Improbable, Impossible, and Murder

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(Bootmakers meeting, Toronto, October 26, 2024)

About Me . . .

I'm a Professor of Statistics. A typical day's work:

Therefore

$$\alpha^-(\beta_i^{(d)}) = \alpha^+(\beta_i^{(d)} - \ell/\sqrt{d})$$

$$\overset{d^{1/2}}{\approx} \alpha^+(\beta_i^{(d)}) - \frac{(\ell(\beta_i^{(d)})I^{1/2}(\beta_i^{(d)}))'}{2}\left(\frac{-\ell}{\sqrt{d}}\right)\phi\Big(-\frac{I^{1/2}(\beta_i^{(d)})\ell}{2} - \frac{\epsilon\ell K'''(\beta_i^{(d)})}{6I^{1/2}(\beta_i^{(d)})}\Big)$$

$$-\exp(-\epsilon\ell^2(\beta_i^{(d)})K'''(\beta_i)/6)\frac{(\ell(\beta_i^{(d)})I^{1/2}(\beta_i^{(d)}))'}{2}\left(\frac{-\ell}{\sqrt{d}}\right)\times$$

$$\times\phi\Big(-\frac{I^{1/2}(\beta_i^{(d)})\ell}{2} + \frac{\epsilon\ell K'''(\beta_i^{(d)})}{6I^{1/2}(\beta_i^{(d)})}\Big)$$

Then, since $\underline{\ell} \overset{d^{1/2}}{\approx} \ell + \underline{\epsilon}\ell' \overset{d^{1/2}}{\approx} \ell + \epsilon\ell' = \ell + \frac{\ell\ell'}{d^{1/2}}$, we have that

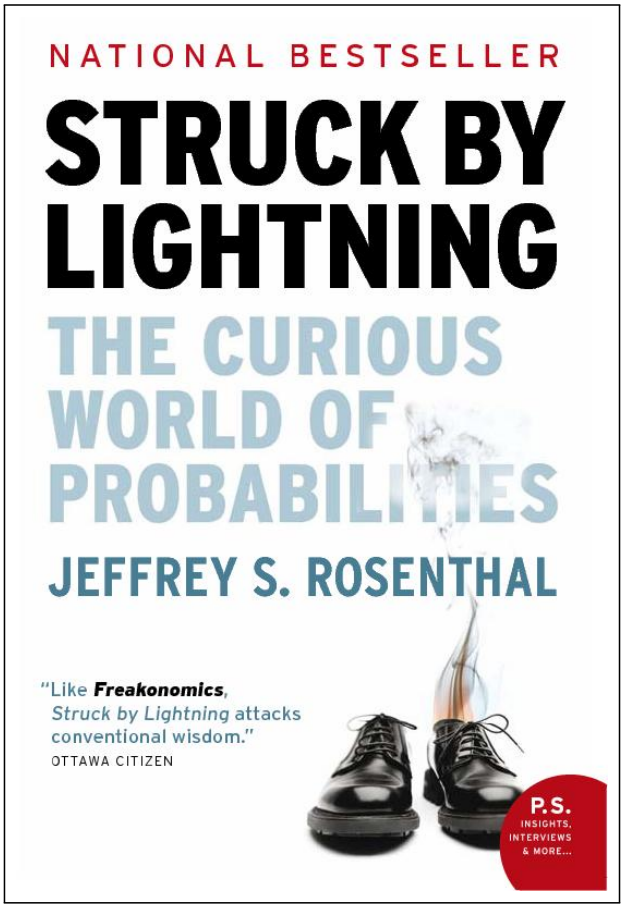
$$\mu(\beta_i^{(d)}) \overset{d^{1/2}}{\approx} \frac{1}{2d^{1/2}}\Big[-\alpha^+\ell + \Big(\ell + \frac{\ell\ell'}{d^{1/2}}\Big)\times$$

$$\Big(\alpha^+(\beta_i^{(d)}) - \frac{(\ell(\beta_i^{(d)})I^{1/2}(\beta_i^{(d)}))'}{2}\left(\frac{-\ell}{\sqrt{d}}\right)\phi\Big(-\frac{I^{1/2}(\beta_i^{(d)})\ell}{2} - \frac{\epsilon\ell K'''(\beta_i^{(d)})}{6I^{1/2}(\beta_i^{(d)})}\Big) -$$

With a little fun thrown in . . .

