

2004 AP® STATISTICS FREE-RESPONSE QUESTIONS

2. Researchers who are studying a new shampoo formula plan to compare the condition of hair for people who use the new formula with the condition of hair for people who use the current formula. Twelve volunteers are available to participate in this study. Information on these volunteers (numbered 1 through 12) is shown in the table below.

Volunteer	Gender	Age
1	Male	21
2	Female	20
3	Male	47
4	Female	60
5	Female	62
6	Male	61
7	Male	58
8	Female	44
9	Male	44
10	Female	24
11	Male	23
12	Female	46

- (a) These researchers want to conduct an experiment involving the two formulas (new and current) of shampoo. They believe that the condition of hair changes with age but not gender. Because researchers want the size of the blocks in an experiment to be equal to the number of treatments, they will use blocks of size 2 in their experiment. Identify the volunteers (by number) that would be included in each of the six blocks and give the criteria you used to form the blocks.
- (b) Other researchers believe that hair condition differs with both age and gender. These researchers will also use blocks of size 2 in their experiment. Identify the volunteers (by number) that would be included in each of the six blocks and give the criteria you used to form the blocks.
- (c) The researchers in part (b) decide to select three of the six blocks to receive the new formula and to give the other three blocks the current formula. Is this an appropriate way to assign treatments? If so, describe a method for selecting the three blocks to receive the new formula. If not, describe an appropriate method for assigning treatments.

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3. At an archaeological site that was an ancient swamp, the bones from 20 brontosaur skeletons have been unearthed. The bones do not show any sign of disease or malformation. It is thought that these animals wandered into a deep area of the swamp and became trapped in the swamp bottom. The 20 left femur bones (thigh bones) were located and 4 of these left femurs are to be randomly selected without replacement for DNA testing to determine gender.
- Let X be the number out of the 4 selected left femurs that are from males. Based on how these bones were sampled, explain why the probability distribution of X is not binomial.
 - Suppose that the group of 20 brontosaurs whose remains were found in the swamp had been made up of 10 males and 10 females. What is the probability that all 4 in the sample to be tested are male?
 - The DNA testing revealed that all 4 femurs tested were from males. Based on this result and your answer from part (b), do you think that males and females were equally represented in the group of 20 brontosaurs stuck in the swamp? Explain.
 - Is it reasonable to generalize your conclusion in part (c) pertaining to the group of 20 brontosaurs to the population of all brontosaurs? Explain why or why not.

4. Two antibiotics are available as treatment for a common ear infection in children.

- Antibiotic A is known to effectively cure the infection 60 percent of the time. Treatment with antibiotic A costs \$50.
- Antibiotic B is known to effectively cure the infection 90 percent of the time. Treatment with antibiotic B costs \$80.

The antibiotics work independently of one another. Both antibiotics can be safely administered to children. A health insurance company intends to recommend one of the following two plans of treatment for children with this ear infection.

- Plan I: Treat with antibiotic A first. If it is not effective, then treat with antibiotic B.
 - Plan II: Treat with antibiotic B first. If it is not effective, then treat with antibiotic A.
- If a doctor treats a child with an ear infection using plan I, what is the probability that the child will be cured?
If a doctor treats a child with an ear infection using plan II, what is the probability that the child will be cured?
 - Compute the expected cost per child when plan I is used for treatment.
Compute the expected cost per child when plan II is used for treatment.
 - Based on the results in parts (a) and (b), which plan would you recommend?
Explain your recommendation.

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Question 2

Solution

Part (a):

Block	Volunteers	Ages
1	1, 2	20, 21
2	10, 11	23, 24
3	8, 9	44, 44
4	3, 12	46, 47
5	4, 7	58, 60
6	5, 6	61, 62

Since these researchers believe that the condition of hair changes with age but not gender, the volunteers are sorted from youngest to oldest. The volunteers in the sorted list are paired to form six blocks of size two. More specifically, the youngest two volunteers are placed in the first block. The next two volunteers in the sorted list are placed in the second block. This pairing continues until all six blocks of two are formed, with the oldest two volunteers in the sixth block.

Part (b):

Block	Volunteers	Ages
Female 1	2, 10	20, 24
Female 2	8, 12	44, 46
Female 3	4, 5	60, 62
Male 1	1, 11	21, 23
Male 2	3, 9	47, 44
Male 3	6, 7	61, 58

Since these researchers believe that the condition of hair changes with both age and gender, the women are sorted from youngest to oldest and then the men are sorted from youngest to oldest. The women (men) in the sorted list are paired to form the blocks of size two. More specifically, the youngest two women (men) are placed in a block. The next two youngest women (men) are placed in another block. Finally, the oldest two women (men) are placed in another block.

Part (c):

No, the researchers in part (b) should not randomly select three blocks to receive the new formula and then give the current formula to the other three blocks. They blocked on both age and gender to form homogeneous groups because they believe hair condition differs with both age and gender. Giving the youngest or oldest women (men) the same formula defeats the purpose of blocking. In a block design, randomization should be carried out separately within each block. That is, for each block, two random numbers are generated (via a random number generator or a table of random digits) and assigned to the two volunteers. The volunteer with the smallest random number is given the new formula and the other volunteer is given the current formula.

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Question 2 (cont'd.)

Scoring

Each part is scored as essentially correct, partially correct, or incorrect.

Parts (a) and (b) are each scored as essentially correct if

1. the six blocks are correctly identified by volunteer number or age AND
2. the correct criterion for assigning volunteers to blocks is clearly stated.

Parts (a) and (b) are scored as partially correct if either component 1 or 2 above is correct.

Notes: 1. If at most two volunteers are misplaced, but it is clear that the student is blocking correctly, component 1 can be considered to be correct.
2. Simply saying “block by age” or “block by age and gender” is not sufficient to get credit for component 2. A student must indicate that the volunteers in each block are similar with respect to age in part (a) or age and gender in part (b). However, if the student has correct blocks but only says to “block by age” in part (a) and “block by age and gender” in part (b), this should only be penalized once.
3. In part (a), if a student blocks correctly by age, each block happens to contain one male and one female. If the student says or implies that this is an important part of the blocking criterion, then component 2 is incorrect. If they simply comment or notice this fact but do not imply or say that it is part of the criterion, component 2 could be correct.

Part (c) is essentially correct if the student recognizes that this is not an appropriate way to assign treatments AND describes an appropriate method for assigning treatments within each block, including a method of randomization that can be implemented by the reader.

Note: Simply saying “use a random number table” or “flip a coin” is not sufficient to get credit for the method of randomization

Part (c) is partially correct if the student recognizes that this is not an appropriate way to assign treatments AND either

1. assigns treatments randomly within blocks but lacks a method of randomization, OR
2. assigns treatments within each block with no mention of randomization, OR
3. gives a correct reason why the assignment is not appropriate.

Part (c) is incorrect if

1. the student says that this is an appropriate way to assign treatments, OR
2. “NO” is the only response, OR
3. “NO” is the response, but the reason is wrong or absent AND either
 - i) no indication is given about assigning treatments within blocks OR
 - ii) an alternative design is proposed (e.g., crossover, completely randomized).

Note: If in part (b) the student makes heterogeneous blocks (i.e., blocks contain one male and one female of disparate ages), then saying “YES” with an appropriate method of randomization is essentially correct for part (c). In the same situation, if the student says to assign treatments to the blocks with no randomization method, this is scored partially correct for part (c).