A study is conducted to assess whether quantitative measurement of heat shock protein 90 alpha (Hsp90α) in plasma can improve diagnostic accuracy and help monitor treatment response in liver cancer patients. A total of 300 individuals (100 liver cancer patients and 200 healthy controls) participate in the study. Analyses reveal that 90 of the liver cancer patients have an abnormally high plasma Hsp90α level and that 12 of the healthy controls have an abnormally high plasma Hsp90α level. An abnormally high plasma Hsp90α level indicates a positive test for liver cancer. Which of the following values best represents the specificity of this test?

- A. 6% (5%)
- B. 10% (1%)
- C. 33% (2%)
- D. 90% (9%)
- ✓ E. 94% (81%)

Omitted
Correct answer
E

81%
Answered correctly

03 secs
Time Spent

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## Explanation

| | Positive condition | Negative condition | |
|---|---|---|---|
| **Positive test result** | TP | FP | PPV = TP / (TP + FP) |



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| | 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 example, 12 out of 200 healthy controls had an abnormally high plasma heat shock protein 90 alpha (Hsp90α) level (ie, tested positive); therefore, FP = 12 and TN = 188 (ie, 200 − 12). Therefore, the specificity of the test is as follows:

Specificity = TN / (TN + FP) = 188 / (188 + 12) = 188 / 200 = 0.94 (or **94%**)

**(Choice A)** In this example, 6% is the false positive rate (FPR): FPR = FP / (TN + FP) = 12 / (188 + 12) = 12 / 200 = 0.06 (or 6%). FPR is the probability of a positive test in a patient without the disease (ie, FP); it is also the complement to specificity (ie, FPR = 1 − specificity = 1 − 0.94 = 0.06).



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the test is as follows:

Specificity = TN / (TN + FP) = 188 / (188 + 12) = 188 / 200 = 0.94 (or **94%**)

**(Choice A)** In this example, 6% is the false positive rate (FPR): FPR = FP / (TN + FP) = 12 / (188 + 12) = 12 / 200 = 0.06 (or 6%). FPR is the probability of a positive test in a patient without the disease (ie, FP); it is also the complement to specificity (ie, FPR = 1 − specificity = 1 − 0.94 = 0.06).

**(Choices B and D)** The sensitivity of a test refers to its ability to correctly identify individuals with the disease. It is calculated as the number of individuals who have the disease and who test positive (true positives [TP]) divided by the total number of individuals with the disease (TP + false negatives [FN]): sensitivity = TP / (TP + FN). In this example, 90 of 100 liver cancer patients had an abnormally high plasma Hsp90α level (ie, tested positive); therefore, TP = 90 and FN = 10 (ie, 100 − 90). Accordingly, the sensitivity of the test is 90 / (90 + 10) = 90 / 100 = 0.90 (or 90%). Sensitivity is related to the false negative rate (FNR): FNR = 1 – sensitivity. FNR is the probability of a negative test result in a patient with the disease (ie, FN): FNR = FN / (TP + FN) = 10 / (10 + 90) = 10 / 100 = 0.10 (or 10%).

**(Choice C)** In this example, 33% represents the proportion of study participants with liver cancer: 100 liver cancer patients / (100 liver cancer patients + 200 health controls) = 0.333 (or 33.3%).

**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 |

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For a case-control study designed to investigate a possible association between endometriosis and systemic lupus erythematosus (SLE), 1,040 women with SLE and 1,260 women without SLE are selected. The investigators inquire about a history of endometriosis in both groups of women. Among women with SLE, 240 had a history of endometriosis; among women without SLE, 210 had a history of endometriosis. Which of the following is the estimated odds ratio of endometriosis in women with SLE compared to women without SLE?

- A. 0.1 (2%)
- B. 0.7 (7%)
- C. 0.8 (6%)
- D. 1.2 (13%)
- ✓ E. 1.5 (70%)

Omitted
Correct answer
E

70%
Answered correctly

02 secs
Time Spent

2023
Version

## Explanation

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 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)



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

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)

In this study, the **disease** of interest is **systemic lupus erythematosus** (SLE), so cases are women with SLE, and controls are women without SLE. The **exposure** of interest is a **history of endometriosis**. Given that 240 of 1,040 women with SLE had a history of endometriosis, 1,040 − 240 = 800 of women with SLE had no history of endometriosis. Given that 210 of 1,260 without SLE had a history of endometriosis, 1,260 − 210 = 1,050 of women without SLE had no history of endometriosis. Based on these data, the standard contingency table is as follows:

| | | **SLE +** | **SLE −** |
|---|---|---|---|
| **History of endometriosis** | **Yes** | 240 (a) | 210 (b) |
| | **No** | 800 (c) | 1,050 (d) |
| | *Total* | 1,040 | 1,260 |

The odds of endometriosis in women with SLE and women without SLE are:

- **Odds** of endometriosis in **cases**: a/c = 240/800 = 0.3
- **Odds** of endometriosis in **controls**: b/d = 210/1,050 = 0.2

Therefore, the OR of endometriosis in women with SLE compared to women without SLE is:



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| | | | |
|---|---|---|---|
| **History of endometriosis** | **Yes** | 240 (a) | 210 (b) |
| | **No** | 800 (c) | 1,050 (d) |
| | *Total* | 1,040 | 1,260 |

The odds of endometriosis in women with SLE and women without SLE are:

- **Odds** of endometriosis in **cases**: a/c = 240/800 = 0.3
- **Odds** of endometriosis in **controls**: b/d = 210/1,050 = 0.2

Therefore, the OR of endometriosis in women with SLE compared to women without SLE is:

**OR** = (odds of endometriosis in cases) / (odds of endometriosis in controls) = (a/c) / (b/d) = 0.3/0.2 = **1.5**

The estimated **OR = 1.5** is >1 (ie, the null value for the OR); this indicates that a history of endometriosis acts as a **risk factor** for SLE.

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 contingency table in the standard format: OR = (ad) / (bc).

| Biostatistics | Biostatistics & Epidemiology | Odds ratio |
|---|---|---|
| Subject | System | Topic |



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Researchers conduct a randomized controlled trial to determine whether prophylactic administration of tranexamic acid (TXA) in addition to prophylactic oxytocin in women undergoing vaginal delivery has an effect on the incidence of postpartum hemorrhage (PPH), defined as blood loss ≥500 mL. Study participants are women in labor who have a planned vaginal delivery of a live singleton at ≥35 weeks gestation. They are randomly assigned to receive 1 g TXA or placebo intravenously in addition to prophylactic oxytocin after delivery. The relative risk of PPH among women receiving TXA in addition to oxytocin is 0.80 (95% confidence interval of 0.66-0.96). Which of the following is the most appropriate conclusion about the effect of TXA in addition to prophylactic oxytocin after delivery on the risk of PPH?

