Helping Doctors and Patients Make Sense of Health Statistics

Towards an Evidence-based Society

Gerd Gigerenzer
Collective Statistical Illiteracy in Health Care

1. Few physicians, patients, and politicians understand health statistics.

2. Causes:
   - non-transparent framing of information, and
   - lack of training in risk communication in medical schools and the educational system in general.

3. There would be a simple solution: teach and implement transparent risk communication.
Collective Statistical Illiteracy

I

5-Year Survival Rates
"I had prostate cancer, five, six years ago. My chances of surviving prostate cancer and thank God I was cured of it, in the United States, 82 percent. My chances of surviving prostate cancer in England, only 44 percent under socialized medicine."

Rudy Giuliani, New Hampshire radio advertisement, October 2007
Lead Time Bias

**Without screening**
- Cancer diagnosed because of symptoms at age 67
- 5-year survival = 0%
- Cancer starts
- Dead at age 70

**With screening**
- Cancer diagnosed because of screening at age 60
- 5-year survival = 100%
- Cancer starts
- Dead at age 70

Do Physicians Understand 5-Year Survival Rates?

65 German physicians (internal medicine)

*When the (same) information about PSA tests was framed as*
Survival rates: 79% judged screening as effective
Mortality rates: 5% judged screening as effective

Lead-time-bias? 2 out of 65 knew
Overdiagnosis? 0 out of 65 knew

➤ Costs of PSA mass screening: first year $12 – 28 billion (US)

Wegwarth, Gaissmaier & Gigerenzer 2010
Deception by Medical Institutions
One of the most prestigious cancer centers in the US: M. D. Anderson

Prostate Cancer

Over four decades, the overall survival rate has more than doubled for men with prostate cancer treated at M. D. Anderson.

As national mortality rates for prostate cancer fluctuated between 1960 and 1990, five-year survival rates for prostate cancer among M. D. Anderson patients continued to improve. More effective radiation therapy and surgery have contributed to the overall increase in longevity, with chemotherapy and hormone treatments now playing an increasing role in the treatment of prostate cancer.

What makes these survival statistics even more remarkable is that the M. D. Anderson patient population includes more advanced patients. If the cancer center’s case mix was more like that seen nationally, its survival rates would likely be even higher.

* Medical Informatics, The University of Texas M. D. Anderson Cancer Center
** National Center for Health Statistics public use tapes provided to the National Cancer Institute. The rates are per 100,000 and are age-adjusted to the 1970 U.S. standard population.

Confusion about progress against cancer.
Unwarranted enthusiasm for medical center.
PSA Tests
Annual Costs: $6 – 8 billion (US)

<table>
<thead>
<tr>
<th>Benefit?</th>
<th>No Screening</th>
<th>Screening (9 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cancer mortality</td>
<td>23.8</td>
<td>23.9</td>
</tr>
<tr>
<td>prostate cancer mortality</td>
<td>3.7</td>
<td>3.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harm?</th>
<th></th>
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<tbody>
<tr>
<td>unnecessary biopsies</td>
<td>-</td>
<td>50 – 200</td>
</tr>
<tr>
<td>unnecessary treatments</td>
<td>-</td>
<td>10 – 30</td>
</tr>
<tr>
<td>incontinence / impotence</td>
<td>-</td>
<td>3 – 20</td>
</tr>
</tbody>
</table>

PERCEIVED BENEFITS OF PSA SCREENING

Out of 1000 men who regularly participate in screening, how many fewer will die of prostate cancer in comparison to those who do not participate?

Gigerenzer, Mata, & Frank JNCI 2009
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[Bar chart showing perceived benefits across different countries and age groups.]

