M362K Extra credit #1

Sally Clark

Please, provide your **complete solutions** to any problems appearing in this case study. Final answers only, even if correct will earn zero points. Likewise, partial credit will not be negotiable.

For short-answer questions, please provide between five and seven sentences touching the salient points of your argument.

1.1. **Introduction.** Here is an excerpt from [2] which introduces the tragic protagonist of this case study.

Sally Clark *(August 1964 – 15 March 2007) was an English solicitor who, in November 1999, became the victim of a miscarriage of justice when she was found guilty of the murder of her two infant sons. Clark's first son died in December 1996 within a few weeks of his birth, and her second son died in similar circumstances in January 1998. A month later, Clark was arrested and tried for both deaths. The defense argued that the children had died of sudden infant death syndrome (SIDS).*

1.2. **Meadow's Law.** Let's start with a the definition of SIDS (Sudden Infant Death Syndrome) which was in use at the time of the court case introduced above. According to [5], it was formulated by the American pathologist Beckwith, in 1969, and it reads as follows:

"the sudden death of a baby that is unexpected by history and in whom a thorough post-mortem examination fails to demonstrate an adequate cause of death".

In the United Kingdom, SIDS is habitually referred to as *"cot death"*. This is the term used in **Meadow's Law** - in the past frequently cited in court cases - which states that

"one cot death is a tragedy, two cot deaths is suspicious and, until the contrary is proved, three cot deaths is murder".

1.3. **Logical imperatives.** Our first task is to logically unpack the argument made by Roy Meadow in court. Please, consult [5] with a particular focus on the introduction. Which **two** concerns does the author raise? Explain each in your own words.

1.4. **In dubio pro reo.** As a warm up, start by solving the following simple problem.

Problem 1.1. A test is used to determine whether people exhibiting green spots have the *duckpox* or not. It is believed that at any given time 4% of people exhibiting green spots actually have the *duckpox*. The test is 99% accurate if a person actually has the *duckpox*. The test is 96% accurate if a person does **not** have the *duckpox*. What is the probability that a randomly selected person who tests positive for the *duckpox* actually has the *duckpox*?

In the previous (admittedly frivolous) example, we can recognize the ideas behind *sensitivity* and *specificity* as measures of quality of a test (see, e.g., [3]). A medical practitioner must be aware of the consequences of both false positive and false negative findings and should **make a conscious decision** about which to prioritize. Please, provide two scenarios, one in which *sensitivity* is to be prioritized and one in which *specificity* should be prioritized, in your opinion.

A logically closely related concept exists in the western legal practice. The idea of *in dubio pro reo* is explained in [1]. Explain in your own words the parallels between *sensitivity* vs. *specificity* and the possible errors when a verdict is reached in the court of law. Complete your explanation by tying this legal principle to the first concern raised in [5].

1.5. **The prosecutor's fallacy.** According to [10], the *prosecutor's fallacy* can be summarized as follows:

> *It's when the probability of innocence given the evidence is wrongly assumed to equal an infinitesimally small probability that that evidence would occur if the defendant was innocent.*

Create a probability tree modeling the above situation and clearly indicate which two probabilities are being confused.

Write your own numerical example - perhaps based on the problem above, or maybe based on one of the citations - in which you point out the difference in **scale** between the two numbers being confused.

1.6. **Single estimates vs. comparison of estimates.** In [5], the author posits that its incorrect to consider the probability of double SIDS in isolation. Tie this observation to the *prosecutor's fallacy* and provide a clear description in what was wrongly presented to the jury. You can draw inspiration from [4].

What comparison does the author of [5] suggest be used instead? Explain clearly why the author makes a **conscious decision** to restrict the outcome space.

1.7. **Single probability estimate.** According to the data collected through the CESDI study as described in [5], what was the probability of a single cot death?

Why is the above figure different from the one used for a **single cot death** by Roy Meadow during the Sally Clark trial?

1.8. **The independence assumption.** Write down the definition of **independence** of two events.

Explain how Roy Meadow used the **independence** assumption in his reasoning in court. At what number did he arrive?

What was the verdict in the original Sally Clark trial - influenced largely by Roy Meadow's testimony?

Why is the assumption of independent, identically probable events erroneous in this context? You may consult [9] to bolster your reasoning.

1.9. **Epilogue.** What were the consequences and aftermath of the Sally Clark case? Were there appeals and in what judgement did they result? What were the reasons provided? Find at least one specific relevant **quote** by a court official.

What happened to Sally Clark?

Was this trial an isolated case or was *Meadow's law* utilized more widely? Provide at least one more example of a court case in which Meadow's law - despite being erroneous - was used. Explain the mathematical fallacy behind the original verdict in the example you found and state whether the verdict was eventually overturned. *Hint:* The stunning case of Kathleen Folbigg will prove fascinating to those of you with interest in genetics.

1.10. **How to improve the model and reasoning?** Provide one way in which the **reasoning** could be improved as compared to the original trial and Meadow's testimony. You are welcome to use [5] for inspiration.

Provide **your own** idea about a modification to the model or approach that would be an improvement on the original treatment by Roy Meadow. Explain **in mathematical terms** why you think your model or approach would constitute an improvement.

1.11. **Further reading.** For more about the randomness around us and how to understand it better, look into [7]. For a more specific treatment of ethics in its relation to probability, I suggest [6]. For an even more specific array of applications, I suggest [8]. All these books are available in the UT libraries with the latter two available as online copies.

References

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7. Leonard Mlodinow, *The drunkard's walk : how randomness rules our lives*, 1st ed. ed., Pantheon Books, New York, 2008 (eng).
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