A 73-year-old man comes to the office for follow-up. He was diagnosed with chronic lymphocytic leukemia (CLL) 3 years ago when routine laboratory testing revealed a markedly elevated leukocyte count. He feels well. On examination, he has stable lymphadenopathy. He has been reading about management options should his CLL progress and inquires about an experimental drug that selectively binds malignant lymphocytes. The drug has been shown to significantly prolong survival in patients with stage 3 and 4 CLL, without curing the malignancy. If this new drug were widely used, what changes would be expected in the number of incident and prevalent cases of CLL?

- A. The number of incident cases will decrease, the number of prevalent cases will decrease (0%)
- B. The number of incident cases will increase, the number of prevalent cases will not change (1%)
- C. The number of incident cases will decrease, the number of prevalent cases will increase (1%)
- ✓ D. The number of incident cases will not change, the number of prevalent cases will increase (91%)
- E. The number of incident cases will not change, the number of prevalent cases will not change (4%)

Omitted
Correct answer
D

91%
Answered correctly

02 secs
Time Spent

2023
Version

Explanation

Incident cases represent **new cases** diagnosed in a given period of time. **Prevalent cases** are the **total number of cases** (both old and new) at a particular point in time. For a non-transmissible condition such as chronic lymphocytic leukemia (CLL), the number of incident cases will **not** be changed by any kind of treatment because the disease has already developed when the treatment is started (and treatment of existing patients will

Explanation

Incident cases represent **new cases** diagnosed in a given period of time. **Prevalent cases** are the **total number of cases** (both old and new) at a particular point in time. For a non-transmissible condition such as chronic lymphocytic leukemia (CLL), the number of incident cases will **not** be changed by any kind of treatment because the disease has already developed when the treatment is started (and treatment of existing patients will not prevent new patients from developing CLL). Any treatment that prolongs survival but does not cure the disease will **increase** the number of prevalent cases due to an increase in the number of afflicted (but still living) individuals over time.

Differences in terminology may lead to confusion. Incident cases and prevalent cases are often referred to as simply "incidence" and "prevalence." Incidence can also represent the number of new cases divided by the population at risk over a period of time and can be converted into a rate (eg, annual incidence per 10,000 population). Prevalence typically refers to point prevalence (total number of cases at a particular point in time) as opposed to period prevalence (over a period of time). The specific meaning is often clear from the context.

Educational objective:
Incident cases represent new cases diagnosed in a given period of time. Prevalent cases are the total number of cases (both old and new) at a particular point in time. Any treatment that prolongs survival but does not cure the disease will increase prevalence due to an increase in the number of afflicted (but still living) individuals over time.

Biostatistics	Biostatistics & Epidemiology	Risk, rate, prevalence and incidence
Subject	System	Topic

The specificity of the standard test to detect disease X in the general population is 73%. A team of researchers set forth a goal to increase specificity for detecting disease X. They develop a new test and conduct a study to evaluate its performance on a random sample from the general population. The results of their study are shown below.

	Patients with disease X	Patients without disease X
Positive	270	45
Negative	30	255

According to these results, have the researchers achieved their goal?

- A. Cannot be determined because the prevalence of disease X is not provided (2%)
- B. No, the researchers' new test has about 9% lower specificity than the standard test (1%)
- C. No, the researchers' results lead to nearly the same specificity as the standard test (1%)
- ✓ D. Yes, the researchers achieved an increase in specificity of about 12% (83%)
- E. Yes, the researchers achieved an increase in specificity of about 15% (10%)

Omitted
Correct answer
D

83%
Answered correctly

02 secs
Time Spent

2023
Version

Explanation

	Positive condition	Negative condition	
Positive test result	TP	FP	PPV = TP / (TP + FP)
Negative test result	FN	TN	NPV = TN / (TN + FN)
	Sensitivity = TP / (TP + FN)	Specificity = TN / (TN + FP)	

FN = false negative; **FP** = false positive; **NPV** = negative predictive value; **PPV** = positive predictive value; **TN** = true negative; **TP** = true positive.

The **specificity** of a test refers to its ability to correctly identify individuals without the disease. Specificity is equal to the number of individuals who do not have the disease and who test negative (true negatives [TN]) divided by the total number of individuals without the disease (TN + false positives [FP]):

Specificity = TN / (TN + FP)

In this question, 255 out of 300 (ie, 45 + 255) patients without disease X had a negative test (ie, TN = 255) and 45 had a positive test (ie, FP = 45). Therefore, the specificity of the new test is:

Specificity = TN / (TN + FP) = 255 / (255 + 45) = 255 / 300 = 0.85 (or 85%)

The **specificity** of the **standard test is 73%** and of the **new test is 85%**. Therefore, the researchers achieved an **increase in specificity** of about 85% − 73% = 12% **(Choices B, C, and E)**.

(Choice A) Contrary to positive and negative predictive values, which are influenced by the prevalence of

	TP / (TP + FN)	TN / (TN + FP)	
FN = false negative; **FP** = false positive; **NPV** = negative predictive value; **PPV** = positive predictive value; **TN** = true negative; **TP** = true positive.			

The **specificity** of a test refers to its ability to correctly identify individuals without the disease. Specificity is equal to the number of individuals who do not have the disease and who test negative (true negatives [TN]) divided by the total number of individuals without the disease (TN + false positives [FP]):

Specificity = TN / (TN + FP)

In this question, 255 out of 300 (ie, 45 + 255) patients without disease X had a negative test (ie, TN = 255) and 45 had a positive test (ie, FP = 45). Therefore, the specificity of the new test is:

Specificity = TN / (TN + FP) = 255 / (255 + 45) = 255 / 300 = 0.85 (or 85%)

The **specificity** of the **standard test is 73%** and of the **new test is 85%**. Therefore, the researchers achieved an **increase in specificity** of about 85% − 73% = 12% **(Choices B, C, and E)**.

(Choice A) Contrary to positive and negative predictive values, which are influenced by the prevalence of disease in the population, sensitivity and specificity are intrinsic test performance characteristic that do not depend on disease prevalence.

Educational objective:
The specificity of a test is its ability to correctly identify individuals without the disease. Specificity can be calculated as follows: specificity = true negatives / (true negatives + false positives).

Biostatistics	Biostatistics & Epidemiology	Sensitivity and specificity
Subject	System	Topic

The aim of a case-control study is to investigate the association between probiotic yogurt intake before and during pregnancy and gestational diabetes mellitus (GDM) in women age >18 during their 24 to 28 weeks of a singleton pregnancy. The investigators obtain a history of probiotic yogurt intake between cases and controls. Results of the study are shown below.

Probiotic yogurt intake during pregnancy	GDM +	GDM −	*Total*
Low	82	60	142
High	41	66	107
Total	123	126	249

Which of the following best represents the odds of high probiotic yogurt intake in women with GDM compared to women without GDM?

- A. 0.17 (2%)
- ✓ B. 0.45 (44%)
- C. 0.66 (28%)
- D. 1.51 (3%)
- E. 2.20 (20%)

Omitted
Correct answer
B

44%
Answered correctly

01 sec
Time Spent

2023
Version

The odds of an event are related to the probability P of that event, with odds = P / (1 − P). For example, the probability of rolling a single die and getting a 1 is 1/6, but the odds of rolling a 1 is 1/5. The **odds ratio (OR)** is a measure of association used in case-control studies to compare the **odds of exposure** in **cases** (ie, individuals with disease) relative to **controls** (ie, individuals without disease):

OR = (odds of exposure in cases) / (odds of exposure in controls)

In this study, the disease of interest is gestational diabetes mellitus (GDM), so **cases** are women **with GDM**, and **controls** are women **without GDM**. The **exposure** of interest is **probiotic yogurt intake** before or during pregnancy. More specifically, the OR of interest is the odds of high intake of yogurt in cases (ie, women with GDM) relative to the odds of high intake of yogurt in controls (ie, women without GDM).

