Web-Based Sample Size Calculation

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Learning Objectives

- Familiarize the audience with basic power calculations, sample size concepts and terminology
- Introduce commonly used power calculation methodology
- Describe and illustrate the benefits of careful power and sample size analysis

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The need for sample size

- Why do we need sample size calculation?
  - too small sample
  - too large sample
  - we need an optimal sample size
- Optimal sample size
  - there are many different optimality criteria for sample size calculations (the desired width of a confidence interval, or the desired power against some treatment effect)
- The optimality criteria for sample size calculation comes from the research question. In this presentation we consider two possibilities:
  - Continuous outcome; comparing means between 2 groups
  - Binary outcome; comparing proportions of between 2 groups

Ingredients of sample size

- The null hypothesis
- Alternative hypothesis
- Statistical method for testing the null
- Significance level
- Statistical power
- Sample size formula

The null hypothesis

- The statistical null hypothesis is formulated on the basis on the research question.

- Consider the research question "Is the weight management therapy A more effective than the well established weight management therapy B"?

- This research question leads to the following null hypothesis "H_0: $W_A = W_B$", where W_A is the group mean weight change after 12 months of therapy A and W_B is the group mean weight change after 12 months of therapy B. Here we have a clear outcome W (the weight change in a 12 month period).

The alternative hypothesis

- Obviously, we expect that the new therapy A will be more effective as the previously available therapy B.
- The question remains: What does it mean “More effective”? We needed to define a minimal clinically relevant improvement in weight change, suppose d.
- Then, we formulate the alternative hypothesis H_A: W_A-W_B=d.
- If for example, we want to see an improvement of 5 lbs, then H_A: W_A-W_B=5.

