Resulrts-analysis.r

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```
#Download librariers
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(viridis)
```

```
## Loading required package: viridisLite
```

```
library(tidyverse)
```

```
## -- Attaching packages ---------------------------------------------------------------------------

## v tibble  3.0.3     v purrr   0.3.4
## v tidyr   1.1.0     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0

## -- Conflicts ------------------------------------------------------------------------------------
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(ggpubr)
library(ggrepel)
library(ggsci)
library(ggsignif)
library(ggthemes)
#DISK DIFUSSION TESTS ANALYSIS
# make a variable that contains all bacterial names and print it out.
```

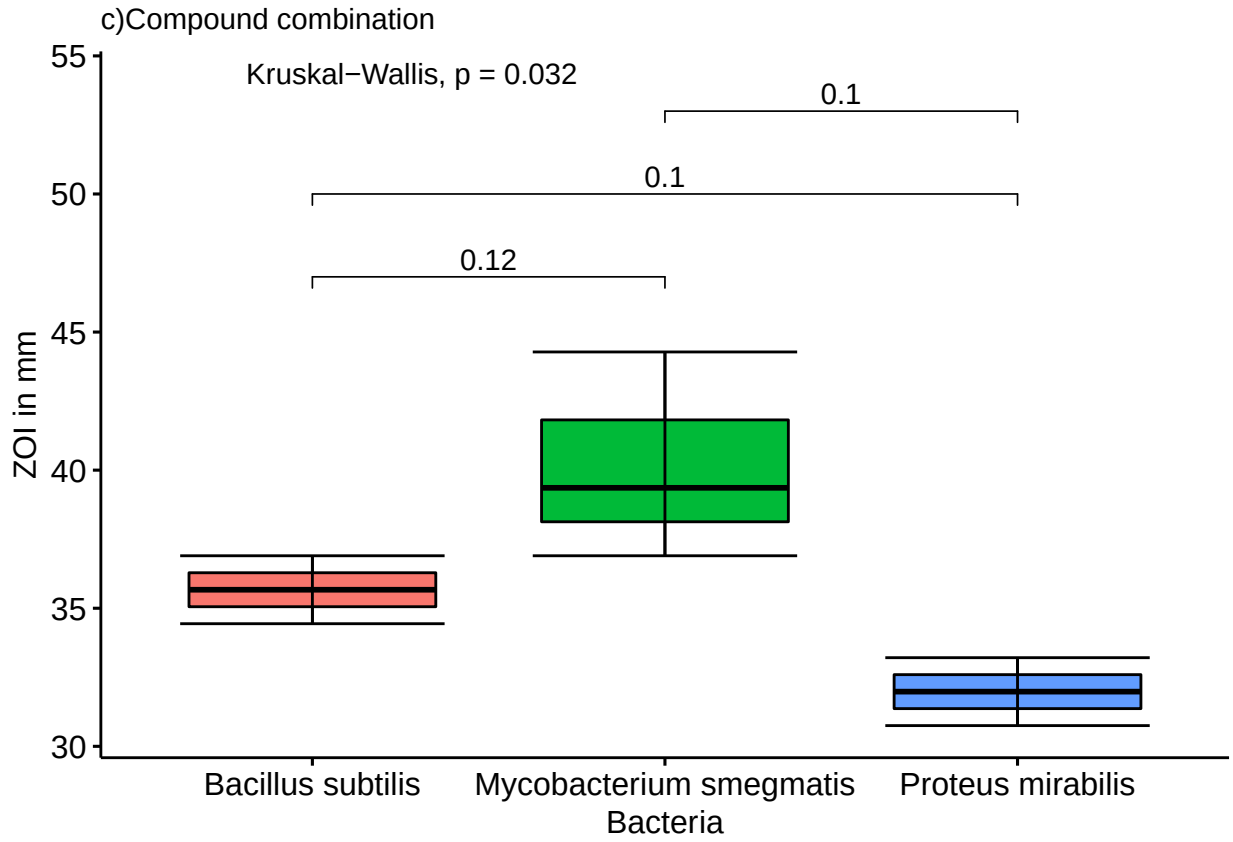
```r
Titles <- c("Bacillus subtilis","Mycobacterium smegmatis","Proteus mirabilis")
#Order the titels
Titles_test <- c(rep("Bacillus subtilis",3),rep("Mycobacterium smegmatis",3),rep("Proteus mirabilis",3))
#Treatment names
Treatment_names <- c("Compound combination", "penicillin only", "Tebipenem only")
#Create variables that contain ZOIs measurements according to the bacteria and the treatment
Bacillus_subtilis_Combination <- c(36.9, 34.44, 35.67)
Bacillus_subtilis_Tebipenem <-c(34.44,29.52,35.67)
Bacillus_subtilis_Penicilin <- c(0,0,0)
Mycobacterium_smegmatis_Combination <- c(39.36,36.9,44.28)
Mycobacterium_smegmatis_Tebipenem <- c(39.36,34.44,41.82)
Mycobacterium_smegmatis_Penicilin <- c(0,0,0)
Proteus_mirabilis_Combination <- c(30.75,31.98,33.21)
Proteus_mirabilis_Tebipenem <- c(33.21,31.98,34.44)
Proteus_mirabilis_Penicillin <- c(27.06,29.52,31.98)
#Create a data frame of pLates results(this will make a table of the results) and print it out
results <- data.frame(Bacteria=Titles_test,
                      Compound_combination= c(Bacillus_subtilis_Combination,
                                              Mycobacterium_smegmatis_Combination,
                                              Proteus_mirabilis_Combination),
                      Tebipenem_only= c(Bacillus_subtilis_Tebipenem,
                                        Mycobacterium_smegmatis_Tebipenem,
                                        Proteus_mirabilis_Tebipenem),
                      Penicillin_only= c(Bacillus_subtilis_Penicilin,
                                         Mycobacterium_smegmatis_Penicilin,
                                         Proteus_mirabilis_Penicillin))
print(results)
```

```
##                 Bacteria Compound_combination Tebipenem_only Penicillin_only
## 1       Bacillus subtilis                36.90          34.44            0.00
## 2       Bacillus subtilis                34.44          29.52            0.00
## 3       Bacillus subtilis                35.67          35.67            0.00
## 4 Mycobacterium smegmatis                39.36          39.36            0.00
## 5 Mycobacterium smegmatis                36.90          34.44            0.00
## 6 Mycobacterium smegmatis                44.28          41.82            0.00
## 7       Proteus mirabilis                30.75          33.21           27.06
## 8       Proteus mirabilis                31.98          31.98           29.52
## 9       Proteus mirabilis                33.21          34.44           31.98
```

```r
#make up the variable that constructs the boxplot for Compound combination effect on three bacteria
my_comparisons <- list(c("Bacillus subtilis","Mycobacterium smegmatis"),
                       c("Bacillus subtilis","Proteus mirabilis"),
                       c("Mycobacterium smegmatis","Proteus mirabilis"))
combin<-ggboxplot(results,x="Bacteria",y="Compound_combination",fill = "Bacteria")+
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  ) +
  ggtitle("c)Compound combination") +
  xlab("Bacteria")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  stat_compare_means(comparisons = my_comparisons,
```

```
                    label.y = c(47, 50, 53))+
  stat_compare_means(label.y = 54)
print(combin)
```

```
## Warning in wilcox.test.default(c(36.9, 34.44, 35.67), c(39.36, 36.9, 44.28:
## cannot compute exact p-value with ties
```

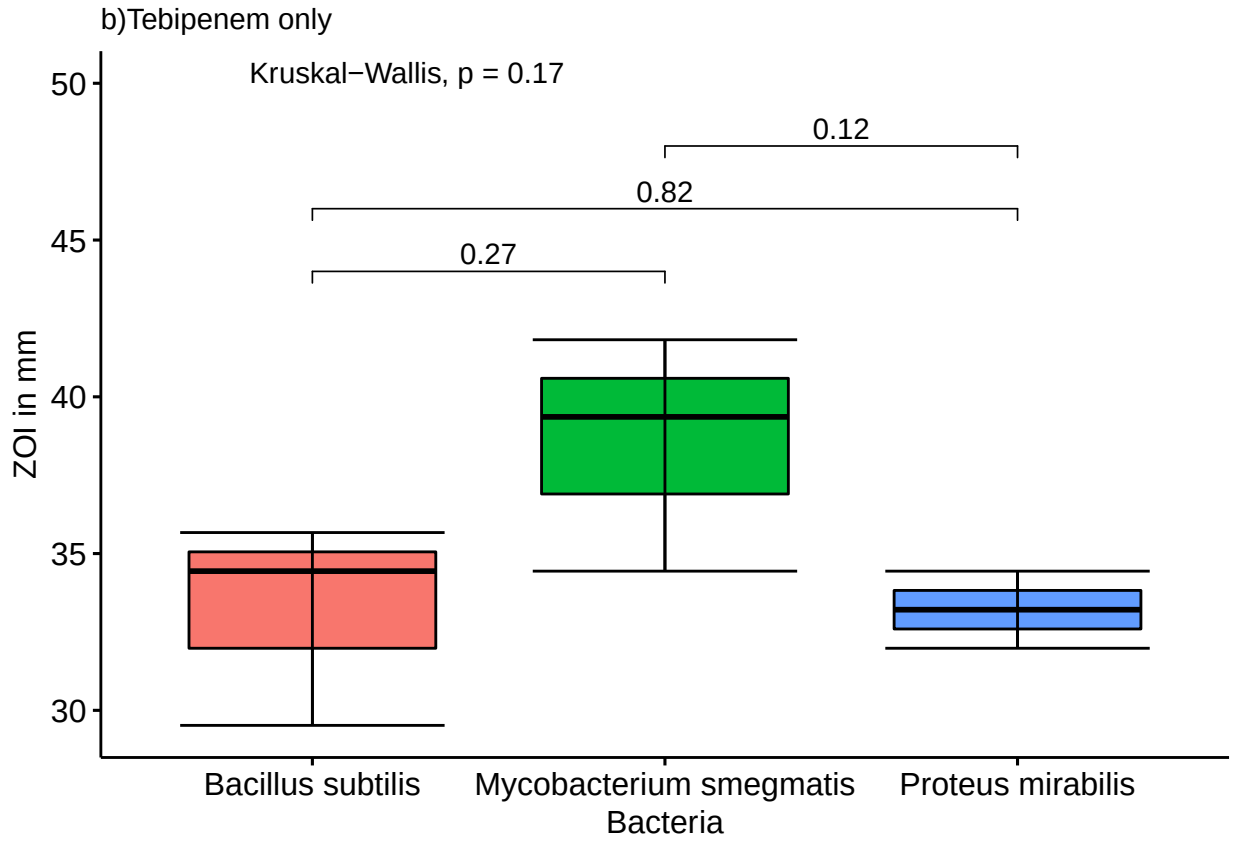



