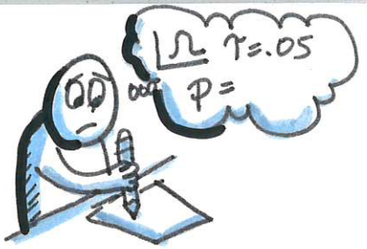
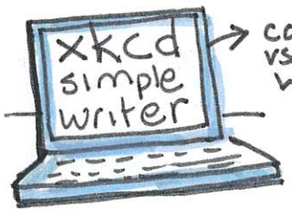
# WHY WRITING about STATISTICS IS SO HARD - AND HOW TO DO IT ANYWAY

Regina Nuzzo




WASHINGTON STATISTICAL SOCIETY Meetup




→ common vs uncommon WORDS

## WHY?

- ABSTRACT
- WORLD'S INFORMATION (vs. people's lives)
- Uncertainty (vs. truth, progress)
- PROCESS

HARD FOR OUR BRAINS!

We need **HUMAN-CENTERED QUANT. COMMUNICATION**

### ABSTRACTIONS
- Data collection, models
- analysis algorithms

### CERTAINTY
- UNCERTAINTY in KNOWLEDGE & FUTURE
- CONFIDENCE, POSSIBILITIES

### NUMBERS
- Magnitudes
- Relationships
- Summaries

### context
- Weave together
- update knowledge
- making decisions
- predicting outcomes

} What are we doing?

Ex:

MAMMOGRAMS

21% ↓ Relative! REDUCTION UNETHICAL? NATURAL FREQ vs ✓

4.3 screened & 5.5 not screened per 1000 over 13 years

Absolute Risk 0.51% → 0.42%

5 → 4 / 1,000

52 → 41 / 10,000

PICTOGRAPH → Ideal Denominator is 250

STUDY

Risk of dying ↓ 25%

How many will die (fewer) if 1,000 screened?

30% said 250 ✗

~1 is correct ✓

IMMUNOTHERAPY & LUNG CANCER

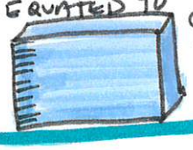
# WHO DIED IN A YEAR ⇒ vs LIVED

FIVE MOS. AVG. LIFE VS. EIGHT MONTHS & 3 WEEKS

**PEOPLE MORE LIKELY TO ACT ON THE NEGATIVE — PREVENTING DEATH VS. LIVING**

HURRICANE HARVEY

33 Trillion gallons of water EQUATED TO



CUBE OVER HOUSTON

→ 1 foot over all of ARIZONA

AVG FOR YEAR

OVER DC TO HEIGHT OF EMPIRE STATE BUILDING


LIFE of EARTH

"IN A SINGLE STROKE W/A MEDIUM GRAINED MAIL FILE, YOU COULD ERADICATE HUMAN HISTORY"

EBOLA VACCINE

"100% PROTECTION"

Really: confidence interval 68%-100%

→ add "in trial"

PEOPLE TRUST MESSAGE MORE IF UNCERTAINTY EXPLAINED

PROVIDE OPEN QUESTIONS

People want to know WHY something is uncertain & if that might change.

- "KNOWN KNOWNS"
- "KNOWN UNKNOWNS"
- "UNKNOWN UNKNOWNS"

CARYN GINSBERG
prioityventures.com
@ PRIORITYV

APRIL 20, 2018

# Why writing about statistics is so hard – and how to do it anyway

Regina Nuzzo, Ph.D.
Freelance Science Writer
Professor, Gallaudet University

Washington Statistical Society
April 20, 2018

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@ReginaNuzzo


# Simple Writer

*Write Like Up Goer Five and Thing Explainer*

(Explained using only the ten hundred words people use the most often)

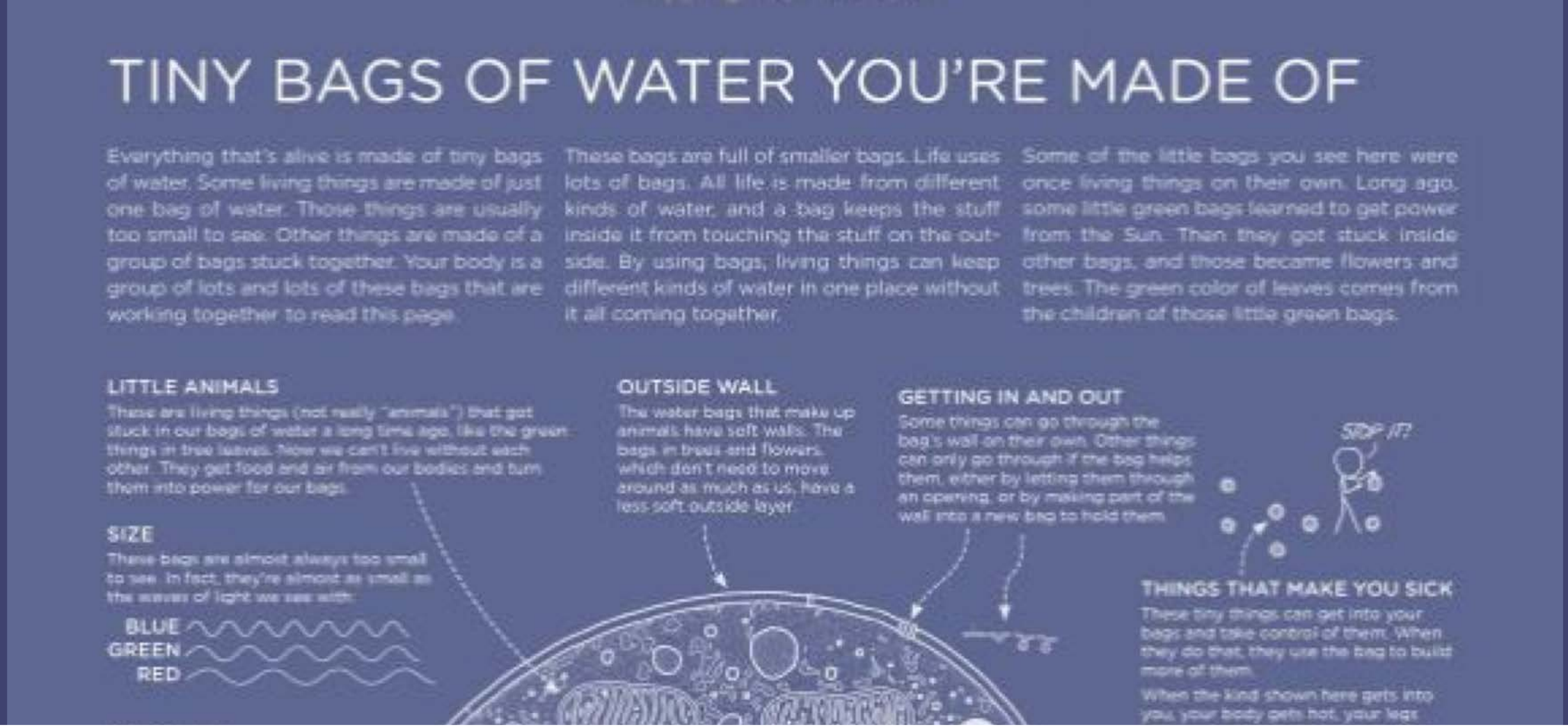
## Put Words Here

Cells consist of cytoplasm enclosed within a membrane, which contains many biomolecules such as proteins and nucleic acids.

