CHILD RESISTANT PACKAGING

RELEVANT JMP PLATFORMS AND STATISTICAL TECHNIQUES

Graph Builder :   Mosaic Plot, Scatterplot

Distribution :   Summary Statistics, Confidence Intervals for Population Proportion

Fit Y by X :   Linear Regression

Fit Model :   Logistic Regression

PROBLEM STATEMENT

There are many products found in a household such as prescription drugs, cleaning solutions, and pestides that pose a serious danger to children if ingested. The Food & Drug Administration (FDA), Consumer Product Safety Commission (CPSC), and other regulatory agencies establish standards that packaging must meet in order to be certified as Child-Resistant Packaging (CRP). One requirement for a package to be considered CRP is that at least 85% of a panel of 200 children tested between the ages of 42-51 months of age would be unable to open it after 5 minutes, and at least 80% would be unable to open after the process of doing so is demonstrated to the child and they are given another 5 minutes to open.

A manufacturer of these type of packaging is experimenting with four different designs for caps that could be sold to pharmaceutical companies to be used in various products.

To test the performance of these four different packaging designs, a test was conducted with a panel of 200 children between 42 to 51 months in age. For each age, 10 boys and 10 girls were selected for the test. Each child tested all 4 packages with 2 days in between testing of each package. The order of testing was chosen at random. The child is given the package and simply instructed to open it to access the contents inside. After 5 minutes, the administrator of the test demonstrates to the child the process of opening the package without any verbal descriptioon. The child is then given another 5 minutes to open the package, after which the testing stops.

The focus of the analysis will be to evaluate and compare how effective these 4 different packaging designs are at preventing opening by a child.

DATA SET

Child Resistant Packaging.jmp

Child ID	Identification of test subject
Age	Age (months)
Gender	Gender of test subject (Boy, Girl)
Design	Package design (A, B, C, D)
Testing Order	Order in which package designs were tested
Demonstration	Trial before/after opening of the package was demonstrated to the subject
Open	Success or failure of subject being able to open package within 5 minutes
Time to Open	Time (mm:ss) for subject to open package

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EXCERCISES

1. Create a mosaic plot displaying the percentage of children who are able/unable to open up the 4 different package designs with and without demonstration. Provide a few short sentences summarizing the results. How do these results compare to the requirements for CRP?

   > *Instructions: Use Graph Builder. Place the variable 'Open' on the Y axis. Place 'Design' and 'Demonstration' on the X axis, with 'Demonstration' within 'Design'. Select the Mosaic Plot from the Graph Palette.* *Choose to 'Label by Percent'.*

2. Create a Bar Chart and Frequency Table of the percentage of the open rate by each design and demonstration. Note: These display the same information as the Mosaic Plot. The Distribution Platform will allow other statistical analyses to be done.

   > *Instructions: Use Distribution. Place 'Open' as the Y role. Place both 'Design' and 'Demonstration' as the By Variable.*

3. The analyses done in 1 and 2 summarized the results of the test. They do not, however, provide an estimate of a population of children who would be unable to open the packages incorporating statistical uncertainty. To do so, create 99% confidence interval estimates for the proportion of children able and unable to open the package. Provide an interpretation of these intervals. Based upon these results, which package designs achieve the results of >85% unable to open prior to demonstration and >80% after demonstration making inference to a population a children not just those tested?

   > *Instructions: Under the red triangle next to each bar chart in the Distribution report, select Confidence Interval > 0.99.*

4. Create a Heat Map displaying the results of each child tested. Provide a few short sentences summarizing what the visualization shows.

   > *Instructions: Use Graph Builder. Place the variable 'Child ID' on the X axis. Place 'Design' and 'Demonstration' on the Y axis. Place the variable 'Open' in the Color Role. Select the Heat Map from the Graph Palette.*

5. Fit the following set of logistic regression models:
   a) 'Open' vs 'Age' for those able to open package B before demonstration
   b) 'Open' vs 'Age' for those able to open package B after demonstration
   c) 'Open' vs 'Age' for those able to open package C before demonstration
   d) 'Open' vs 'Age' for those able to open package C after demonstration

   Provide an interpretation of these logistic regression equations. Which of these equations do you feel least confident in using the results to generalize beyond the children used in the study? Why?

Instructions: Use the Fit Model platform. Place 'Open' in the Y role and 'Age' in the X. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Now a select design and demonstration stage can be chosen and the model and report will update using only those data.

6. Estimate the probability that a child 4 ½ years old would be able to open package B without a demonstration and package C without a demonstration.

    Instructions: Add the Profiler to the report by selecting 'Profiler' under the top red triangle. Enter the value 54 for the Age. Note: Be sure to choose the specific Design and Demonstration stage in the Data Filter before interpreting the results.

