

# Covid ENT surgeries

August 1, 2021

```
library(readxl)
library(dplyr)
library(tidyr)
library(rstatix)
library(pwr)
```

```
d_site <- read_excel("procedure_by_site.xlsx")
d <- read_excel("overall_count.xlsx")
head(d_site)
```

```
## # A tibble: 6 x 5
##   Category      Site Procedure      Precovid Postcovid
##   <chr>         <chr> <chr>         <dbl>     <dbl>
## 1 head_neck    CU    Parotidectomy      81       66
## 2 head_neck    CU    Neck Dissection    196       93
## 3 head_neck    CU    Oral Cavity Resection  42       18
## 4 head_neck    CU    Thyroid/Parathyroidectomy 159       98
## 5 Otology_Audiology CU    Tympanoplasty      150       88
## 6 Otology_Audiology CU    Mastoidectomy      187      120
```

```
head(d)
```

```
## # A tibble: 6 x 5
##   Hospital_type Site Precovid Postcovid 'Original name'
##   <chr>         <chr>   <dbl>   <dbl> <chr>
## 1 Childrens    CU      1156     887 Children's
## 2 County       CU       990     492 DHMC
## 3 VA           CU       750     234 VAMC
## 4 University   CU     2352    1388 University
## 5 Childrens    UCSF     384     464 Children's Hospital of Oakland
## 6 County       UCSF     499     522 SF Gen
```

Question 1: Was there a difference in the total number of ear, nose, and throat cases performed before and after the COVID-19 pandemic?

1-Convert data to long format

```
d_long <- gather(d, covid_status, surgeries_count, Precovid:Postcovid, factor_key=TRUE)
head(d_long)
```

```
## # A tibble: 6 x 5
##   Hospital_type Site 'Original name' covid_status surgeries_count
```

```
##      <chr>          <chr> <chr>          <fct>          <dbl>
## 1 Childrens      CU      Children's      Precovid      1156
## 2 County         CU      DHMC              Precovid      990
## 3 VA             CU      VAMC              Precovid      750
## 4 University     CU      University      Precovid      2352
## 5 Childrens      UCSF    Children's Hospital of Oakla~ Precovid      384
## 6 County         UCSF    SF Gen          Precovid      499
```

```
s1 <- group_by(d_long, covid_status) %>%
  summarise(
    count = n(),
    mean = mean(surgeries_count, na.rm = TRUE),
    sd = sd(surgeries_count, na.rm = TRUE)
  )
s1
```

```
## # A tibble: 2 x 4
##   covid_status count  mean    sd
##   <fct>          <int> <dbl> <dbl>
## 1 Precovid      23 1452. 1576.
## 2 Postcovid     23   978 1063.
```

Sample size calculation

1-calculate effect size using Cohen formula

```
d_long %>% cohens_d(surgeries_count ~ covid_status, var.equal = FALSE)
```

```
## # A tibble: 1 x 7
##   .y.      group1  group2  effsize  n1  n2 magnitude
## * <chr>      <chr>   <chr>    <dbl> <int> <int> <ord>
## 1 surgeries_count Precovid Postcovid 0.352   23   23 small
```

2- calculate the sample size

```
pwr.t.test(n = NULL, d = 0.35, sig.level = 0.05, power = 0.8, type = "two.sample")
```

```
##
##      Two-sample t test power calculation
##
##              n = 129.1121
##              d = 0.35
##      sig.level = 0.05
##              power = 0.8
##      alternative = two.sided
##
## NOTE: n is number in *each* group
```

2- Perform t-test in R.

```
test <- t.test(d_long$surgeries_count ~ d_long$covid_status)
test
```

```
##
## Welch Two Sample t-test
##
## data: d_long$surgeries_count by d_long$covid_status
## t = 1.1946, df = 38.592, p-value = 0.2395
## alternative hypothesis: true difference in means between group Precovid and group Postcovid is not equal to 0
## 95 percent confidence interval:
## -328.5469 1275.6774
## sample estimates:
## mean in group Precovid mean in group Postcovid
## 1451.565 978.000
```

3-Shapiro-wilk normality test.

```
with(d_long, shapiro.test(surgeries_count[covid_status == "Precovid"]))
```

```
##
## Shapiro-Wilk normality test
##
## data: surgeries_count[covid_status == "Precovid"]
## W = 0.74516, p-value = 5.729e-05
```

```
with(d_long, shapiro.test(surgeries_count[covid_status == "Postcovid"]))
```

```
##
## Shapiro-Wilk normality test
##
## data: surgeries_count[covid_status == "Postcovid"]
## W = 0.76766, p-value = 0.0001215
```

4- Wilcox test

```
wilcox.test(d$Precovid, d$Postcovid, alternative = "two.sided")
```

```
## Warning in wilcox.test.default(d$Precovid, d$Postcovid, alternative =
## "two.sided"): cannot compute exact p-value with ties
```

```
##
## Wilcoxon rank sum test with continuity correction
##
## data: d$Precovid and d$Postcovid
## W = 335, p-value = 0.1241
## alternative hypothesis: true location shift is not equal to 0
```

Question 2: Was there a statistically significant decrease in ear, nose, and throat cases before and after COVID-19 in one institution compared to another institution? There are six institutions: CU (University of Colorado), UCSF (University of California San Francisco), Georgetown, Harvard, KU (University of Kansas), and LSU (Louisiana State University).