A shortcut to calculate the OR when a **contingency table** has a standard format (ie, exposure of interest in the first row of exposure status and cases in the first column of disease status) is the following:

OR = (a/c) / (b/d)

The given table is incorrectly formatted (ie, high intake should be in the first row rather than in the second row of exposure status), so it is necessary to reformat the table.

Probiotic yogurt intake during pregnancy	GDM +	GDM −	*Total*
High	41 (a)	66 (b)	107
Low	82 (c)	60 (d)	142

during pregnancy	GDM +	GDM −	*Total*
High	41 (a)	66 (b)	107
Low	82 (c)	60 (d)	142
Total	123	126	249

The odds of high intake of yogurt in women with GDM and women without GDM are:

- **Odds of high intake** of yogurt in **cases**: a/c = 41/82 = 0.50
- **Odds of high intake** of yogurt in **controls**: b/d = 66/60 = 1.10

Therefore, the OR is:

OR = (odds of exposure in cases) / (odds of exposure in controls) = (a/c) / (b/d) = 0.50 / 1.10 = **0.45**

The **OR is <1**: this indicates that a **high intake of probiotic yogurt** during pregnancy has a **protective effect against GDM**.

This example calculated the OR of exposure (ie, odds of exposure among cases relative to controls). The OR is sometimes described as the odds of disease among exposed individuals relative to nonexposed individuals, given by (a/b) / (c/d). Both OR definitions are mathematically equivalent and reduce to OR = (ad) / (bc).

Educational objective:
The odds ratio (OR) is a measure of association calculated as: OR = (odds of exposure in cases) / (odds of exposure in controls). For a correctly formatted contingency table: OR = (ad) / (bc).

A 65-year-old man comes to the office because his family is concerned about his constant cough after smoking. The patient asks about the risk of developing chronic obstructive pulmonary disease (COPD) in adult smokers. A recent cohort study reported that compared to heavy smokers, the relative risk (RR) of COPD for nonsmokers is 0.10 and for moderate smokers is 0.40. The patient is a moderate smoker. Based on the study, which of the following is the RR of COPD for moderate smokers compared to nonsmokers?

A. 0.10 (0%)
B. 0.25 (10%)
C. 0.40 (10%)
D. 2.5 (3%)
E. 4 (74%)
F. 10 (0%)

Omitted
Correct answer
E

74% Answered correctly

02 secs Time Spent

2023 Version

Explanation

The **relative risk (RR)** is the measure of **association** between the exposure to a **risk factor** and an outcome or **disease** commonly used in cohort and experimental studies. RR is equal to the risk of an outcome (eg, chronic obstructive pulmonary disease [COPD]) in an exposed group (eg, moderate smokers) divided by the risk of the same outcome in a nonexposed group (eg, nonsmokers).

outcome in a nonexposed group (eg, nonsmokers).

RR$_{\textbf{mod vs non}}$ = (risk of disease in moderate smokers) / (risk of disease in nonsmokers) = Risk_{mod} / Risk_{non}

In this case, $\text{RR}_{\text{mod vs non}}$ must be calculated from the RRs for COPD and smoking reported in the given cohort study:

- RR for nonsmokers compared to heavy smokers: $\text{RR}_{\text{non vs heavy}}$ = Risk_{non} / $\text{Risk}_{\text{heavy}}$ = 0.10
- RR for moderate smokers compared to heavy smokers: $\text{RR}_{\text{mod vs heavy}}$ = Risk_{mod} / $\text{Risk}_{\text{heavy}}$ = 0.40

$\text{RR}_{\text{mod vs heavy}}$ and $\text{RR}_{\text{non vs heavy}}$ have the same comparison group (ie, denominator: $\text{Risk}_{\text{heavy}}$ for heavy smokers). Therefore, dividing $\text{RR}_{\text{mod vs heavy}}$ by $\text{RR}_{\text{non vs heavy}}$ results in $\text{RR}_{\text{mod vs non}}$ (ie, Risk_{mod} / Risk_{non}).

$$\frac{RR_{\text{mod vs heavy}}}{RR_{\text{non vs heavy}}} = \frac{\frac{\text{Risk}_{\text{mod}}}{\text{Risk}_{\text{heavy}}}}{\frac{\text{Risk}_{\text{non}}}{\text{Risk}_{\text{heavy}}}} = \frac{\text{Risk}_{\text{mod}}}{\text{Risk}_{\text{non}}} = RR_{\text{mod vs non}}$$

Therefore, **RR**$_{\textbf{mod vs non}}$ **= 0.40 / 0.10 = 4**. This means that the risk of COPD is four times greater for moderate smokers compared to nonsmokers.

(Choice A) 0.10 is the given RR for nonsmokers compared to heavy smokers: $\text{RR}_{\text{non vs heavy}}$.

(Choice B) 0.25 is the RR for nonsmokers compared to moderate smokers: $\text{RR}_{\text{non vs mod}}$ = 0.10 / 0.40 = 0.25, meaning that the risk of COPD is 75% (ie, 100% − 25%) lower in nonsmokers compared to moderate smokers.

(Choice C) 0.40 is the given RR for moderate smokers compared to heavy smokers: $\text{RR}_{\text{mod vs heavy}}$.

(Choice D) 2.5 is the RR for heavy smokers compared to moderate smokers ($\text{RR}_{\text{heavy vs mod}}$); it is the inverse of the given $\text{RR}_{\text{mod vs heavy}}$ (ie, $\text{RR}_{\text{heavy vs mod}}$ = 1 / 0.40 = 2.5).

(Choice F) 10 is the RR for heavy smokers compared to nonsmokers ($\text{RR}_{\text{heavy vs non}}$); it is the inverse of the given

...fore, dividing $RR_{\text{mod vs heavy}}$ by $RR_{\text{non vs heavy}}$ results in $RR_{\text{mod vs non}}$ (ie, $Risk_{mod}$ / $Risk_{non}$).

$$\frac{RR_{\text{mod vs heavy}}}{RR_{\text{non vs heavy}}} = \frac{\frac{\text{Risk}_{\text{mod}}}{\text{Risk}_{\text{heavy}}}}{\frac{\text{Risk}_{\text{non}}}{\text{Risk}_{\text{heavy}}}} = \frac{\text{Risk}_{\text{mod}}}{\text{Risk}_{\text{non}}} = RR_{\text{mod vs non}}$$

Therefore, **$RR_{\text{mod vs non}}$ = 0.40 / 0.10 = 4**. This means that the risk of COPD is four times greater for moderate smokers compared to nonsmokers.

(Choice A) 0.10 is the given RR for nonsmokers compared to heavy smokers: $RR_{\text{non vs heavy}}$.

(Choice B) 0.25 is the RR for nonsmokers compared to moderate smokers: $RR_{\text{non vs mod}}$ = 0.10 / 0.40 = 0.25, meaning that the risk of COPD is 75% (ie, 100% − 25%) lower in nonsmokers compared to moderate smokers.