```
#Make up the boxplot for Tebipenem only on three bacteria
tebip <- ggboxplot(results,x="Bacteria",y="Tebipenem_only",fill = "Bacteria")+
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  ) +
  ggtitle("b)Tebipenem only") +
  xlab("Bacteria")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  stat_compare_means(comparisons = my_comparisons,
                     label.y = c(44, 46, 48))+
  stat_compare_means(label.y = 50)
print(tebip)
```

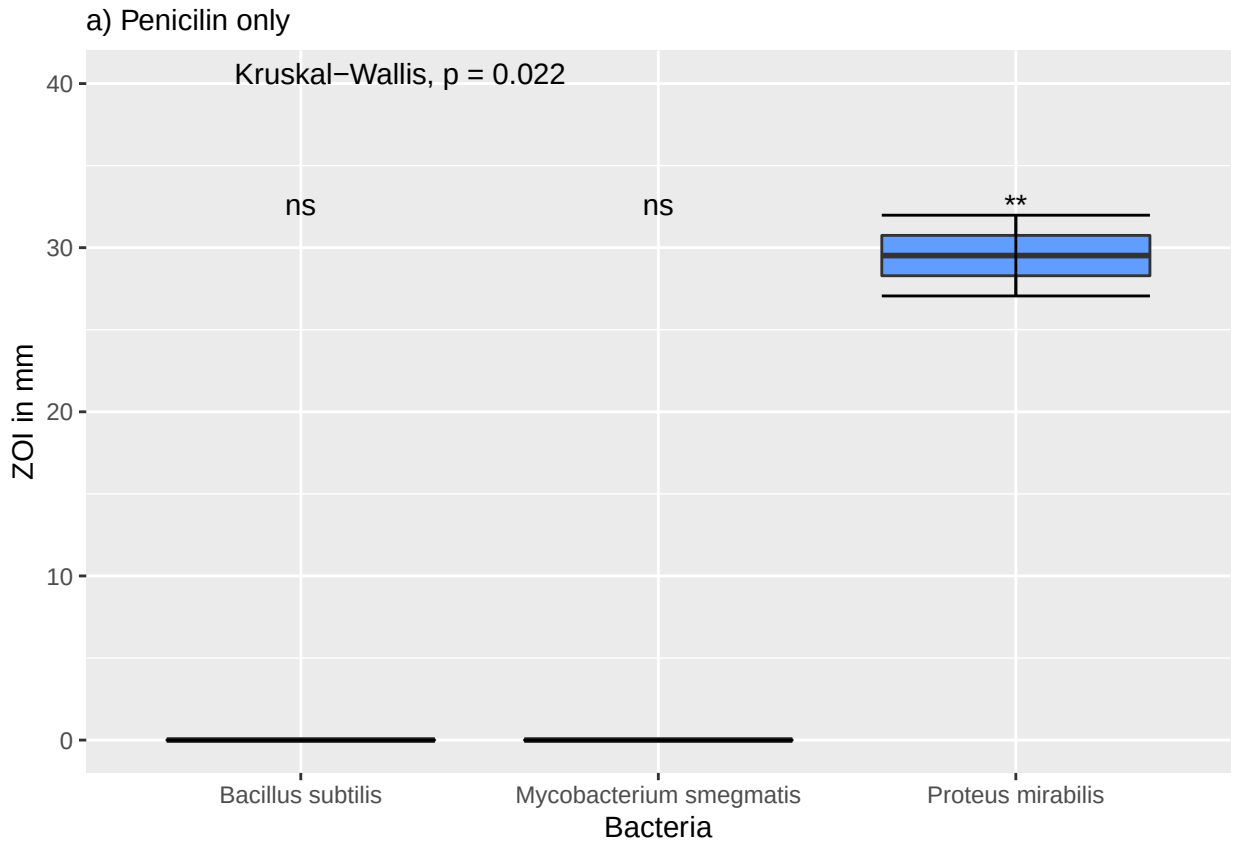
```
## Warning in wilcox.test.default(c(34.44, 29.52, 35.67), c(39.36, 34.44, 41.82:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(34.44, 29.52, 35.67), c(33.21, 31.98, 34.44:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(39.36, 34.44, 41.82), c(33.21, 31.98, 34.44:
## cannot compute exact p-value with ties
```




```
#Make up boxplot for Penicillin only on three bacteria
p<-results %>%
  ggplot(aes(x=Bacteria,y=Penicillin_only,fill=Bacteria))+
  geom_boxplot() +
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  ) +
  ggtitle("a) Penicilin only") +
  xlab("Bacteria")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  #Cannot compare pairwise because of the zero's
  stat_compare_means(method = "kruskal.test", label.y = 40)+
  stat_compare_means(label = "p.signif", method = "t.test",
                     ref.group = ".all.")
print(p)
```




```
#Compare drug effect on the Bacillus subtilis with a new dataframe + boxplot
my_comparisons_2 <- list(c("Compound combination","Tebipenem only"),
                         c("Compound combination","Penicillin only"),
                         c("Penicillin only","Tebipenem only"))
Bacillus_subtilis_data_frame <- data.frame(Treatments_names= c(rep("Compound combination",3),
                                                               rep("Tebipenem only",3),
                                                               rep("Penicillin only",3)),
                                           Treatment=c(Bacillus_subtilis_Combination,
                                                       Bacillus_subtilis_Tebipenem,
                                                       Bacillus_subtilis_Penicilin))
print(Bacillus_subtilis_data_frame)
```