(3/22)

Meanwhile, one day I wrote a successful book . . .



(4/22)

Then I was interviewed by the media about: Opinion Polls . . .

TORONTO STAR
www.thestar.com

Use caution when approaching polls

Party preference numbers have varied

But differences deceiving, experts say

Jan. 21, 2006. 01:00 AM

ROBERT BENZIE

QUEEN'S PARK BUREAU CHIEF

Not a vote has been counted. The party leaders are still criss-crossing the country in a frantic final bid for support. Campaign volunteers are working the phones, replacing lawn signs and arranging election day transportation for voters who require it.

And yet we already know — or at least we think we know — that on Monday Stephen Harper's Conservatives will defeat Paul Martin's Liberals, and the NDP's Jack Layton will be the federalist leader holding the balance of power in a minority Parliament.

How have we concluded this? Well, the polls tell us so.

But don't different major polls all seem to have differing results?

Yes and no, says Jeffrey Rosenthal, professor of probability theory at the University of Toronto and a leading expert on polling.

Rosenthal, author of the recent bestseller *Struck by Lightning: The Curious World of Probabilities*, says "any one poll should always be taken with a grain of salt.

(5/22)

Crime statistics . . .

You're safer than you think: Statistics expert

Article | Photos (4)

Published On Sat Jan 19 2008

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Paola Loriggio
Staff Reporter

As long as there have been cities, there has been fear. Fear of violence, fear of death, fear of anonymous, big city crime.

High-profile cases of random crime — like the recent shootings of John O'Keefe and Hou Chang Mao, both innocent bystanders killed within a week — feed the public's anxieties.

Police cordon Gerrard St. E. near Broadview Ave. as part of the investigation into a fatal shooting Thursday. A statistics expert says the odds are better of dying in a car accident, than being killed by random crime.

HENRY STANCU/TORONTO STAR FILE PHOTO

But is that fear justified? Random crime isn't going away, but neither is it increasing. Does a spate of random killings put us in greater danger than before? The *Star* asked an expert statistician to assess the risk.

University of Toronto professor Jeffrey S. Rosenthal is the author of *Struck*

(6/22)

Pedestrian death counts . . .

Not so rare for rarities to occur in waves: Professor

TORSTAR NEWS SERVICE
Published: January 29, 2010 5:23 a.m.
Last modified: January 29, 2010 12:40 a.m.

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Scary numbers have dominated Toronto headlines this month: Seven dead in seven days.

