#### **Case Studies**

- collecting data: reproducibility, consensus, and random sampling
- presenting data: entire data set versus numerical or visual snapshots of it
- expected value: weighted probabilities for decisions
- mean and median: central tendencies
- box plots: comparisons
- regressions: correlations
- confidence intervals: uncertainty in even the best polls



all can be subject to bias and distortion, and are definitely subject to probability and random variations

# Gallup Polls



Americans' Concerns About Water Pollution, 1999-2017

SOCIAL & POLICY ISSUES MARCH 31, 2017

#### In U.S., Water Pollution Worries Highest Since 2001

#### BY JUSTIN MCCARTHY

AMERICANS WORRIED A GREAT DEAL ABOUT POLLUTION OF DRINKING WATER

63%

GALLUP, MAR 1-5

#### SURVEY METHODS

Results for this Gallup poll are based on telephone interviews conducted March 1-5, 2017, with a random sample of 1,018 adults, aged 18 and older, living in all 50 U.S. states and the District of Columbia. For results based on the total sample of national adults, the margin of sampling error is  $\pm 4$  percentage points at the 95% confidence level. All reported margins of sampling error include computed design effects for weighting.

Each sample of national adults includes a minimum quota of 70% cellphone respondents and 30% landline respondents, with additional minimum quotas by time zone within region. Landline and cellular telephone numbers are selected using random-digit-dial methods.

## Gallup Polls

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# Statistically Accurate Claim?



not higher than upper boundaries, or even center of intervals

1. On April 4, 2017, Gallup published poll results on its web site under the headline, "Affordable Care Act Gains Majority Approval for First Time."

If this was a simple random sample of the 1023 adults in 2017, what would the conservative 95% confidence interval margin of error be?

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- a) approximately 5%
- b) approximately .03%
- c) approximately 3.13%
- d) other

1. On April 4, 2017, Gallup published poll results on its web site under the headline, "Affordable Care Act Gains Majority Approval for First Time."

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- d) other

Gallup used 4% and gives a 95% confident margin of error of plus or minus 3% for the 2012 poll, which had 48% of the sample "approved." So the lower and upper boundaries for the confidence interval are 48% - 3% = 45% to 51% = 48% + 3% =

2.

2012: 45% to 51% interval for the 95% confidence level 2017:

- First, compute the lower and upper boundaries for 2017 which had 55% of the sample "approved" and a margin of error plus or minus 4% for the 95% confidence level
- Second, was it likely a majority (> 50%) in 2017?
- Third, could it have been a majority earlier—in 2012?

Is the headline "Affordable Care Act Gains Majority Approval for First Time" statistically accurate?

- a) yes, it was likely a majority, and also a majority for the first time
- b) no, the headline isn't statistically accurate when we take the full confidence interval into consideration

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3. Assume little to no bias and truly a random sample. If a polling company conducted 100 such polls with a 95% confidence interval, then about how many of them are likely to include the true population percentage?

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- <mark>a)</mark> 95
- <mark>b)</mark> 5
- c) other

3. Assume little to no bias and truly a random sample. If a polling company conducted 100 such polls with a 95% confidence interval, then about how many of them are likely to include the true population percentage?

- <mark>a)</mark> 95
- b) 5
- c) other



4. Is there any way to know which intervals from the 100 polls contain the true percentage and which ones don't? NO

5. Gallup specifically targeted both landline and cellphone users in its polls. Are there any voices that are left out?

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a) yes

b) no

5. Gallup specifically targeted both landline and cellphone users in its polls. Are there any voices that are left out?

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a) yes

b) no

What percentage of US population has a phone? How many US adults do not use the internet? 5. Gallup specifically targeted both landline and cellphone users in its polls. Are there any voices that are left out?

a) yes

b) no

What percentage of US population has a phone? How many US adults do not use the internet?

6. How should we interpret the margin of error if the sample is very biased?

- a) It is still valid as is
- b) Garbage in garbage out, so the margin of error would not represent the entire population, although it could still be useful to interpret whatever biased sample it did represent.

7. For a simple random sample at the 95% confidence level, what sample size would be required to achieve a plus or minus 1% margin of error, using the conservative estimate?

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- a) 1
- b) 100
- **c)** 1000
- d) 10000
- e) other

7. For a simple random sample at the 95% confidence level, what sample size would be required to achieve a plus or minus 1% margin of error, using the conservative estimate?

- a) 1
- b) 100
- **c)** 1000
- d) 10000
- e) other

8. In which of the following examples will the margin of error be the smallest? Assume each refers to a random sample that is not biased for a 95% confidence interval.

- a) a sample of n = 400 from a population of 50,000
- b) a sample of n = 1000 from a population of 10 million
- c) a sample of n = 2500 from a population of 200 million
- d) other

7. For a simple random sample at the 95% confidence level, what sample size would be required to achieve a plus or minus 1% margin of error, using the conservative estimate?