1- Two-way ANOVA test

```
res.aov <- aov(surgeries_count ~ covid_status * Site, data = d_long)
summary(res.aov)
```

```
##              Df    Sum Sq Mean Sq F value Pr(>F)
## covid_status    1  2579036 2579036   1.171  0.287
## Site            5  4234334  846867   0.385  0.856
## covid_status:Site 5   421169   84234   0.038  0.999
## Residuals      34 74862942 2201851
```

Question 3: If there was a difference in cases between institutions, was there a difference in the procedure type performed? Examples of procedure types are head\_neck\_cancer, otology\_audiology, facial\_plastic\_reconstructive\_surgery, and General\_peds.

```
head(d_site)
```

```
## # A tibble: 6 x 5
##   Category      Site Procedure      Precovid Postcovid
##   <chr>         <chr> <chr>         <dbl>     <dbl>
## 1 head_neck    CU    Parotidectomy      81       66
## 2 head_neck    CU    Neck Dissection    196      93
## 3 head_neck    CU    Oral Cavity Resection 42       18
## 4 head_neck    CU    Thyroid/Parathyroidectomy 159      98
## 5 Otology_Audiology CU    Tympanoplasty      150      88
## 6 Otology_Audiology CU    Mastoidectomy      187     120
```

1- Convert data to long format.

```
d2_long <- gather(d_site, covid_status, surgeries_count, Precovid:Postcovid, factor_key=TRUE)
head(d2_long)
```

```
## # A tibble: 6 x 5
##   Category      Site Procedure      covid_status surgeries_count
##   <chr>         <chr> <chr>         <fct>             <dbl>
## 1 head_neck    CU    Parotidectomy      Precovid             81
## 2 head_neck    CU    Neck Dissection    Precovid            196
## 3 head_neck    CU    Oral Cavity Resection Precovid             42
## 4 head_neck    CU    Thyroid/Parathyroidectomy Precovid            159
## 5 Otology_Audiology CU    Tympanoplasty      Precovid            150
## 6 Otology_Audiology CU    Mastoidectomy      Precovid            187
```

2- Two-way ANOVA

```
res.aov2 <- aov(surgeries_count ~ covid_status * Category, data = d2_long)
summary(res.aov2)
```

```
##              Df    Sum Sq Mean Sq F value  Pr(>F)
## covid_status    1   81130   81130   5.917 0.0163 *
## Category        3  337119  112373   8.196 4.7e-05 ***
## covid_status:Category 3    7006    2335   0.170 0.9163
## Residuals      136 1864586   13710
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
TukeyHSD(res.aov2, which = "covid_status:Category")
```

```
## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = surgeries_count ~ covid_status * Category, data = d2_long)
##
## $'covid_status:Category'
##
## Postcovid:facial_plastic_reconstructive_surgery-Precovid:facial_plastic_reconstructive_surgery -49.8
## Precovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery -153.8
## Postcovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery -174.8
## Precovid:head_neck-Precovid:facial_plastic_reconstructive_surgery -33.8
## Postcovid:head_neck-Precovid:facial_plastic_reconstructive_surgery -95.8
## Precovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery -96.8
## Postcovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery -138.8
## Precovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery -103.8
## Postcovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery -124.8
## Precovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery 16.8
## Postcovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery -45.8
## Precovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery -46.8
## Postcovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery -88.8
## Postcovid:General_Peds-Precovid:General_Peds -21.8
## Precovid:head_neck-Precovid:General_Peds 119.8
## Postcovid:head_neck-Precovid:General_Peds 57.8
## Precovid:Otology_Audiology-Precovid:General_Peds 57.8
## Postcovid:Otology_Audiology-Precovid:General_Peds 14.8
## Precovid:head_neck-Postcovid:General_Peds 141.8
## Postcovid:head_neck-Postcovid:General_Peds 79.8
## Precovid:Otology_Audiology-Postcovid:General_Peds 78.8
## Postcovid:Otology_Audiology-Postcovid:General_Peds 36.8
## Postcovid:head_neck-Precovid:head_neck -62.8
## Precovid:Otology_Audiology-Precovid:head_neck -62.8
## Postcovid:Otology_Audiology-Precovid:head_neck -105.8
## Precovid:Otology_Audiology-Postcovid:head_neck -0.8
## Postcovid:Otology_Audiology-Postcovid:head_neck -42.8
## Postcovid:Otology_Audiology-Precovid:Otology_Audiology -42.8
##
## Postcovid:facial_plastic_reconstructive_surgery-Precovid:facial_plastic_reconstructive_surgery -170.8
## Precovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery -287.8
## Postcovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery -309.8
## Precovid:head_neck-Precovid:facial_plastic_reconstructive_surgery -145.8
## Postcovid:head_neck-Precovid:facial_plastic_reconstructive_surgery -208.8
## Precovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery -216.8
## Postcovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery -258.8
## Precovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery -237.8
## Postcovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery -259.8
## Precovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery -95.8
## Postcovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery -158.8
## Precovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery -166.8
## Postcovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery -208.8
## Postcovid:General_Peds-Precovid:General_Peds -168.8
## Precovid:head_neck-Precovid:General_Peds -7.8
```