```
##       Treatments_names Treatment
## 1 Compound combination     36.90
## 2 Compound combination     34.44
## 3 Compound combination     35.67
## 4       Tebipenem only     34.44
## 5       Tebipenem only     29.52
## 6       Tebipenem only     35.67
## 7      Penicillin only      0.00
## 8      Penicillin only      0.00
## 9      Penicillin only      0.00
```

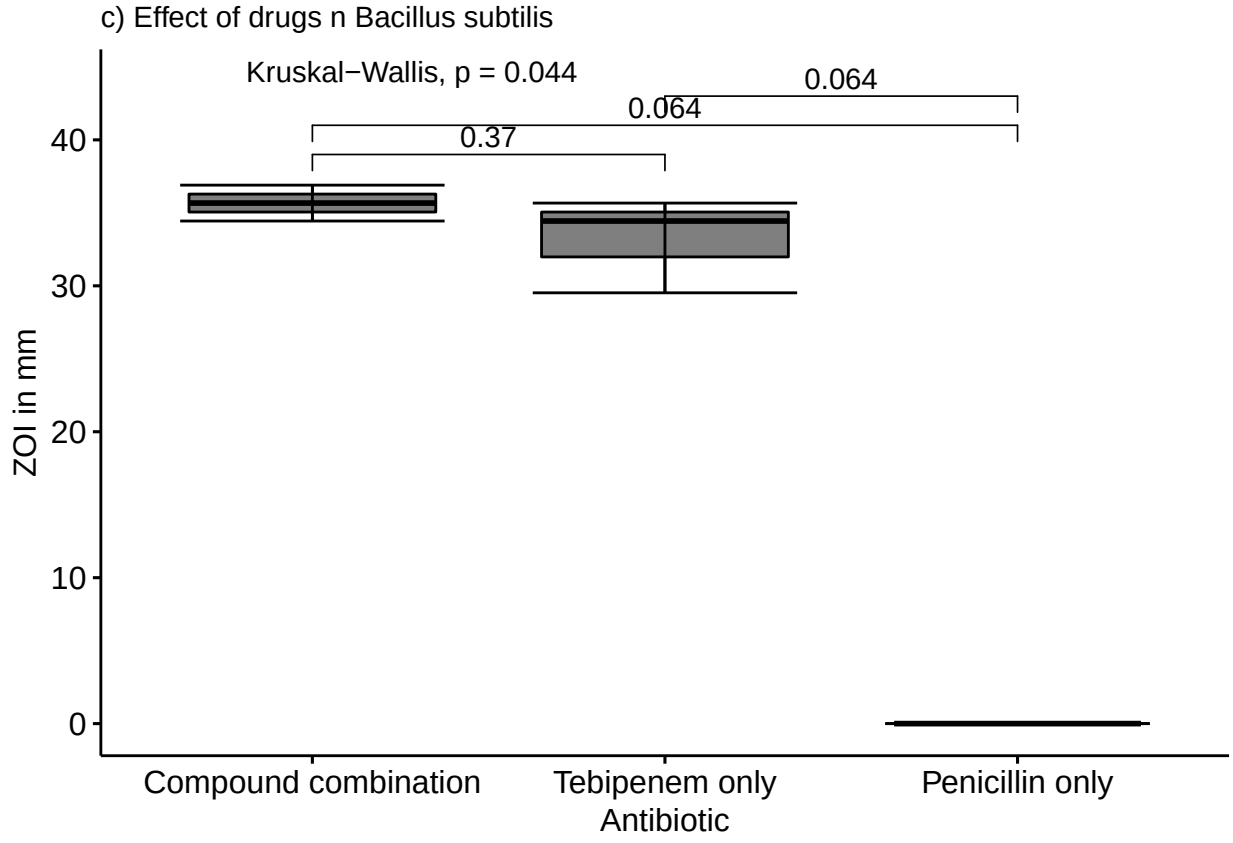
```
#Making a boxplot
Bacillus_subtilis_boxplot <-
```

```
  ggboxplot(Bacillus_subtilis_data_frame,x="Treatments_names",y="Treatment",
            fill = "Treatment")+
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  ) +
  ggtitle("c) Effect of drugs n Bacillus subtilis") +
  xlab("Antibiotic")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  stat_compare_means(comparisons = my_comparisons_2,
                     label.y = c(39, 41, 43))+
  stat_compare_means(label.y = 44)
print(Bacillus_subtilis_boxplot)
```

```
## Warning in wilcox.test.default(c(36.9, 34.44, 35.67), c(34.44, 29.52, 35.67:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(36.9, 34.44, 35.67), c(0, 0, 0), paired =
## FALSE): cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(0, 0, 0), c(34.44, 29.52, 35.67), paired =
## FALSE): cannot compute exact p-value with ties
```



```r
#Compare drugs effects on Mycobacterium smegmatis (do the same as the previous part)
Mycobacterium_smegmatis_data_frame <- data.frame(Treatments_names_2=
                                                   c(rep("Compound combination",3),
                                                     rep("Tebipenem only",3),
                                                     rep("Penicillin only",3)),
                                                 Treatment_2=c(Mycobacterium_smegmatis_Combination,
                                                               Mycobacterium_smegmatis_Tebipenem,
                                                               Mycobacterium_smegmatis_Penicilin))
print(Mycobacterium_smegmatis_data_frame)
```

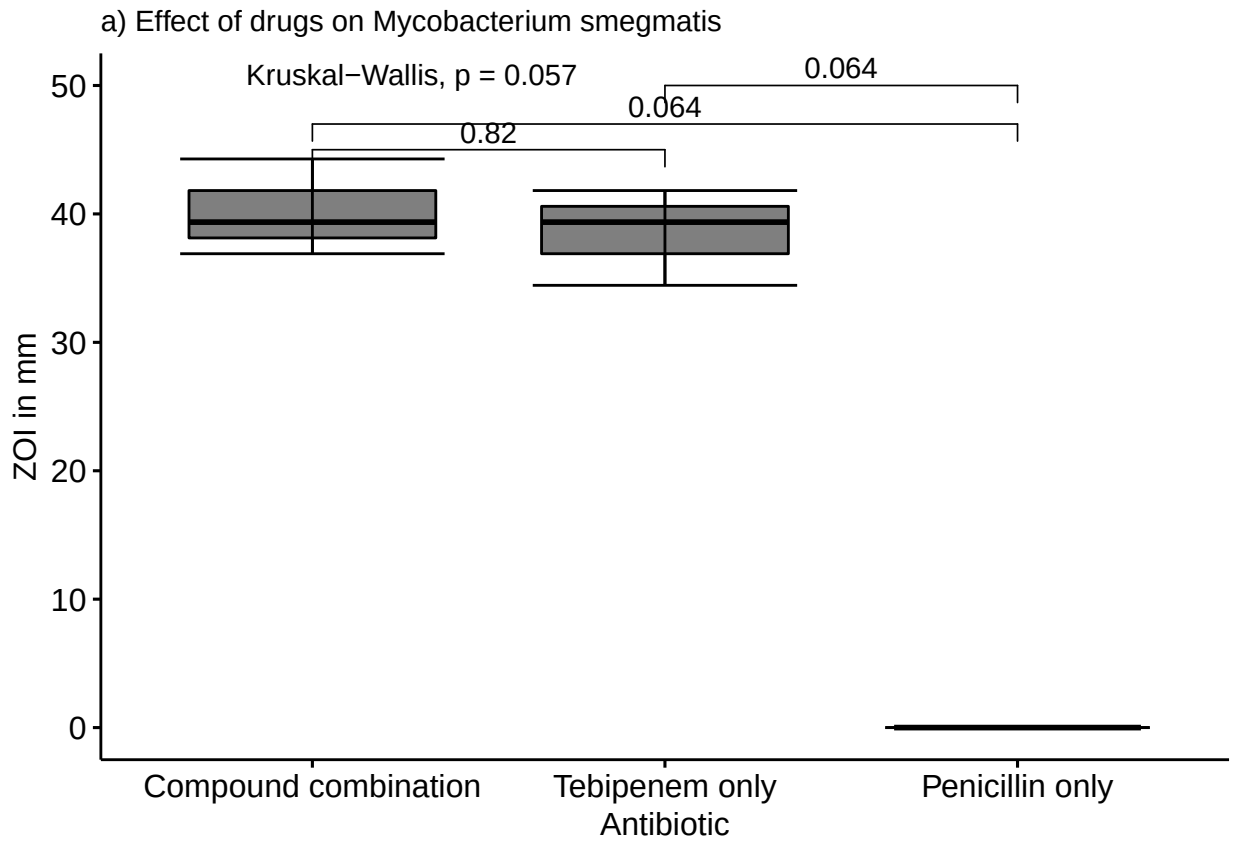
```
##     Treatments_names_2 Treatment_2
## 1 Compound combination       39.36
## 2 Compound combination       36.90
## 3 Compound combination       44.28
## 4       Tebipenem only       39.36
## 5       Tebipenem only       34.44
## 6       Tebipenem only       41.82
## 7      Penicillin only        0.00
## 8      Penicillin only        0.00
## 9      Penicillin only        0.00
```

```r
Mycobacterium_smegmatis_boxplot <-
  ggboxplot(Mycobacterium_smegmatis_data_frame,x="Treatments_names_2",
            y="Treatment_2",fill="Treatment_2")+
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  ) +
  ggtitle("a) Effect of drugs on Mycobacterium smegmatis") +
  xlab("Antibiotic")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  stat_compare_means(comparisons = my_comparisons_2,
                     label.y = c(45, 47 , 50))+
  stat_compare_means(label.y = 50)
print(Mycobacterium_smegmatis_boxplot)
```