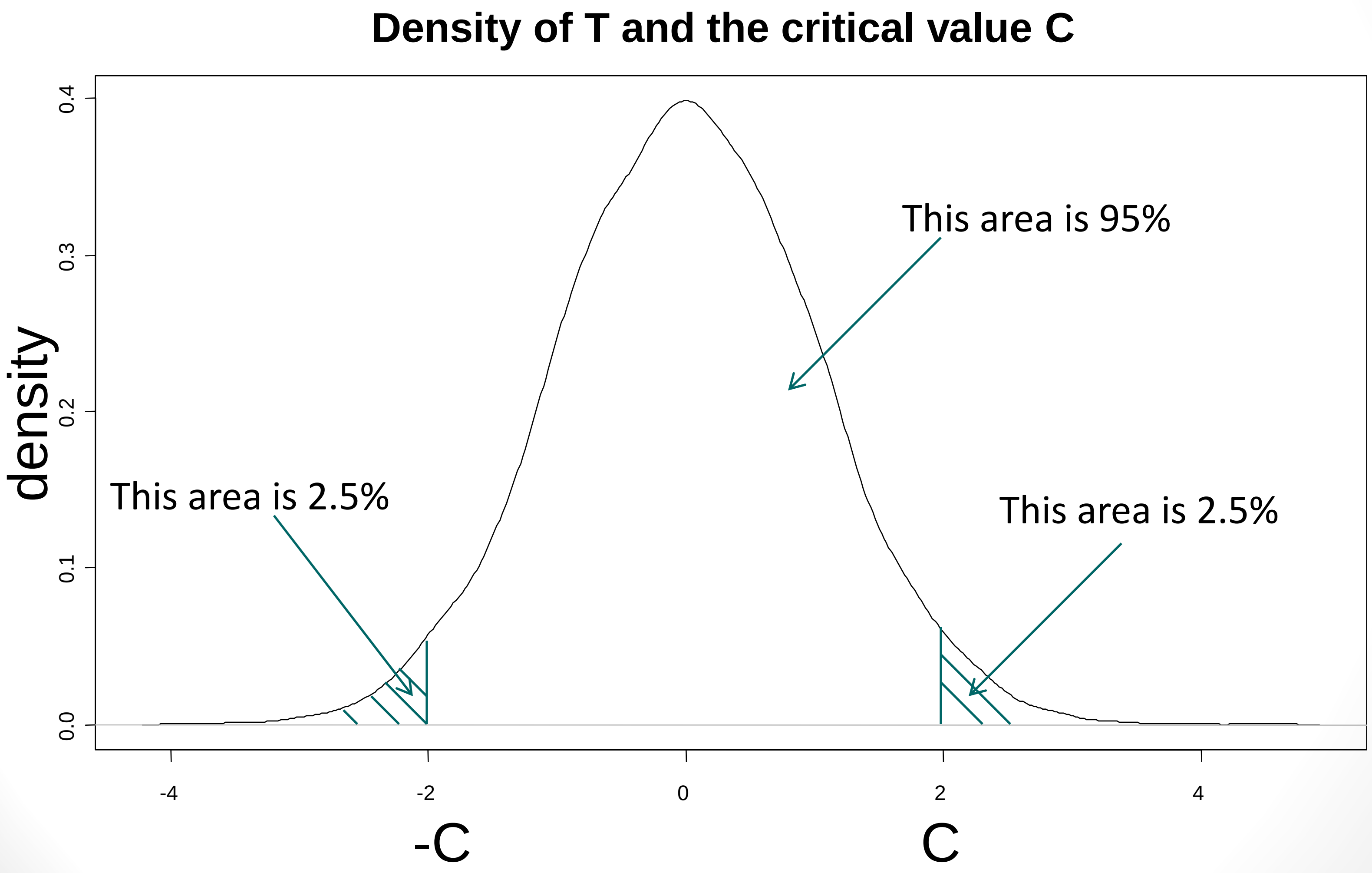
Statistical method for testing the null

- What method is to be used for comparing mean group changes? The two sample t-test is a popular solution.
- The two sample t-test tests the *simple* null hypothesis H_0: $W_A = W_B$ (no difference between therapies)
- The two sample t-test calculates the test statistic T and the test is performed with comparing this T against a critical value C.
- If $T > C$ or $T < -C$ the null hypothesis H_0 is rejected in favor of the alternative H_A , otherwise we “fail to reject the null”
- Where does this C comes from? Significance level!

Significance level

- Significance level defines the probability of type I error. The error that “the null hypothesis is rejected when it actually is true”
- Significance level is usually = 5%, which for the two sample t-test defines a critical value of approximately 2. More accurate values are tabulated in books or can be calculated using a statistical software.
- Significance level defines a *critical region* (the values of T when H_0 is rejected). In our case T< -C and T> C is the critical region.

Significance level



Statistical Power

- Statistical power is the probability to reject H_0 if the alternative H_A is true. Power is usually defined against a simple alternative hypothesis.
- For example, if H_A: W_A-W_B = d then the probability that we will be able to claim that the groups are different is the POWER
- This d is called *the effect size.*
- In sample size calculations POWER is traditionally = 80%

Sample size formula

- For the two-sample t-test the formula for sample size is

$$N = 4\sigma^2 \frac{7.85}{d^2}$$

- In this formula we assumed that the significance level = 5%, POWER=80%, d is selected a minimally clinically relevant effect size… the problem is in σ.
- The σ is usually unknown and is estimated from a pilot data, or extracted from literature review, or estimate from a previously completed study with similar outcomes.

Example: Weight management (1)

- Suppose we are designing a study to compare a new weight management therapy A with a previously established therapy B.
- Previous therapy is known to reduce weight (on average) by 5 lbs after 3 months on this therapy. From a previous study we know that the standard deviation of this reduction is 5 lbs ($\sigma=5$) .
- We expect that our new therapy will decrease the weight by 10 lbs in 3 month. Then, d=10 – 5 = 5 lbs.
- Then the null hypothesis is H_0: $W_A = W_B$
- Then the alternative hypothesis is H_A: $W_A - W_B = 5$

Example: Weight management (2)

