

WS #21 - Ioannidis - most published research is false

Math 150, Jo Hardin

Monday, April 13, 2026

Your Name: _____

Names of people you worked with: _____

What is your favorite sea creature?

Task: As defined in Ioannidis, “Why Most Published Research Findings are False”

R:

$$R = \frac{\# \text{ true relationships}}{\# \text{ null relationships}} \quad \text{in the population}$$

TRUE:

$$\begin{aligned} P(\text{study is true}) &= \frac{\# \text{ true relationships}}{\# \text{ total}} \\ &= \frac{\# \text{ true relationships}}{\# \text{ true} + \# \text{ null}} \\ &= \frac{R(\# \text{ null relationships})}{R(\# \text{ null}) + \# \text{ null}} \\ &= \frac{R}{R + 1} \end{aligned}$$

size:

$$\begin{aligned} \alpha &= P(\text{type I error}) \\ &= P(\text{reject } H_0 | H_0 \text{ true}) \end{aligned}$$

power:

$$\begin{aligned} 1 - \beta &= P(\text{reject } H_0 | H_0 \text{ false}) \\ \beta &= P(\text{type II error}) \\ &= P(\text{not reject } H_0 | H_0 \text{ false}) \end{aligned}$$

Research Finding	True relationship		Total
	Yes	No	
Yes	5.	4.	7.
No	3.	6.	8.
Total	1.	2.	c

tests:

$$c = \# \text{ of tests run}$$

Fill in the table (hint: I put numbers to suggest what I think is the easiest order for filling in the table). Find PPV (positive predictive value) = probability that the positive result is actually true.

Solution:

Research Finding	True relationship		
	Yes	No	Total
Yes	$c(1 - \beta)R/(R + 1)$	$c\alpha/(R + 1)$	$c(R + \alpha - \beta R)/(R + 1)$
No	$c\beta R/(R + 1)$	$c(1 - \alpha)/(R + 1)$	$c(1 - \alpha + \beta R)/(R + 1)$
Total	$cR/(R + 1)$	$c/(R + 1)$	c

$$\begin{aligned}
PPV &= \frac{c(1 - \beta)R/(R + 1)}{c(1 - \beta)R/(R + 1) + c\alpha/(R + 1)} \\
&= \frac{c(1 - \beta)R}{c(1 - \beta)R + c\alpha} \\
&= \frac{(1 - \beta)R}{(1 - \beta)R + \alpha} \\
&= \frac{1}{1 + \alpha/(1 - \beta)R}
\end{aligned}$$

$$\begin{aligned}
PPV &> 0.5 \text{ more likely true} \\
\text{iff } (1 - \beta)R &> (R - \beta R + \alpha)0.5 \\
(1 - \beta)R0.5 &> \alpha0.5 \\
(1 - \beta)R &> \alpha
\end{aligned}$$

$$\begin{aligned}
PPV &< 0.5 \text{ more likely false} \\
\text{iff } (1 - \beta)R &< \alpha
\end{aligned}$$