```
## Warning in wilcox.test.default(c(39.36, 36.9, 44.28), c(39.36, 34.44, 41.82:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(39.36, 36.9, 44.28), c(0, 0, 0), paired =
## FALSE): cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(0, 0, 0), c(39.36, 34.44, 41.82), paired =
## FALSE): cannot compute exact p-value with ties
```

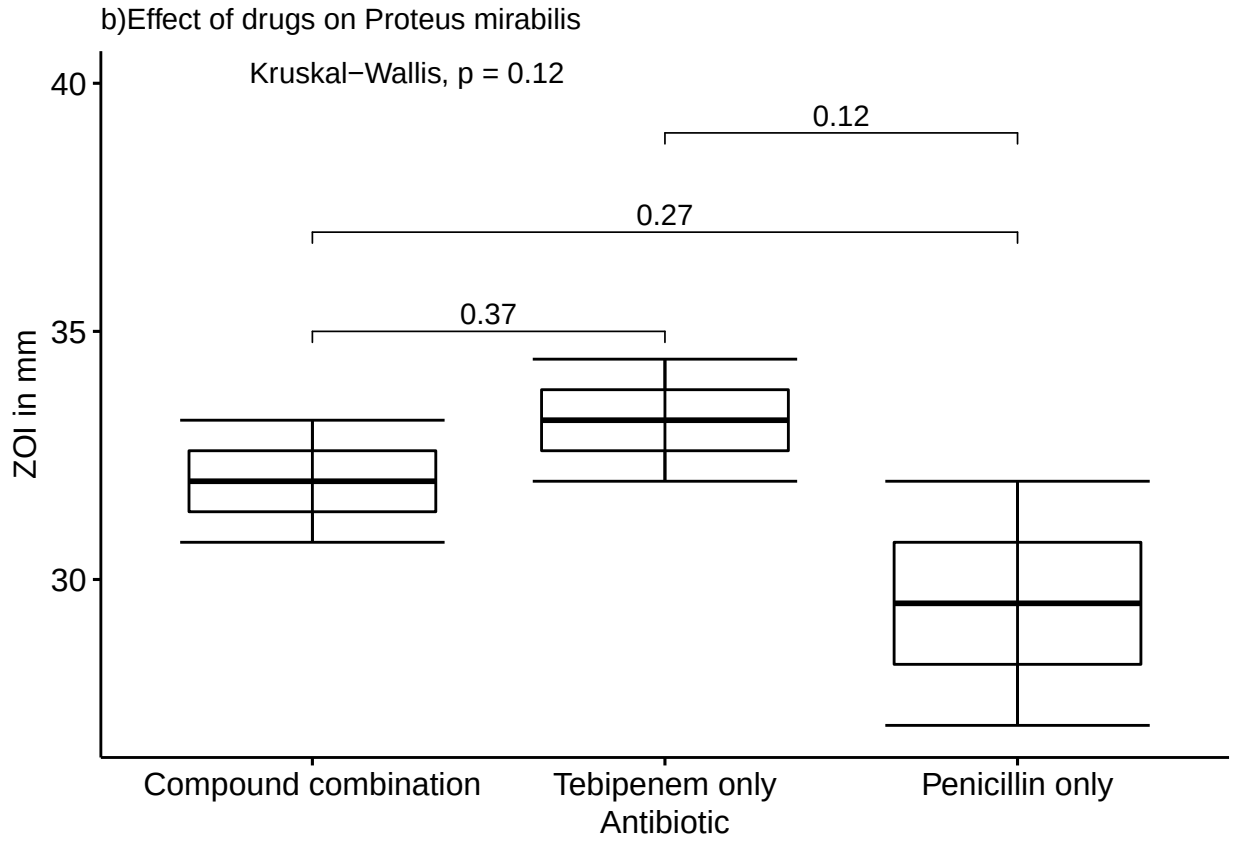



```
# Compare drugs effects on Proteus mirabilis (do the same as the previous part)
Proteus_mirabilis_dataframe <-data.frame(Treatments_names_3=
                                           c(rep("Compound combination",3),
                                             rep("Tebipenem only",3),
                                             rep("Penicillin only",3)),
                                         Treatment_3=c(Proteus_mirabilis_Combination,
                                                       Proteus_mirabilis_Tebipenem,
                                                       Proteus_mirabilis_Penicillin))
Proteus_mirabilis_boxplot <-
  ggboxplot(Proteus_mirabilis_dataframe,x="Treatments_names_3",
            y="Treatment_3",fill="Treatment_3")+
  theme(
    legend.position="none",
    plot.title = element_text(size=11)
  )+
  ggtitle("b)Effect of drugs on Proteus mirabilis")+
  xlab("Antibiotic")+
  ylab("ZOI in mm")+
  stat_boxplot(geom = "errorbar")+
  stat_compare_means(comparisons = my_comparisons_2,
                     label.y = c(35,37,39))+
  stat_compare_means(label.y = 40)
print(Proteus_mirabilis_boxplot)
```

```
## Warning in wilcox.test.default(c(30.75, 31.98, 33.21), c(33.21, 31.98, 34.44:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(30.75, 31.98, 33.21), c(27.06, 29.52, 31.98:
## cannot compute exact p-value with ties
```

```
## Warning in wilcox.test.default(c(27.06, 29.52, 31.98), c(33.21, 31.98, 34.44:
## cannot compute exact p-value with ties
```



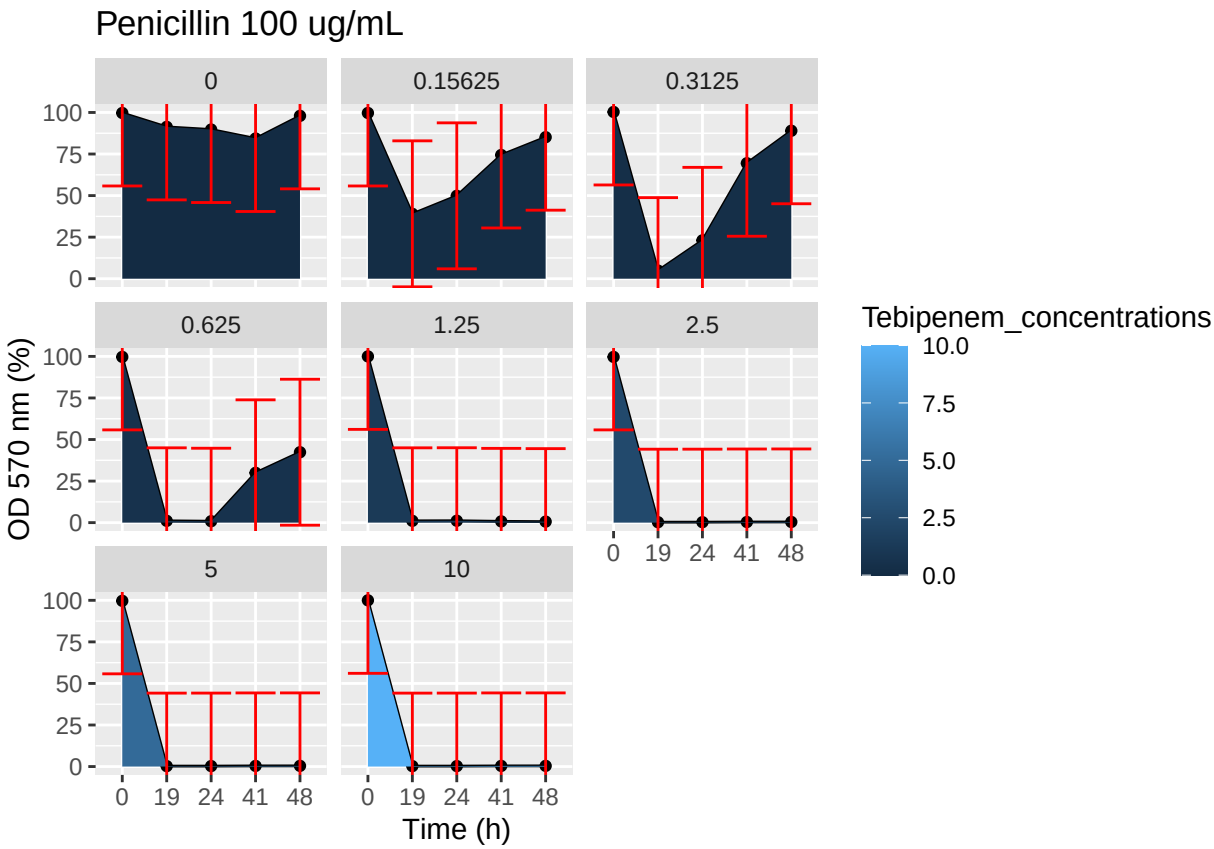

```
# CHECHERBOARD ASSAY TESTS ANALYSIS
#BACILLUS SUBTILIS RESULTS AND PLOTS
#Penicillin 100 ug/mL
Bacillus_Penicillin_100ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep
                                             Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,
                                             Optical_density_mean_values=c(((mean(0.053 , 0.052 , 0.05)-
                                                                            ((mean(0.054, 0.052, 0.052)-
                                                                            ((mean(0.054, 0.052, 0.052)-
                                                                            ((mean(0.053,0.054,0.053)-0.
                                                                            ((mean(0.054,0.044,0.053)-0.
                                                                            ((mean(0.052,0.054,0.054)-0.
                                                                            ((mean(0.054,0.054,0.053)-0.
                                                                            ((mean(0.054,0.055,0.054)-0.
                                                                            ((mean(0.038, 0.038,0.038)-me
                                                                            ((mean(0.038,0.038,0.362)-mea
                                                                            ((mean(0.038,0.038,0.038)-mea
                                                                            ((mean(0.041,0.04,0.041)-mean
                                                                            ((mean(0.041,0.372,0.039)-mea
                                                                            ((mean(0.055,0.041,0.146)-mea
```