Gigerenzer, Mata, & Frank JNCI 2009
II
Conditional Probabilities

Collective Statistical Illiteracy
Gynecologists’ (n = 160) estimates of $p(\text{breast cancer} \mid \text{positive mammogram})$

- Before training:
  - 10%: 21%
  - 1%: 19%
  - 81%: 13%
  - 90%: 47%

Gynecologists can learn quickly:
Translate conditional probabilities into natural frequencies

Before training

After training

Natural Frequencies

1000 people

8 disease

7 positive

1 negative

992 no disease

70 positive

922 negative

Conditional Probabilities

Relative Frequencies

\[
p(\text{disease}) = 0.008 \\
p(\text{pos|disease}) = 0.90 \\
p(\text{pos|no disease}) = 0.07
\]

\[
p(\text{disease|positive}) = \frac{7}{7 + 70}
\]

\[
p(\text{disease|positive}) = \frac{0.008 \times 0.90}{0.008 \times 0.90 + 0.992 \times 0.07}
\]

Gigerenzer & Hoffrage Psychological Review 1995, 1999
DNA Evidence in the Courtroom

German Bundestag, June 28, 2002: Mammography screening

\[ p(\text{cancer}) = 0.4\%; \quad p(\text{positive}) = 5\%; \]
\[ p(\text{cancer}|\text{positive}) = 20\% \]

\[ p(\text{cancer}) = 0.4\%; \ p(\text{positive}) = 5\%; \ p(\text{cancer|positive}) = 20\% \]


- 5000 women
- 20 cancer
  - correct positive
  - miss
- 4,980 no cancer
  - false positive
  - negative

\[ \rightarrow 250 \text{ women test positive.} \]
\[ \rightarrow 50 \text{ of these have cancer.} \]
\[ \rightarrow \text{There are 50 women with cancer among 20 women!} \]
How to learn Bayes in less than two hours

American Students

Correct estimates (%)

Training | Follow-up
---|---
before | after | 1 week | 5 weeks

Representation Training
Rule Training

German Students

Correct estimates (%)

Training | Follow-up
---|---
before | after | 1 week | 3 months

Representation Training
Rule Training

Sedlmeier & Gigerenzer 2001, *Journal of Experimental Psychology: General*
III
Relative Risks
Unwarranted enthusiasm for treatment: Reduction from 2.8 to 1.5 per 100
## Mammography Screening

**Breast cancer screening with mammography: per 1,000 women 50+**

<table>
<thead>
<tr>
<th></th>
<th>No screening</th>
<th>Yearly screening over 10 years</th>
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<tbody>
<tr>
<td><strong>Benefits?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer mortality</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Breast cancer mortality</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Risks?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>False positives with biopsies</td>
<td>50 – 200</td>
<td></td>
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<tr>
<td>Unnecessary treatments (e.g. lumpectomy)</td>
<td>2 - 10</td>
<td></td>
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</tbody>
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Gynecologists‘ understanding of a relative risk reduction

Participants: 150 German gynecologists
Setting: Continuing education session

“Mammography screening reduces mortality from breast cancer by about 25%. Assume that 1,000 women age 40 and over participate in mammography screening. How many fewer women are likely to die of breast cancer?”

• 1 [66%]
• 25 [16%]
• 100 [3%]
• 250 [15%]

Deception Begins in Medical Journals

**Trick #1:** Report benefits in **BIG** numbers and harms in **SMALL** numbers (e.g. relative risks for benefits of treatments, and absolute risks for harms).


**Trick #2:** Report neither benefits nor harms in a transparent way.

*BMJ, JAMA, and The Lancet, 2004-2006:* No absolute risks or other transparent frequency data reported in 1 out of 2 articles.

Sedrakyan & Shih 2007 *Medical Care*
Statistical Literacy

Representations that foster insight

- 5-year survival rates
- Mortality rates
- Conditional probabilities
- Natural frequencies
- Relative risks
- Absolute risks
Risk Literacy

Few doctors and patients understand health statistics.

Collective Statistical Illiteracy is largely caused by
- lack of education in statistical thinking,
- lack of training in transparent risk communication.

Solution: Teach statistical thinking and risk communication in school.

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