- A. Adding TXA is associated with a 20% increase in the risk of PPH (3%)
- B. Receiving TXA in addition to prophylactic oxytocin decreases the risk of PPH by 80% (13%)
- ✓ C. The risk of PPH is reduced by 20% when TXA is added to prophylactic oxytocin (64%)
- D. The risk of developing PPH in the TXA treatment group is 0.8% (8%)
- E. TXA prophylaxis has no significant effect on the risk of PPH (11%)

Omitted
Correct answer
C

64%
Answered correctly

02 secs
Time Spent

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Version

## Explanation

**Relative risk (RR)** is a measure of **association** between exposure to a risk modifier (eg, **treatment**) and an **outcome** (eg, disease course) that is commonly used in cohort and experimental studies. RR is the risk of an outcome (eg, postpartum hemorrhage [PPH]) in the exposed group (eg, tranexamic acid [TXA]) divided by the



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**Relative risk (RR)** is a measure of **association** between exposure to a risk modifier (eg, **treatment**) and an **outcome** (eg, disease course) that is commonly used in cohort and experimental studies. RR is the risk of an outcome (eg, postpartum hemorrhage [PPH]) in the exposed group (eg, tranexamic acid [TXA]) divided by the risk of the same outcome or disease in the nonexposed group (eg, placebo):

**RR** = (risk of disease in exposed group) / (risk of disease in nonexposed group)

The RR may be interpreted as follows:

- RR <1.0 indicates that the exposure decreases the risk of disease.
- RR = 1.0 (null value) indicates that the exposure has no effect on the risk of disease.
- RR >1.0 indicates that the exposure increases the risk of disease.

The confidence interval (CI) of RR indicates, with a certain confidence level (eg, 95%), whether a given RR is statistically different from the null value (ie, RR = 1.0). A CI that includes the null value (ie, RR = 1.0) is not statistically significant, and a CI that excludes the null value is statistically significant.

In this study, the **RR of PPH** (ie, disease) among women receiving TXA (ie, exposed) compared to women receiving placebo (ie, nonexposed) is 0.80. Because this RR is <1.0, the exposure decreases the risk of disease. The RR of 0.80 indicates that adding TXA **decreases the risk** of PPH by **20%** (ie, 1 − 0.80 = **0.20**) **(Choices A and B)**.

**(Choice D)** In this study, 0.80 represents the *relative risk* (not absolute risk) of PPH among women receiving TXA compared to those receiving placebo. For instance, the actual risk of PPH could be 1.6% with TXA compared to 2.0% with placebo, producing the RR of 0.80 (ie, RR = 1.6 / 2.0 = 0.80).

**(Choice E)** The reported CI for RR in this study is 0.66-0.96. It excludes the null value (ie, RR = 1.0); therefore, adding TXA has a statistically significant effect on the risk of PPH.

**Educational objective:**



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RR = 1.0 (null value) indicates that the exposure has no effect on the risk of disease.

- RR >1.0 indicates that the exposure increases the risk of disease.

The confidence interval (CI) of RR indicates, with a certain confidence level (eg, 95%), whether a given RR is statistically different from the null value (ie, RR = 1.0). A CI that includes the null value (ie, RR = 1.0) is not statistically significant, and a CI that excludes the null value is statistically significant.

In this study, the **RR of PPH** (ie, disease) among women receiving TXA (ie, exposed) compared to women receiving placebo (ie, nonexposed) is 0.80. Because this RR is <1.0, the exposure decreases the risk of disease. The RR of 0.80 indicates that adding TXA **decreases the risk** of PPH by **20%** (ie, 1 − 0.80 = **0.20**) **(Choices A and B)**.

**(Choice D)** In this study, 0.80 represents the *relative risk* (not absolute risk) of PPH among women receiving TXA compared to those receiving placebo. For instance, the actual risk of PPH could be 1.6% with TXA compared to 2.0% with placebo, producing the RR of 0.80 (ie, RR = 1.6 / 2.0 = 0.80).

**(Choice E)** The reported CI for RR in this study is 0.66-0.96. It excludes the null value (ie, RR = 1.0); therefore, adding TXA has a statistically significant effect on the risk of PPH.

**Educational objective:**
Relative risk is the ratio of the probability of an event (eg, disease outcome) occurring in the exposed group (eg, treatment group) versus the probability of the event occurring in the unexposed group (eg, control group).

**References**

- Measures of effect in epidemiological research.

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

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A test is used to diagnose dementia in a population of 1,000 women age ≥75. The test has a sensitivity of 80% and a specificity of 90%. The test is then used as a diagnostic tool in 2 other populations of women of the same age: population 1 has a prevalence of dementia of 15%, and population 2 has a prevalence of dementia of 30%. Which of the following best describes how the negative predictive values (NPV) and the positive predictive values (PPV) from populations 1 and 2 relate to each other?

- A. NPV and PPV do not change as prevalence changes (7%)
- B. NPV in population 1 < NPV population 2; PPV in population 1 < PPV population 2 (7%)
- C. NPV in population 1 < NPV population 2; PPV in population 1 > PPV population 2 (7%)
- ✓ D. NPV in population 1 > NPV population 2; PPV in population 1 < PPV population 2 (76%)
- E. NPV in population 1 > NPV population 2; PPV in population 1 > PPV population 2 (1%)