- The use of our sample size formula leads to

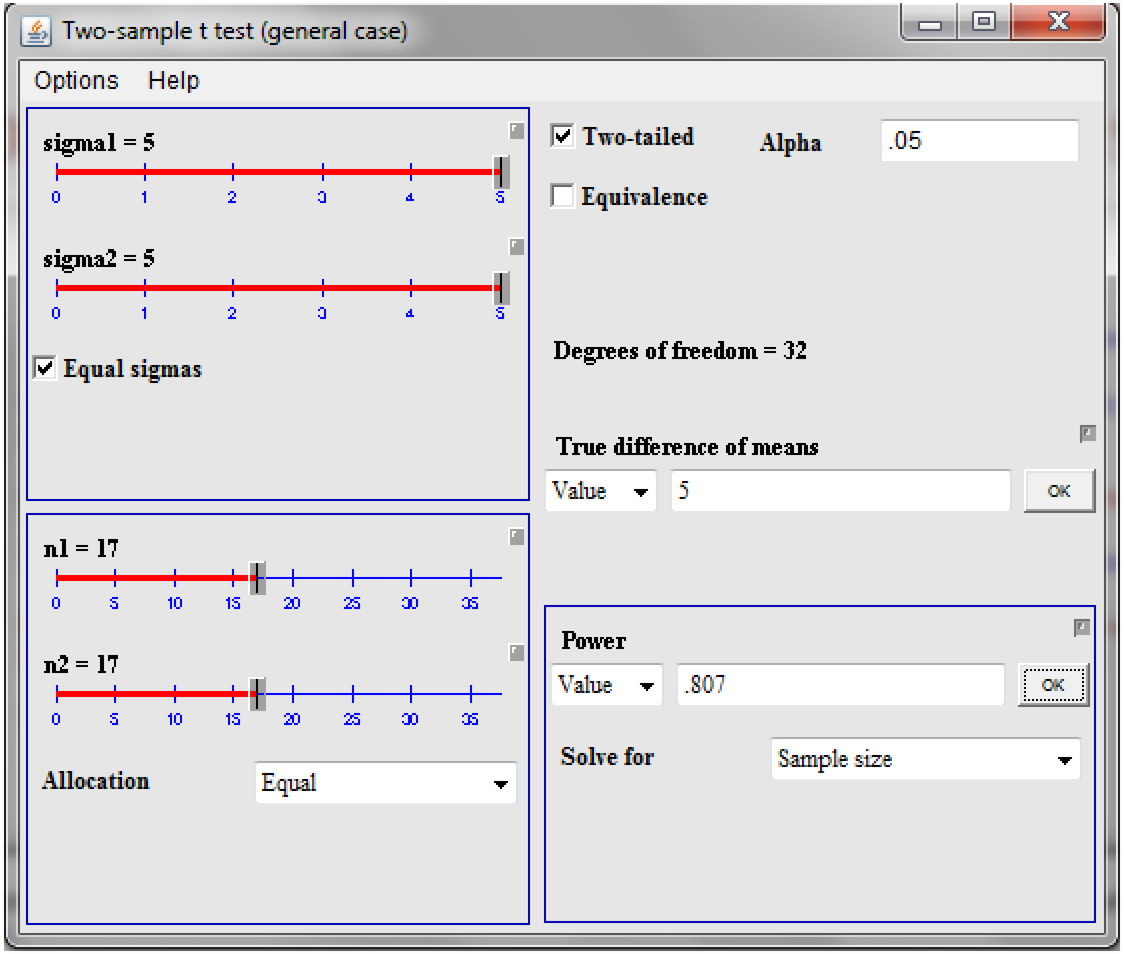
$$N = 4\sigma^2 \frac{7.85}{d^2} = 4 \cdot 5^2 \frac{7.85}{5^2} = 31.4$$

- This means that we will need to enroll 32 subjects into the study and randomize them: 16 to one group and 16 to another group. This sample size secures approximately 80% power at 5% significance.
- The above formula is only a rough approximation of how many subjects we will need. Statistical software: standalone or WEB-based would give a more accurate sample size estimate.

