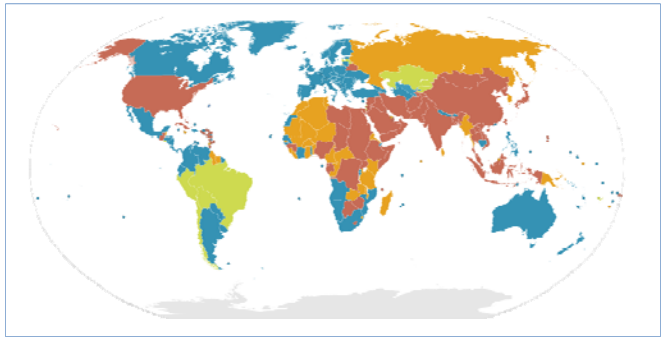


- **Blue**: Abolished for all crimes
- **Green**: Abolished for crimes not committed in exceptional circumstances (such as crimes committed in time of war)
- **Orange**: Abolished in practice
- **Red**: Legal form of punishment for certain offences

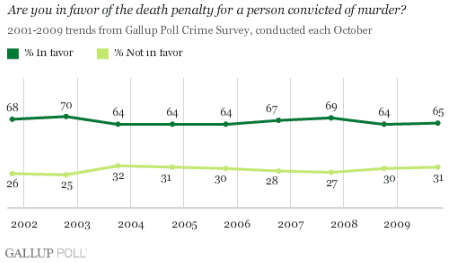
Chapter 20 – Testing Hypotheses About Proportions

Preview Example: Bias in Jury Selection

- Example from **The Cartoon Guide to Statistics** by Gonick and Smith
- Claim ~ Propose a Model
  - Jurors were selected from the population
  - 50% of eligible citizens were African American
  - P = .5
- Evidence
  - On an 80 person panel of potential jurors, only 4 were African Americans
- Question: Was this pure chance?
  - P(4 or less) = 1.4×10^{-18} = 1 in quintillion
  - Probability is less than drawing 3 consecutive royal flushes

Gallup Poll: Death Penalty

- http://www.gallup.com/poll/123638/In-U.S.-Two-Thirds-Continue-Support-Death-Penalty.aspx



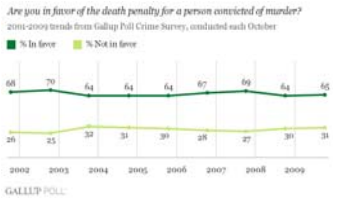
- Question of Interest: Are Americans today more against the death penalty than they were in 2001?
  - Results are based on telephone interviews with 1,013 national adults, aged 18 and older, conducted Oct. 1-4, 2009.

Step 1: Hypotheses

- The **null hypothesis**, H_0, specifies a population model parameter of interest (p in Chapter 20) and proposes a value for that parameter.
  - Form: H_0: *parameter* = *hypothesized value*
  - The null hypothesis indicates status quo.
- The **alternative hypothesis**, H_A, is the change we're trying to investigate.
  - In this chapter, we focus on p, so the forms of the alternative are
    $H_A: p \neq p_0$ $H_A: p > p_0$ $H_A: p < p_0$
- The research hypothesis usually follows something to the effect of "test the claim…"
- Now is also a good time to name the test you will perform: *one proportion z-test*

Example: Death Penalty

- Question of Interest: Are Americans today more against the death penalty than they were in 2001?
- Find the hypotheses and name the test.



Example: Death Penalty

- Of 1013 national adults in 2009, 31% are against the death penalty. In 2001, 26% of national adults were against the death penalty.
- Check that we can use the sampling distribution model and fit the model.

Step 2: The Model

- We are examining a claim about p (using $\hat{p}$ as evidence), so we want to look at the sampling distribution model for $\hat{p}$.

a) Check that we can use the model
   - Independence (randomization, 10% condition) and Success/Failure condition (np, nq ≥ 10)
   - If you the conditions aren't met, add a disclaimer and continue.

b) Create the model. Note: We ASSUME we know p…
   a) Mean =
   b) SD =
   c) Make a sketch of the sampling model

Step 3: Mechanics

a) Gather sample information.
   - Write down the statistics: sample size, observed number of successes, sample proportion

b) On the sampling model you drew, mark the observed statistic and shade the appropriate tail(s)

c) Use Minitab to
   - Calculate the test statistic
     - The **test statistic** is a standardized value of the sample proportion under the assumption of H_0.
   - Calculate the p-value
     - The **p-value** is the probability that we would observe a $\hat{p}$ at least as extreme as the one we did, under the assumption of the null hypothesis.

Example: Death Penalty

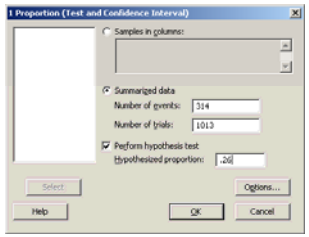
- Question of Interest: Are Americans today more against the death penalty than they were in 2001?
- Of 1013 national adults in 2009, 31% are against the death penalty. In 2001, 26% of national adults were against the death penalty.

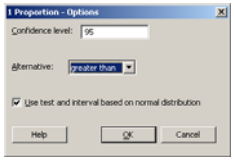
a) Write down the statistics
   - Sample size =
   - Observed Number of Successes =
   - Sample Proportion =

b) On the model we drew, mark the sample proportion. Shade the appropriate tail(s).