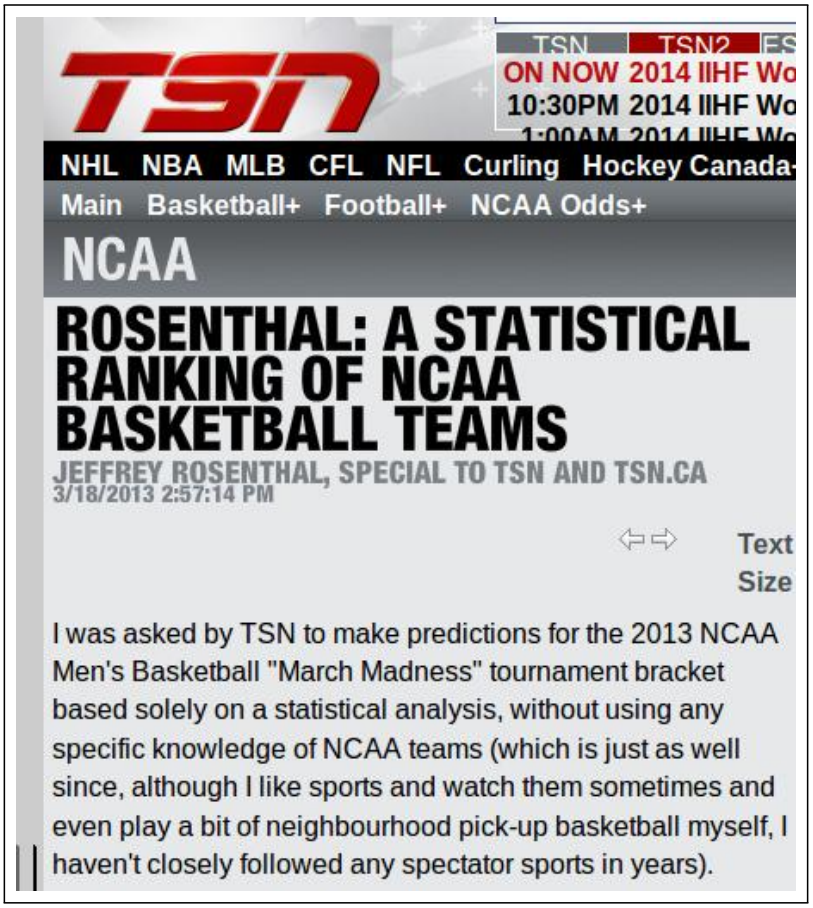
Fourteen pedestrians killed across the GTA. The deadliest January for city pedestrians in a decade.

No wonder people are walking scared.