## You Used Some Less Simple Words

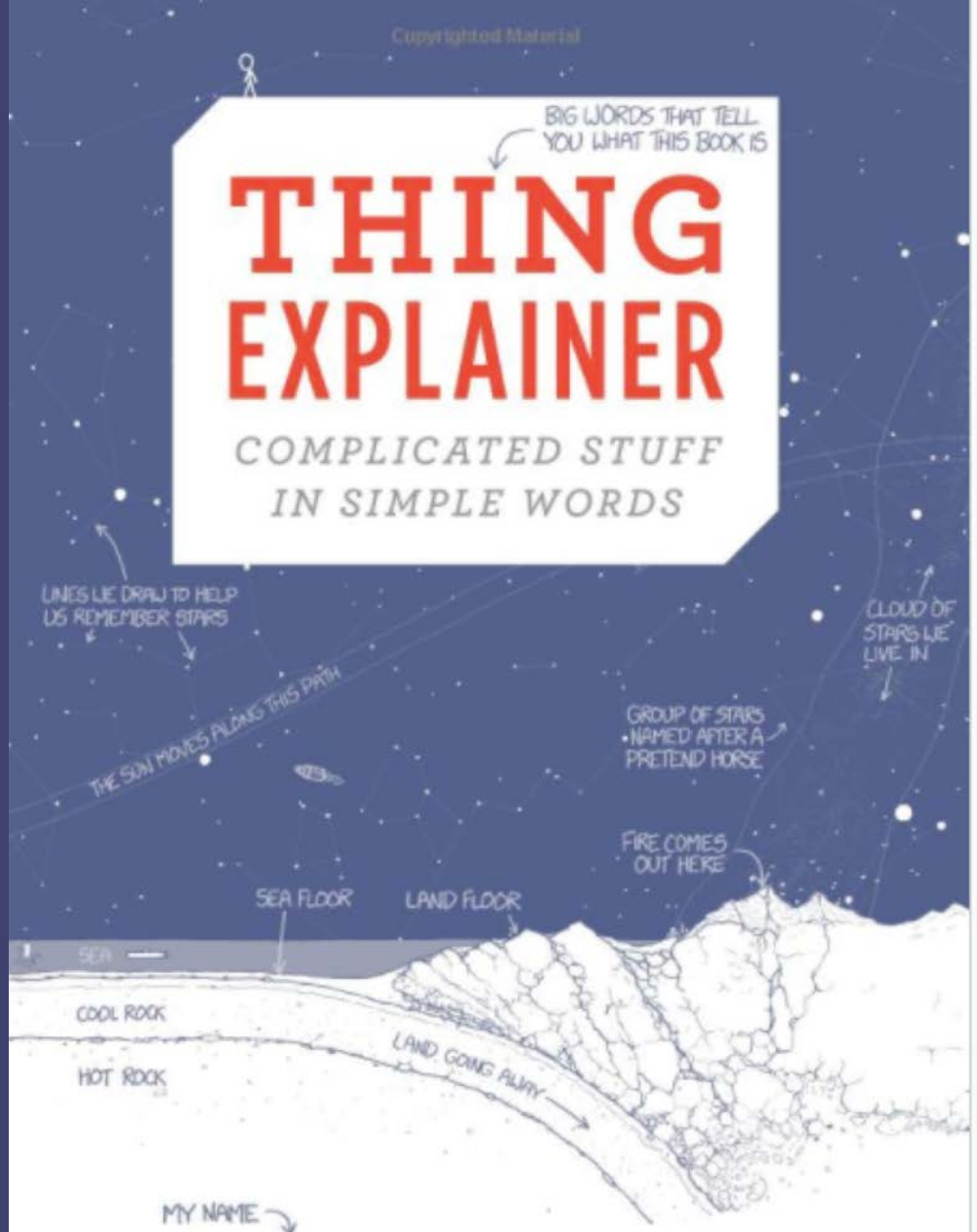
Cells consist cytoplasm enclosed membrane contains biomolecules proteins nucleic acids

https://xkcd.com/simplewriter/




**Put Words Here**

Everything that's alive is made of tiny bags of water. Some living things are made of just one bag of water. Those things are usually too small to see.




# THING EXPLAINER

## COMPLICATED STUFF IN SIMPLE WORDS

MY NAME

RANDALL MUNROE

author of *What If?* and creator of xkcd

Copyrighted Material

## Put Words Here

The probability for a given statistical model that, when the null hypothesis is true, the statistical summary (such as the sample mean difference between two compared groups) would be the same as or of greater magnitude than the actual observed results.

## Put Words Here

A number that tells us how surprising another group of numbers is.

# Why do we have a hard time communicating statistics well?

Because it's an inherently hard thing to do.

(Harder than science communication.)

| Communicating science: | Communicating stats: |
| --- | --- |
| Empirical world | Abstract world |
| “Discover” | “Develop” |
| Tasty cake | New baking pans |
| Gas pedal | Brake |
| People’s lives | The world’s information |
| Truth | Uncertainty |

"This beautiful, approachable book not only teaches you how to cook, but captures how it should *feel* to cook: full of exploration, spontaneity and joy. Samin is one of the great teachers I know." —Alice Waters

# SALT FAT ACID HEAT

MASTERING THE ELEMENTS of GOOD COOKING

by SAMIN NOSRAT

and ART by WENDY MacNAUGHTON

with A FOREWORD by MICHAEL POLLAN

NUMBERS CERTAINTY

ABSTRACTIONS CONTEXT

We need

Human-Centered

Quantitative Communication

- Magnitudes
- Relationships
- Data Summaries

- Unknowns in knowledge
- Unknowns in future
- Confidence
- Possibilities


- "Drawn away" from concrete world
- Data collection
- Algorithms
- Methodology
- Models

- "Weave together"
- Updating knowledge
- Predictions
- Decisions

# NUMBERS:

## Mammograms

### Important things to know about mammograms

- **They can save your life.** Finding breast cancer early reduces your risk of dying from the disease by 25-30% or more. Women should begin having mammograms yearly at age 40, or earlier if they're at high risk.

