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# AP<sup>®</sup> Statistics

## Sample Student Responses and Scoring Commentary

### **Inside:**

#### **Free Response Question 2**

- Scoring Guideline**
- Student Samples**
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**Question 2: Focus on Collecting Data****4 points****General Scoring Notes**

- Each part of the question (indicated by a letter) is initially scored by determining if it meets the criteria for essentially correct (E), partially correct (P), or incorrect (I). The response is then categorized based on the scores assigned to each letter part and awarded an integer score between 0 and 4 (see the table at the end of the question).
- The model solution represents an ideal response to each part of the question, and the scoring criteria identify the specific components of the model solution that are used to determine the score.

Model Solution	Scoring
<p>(a) Keeping daily journals could introduce response bias due to the self-reporting by subjects who may have a poor or incomplete memory of the amount of walking that was done. If most subjects who keep daily journals underreport the number of miles walked per day because they cannot remember all of their walking at the end of the day, then the estimate of mean daily miles walked for the target population will be biased too low. Wearing activity trackers would likely provide a more accurate record of daily miles walked by each subject in the study.</p>	<p><b>Essentially correct (E)</b> if the response satisfies the following two components:</p> <ol style="list-style-type: none"> <li>1. Indicates that keeping a daily journal could result in a bias that would be avoided by using activity trackers AND provides a reasonable explanation</li> <li>2. Provides a description of a bias that refers to at least one of the following: <ul style="list-style-type: none"> <li>• The use of a daily journal may result in a systematic/consistent underreporting, or systematic/consistent overreporting of daily miles walked</li> <li>• The use of a daily journal may result in a biased estimation (underestimation or overestimation) of a population parameter (e.g., mean daily miles walked for the members of the target population)</li> </ul> </li> </ol> <p><b>Partially correct (P)</b> if the response satisfies only one of the two components.</p> <p><b>Incorrect (I)</b> if the response does not meet the criteria for E or P.</p>

**Additional Notes:**

- A response does not need to specifically name a type of bias (e.g., response bias).
- The response may refer to the explanatory variable as “activity level.”
- The direction of the bias need not be specified in order to satisfy component 1.
- Examples of reasonable explanations for indicating that keeping a daily journal may result in a bias include:
  - “Because the subjects are self-reporting their daily miles walked.”
  - “Because the subjects may not accurately recall their daily miles walked.”
  - “Because the subjects may forget to complete an entry in their journal.”
- The direction of the bias must be specified in order to satisfy component 2.

- The response must indicate the underreporting or overreporting is systematic across the subjects (or there is a tendency to underreport or overreport) in order to satisfy component 2. Examples of responses that satisfy component 2 include:
    - “The subjects in the study may consistently underreport their daily miles walked.”
    - “Subjects are likely to underreport their daily miles walked.”
    - “Most subjects may overreport their daily miles walked.”
    - “The bias may result in an estimate of the mean daily miles walked by members of the target population that is lower than the target population mean.”
  - A response that indicates the underreporting or overreporting for only some people does not satisfy component 2 (e.g., “Some people might record higher miles than they actually walk.”).
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Model Solution	Scoring
<p>(b) It is necessary to have a representative sample of subjects from the population in order to make an unbiased inference about the difference between the mean cholesterol levels for all adult members of the target population who walk fewer miles per day and the mean cholesterol levels for all adult members of the target population who walk more miles per day.</p>	<p><b>Essentially correct (E)</b> if the response satisfies the following two components:</p> <ol style="list-style-type: none"> <li>1. Provides an explanation that the use of a representative sample is necessary in order to make a valid generalization about the target population</li> <li>2. Refers to estimation, or inference, for cholesterol levels in the target population OR an association between cholesterol level and amount of walking in the target population</li> </ol> <p><b>Partially correct (P)</b> if the response satisfies only one of the two components.</p> <p><b>Incorrect (I)</b> if the response does not meet the criteria for E or P.</p>