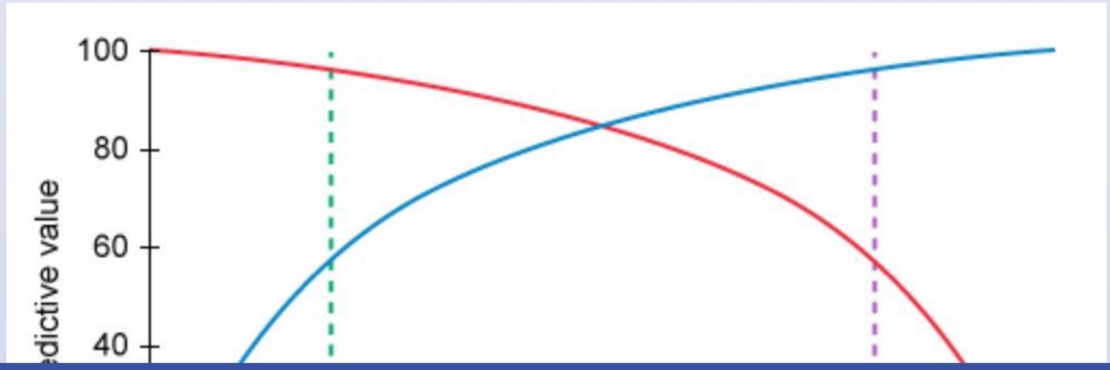
Omitted
Correct answer
D

76%
Answered correctly

02 secs
Time Spent

2023
Version

## Explanation



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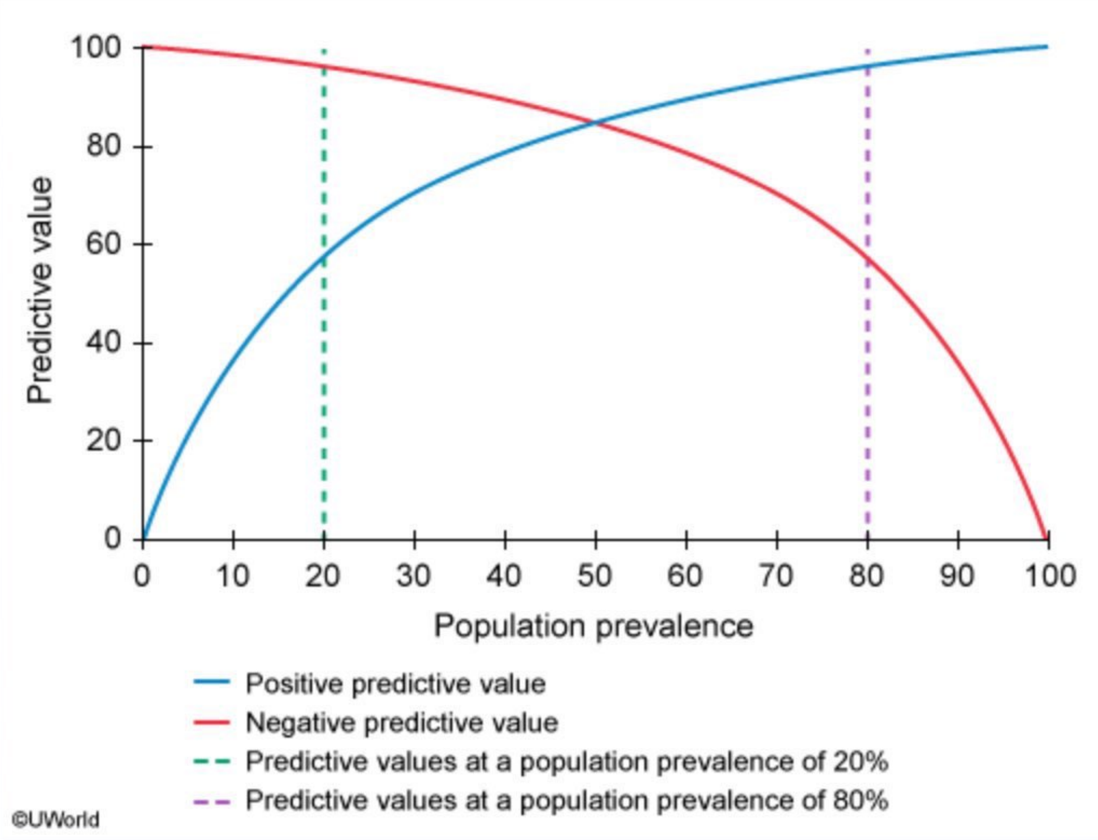


Predictive values are performance measures of diagnostic tests that are **dependent on the prevalence** of disease in a population of interest.

- **Negative predictive value** (NPV) is the probability (ie, likelihood) that an individual truly does not have the disease given a negative test result. NPV is equal to the number of individuals who do not have the disease and who test negative (true negatives [TN]) divided by all those with a negative test result (TN + false negatives [FN]): **NPV** = TN / (TN + FN).
- **Positive predictive value** (PPV) is the probability (ie, likelihood) that an individual truly does have the disease given a positive test result. PPV is equal to the number of individuals who have the disease and who test positive (true positives [TP]) divided by all those with a positive test result (TP + false positives [FP]): **PPV** = TP / (TP + FP).



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[FP]): **PPV** = TP / (TP + FP).

Disease prevalence affects NPV by changing the number of TN and FN tests. It affects PPV by changing the number of TP and FP tests **(Choice A)**:

- Populations with exceptionally **low disease prevalence** (eg, prevalence close to 0%) have almost all TN (ie, more TN) with almost no TP (ie, fewer TP), and most positive tests would be FP (ie, more FP) with almost no FN (ie, fewer FN). In this scenario, NPV is close to 100%, and PPV is close to 0%. This explains why, with decreasing prevalence, **NPV increases** (more TN, fewer FN) and **PPV decreases** (fewer TP, more FP).
- Populations with exceptionally **high disease prevalence** (eg, prevalence close to 100%) have almost all TP (ie, more TP) with almost no TN (ie, fewer TN), and most negative tests would be FN (ie, more FN) with almost no FP (ie, fewer FP). In this scenario, NPV is close to 0%, and PPV is close to 100%. This explains why, with increasing prevalence, **NPV decreases** (fewer TN, more FN) and **PPV increases** (more TP, fewer FP).

**(Choices B, C, and E)** In this example, population 1 has a lower prevalence (15%) of dementia in women age ≥75 compared to population 2 (30%). Therefore, NPV in population 1 > NPV population 2, and PPV in population 1 < PPV population 2.

**Educational objective:**
Predictive values change depending on the prevalence of disease in a study population. As disease prevalence increases, the positive predictive value increases, and the negative predictive value decreases.

**References**

- Diagnostic methods I: sensitivity, specificity, and other measures of accuracy.

Biostatistics Biostatistics & Epidemiology Sensitivity, specificity, NPV, PPV



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A healthy 31-year-old woman comes to the office as she and her husband desire a second child. The husband is infertile and the patient's son, who was conceived via donor insemination, was recently diagnosed with glycogen storage disease type II (Pompe disease). This rare autosomal recessive disease is known to affect 1 in 40,000 of the general population. Genetic testing confirms that the patient is a carrier for the disease. A different sperm donor is selected with no personal or family history of Pompe disease; however, his carrier status is unknown. What is the probability of the patient having an affected child with the new sperm donor?

- A. 1/4 (9%)
- B. 1/240 (2%)
- ✓ C. 1/400 (23%)
- D. 1/800 (18%)
- E. 1/40,000 (14%)
- F. 1/160,000 (31%)

Omitted
Correct answer
C

23%
Answered correctly

02 secs
Time Spent

2023
Version

## Explanation

| Hardy-Weinberg analysis | |
|---|---|
| [illegible] | $p + q = 1$ |



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| Hardy-Weinberg analysis | |
|---|---|
| Allele frequency | $p + q = 1$<br>$p$: Normal allele frequency; $q$: Mutant allele frequency; 1: Total |
| Phenotypic frequency | $p^2 + 2pq + q^2 = 1$<br>$p^2$: Frequency of normal individuals; $2pq$: Carrier frequency; $q^2$: Frequency of diseased individuals; 1: Total |
| Calculating mutant allele frequency from disease prevalence | $\sqrt{q^2} = q$<br>$q^2$: Disease prevalence; $q$: Mutant allele frequency |

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To be affected by an autosomal recessive disorder, an offspring must inherit 2 copies of the mutant allele (a), a copy from the mother and another copy from the father (in this case, the sperm donor).

In this example, genetic analysis confirms that the **mother is a carrier** (Aa), which gives her a **50%** chance of passing 1 mutant allele (a) to her child.

The **sperm donor** does not have Pompe disease, but his **carrier status is unknown** (ie, he has either an AA or Aa genotype). Given that he has no family history of the disease, his risk of being a carrier is the same as that of the general population. **Hardy-Weinberg analysis** can be used to estimate the frequency of alleles and genotypes in the general population:



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genotype). Given that he has no family history of the disease, his risk of being a carrier is the same as that of the general population. **Hardy-Weinberg analysis** can be used to estimate the frequency of alleles and genotypes in the general population:

- The total gene pool is given by $(p + q) = 1$. By convention, $p$ = normal allele (A) frequency and ***q* = mutant allele (a) frequency** in the population of interest.
- Disease frequency is equivalent to the proportion of homozygous recessive individuals. These affected individuals have 2 copies of the mutant allele (aa); therefore, the frequency of affected individuals = $q \times q = q^2$.
- **Carrier frequency** is equal to the proportion of heterozygous individuals. Carriers have only 1 mutant allele that may be inherited in 2 different ways (ie, Aa or aA); consequently, the probability of being a carrier = $2pq$. For rare autosomal recessive disorders, $p \approx 1$; therefore, the probability approximates to 2 times the frequency of the mutant allele, or $\mathbf{2q}$.