First, it is important to know what evidence there is that mammograms save lives. Six large clinical studies performed by researchers over several decades, incorporating data from hundreds of thousands of women in three countries, have shown that using mammograms to screen for breast cancer helps to prevent deaths from breast cancer-with decreases in the number of breast cancer deaths ranging from 13% to 45%.[9][10] Only

http://stopcancerfund.org/p-breast-cancer/women-undergo-mammograms-yes/

http://www.breastcancer.org/symptoms/testing/types/mammograms/benefits_risks

# Long-term effects of mammography screening: updated overview of the Swedish randomised trials

THE LANCET • Vol 359 • March 16, 2002 •

*Lennarth Nyström, Ingvar Andersson, Nils Bjurstam, Jan Frisell, Bo Nordenskjöld, Lars Erik Rutqvist*

**Findings** The median trial time—the time from randomisation until the first round was completed for the control group or if the control group was not invited, until end of follow-up—was 6·5 years (range 3·0–18·1). The median follow-up time, the time from randomisation, to the end of follow-up, was 15·8 years (5·8–20·2). There were 511 breast cancer deaths in 1 864 770 women-years in the invited groups and 584 breast cancer deaths in 1 688 440 women-years in the control groups, a significant 21% reduction in breast cancer mortality (RR=0·79, 95% CI 0·70–0·89). The reduction was

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# IN SCREENING GROUP:

$$\frac{511 \text{ DEATHS}}{1{,}864{,}770 \text{ WOMEN·YEARS}} = \frac{0.000274 \text{ deaths}}{1 \text{ woman-year}} \cdot \frac{15.8 \text{ years}}{\text{study}} = \frac{0.0043 \text{ deaths}}{1 \text{ woman·study}} \cdot 1000 \text{ women}$$

$$= \frac{4.3 \text{ deaths}}{1000 \text{ women}}$$

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1000 WOMEN SCREENED → ~4,3 DEATHS

1000 WOMEN NOT SCREENED → ~5.5 DEATHS

NON-SCREENED:

$$\frac{584 \text{ DEATHS}}{1{,}688{,}440 \text{ WOMEN·YEARS}} \cdot \frac{15.8 \text{ YEARS}}{\text{STUDY}} \cdot \frac{1000 \text{ WOMEN}}{1}$$

$$= \frac{5.5 \text{ deaths}}{1000 \text{ women}}$$

$$\frac{\text{Death Rate/yr, Screened}}{\text{Death Rate/yr, Non-Screened}} = \frac{511/1864770}{584/1688440} = \frac{0.000274}{0.000346} = 0.79$$

$$= 100\% - 21\%$$

# Absolute Risk Reduction vs Relative Risk Reduction

Researchers estimate that over a 15-year period, the chances of a woman dying of breast cancer if she's not screened are 0.52%. That number will drop to 0.41% with regular screening.

Researchers estimate women who are regularly screened are 21% less likely to die of breast cancer.

# Natural Frequencies vs Percentages

Researchers estimate that for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, but this number will drop to only about 4 deaths for women who are screened.

Researchers estimate that over a 15-year period, the chances of a woman dying of breast cancer if she's not screened are 0.52%. That number will drop to 0.41% with regular screening.

# Varying numerator vs denominator

Researchers estimate that for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, compared to about 4 who will die even if they are screened.

Researchers estimate that without regular screening, about one in every 192 women will die of breast cancer over a 15-year period, compared to one in about 244 who do get screening.

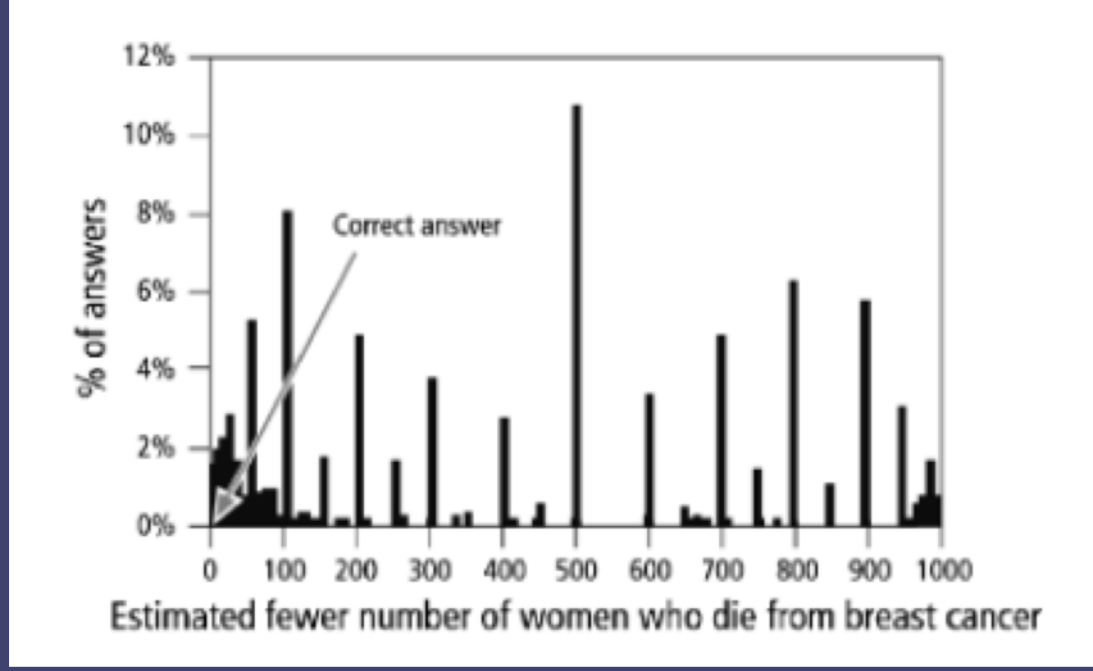
# Larger vs smaller denominator

Researchers estimate that for every 10,000 women who are not screened, about 52 will die of breast cancer over 15 years, compared to about 41 who will die even if they are screened.

Researchers estimate that for every 1,000 women who are not screened, about 5 will die of breast cancer over 15 years, compared to about 4 who will die even if they are screened.

# IN THE REAL WORLD:

"Early detection with mammography reduces the risk of dying from breast cancer by 25%. Assume that 1,000 women aged 40 and older participate regularly in screening. How many fewer would die of breast cancer?"




Three out of 10 of German gynecologists answered: 250 fewer would die.

(True answer: About one fewer woman would die.)

Gigerenzer, Gerd, et al. "Helping doctors and patients make sense of health statistics." *Psychological science in the public interest* 8.2 (2007): 53-96.

HEALTH NEWS AUGUST 21, 2017 / 12:25 AM / 8 MONTHS AGO

# U.S. study revives argument over mammogram screening

Andrew M. Seaman

EXTRA CREDIT FOR LATER

3 MIN READ

(Reuters Health) - Yearly mammograms starting at age 40 would prevent the most deaths from breast cancer, U.S. researchers reported on Monday in a challenge to more conservative recommendations that take into account both the harms and the benefits of screening.

The study, led by Dr. Elizabeth Arleo, a radiologist specializing in mammography at Weill Cornell Medicine and New York-Presbyterian, found that yearly mammograms between the age of 40 and 80 could cut breast cancer deaths by 40 percent.