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**Additional Notes:**

- A response that discusses the accuracy or validity of a significance test does not satisfy component 1 unless the response makes it clear that the inference is being generalized to the target population.
  - In order to satisfy component 2, the response need not state a specific population parameter(s).
  - If a parameter is specified, it must be relevant to cholesterol level or the association between cholesterol level and amount of walking. Some examples include:
    - Individual population mean cholesterol level
    - One or more differences between population mean cholesterol levels
    - Individual population median cholesterol level
    - One or more differences between population median cholesterol levels
    - A population correlation between cholesterol level and amount of walking
    - A population regression model for cholesterol level and amount of walking
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Model Solution	Scoring
<p>(c) No, since the treatments (amounts of walking) were not randomly assigned to the subjects in the study, it would not be valid to claim that increased walking causes a decrease in average cholesterol levels for adults in the target population. The researchers would only be able to conclude that cholesterol level has a negative association with daily miles walked for adults in the target population. There may be one or more confounding variables that are the actual cause of the relationship. For example, people who walk more may be more concerned about maintaining a healthy diet and eat more foods that are low in cholesterol, while people who walk less may eat more foods that are high in cholesterol. Consequently, the association between cholesterol and daily miles walked could actually be caused by differences in diets and not differences in amount of walking.</p>	<p><b>Essentially correct (E)</b> if the response satisfies the following two components:</p> <ol style="list-style-type: none"> <li>1. Indicates that a causal inference cannot be made</li> <li>2. Provides a valid explanation that is based on one of the following: <ul style="list-style-type: none"> <li>• the lack of (random) assignment of treatments to subjects</li> <li>• being an observational study/not an experiment</li> <li>• the existence of a possible confounding variable that is associated with amount of walking and associated with cholesterol level</li> </ul> </li> </ol> <p><b>Partially correct (P)</b> if the response satisfies only component 1 AND provides a weak explanation.</p> <p><b>Incorrect (I)</b> if the response does not meet the criteria for E or P.</p>

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**Additional Notes:**

- A response that provides an explanation that is based on the existence of a possible confounding variable may or may not identify a specific confounding variable. In either case, the response must indicate that the confounding variable has an association with amount of walking AND also indicate that the confounding variable has an association with cholesterol level in order to satisfy component 2. Examples of responses that satisfy component 2:
    - A response that identifies a reasonable confounding variable: “Diet could be a confounding variable. People who walk more may tend to eat more foods that are low in cholesterol, while people who walk less may tend to eat more foods high in cholesterol.”
    - A response that does not identify a confounding variable: “There could be a confounding variable that has an association with cholesterol level and also has an association with amount of walking.”
  - If a response identifies a specific confounding variable, then any variable that is reasonable (e.g., diet, weight, body mass index, etc.) should be accepted in scoring component 2.
  - In component 2, the following are examples of weak explanations:
    - The response indicates the existence of a confounding variable but does not indicate that the confounding variable has an association with amount of walking AND an association with cholesterol level.
    - The response communicates that an association between cholesterol level and amount of walking does not imply that there is a causal relationship between cholesterol level and amount of walking. However, a general statement, without context, that association does not imply causation should be scored incorrect (I).
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- A response that only references specific elements of an experiment (e.g., placebo, control group, replication) aside from assignment of treatments to subjects should be scored incorrect (I).
  - A response that states that a causal relationship can be concluded due to the statistically significant result and goes on to say that there may be a confounding variable that is associated with amount of walking and cholesterol level (e.g., diet) should be read as parallel solutions and scored incorrect (I).
  - Responses in parts (a) or (b) cannot be carried down to part (c) to satisfy component 2 unless the response in part (c) refers to specific statements in part (a) or (b).
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<b>Scoring for Question 2</b>	<b>Score</b>
<b>Complete Response</b> Three parts essentially correct	<b>4</b>
<b>Substantial Response</b> Two parts essentially correct and one part partially correct	<b>3</b>
<b>Developing Response</b> Two parts essentially correct and no part partially correct <i>OR</i> One part essentially correct and one or two parts partially correct <i>OR</i> Three parts partially correct	<b>2</b>
<b>Minimal Response</b> One part essentially correct and no part partially correct <i>OR</i> No part essentially correct and two parts partially correct	<b>1</b>

Begin your response to **QUESTION 2** on this page.

2. Researchers will conduct a year-long investigation of walking and cholesterol levels in adults. They will select a random sample of 100 adults from the target population to participate as subjects in the study.
- (a) One aspect of the study is to record the number of miles each subject walks per day. The researchers are deciding whether to have subjects wear an activity tracker to record the data or to have subjects keep a daily journal of the miles they walk each day. Describe what bias could be introduced by keeping the daily journal instead of wearing the activity tracker.