(Choice C) 0.40 is the given RR for moderate smokers compared to heavy smokers: $RR_{\text{mod vs heavy}}$.

(Choice D) 2.5 is the RR for heavy smokers compared to moderate smokers ($RR_{\text{heavy vs mod}}$); it is the inverse of the given $RR_{\text{mod vs heavy}}$ (ie, $RR_{\text{heavy vs mod}}$ = 1 / 0.40 = 2.5).

(Choice F) 10 is the RR for heavy smokers compared to nonsmokers ($RR_{\text{heavy vs non}}$); it is the inverse of the given $RR_{\text{non vs heavy}}$ (ie, $RR_{\text{heavy vs non}}$ = 1 / 0.10 = 10).

Educational objective:
The relative risk (RR) is the measure of association between the exposure to a risk factor or treatment and an outcome or disease and is commonly used in cohort and experimental studies. The interpretation of the RR depends on which groups are identified as exposed and unexposed.

Biostatistics	Biostatistics & Epidemiology	Risk
Subject	System	Topic

A clinical study examines the usefulness of 5 different biomarkers to detect Barrett esophagus (BE), the only known precursor lesion of esophageal adenocarcinoma. Researchers evaluate the performance of each biomarker and report the sensitivity, specificity, and area under the curve (AUC) estimates.

Biomarker	Sensitivity (%)	Specificity (%)	AUC
1	41.7	83.3	0.603
2	68.0	70.8	0.758
3	70.8	91.7	0.879
4	84.0	62.8	0.763
5	91.7	58.3	0.756

Which of the biomarkers is most accurate?

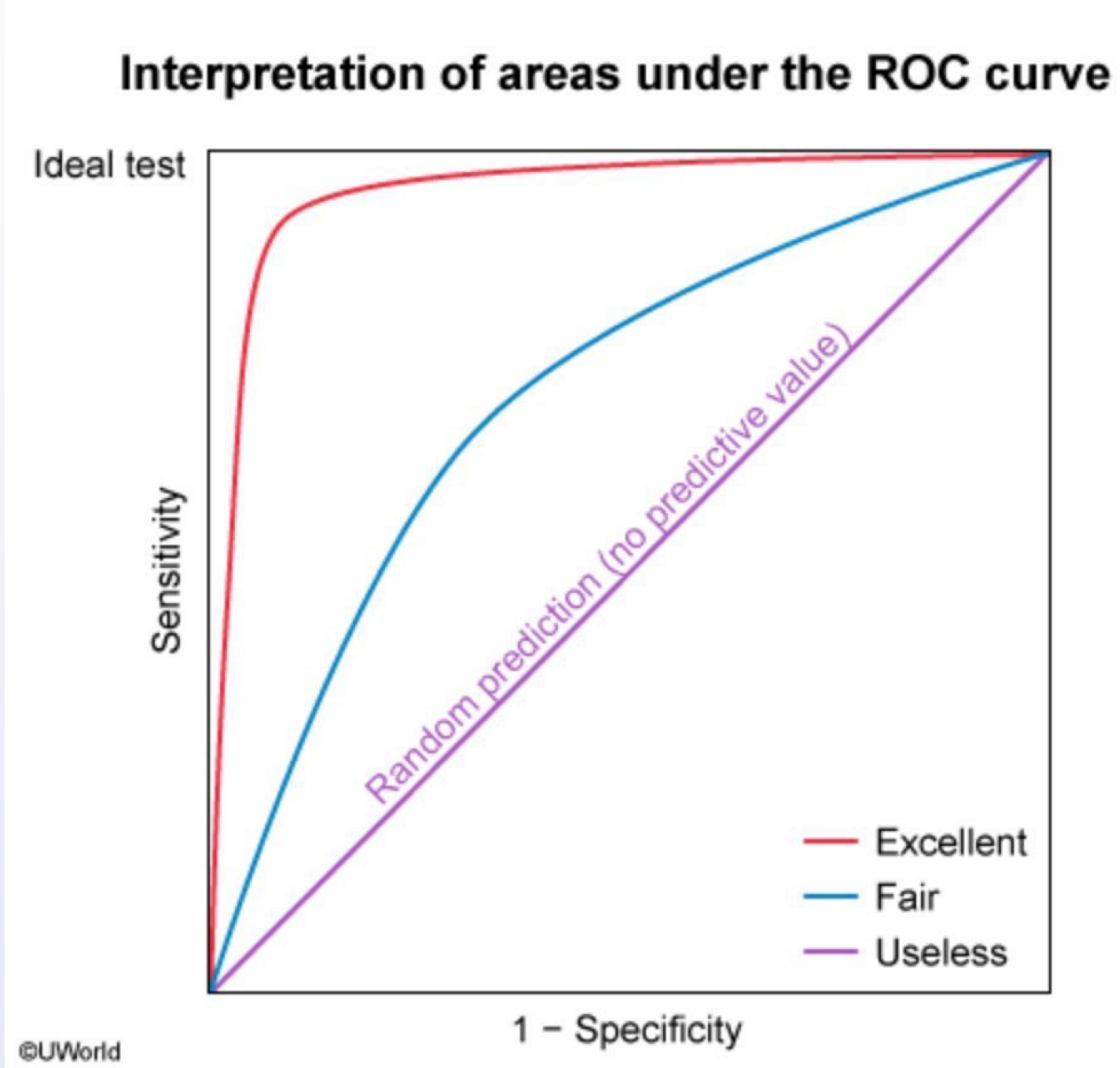
- A. 1 (2%)
- B. 2 (1%)
- ✓ C. 3 (86%)
- D. 4 (1%)
- E. 5 (8%)

Omitted
Correct answer
C

86%
Answered correctly

02 secs
Time Spent

2023
Version



The **accuracy** of screening or diagnostic tests (defined as the number of true positives plus true negatives divided by the number of all observations) is generally quantified by the **area under the ROC curve (AUC)**. ROC (receiver operating characteristic) curves are created by plotting sensitivity (true-positive rate) against 1 − specificity (false-positive rate) for various cutoff thresholds (ie, the value that determines if a given test result is positive or negative). A highly accurate test is highly sensitive (high true-positive rate) and highly specific (low false-positive rate). The **more accurate the test** is (ie, the higher sensitivity and specificity), the closer the **AUC value is to 1.0**. Therefore, tests with higher AUCs are more accurate than tests with lower AUCs.

In this study, the ROCs for the tests (ie, biomarkers) are not provided; however, it is possible to draw conclusions about the accuracy of each biomarker based on the values given for their AUCs. **Biomarker 3** has the **largest**

Accuracy of screening or diagnostic tests (defined as the number of true positives plus true negatives divided by the number of all observations) is generally quantified by the **area under the ROC curve (AUC)**. ROC (receiver operating characteristic) curves are created by plotting sensitivity (true-positive rate) against 1 − specificity (false-positive rate) for various cutoff thresholds (ie, the value that determines if a given test result is positive or negative). A highly accurate test is highly sensitive (high true-positive rate) and highly specific (low false-positive rate). The **more accurate the test** is (ie, the higher sensitivity and specificity), the closer the **AUC value is to 1.0**. Therefore, tests with higher AUCs are more accurate than tests with lower AUCs.