Example – Two sample mean

- Consider http://www.stat.uiowa.edu/~rlenth/Power/
- Assume that the significance level is 0.05.
- Assume that we want to compare two independent group means.
  - The null hypothesis: $\mu 1 = \mu 2$
  - The alternative hypothesis: $\mu 1 \neq \mu 2$
- We want to detect at least 5 mean difference with SD 5 with 80% of statistical power in the weight management example.

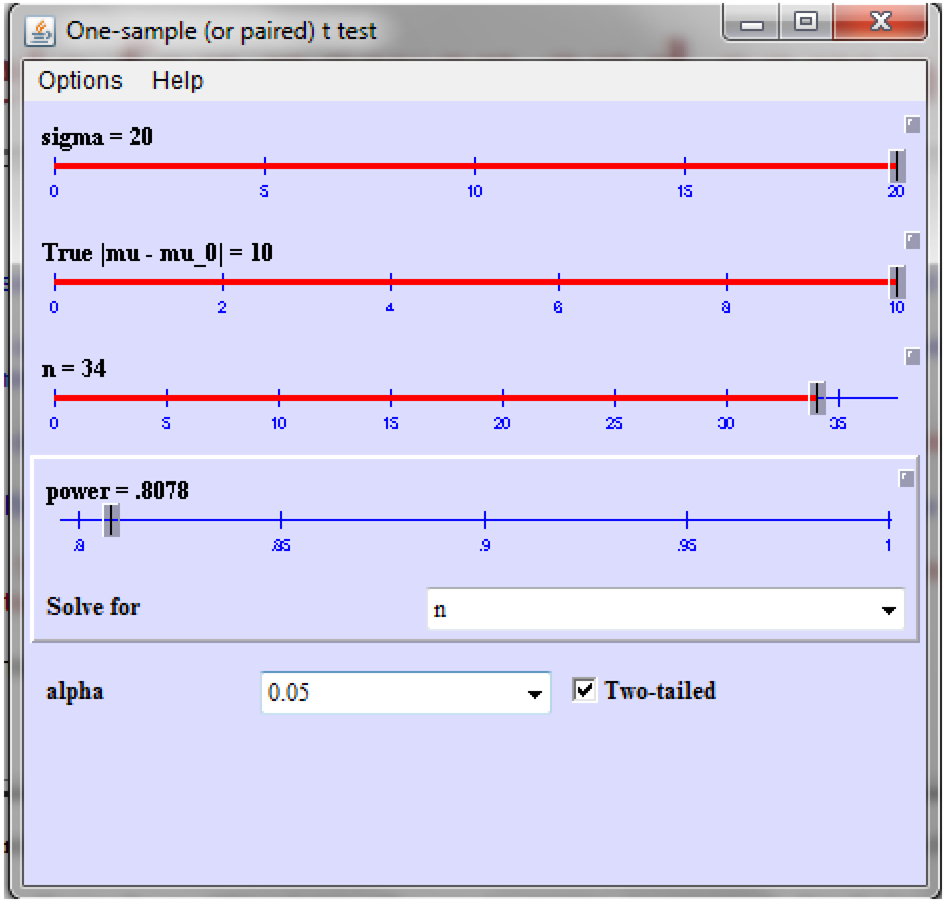
Example - continued



Example – One sample mean

- Assume that we want to test whether the group mean μ is equal to μ_0.
  - The null hypothesis: $\mu = \mu_0$
  - The alternative hypothesis: $\mu \neq \mu_0$
- Suppose that we want to test to see whether a new weight management therapy is effective in reducing weight.
- Suppose that the null hypothesis is that $\mu=130$.
- We want to detect at least 10 difference between μ and 130 with SD 20 with 80% of statistical power.