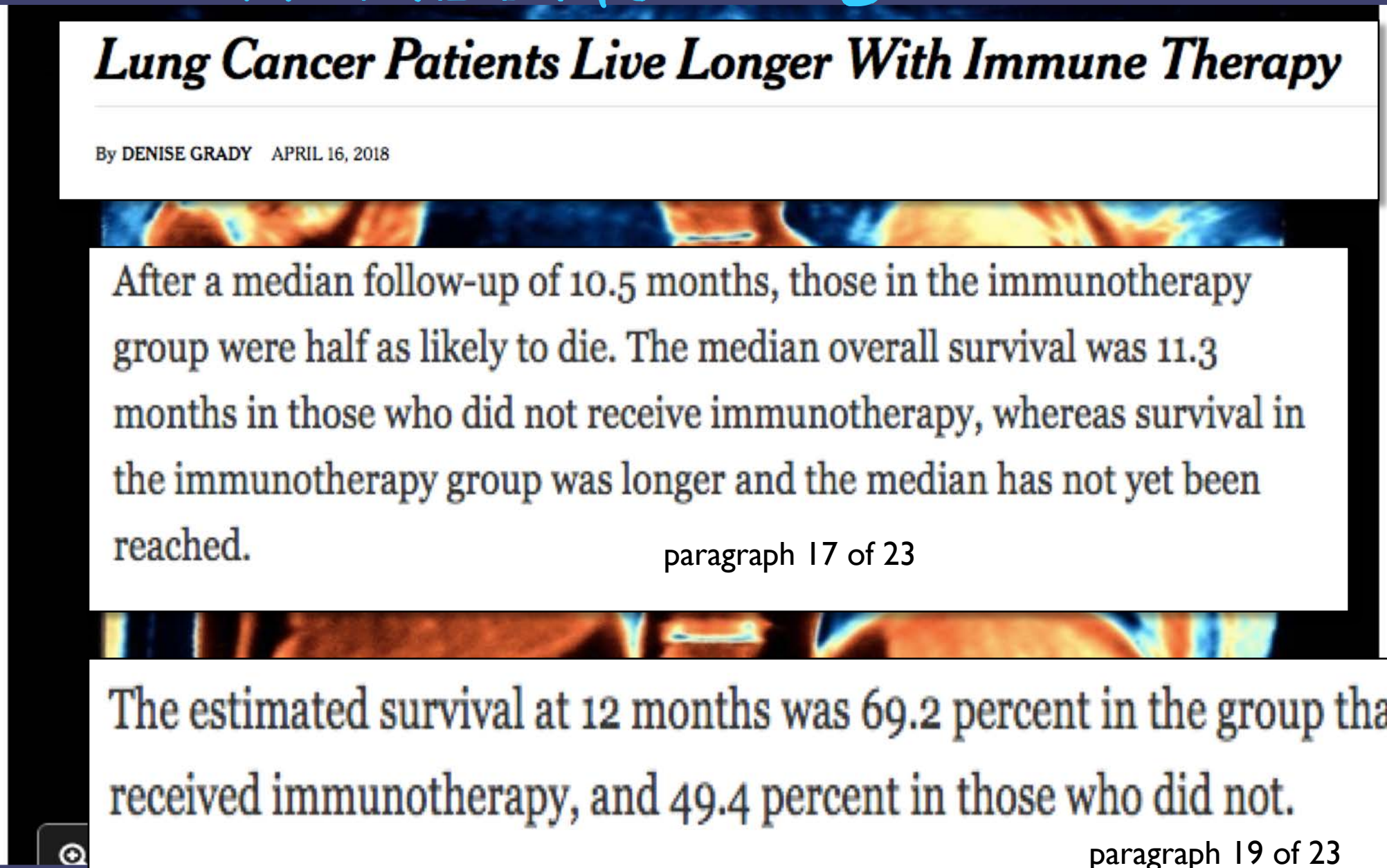
That compares with a reduction of 23 to 31 percent with current screening recommendations that call for less frequent screening starting at an older age.

The New York Times

# NUMBERS: Lung Cancer

## *Lung Cancer Patients Live Longer With Immune Therapy*

By DENISE GRADY APRIL 16, 2018

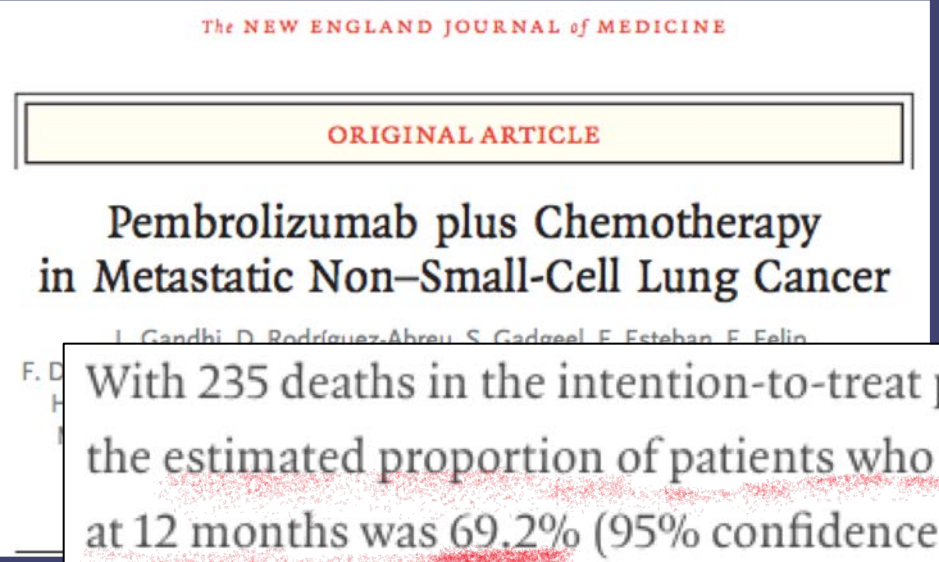


After a median follow-up of 10.5 months, those in the immunotherapy group were half as likely to die. The median overall survival was 11.3 months in those who did not receive immunotherapy, whereas survival in the immunotherapy group was longer and the median has not yet been reached.

paragraph 17 of 23

The estimated survival at 12 months was 69.2 percent in the group that received immunotherapy, and 49.4 percent in those who did not.

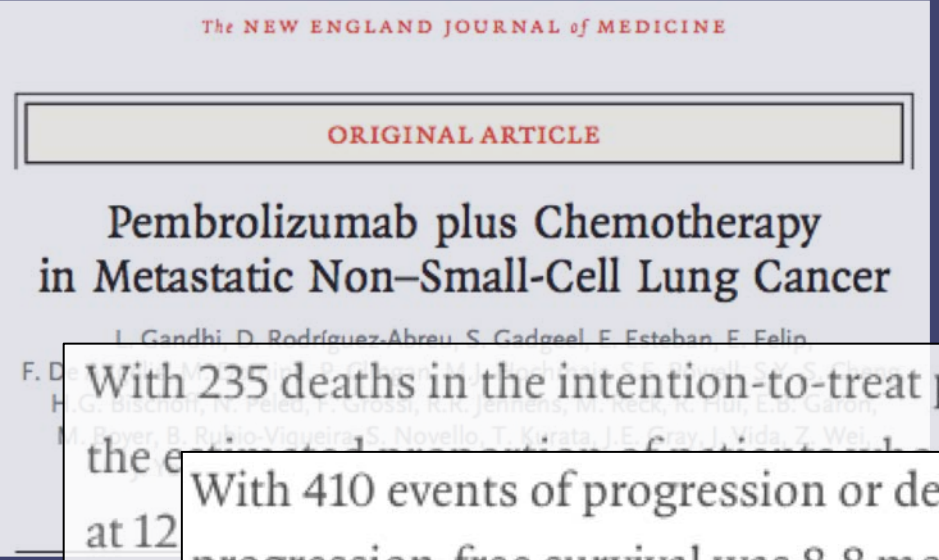
paragraph 19 of 23




With 235 deaths in the intention-to-treat population, the estimated proportion of patients who were alive at 12 months was 69.2% (95% confidence interval [CI], 64.1 to 73.8) in the pembrolizumab-combination group and 49.4% (95% CI, 42.1 to 56.2) in the placebo-combination group. The median overall survival was not reached in the pembrolizumab-combination group and was 11.3 months (95% CI, 8.7 to 15.1) in the placebo-combination group (hazard ratio for death, 0.49; 95% CI, 0.38 to 0.64; P<0.001) (Figure 1A). The

For every 100 patients on the regular treatment, about 49 were still alive after one year. That number rose to about 69 for those who had the immunotherapy.