Using Minitab: Test Statistic, P-value

- Minitab > Stat > Basic > 1P
  - Number of Events = x
    - Number of Successes
  - Number of Trials = n
  - CHECK "Perform hypothesis…"
  - Hypothesized Proportion = p_0
  - Options
    - Confidence: Doesn't matter
    - Alternative: Sign from H_A
    - CHECK "Use … normal"





- Question of Interest: Are Americans today more against the death penalty than they were in 2001? Of 1013 national adults in 2009, 31% are against the death penalty. In 2001, 26% of national adults were against the death penalty.

Just Checking…

Test and CI for One Proportion

```
Test of p = 0.26 vs p > 0.26

                                  95% Lower
Sample    X     N  Sample p       Bound  Z-Value  P-Value
1       314  1013  0.309970    0.286069     3.63    0.000

Using the normal approximation.
```

DOUBLE CHECK DATA ENTRY

TEST STATISTIC

P-VALUE

More on Test Statistic and P-Value…

- The **test statistic** is a standardized value of the sample proportion under the assumption of H_0.
  - Our test statistic is `3.63`. What does that mean?

- The **p-value** is the probability that we would observe a $\hat{p}$ at least as extreme as the one we did, under the assumption of the null hypothesis..
  - Our p-value is `0.000`. What does that mean in this context?

Step 4: Conclusions

a) Examine the p-value

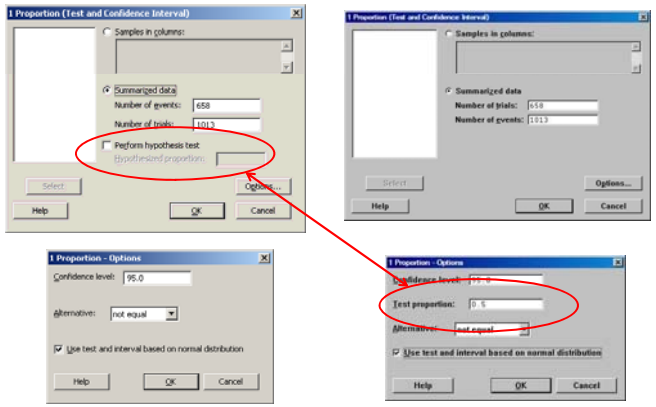
b) Decide fate of null hypothesis (Statistical Conclusion)
- If p-value is small, **reject H_0**
- If p-value is large, **fail to reject H_0**
- How "small" is small? It varies, but 5% is a good rule of thumb for "statistical significance".

c) Interpret the decision in the context of the problem (Experimental Conclusion)
- Possible phrasing: "Evidence does/does not support the claim that…"

Example: Death Penalty

- Question of Interest: Are Americans today more against the death penalty than they were in 2001?
- Of 1013 national adults in 2009, 31% are against the death penalty. In 2001, 26% of national adults were against the death penalty.
- Our test statistic is `3.63`. Our p-value is `0.000`.
- Determine the statistical conclusion:
- Determine the experimental conclusion:

Minitab 15 vs Minitab 14



Recap: The Steps in a Hypothesis Test

1. Hypotheses
   - Form null/alternative hypotheses
   - Name the test
2. Model
   - Check assumptions
   - Specify model, including mean/SD
   - Draw model
3. Mechanics
   - Summarize sample information; label sample value on diagram (and shade)
   - Find the test statistic and p-value
4. Conclusions
   - Analyze the p-value
   - Statistical conclusion – statistical results
   - Experimental conclusion – conclusion in layman's terms

Another Example

- Of 1013 national adults in 2009, 65% are in favor of the death penalty. The year before, 64% of national adults were in favor of the death penalty. Has the proportion of American adults in favor of the death penalty changed from a year ago?
- Hypotheses
- Model
- Find the test statistic, p-value, and form conclusions…

Just Checking…

Test and CI for One Proportion

Test of p = 0.64 vs p not = 0.64

Sample	X	N	Sample p	95% CI	Z-Value	P-Value
1	658	1013	0.649556	(0.620175, 0.678936)	0.63	0.526

Using the normal approximation.

- Conclusions?

Example: Changing Alternative

- Of 1013 national adults in 2009, 65% are in favor of the death penalty. The year before, 64% of national adults were in favor of the death penalty. Are Americans more in favor of the death penalty now than they were a year ago?
- New Hypotheses
- What will change?
  - Find the model?
  - The test statistic?
  - The p-value?
  - Conclusions?

Just Checking…

Test and CI for One Proportion

Test of p = 0.64 vs p > 0.64

Sample	X	N	Sample p	95% Lower Bound	Z-Value	P-Value
1	658	1013	0.649556	0.624899	0.63	0.263

Using the normal approximation.

Only One Alternative Left…

- Of 1013 national adults in 2009, 65% are in favor of the death penalty. The year before, 64% of national adults were in favor of the death penalty. Are less Americans in favor of the death penalty now than they were a year ago?
- New Hypotheses
- What changes? Stop the problem before you start! Why?

Class Work

- To get credit, it is your responsibility to get checked off.
  1. Chapter 20 Handout
     - Checking solutions? No pens in the front!

Homework

- Textbook/Routine Homework
  – Due Next Week (25% chance of collection)
  1. Read Chapter 20
  2. Pg 527-530: #1, 3, 5, 7, 9, 11, 13, 15, 17, 23