In this study, the ROCs for the tests (ie, biomarkers) are not provided; however, it is possible to draw conclusions about the accuracy of each biomarker based on the values given for their AUCs. **Biomarker 3** has the **largest AUC (0.879)** compared to biomarker 1 (0.603), biomarker 2 (0.758), biomarker 4 (0.763), and biomarker 5 (0.756). Therefore, biomarker 3 is the **most accurate test** of the 5 tests for Barrett esophagus screening.

(Choices A, B, D, and E) Biomarker 3 (0.879) is more accurate than biomarker 4 (0.763); biomarker 4 is more accurate than biomarker 2 (0.758); biomarker 2 is more accurate than biomarker 5 (0.756); and biomarker 5 is more accurate than biomarker 1 (0.603).

Educational objective:
The accuracy of screening or diagnostic tests is quantified by the area under the ROC curve (AUC). The more accurate the test is (ie, higher sensitivity and specificity), the closer the AUC value is to 1.0. Tests with higher AUCs are more accurate than tests with lower AUCs.

References

- Diagnostic accuracy measures.

Biostatistics	Biostatistics & Epidemiology	Receiver Operating Characteristic
Subject	System	Topic

Drugs A and B are 2 new experimental drugs being tested for the treatment of a novel respiratory viral infection that causes acute respiratory failure and death in children. Part of the testing process is to analyze the 2-week survival after treatment to determine the clinical efficacy of the experimental drugs. A total of 60 children recently diagnosed with the disease are randomly assigned in a 1:1:1 ratio to receive Drug A, Drug B, or placebo. The absolute risk reduction of Drug A compared to placebo was found to be 0.05, whereas the absolute risk reduction of Drug B compared to placebo was found to be 0.20. Based on these results, which of the following statements comparing the effectiveness of Drugs A and B in treating children infected with the novel virus is most appropriate?

- A. Drugs A and B require treating the same number of children to prevent 1 additional death, so they are equally effective (0%)
- B. Drug A requires treating fewer children to prevent 1 additional death compared to Drug B, so Drug A is less effective than Drug B (1%)
- C. Drug A requires treating fewer children to prevent 1 additional death compared to Drug B, so Drug A is more effective than Drug B (11%)
- ✓ D. Drug A requires treating more children to prevent 1 additional death compared to Drug B, so Drug A is less effective than Drug B (84%)
- E. Drug A requires treating more children to prevent 1 additional death compared to Drug B, so Drug A is more effective than Drug B (2%)

Omitted
Correct answer
D

84%
Answered correctly

02 secs
Time Spent

2023
Version

Common measures of therapeutic efficacy		
Term	**Definition**	**Calculation**
Absolute risk reduction (ARR)	Percentage indicating the actual difference in event rate between control & treatment groups	ARR = control rate – treatment rate
Relative risk reduction (RRR)	Percentage indicating relative reduction in the treatment event rate compared to the control group	RRR = ARR / control rate
Relative risk (RR)	Ratio of the probability of an event occurring in the treatment group compared to the control group	RR = treatment rate / control rate
Number needed to treat (NNT)	Number of individuals who need to be treated to prevent a negative outcome in 1 patient	NNT = 1 / ARR

The **absolute risk reduction** (ARR) describes the efficacy of a treatment (eg, Drug A) compared to a control group (eg, placebo); it is the difference in the risk (or rate) of a negative event (eg, death) between treatment and control groups:

$$ARR = (Risk_{control} - Risk_{treatment})$$

ARR expressed as a percentage describes the number of negative events (eg, deaths) prevented in 100 patients. For example, an ARR of 0.05 indicates that 5 of 100 patients treated with a treatment (eg, Drug A) would be prevented from developing a negative event. Therefore, to prevent 1 patient from developing a expressed as a percentage describes the number of negative events (eg, deaths) prevented in 100 patients. For example, an ARR of 0.05 indicates that 5 of 100 patients treated with a treatment (eg, Drug A) would be prevented from developing a negative event. Therefore, to prevent 1 patient from developing a negative event, it would be necessary to treat 100 / 5 = 1 / 0.05 = 20 patients. This is the **number needed to treat (NNT)**.

NNT is the number of patients who need to be treated with a treatment (eg, Drug A) to **prevent 1 additional negative event** (eg, death) compared to a control group (eg, placebo); NNT is the **inverse of the ARR**:

NNT = 1 / ARR

A **lower NNT** indicates **more effective treatments** because fewer patients would need to be treated to prevent 1 additional negative outcome. NNTs can be used to compare the effectiveness of different treatments within a single study or between similar studies (eg, similar patient characteristics, control groups, duration of follow-up). In this example, a single study is testing 2 treatments (ie, Drugs A and B) against placebo (ie, control group) to prevent death (ie, negative effect) in recently diagnosed children randomized to treatment groups with a similar follow-up (ie, 2-week survival):

- Drug A versus placebo: ARR = 0.05, so NNT = 1 / 0.05 = 20
- Drug B versus placebo: ARR = 0.20, so NNT = 1 / 0.20 = 5

Drug A requires treating more children to prevent 1 additional death compared to Drug B (20 vs 5). A higher NNT indicates a lower effectiveness; therefore, **Drug A is less effective** compared to Drug B **(Choices A, B, C, and E)**.

Educational objective:
The number needed to treat (NNT) is the number of patients who need to receive a treatment to prevent 1 additional negative event. NNT is the inverse of the absolute risk reduction. The lower the NNT, the more effective the treatment because fewer patients need be treated to prevent 1 additional negative event.

A suburban hospital is undergoing an annual review by a health care accreditation organization. As part of the process, iatrogenic infection rates are assessed for all major hospital services. Inpatient surgical infection statistics for the last year are shown below.

Surgical infection	**Number of fatal cases**	**% of all fatal cases**	**Number of nonfatal cases**	**% of all nonfatal cases**
Cl difficile	2	3	14	6
S aureus, methicillin-sensitive	10	13	25	11
S aureus, methicillin-resistant	40	53	70	32
E coli	10	13	50	23
Cl perfringens	1	1	1	<1
S epidermidis	2	3	30	14
Other	10	13	30	14
Total	**75**	**100**	**220**	**100**

What is the case-fatality rate for methicillin-resistant *S aureus* surgical infections in this hospital?

- A. 40/70 (6%)
- ✓ B. 40/110 (80%)
- C. 40/75 (9%)
- D. 53/100 (2%)
- E. 70/220 (0%)

itted
Correct answer
B

80% Answered correctly

03 secs Time Spent

2023 Version

Explanation

Case-fatality rate (CFR) is a measure of the **severity of a disease** or condition. It is defined as the **proportion** of reported cases of a specific disease or condition (eg, methicillin-resistant *S aureus*, [MRSA]) that are **fatal** within the population affected by the disease or condition over a specific time. The CFR can be calculated as the number of fatal cases of disease or condition divided by the total number of people with the disease or condition.

In this scenario, 40 fatal and 70 nonfatal cases of MRSA infection are reported. Therefore, the CFR is:

$$CFR = 40 / (40 + 70) = \mathbf{40 / 110}$$

(Choice A) This choice describes the ratio of fatal to nonfatal MRSA infection cases (40/70).

(Choices C and D) These choices describe the proportion of MRSA deaths out of all surgical infection deaths (40/75 = 53/100).

(Choice E) This choice describes the proportion of nonfatal cases of MRSA infection out of all nonfatal surgical infection cases (70/220).

Educational objective:
Case-fatality rate is calculated by dividing the number of fatal cases of a disease or condition by the total number of people with that disease or condition.