Gandhi, Leena, et al. "Pembrolizumab plus chemotherapy in metastatic non–small-cell lung cancer." *New England Journal of Medicine* (2018).




With 235 deaths in the intention-to-treat population, the e… at 12… [CI], com… in th… over… pem… mon… com… 95%…

With 410 events of progression or death, the median progression-free survival was 8.8 months (95% CI, 7.6 to 9.2) in the pembrolizumab-combination group and 4.9 months (95% CI, 4.7 to 5.5) in the placebo-combination group (hazard ratio for progression or death, 0.52; 95% CI, 0.43 to 0.64; P<0.001) (Figure 3A). The estimated proportion of patients who were alive and progression-free at 12 months was 34.1% (95% CI, 28.8 to 39.5) in the pembrolizumab-combination group and 17.3% (95% CI, 12.0 to 23.5) in the placebo-combination group. The results were

The researchers also looked at how much the cancers in each group progressed. With the regular treatment, patients lived an average of almost five months progression-free; for those who had the immunotherapy, that number rose to about eight months and three weeks.

After a median follow-up of 10.5 months, those in the immunotherapy group were half as likely to die. The median overall survival was 11.3 months in those who did not receive immunotherapy, whereas survival in the immunotherapy group was longer and the median has not yet been reached.

For every 100 patients getting regular treatment, about 49 were still alive after one year, compared to about 69 for those who had the immunotherapy.

The estimated survival at 12 months was 69.2 percent in the group that received immunotherapy, and 49.4 percent in those who did not.

With the regular treatment, patients lived an average of almost five months progression-free; for those who had the immunotherapy, that number rose to about eight months and three weeks.

Gandhi, Leena, et al. "Pembrolizumab plus chemotherapy in metastatic non–small-cell lung cancer." *New England Journal of Medicine* (2018).

# Framing

For every 100 patients on the regular treatment, about 51 died within a year. For those who had the immunotherapy, that number dropped to about 31.

For every 100 patients on the regular treatment, about 49 were still alive after one year. For those who had the immunotherapy, that number rose to about 69.

# NUMBERS : Rain

Capital Weather Gang

## Harvey unloaded 33 trillion gallons of water in the U.S.

By Angela Fritz and Jason Samenow September 2, 2017 Email the author

If you piled up 20 trillion gallons of water over the District of Columbia (approximately 68 square miles), the height of the water would be 1,410 feet — or almost the height of the Empire State Building. (Ryan Maue)

The amount of rain that fell in Texas and Louisiana would have ended the historic California drought, twice over. (Paul Deanno)

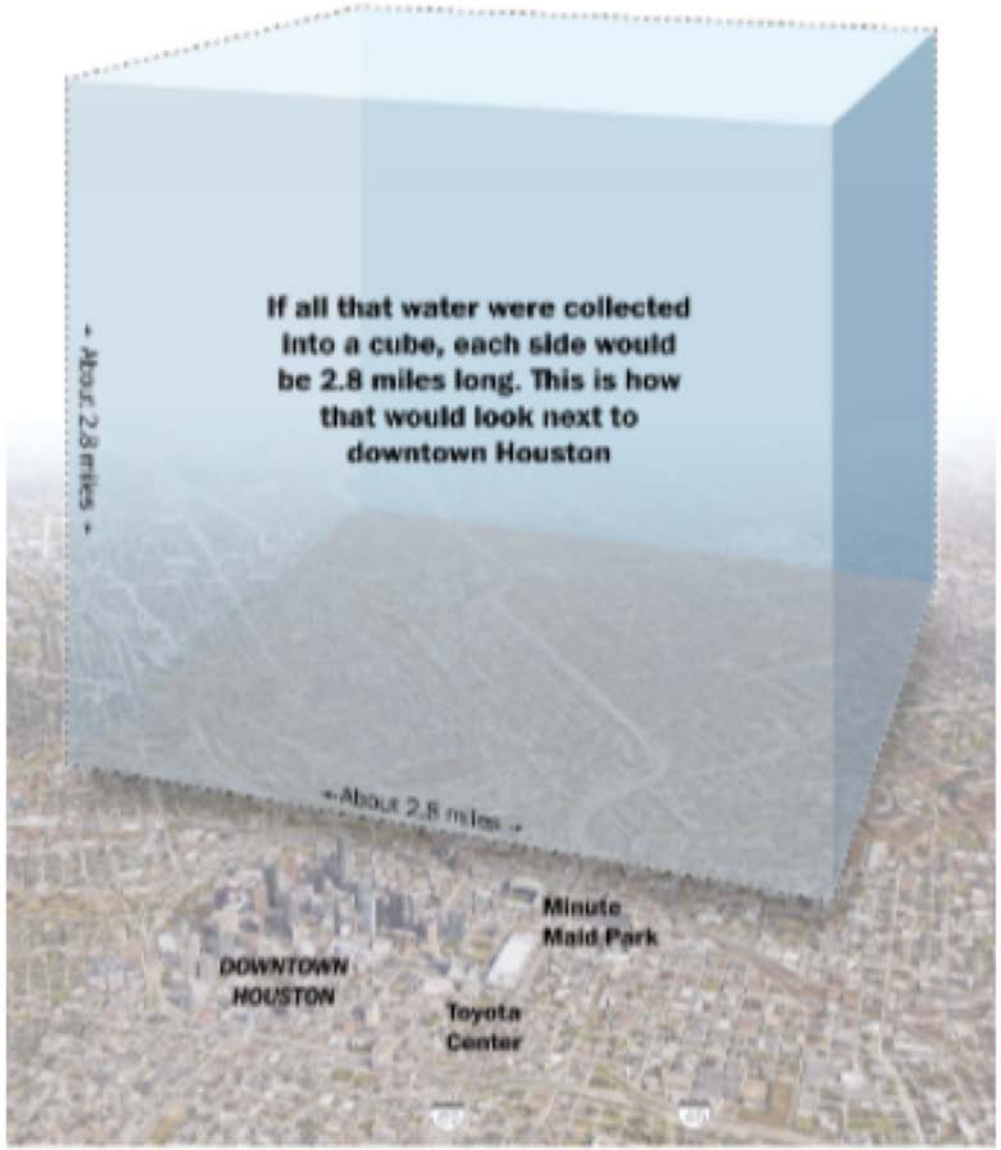
It's enough to cover the entire state of Arizona in more than a foot of water.