Using a journal to track mileage is likely to underestimate true miles walked each day because the adults will likely not record the small distances they walked each day, like walking from the kitchen to the couch.



Continue your response to **QUESTION 2** on this page.

During the course of the study, the subjects will have their cholesterol levels measured each month by a doctor. The researchers will perform a significance test at the end of the study to determine whether the average cholesterol level for subjects who walk fewer miles each day is greater than for those who walk more miles each day.

- (b) Selecting a random sample creates a reasonable representative sample of the target population. Explain the benefit of using a representative sample from the population.

Using a representative sample makes it easier to collect data within the study, and that data can be used to make an accurate conclusion about the relationship between walking miles and cholesterol levels in the target population.

- (c) Suppose the researchers conduct the test and find a statistically significant result. Would it be valid to claim that increased walking causes a decrease in average cholesterol levels for adults in the target population? Explain your reasoning.

No. Because this was an observational study and not an experiment, we cannot determine causation between miles walked and cholesterol levels.

Begin your response to **QUESTION 2** on this page.

2. Researchers will conduct a year-long investigation of walking and cholesterol levels in adults. They will select a random sample of 100 adults from the target population to participate as subjects in the study.
- (a) One aspect of the study is to record the number of miles each subject walks per day. The researchers are deciding whether to have subjects wear an activity tracker to record the data or to have subjects keep a daily journal of the miles they walk each day. Describe what bias could be introduced by keeping the daily journal instead of wearing the activity tracker.

Response bias could be introduced by keeping the daily journal instead of wearing the activity tracker.

Subjects in this study may be more inclined to lie and record a larger number of miles walked each day than what was actually true. This bias could be avoided using the activity tracker because the tracker could record the honest number of miles walked.

Continue your response to **QUESTION 2** on this page.

During the course of the study, the subjects will have their cholesterol levels measured each month by a doctor. The researchers will perform a significance test at the end of the study to determine whether the average cholesterol level for subjects who walk fewer miles each day is greater than for those who walk more miles each day.

- (b) Selecting a random sample creates a reasonable representative sample of the target population. Explain the benefit of using a representative sample from the population.

The benefit of using a representative sample from the population is to avoid confounding variables. For instance, in a sample, some subjects may have pre-existing health conditions that increase their cholesterol levels & skew the data results. By using a random sample, subjects with all varying levels of cholesterol can be represented & the researchers will be able to obtain more accurate data.

- (c) Suppose the researchers conduct the test and find a statistically significant result. Would it be valid to claim that increased walking causes a decrease in average cholesterol levels for adults in the target population? Explain your reasoning.

No, because cause and effect cannot be established in an observational study such as this one. The subjects in the study were not randomly assigned to treatments so it is not valid to claim that increased walking causes a decrease in average cholesterol levels.

Begin your response to **QUESTION 2** on this page.

2. Researchers will conduct a year-long investigation of walking and cholesterol levels in adults. They will select a random sample of 100 adults from the target population to participate as subjects in the study.
- (a) One aspect of the study is to record the number of miles each subject walks per day. The researchers are deciding whether to have subjects wear an activity tracker to record the data or to have subjects keep a daily journal of the miles they walk each day. Describe what bias could be introduced by keeping the daily journal instead of wearing the activity tracker.

Wearing an activity tracker gives the miles walked to a specific decimal—it does not round or "guesstimate." A fitness tracker gives an accurate representation of how many miles a subject walked in a given day. The daily journal—on the other hand—is not as accurate. By allowing a subject to log how many miles they walked per day, they introduce bias into the study by giving nonrepresentative amounts and responses. A subject that logs their miles may round, guess how many miles they walked, and/or lie about their fitness. These factors add bias into a sample and make it unrepresentative of the true results.

Continue your response to **QUESTION 2** on this page.

During the course of the study, the subjects will have their cholesterol levels measured each month by a doctor. The researchers will perform a significance test at the end of the study to determine whether the average cholesterol level for subjects who walk fewer miles each day is greater than for those who walk more miles each day.

- (b) Selecting a random sample creates a reasonable representative sample of the target population. Explain the benefit of using a representative sample from the population.

Using a representative sample from the population allows one to relate the results to the entire population. Using randomization and representativeness eliminates lingering bias and possible confounding variables. By doing this, the data and information reported in the sample can be related to the whole population.

