# BST225

## HW5

### 1a)

Calculate sample size using all these values, change values for one factor at one time and keep other factors the sampe; and make a sample size analysis table; then summarize how difference between u1 and u0, sigma and power affect sample size

```
for (power in c(0.95,0.9,0.85,0.8))
{
  for (sigma_1 in c(2.2,2.0,1.8))
  {
    for (sigma_2 in c(1.8))
    {
      for (mu1_min_mu2 in c(1.5,1.0,0.5))
      {

        n <- ((sigma_1^2 + sigma_2^2)/(mu1_min_mu2)^2)*(qnorm(0.05/2)+qnorm(1-power))^2
        print (sprintf("Power: %s  Sigma1: %s  Sigma2: %s  Mu1-Mu2: %s  Sample size: %s",  power, sigma_
      }
    }
  }
}
```

```
## [1] "Power: 0.95  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 47"
## [1] "Power: 0.95  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 105"
## [1] "Power: 0.95  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 420"
## [1] "Power: 0.95  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 42"
## [1] "Power: 0.95  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 94"
## [1] "Power: 0.95  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 376"
## [1] "Power: 0.95  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 37"
## [1] "Power: 0.95  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 84"
## [1] "Power: 0.95  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 337"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 38"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 85"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 340"
## [1] "Power: 0.9  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 34"
## [1] "Power: 0.9  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 76"
## [1] "Power: 0.9  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 304"
## [1] "Power: 0.9  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 30"
## [1] "Power: 0.9  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 68"
## [1] "Power: 0.9  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 272"
## [1] "Power: 0.85  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 32"
## [1] "Power: 0.85  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 73"
```

```
## [1] "Power: 0.85  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 290"
## [1] "Power: 0.85  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 29"
## [1] "Power: 0.85  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 65"
## [1] "Power: 0.85  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 260"
## [1] "Power: 0.85  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 26"
## [1] "Power: 0.85  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 58"
## [1] "Power: 0.85  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 233"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 28"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 63"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 254"
## [1] "Power: 0.8  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 25"
## [1] "Power: 0.8  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 57"
## [1] "Power: 0.8  Sigma1: 2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 227"
## [1] "Power: 0.8  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1.5  Sample size: 23"
## [1] "Power: 0.8  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 51"
## [1] "Power: 0.8  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 203"
```

- As difference between mu1 and mu2 decrease the sample size needs to increase.
- As the pooled variance decreases then the necessary sample size will also decrease.
- As the power decreases the sample size decreases.

## 1b) Is this what is wanted?Z

300 and 700 as n1 and n2 Calculate power using parameters values and make a power analysis table and summarize the effect of the parameters.

**For n2, For n1 (same result as n2)**

```
n1 <- 300
n2 <- 700
k <- n1/n2

for (sigma_2 in c(2.2,2.0,1.8))
{
  for (mu1_min_mu2 in c(1.5,1.0,0.5))
  {
    q_norm_power <- sqrt(n2/((sigma_2^2*(1+1/k))/(mu1_min_mu2)^2)) + qnorm(0.05/2)
    print (sprintf("Power: %s  Sigma1: %s  Sigma2: %s  Mu1-Mu2: %s ",  pnorm(q_norm_power), sigma_1, si
  }
}
```

```
## [1] "Power: 0.999999999999999  Sigma1: 1.8  Sigma2: 2.2  Mu1-Mu2: 1.5 "
## [1] "Power: 0.999998145225234  Sigma1: 1.8  Sigma2: 2.2  Mu1-Mu2: 1 "
## [1] "Power: 0.908821151138328  Sigma1: 1.8  Sigma2: 2.2  Mu1-Mu2: 0.5 "
## [1] "Power: 1  Sigma1: 1.8  Sigma2: 2  Mu1-Mu2: 1.5 "
## [1] "Power: 0.999999937395856  Sigma1: 1.8  Sigma2: 2  Mu1-Mu2: 1 "
## [1] "Power: 0.95183179092774  Sigma1: 1.8  Sigma2: 2  Mu1-Mu2: 0.5 "
## [1] "Power: 1  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1.5 "
## [1] "Power: 0.999999999438264  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 1 "
## [1] "Power: 0.980558287587443  Sigma1: 1.8  Sigma2: 1.8  Mu1-Mu2: 0.5 "
```

- As the sample size increase so does the power
- As the difference between the two groups incrases then the power increases
- As the pooled variance between the two groups increases the the power decreases

### 2)

Test non-inferiority with two different margins and study how the values of margins affect the sample size.

```
for (power in c(0.9,0.8))
{
  for (sigma_1 in c(2.2))
  {
    for (sigma_2 in c(1.8))
    {
      for (mu1_min_mu2 in c(1.0,0.5))
      {
        for (margin in c(1.1,0.4))
        {
          n <- ((sigma_1^2 + sigma_2^2)/(mu1_min_mu2-margin)^2)*(qnorm(0.05/2)+qnorm(1-power))^2
          print (sprintf("Power: %s  Sigma1: %s  Sigma2: %s  Mu1-Mu2: %s  Sample size: %s  Margin: %s",
        }
      }
    }
  }
}
```

```
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 8490  Margin: 1.1"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 236  Margin: 0.4"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 236  Margin: 1.1"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 8490  Margin: 0.4"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 6342  Margin: 1.1"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 176  Margin: 0.4"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 176  Margin: 1.1"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 6342  Margin: 0.4"
```

- As the difference between mu1-mu2 and margin decreases then the necessary sample size to show inferiority increases.

