

# Statistical Inference

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## 1 Inference

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**Definition 1.1** (Statistical inference). Statistical inference is the process of analyzing data in order to learn about the shape and structure of a probability distribution. <sup>1</sup>

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Statistical inference typically consists of two steps:

1. fitting a statistical model to data
  2. summarizing our uncertainty about the parameters of the fitted model based on the data (and our prior beliefs).
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There are two predominant paradigms for statistical inference:

1. Bayesian inference<sup>2</sup>
2. Frequentist inference<sup>3</sup>

### 1.1 Interpretation of Negative Findings

If an estimation interval includes the null hypothesis, or equivalently if a hypothesis test fails to reject the null hypothesis, that doesn't *necessarily* mean that the null hypothesis is true. Accordingly, we should not write interpretations of results as “the odds (or risks/hazards/means) are not significantly different”; instead, we should write something like “the data does not provide statistically significant EVIDENCE that the odds (or analogous estimands) differ”. Statistical significance is a characteristic of evidence, not of the estimands.

P-values do not distinguish between absence of evidence and evidence of absence.

Confidence intervals do: if the confidence interval is narrow and includes the null value, then that confidence interval represents evidence of absence. If a confidence interval includes the null value but also includes substantially non-null values, then that confidence interval represents absence of evidence.

Also, even if we do have statistically significant evidence of a non-null value, the estimated value may not be **substantially different from 0**, depending on what estimand is. For example, we might have statistically significant evidence that a certain exercise prolongs human lifespans by 20 seconds, but that effect would probably not be substantially different from 0 in practical terms.

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<sup>1</sup>I adapted this definition from Wikipedia's (Wikipedia contributors 2025).

<sup>2</sup>[intro-bayes.html#sec-bayes](https://intro-bayes.html#sec-bayes)

<sup>3</sup>[intro-MLEs.html#sec-intro-MLEs](https://intro-MLEs.html#sec-intro-MLEs)

(Evidence of difference)  
 (absence of evidence)  
 (evidence of absence) (substantial, but imprecise)  
 uncertainty  
 (whether negligible or substantial)  
 (1.02-1.1) (1.7-1.8)  
 evidence of substantial effect  
 evidence of negligible effect  
 age [period]  
 trending toward significance  
 but know nothing not enough data

Death rate  
 f Pareto  
 $\beta$  baseline  
 $\beta$

Peri  
 baseline  
 Peri  
 not

See also Vittinghoff et al. (2012) §3.7 (p64).

## 1.2 Confidence intervals

**Definition 1.2** (margin of error). The **margin of error** (a.k.a. the **radius**) is one-half the width of a confidence interval.

more:

- Anatomy of a confidence interval (text)<sup>4</sup>
- <https://www.youtube.com/watch?v=vq1KrE7gU5M>

Vittinghoff, Eric, David V Glidden, Stephen C Shiboski, and Charles E McCulloch. 2012. *Regression Methods in Biostatistics: Linear, Logistic, Survival, and Repeated Measures Models*. 2nd ed. Springer. <https://doi.org/10.1007/978-1-4614-1353-0>.

Wikipedia contributors. 2025. “Statistical Inference — Wikipedia, the Free Encyclopedia.” [https://en.wikipedia.org/w/index.php?title=Statistical\\_inference&oldid=1304071803](https://en.wikipedia.org/w/index.php?title=Statistical_inference&oldid=1304071803).

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<sup>4</sup><https://wmed.edu/sites/default/files/ANATOMY%20OF%20A%20CONFIDENCE%20INTERVAL%20%28full%29.pdf>