Over Harris County alone — which is home to Houston — 1 trillion gallons of water fell in the four days from Saturday through Tuesday. That's as much water as flows over Niagara Falls in 15 days. (Jeff Lindner)

https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/08/30/harvey-has-unloaded-24-5-trillion-gallons-of-water-on-texas-and-louisiana/

## What would 24.5 trillion gallons of water look like?

As of Wednesday morning, about 24.5 trillion gallons of rain have fallen along the Gulf of Mexico. About 19 trillion gallons across the greater Houston area and Southeast Texas, as well as an additional 5.5 trillion in Louisiana.




Sources: Capital Weather Gang, Google Earth

THE WASHINGTON POST

Near Mont Belvieu, Tex., 51.88 inches of rain fell. That's the highest rainfall total in any storm in the history of the United States.

- It's approximately how much rain falls in Houston in an entire (average) year.
- It has taken Death Valley 23 years to accumulate that much rain. (Ian Livingston)
- It would take Los Angeles four years to hit 52 inches. (New York Times)
- In the arid climate of Southern California, it would take more than a decade for 52 inches of rain to accumulate

# NUMBERS: The Earth

About 4.6 billion years ago the earth was formed.

About 541 million years ago, the Cambrian Period began.

About 252 million years ago the Permian Extinction occurred.

The Cenozoic began about 66 million years ago and extends into the present.

All recorded history lies within the Holocene, which began 11,700 years ago.

If you were to lift your arms and spread them wide and hold them straight out to either side and think of the distance from fingertips to fingertips as representing the earth's entire history, then you would have all the principal events in that hillside in the middle of the palm of one hand . . . Look at one hand with its line of life. The Cambrian begins in the wrist, and the Permian Extinction is at the outer end of the palm. All of the Cenozoic is in a fingerprint, and in a single stroke with a medium-grained nail file you could eradicate human history.

-- John McPhee
*Annals of the Former World*

# CERTAINTY : Ebola Vaccine

HEALTH

## *New Ebola Vaccine Gives 100 Percent Protection*

By DONALD G. McNEIL Jr. DEC. 22, 2016

In a scientific triumph that will change the way the world fights a terrifying killer, an experimental Ebola vaccine tested on humans in the waning days of the West African epidemic has been shown to provide 100 percent protection against the lethal disease.

The Lancet study was done in 11,841 residents of Guinea last year. Among the 5,837 people who got the vaccine, none came down with Ebola 10 or more days later. There were 23 Ebola cases among the thousands of others not immediately vaccinated.

Paragraph 11 out of 24

# Efficacy and effectiveness of an rVSV-vectored vaccine in preventing Ebola virus disease: final results from the Guinea ring vaccination, open-label, cluster-randomised trial (Ebola Ça Suffit!)

www.thelancet.com Vol 389 February 4, 2017

No cases of Ebola virus disease occurred 10 days or more after randomisation among randomly assigned contacts and contacts of contacts vaccinated in immediate clusters versus 16 cases (7 clusters affected) among all eligible individuals in delayed clusters. Vaccine efficacy was 100% (95% CI 68·9–100·0, p=0·0045), and the calculated intraclass correlation coefficient was 0·035. Additionally, we defined 19 non-randomised clusters in which we enumerated 2745 contacts and contacts of contacts, 2006 of whom were eligible and 1677 were immediately

# Three Types of Uncertainty

## 1st Order: Aleatory

- "Risk"
- Randomness
- Future
- Unknowable (to humans)

## 2nd Order: Epistemic

- "Confidence intervals"
- Uncertainty around results
- Lack of knowledge
- Need more information

## 3rd Order: Ontological

- "Ignorance"
- Unknown unknowns
- Need humility

Spiegelhalter, David. "Risk and Uncertainty Communication." *Annual Review of Statistics and Its Application* 4 (2017): 31-60.

# *New Ebola Vaccine Gives 100 Percent Protection* in Trial

It's not guaranteed that the vaccine will be 100 percent effective in the real world.

Right now, researchers' best guess is that it will be at least 69 percent effective. That means that for every 100 people who get the vaccine, at least 69 of them will be fully protected against the virus. (It doesn't mean that each person will be 69 percent protected.)

Researchers will have a better estimate of the true efficacy after more studies. It seems certain, however, that the vaccine will be effective enough to contain large outbreaks.

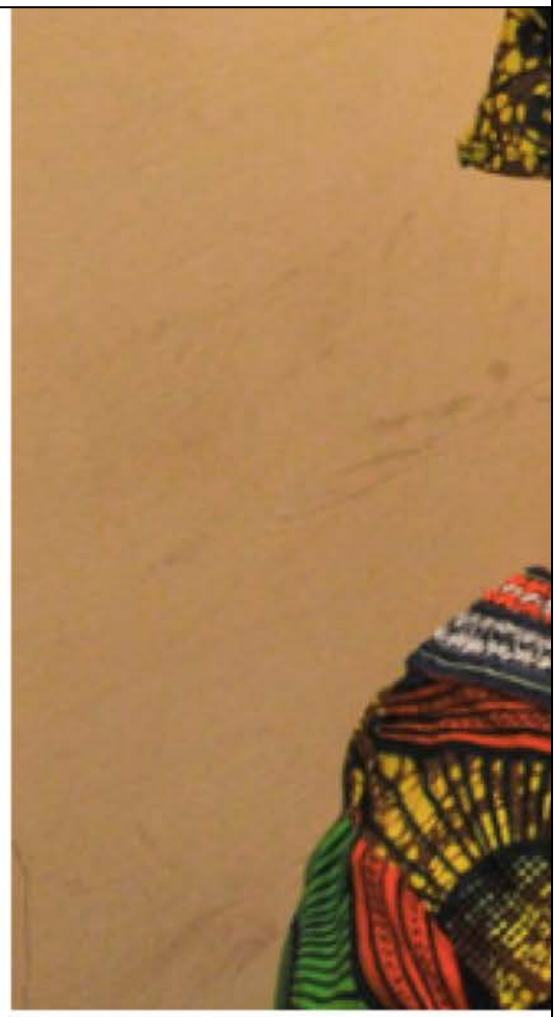
There are other important questions around the vaccine. It could work well in the short term, for example, but its effectiveness might fade quickly, requiring more frequent vaccinations.

HEALTH

# First Ebola Vaccine Likely To Stop The Next Outbreak

December 22, 2016 · 6:31 PM ET
Heard on Morning Edition

MICHAELEEN DOUCLEFF



When Ebola struck West Africa a few years ago, the world was defenseless. There was no cure. No vaccine. And the result was catastrophic: More than 11,000 people died. Nearly 30,000 were infected.