Test equivalence with two different margins and study how the values of margins affect the sample size.

```
for (power in c(0.9,0.8))
{
  for (sigma_1 in c(2.2))
  {
    for (sigma_2 in c(1.8))
    {
      for (mu1_min_mu2 in c(1.0,0.5))
      {
        for (margin in c(1.1,0.4))
        {
          n <- ((sigma_1^2 + sigma_2^2)/(mu1_min_mu2-margin)^2)*(qnorm(0.05/2)+qnorm((1-power)/2))^2
          print (sprintf("Power: %s  Sigma1: %s  Sigma2: %s  Mu1-Mu2: %s  Sample size: %s  Margin: %s",
```

```
        }
      }
    }
  }
}
```

```
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 10500  Margin: 1.1"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 292  Margin: 0.4"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 292  Margin: 1.1"
## [1] "Power: 0.9  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 10500  Margin: 0.4"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 8490  Margin: 1.1"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 1  Sample size: 236  Margin: 0.4"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 236  Margin: 1.1"
## [1] "Power: 0.8  Sigma1: 2.2  Sigma2: 1.8  Mu1-Mu2: 0.5  Sample size: 8490  Margin: 0.4"
```

- As the difference between abs(mu1-mu2) and margin decreases then the necessary sample size to show equivalence increases.

# HW6

## 1a)

Calculate sample size using all these values, change values for one factor at one time and keep other factors the sampe; and make a sample size analysis table; then summarize how difference between p1 and p2, sigma and power affect sample size

```r
for (power in c(0.95,0.9,0.85,0.8))
{
  for (p_1 in c(0.85))
  {
    for (p_2 in c(0.8,0.7,0.6))
    {
        n <- ((p_1*(1-p_1) + p_2*(1-p_2))/(p_1-p_2)^2)*(qnorm(0.05/2)+qnorm(1-power))^2
        print (sprintf("Power: %s  P1: %s  P2: %s  Sample size: %s",  power, p_1, p_2, round(n)))

    }
  }
}
```

```
## [1] "Power: 0.95  P1: 0.85  P2: 0.8  Sample size: 1494"
## [1] "Power: 0.95  P1: 0.85  P2: 0.7  Sample size: 195"
## [1] "Power: 0.95  P1: 0.85  P2: 0.6  Sample size: 76"
## [1] "Power: 0.9  P1: 0.85  P2: 0.8  Sample size: 1208"
## [1] "Power: 0.9  P1: 0.85  P2: 0.7  Sample size: 158"
## [1] "Power: 0.9  P1: 0.85  P2: 0.6  Sample size: 62"
## [1] "Power: 0.85  P1: 0.85  P2: 0.8  Sample size: 1033"
## [1] "Power: 0.85  P1: 0.85  P2: 0.7  Sample size: 135"
## [1] "Power: 0.85  P1: 0.85  P2: 0.6  Sample size: 53"
## [1] "Power: 0.8  P1: 0.85  P2: 0.8  Sample size: 903"
## [1] "Power: 0.8  P1: 0.85  P2: 0.7  Sample size: 118"
## [1] "Power: 0.8  P1: 0.85  P2: 0.6  Sample size: 46"
```

- As power decreases so does the necessary sample size
- As the difference between p_1 and p_2 increases the sample size decreases