Biostatistics
Subject

Biostatistics & Epidemiology
System

Morbidity and mortality rates
Topic

A pediatrician examines a population of 1,000 children with a new test to diagnose asthma. The prevalence of asthma in this population is 10%. The sensitivity of the pediatrician's diagnostic test is 95%, and the specificity is 80%. Which of the following is the likelihood that a child from this population with a positive test result really has asthma?

- A. 5 / (5 + 95) (2%)
- ✓ B. 95 / (95 + 180) (62%)
- C. 95 / (95 + 5) (23%)
- D. 720 / (720 + 180) (9%)
- E. 720 / (720 + 5) (1%)

Omitted
Correct answer
B

62%
Answered correctly

07 secs
Time Spent

2023
Version

Explanation

Standard 2 × 2 table

	Disease present	Disease absent
Test positive	True positive	False positive
Test negative	False negative	True negative

→

Asthma diagnostic test

	Disease present	Disease absent	Total tests
Test positive	95	180	275
Test negative	5	720	725

Standard 2 × 2 table

	Disease present	Disease absent
Test positive	True positive	False positive
Test negative	False negative	True negative
	Total with disease	Total without disease

→

Asthma diagnostic test

	Disease present	Disease absent	Total tests
Test positive	95	180	275
Test negative	5	720	725
	100	900	1,000

The **positive predictive value** (PPV) of a diagnostic test is the probability (ie, likelihood) that an individual truly **has the disease** given a **positive test**. PPV is equal to the number of individuals who have the disease and who test positive (ie, true positives [TP]) divided by the total number of individuals with a positive test result (TP + false positives [FP]):

PPV = TP / (TP + FP)

To determine PPV in this example, it helps to construct a 2 × 2 table with the expected data for this population according to the properties of the diagnostic test. In this example, the pediatrician examined 1,000 children in a population with a 10% prevalence of asthma (ie, 100 children have asthma, 900 do not). The sensitivity, which is equal to TP / (TP + false negatives [FN]), and the specificity, which is equal to true negatives (TN) / (TN + FP), are 95% and 80% respectively. Therefore, the number of **TP is 95** (ie, 100 × 0.95), the number of **FN is 5** (ie, 100 − 95), the number of **TN is 720** (ie, 900 × 0.80), and the number of **FP is 180** (ie, 900 − 720).

The PPV can be calculated as follows:

PPV = TP / (TP + FP) = 95 / (95 + 180)

Predictive values **depend on the prevalence** of the disease in the study population; as the disease prevalence

95), the number of **TN is 720** (ie, 900 × 0.80), and the number of **FP is 180** (ie, 900 − 720).

The PPV can be calculated as follows:

PPV = TP / (TP + FP) = 95 / (95 + 180)

Predictive values **depend on the prevalence** of the disease in the study population; as the disease prevalence increases, PPV increases and NPV decreases, and vice versa.

(Choice A) 5 / (5 + 95) is the false negative rate (FNR). FNR is equal to FN / (FN + TP) and describes the proportion of individuals with a known positive condition for which the test result is negative. It is also known as the miss rate.

(Choice C) 95 / (95 + 5) is the test's sensitivity. Sensitivity is equal to TP / (TP + FN) and describes the proportion of individuals with a known positive condition for which the test result is positive. It is an intrinsic measure of the test's ability to correctly identify individuals with the disease, but by itself, it does not provide enough information to interpret a positive test result in a particular individual.

(Choice D) 720 / (720 + 180) is the test's specificity. Specificity is equal to TN / (TN + FP) and describes the proportion of individuals with a known negative condition for which the test result is negative.

(Choice E) 720 / (720 + 5) is the test's negative predictive value (NPV). NPV is equal to TN / (TN + FN) and describes the proportion of individuals with a negative test result who really do not have the disease.

Educational objective:
Positive predictive value is the probability that an individual has a disease given a positive test. It is calculated as follows: true positives / (true positives + false positives).

Biostatistics	Biostatistics & Epidemiology	Sensitivity, specificity, NPV, PPV
Subject	System	Topic

A residency program organized a barbecue at the beginning of the academic year to welcome the new class of first-year residents. The total number of attendees was 100, including faculty, administrative staff, and residents. Hamburgers, hotdogs, and potato salad were served. The following day, 28 of the attendees had diarrhea and vomiting. All of the attendees were questioned about what they had eaten, and the following table was obtained:

Food item or combination of items	Number of attendees who ate food item or combination of items	Number of attendees who developed diarrhea and vomiting
Hamburgers only	15	2
Hotdogs only	12	1
Potato salad only	10	3
Hamburgers and potato salad	25	5
Hotdogs and potato salad	8	3
Hamburgers, hotdogs, and potato salad	30	14

Which of the following best describes the attack rate among all of the attendees who had potato salad?

- A. 8% (0%)
- B. 11% (1%)
- C. 13% (1%)
- D. 20% (2%)
- E. 28% (5%)
- F. 30% (15%)
- G. 34% (69%)
- H. 47% (2%)

Omitted
Correct answer
G

69%
Answered correctly

05 secs
Time Spent

2023
Version

Explanation

There appears to be an **outbreak** as almost a third of the attendees (28/100) developed diarrhea and vomiting; this is clearly a larger number than expected. The **attack rate** is the ratio of the number of individuals who become ill divided by the number of individuals who are at risk of contracting that illness; it is often used in outbreak investigations. The attack rate for potato salad corresponds to the proportion of attendees who became ill out of the total number of attendees who had potato salad (alone or in combination with other food items).

Total number of attendees who had potato salad
= Number of attendees who had potato salad only + number of attendees who had hamburgers and potato salad

There appears to be an **outbreak** as almost a third of the attendees (28/100) developed diarrhea and vomiting; this is clearly a larger number than expected. The **attack rate** is the ratio of the number of individuals who become ill divided by the number of individuals who are at risk of contracting that illness; it is often used in outbreak investigations. The attack rate for potato salad corresponds to the proportion of attendees who became ill out of the total number of attendees who had potato salad (alone or in combination with other food items).

Total number of attendees who had potato salad
= Number of attendees who had potato salad only + number of attendees who had hamburgers and potato salad + number of attendees who had hotdogs and potato salad + number of attendees who had hamburgers, hotdogs, and potato salad
= 10 + 25 + 8 + 30
= 73

Among those, the number who became ill was 25 (3 out of the 10 who had potato salad only + 5 out of the 25 who had hamburgers and potato salad + 3 out of the 8 who had hotdogs and potato salad + 14 out of the 30 who had hamburgers, hot dogs, and potato salad = 25). Therefore, the attack rate for potato salad was: (25/73) × 100 = 34%.

(Choice B) There were 27 attendees who did not eat potato salad: the 15 who had hamburgers only and the 12 who had hotdogs only. Of those, a total of 3 (2 out of the 15 who ate hamburgers only + 1 out of the 12 who ate hotdogs only = 3) became ill. Therefore, the attack rate among those who did not eat potato salad was: (3/27) × 100 = 11%. Despite the fact that these individuals only ate hotdogs and hamburgers, a percentage of them still became ill, probably as a result of some contamination of these food items with the potato salad.

