Statistics and the Law

The Case of the Nonchalant Nurse

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k=8 incidents (cases of *unexplained* death/reanimation)

N=27 Nurses (# nursing positions in unit)

S=1029 total # of 8-hour Shifts

s=142 shifts of Lucia

F : Fact "each of incidents during Lucia's shifts"

LI : hypothesis "Lucia Innocent"

LG : hypothesis "Lucia Guilty"

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Elffers (for prosecution) : Suppose **LI** (Lucia Innocent)

Urn model : $S = 1029$ balls (shifts)

$s = 142$ black balls (Lucia's shifts)

$S - s = 887$ white balls

Draw at random $k = 8$ balls (shifts with incidents)

F: all balls drawn are black (all incidents in Lucia's shifts)

$$\Pr(\mathbf{F} \mid \mathbf{LI}) = (S\text{-}k)!\, s! \,/\, (s\text{-}k)!\, S! = 1.1 \times 10^{-7}$$

Correction & other facts $(\times 27 \times 0.07 \times 0.01) = 3 \times 10^{-9}$

This is not due to chance ! The rest is up to the court !

Judge (rechtbank den Haag) combines for each incident

- Statements of witnesses
- Toxicological evidence
- Statistical argument

and concludes that 8 (attempted) murders have been committed by Lucia and hands down a life sentence

Judge did not separate the questions :

(1) Were the incidents (attempted) murders ?
(2) If so, did Lucia commit them ?

Appeal Court (Gerechtshof Den Haag)
Meester, Van Lambalgen (for defence) :
"Elffers' analysis has little relevance"

- Attention was caught because something very improbable happened in a particular ward of a particular hospital. But there are many wards in many hospitals. Correcting by multiplying by N=27 is nonsense. Multiply by # nurses in the Hague, Netherlands, world, … ??

- Urn model is too special. e.g., different probability of incident during night and day, or for certain nurses? Was Lucia given more difficult shifts ?

Appeal Court completely muddled. Delete statistics (?)
She's guilty, 10 murders. Life sentence confirmed (+ *tbr*)

Supreme Court confirms sentence (– *tbr*)

Rule 1 of statistical consulting :
Discuss with client what the problem is and what the statistician can and cannot do. Don't just answer a single question but continue dialogue throughout decision process

Judge's single question : Can it be due to chance that all incidents occured while Lucia was on duty ?

Wrong question (see Meester)

Preliminary question : Were these incidents (attempted) murders ??

This is up to the judge to decide on the basis of

- Statements by witnesses
- Forensic (toxicological) evidence

but statistical analysis of data **F** cannot possibly help answer this

Judge should decide whether incidents are murder-(attempt)s on the basis of other evidence. No : Lucia should be acquitted. Yes : start thinking

Judge should also decide who are possible suspects, in this case (apparently) N nurses

M = event that 8 murders-(attempt)s took place. Now the statistician may assume that the event **M** took place and the murders were committed by one of N=27 nurses

Now Elffers' analysis is convincing !! It is the classical statistical test to solve this problem

- This hospital is not just one of many but the one where the murders occurred and Lucia is one of 27 suspects

- Differences between night and day, between nurses, ... , refer to natural deaths and these are murders

So if judge decides 8 murders (c.q. attempts) by a nurse, then a statistical test tells us Lucia is guilty

Interview of De Vos in leading Dutch newspaper

Aggressive Bayes !

Two possible hypotheses **LI** and **LG** with a priori probabilities Pr(**LI**) and Pr(**LG**)

$$\Pr(\mathbf{LG}) = \Pr(\text{random nurse starts murdering})$$
$$= 1/4 \times 10^{-5}$$

With this kind of prior belief you can kill any data :

$$\Pr(\mathbf{LI} \mid \mathbf{F}) = 0.088$$

De Vos: Lucia should be acquitted! Big newspaper scoop !

My conditional Bayesian analysis. If we know **M** we calculate conditionally on **M**

Prior probabilities :

$$\Pr(\mathbf{LG} \mid \mathbf{M}) = N^{-1} = 1/27, \quad \Pr(\mathbf{LI} \mid \mathbf{M}) = 1 - N^{-1} = 26/27$$

Conditional Bayes :

$$\Pr(\mathbf{LI} \mid \mathbf{F}, \mathbf{M}) \approx (N-1) \times 1.1 \times 10^{-7} = 3 \times 10^{-6}$$

(cf. frequentist result : $p = N \times 1.1 \times 10^{-7}$)

Once murders are established Pr(**LI**) and Pr(**LG**) are irrelevant (cf., OJ Simpson murder trial). De Vos' unconditional analysis is attempt to achieve the impossible

Conclusions so far:

- Elffers was a bit too vague when saying "the rest is up to you". The "client" has a right to more guidance. Eight murders needed to be proved first
- In this context Meester's objections were valid, but his claim that Elffers' analysis was irrelevant was not
- The guilty verdict can be defended if and only if the non-statistical evidence proves that the incidents were murder-(attempt)s. Elffers' analysis then proves the guilt of Lucia. Conditional Bayes confirms this result
- De Vos' analysis is just another attempt to achieve the impossible, i.e., to deal with this unconditionally

But the statistician should also ask …

- Is there proof of 8 murder-(attempt)s ?
- How were the data collected ?

Only two murders were "proved" and the proof is problematical. The data were selected rather than collected !

After a number of similar legal blunders, a revision is now being sought

Legal people should learn more than the law and we should advise them better