In this case, 1 in 40,000 individuals is affected by the condition in the general population, so $q^2 = 1/40{,}000$ and $q = 1/\sqrt{40{,}000} = 1/200$. Thus, the probability of the **sperm donor** being a carrier = $2q = 2 \times (1/200)$ = **1/100**. Given that a carrier sperm donor would have a **50%** chance of passing on the mutant allele (a), the probability of the child being affected is:

P (mother gives recessive allele) × P (donor is a carrier) × P (donor gives recessive allele) = (1/2 × 1/100 ×1/2) = **1/400**

**(Choices E and F)** 1/40,000 represents the disease frequency ($q^2$), not the mutant allele frequency ($q$).

**Educational objective:**
The Hardy-Weinberg equation can be used to estimate carrier frequency, disease frequency, and frequency of different genotypes if at least 1 of these values is known.



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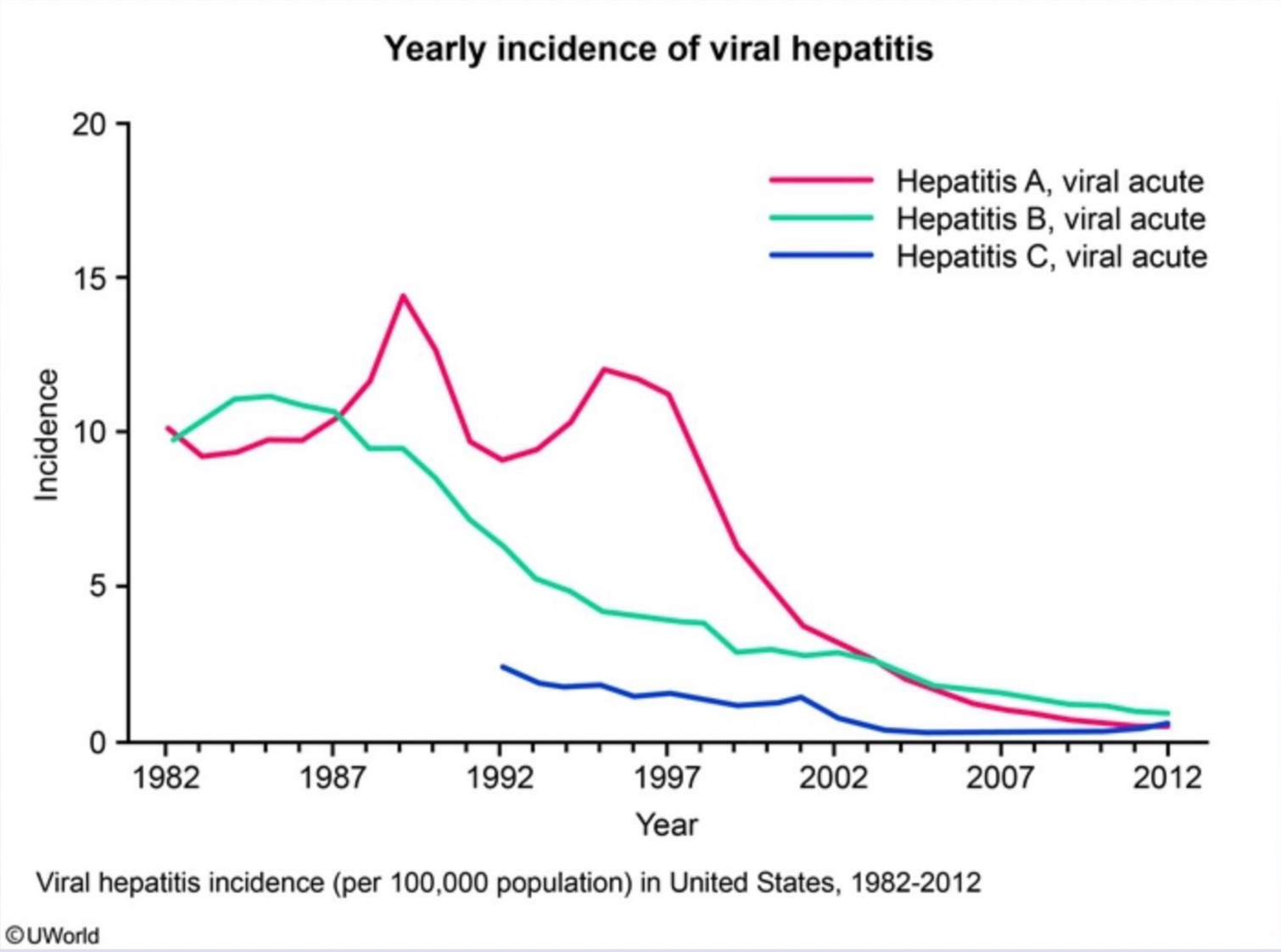
The graph below shows the yearly incidence of viral hepatitis per 100,000 population from 1982-2012 in the United States (US).




During this period, the total population in the US continued to increase, as shown in the table below:

| Year | 1982 | 1987 | 1992 | 1997 | 2002 | 2007 | 2012 |
|---|---|---|---|---|---|---|---|
| US | | | | | | | |



Scanned with CamScanner

During this period, the total population in the US continued to increase, as shown in the table below:

| Year | 1982 | 1987 | 1992 | 1997 | 2002 | 2007 | 2012 |
|---|---|---|---|---|---|---|---|
| US population (in millions) | ~230 | ~243 | ~258 | ~275 | ~290 | ~303 | ~315 |

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 (5%)
- B. In 1987, there were as many individuals with hepatitis A as with hepatitis B in the US (4%)
- C. In 1989, there were more individuals with hepatitis A than with hepatitis B in the US (6%)
- ✓ D. In 1997, there were more new cases of hepatitis A than of hepatitis B and C combined (78%)
- E. The number of new cases of hepatitis A diagnosed in 1982 and 1998 were exactly the same (4%)

Omitted
Correct answer
D

78%
Answered correctly

29 secs
Time Spent

2023
Version

Explanation

**Incidence** corresponds to the number of **new** cases of a disease diagnosed in a population at risk over a given time period. In 1997, incidence was >10 new cases/100,000 population for hepatitis A virus (HAV), <5/100,000



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**Incidence** corresponds to the number of **new** cases of a disease diagnosed in a population at risk over a given time period. In 1997, incidence was >10 new cases/100,000 population for hepatitis A virus (HAV), <5/100,000 for hepatitis B virus (HBV), and <3/100,000 for hepatitis C virus (HCV). Assuming, as instructed, that the entire United States (US) population is at risk (reasonable theory given low number of hepatitis cases among the total population), then, in 1997 (US population ~275 million):

New HAV cases in 1997 = >10 new cases/100,000 population × 275,000,000 population = >27,500
New HBV cases in 1997 = <5/100,000 × 275,000,000 = <13,750
New HCV cases in 1997 = <3/100,000 × 275,000,000 = <8,250

There were thousands more new HAV (>27,500) than HBV and HCV cases combined (<13,750 + <8,250 = <22,000). The calculations incorporating total population (included for completion) are not needed to answer the question.

After 2006, HBV incidence surpassed HAV and HCV incidence. However, no information can be deduced regarding **prevalence**, which is the **total** number of cases in the population **(Choice A)**. Compared to new HBV cases, there were approximately just as many **new** HAV cases in 1987 and more new HAV cases in 1989. However, the **total** number of HAV or HBV cases in the population cannot be calculated without additional information. In fact, there were likely more total cases (ie, higher prevalence) of HBV as it can progress to a chronic form **(Choices B and C)**.