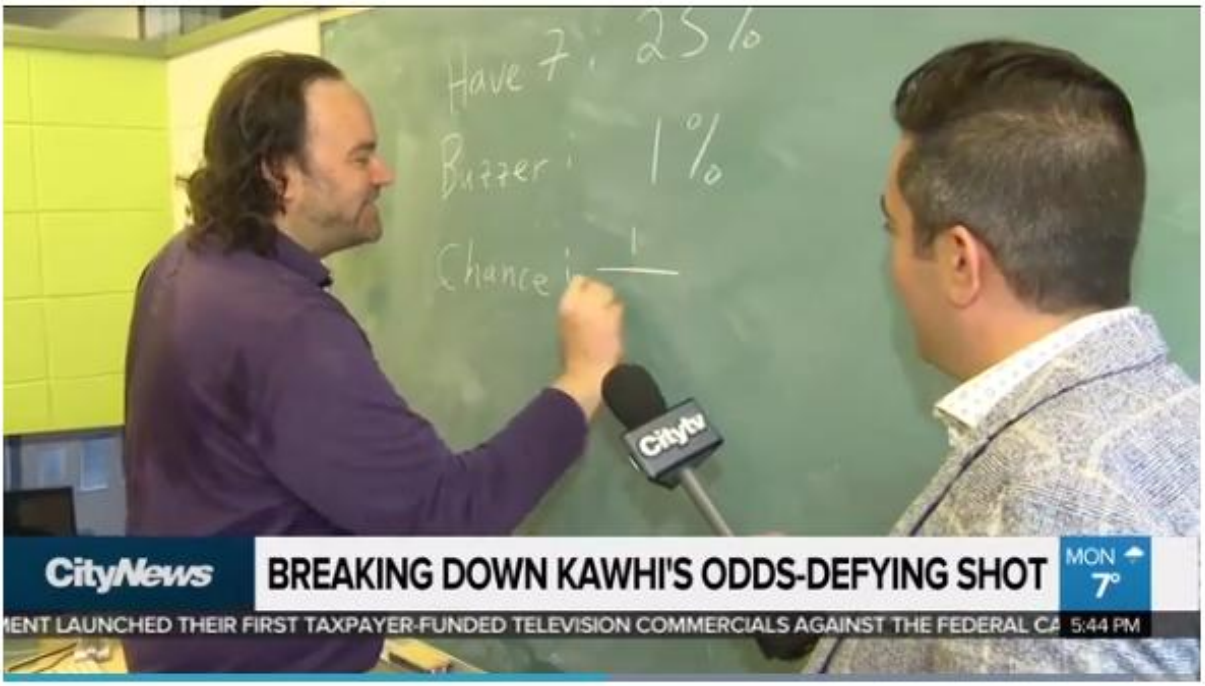
31.9

- Seven isn't that big a number when looked at through a statistician's lens. Jeffrey Rosenthal calculates that between 2000 and 2009, Toronto witnessed an average of 31.9 pedestrian deaths per year and 2.7 deaths per month. Using Poisson distribution, this means there is about a 1.9 per cent chance of there being seven or more pedestrian deaths in a single month.

Sports . . .



Yes, even the Raptors . . .



And lottery jackpots . . .

TORONTO STAR
www.thestar.com

Advice for lottery winners: Chill out

Apr. 30, 2006. 10:14 AM

ELLEN ROSEMAN

What are your odds of winning the lottery?

Unimaginably small, says University of Toronto statistics professor Jeffrey Rosenthal.

You have one chance in 14 million to score big playing Lotto 6/49. (That's where you have to match all six numbers chosen from 1 to 49.)

"To put it in context, you are over 1,000 times more likely to die in a car crash within the year," Rosenthal says in his book, *Struck by Lightning: The Curious World of Probabilities* (HarperCollins, $34.95).

"In fact, you are more likely to die in a car crash on your way to the store to buy your lottery ticket than you are to win the lottery jackpot.

Including the Lottery Retailer Scandal

University of Toronto statistician Prof. Jeffrey Rosenthal holds up a 6/49 ticket. He says so many retailers have won prizes it raises suspicions.

MARK O'NEILL

Storekeepers lucky?

Lottery officials dismiss statistician's claim that retailers' wins defy odds

(11/22)

Which Had Serious Consequences

Ontario Lottery chief fired

Mar. 24, 2007, 6:12 a.m. 5 comments

LOTTERY POST

OLG

Ontario Lottery and Gaming Corporation: Ontario Lottery chief fired

E-mail to a friend

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Link to this story

Rating: ★★★★½

The head of the Ontario Lottery and Gaming Corporation was dismissed from the scandal-plagued organization on Friday, according to CBC News.

CEO Duncan Brown was escorted out of the lottery corporation's offices in Toronto, two sources told the CBC, speaking on condition of anonymity.

(12/22)

And Led to Criminal Charges

$12.5M lottery prize theft leads to 3 arrests

Last Updated: Wednesday, September 29, 2010 | 10:25 PM ET
Comments 462 Recommend 322
CBC News

The case of Kathleen Chung, who allegedly cashed the winning ticket at her brother's convenience store in Burlington in early 2004, was profiled by the CBC's Fifth Estate, triggering a report by the Ontario ombudsman. (CBC)

Three family members in the Toronto area have been charged in the theft of a $12.5-million lottery prize, while police seek the rightful owner of the Lotto Super 7 ticket bought in 2003.

Two of the accused are a father and son who worked at a Burlington lottery outlet and were actively stealing tickets from customers, Ontario Provincial Police Commissioner Chris Lewis

. . . And Millions of Dollars Repaid!

Lottery fraud victims claim $12.5M prize – plus interest

Seven men with wraparound smiles claimed their seven-year-old $12.5 million lottery win Thursday, which stands now at $14.85 million.