- a) 1
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- **c)** 1000
- d) 10000
- e) other

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- a) a sample of n = 400 from a population of 50,000
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- d) other

Chicken Soup

9. What was the main point of Fisher's experiment on the Lady Tasting Tea from the homework readings?

- a) sample size and random representative selection is what is important—not the percentage of the overall population
- b) we can't assume that unusual data is incorrect
- c) statistical significance can be obtained by deciding in advance the level of confidence we accept as persuasive and to collect data to make reasoned inferences

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#### THE LADY TASTING TEA

How Statistics Revolutionized Science in the Twentieth century

DAVID SALSBURG

Front cover for The Lady Tasting Tea by David Salsburg

# Readings: Deciding Personal & Public Policy



Image Credit: Linda Cai http://cdn1.theodysseyonline.com/files/2015/07/20/

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6357302788007031102045264443_price-of-life-by-linda-cai.png
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- What are the strongest arguments for each side? What makes the most sense from a probability argument?
- Should we vaccinate each citizen?
  Price to save a life: Cost per injection × number of shots to save just one life from the entire population
- If we had to choose between them, should we spend money to make airlines safer or cars safer?

### Decision Matrix for Medical Testing

Combines probability with public policy

	Test +	Test -
Person is +		
Person is -		
Total		

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# Decision Matrix for Medical Testing

#### Combines probability with public policy

	Test +	Test -
Person is +		
Person is -		
Total		

	Test +	Test -
Person is +	true positive people	false negative people
Person is -	false positive people	true negative people
Total	total who test +	total who test -

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01

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Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000

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	Test +	Test -
Person is HIV+		

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV-: 1 - .003 = .997

	Test +	Test -
Person is HIV+	34000000  imes .003	

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	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV-: 1 - .003 = .997

	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	34000000 × .003

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	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	$34000000 \times .003 \times .05$
	969000	51000
Person is HIV-		

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV+: 1 - .003 = .997

	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	$34000000 \times .003 \times .05$
	969000	51000
Person is HIV-	340000000 × .997	

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV-: 1 - .003 = .997

	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	$34000000 \times .003 \times .05$
	969000	51000
Person is HIV-	$34000000 \times .997 \times .01$	

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	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	34000000  imes .003  imes .05
	969000	51000
Person is HIV-	$34000000 \times .997 \times .01$	34000000 × .997

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV+: 1 - .003 = .997

	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	$34000000 \times .003 \times .05$
	969000	51000
Person is HIV-	$34000000 \times .997 \times .01$	$34000000 \times .997 \times .99$
	3389800	335590200
Total		

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV+: 1 - .003 = .997

	Test +	Test -
Person is HIV+	$34000000 \times .003 \times .95$	34000000  imes .003  imes .05
	969000	51000
Person is HIV-	$34000000 \times .997 \times .01$	34000000  imes .997  imes .99
	3389800	335590200
Total	4358800	

Sensitivity: probability the test correctly identifies someone who is HIV+ as positive = 95% = .95False Negative: The probability is 1 - .95 = .05Specificity: probability correctly identifies HIV- = 99% = .99False Positive: The probability is 1 - .99 = .01US:  $\approx 340,000,000$  https://www.census.gov/popclock/ probability of HIV+: 3/1000 = .003probability of HIV-: 1 - .003 = .997

	Test +	Test -
Person is HIV+	34000000  imes .003  imes .95	34000000  imes .003  imes .05
	969000	51000
Person is HIV-	$34000000 \times .997 \times .01$	$34000000 \times .997 \times .99$
	3389800	335590200
Total	4358800	335641200
f you test positive your chance of having HIV: 969000/4358800		

 $\sim 22\%$ 

## Connections to Geometry Segment



Russell Knightley. http://www.rkm.com.au/VIRUS/HIV

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10. You chose one to complete: amazing stats or internet askew or worst graph. Share as below:

If you selected amazing stats:

- a) What is the question you asked?
- b) What is the sample and the sample size?
- c) What is the dubious conclusion?
- d) How could one reduce bias in this instance?

If you selected internet askew:

- a) What is the title or topic and provide the source
- b) Summarize the graph
- c) Is there distortion or bias? Explain.
- d) How could one reduce bias in this instance?

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If you selected worst graph:

- a) Summarize the graph
- b) What makes it the worst graph?
- c) What would improve the graph

#### https://news.gallup.com/home.aspx Select a Gallup poll which also has a Survey Methods section that includes a margin of sampling error %

SURVEY METHODS

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The results of this Wells Fargo/Gallup Investor and Retirement Optimism Index survey are based on a Gallup Panel web study completed by 1,059 U.S. investors, aged 18 and older, Aug. 13-20, 2018. The Gallup Panel is a probability-based longitudinal panel of U.S. adults. Gallup recruits panelists using random-digit-dial phone interviews that cover landlines and cellphones, as well as using address-based sampling methods. The Gallup Panel is not an opt-in panel.

The sample for this study was weighted to be demographically representative of the U.S. adult population, using the most recent Current Population Survey figures. For results based on this sample, the margin of sampling error is ±5 percentage points at the 95% confidence level. Margins of error are higher for subsamples. In addition to sampling error, question wording and practical difficulties in conducting surveys can introduce error or bias into the findings of public opinion polls.

Not all Gallup articles have this—articles that are tagged in Green with Report, Gallup Vault, Polling Matters, Gallup Blog, Gallup Podcast and more do not typically. Many articles that are tagged in Green with topic headers like Economy, Education, Politics, Social & Policy Issues, Well Being, and World are more likely to. May need to look around some....