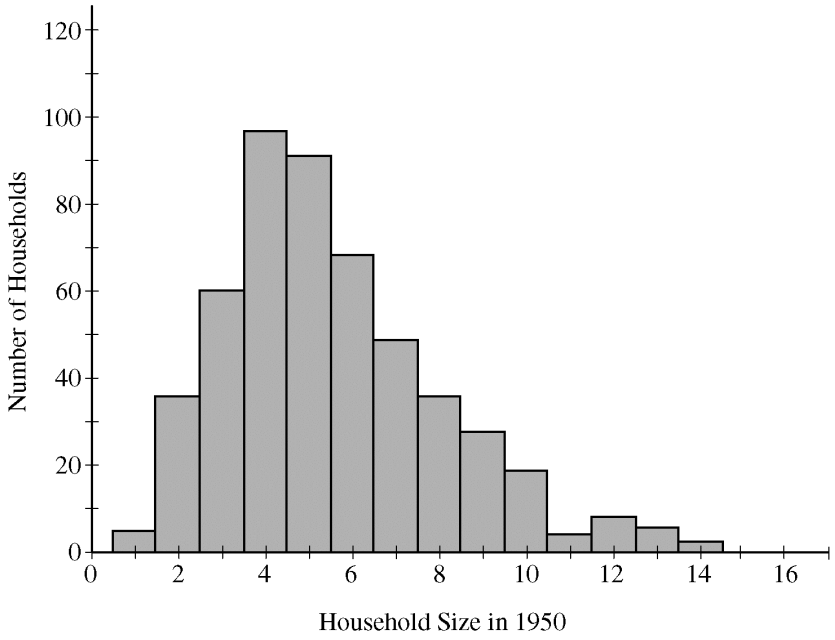
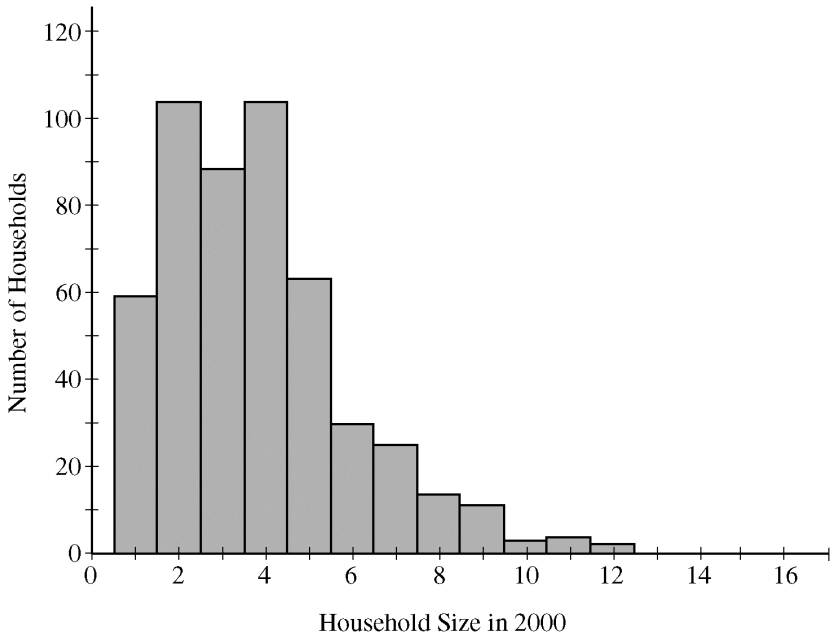
3. Independent random samples of 500 households were taken from a large metropolitan area in the United States for the years 1950 and 2000. Histograms of household size (number of people in a household) for the years are shown below.





(a) Compare the distributions of household size in the metropolitan area for the years 1950 and 2000.

(b) A researcher wants to use these data to construct a confidence interval to estimate the change in mean household size in the metropolitan area from the year 1950 to the year 2000. State the conditions for using a two-sample *t*-procedure, and explain whether the conditions for inference are met.

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4. A survey organization conducted telephone interviews in December 2008 in which 1,009 randomly selected adults in the United States responded to the following question.