## Postcovid:head_neck-Precovid:General_Peds	-69.9
## Precovid:Otology_Audiology-Precovid:General_Peds	-77.2
## Postcovid:Otology_Audiology-Precovid:General_Peds	-119.4
## Precovid:head_neck-Postcovid:General_Peds	14.1
## Postcovid:head_neck-Postcovid:General_Peds	-48.3
## Precovid:Otology_Audiology-Postcovid:General_Peds	-55.3
## Postcovid:Otology_Audiology-Postcovid:General_Peds	-97.7
## Postcovid:head_neck-Precovid:head_neck	-166.1
## Precovid:Otology_Audiology-Precovid:head_neck	-175.2
## Postcovid:Otology_Audiology-Precovid:head_neck	-217.4
## Precovid:Otology_Audiology-Postcovid:head_neck	-112.7
## Postcovid:Otology_Audiology-Postcovid:head_neck	-154.9
## Postcovid:Otology_Audiology-Precovid:Otology_Audiology	-162.3
##	
## Postcovid:facial_plastic_reconstructive_surgery-Precovid:facial_plastic_reconstructive_surgery	70.2
## Precovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery	-18.8
## Postcovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery	-40.5
## Precovid:head_neck-Precovid:facial_plastic_reconstructive_surgery	79.1
## Postcovid:head_neck-Precovid:facial_plastic_reconstructive_surgery	16.6
## Precovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery	24.1
## Postcovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery	-18.1
## Precovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery	31.0
## Postcovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery	9.3
## Precovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery	129.0
## Postcovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery	66.5
## Precovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery	73.9
## Postcovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery	31.7
## Postcovid:General_Peds-Precovid:General_Peds	125.5
## Precovid:head_neck-Precovid:General_Peds	247.4
## Postcovid:head_neck-Precovid:General_Peds	184.9
## Precovid:Otology_Audiology-Precovid:General_Peds	191.4
## Postcovid:Otology_Audiology-Precovid:General_Peds	149.2
## Precovid:head_neck-Postcovid:General_Peds	269.0
## Postcovid:head_neck-Postcovid:General_Peds	206.5
## Precovid:Otology_Audiology-Postcovid:General_Peds	213.1
## Postcovid:Otology_Audiology-Postcovid:General_Peds	170.9
## Postcovid:head_neck-Precovid:head_neck	41.5
## Precovid:Otology_Audiology-Precovid:head_neck	49.5
## Postcovid:Otology_Audiology-Precovid:head_neck	7.3
## Precovid:Otology_Audiology-Postcovid:head_neck	112.0
## Postcovid:Otology_Audiology-Postcovid:head_neck	69.8
## Postcovid:Otology_Audiology-Precovid:Otology_Audiology	77.9
##	p
## Postcovid:facial_plastic_reconstructive_surgery-Precovid:facial_plastic_reconstructive_surgery	0.905
## Precovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery	0.013
## Postcovid:General_Peds-Precovid:facial_plastic_reconstructive_surgery	0.002
## Precovid:head_neck-Precovid:facial_plastic_reconstructive_surgery	0.984
## Postcovid:head_neck-Precovid:facial_plastic_reconstructive_surgery	0.157
## Precovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery	0.221
## Postcovid:Otology_Audiology-Precovid:facial_plastic_reconstructive_surgery	0.012
## Precovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery	0.265
## Postcovid:General_Peds-Postcovid:facial_plastic_reconstructive_surgery	0.088
## Precovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery	0.999
## Postcovid:head_neck-Postcovid:facial_plastic_reconstructive_surgery	0.913

```
## Precovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery 0.935
## Postcovid:Otology_Audiology-Postcovid:facial_plastic_reconstructive_surgery 0.320
## Postcovid:General_Peds-Precovid:General_Peds 0.999
## Precovid:head_neck-Precovid:General_Peds 0.081
## Postcovid:head_neck-Precovid:General_Peds 0.861
## Precovid:Otology_Audiology-Precovid:General_Peds 0.893
## Postcovid:Otology_Audiology-Precovid:General_Peds 0.999
## Precovid:head_neck-Postcovid:General_Peds 0.018
## Postcovid:head_neck-Postcovid:General_Peds 0.545
## Precovid:Otology_Audiology-Postcovid:General_Peds 0.617
## Postcovid:Otology_Audiology-Postcovid:General_Peds 0.990
## Postcovid:head_neck-Precovid:head_neck 0.587
## Precovid:Otology_Audiology-Precovid:head_neck 0.673
## Postcovid:Otology_Audiology-Precovid:head_neck 0.085
## Precovid:Otology_Audiology-Postcovid:head_neck 1.000
## Postcovid:Otology_Audiology-Postcovid:head_neck 0.940
## Postcovid:Otology_Audiology-Precovid:Otology_Audiology 0.959
```