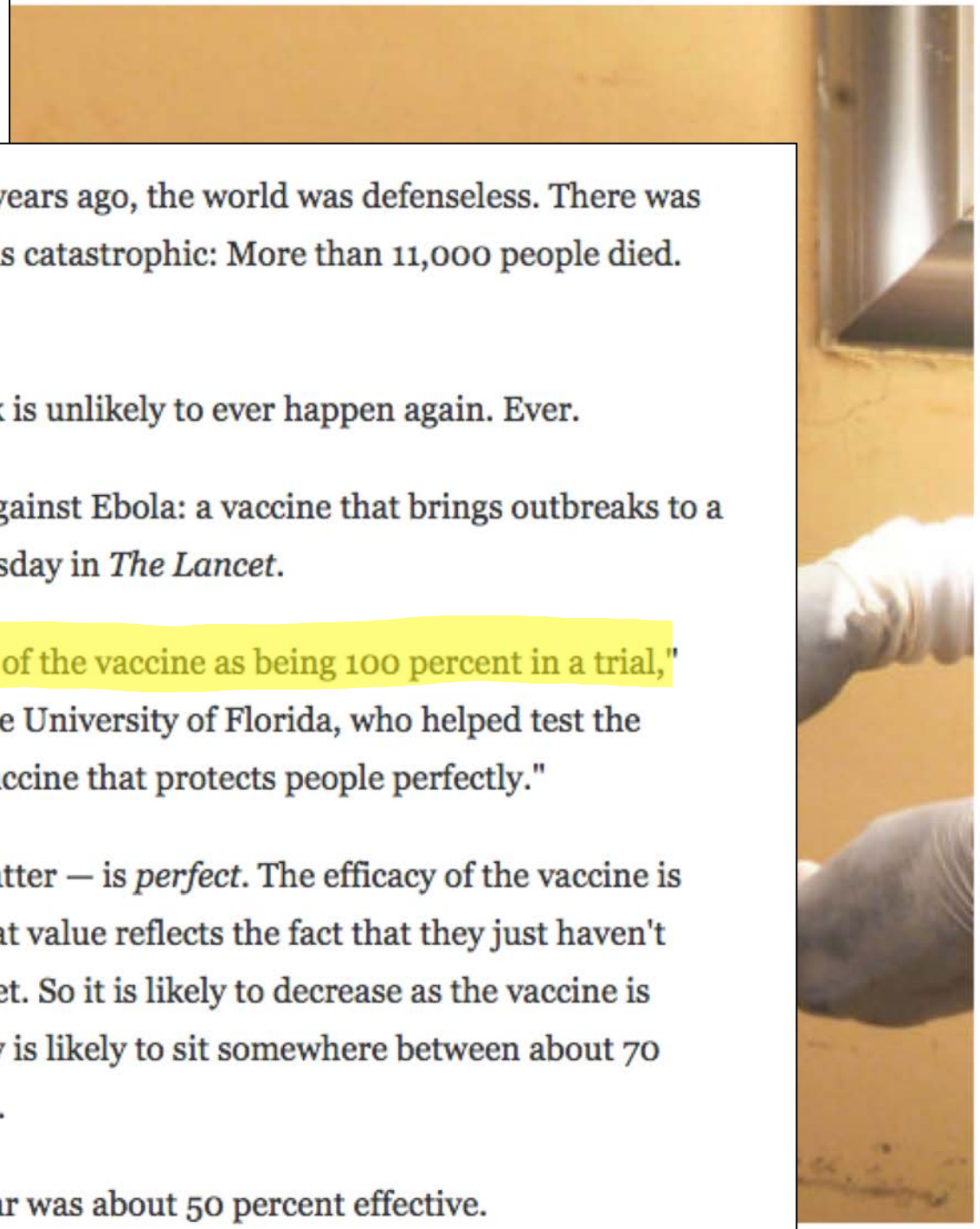
Now it looks like such a large outbreak is unlikely to ever happen again. Ever.

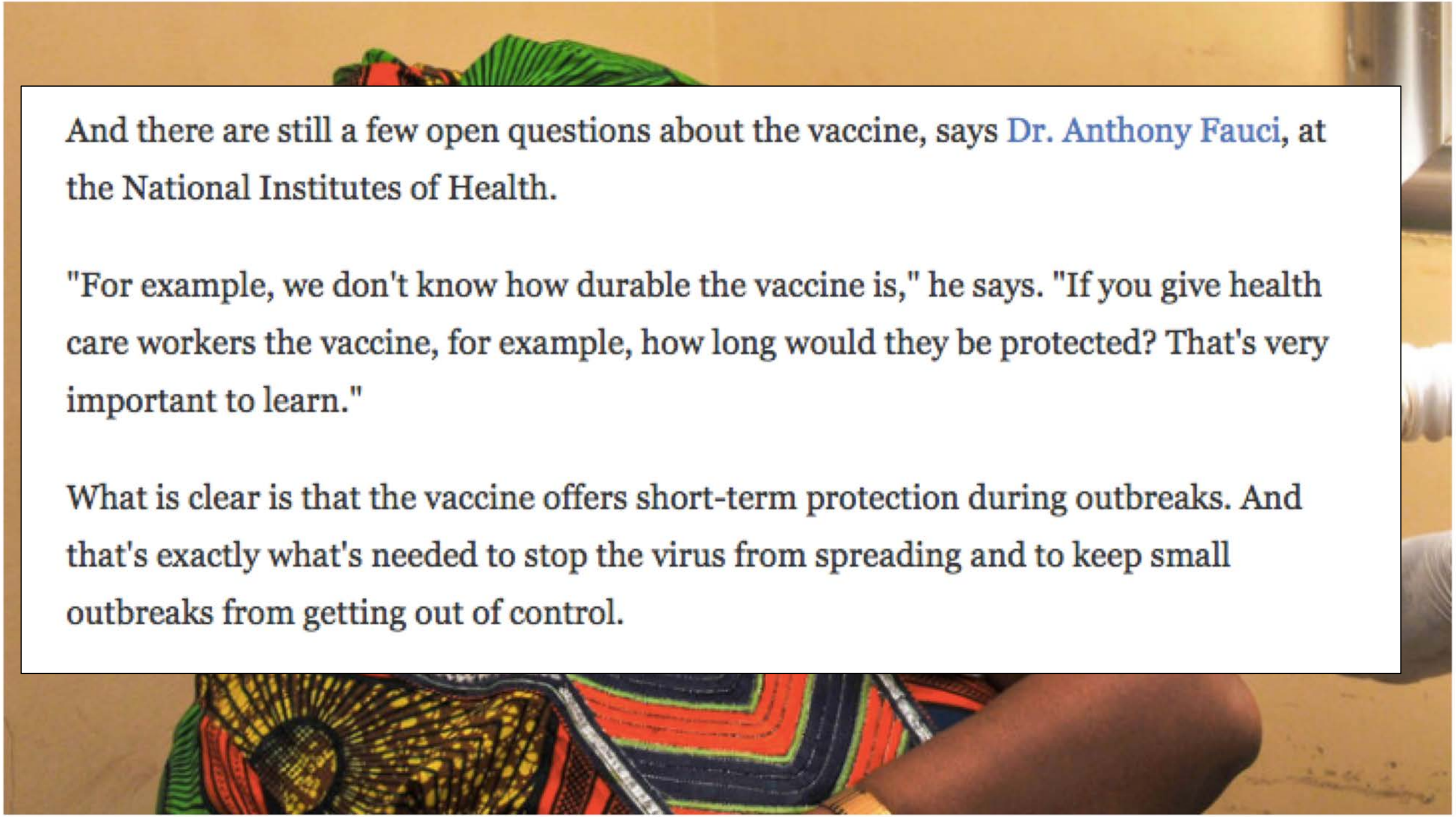
The world now has a potent weapon against Ebola: a vaccine that brings outbreaks to a screeching halt, scientists report Thursday in *The Lancet*.

"We were able to estimate the efficacy of the vaccine as being 100 percent in a trial," says Ira Longini, a biostatistician at the University of Florida, who helped test the vaccine. "It's very unusual to have a vaccine that protects people perfectly."