A simplified diagram compares incidence and prevalence to adding new drops (incident cases) into a water-containing sink (prevalent cases).

**(Choice E)** HAV incidence **per 100,000 population** was similar in 1982 and 1998. However, the overall US population, and consequently the number of new HAV cases, was different. Assuming HAV incidence was ~10 new cases/100,000 population for both years, then, in 1982 (US population ~230 million):



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, there were approximately just as many **new** HAV cases in 1987 and more new HAV cases in 1989. However, the **total** number of HAV or HBV cases in the population cannot be calculated without additional information. In fact, there were likely more total cases (ie, higher prevalence) of HBV as it can progress to a chronic form **(Choices B and C)**.

A simplified diagram compares incidence and prevalence to adding new drops (incident cases) into a water-containing sink (prevalent cases).

**(Choice E)** HAV incidence **per 100,000 population** was similar in 1982 and 1998. However, the overall US population, and consequently the number of new HAV cases, was different. Assuming HAV incidence was ~10 new cases/100,000 population for both years, then, in 1982 (US population ~230 million):

New HAV cases in 1982 = 10/100,000 × 230,000,000 = 23,000

Also, in 1998 (US population ~275 million at least):

New HAV cases in 1998 = 10/100,000 × 275,000,000 = 27,500

Even with different incidences, it is unlikely that exactly the same number of new HAV diagnoses were made.

**Educational objective:**
Incidence corresponds to the number of new cases of a disease in a certain population at risk over a given time period. Prevalence is the total number of cases in the population over a given period.

**References**

- Summary of notifiable diseases--United States, 2012.

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

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The prevalence of a chronic disease that affects mostly older individuals has been constant in a population for the last 15 years. As a result of worsening economic conditions that have no effect on the disease itself, many young healthy individuals emigrate from the population. Which of the following is the most likely effect of the emigration on the estimate of disease prevalence over the next few years?

- A. The prevalence would decrease (15%)
- ✓ B. The prevalence would increase (52%)
- C. The prevalence would remain the same (26%)
- D. It is not possible to determine the effect on prevalence from the information given (5%)

Omitted
Correct answer
B

52%
Answered correctly

02 secs
Time Spent

2023
Version

Explanation

**Prevalence** is the actual number of existing cases (old and new) of disease, either at a particular point in time (point prevalence), or during a period of time (period prevalence). These measures are calculated as follows:

Point prevalence = (existing cases in a population) / (total number of people in the population)

Period prevalence = (existing cases in a population in a period) / (total number of people in the population)

**Estimates of prevalence** of disease (ie, point or period prevalence) in a population are affected by **population dynamics**:

- The emigration of healthy individuals will increase disease prevalence estimates by decreasing the



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Period prevalence = (existing cases in a population in a period) / (total number of people in the population)

**Estimates of prevalence** of disease (ie, point or period prevalence) in a population are affected by **population dynamics**:

- The emigration of healthy individuals will increase disease prevalence estimates by decreasing the population size (denominator).
- The immigration of cases will increase disease prevalence estimates by increasing the number of existing cases (numerator).
- The emigration of cases will decrease disease prevalence estimates by decreasing the number of existing cases (numerator).
- The immigration of healthy individuals will decrease disease prevalence estimates by increasing the population size (denominator).

In this example, the prevalence of a chronic disease has been constant for the last 15 years; therefore, new cases have been balanced by cures or deaths of prevalent cases. If a large number of **healthy individuals emigrate** from the population, then the number of **cases** (numerator) would **remain the same**, but the **population size** would **decrease** (denominator). Therefore, estimates of disease **prevalence would increase**.

**Educational objective:**
Prevalence is the actual number of existing cases (old and new) of disease, either at a particular point in time (point prevalence), or during a period of time (period prevalence). Estimates of disease prevalence in a population are affected by population dynamics.

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

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A group of psychiatrists conducts a double-blind placebo-controlled randomized trial to determine the efficacy and safety of cariprazine for the treatment of depressive episodes associated with bipolar I disorder (bipolar depression) in adults. The treatment response rate was 46% for cariprazine versus 32% for placebo, and the rate for all adverse events was 7% for cariprazine versus 5% for placebo. The differences in rates were statistically significant. Which of the following is the approximate number of patients who must be exposed to cariprazine to cause harm to 1 person who otherwise would not have been harmed?

- A. 2 (9%)
- B. 8 (11%)
- C. 14 (17%)
- D. 21 (5%)
- ✓ E. 50 (56%)

Omitted
Correct answer
E

56%
Answered correctly

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Time Spent

2023
Version

## Explanation

The number of people who must be exposed to a treatment to cause harm to 1 person who otherwise would not have been harmed is known as the **number needed to harm (NNH)**. It is calculated in a manner similar to the number needed to treat (NNT) but using the **absolute risk increase (ARI)** instead of the absolute risk reduction:

**NNH** = (1 / ARI)



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s the **difference in the rate** (risk) of the **adverse event** (AE) between the treatment group (eg, cariprazine) and the control group (eg, placebo):

**ARI** = (Rate $AE_{cariprazine}$ − Rate $AE_{placebo}$)

In this study, the rate of any AE in the treatment group (ie, cariprazine) is 0.07 (ie, 7%) and in the control (ie, placebo) group is 0.05 (5%). Therefore, the ARI in adverse events of cariprazine versus placebo is:

ARI = (Rate $AE_{cariprazine}$ − Rate $AE_{placebo}$) = 0.07 − 0.05 = 0.02 (or 2%) **(Choice A)**

Consequently, the NNH is:

NNH = (1 / ARI) = 1 / 0.02 = 50

Therefore, **approximately 50 patients** would need to be treated with cariprazine to cause harm to 1 person who otherwise would not have been harmed. The lower the NNH, the more risk of harm; an NNH of 1 means that every patient treated is harmed.

**(Choices B, C, and D)** The absolute risk reduction (ARR) is the difference in risk of an unfavorable event (eg, treatment nonresponse) between the cariprazine and placebo groups: ARR = ($Rate_{placebo}$ − $Rate_{cariprazine}$). In this case, the rate of no response in the cariprazine group is 100% − 46% = 54% and in the placebo group is 100% − 32% = 68%, so ARR = 0.68 − 0.54 = 0.14 (ie, 14%). The relative risk reduction (RRR) is ($Rate_{placebo}$ − $Rate_{cariprazine}$) / $Rate_{placebo}$, so RRR = (0.68 − 0.54) / 0.68 ≈ 0.21 (ie, 21%). The number needed to treat (NNT) to avoid 1 additional negative event (ie, no treatment response) compared to placebo is the inverse of the absolute risk reduction (ARR): NNT = 1 / ARR = 1 / 0.14 ≈ 8.

**Educational objective:**
The number needed to harm (NNH) is the number of people who must be exposed to a treatment to cause harm to 1 person who otherwise would not have been harmed. To calculate NNH, the absolute risk increase (ARI) between the treatment and control groups must be known: NNH = 1 / ARI.



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A study is conducted to assess the effectiveness of a new medication X added to standard antihypertensive therapy compared to standard antihypertensive therapy alone for preventing the development of proteinuria in patients recently diagnosed with essential hypertension. Five years after diagnosis, 97 of 100 patients on the medication X + standard antihypertensive therapy regimen have not developed proteinuria, and 90 of 100 patients on a standard antihypertensive therapy regimen have not developed proteinuria. According to these results, which of the following represents the approximate number of patients with essential hypertension who need to be treated with medication X to prevent an additional patient from developing proteinuria within 5 years?