```
                                                                    ((mean(0.181,0.176,0.187)-mea
                                                                    ((mean(0.374,0.367,0.364)-mea
                                                                    ((mean(0.038,0.038,0.039)-mea
                                                                    ((mean(0.038,0.038,0.289)-mea
                                                                    ((mean(0.038,0.038,0.039)-mea
                                                                    ((mean(0.041,0.039,0.041)-mea
                                                                    ((mean(0.04,0.397,0.041)-mean
                                                                    ((mean(0.118,0.039,0.213)-mea
                                                                    ((mean(0.212,0.227,0.252)-mea
                                                                    ((mean(0.352,0.389,0.409)-mea
                                                                    ((mean(0.038,0.037,0.038)-0.0
                                                                    ((mean(0.038,0.038,0.518)-0.0
                                                                    ((mean(0.038,0.038,0.038)-0.0
                                                                    ((mean(0.04,0.04,0.038)-0.030
                                                                    ((mean(0.193,0.449,0.039)-0.0
                                                                    ((mean(0.4,0.122,0.568)-0.030
                                                                    ((mean(0.426,0.36,0.521)-0.03
                                                                    ((mean(0.478,0.444,0.57)-0.03
                                                                    ((mean(0.038,0.042,0.037)-0.0
                                                                    ((mean(0.038,0.037,0.479)-0.0
                                                                    ((mean(0.038,0.038,0.039)-0.0
                                                                    ((mean(0.039,0.039,0.06)-0.03
                                                                    ((mean(0.244,0.503,0.048)-0.0
                                                                    ((mean(0.473,0.205,0.575)-0.0
                                                                    ((mean(0.454,0.371,0.478)-0.0
                                                                    ((mean(0.517,0.452,0.566)-0.0
print(Bacillus_Penicillin_100ug_data)
```

```
##    Time Tebipenem_concentrations Optical_density_mean_values
## 1     0                 10.00000                  100.0000000
## 2     0                  5.00000                   99.6941896
## 3     0                  2.50000                   99.6941896
## 4     0                  1.25000                  100.0000000
## 5     0                  0.62500                   99.6941896
## 6     0                  0.31250                  100.3058104
## 7     0                  0.15625                   99.6941896
## 8     0                  0.00000                   99.6941896
## 9    19                 10.00000                    0.2710027
## 10   19                  5.00000                    0.2710027
## 11   19                  2.50000                    0.2710027
## 12   19                  1.25000                    1.0840108
## 13   19                  0.62500                    1.0840108
## 14   19                  0.31250                    4.8780488
## 15   19                  0.15625                   39.0243902
## 16   19                  0.00000                   91.3279133
## 17   24                 10.00000                    0.2849003
## 18   24                  5.00000                    0.2849003
## 19   24                  2.50000                    0.2849003
## 20   24                  1.25000                    1.1396011
## 21   24                  0.62500                    0.8547009
## 22   24                  0.31250                   23.0769231
## 23   24                  0.15625                   49.8575499
## 24   24                  0.00000                   89.7435897
```

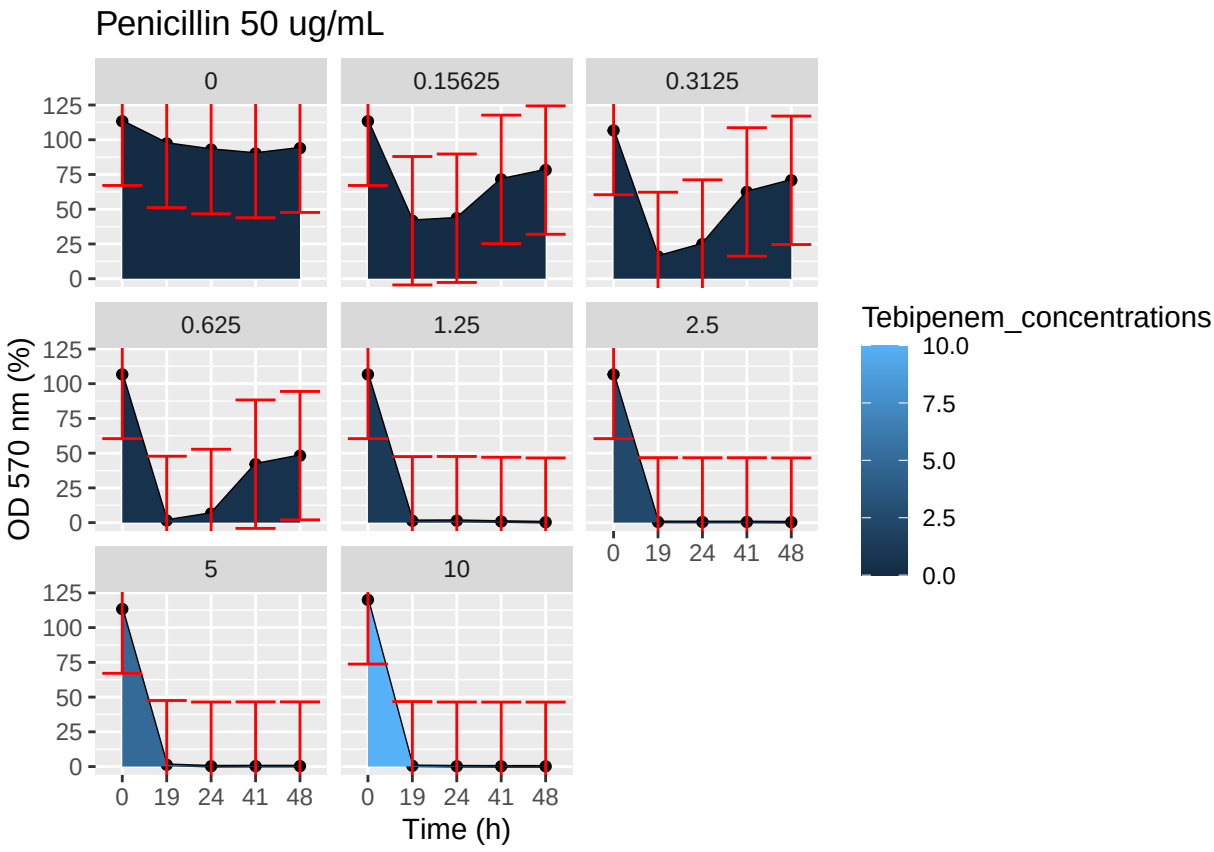
```
## 25   41                10.00000                  0.3816794
## 26   41                 5.00000                  0.3816794
## 27   41                 2.50000                  0.3816794
## 28   41                 1.25000                  0.7633588
## 29   41                 0.62500                 29.9618321
## 30   41                 0.31250                 69.4656489
## 31   41                 0.15625                 74.4274809
## 32   41                 0.00000                 84.3511450
## 33   48                10.00000                  0.4073320
## 34   48                 5.00000                  0.4073320
## 35   48                 2.50000                  0.4073320
## 36   48                 1.25000                  0.6109980
## 37   48                 0.62500                 42.3625255
## 38   48                 0.31250                 89.0020367
## 39   48                 0.15625                 85.1323829
## 40   48                 0.00000                 97.9633401
```

```
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp1<- Bacillus_Penicillin_100ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 100 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_Penicillin_100ug_data$Optical_density_mean_values-sd(Bacillus_Penicillin_
                ymax=Bacillus_Penicillin_100ug_data$Optical_density_mean_values+sd(Bacillus_Penicillin_
print(bp1)
```



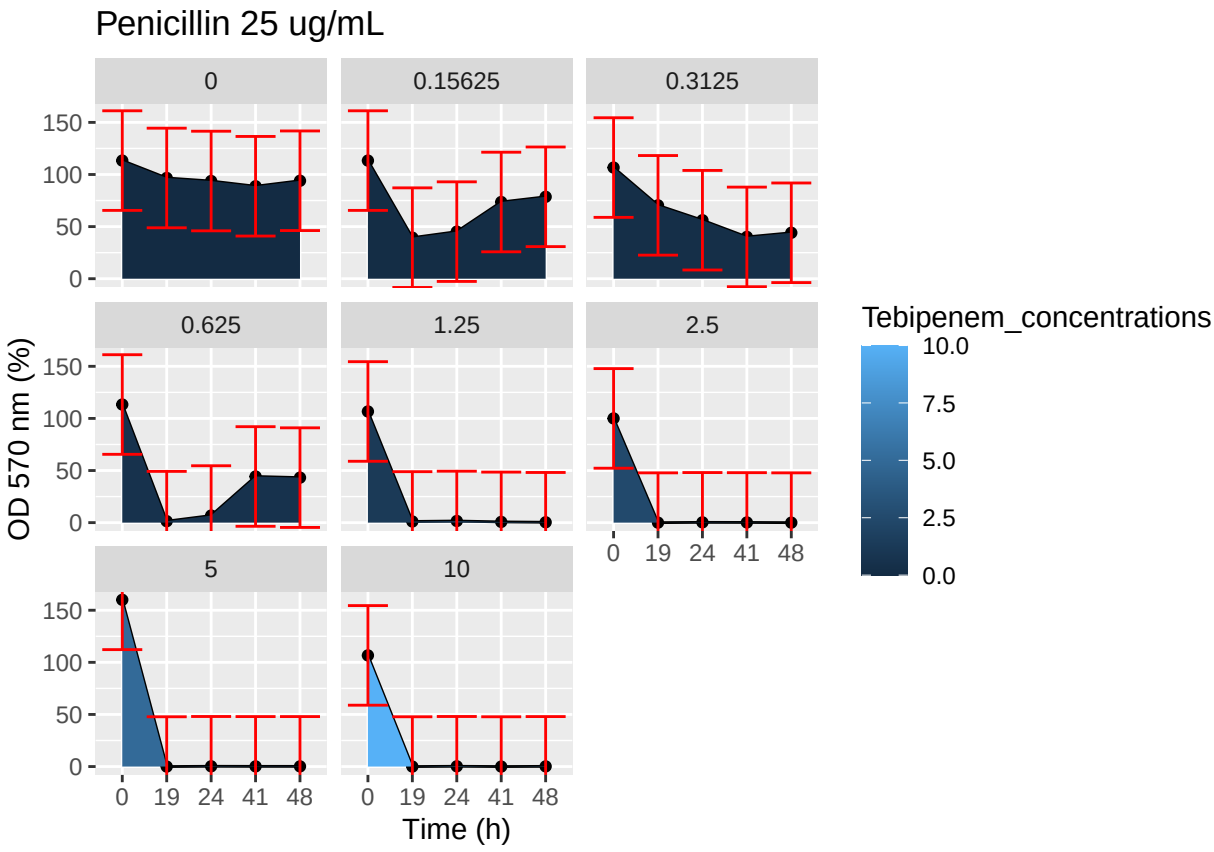

