

Exercises day 1 – Power and Sample size

Sample size

```
library(tidyverse)
library(pwr)
library(pwrss)
```

Exercise 1.

In a study evaluating a new neonatal intensive care unit (NICU) care model, referred to as the MNICU, compared with the traditional NICU model, stress levels among mothers and neonates admitted to the two units will be compared. The primary outcome is salivary cortisol concentration as a biomarker of stress.

Previous studies by Milica Rancovic et al. (2016), Evalotte Morelius et al. (2005), and Sze m Ng et al. (2017) provide relevant estimates for mean cortisol levels and variability. Reported values were:

Maternal salivary cortisol: 57 ± 15 ng/mL versus 52.7 ± 15 ng/mL (mean $\pm$ SD)

Neonatal salivary cortisol: 10 ± 4 ng/mL versus 8 ± 4 ng/mL (mean $\pm$ SD)

Assuming a two-sided significance level of $\alpha = 0.05$ and a statistical power of 90% ($\beta = 0.10$), estimate the required sample size per group and the total sample size needed to detect differences in mean salivary cortisol levels between the NICU and MNICU groups for both mothers and neonates. Calculate and interpret the standardized effect size (Cohen's d). Would you consider the effect small, medium, or large?

Sample size for studying maternal stress

? pwr.t.test

Parameters

```
m1 <- 57          # Mean Maternal NICU
m2 <- 52.7        # Mean Maternal MNICU
sd <- 15          # SD Maternal cortisol
power <- 0.90     # Study power
alpha <- 0.05     # Significance level
```

```
d = (m1 - m2) / sd # Effect size (Cohen's d)
```

```
maternal_ss <- pwr.t.test(
  d = d,
  power = power,
  sig.level = alpha,
  type = "two.sample",
```

```
alternative = "two.sided"  
)
```

maternal_ss

Use a similar code for neonatal stress.

Repeat the calculations for both maternal and neonatal stress but set the power to 80%. Before you do the calculations, what are your expectations, will the necessary sample size increase or decrease?

How would the required sample size change if the significance level were reduced from 0.05 to 0.01?

Why is the required sample size different for mothers and neonates?

Exercise 2

In a cohort study investigating risk factors associated with acute pancreatitis, alcohol consumption is the primary exposure of interest. The expected proportion of acute pancreatitis in the non-alcoholic group is 0.001 (1 per 1,000 individuals), whereas the expected proportion in the alcoholic group is 0.05 (5%).

The study objective is to compare the incidence proportions of acute pancreatitis between the alcoholic and non-alcoholic groups. The prevalence of alcohol use in the cohort is assumed to be 25%, resulting in an allocation ratio of 3:1 between non-alcoholic and alcoholic participants (approximately 3 non-alcoholic participants for every 1 alcoholic participant, i.e., allocation ratio $n_1:n_2 = 3:1$).

Assuming a significance level of $\alpha = 0.05$ and a desired statistical power of 90%, estimate:

1. The required sample size for the non-alcoholic group.
2. The required sample size for the alcoholic group.
3. The total sample size required for the study.
4. Assuming a 10% loss to follow-up, how many participants should be recruited?

```
library(pwrss)  
? power.z.twoprops
```

Parameters

```
p1 <- 0.001 # Proportion with acute pancreatis in non-alcoholics  
p2 <- 0.05  # Proportion with acute pancreatis in alcoholics  
power <- 0.90 # Study power  
alpha <- 0.05 # Significance level  
ratio <- 3    # Ratio non-alcoholics (n1) / alcoholics (n2)
```

```
power.z.twoprops(
```

```

prob1 = p1,
prob2 = p2,
alpha = alpha,
power = power,
n.ratio = ratio
)

```

Power

Exercise 3.

For question 1, we have collected data from 200 participants in total (100 per group), assuming the same estimate for the means. What is the power of the study regarding maternal stress and neonatal stress?