- A. 3 (6%)
- B. 7 (15%)
- C. 10 (5%)
- ✓ D. 15 (69%)
- E. 70 (3%)

Omitted
Correct answer
D

69%
Answered correctly

03 secs
Time Spent

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Explanation

| Common measures of therapeutic efficacy | | |
|---|---|---|
| **Term** | **Definition** | **Calculation** |
| | Percentage indicating the actual | |



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| 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 **number needed to treat (NNT)** is the number of patients who need to be treated with a specific drug (eg, medication X) to **prevent an additional negative event** (eg, 1 fewer patients with essential hypertension who develop proteinuria within 5 years of diagnosis) when compared with a control group (eg, standard antihypertensive therapy). NNT is the **inverse** of the **absolute risk reduction (ARR)**:

NNT = 1 / ARR

The ARR describes the difference in risk of an unfavorable event (eg, development of proteinuria within 5 years of hypertension diagnosis) between the treatment group (eg, medication X + standard antihypertensive therapy)



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$$NNT = 1 / ARR$$

The ARR describes the difference in risk of an unfavorable event (eg, development of proteinuria within 5 years of hypertension diagnosis) between the treatment group (eg, medication X + standard antihypertensive therapy) and the control group (eg, standard antihypertensive therapy):

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

In this question, 100 − 90 = 10 out of 100 patients in the control group developed proteinuria within 5 years of hypertension diagnosis, so **$Risk_{control}$ is 10/100 = 0.10**. Similarly, 100 − 97 = 3 out of 100 patients in the treatment group developed proteinuria within 5 years of hypertension diagnosis, so **$Risk_{treatment}$ is 3/100 = 0.03**. Therefore, the ARR for development of proteinuria within 5 years of hypertension diagnosis in the treatment group is:

$$ARR = (Risk_{control} - Risk_{treatment}) = (0.10 - 0.03) = 0.07$$

and the NNT is:

$$NNT = 1 / ARR = 1 / 0.07 = 14.3 \approx 15$$

NNTs are always **rounded up** to the nearest whole number, so **approximately 15 patients** need to be treated with medication X + standard therapy to prevent 1 additional case of proteinuria within 5 years of hypertension diagnosis.

**(Choices A and C)** 3 and 10 represent the number of patients in the treatment group and in the control group, respectively, who developed proteinuria within 5 years of diagnosis.

**(Choice B)** 7 represents the ARR expressed as a percentage, calculated as: $ARR = 100 \times (Risk_{control} - Risk_{treatment}) = 100(0.10 - 0.03) = 7$.

**(Choice E)** 70 represents the relative risk reduction (RRR) expressed as a percentage. The RRR describes the relative decrease in the risk of an adverse event in the treatment group compared to a control group; it is



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group developed proteinuria within 5 years of hypertension diagnosis, so **$Risk_{treatment}$ is 3/100 = 0.03**. Therefore, the ARR for development of proteinuria within 5 years of hypertension diagnosis in the treatment group is:

$$ARR = (Risk_{control} - Risk_{treatment}) = (0.10 - 0.03) = 0.07$$

and the NNT is:

$$NNT = 1 / ARR = 1 / 0.07 = 14.3 \approx 15$$

NNTs are always **rounded up** to the nearest whole number, so **approximately 15 patients** need to be treated with medication X + standard therapy to prevent 1 additional case of proteinuria within 5 years of hypertension diagnosis.

**(Choices A and C)** 3 and 10 represent the number of patients in the treatment group and in the control group, respectively, who developed proteinuria within 5 years of diagnosis.

**(Choice B)** 7 represents the ARR expressed as a percentage, calculated as: $ARR = 100 \times (Risk_{control} - Risk_{treatment}) = 100(0.10 - 0.03) = 7$.

**(Choice E)** 70 represents the relative risk reduction (RRR) expressed as a percentage. The RRR describes the relative decrease in the risk of an adverse event in the treatment group compared to a control group; it is calculated as: $RRR = 100 \times [(Risk_{control} - Risk_{treatment}) / Risk_{control}] = 100[(0.10 - 0.03) / 0.10] = 70$.

**Educational objective:**
The number needed to treat (NNT) is the number of patients who need to be treated with a specific treatment to avoid an additional negative event. NNT is the inverse of the absolute risk reduction.

| Biostatistics | Biostatistics & Epidemiology | Number Needed To Treat |
|---|---|---|
| Subject | System | Topic |

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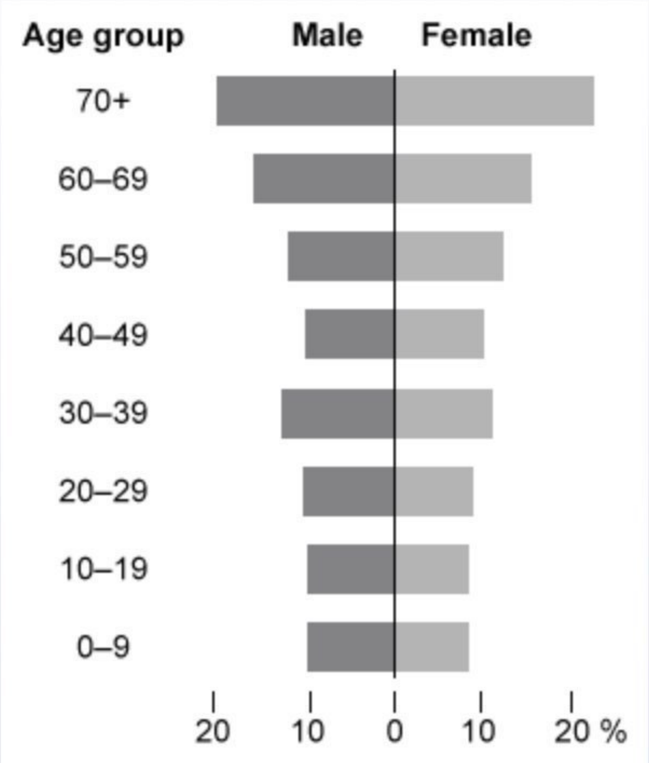
A study is conducted to describe the age-sex distribution of a certain country. According to national data, the population pyramid of the country has the shape shown below.




Based on the population pyramid, which of the following is most likely true about this country and its population?

- A. The country seems to have high birth rates; therefore, the population must be growing (0%)
- B. The country seems to have a high death rate; therefore, the population must be shrinking (1%)
- ✓ C. The country seems to have a low birth rate; therefore, the population must be old (77%)
- D. The country seems to have a short life expectancy; therefore, the population must be young (0%)
- E. The country seems to have a similar percentage of people in each age cohort; therefore, the population must be stable (19%)



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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



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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 narrow bottom, which represents a **low birth rate**, and a wide top, which represents a **low mortality rate (Choices A and B)**. The percentage of people in each age cohort **increases with age**, with the greatest proportion of people in the age 70+ cohort **(Choice E)**. This means that the population has a **long life expectancy**—a characteristic of **old populations (Choice D)**.

Because the percentage of people in the age 0-9 cohort (about 10% for both men and women) is lower than the percentage of people in the age 70+ cohort (about 20% for both men and women), the younger cohorts are not able to replace the older cohorts as they die off, leading to a reduction in the population (ie, **population shrinks**). This is a classic example of a **constrictive pyramid**.