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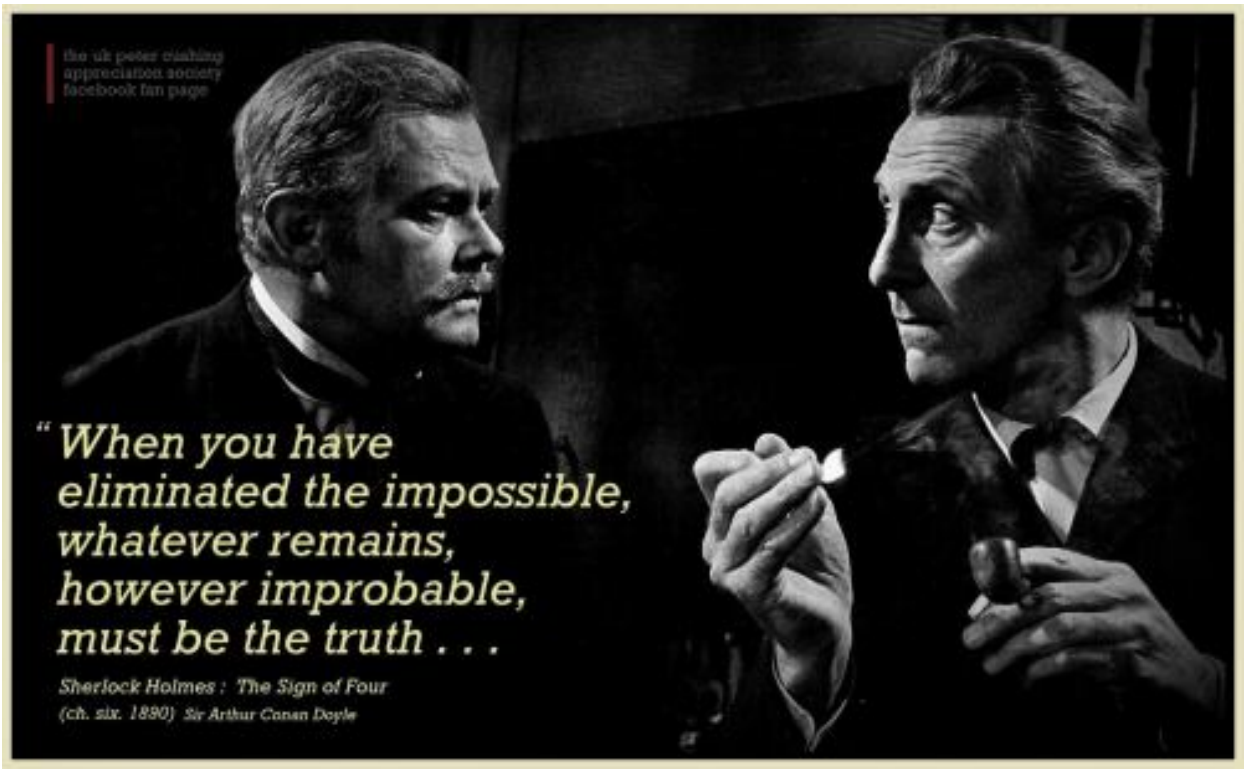
TANNIS TOOHEY / TORONTO STAR

http://probability.ca/lotteryscandal/

Probability related to MURDER?? Sherlock says . . .



Logically impeccable, if everything else is truly eliminated. But . . .

A Legal Case: Sally Clark (England)

- Solicitor in Cheshire, England.
- Had two sons; each died in infancy.
- "cot death" (SIDS)? Or murder!?!
- 1999 testimony by paediatrician Sir Roy Meadow: "the odds against two cot deaths in the same family are 73 million to one".
- "Impossible"(?). What remains? Murder!
- So, she was convicted! Jailed! Vilified! Third son temporarily taken away!
- So, justice was served! Or was it?

How did Meadow compute that "73 million to one"?

He said the probability of one child dying of SIDS was one in 8,543, so for two children dying, we multiply: $(1/8,543) \times (1/8,543) = 1/72,982,849 \approx 1/73,000,000$.

Clark Case: Valid Probability Calculation?

Was the multiplication valid? No! SIDS tends to run in families, so once a family has had one SIDS case, the second one is more likely.

Were the probabilities accurate? No! He neglected factors which increase the probability, e.g. twice as likely for boys. (1/170,000?)

Was the interpretation valid? No! One case, but "out of how many"? (Millions of families in the U.K. / World!)

"Prosecutor's Fallacy": conflating two different probabilities.

