Recap:
- With a randomized, comparative experiment have the potential to draw a cause-and-effect conclusion between the explanatory and response variable.
  o Experiment: active imposition/control of explanatory variable
  o Comparative: use at least 2 groups to compare; guards against other changes over time
  o Random assignment: Willing to believe all other variables have been “balanced out” among the explanatory variable groups
  o Observational studies on the other hand always have the potential for confounding variables and you should be very cautious of drawing cause-and-effect conclusions.
- Want to compare groups on a categorical variable
  o May want to designate one variable as the explanatory variable and the other as the response variable
  o Organizing data: two-way table
  o Statistic: difference in conditional proportions (“of the home games with a sell out crowd...” vs. “of the home games that did not have a sell out crowd”)
  o Graphical summary: segmented bar graphs

Example 1: For many years, if a person experienced a heart attack and a bystander called 911, the dispatcher instructed the bystander in how to administer chest compression plus mouth-to-mouth ventilation (a combination known as CPR) until the emergency team arrived. Some researchers believe that giving instruction in chest compression alone (CC) would be a more effective approach. In the 1990s, a randomized study was conducted in Seattle involving 518 cases (Hallstrom, Cobb, Johnson, & Copass, *New England Journal of Medicine*, 2000).

In 278 cases, the dispatcher gave instructions in standard CPR to the bystander, and in the remaining 240 cases the dispatcher gave instructions in CC alone. A total of 64 patients survived to discharge from the hospital: 29 in the CPR group and 35 in the CC group.

(a) Create a two-way table to summarize these data, using the explanatory variable as the columns:

<table>
<thead>
<tr>
<th>Survived to discharge</th>
<th>CPR</th>
<th>CC alone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Calculate the difference in conditional proportions for these data (our statistic). What do you learn?

(c) State null and alternative hypotheses for this research question (in symbols and in words).
(d) To carry out a simulation analysis to replicate the random assignment under the null hypothesis of no treatment effect,
   - We can use _____ index cards, _____ green and _____ blue.
   - Shuffle the cards and deal __________ to represent _______________
   - After each shuffle calculate __________________________________________________________________

(e) If I repeat this process many, many times, where do you expect the null distribution for the difference in sample proportions to be centered? Why?

(f) How will I estimate a p-value from this null distribution?

(g) After I run the simulation in the Two Proportions applet, sketch the resulting null distribution for the difference in sample proportions (shape, center, spread), and shade the region corresponding to the p-value.

(h) Write a one-sentence interpretation of this p-value.

(i) What do you conclude from this p-value?

(j) Is it reasonable to conclude that use of CC alone causes more people (a higher probability) to survive to discharge than CPR? Explain.

(k) To what population are you willing to generalize these results?
(l) Suggest a method for approximating a confidence interval for the difference in the probability surviving to discharge between these two treatments.

Example 2: For several years in the 1990s, Kristen Gilbert worked as a nurse in the intensive care unit (ICU) of the Veteran’s Administration hospital in Northampton, Massachusetts. Over the course of her time there, other nurses came to suspect that she was killing patients by injecting them with the heart stimulant epinephrine. Gilbert was eventually arrested and charged with these murders. Part of the evidence presented against Gilbert at her murder trial was a statistical analysis of 1641 eight-hour shifts during the time Gilbert worked in the ICU. For each of these shifts, researchers recorded two variables: whether or not Gilbert worked on the shift, and whether or not at least one patient died during the shift.

<table>
<thead>
<tr>
<th></th>
<th>Gilbert</th>
<th>No Gilbert</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one death</td>
<td>40</td>
<td>34</td>
<td>74</td>
</tr>
<tr>
<td>No deaths</td>
<td>217</td>
<td>1350</td>
<td>1567</td>
</tr>
<tr>
<td>Total</td>
<td>257</td>
<td>1384</td>
<td>1641</td>
</tr>
</tbody>
</table>

(a) Identify the observational units in this study. (Hint: The observational units are not people. Think about what the sample size is.)

(b) Which variable are you considering the explanatory variable?

(c) Calculate the statistic.
(d) The graph below simulates randomly assigning the 1641 shifts to be with or without Gilbert. Based on the following output, will you reject or fail to reject the null hypothesis?

![Histogram of shuffled shifts](image)

Total Shuffles = 10000

Mean = 0.000
SD = 0.014

(e) Is this convincing evidence that Gilbert caused the higher probability of death of her shifts? Explain (as if her lawyer!).

(f) Have these two distributions reminded you of anything? Do you think this will always be true?

(g) Suggest another way of measuring how extreme the observed statistic is in the null distribution.