At the present time, do you think television commercials are an effective way to promote a new product?

Of the 1,009 adults surveyed, 676 responded "yes." In December 2007, 622 of 1,020 randomly selected adults in the United States had responded "yes" to the same question. Do the data provide convincing evidence that the proportion of adults in the United States who would respond "yes" to the question changed from December 2007 to December 2008 ?

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Question 3

Intent of Question

The primary goals of this question were to assess students' ability to (1) compare two distributions presented with histograms; (2) comment on the appropriateness of using a two-sample *t*-procedure in a given setting.

Solution

Part (a):

Household size tended to be larger in 1950 than in 2000. The histograms reveal a much larger proportion of small (1-, 2-, and 3-person) households in 2000 than in 1950. Similarly, the histograms reveal a much smaller proportion of large (5-person and larger) households in 2000 than in 1950. Also, the median household sizes can be calculated to be 5 people per household in 1950 compared with 3 or 4 people per household in 2000. The year 1950 displayed slightly more variability in household sizes than the year 2000. Although the interquartile ranges for both years are the same (3 people), the standard deviation (1950: about 2.6 people; 2000: about 2.1 people) and the range (1950: 13 people; 2000: 11 people) are larger for 1950 than for 2000. Both distributions of household size are skewed to the right. In both years, there are a few households with very large families, as large as 14 people in 1950 and 12 people in 2000.

Part (b):

The conditions for applying a two-sample *t*-procedure are:

1. The data come from independent random samples or from random assignment to two groups;
2. The populations are normally distributed, or both sample sizes are large;
3. The population sizes are at least 10 (or 20) times the sample sizes.

The first condition is satisfied because independent random samples were selected for the years 1950 and 2000. The second condition is satisfied because the sample sizes (500 in each group) are quite large, despite the right skewness of the distributions of household sizes in the sample data. The third condition is satisfied because the number of households in the large metropolitan area in both 1950 and 2000 would easily exceed $10 \times 500 = 5{,}000$.

Scoring

This question is scored in four sections. Part (a) has three components: (1) comparing the centers of the two distributions; (2) comparing variability for the two distributions; (3) identifying the shapes of both distributions and including context related to the variable of interest. Section 1 consists of part (a), component 1; section 2 consists of part (a), component 2; section 3 consists of part (a), component 3. Section 4 consists of part (b). Sections 1 and 2 are scored as essentially correct (E) or incorrect (I). Sections 3 and 4 are scored as essentially correct (E), partially correct (P), or incorrect (I).

Section 1 is scored as follows:

Essentially correct (E) if the response correctly compares center (or location) for both distributions.

Incorrect (I) otherwise.

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Question 3 (continued)

Section 2 is scored as follows:

Essentially correct (E) if the response correctly compares variability for both distributions.

Incorrect (I) otherwise.

Section 3 is scored as follows:

Essentially correct (E) if the response includes context related to the variable of interest (household size) *AND* the response correctly identifies the shapes of both distributions.

Partially correct (P) if the response correctly identifies the shapes of both distributions *BUT* does *NOT* include context related to the variable of interest (household size),
OR
if the response correctly identifies the shape of only one distribution *AND* includes context related to the variable of interest (household size).

Incorrect (I) otherwise.

Section 4 is scored as follows:

Essentially correct (E) if the response correctly states and checks the following two conditions.
1. The data come from independent random samples
2. Normality/sample size conditions.

Partially correct (P) if the response correctly states and checks only one of the two conditions listed above,
OR
if the response correctly refers to random samples and large sample size, *BUT* does *NOT* state and check either condition correctly.

Incorrect (I) otherwise.

Note: The population size condition does not need to be checked to earn E or P.

Each essentially correct (E) section counts as 1 point. Each partially correct (P) section counts as ½ point.

4 **Complete Response**

3 **Substantial Response**

2 **Developing Response**

1 **Minimal Response**

If a response is between two scores (for example, 2½ points), use a holistic approach to decide whether to score up or down, depending on the overall strength of the response and communication.

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