Study power for studying maternal stress

Parameters (fill in all parameters)

```
m1 <- ??
```

```
m2 <- ??
```

```
sd <- ??
```

```
n <- ??
```

```
alpha <- ??
```

```

maternal_p <- pwr.t.test(
  d = (m1 - m2) / sd, # Effect size (Cohen's d)
  n = n,
  sig.level = alpha,
  type = "two.sample",
  alternative = "two.sided"
)

```

maternal_p

Similar code for neonatal stress.

Exercise 4.

For the study of maternal stress: plot a power curve by varying the sample size per group from 10 to 300 (corresponding to a total sample size from 20 to 600) and observe how the power changes. How large sample size is needed for a power of 80%? How large sample size is needed for a power of 90%? Explain why the power curve begins to flatten at larger sample sizes.

```
mean1 <- 57
```

```
mean2 <- 52.7
```

```
sd <- 15
```

```
d <- abs(mean1 - mean2) / sd
```

```
# Sample sizes per group
```

```
n_seq <- seq(10, 300, by = 10)
```

```
# Power calculation
```

```
power_df <- tibble(n = n_seq) %>%
```

```
  mutate(
```

```
    power = map_dbl(
```

```
      n,
```

```
      ~ pwr.t.test(
```

```
        n = .x,
```

```
        d = d,
```

```
        sig.level = 0.05,
```

```
        type = "two.sample",
```

```
        alternative = "two.sided"
```

```
      )$power
```

```
    )
```

```
  )
```

```
# Plot
```

```
power_plot <- ggplot(power_df, aes(x = n, y = power)) +
```

```
  geom_line(linewidth = 1) +
```

```
  theme_minimal()
```

```
power_plot
```

```
# Add text, 80% power red line, and points
```

```
power_plot <- power_plot +
```

```
  geom_hline(yintercept = 0.80, linetype = "dashed", colour = "red") +
```

```
  labs(
```

```
    x = "Sample size per group",
```

```
    y = "Power",
```

```
    title = "Power for Two-Sample t-test",
```

```
    subtitle = sprintf(
```

```
      "Means = %.1f vs %.1f, SD = %.1f (d = %.3f)",
```

```
      mean1, mean2, sd, d
```

```
    )
```

```
  ) +
```

```
  geom_point(size = 2)
```

```
power_plot
```

Exercise 5.

For question 2, with data collected from 500 participants in total, Given a 3:1 allocation ratio, first determine the number of alcoholic participants (n_2) and non-alcoholic participants (n_1). What is the power of the study?

Parameters

Set parameter names and corresponding values

```
power.z.twoprops(  
  prob1 = p1,  
  prob2 = p2,  
  alpha = alpha,  
  n2 = n2,  
  n.ratio = ratio  
)
```

Exercise 6.

Plot a power curve for the previous question by varying the total sample size from 100 to 1000 and observe how the power changes. How large sample size is needed for a power of 80%? How large sample size is needed for a power of 90%?

Parameters

Set parameter names and corresponding values

Power calculation

```
power_df <- tibble(n = n_seq) %>%  
  mutate(  
    power = map_dbl(  
      n,  
      ~ power.z.twoprops(  
        prob1 = p1,  
        prob2 = p2,  
        alpha = alpha,  
        n2 = .x,  
        n.ratio = ratio  
      )$power  
    )  
  )
```

Plot

```
power_plot <- ggplot(power_df, aes(x = n, y = power)) +  
  geom_line(linewidth = 1) +  
  theme_minimal()
```

power_plot

```

# Add text, 80% power red line, and points
power_plot <- power_plot +
  geom_hline(yintercept = 0.80, linetype = "dashed", colour = "red") +
  labs(
    x = "N alcoholics",
    y = "Power",
    title = "Power for a Two-Sample Proportions Test",
    subtitle = sprintf(
      "p1 = %.3f, p2 = %.3f, Ratio = %.0f",
      p1, p2, ratio
    )
  ) +
  geom_point(size = 2)

```

power_plot

Exercise 7.

Which parameter has the largest impact on required sample size:

- effect size
- significance level
- power
- variability

Explain your reasoning.