```
#Penicillin 50 ug/ml
Bacillus_subtilis_50ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
                                          Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                          Optical_density_mean_values=c(((mean(0.054,0.051,0.05)-0.036),
                                                                        ((mean(0.053,0.078,0.052)-0.036
                                                                        ((mean(0.052,0.06,0.052)-0.036),
                                                                        ((mean(0.052,0.056,0.053)-0.036
                                                                        ((mean(0.052,0.046,0.054)-0.036
                                                                        ((mean(0.052,0.056,0.054)-0.036
                                                                        ((mean(0.053,0.054,0.055)-0.036
                                                                        ((mean(0.053,0.054,0.054)-0.036
                                                                        ((mean(0.037,0.036,0.036)-mean(
                                                                        ((mean(0.04,0.037,0.049)-mean(0
                                                                        ((mean(0.037,0.037,0.04)-mean(0
                                                                        ((mean(0.04,0.04,0.041)-mean(0.
                                                                        ((mean(0.041,0.404,0.041)-mean(
                                                                        ((mean(0.096,0.041,0.105)-mean(
                                                                        ((mean(0.194,0.173,0.219)-mean(
                                                                        ((mean(0.406,0.414,0.414)-mean(
                                                                        ((mean(0.038,0.039,0.039)-mean(
                                                                        ((mean(0.038,0.039,0.049)-mean(
                                                                        ((mean(0.039,0.038,0.042)-mean(
                                                                        ((mean(0.043,0.042,0.044)-mean(
                                                                        ((mean(0.065,0.431,0.043)-mean(
                                                                        ((mean(0.143,0.045,0.158)-mean(
                                                                        ((mean(0.222,0.216,0.262)-mean(
```

```
                                                                    ((mean(0.432,0.467,0.442)-mean(
                                                                    ((mean(0.038,0.039,0.038)-mean(
                                                                    ((mean(0.039,0.039,0.047)-mean(
                                                                    ((mean(0.04,0.039,0.041)-mean(0
                                                                    ((mean(0.042,0.041,0.041)-mean(
                                                                    ((mean(0.297,0.575,0.044)-mean(
                                                                    ((mean(0.423,0.078,0.467)-mean(
                                                                    ((mean(0.479,0.379,0.51)-mean(0
                                                                    ((mean(0.594,0.517,0.632)-mean(
                                                                    ((mean(0.038,0.042,0.059)-mean(
                                                                    ((mean(0.039,0.04,0.048)-mean(0
                                                                    ((mean(0.039,0.039,0.041)-mean(
                                                                    ((mean(0.039,0.041,0.041)-mean(
                                                                    ((mean(0.331,0.595,0.06)-mean(0
                                                                    ((mean(0.469,0.153,0.506)-mean(
                                                                    ((mean(0.514,0.448,0.54)-mean(0
                                                                    ((mean(0.61,0.573,0.643)-mean(0
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp2 <-Bacillus_subtilis_50ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 50 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_50ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_50ug_
                ymax=Bacillus_subtilis_50ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_50ug_
print(bp2)
```



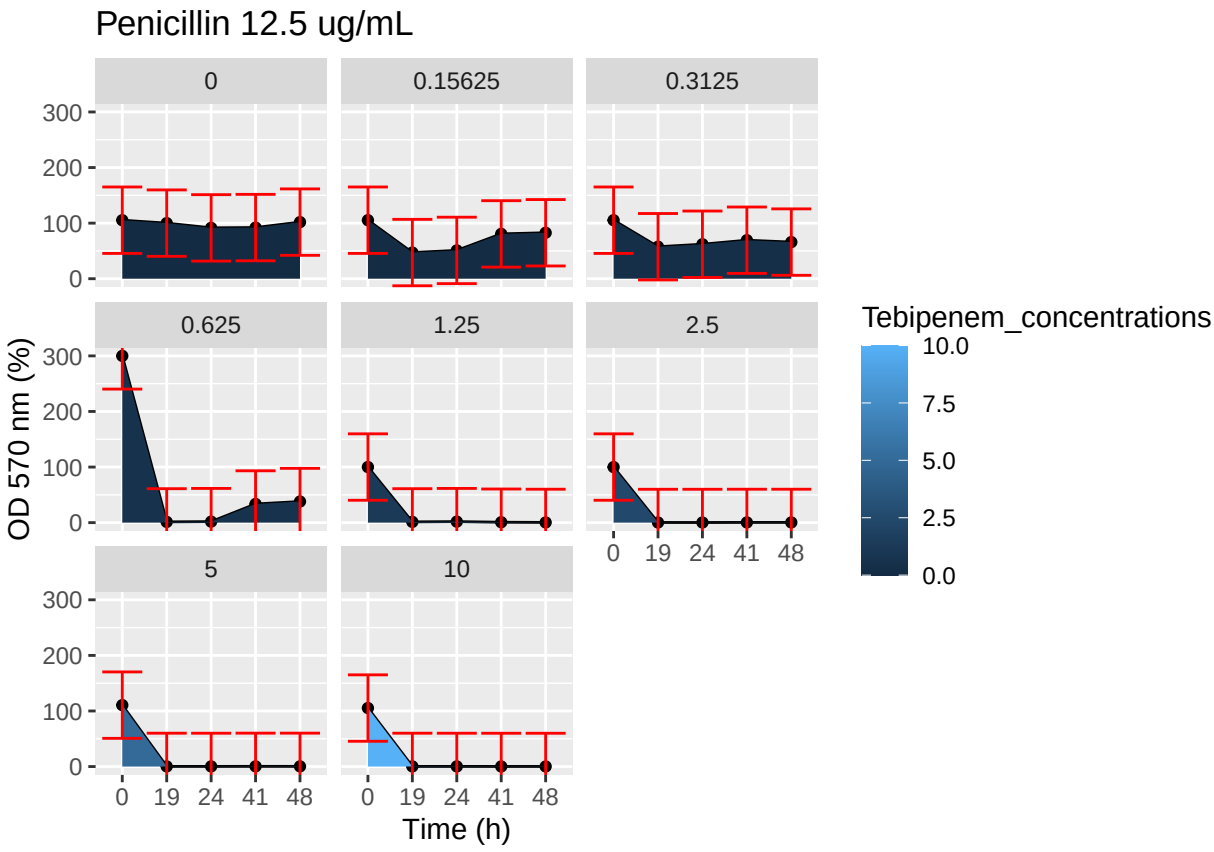

```
#Penicillin 25 ug/mL
Bacillus_subtilis_25ug_data <-data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
                                         Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                         Optical_density_mean_values =c(((mean(0.051,0.05,0.049)-0.035),
                                                                        ((mean(0.059,0.05,0.052)-0.035),
                                                                        ((mean(0.05,0.051,0.05)-0.035)/
                                                                        ((mean(0.051,0.053,0.053)-0.035
                                                                        ((mean(0.052,0.051,0.053)-0.035
                                                                        ((mean(0.051,0.053,0.051)-0.035
                                                                        ((mean(0.052,0.054,0.053)-0.035
                                                                        ((mean(0.052,0.053,0.054)-0.035
                                                                        ((mean(0.038,0.039,0.04)-mean(0
                                                                        ((mean(0.038,0.039,0.041)-mean(
                                                                        ((mean(0.038,0.039,0.039)-mean(
                                                                        ((mean(0.042,0.043,0.043)-mean(
                                                                        ((mean(0.043,0.385,0.043)-mean(
                                                                        ((mean(0.29,0.044,0.088)-mean(0
                                                                        ((mean(0.179,0.173,0.201)-mean(
                                                                        ((mean(0.384,0.402,0.401)-mean(
                                                                        ((mean(0.036,0.068,0.039)-mean(
                                                                        ((mean(0.036,0.037,0.038)-mean(
                                                                        ((mean(0.036,0.037,0.037)-mean(
                                                                        ((mean(0.041,0.042,0.041)-mean(
                                                                        ((mean(0.061,0.384,0.041)-mean(
                                                                        ((mean(0.25,0.041,0.142)-mean(0
                                                                        ((mean(0.208,0.212,0.233)-mean(
```