**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).



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A state's population for 2016 was estimated at 4,000,000. At the beginning of the same year, the state reported having 20,000 cases of a rare and fatal neurodegenerative condition. At the end of 2016, the state reported 7,000 new cases, as well as 1,000 deaths attributable to this condition. Another 40,000 deaths from all other causes were also reported at the end of the year. What was the cumulative incidence of the disease in 2016?

- A. 1,000 / 4,000,000 (0%)
- B. 6,000 / 3,980,000 (2%)
- C. 6,000 / 4,000,000 (1%)
- ✓ D. 7,000 / 3,980,000 (52%)
- E. 7,000 / 4,000,000 (30%)
- F. 26,000 / 3,959,000 (12%)
- G. 41,000 / 4,000,000 (0%)

Omitted
Correct answer
D

52%
Answered correctly

03 secs
Time Spent

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Version

## Explanation

**Cumulative incidence** (CI) is calculated as the total number of **new cases** of a disease (eg, neurodegenerative condition) over a **specific period** (eg, during 2016) divided by the number of **people at risk** at the **beginning** of the period. It does not account for deaths in the period under study because the patients who died were, at some point in the intervening period, still considered part of the baseline population at risk for the disease. In this



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**Cumulative incidence** (CI) is calculated as the total number of **new cases** of a disease (eg, neurodegenerative condition) over a **specific period** (eg, during 2016) divided by the number of **people at risk** at the **beginning** of the period. It does not account for deaths in the period under study because the patients who died were, at some point in the intervening period, still considered part of the baseline population at risk for the disease. In this case, there were 3,980,000 people at risk (ie, 4,000,000 − 20,000 already with the disease) at the beginning of 2016, and 7,000 new cases of the disease occurred over the 1-year period being analyzed. Therefore, the CI is:

CI = 7,000 / (4,000,000 − 20,000) = **7,000 / 3,980,000**

Unlike incidence rate (which is typically reported as the number of cases per person-year), CI does not incorporate time into the denominator; it is simply the proportion of at-risk individuals who contract the disease over the specified period.

**(Choice A)** The disease-specific mortality (in this example: 1,000 / 4,000,000) is the number of deaths attributable to a disease per year divided by the total population.

**(Choice B)** The CI does not account for deaths in the period under study. In this case, the numerator is 7,000, not 6,000.

**(Choice C)** The rate of increase of a disease (ie, the increase in disease prevalence) is the number of new cases per year minus the number of deaths (or cures) attributable to the disease per year, divided by the total population. This yields (7,000 − 1,000) / 4,000,000.

**(Choice E)** The CI is calculated by taking into consideration the population at risk at the beginning of the period under study. In this case, the denominator must be reduced by the number of cases reported at the beginning of the year 2016 (ie, 4,000,000 − 20,000 = 3,980,000).

**(Choice F)** The prevalence of disease at the end of 2016 takes into consideration the prevalent cases at the beginning of the year, the incident cases throughout the year, and all the deaths reported by the end of the year.



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**(Choice A)** The disease-specific mortality (in this example: 1,000 / 4,000,000) is the number of deaths attributable to a disease per year divided by the total population.

**(Choice B)** The CI does not account for deaths in the period under study. In this case, the numerator is 7,000, not 6,000.

**(Choice C)** The rate of increase of a disease (ie, the increase in disease prevalence) is the number of new cases per year minus the number of deaths (or cures) attributable to the disease per year, divided by the total population. This yields (7,000 − 1,000) / 4,000,000.

**(Choice E)** The CI is calculated by taking into consideration the population at risk at the beginning of the period under study. In this case, the denominator must be reduced by the number of cases reported at the beginning of the year 2016 (ie, 4,000,000 − 20,000 = 3,980,000).

**(Choice F)** The prevalence of disease at the end of 2016 takes into consideration the prevalent cases at the beginning of the year, the incident cases throughout the year, and all the deaths reported by the end of the year. In this case, the prevalence at the closing of 2016 is: ([20,000 + 7,000] – 1,000) / (4,000,000 – [40,000 + 1,000]).

**(Choice G)** The mortality rate is the number of deaths per year divided by the total population. This yields 41,000 / 4,000,000.

**Educational objective:**
The cumulative incidence of a disease is the number of new cases of a disease over a specific period divided by the total population at risk at the beginning of the study (ie, the proportion of at-risk individuals who contract the disease over the specified period).

| Biostatistics | Biostatistics & Epidemiology | Prevalence and incidence |
|---|---|---|
| Subject | System | Topic |

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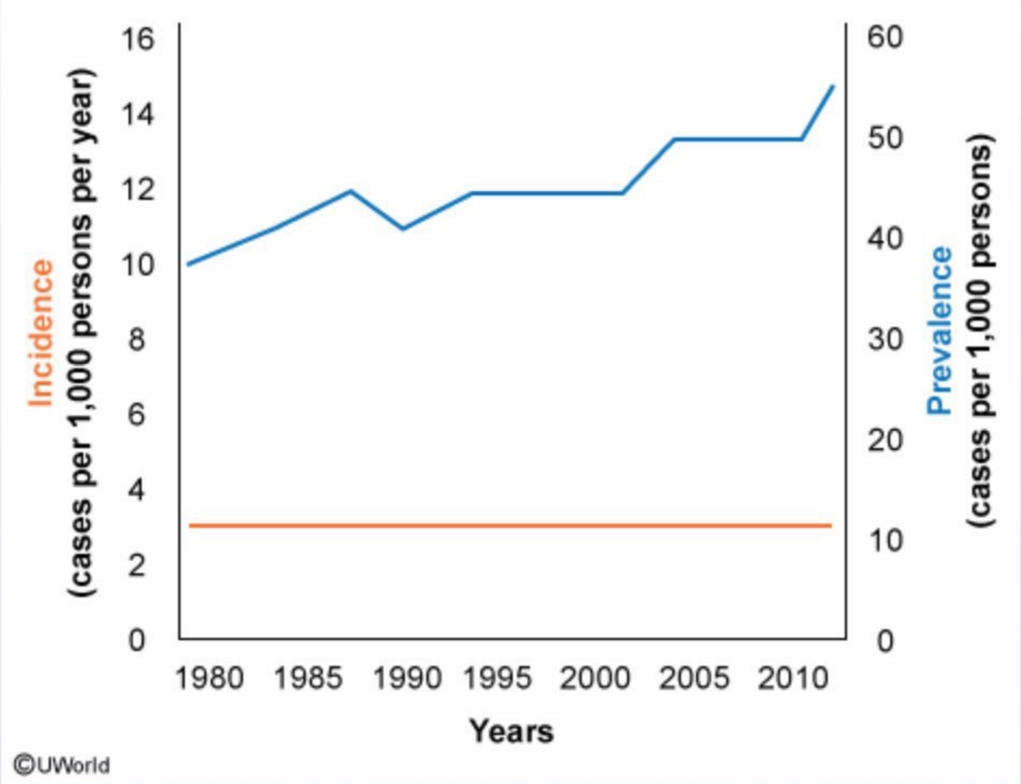
An epidemiological study is initiated to assess the impact of type II diabetes mellitus in a large population with little migration. Disease incidence and prevalence are monitored and recorded as the number of cases per 1,000 individuals over a 30-year period.