Question 4: Overall, there is a difference in ENT case volume between the types of hospitals where university hospitals do a statistically larger number of cases than a county, VA, or Children's hospitals ( $p < 0.01$ ). Was there a statistically significant decrease in the cases explained by the different types of hospitals? (e.g., county, VA, university, or Children's hospitals)

1- ANOVA test

```
res.aov3 <- aov(surgeries_count ~ Hospital_type, data = d_long)
summary(res.aov3)
```

```
##           Df    Sum Sq Mean Sq F value    Pr(>F)
## Hospital_type  4 45507532 11376883   12.75 7.89e-07 ***
## Residuals    41 36589949   892438
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2-Tukey test

```
TukeyHSD(res.aov3)
```

```
##      Tukey multiple comparisons of means
##      95% family-wise confidence level
##
## Fit: aov(formula = surgeries_count ~ Hospital_type, data = d_long)
##
## $Hospital_type
##              diff            lwr            upr      p adj
## Community-Childrens 1924.83333 -133.5639 3983.2306 0.0766520
## County-Childrens    -247.66667 -1347.9263  852.5929 0.9671343
## University-Childrens 1981.25000  880.9904 3081.5096 0.0000680
## VA-Childrens        -323.79167 -1553.9193  906.3360 0.9429148
## County-Community    -2172.50000 -4230.8973 -114.1027 0.0340724
## University-Community  56.41667 -2001.9806 2114.8139 0.9999911
## VA-Community        -2248.62500 -4379.2686 -117.9814 0.0340866
## University-County   2228.91667  1128.6571 3329.1763 0.0000086
```

```
## VA-County          -76.12500 -1306.2526  1154.0026  0.9997728
## VA-University      -2305.04167 -3535.1693 -1074.9140  0.0000348
```

3- Shapiro wilk normality test

```
# Extract the residuals
aov_residuals <- residuals(object = res.aov3 )
# Run Shapiro-Wilk test
shapiro.test(x = aov_residuals )
```

```
##
##  Shapiro-Wilk normality test
##
## data:  aov_residuals
## W = 0.87297, p-value = 0.0001289
```

4- Kruskal walis test

```
kruskal.test(surgeries_count ~ Hospital_type, data = d_long)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  surgeries_count by Hospital_type
## Kruskal-Wallis chi-squared = 20.83, df = 4, p-value = 0.0003422
```

5- pairwise Wilcox test

```
p <- pairwise.wilcox.test(d_long$surgeries_count, d_long$Hospital_type,
                           p.adjust.method = "BH")
```

```
## Warning in wilcox.test.default(xi, xj, paired = paired, ...): cannot compute
## exact p-value with ties
```

```
## Warning in wilcox.test.default(xi, xj, paired = paired, ...): cannot compute
## exact p-value with ties
```

```
## Warning in wilcox.test.default(xi, xj, paired = paired, ...): cannot compute
## exact p-value with ties
```

```
## Warning in wilcox.test.default(xi, xj, paired = paired, ...): cannot compute
## exact p-value with ties
```

```
p <- as.data.frame(p$p.value)
p
```

```
##           Childrens  Community      County  University
## Community  0.043956044          NA          NA          NA
## County     0.247260143  0.04395604          NA          NA
## University 0.007163048  1.00000000  0.004955335          NA
## VA         0.117805523  0.08248539  0.745784118  0.008674478
```