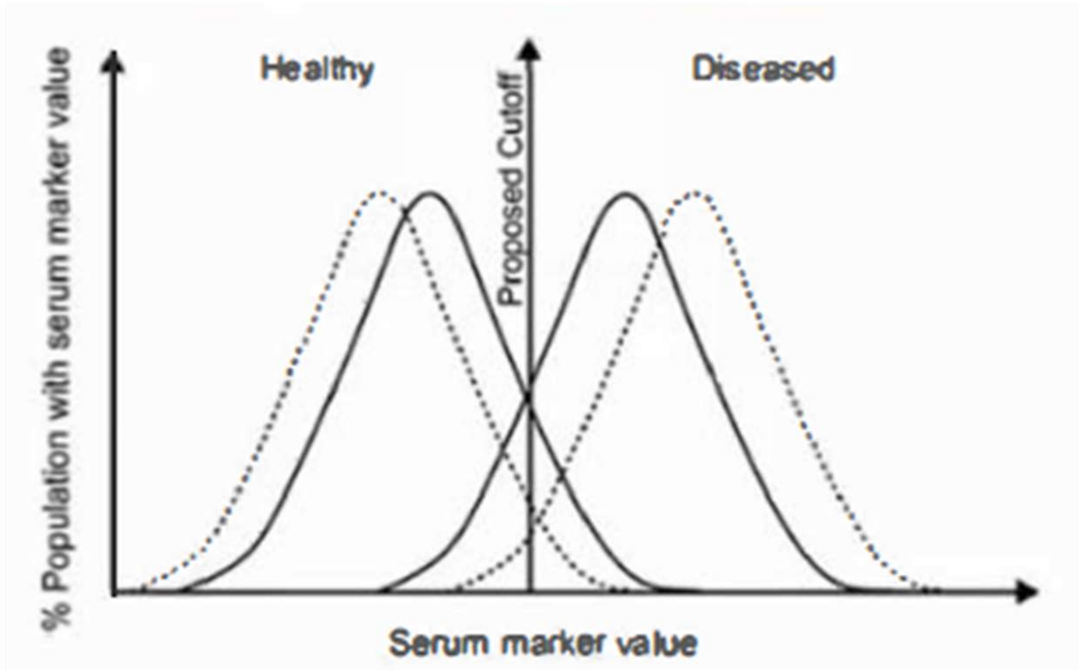
A screening test using a new serum mariker is developed for diagnosing ovarian cancer. Healthy and diseased population curves along the screening dimension, along with the proposed serum marker cutoff value, are given below. Compared to the solid curves, the dashed curves are associated with:



A. Higher sensitivity and higher specificity

B. Higher sensitivity and lower specificity

C. Higher sensitivity and same specificity

D. Lower sensitivity and higher specificity

E. Lower sensitivity and lower specificity

Biostatistics

Researchers studying the effects of hormone replacement therapy (HRT) on the risk of myocardial infarction (MI) among postmenopausal women calculate the relative risk (RR) of MI to be 1.30 ($p = 0.07$) among women who are taking HRT compared to those who are not. The researchers conclude that there is no statistically significant increased risk of MI with HRT (based on a cut off of $\alpha = 0.05$). Subsequently, the results of a meta-analysis determine that there actually is an increased risk of MI, with an overall RR= 1.32 ($p = 0.03$) among postmenopausal women who are taking HRT compared to those who are not Which of the following was the most likely problem in the first study?

A. Berkson's bias

B. Placebo effect

C. Poor blinding

D. Researcher expectancy

E. Sample size

Biostatistics

18. A report of a clinical trial of a new drug for herpes simplex II versus a placebo noted that the new drug gave a higher proportion of success than the placebo. The report ended with the statement: *chi*-square = 4.72, $p < 0.05$. In light of this information, we may conclude that

A. fewer than 1 in 20 will fail to benefit from the drug.

B. the chance that an individual patient will fail to benefit is less than 0.05.

C. if the drug were effective, the probability of the reported finding is less than 1 in 20.

D. if the drug were ineffective, the probability of the reported finding is less than 0.05.

E. the null hypothesis is false.

Blostatistics

A recent study was conducted to assess the intelligence of students

enrolled in an alternative high school program. The results showed the Iqs of the students distributed according to the normal curve, with a mean of 115 and a standard deviation of 10. Based on this information it is most reasonable to conclude that

A. 50% of the students will have an IQ below the standard mean of 100.

B. 5% of the students will have IQs below 105.

C. Students with IQs of 125 are at the 84th percentile.

D. 2.5% of the students will have IQs greater than 125.

E. All of the students’ scores fall between 85 and 135.

BIOSTATISTICS

A correlation of +0.56 is found between alcohol consumption and systolic blood pressure in men. This correlation is significant at the 0.001 level. From this information we may conclude that:

A. There is no association between alcohol consumption and systolic pressure.

B. Men who consume less alcohol are at lower risk for increased systolic pressure.

C. Men who consume less alcohol are at higher risk for increased systolic pressure.

D. High alcohol consumption can cause increased systolic pressure in men.

E. High systolic pressure can cause increased alcohol consumption in men.

BIOSTATISTICS

A study is conducted to examine the relationship between myocardial infarction and time spent driving when commuting to and from work. One hundred married males who had suffered infarcts were selected and their average commuting time ascertained from either the subject, or if the infarct had been fatal, their spouse. A comparison group of 100 married males who had not suffered infarcts was also selected and their average commuting time recorded. When examining this data for a possibly causal relationship between commuting time and the occurrence of myocardial infarcts, the most likely measure of association is

A. odds ratio.

B. relative risk.

C. incidence rate.

D. attributable risk.

E. correlation coefficient.

BIOSTATISTICS

A association determines membership based on members' IQ scores. Only those people who have documented IQ scores at least 2 SDs above the mean on the Wechsler Adult Intelligence Scale, Revised (WAIS-R), are eligible for admission. Out of a group of 400 people randomly selected from the population at large, how many would be eligible for membership in this society?

A. 2

B. 4

C. 6

D. 8

E. 10

BIOSTATISTICS

A physician wishes to study whether moderate alcohol consumption is associated with heart disease. If moderate alcohol consumption leads to a relative risk of heart disease of 0.60, the physician wants to have a 95% chance of detecting an effect this large in the planned study. This statement is an illustration of specifying

A. alpha error.

B. beta error.

C. a null hypothesis.

D. criterion odds.

E. statistical power.

BIOSTATISTICS

Public health officials were examining a suspicious outbreak of diarrhea in an inner-city community child-care center. Center workers identified children with diarrhea and all children at the center were studied. Officials discovered that children who drank liquids from a bottle were more likely to have diarrhea than children who drank from a glass. They concluded that drinking from unclean bottles was the cause of the outbreak. The use of bottles was subsequently banned from the center. The outbreak subsided. Which of the following is the most likely source of bias in this study?

A. Recall bias

B. Lead-time bias

C. Measurement bias

D. Confounding

E. Random differences as to the identification of diarrhea

BIOSTATISTICS

Comparing the blood sugar levels of husbands and wives

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

Comparing the number of staff who do or do not call in sick for each of 3 different nursing shifts

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

Relationship between time spent on studying and test score

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

A researcher believes that boys with same-sex siblings are more likely to have higher testosterone levels.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

A physician believes that drawing blood is faster with a vacutainer for someone once that person is trained, but faster with a standard syringe for someone with no training.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

To assess the efficacy of surgical interventions for breast cancer, the quality of life, measured on a 10-point scale, of 30 women who underwent radical mastectomies was compared with 30 women who received radiation treatments and 15 women who refused any medical intervention.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

To assess the efficacy of surgical interventions for breast cancer, the quality of life, measured on a 10-point scale, of 30 women who underwent radical mastectomies was compared with 30 women who received radiation Treat ments and 15 women who refused any medical intervention.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

Comparison of passing and failure rates at each of 3 test sites.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

37. Comparison of actual measured test scores for students at each of 3 test sites.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

Assessing changes in blood pressure for a group of 30 hypertensives 1 week before and 3 months after beginning a course of antihypertensive medication.

A. *t*-test

B. *Chi*-square test

C. One-way ANOVA

D. Two-way ANOVA

E. Pearson correlation

F. Matched pairs *t*-test

BIOSTATISTICS

In a study of chemical workers, 400 workers with respiratory disease and 150 workers without respiratory disease were selected for examination. The investigators obtained a history of exposure to a particular solvent in both groups of workers. Among workers with the respiratory disease, 250 gave a history of exposure to the solvent, compared to 50 of the workers without respiratory disease. The study design can best be described as a

A. case-control study.

B. cohort study.

C. cross-sectional study.

D. community trial.

E. comparative clinical trial.

BIOSTATISTICS

The air quality is assessed in two Midwestern cities, one in which a government program has instituted reducing the amount of carbon monoxide emissions allowed, and one without the government program. The rates of respiratory problems in both cities are recorded over a 5-yea period. Given the design of this study, an appropriate one-tailed null hypothesis would be

A. air quality is related to respiratory problems in both of the cities under study.

B. air quality is related to respiratory problems in the city with the government program but not in the other city.

C. no evidence will be found for differences in air quality between the two cities.

D. the rate of respiratory problems in the city with the government program will not be any lower than that of the other city.

E. air quality will be inversely related to the rate of respiratory problems in both cities.