7. Determine if there is any statistical evidence indicating that girls are more or less likely to be able to open the packages than boys.

    Instructions: Use the Fit Model platform. Place 'Open' in the Y role. Select 'Age' and 'Gender' from the column list, and choose Macros > Degree 2 from Construct Model Effects section. Note: This will fit a model that includes the main effects of 'Age' and 'Gender' as well as the 'Age*Gener' interaction. This equation if for all the package designs and demonstration stages. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Now a select design and demonstration stage can be chosen and the report will update using only those data. For each 'Design' and 'Demonstration' stage, examine the p-values tesing the significant of the 'Age*Gener' interaction term as well as the 'Gender' main effect.

8. Create a scatterplot showing the relationship between 'Time to Open' and 'Age' for those children able to open thep packages. Provide a few sentences summarizing these results.

    Instructions: Use Graph Builder. Place the 'Time to Open' on the Y axis and 'Age' on the X axis. Place 'Demonstration' in the Overlay role and 'Design' in the Color role.

9. Fit the following set of linear regression models:
    a) 'Time to Open' vs 'Age' for those able to open package B before demonstration
    b) 'Time to Open' vs 'Age' for those able to open package B after demonstration
    c) 'Time to Open' vs 'Age' for those able to open package C before demonstration
    d) 'Time to Open' vs 'Age' for those able to open package C after demonstration

    Provide an interpretation of these linear regression equations. Which of these equations to you feel least confident in using the results to generalize beyond the children used in the study?

    Instructions: Use the Fit Y by X platform. Place 'Time to Open' in the Y role and 'Age' in the X. From the red triangle at the top of the report, choose 'Fit Line'. Note: This equation if for all the packages that have been opened. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Now a select design and demonstration stage can be

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chosen and the model and report will update using only those data.

10. For both package B and C, estimate the 'Time to Open' for children 4 ½ years of age who are able to open the package within 5 minutes without a demonstration. Why should you not use this equation to make predictions of 'Time to Open' for 4 ½ year old children in general?

> *Instructions: Add the Profiler to the report by selecting 'Profiler' under the top red triangle. Enter the value 54 for the Age. Note: Be sure to choose the specific Design and Demonstration stage in the Data Filter before interpreting the results.*

11. Determine if there is statistical evidence indicating that for those children that are able to open the package within 5 minutes, one gender does so faster than the other. Why do these conclusions not necessary extend to children in the 41-52 age range in general?

> *Instructions: Use the Fit Model platform. Place 'Time to Open' in the Y role. Select 'Age' and 'Gender' from the column list, and choose Macros > Degree 2 from Construct Model Effects section. Note: This will fit a model that includes the main effects of 'Age' and 'Gender' as well as the 'Age*Gener' interaction. This equation if for all the package designs and demonstration stages. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Now a select design and demonstration stage can be chosen and the report will update using only those data. For each 'Design' and 'Demonstration' stage, examine the p-values tesing the significant of the 'Age*Gener' interaction term as well as the 'Gender' main effect.*

12. Create a mosaic plot displaying the percentage of children who are able/unable to open up the packages by 'Testing Order'. Is there any evidence to indicate that the likelihood of a child being able to open a package increases if it occurs later in the testing?

> *Instructions: You'll first need to create a new variable for 'Testing Order' that is Ordinal. Do so by choosing Cols > New Cols. Copy and Paste the 'Testing Order' column into the new column created. Right-click on the column and choose Column Info. Change the Modeling Type to Ordinal. Name this new column 'Testing Order_Ordinal'. Use Graph Builder. Place the variable 'Open' on the Y axis. Place 'Testing Order_Ordinal' on the X axis. Select the Mosaic Plot from the Graph Palette.*
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> *Note: The initial graph is for all the packages and stages of demonstration. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Select all the different design and demonstration stages and examine the proportions of open/unopen.*

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13. Create a scatterplot displaying the 'Time to Open' vs. 'Testing Order'. Is there any evidence to indicate that the 'Time to Open' decreases if it occurs later in the testing?

> *Instructions:* Use Graph Builder. Place the 'Time to Open' on the Y axis and 'Testing Order' on the X axis. Place 'Demonstration' in the Overlay role and 'Design' in the Color role. Note: This initial graph is for all the packages and stages of demonstration. To examine subsets of the data, choose 'Local Data Filter' under the red triangle and choose to use the variables 'Design' and 'Demonstration'. Select all the different design and demonstration stages and examine the 'Time to Open' across the 'Testing Order'.

14. What are some ideas for further testing that would help better understand the level of child resistance of these package designs?