For the sake of completion, the attack rates for the other individual food items or combinations of food items are shown in the following table (they do not need to be calculated to arrive at the correct answer):

		Number of	Number of	

	Food item or combination of items	Number of attendees who ate food item or combination of items	Number of attendees who developed diarrhea and vomiting	Attack rate
Did not have potato salad = 27 (attack rate 11%)	Hamburgers only	15	2	(2/15) × 100 = 13% **(Choice C)**
	Hotdogs only	12	1	(1/12) × 100 = 8% **(Choice A)**
Had potato salad = 73 (attack rate 34%)	Potato salad only	10	3	(3/10) × 100 = 30% **(Choice F)**
	Hamburgers and potato salad	25	5	(5/25) × 100 = 20% **(Choice D)**
	Hotdogs and potato salad	8	3	(3/8) × 100 = 38%
	Hamburgers,			(14/30) ×

				(Choice F)
Had potato salad = 73 (attack rate 34%)	Hamburgers and potato salad	25	5	(5/25) × 100 = 20% **(Choice D)**
	Hotdogs and potato salad	8	3	(3/8) × 100 = 38%
	Hamburgers, hotdogs, and potato salad	30	14	(14/30) × 100 = 47% **(Choice H)**
Overall		100	28	28/100 × 100 = 28% **(Choice E)**

The food item responsible for an outbreak often (though not always) has the largest attack rate and the largest difference in attack rates between those who consumed the item and those who did not. In this example, as calculated above, the difference in attack rate between those who had potato salad and those who did not was: 34% − 11% = 23%. As seen in the exhibit, the differences in attack rates were smaller for hamburgers (7%) and hotdogs (16%). It is possible that potato salad is the source of the outbreak.

Educational objective:
The attack rate is the ratio of the number of people who contract an illness divided by the number of people who are at risk of contracting that illness.

Biostatistics | Biostatistics & Epidemiology | Epidemics and pandemics
Subject | System | Topic

Researchers develop a new test to detect the presence of a recently identified biomarker for hepatocellular carcinoma (HCC). The initial evaluation of the test shows the following:

	HCC Present	HCC Not Present	
Test positive	45	30	75
Test negative	5	120	125
	50	150	200

Which of the following is the likelihood that a patient with a negative test does not have HCC?

- A. 0.10 (3%)
- B. 0.20 (2%)
- C. 0.60 (3%)
- D. 0.80 (13%)
- ✓ E. 0.96 (77%)

Omitted
Correct answer
E

77%
Answered correctly

05 secs
Time Spent

2023
Version

Explanation

	Positive condition	Negative condition	
Positive test result	TP	FP	PPV = TP / (TP + FP)
Negative test result	FN	TN	NPV = TN / (TN + FN)
	Sensitivity = TP / (TP + FN)	Specificity = TN / (TN + FP)	

FN = false negative; **FP** = false positive; **NPV** = negative predictive value; **PPV** = positive predictive value; **TN** = true negative; **TP** = true positive.

The **negative predictive value** (NPV) of a diagnostic test is the probability (ie, likelihood) that an individual truly **does not have the disease** given a **negative test**. It is equal to the number of individuals who do not have the disease and who have a negative test result (ie, true negatives [TN]) divided by the total number of individuals with a negative test result (TN + false negatives [FN]). Therefore, NPV is calculated as:

NPV = TN / (TN + FN)

In this example, 120 individuals are TN and 5 individuals are FN; therefore, the total number of individuals with a negative test result (TN + FN) is 125 (ie, 120 + 5), and the test's NPV is calculated as follows:

NPV = TN / (TN + FN) = 120 / (120 + 5) = 120 / 125 = 0.96

Positive and negative predictive values **depend on the prevalence** of the disease in the study population. For example, it is more likely that individuals who test positive truly have the disease and less likely that individuals who test negative do not have the disease in a high-prevalence population compared to a low-prevalence

...ve and negative predictive values **depend on the prevalence** of the disease in the study population. For example, it is more likely that individuals who test positive truly have the disease and less likely that individuals who test negative do not have the disease in a high-prevalence population compared to a low-prevalence population.

(Choice A) 0.10 is the false negative rate (FNR). FNR is equal to FN / (FN + TP) and describes the proportion of the individuals who really have the disease for which the test result is negative. It is also known as the miss rate.

(Choice B) 0.20 is the false positive rate (FPR). FPR is equal to FP / (FP + TN) and describes the proportion of the individuals who really do not have the disease for which the test result is positive. It is also known as the fall-out rate.

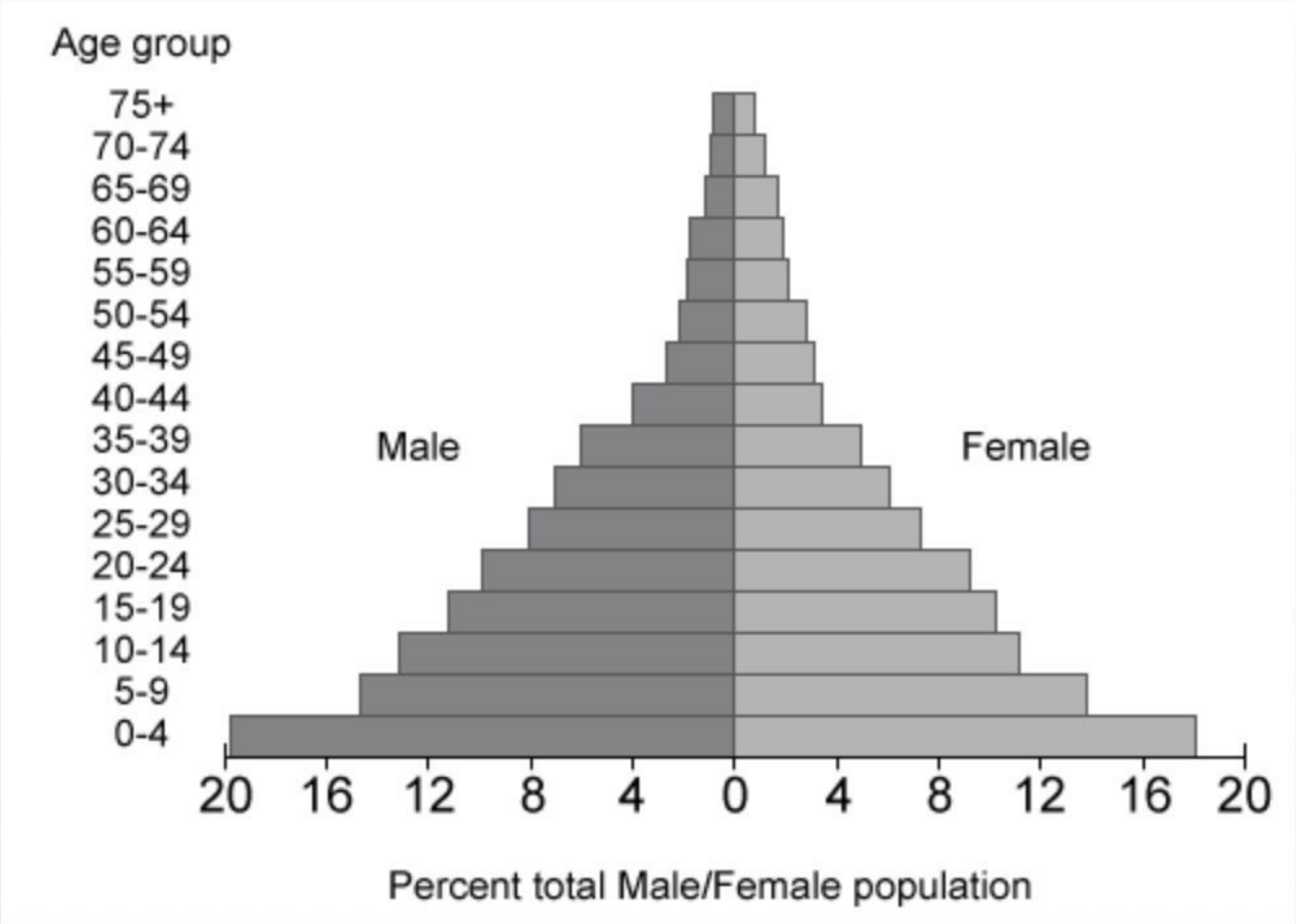
(Choice C) 0.60 is the overall proportion of TN in the entire study: TN / (TP + TN + FP + FN).

