How things go wrong and how we can do statistics better

Data Analysis for Decision-Making

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1 Introduction

Statistics have the power to guide decisions, shape policies, and enhance our understanding of the world. However, when misused or misinterpreted, they can lead to misconceptions, faulty conclusions, and unintended consequences. It's important to emphasize that data ethics plays a pivotal role in shaping how to handle and interpret data. By adhering to core principles such as fairness, transparency, honesty, reproducibility, and reliable communication, we can foster trust and integrity in data practices. This handout examines how things can go wrong with statistics and offer practical strategies for doing statistics better. It complements my presentation and provides additional insights on the topic, drawing key insights from chapters 13 and 14 from *The Art of Statistics Learning from Data* by Spiegelhalter (2019).

2 Producers: Ensure Trustworthy and Reproducible Science

To enhance the quality and integrity of scientific work, two key goals must be prioritized: trustworthiness and reproducibility. Reproducibility refers to the ability of others to replicate the results of a study by having access to the original data, methods and results. Trustworthiness, on the other hand, focuses on presenting the data in a clear and transparent manner. Enabling others to critically evaluate the validity of the conclusions drawn from the research. Below are key actions that contribute to this effort:

- Implementing a standardized framework and measure to optimize scientific processes, as outlined by Munafò et al. (2017, pp. 2–7) in *Manifesto for Reproducible Science*.
- Share raw datasets and code with appropriate documentation, facilitated through platforms like the project-management-tool Open Science Framework (2024)
- Adhere to standards such as FAIR principles (findable, accessible, interoperable, and reusable) by Wilkinson et al. (2016, p. 4).
- Ensure referees should not only check for compliance with journal requirements but encourage honest reporting, as highlighted by Simmons et al. (2011, p. 1363).
- Employ robust statistical methodologies, and clearly explain assumptions and limitations, and
- Avoid cherry-picking study design, hypotheses, and analyses that support only a desired narrative.

3 Communicators: Resist Standard Narraives

Statistics often fail to conform to conventional narrative structures, leading to widespread distortions or or misinterpretations when simplified for mass consumption. To mitigate this, communicators should:

- Avoid oversimplifying complex statistical findings for the sake of coherence.

- Highlight uncertainties and nuances rather than focusing solely on a single number or outcome.
- Use visualizations effectively but responsibly, avoiding misleading scales or representations.
- Collaborate with statisticians to ensure accurate communication.

3.1 Publication Bias

A common occurring issue that undermines the reliability of scientific findings is the publication bias. Systematic reviews, which synthesize results from published studies, are particularly vulnerable to this bias. It occurs when studies with negative or null results are less likely to be published, while questionable research practices inflate the prevalence of significant findings. As a result, the literature may present a distorted view of the evidence, potentially leading to incorrect conclusions. To mitigate this issue, statistical methods for detecting publication bias, such as those developed by Simonsohn (2014), have been introduced to help identify and correct for the distortion of the scientific record.

4 Trustworthiness in Data

Trustworthiness in data is crucial, and it requires more than just presenting raw information. To be trustworthy, data must meet four key criteria: it should be accessible, intelligible, assessable, and usable. The Table 1 outlines these essential aspects for ensuring data reliability and transparency, based on O'Neill (2013).

Table 1: Criteria for Demonstrating Trustworthiness in Data (O'Neill, 2013)

Criterion	Explanation
accessible	audiences should be able to get at the information.
intelligible	audiences should be able to understand the information.
assessable	audiences should be able to check the reliability of the claims.
useable	audiences should be able to exploit the information for their needs.

When confronted with claims based on statistical evidence, it's important to critically assess their trustworthiness. First, evaluate the **trustworthiness of the numbers** by considering how rigorously the study was conducted, including sample size, randomization, and control groups. Check for statistical uncertainty, such as margins of error and confidence intervals, and ensure the data is summarized accurately. Next, examine the **the trustworthiness of the souce**. Is it from a credible, unbiased source? Look for potential conflicts of interest, and ensure the publication is peer-reviewed. Be cautious of emotional appeals, exaggerated headlines, or misleading visuals. Also, think about what information might be missing or left out to support the story. Finally, consider the **the trustworthiness of the interpretation** of the findings. Does the claim align with other research or historical data? Is the study applicable to a broader population, or is it limited to a specific group? Assess whether the claimed effect is practically significant, particularly when discussing risks. These steps help ensure the statistical claim is reliable and accurately represented.

4.1 Ten Simple Rules for Navigating Statistics

In an effort to simplify and clarify the complexities of statistics, Kass et al. (2016, pp. 1–7) presents a set of key guidelines designed to improve understanding and application of statistical principles. The following rules serve as a practical framework to guide anyone through the often daunting world of statistics:

1. Use statistics to answer scientific questions: Focus on the purpose behind your analysis rather than just picking a method.
2. Recognize that signals come with noise: The challenge lies in distinguishing meaningful patterns from random variability, which is why probability models are invaluable.
3. Plan thoroughly and early: In confirmatory studies, predefine your approach to avoid introducing bias or unnecessary flexibility.
4. Prioritize data quality: The foundation of any statistical work is reliable, well-gathered data.
5. Go beyond calculations: Understand the reasoning behind the formulas and software outputs instead of blindly applying them.
6. Favor simplicity: Communicate findings in a straightforward manner, resorting to complex methods only when essential.
7. Quantify uncertainty: Remember that reported margins of error often underestimate the true variability.
8. Validate your assumptions: Clearly state your assumptions and acknowledge any limitations in verifying them.
9. Encourage replication: Replicate your findings or promote replication by others to confirm results.
10. Ensure reproducibility: Share your data and methods so others can repeat and verify your analysis.

5 References

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