- (c) Suppose the researchers conduct the test and find a statistically significant result. Would it be valid to claim that increased walking causes a decrease in average cholesterol levels for adults in the target population? Explain your reasoning. hypothesis

NO, because a significance test does not imply causation. Using a significance test one can assess relation and significance, but not <sup>OF</sup> causation. For these reasons, one cannot claim that increasing walking causes decreased average cholesterol. hypothesis

## Question 2

**Note:** Student samples are quoted verbatim and may contain spelling and grammatical errors.

### Overview

The primary goals of this question were to assess a student’s ability to (1) describe bias that could be introduced by allowing subjects to self-report results instead of recording results by fitting each subject with a monitor; (2) explain the statistical benefit of using random sampling to obtain a representative sample of subjects from a target population; and (3) provide an explanation of whether a statistically significant outcome from a particular type of study may be used to justify a conclusion about a cause and effect relationship.

This question primarily assesses skills in skill category 1: Selecting Statistical Methods. Skills required for responding to this question include (1.C) Describe an appropriate method for gathering and representing data, and (4.A) make an appropriate claim or draw an appropriate conclusion.

This question covers content from Unit 3: Collecting Data of the course framework in the AP Statistics Course and Exam Description. Refer to topics 3.2, and 3.4, and learning objectives DAT-2.E, and DAT-2.B.

### Sample: 2A

#### Score: 4

The response earned the following: part (a) – E; part (b) – E; part (c) – E.

In part (a) the response states that “adults will likely not record the small distances,” which indicates a bias and a reasonable explanation, satisfying component 1. The response also states, “Using a journal to track mileage is likely to underestimate true miles walked each day,” which refers to a biased estimation of a population parameter, including direction, satisfying component 2. Part (a) was scored essentially correct (E).

In part (b) the response states that “... and that data can be used to make an accurate conclusion about the relationship between walking miles and cholesterol levels in the target population.” This statement indicates results can be generalized to the target population, satisfying component 1, and refers to an association between cholesterol level and amount of walking in the target population, satisfying component 2. Part (b) was scored essentially correct (E).

In part (c) the response correctly states that a causal inference cannot be made, satisfying component 1. The response provides a valid explanation that this answer is based on the study being an observational study, satisfying component 2. The response gives a second valid explanation based on not being an experiment; however, only one valid explanation is required to satisfy component 2. Part (c) was scored essentially correct (E).

### Sample: 2B

#### Score: 2

The response earned the following: part (a) – E; part (b) – I; part (c) – E.

In part (a) the response identifies a bias (“response bias”) and provides a reasonable explanation (“subjects ... may... lie”). Thus the response satisfies component 1. The response further states, “Subjects in the study may be more inclined to lie and record a larger number of miles walked each day than what was actually true.” The statement “more inclined” establishes a consistent over-reporting or under-reporting of miles walked. The statement “larger number of miles walked” establishes a direction of the bias. Thus the response satisfies component 2. Part (a) was scored essentially correct (E).

## Question 2 (continued)

In part (b) the response states that “all varying levels of cholesterol can be represented.” However, this is simply a restatement of the fact that we have a representative sample. This is not sufficient to satisfy component 1. The response does not indicate a generalization of results can be made to the target population. Thus the response does not satisfy either of the two components. Part (b) was scored incorrect (I).

In part (c), the response states, “No,” with justification based on the study being an observational study and based on lack of random assignment, either of which is sufficient to satisfy component 2. Part (c) was scored essentially correct (E).

### **Sample: 2C**

#### **Score: 1**

The response earned the following: part (a) – P; part (b) – P; part (c) – I.

In part (a) the response identifies several biases that may result each with a reasonable explanation, satisfying component 1. The response does not satisfy component 2. Part (a) was scored partially correct (P).

In part (b) the response states that one can “relate the results to the entire population.” This is sufficient to indicate results can be generalized to the population, satisfying component 1. The response does not satisfy component 2. Part (b) was scored partially correct (P).

In part (c) the response satisfies component 1. The statement, “a significance test does not imply causation,” is not sufficient for a weak explanation because it does not refer to an association between cholesterol level and amount of walking. Furthermore, the last sentence of the response does not provide an explanation as to why a causal inference is not valid; it simply restates a causal inference can’t be made. The reasons the response alludes to are not valid explanations. Part (c) was scored incorrect (I).