(Choice D) 0.80 is the test's specificity. Specificity is equal to TN / (TN + FP) and describes the proportion of individuals who do not have the disease for which the test result is negative. It is an intrinsic measure of the test's ability to correctly identify individuals without the disease, but by itself, it does not provide enough information to interpret a negative test result in a particular individual.

Educational objective:
Negative predictive value (NPV) is the probability that an individual does not have a disease given a negative test result. It is equal to the number of individuals who do not have the disease and who have a negative test result (ie, true negatives [TN]) divided by the total number of individuals with a negative test result (TN + false negatives [FN]): NPV = TN / (TN + FN).

Biostatistics	Biostatistics & Epidemiology	Sensitivity, specificity, NPV, PPV
Subject	System	Topic

The population pyramid of a certain country is shown below.



Based on the diagram, which of the following best characterizes this population?

- A. High mortality rate (72%)
- B. Long life expectancy (3%)
- C. Low birth rate (0%)
- D. Shrinking population (7%)
- E. Stable population (16%)

Omitted
Correct answer

72%

03 secs

2023

A **population pyramid** displays the percentage of individuals in each age cohort to describe the current population profile, and to project how the population will increase/decrease in the future. Every population pyramid is unique, but most fit into one of three general categories.

- **Expansive** populations have **high birth and mortality rates** and **short life expectancies**. Therefore, they show a larger percentage of people in younger cohorts (ie, graph has a broad bottom and narrow top). These populations are **young and growing**, and their pyramids characterize many developing countries.
- **Stationary** populations have **declining birth rates**, **low mortality rates**, and **long life expectancies**. Therefore, they show a somewhat equal percentage of people in each age cohort (ie, graph has a

…id is unique, but most fit into one of three general categories:

- **Expansive** populations have **high birth and mortality rates** and **short life expectancies**. Therefore, they show a larger percentage of people in younger cohorts (ie, graph has a broad bottom and narrow top). These populations are **young and growing**, and their pyramids characterize many developing countries.
- **Stationary** populations have **declining birth rates**, **low mortality rates**, and **long life expectancies**. Therefore, they show a somewhat equal percentage of people in each age cohort (ie, graph has a somewhat rectangular shape). These populations are **stable** (ie, neither growing nor shrinking), and their pyramids are characteristic of many developed countries.
- **Constrictive** populations have **significantly low birth and mortality rates**, and **long life expectancies**. Therefore, they show a smaller percentage of people in younger cohorts (ie, graph has a narrower bottom). These populations are **shrinking**, and their pyramids are characteristic of very advanced countries with a high level of literacy, easy access to birth control measures, and exceptional health and medical resources.

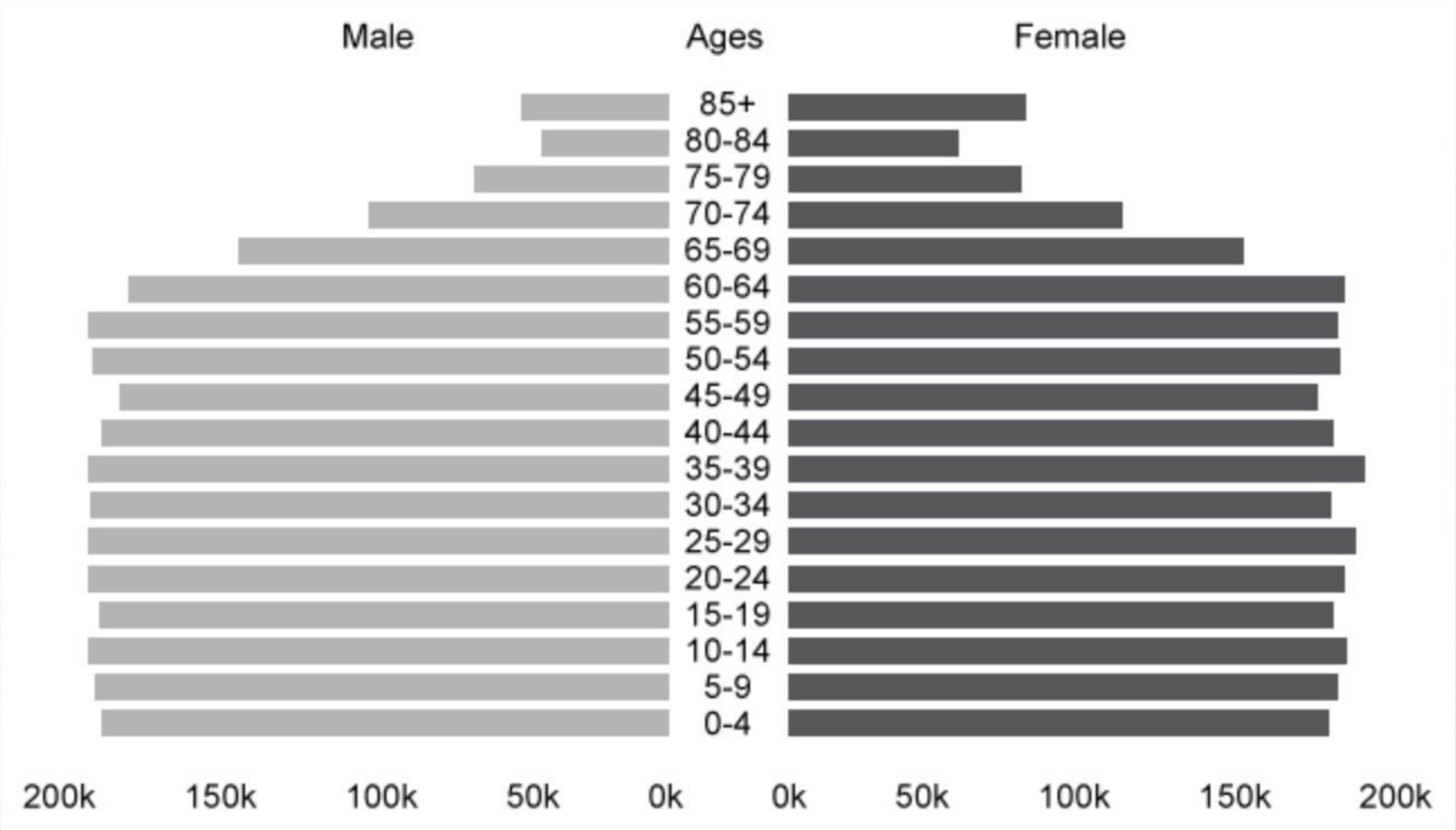
In this question, the population pyramid has a broad bottom, indicating a high birth rate, and a narrow top, indicating a higher mortality rate that results in a short life expectancy **(Choices B and C)**. Populations with high birth rates are populations that are young and growing **(Choices D and E)**. Therefore, the population pyramid is characteristic of many developing countries.