```
                                                                    ((mean(0.394,0.405,0.402)-mean(
                                                                    ((mean(0.034,0.049,0.036)-mean(
                                                                    ((mean(0.035,0.036,0.044)-mean(
                                                                    ((mean(0.035,0.036,0.039)-mean(
                                                                    ((mean(0.038,0.04,0.039)-mean(0
                                                                    ((mean(0.289,0.543,0.15)-mean(0
                                                                    ((mean(0.265,0.079,0.438)-mean(
                                                                    ((mean(0.458,0.338,0.488)-mean(
                                                                    ((mean(0.545,0.409,0.602)-mean(
                                                                    ((mean(0.035,0.055,0.036)-mean(
                                                                    ((mean(0.035,0.037,0.042)-mean(
                                                                    ((mean(0.034,0.068,0.036)-mean(
                                                                    ((mean(0.036,0.038,0.037)-mean(
                                                                    ((mean(0.278,0.557,0.226)-mean(
                                                                    ((mean(0.283,0.145,0.477)-mean(
                                                                    ((mean(0.478,0.417,0.511)-mean(
                                                                    ((mean(0.565,0.5,0.628)-mean(0.
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp3 <- Bacillus_subtilis_25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_25ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_25ug_
                ymax=Bacillus_subtilis_25ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_25ug_
print(bp3)
```



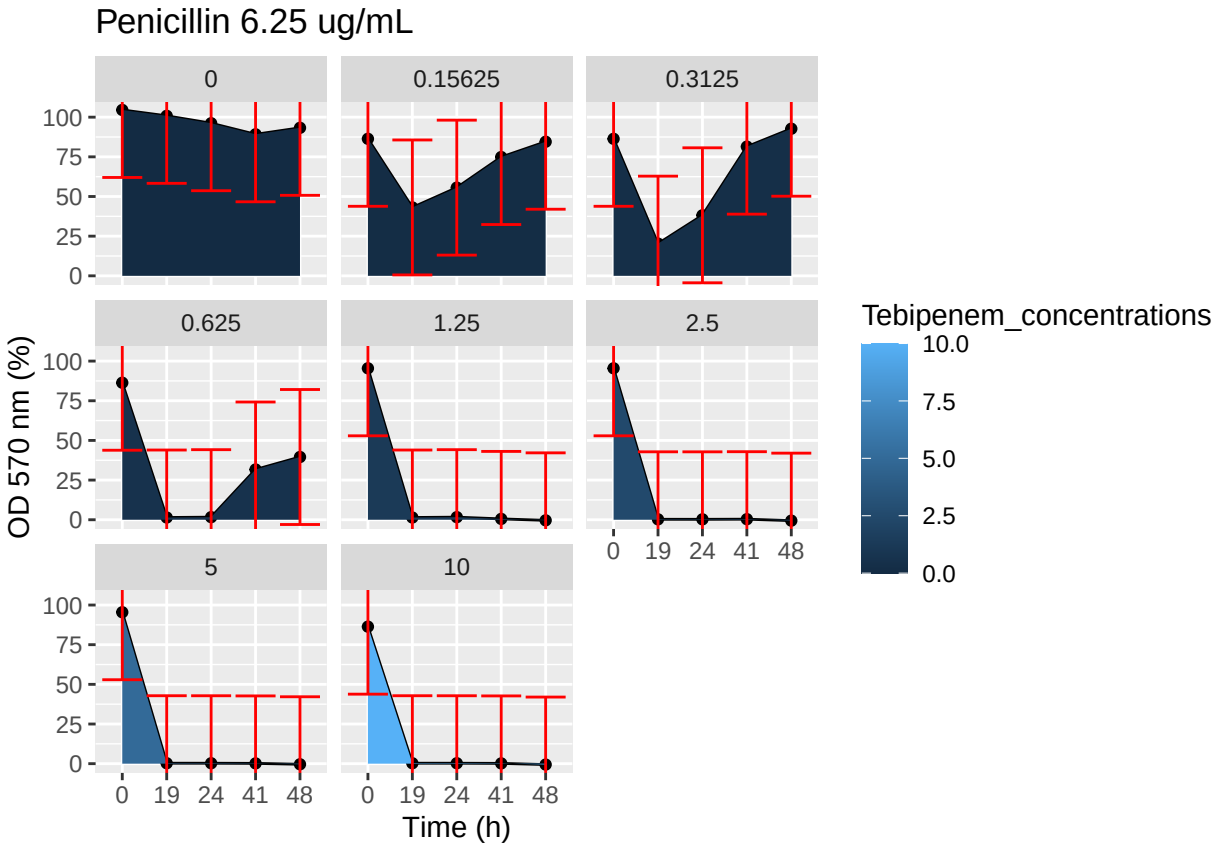

```
#Penicillin 12.5 ug/mL
Bacillus_subtilis_12.5ug_data <-data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("
                                                   Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.
                                                   Optical_density_mean_values =c(((mean(0.058,0.057,0.054)-mea
                                                                                  ((mean(0.059,0.054,0.057)-mea
                                                                                  ((mean(0.057,0.059,0.055)-mea
                                                                                  ((mean(0.057,0.058,0.058)-mea
                                                                                  ((mean(0.057,0.057,0.058-mean
                                                                                  ((mean(0.058,0.061,0.057)-mea
                                                                                  ((mean(0.058,0.061,0.061)-mea
                                                                                  ((mean(0.058,0.06,0.059)-mean
                                                                                  ((mean(0.038,0.038,0.039)-mea
                                                                                  ((mean(0.038,0.039,0.039)-mea
                                                                                  ((mean(0.038,0.039,0.039)-mea
                                                                                  ((mean(0.042,0.043,0.043)-mea
                                                                                  ((mean(0.042,0.396,0.063)-mea
                                                                                  ((mean(0.251,0.044,0.122)-mea
                                                                                  ((mean(0.212,0.194,0.233)-mea
                                                                                  ((mean(0.409,0.41,0.403)-mean
                                                                                  ((mean(0.038,0.049,0.042)-mea
                                                                                  ((mean(0.038,0.04,0.041)-mean
                                                                                  ((mean(0.038,0.039,0.04)-mean
                                                                                  ((mean(0.044,0.044,0.044)-mea
                                                                                  ((mean(0.044,0.389,0.084)-mea
                                                                                  ((mean(0.277,0.043,0.175)-mea
                                                                                  ((mean(0.234,0.234,0.269)-mea
```

```
                                                                    ((mean(0.391,0.395,0.396)-mea
                                                                    ((mean(0.038,0.054,0.039)-mea
                                                                    ((mean(0.039,0.041,0.045)-mea
                                                                    ((mean(0.039,0.039,0.04)-mean
                                                                    ((mean(0.041,0.042,0.042)-mea
                                                                    ((mean(0.217,0.505,0.358)-mea
                                                                    ((mean(0.409,0.142,0.54)-mean
                                                                    ((mean(0.47,0.339,0.494)-mean
                                                                    ((mean(0.531,0.393,0.58)-mean
                                                                    ((mean(0.038,0.059,0.04)-mean
                                                                    ((mean(0.039,0.04,0.041)-mean
                                                                    ((mean(0.039,0.086,0.04)-mean
                                                                    ((mean(0.039,0.04,0.041)-mean
                                                                    ((mean(0.245,0.533,0.351)-mea
                                                                    ((mean(0.398,0.241,0.532)-mea
                                                                    ((mean(0.49,0.408,0.507)-mean
                                                                    ((mean(0.558,0.483,0.624-mean
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp4 <- Bacillus_subtilis_12.5ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point() +
  geom_area()+
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 12.5 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_12.5ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_12.5
                ymax=Bacillus_subtilis_12.5ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_12.5
print(bp4)
```



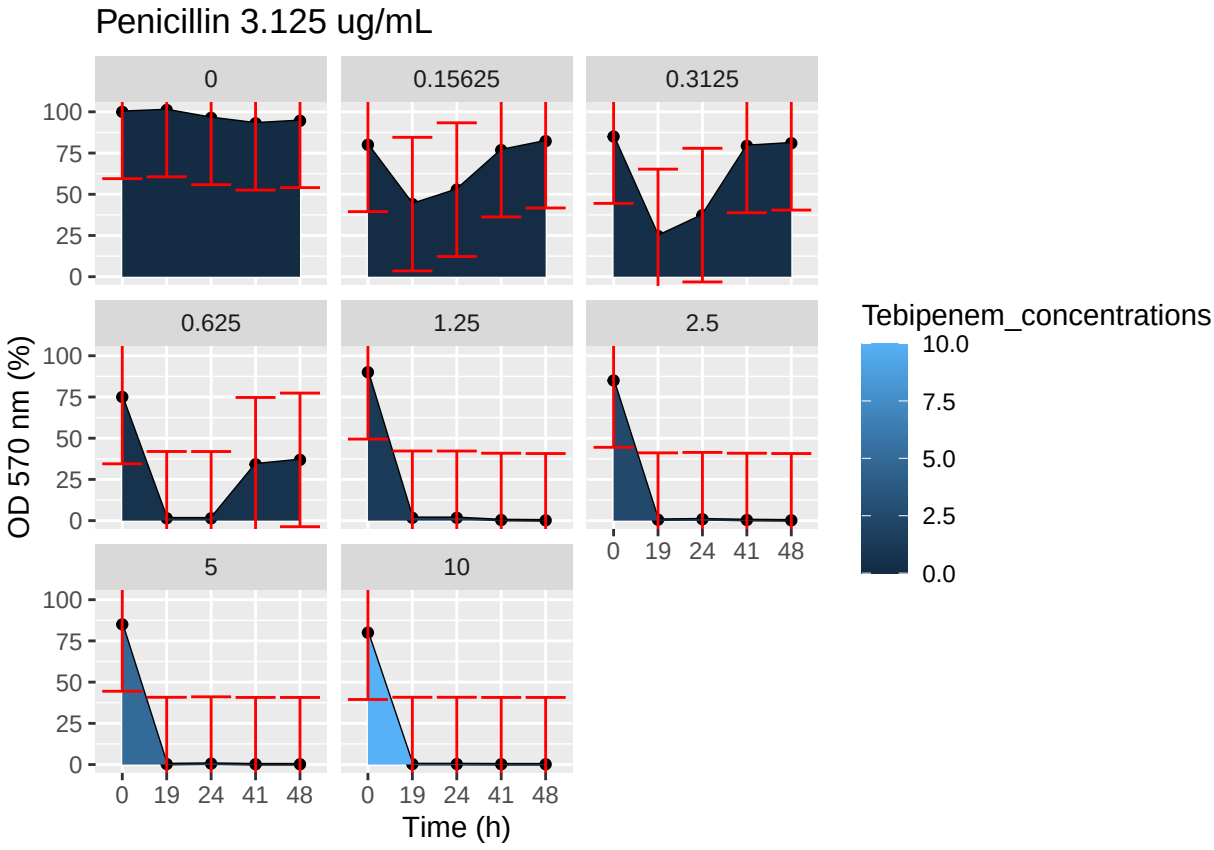

