

3 Primary Scientific Question

What sample size do we need in order to produce a study with a statistically significant result?

4 Data Example, Continuous Data, Power 50 %

An essential part of clinical studies is the question, how many subject need to be studied in order to answer the studies' objectives. As an example, we will use an intended study that has an expected mean effect of 5, and a standard deviation (SD) of 15.

What required sample size do we need in order to obtain a significant result, or, in other words, to obtain a p-value of at least 0.05.

- A. 16,
- B. 36,
- C. 64,
- D. 100.

A suitable equation to assess this question can be constructed as follows. With a study's t-value of 2.0 SEM-units (SEM = standard error of the mean), a significant p-value of 0.05 will be obtained. This should not be difficult for you to understand, when you think of the 95 % confidence interval of the mean of a study being between - 2 and +2 SEM-units (Chap. 13).

We assume

$$\begin{aligned} \text{t-value} &= 2 \text{ SEMs} \\ &= (\text{mean study result}) / (\text{standard error}) \\ &= (\text{mean study result}) / (\text{standard deviation} / \sqrt{n}) \end{aligned}$$

(n = study's sample size)

From the above equation it can be derived that

$$\begin{aligned} \sqrt{n} &= 2 \times \text{standard deviation (SD)} / (\text{mean study result}) \\ n &= \text{required sample size} \\ &= 4 \times (\text{SD}/(\text{mean study result}))^2 \\ &= 4 \times (15 / 5)^2 = 36 \end{aligned}$$

Answer B is correct.

You are testing here whether a result of 5 is significantly different from a result of 0. Often two groups of data are compared and the standard deviations of the two groups have to be pooled (see Chap. 7). As stated above, with a t-value of 2.0 SEMs a significant result of $p = 0.05$ will be obtained. However, the power of this study is

only 50 %, indicating, that you will have a power of only 50 % (= the chance of an insignificant result the next time you perform a similar study).

5 Data Example, Continuous Data, Power 80 %

What is the required sample size of a study with an expected mean result of 5, and SD of 15, and, that should have a p-value of at least 0.05 and a power of at least 80 % (power index = $(z_{\alpha} + z_{\beta})^2 = 7.8$).

- A. 140,
- B. 70,
- C. 280,
- D. 420.

An adequate equation is the following.

$$\begin{aligned} \text{Required sample size} &= \text{power index} \times (\text{SD}/\text{mean})^2 \\ &= 7.8 \times (15 / 5)^2 = 70 \end{aligned}$$

If you wish to have a power in your study of 80 % instead of 50 %, you will need a larger sample size. With a power of only 50 % your required sample size was only 36.

6 Data Example, Continuous Data, Power 80 %, Two Groups

What is the required sample size of a study with two groups and a mean difference of 5 and SDs of 15 per Group, and that will have a p-value of at least 0.05 and a power of at least 80 % (Power index = $(z_{\alpha} + z_{\beta})^2 = 7.8$).

- A. 140,
- B. 70,
- C. 280,
- D. 420.

The suitable equation is given underneath.

$$\begin{aligned} \text{Required sample size} &= \text{power index} \times (\text{pooled SD})^2 / (\text{mean difference})^2 \\ (\text{pooled SD})^2 &= \text{SD}_1^2 + \text{SD}_2^2. \\ \text{Required sample size} &= 7.8 \times (15^2 + 15^2) / 5^2 = 140. \end{aligned}$$

The required sample size is 140 patients per group. And so, with two groups you will need considerably larger samples than you will with 1 group.

7 Conclusion

When writing a study protocol, just pulling the sample size out of a hat gives rise to (1) ethical, (2) scientific, and (3) financial problems. An essential part of preparing clinical studies is the question, how many subject need to be studied in order to answer the studies' objectives. Equations are provided, that can be used for the purpose.

8 Note

More background, theoretical and mathematical information of sample size requirements is given in *Statistics applied to clinical studies* 5th edition, Chap. 6, Springer Heidelberg Germany, 2012, from the same authors.