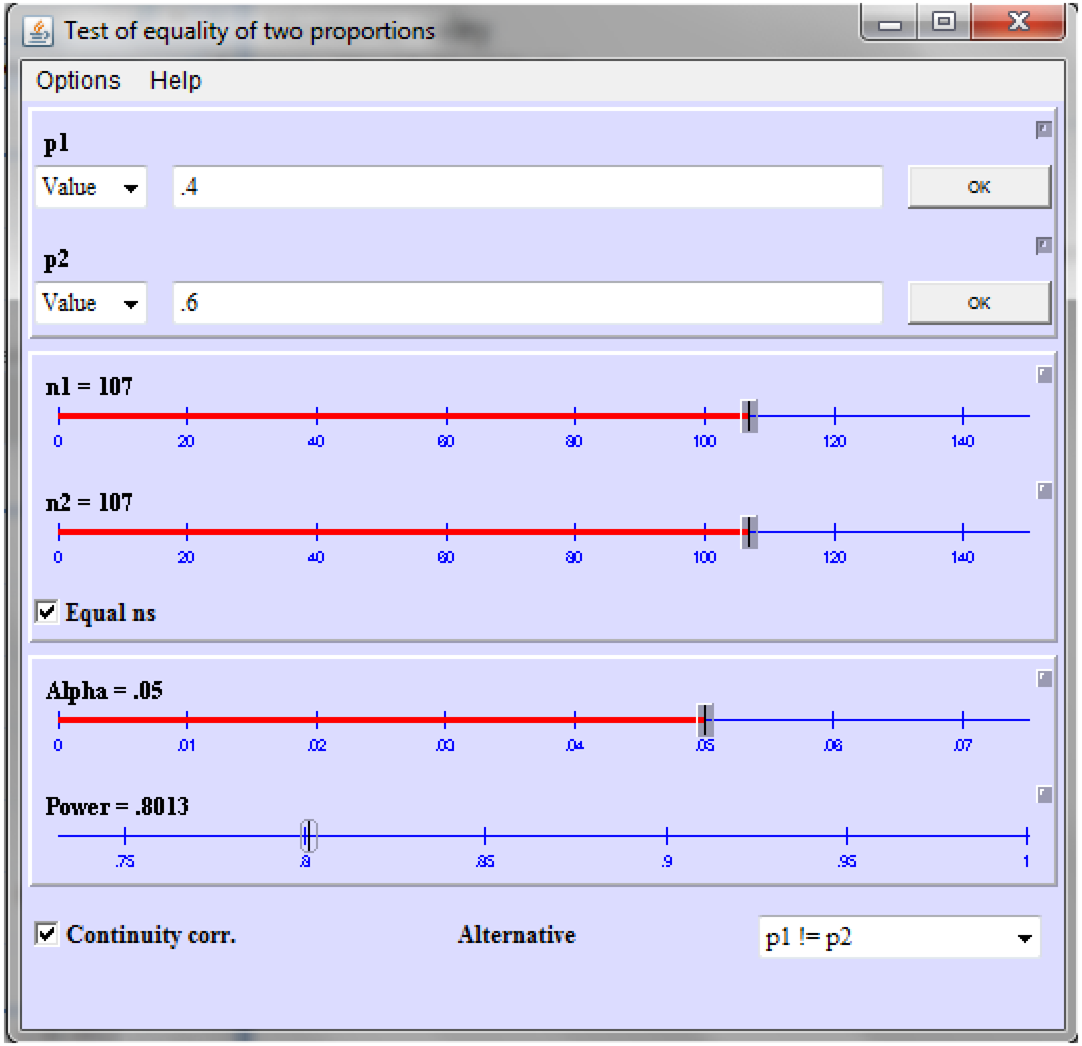
Example - continued



Example – Two proportions

- Assume that we want to compare two independent group proportions.
  - The null hypothesis: $p1 = p2$
  - The alternative hypothesis: $p1 \neq p2$
- We want to detect difference when $p1=0.4$ and $p2=0.6$ with 80% of statistical power.

Example - continued



Recommendation

- The Division of Biostatistics provides free consulting service including study design, sample size and power calculation, analysis, etc for MCW, Marquette, and UWM faculty and staff.
- Consulting service applications can be submitted here:
  - http://www.mcw.edu/biostatsconsult/ConsultingApplication/Application.htm

Thank You!!!

- Questions???