### 1b)

Sample size = 90,170 for each arm, calculate power using the above parameter values, change values for one factor at one time and keep other factors the same. Make a power analysis table and summarize how the difference between p1 and p2, and sample size affect power.

```
for (n_1 in c(80,90))
{
  for (n_2 in c(170,180,190))
  {
    for (p_1 in c(0.85))
    {
      for (p_2 in c(0.8,0.7,0.6))
      {
          k <- n_1/n_2
          q_norm_power <- sqrt(n/((((p_1*(1-p_1))/k + p_2*(1-p_2))/(p_1-p_2)^2))) + qnorm(0.05/2)
          print (sprintf("Power: %s  P1: %s  P2: %s  N1: %s  N2: %s",  pnorm(q_norm_power), p_1, p_2, n_

      }
    }
  }
}
```

```
## [1] "Power: 0.0745765264369497  P1: 0.85  P2: 0.8  N1: 80  N2: 170"
## [1] "Power: 0.311866717973062  P1: 0.85  P2: 0.7  N1: 80  N2: 170"
## [1] "Power: 0.661312545718699  P1: 0.85  P2: 0.6  N1: 80  N2: 170"
## [1] "Power: 0.0732730136666671  P1: 0.85  P2: 0.8  N1: 80  N2: 180"
## [1] "Power: 0.303512782702634  P1: 0.85  P2: 0.7  N1: 80  N2: 180"
## [1] "Power: 0.64796637980382  P1: 0.85  P2: 0.6  N1: 80  N2: 180"
## [1] "Power: 0.0720535859616882  P1: 0.85  P2: 0.8  N1: 80  N2: 190"
## [1] "Power: 0.295645745736641  P1: 0.85  P2: 0.7  N1: 80  N2: 190"
## [1] "Power: 0.635039488684074  P1: 0.85  P2: 0.6  N1: 80  N2: 190"
## [1] "Power: 0.0773027916025928  P1: 0.85  P2: 0.8  N1: 90  N2: 170"
## [1] "Power: 0.329136219441028  P1: 0.85  P2: 0.7  N1: 90  N2: 170"
## [1] "Power: 0.68768459899859  P1: 0.85  P2: 0.6  N1: 90  N2: 170"
## [1] "Power: 0.0759735908914191  P1: 0.85  P2: 0.8  N1: 90  N2: 180"
## [1] "Power: 0.320752018700229  P1: 0.85  P2: 0.7  N1: 90  N2: 180"
## [1] "Power: 0.675083832812154  P1: 0.85  P2: 0.6  N1: 90  N2: 180"
## [1] "Power: 0.0747269493569641  P1: 0.85  P2: 0.8  N1: 90  N2: 190"
## [1] "Power: 0.312826871764853  P1: 0.85  P2: 0.7  N1: 90  N2: 190"
## [1] "Power: 0.662821610429767  P1: 0.85  P2: 0.6  N1: 90  N2: 190"
```

- As the diffference between p_1 and p_2 increases then so does the power
- As the sample size increases for n_1 then the power increases.
- As the sample size incrase for n_2 then the power increases

# HW7

Trial to compare a new therapy with a routine bath care in terms of the time to infection. - Hazard ratio (HR) of 1.5, 2.5, (beta=log(HR)), respectively, for routine bathing care/test therapy is considered of clinical importance. - 60%, 80% of patients' infection may be observed, respectively (=d) - n=n1=n2 (p1=p2=0.5), equal size treatment groups - Significance level: a=0.05

## 1A)

If Power = 0.8, b=1-0.8=0.2, calculate sample size for above various HRs and d's.

```
for (d in c(0.6, 0.8))
{
  for (hr in c(1.5, 2.0, 2.5))
  {
    n <- (qnorm(0.05/2) + qnorm(1-0.8))^2/(log(hr)^2*0.5*0.5*d)
    print(sprintf("HR: %s  Patiends observed(d): %s  Sample size: %s", hr, d, n))
  }
}
```

```
## [1] "HR: 1.5  Patiends observed(d): 0.6  Sample size: 318.280066973315"
## [1] "HR: 2  Patiends observed(d): 0.6  Sample size: 108.909432098118"
## [1] "HR: 2.5  Patiends observed(d): 0.6  Sample size: 62.3232120253598"
## [1] "HR: 1.5  Patiends observed(d): 0.8  Sample size: 238.710050229987"
## [1] "HR: 2  Patiends observed(d): 0.8  Sample size: 81.6820740735886"
## [1] "HR: 2.5  Patiends observed(d): 0.8  Sample size: 46.7424090190198"
```

## 1B)

If n1 = n2 = 20, 50, respectively, calculate power for above various HRs and d's.

```
for (n in c(20,50))
{
  for (d in c(0.6, 0.8))
  {
    for (hr in c(1.5, 2.5))
    {
      q_norm_power <- - sqrt((n*(log(hr)^2*0.5*0.5*d))) - (qnorm(0.05/2))
      print(sprintf("HR: %s  Patiends observed(d): %s  Sample size: %s  Power: %s", hr, d, n, pnorm(q_n
    }
  }
}
```

```
## [1] "HR: 1.5  Patiends observed(d): 0.6  Sample size: 20  Power: 0.895745850962353"
## [1] "HR: 2.5  Patiends observed(d): 0.6  Sample size: 20  Power: 0.64538926453217"
## [1] "HR: 1.5  Patiends observed(d): 0.8  Sample size: 20  Power: 0.874728971655608"
## [1] "HR: 2.5  Patiends observed(d): 0.8  Sample size: 20  Power: 0.550681175037879"
## [1] "HR: 1.5  Patiends observed(d): 0.6  Sample size: 50  Power: 0.80221291111564"
## [1] "HR: 2.5  Patiends observed(d): 0.6  Sample size: 50  Power: 0.291364961871538"
## [1] "HR: 1.5  Patiends observed(d): 0.8  Sample size: 50  Power: 0.751041464227333"
## [1] "HR: 2.5  Patiends observed(d): 0.8  Sample size: 50  Power: 0.174224561748361"
```