Royal Statistical Society: "approach is ... statistically invalid"

- Clark was eventually acquitted, on second appeal. (then died)
- The U.K. General Medical Council ruled that Meadow's evidence was "misleading and incorrect", constituting "serious professional misconduct". He was barred from future court work.
- Several other people's convictions were overturned on appeal.
- Prosecutors/judges everywhere learned a valuable lesson. (?)

A Related Case: Waneta & Tim Hoyt (New York)

Had five babies in 1965 – 1971. All died.
Ages (months): 3, 28, 1.5, 2.5, 2.5.

Pediatrician Alfred Steinschneider investigated, wrote 1972 article for journal *Pediatrics*.
Conclusion: "genetically-linked SIDS".

In 1977, they were allowed to adopt a son, who survived to adulthood.

In 1985, some prosecutors and pathologists got suspicious, and investigated. Eventually, Waneta Hoyt confessed to suffocating all five children, to stop them from crying.

She later "recanted" her confession, but was still convicted in 1985 of five murders. She died in prison in 1998 (age 52).

So, sometimes statistical evidence is indicative, even when you can't just multiply. It shouldn't necessarily be ignored.

The Cases Keep Coming: Kathleen Folbigg (Australia)

The Washington Post | Published June 4, 2023

Mother who served 20 years in deaths of 4 children freed after new evidence

Her trial in 2003 focused on her diary entries, in which Folbigg — now in her 50s — wrote she had "failed as a mother, a woman." Prosecutors argued that the deaths of four young children in a row could not be a tragic coincidence, and she was excoriated in the media. A jury convicted her of

In 2021, dozens of scientists — including two Nobel laureates — signed a petition urging the governor of New South Wales to pardon Folbigg, arguing that she was "wrongfully incarcerated" and that genetics may have caused the deaths. Geneticists have found rare mutations in the DNA of Folbigg and her daughters that can cause sudden death in infancy and childhood, and other variants found in her sons' DNA have also been connected to deaths in young children.

A Case I was Involved With: Leighton Hay

Accused of being 2002 murder accomplice.

Witnesses: Hair was "two inch picky dreads".

But Hay was shaved nearly bald when arrested.

Crown: He shaved his head after the crime!

Evidence: Tiny hair clippings in a garbage bin and on an electric shaver in his home.

Convicted in 2004. Fresh appeal in 2011.

Question: Were those clippings from a scalp?

Statistical data: Thickness of the clippings.

Fact: Scalp hairs are usually ≤ 125 microns thick, but beard hairs are often thicker. So what did that tell us?

My expert report: Of the 368 clippings collected, the number from a scalp was between 0 and 106 (29%), with the rest from a beard.

2013 SCC 61 judgment: New trial granted. Hay released from jail.

Another Case I was Involved With: Yuk Yuen Lee

Accused in 2013 of running a marijuana grow-up in Toronto.

Police seized 1378 + 2240 plants, all claimed to be marijuana.

However, they only actually tested 2 + 1 of them (!).

Convicted at trial, but what about the sentence?

If more than 500 plants, then mandatory three-year jail term.

My expert report: The testing was only sufficient to statistically conclude that at least 138 + 16 of the plants were marijuana.

2017 ONSC 2403 judgment: "Crown counsel took issue with respect to Professor Rosenthal's credibility. ... I did not find Professor Rosenthal lacking in credibility. His evidence was offered in the manner that one expects of an expert. ... I do not accept that the Crown has established the number of marijuana plants, thereby allowing the Crown to rely on the mandatory minimum."

Final sentence: Just the time already served in jail.

Final Words

- Statistics and probability have many important applications.
- Including to issues of law and justice and murder.
- But "improbable" does not imply "impossible".
- And murder might not be all that "remains".
- Have to consider the relative probabilities, even if unlikely.

CONCLUSION:

Statistical analysis can sometimes help achieve justice.

But it must be used carefully, with caution!

- My web page: www.probability.ca
- My book Struck By Lightning: www.probability.ca/sbl
- My justice-related article: www.probability.ca/justice
- My email: jeff@math.toronto.edu