Now, no vaccine — or drug for that matter — is *perfect*. The efficacy of the vaccine is clearly high but not "100 percent." That value reflects the fact that they just haven't tested the vaccine on enough people yet. So it is likely to decrease as the vaccine is used over time. In the end, the efficacy is likely to sit somewhere between about 70 percent and 100 percent, Longini says.

By comparison, the flu vaccine last year was about 50 percent effective.





And there are still a few open questions about the vaccine, says Dr. Anthony Fauci, at the National Institutes of Health.

"For example, we don't know how durable the vaccine is," he says. "If you give health care workers the vaccine, for example, how long would they be protected? That's very important to learn."

What is clear is that the vaccine offers short-term protection during outbreaks. And that's exactly what's needed to stop the virus from spreading and to keep small outbreaks from getting out of control.

# CERTAINTY : Not Sitting

HEALTH

## There's a better way to use a standing desk

Is standing actually better than sitting?

POPULAR SCIENCE

*By Claire Maldarelli* *February 27, 2018*

Twenty participants is a pretty small study. When conducting research, having a large number of people to analyze is always better. With so many variables at play, a bigger group helps eliminate anything that might be influencing the results. For example, those who might have a genetic predisposition for leg pain or chronic back pain might be particularly susceptible to the effects of sitting and standing. When you only have a small number of people in the study, having a disproportionate number of people with those predispositions could really sway the results. The bigger and more randomly selected your group is, the more likely you are to get something close to a representative sample of the whole population. So, generally speaking, we wouldn't recommend taking the findings of any study with just 20 participants as gospel.

# CERTAINTY: National Security

PODCASTS

## The Lawfare Podcast, Special Edition: The Kushercast

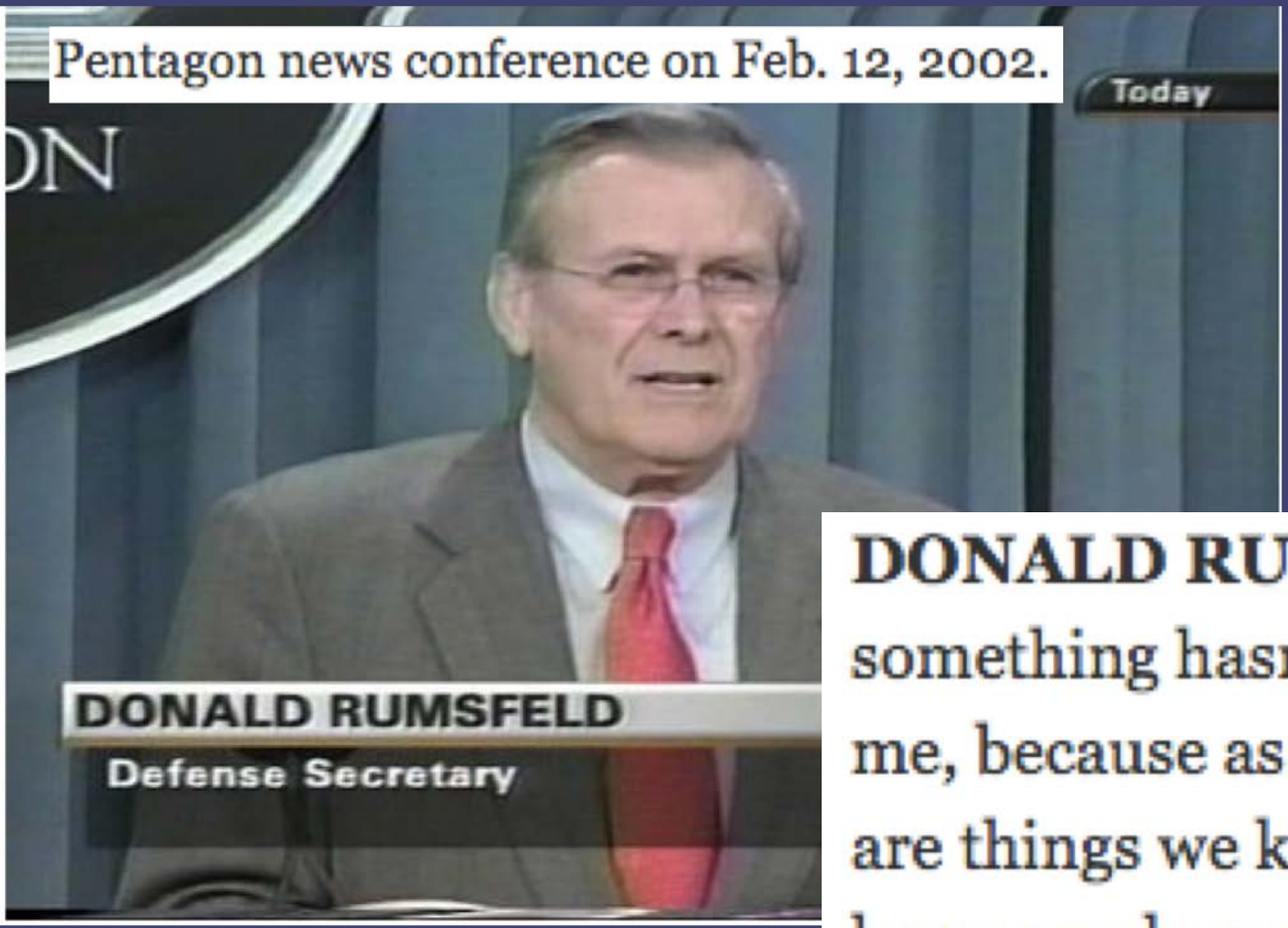
By **Benjamin Wittes** Tuesday, May 30, 2017, 9:01 PM

"What do we know?"

"What are the facts that are in question?"

"And how confident are we in what we know?"

# CERTAINTY: Politicians




**DONALD RUMSFELD:** Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns — the ones we don't know we don't know.

## Strategies for numbers:

- Absolute risk reductions vs relative risk reductions
- Frequencies vs percentages
- "Human-sized" reference population vs too large or too small
- Keep denominators constant
- Human-centered analogies for large numbers
- The more physical and concrete, the better

## Strategies for uncertainty:

- Don't avoid it
- Acknowledge any uncertainty about the future, especially personal (aleatory)
- Gently include uncertainty about numbers, explain why, say how it will be resolved (epistemic)
- Mention open questions and unknown unknowns, with specificity (ontological)

# Thank You!

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# Comparison of Recommendations for Screening Mammography Using CISNET Models

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tion. If none of these women underwent screening mammography, the 2009 CISNET estimates that from age years 40, 3%,[10] or approximately 74,000 women in this single-year cohort of 2,468,000 women would die due to breast cancer. Alternatively, if this cohort of women followed the first recommendation of annual screening at ages 40 to 84 years with 100% compliance, then 29,369 breast cancer deaths could be averted, a 39.6% mortality reduction. This is 29% more deaths averted than by the same group of women following the hybrid recommendation (22,829 deaths averted, a 30.8% mortality reduction) and 71% more deaths averted than by the same group following the third recommendation (17,153 deaths averted, a 23.2% mortality reduction). Likewise, the largest num-