Educational objective:

There are three types of population pyramids: expansive (ie, young and growing population; high birth and mortality rates), stationary (ie, stable population; declining birth rates and low mortality rates), and constrictive (ie, shrinking population; significantly low birth and mortality rates).

Biostatistics	Biostatistics & Epidemiology	Principles and methods of epidemiology
Subject	System	Topic

The population pyramid of all races and ethnicities for a certain state in the United States is shown below.



Which of the following statements best describes the population of this specific state?

A. Life expectancy is low due to its high mortality rate (3%)

B. The high birth rate indicates the population is growing (11%)

C. The population is shrinking due to the migration of older people (2%)

✓ D. The similar number of people in each age cohort indicates the population is stable (71%)

E. The state has a young population because of its high birth rate (10%)

A population pyramid displays the percentage of individuals in each age cohort to describe the current population profile, and to project how the population will increase/decrease in the future. Every population pyramid is unique, but most fit into one of three general categories.

- **Expansive** populations have **high birth and mortality rates** and short life expectancies. Therefore, they show a larger percentage of people in younger cohorts (ie, graph has a broad bottom and narrow top). These populations are **young and growing**, and their pyramids characterize many developing countries.
- **Stationary** populations have **declining birth rates**, **low mortality rates**, and long life expectancies.

Therefore, they show a somewhat equal percentage of people in each age cohort (ie, graph has a somewhat rectangular shape). These populations are **stable** (ie, neither growing nor shrinking), and their pyramids are characteristic of many developed countries.

- **Constrictive** populations have **significantly low birth and mortality rates** and long life expectancies. Therefore, they show a smaller percentage of people in younger cohorts (ie, graph has a narrow bottom). These populations are **shrinking**, and their pyramids are characteristic of very advanced countries with a high level of literacy, easy access to birth control measures, and exceptional health and medical resources.

In this question, the population pyramid has a **rectangular shape** that tapers off significantly only in the advanced age cohorts. This indicates that the population has gone through a **decline in both birth and mortality rates**, resulting in a **longer life expectancy (Choices A and E)**. When a population reaches a balance between its birth and mortality rates (ie, rectangular shape), it is neither growing nor shrinking; therefore, it is a **stable population (Choice B)**.

(Choice C) A small proportion of older cohorts (eg, age ≥75) is expected in any population; this tapering off at the top of the pyramid occurs due to a natural increase in age-related mortality rather than migration of older people.

Educational objective:
There are three types of population pyramids: expansive (ie, young and growing population; high birth and mortality rates), stationary (ie, stable population; declining birth rates and low mortality rates), and constrictive (ie, shrinking population; significantly low birth and mortality rates).

Biostatistics	Biostatistics & Epidemiology	Principles and methods of epidemiology
Subject	System	Topic

Researchers at an academic trauma center conducted a randomized clinical trial comparing 2 surgical techniques (Technique A and Technique B) for repairing a mandible fracture. They examined rates of infectious complications and rates of malocclusion (defined as misaligned dental arches on visual examination when the jaw is closed). A total of 100 patients were enrolled in the study. Outcome assessments of each patient were conducted at 2 weeks, 4 weeks, and 8 weeks after surgery. Results showed that the relative rate of infection with Technique A compared with Technique B was 0.86 with a 95% confidence interval of 0.57-1.28; the 2 techniques had similar malocclusion rates at 8 weeks after surgery. Which of the following statements most accurately represents the comparison of Technique A and Technique B in a clinical care setting?

- A. Neither surgery technique is superior (75%)
- B. Technique A is superior to Technique B (12%)
- C. Technique B is superior to Technique A (8%)
- D. The techniques should not be used in a clinical care setting (3%)

Omitted
Correct answer
A

75%
Answered correctly

02 secs
Time Spent

2023
Version

Explanation

The **relative risk (RR)** is commonly used in cohort and experimental studies as a measure of **association** between a risk factor or **treatment** and a disease or **outcome**. RR is equal to the risk of an outcome or disease (eg, infection) in a group exposed to a treatment (eg, Treatment A) divided by the risk of the same outcome or disease in a group exposed to a different treatment (eg, Treatment B).

The **relative risk (RR)** is commonly used in cohort and experimental studies as a measure of **association** between a risk factor or **treatment** and a disease or **outcome**. RR is equal to the risk of an outcome or disease (eg, infection) in a group exposed to a treatment (eg, Treatment A) divided by the risk of the same outcome or disease in a group exposed to a different treatment (eg, Treatment B).

RR = (risk of disease in Treatment A) / (risk of disease in Treatment B)

The RR may be interpreted as follows:

- RR < 1.0 indicates that exposure to Treatment A is associated with a decrease in risk of disease with respect to Treatment B.
- **RR = 1.0 (null value)** indicates that there is no association between the treatments and risk of disease.
- RR > 1.0 indicates that exposure to Treatment A is associated with an increase in risk of disease with respect to Treatment B.

The **confidence interval** (CI) of a RR indicates, with a certain confidence level, whether a given RR is statistically different from the null value (ie, RR = 1). A CI that **includes the null value** (ie, RR = 1) is **not statistically significant**, and a CI that **excludes** the null value (ie, RR = 1) is **statistically significant** (at that confidence level).

In this study, the RR for infection among those assigned to surgery Technique A compared to those assigned to surgery Technique B is 0.86 with a 95% CI of 0.57-1.28. An RR = 0.86 indicates that exposure to surgery Technique A decreases the risk of infection. However, because the CI includes the null value (ie, RR = 1), the decrease in risk is **not statistically significant**. Therefore, neither surgery technique is superior at reducing infection **(Choices B and C)**.

(Choice D) The study results show that the surgery techniques have similar rates of infectious complications

The **confidence interval** (CI) of a RR indicates, with a certain confidence level, whether a given RR is statistically different from the null value (ie, RR = 1). A CI that **includes the null value** (ie, RR = 1) is **not statistically significant**, and a CI that **excludes** the null value (ie, RR = 1) is **statistically significant** (at that confidence level).

In this study, the RR for infection among those assigned to surgery Technique A compared to those assigned to surgery Technique B is 0.86 with a 95% CI of 0.57-1.28. An RR = 0.86 indicates that exposure to surgery Technique A decreases the risk of infection. However, because the CI includes the null value (ie, RR = 1), the decrease in risk is **not statistically significant**. Therefore, neither surgery technique is superior at reducing infection **(Choices B and C)**.

(Choice D) The study results show that the surgery techniques have similar rates of infectious complications and malocclusion. Assuming these rates are acceptable and there are no other major complications, there is no reason to determine the surgical techniques should not be used in a clinical care setting, but further information may be useful.

Educational objective:

- The relative risk (RR) is a measure of association: RR < 1.0 indicates a lower risk of disease in the exposed group relative to the nonexposed group; RR = 1.0 indicates no association between exposure and disease; and RR > 1.0 indicates a greater risk of disease in the exposed group relative to the nonexposed group.
- A confidence interval (CI) that includes the null value for an RR (ie, RR = 1) is not statistically significant, and a CI that excludes the null value (ie, RR = 1) is statistically significant.

Biostatistics	Biostatistics & Epidemiology	Statistical vs. clinical significance
Subject	System	Topic