Which of the following is the most likely explanation for the change in disease prevalence seen in the graph?

- A. Decreased hospitalization rate (0%)
- B. High mortality in diabetics (1%)
- ✓ C. Improved quality of care (76%)
- D. Increased accuracy of diagnostic testing (7%)
- E. Increased exposure to risk factors (3%)



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Incidence and prevalence are important concepts for evaluating the impact of disease on a population. **Incidence** corresponds to the number of **new cases** of a disease diagnosed in a population at risk over a given period. **Prevalence** refers to the **total number of diseased individuals** in the population at a particular point; it is dependent on incidence and the average duration of the disease (ie, time from diagnosis to cure or death):

Prevalence = (Incidence) x (Duration of disease)

A simplified diagram compares incidence and prevalence to adding new drops (incident cases) to a sink collecting water (prevalent cases).

The above graph shows that the incidence of type II diabetes mellitus has been constant for the last 30 years **(Choice F)**, but that **prevalence is rising**. Because this is a steady-state population with little migration, a constant incidence rate should result in a nearly stable disease prevalence, unless there is some additional factor affecting the duration of the condition. Factors that **prolong disease duration** can increase disease prevalence even when the incidence is unchanged because diseased individuals live longer on average. In this case, **improved quality of care** likely led to a lower mortality rate in diabetics over time, resulting in a higher prevalence of the disease in the population **(Choice B)**.

**(Choice A)** A decreased hospitalization rate would indicate reduced morbidity (ie, burden of disease) among diabetic individuals. However, a decrease in hospitalization rate would not necessarily be associated with reduced mortality and increasing disease prevalence.

**(Choice D)** Increased accuracy of diagnostic testing would affect both the prevalence and incidence of a disease as it changes the rate at which new cases are detected.

**(Choice E)** Increased exposure to diabetes risk factors would likely increase both disease incidence and prevalence.

**(Choice G)** Selective survival bias occurs in case-control studies when cases are selected from the entire



Scanned with CamScanner

bove graph shows that the incidence of type II diabetes mellitus has been constant for the last 30 years **(Choice F)**, but that **prevalence is rising**. Because this is a steady-state population with little migration, a constant incidence rate should result in a nearly stable disease prevalence, unless there is some additional factor affecting the duration of the condition. Factors that **prolong disease duration** can increase disease prevalence even when the incidence is unchanged because diseased individuals live longer on average. In this case, **improved quality of care** likely led to a lower mortality rate in diabetics over time, resulting in a higher prevalence of the disease in the population **(Choice B)**.

**(Choice A)** A decreased hospitalization rate would indicate reduced morbidity (ie, burden of disease) among diabetic individuals. However, a decrease in hospitalization rate would not necessarily be associated with reduced mortality and increasing disease prevalence.

**(Choice D)** Increased accuracy of diagnostic testing would affect both the prevalence and incidence of a disease as it changes the rate at which new cases are detected.

**(Choice E)** Increased exposure to diabetes risk factors would likely increase both disease incidence and prevalence.

**(Choice G)** Selective survival bias occurs in case-control studies when cases are selected from the entire disease population instead of from just those that are newly diagnosed. For instance, a study on cancer survival that is not limited to newly diagnosed patients could contain a higher proportion of relatively benign malignancies, as these patients generally live longer.

**Educational objective:**
Prevalence equals the incidence rate multiplied by the average disease duration. Changing disease prevalence in a steady-state population with a constant incidence rate means that there is an additional factor affecting the duration of the condition. A factor that prolongs disease duration (eg, improved quality of care) will increase disease prevalence, as affected patients survive longer.



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A 28-year-old woman comes to the office to establish care. She recently moved to New York to begin a job as a copy editor at a major newspaper. She has no known medical problems. The patient is in a monogamous relationship with her husband. She usually eats fast food for lunch, and she and her husband cook in the evenings. She goes to the gym about once every 2 weeks. The patient's temperature is 36.7 C (98 F), blood pressure is 118/64 mm Hg, pulse is 60/min, and respirations are 14/min. Her BMI is 24.6 kg/m$^2$. Physical examination is unremarkable. Laboratory results are within the normal range. Counseling this patient regarding diet and exercise habits would be an example of which of the following?

- A. Case finding (0%)
- B. Cognitive-behavioral therapy (0%)
- C. Community-level intervention (1%)
- ✓ D. Health promotion (81%)
- E. Health risk assessment (5%)
- F. Precontemplative stage intervention (5%)
- G. Tertiary prevention (5%)

Omitted
Correct answer
D

81%
Answered correctly

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Explanation

Primary, secondary & tertiary prevention



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| Primary, secondary & tertiary prevention | | |
|---|---|---|
| **Level** | **Definition** | **Example(s)** |
| **Primary** | Preventing a disease process from becoming established | • Health promotion (eg, regular exercise, no smoking, weight loss) |
| **Secondary** | Detecting a disease process before it causes symptoms | • Individual case finding (eg, cervical cancer screening)<br>• Community screening (eg, blood pressure screening at state fair) |
| **Tertiary** | Treating a disease to prevent progression/complications | • Disability limitation (eg, blood sugar and blood pressure control in diabetes)<br>• Rehabilitation (eg, physical therapy after stroke) |

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According to the World Health Organization, **health promotion** is "the process of enabling people to increase control over their health and its determinants, and thereby improve their health". Examples include improving dietary habits (limiting fat intake, consuming fruits and vegetables), exercising regularly, abstaining from smoking, and losing weight if needed. Health promotion typically falls under **primary** prevention, which is preventing a disease process from getting established.

**Secondary prevention** refers to interrupting the disease process before symptoms develop. An example is case finding, which is looking for disease that may be present but **asymptomatic** in patients receiving medical care (eg, age- and gender-appropriate screening) **(Choice A)**. Community screening is an analogous



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**Secondary prevention** refers to interrupting the disease process before symptoms develop. An example is case finding, which is looking for disease that may be present but **asymptomatic** in patients receiving medical care (eg, age- and gender-appropriate screening) **(Choice A)**. Community screening is an analogous intervention at the community level (eg, measuring hypertension at a state fair). **Tertiary** prevention corresponds to treating an established condition with the goal of minimizing its progression or complications **(Choice G)**.

**(Choice B)** Cognitive-behavioral therapy is a standardized psychotherapeutic modality focusing on identifying and addressing persistent maladaptive thought patterns. It is used as monotherapy or in combination with medication to treat a variety of mental illnesses (eg, anxiety, mood, personality, somatic symptom, eating disorders).

**(Choice C)** Interventions such as imposing taxes on cigarettes or soda or mandating smoke-free establishments can be implemented at the community level to improve the health of the public.

**(Choice E)** Health risk assessments rely on questionnaires that use demographic, medical, lifestyle, and family history information to calculate a patient's "risk age". A patient whose risk age is greater than chronological age has a higher risk of death than the average individual of that chronological age.

**(Choice F)** The "stages of change" model (originally developed to help patients quit smoking) assesses an individual's readiness to change a problem behavior. The precontemplative stage is when a patient does not believe there is a problem (eg, smoking) and is unwilling to contemplate a change (eg, quitting). The subsequent stages are contemplation, preparation, action, and maintenance.

**Educational objective:**
Health promotion, according to the World Health Organization, is "the process of enabling people to increase control over their health and its determinants, and thereby improve their health."

Biostatistics Biostatistics & Epidemiology Prevention levels



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