```
#Penicillin 6.25 ug/mL
Bacillus_subtilis_6.25ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep(
                                                    Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0
                                                    Optical_density_mean_values =c(((mean(0.055,0.055,0.052)-mea
                                                                                   ((mean(0.057,0.053,0.054)-mea
                                                                                   ((mean(0.057,0.056,0.054)-mea
                                                                                   ((mean(0.057,0.061,0.056)-mea
                                                                                   ((mean(0.055,0.054,0.056)-mea
                                                                                   ((mean(0.055,0.055,0.054)-mea
                                                                                   ((mean(0.055,0.058,0.057)-mea
                                                                                   ((mean(0.059,0.055,0.057)-mea
                                                                                   ((mean(0.036,0.036,0.038)-mea
                                                                                   ((mean(0.036,0.037,0.037)-mea
                                                                                   ((mean(0.036,0.037,0.037)-mea
                                                                                   ((mean(0.04,0.04,0.041)-mean
                                                                                   ((mean(0.04,0.403,0.042)-mean
                                                                                   ((mean(0.107,0.042,0.111)-mea
                                                                                   ((mean(0.188,0.183,0.233)-mea
                                                                                   ((mean(0.393,0.411,0.408)-mea
                                                                                   ((mean(0.036,0.037,0.039)-mea
                                                                                   ((mean(0.036,0.037,0.037)-mea
                                                                                   ((mean(0.036,0.037,0.036)-mea
                                                                                   ((mean(0.041,0.041,0.041)-mea
                                                                                   ((mean(0.041,0.391,0.067)-mea
                                                                                   ((mean(0.175,0.041,0.174)-mea
                                                                                   ((mean(0.239,0.224,0.271)-mea
```

```
                                                                                ((mean(0.388,0.394,0.392)-mea
                                                                                ((mean(0.036,0.097,0.041)-mea
                                                                                ((mean(0.036,0.037,0.044)-mea
                                                                                ((mean(0.037,0.038,0.037)-mea
                                                                                ((mean(0.038,0.212,0.04)-mean
                                                                                ((mean(0.214,0.516,0.358)-mea
                                                                                ((mean(0.495,0.14,0.488)-mean
                                                                                ((mean(0.458,0.33,0.5)-mean(
                                                                                ((mean(0.539,0.374,0.579)-mea
                                                                                ((mean(0.036,0.104,0.04)-mean
                                                                                ((mean(0.037,0.038,0.038)-mea
                                                                                ((mean(0.036,0.038,0.037)-mea
                                                                                ((mean(0.037,0.216,0.038)-mea
                                                                                ((mean(0.251,0.517,0.374)-mea
                                                                                ((mean(0.536,0.257,0.504)-mea
                                                                                ((mean(0.492,0.392,0.51)-mean
                                                                                ((mean(0.539,0.464,0.62)-mean
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp5<- Bacillus_subtilis_6.25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 6.25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_6.25ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_6.25
                ymax=Bacillus_subtilis_6.25ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_6.25
print(bp5)
```



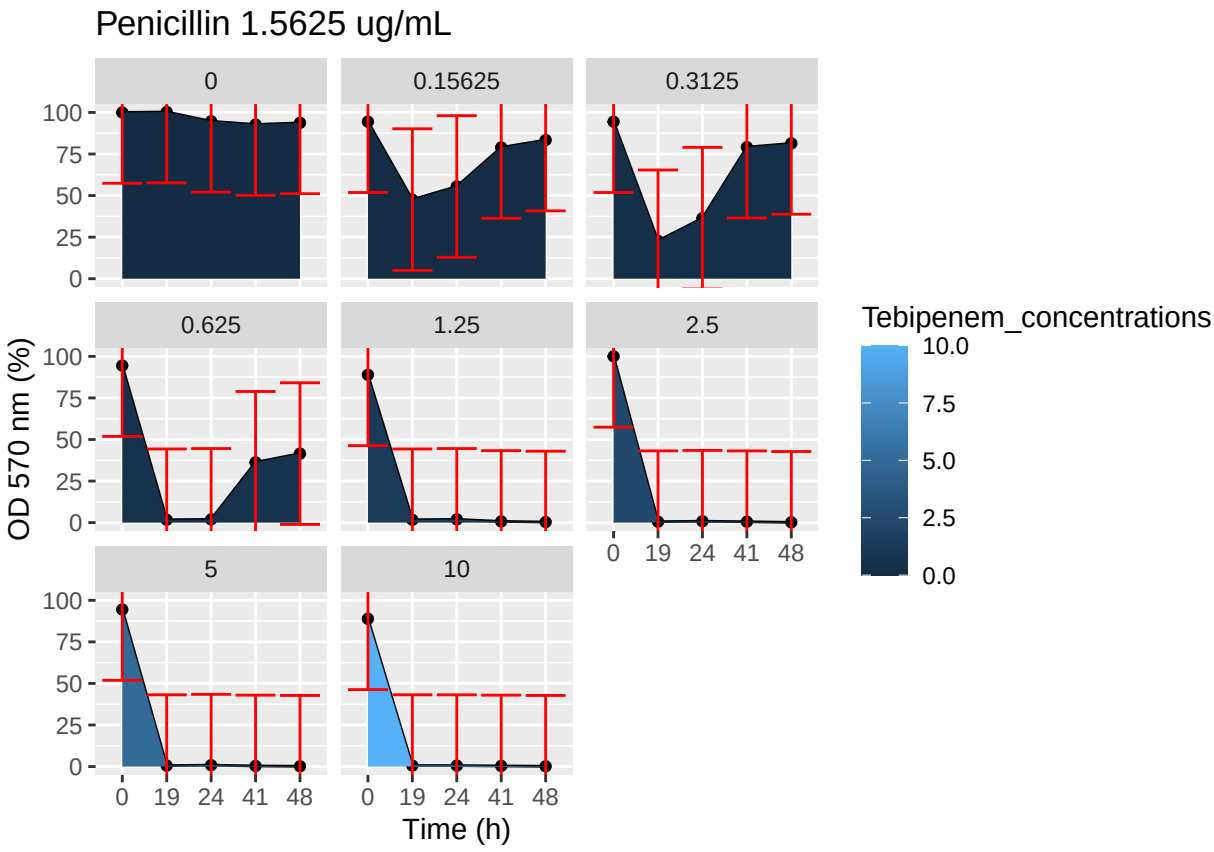

```
#Penicillin 3.125 ug/mL
Bacillus_subtilis_3.125ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep
                                                     Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,
                                                     Optical_density_mean_values =c(((mean(0.053,0.054,0.053)-me
                                                                                     ((mean(0.054,0.054,0.053)-me
                                                                                     ((mean(0.054,0.055,0.053)-me
                                                                                     ((mean(0.055,0.056,0.054)-me
                                                                                     ((mean(0.052,0.055,0.055)-me
                                                                                     ((mean(0.054,0.055,0.054)-me
                                                                                     ((mean(0.053,0.057,0.056)-me
                                                                                     ((mean(0.057,0.055,0.055)-me
                                                                                     ((mean(0.037,0.037,0.041)-me
                                                                                     ((mean(0.037,0.038,0.04)-mea
                                                                                     ((mean(0.038,0.038,0.04)-mea
                                                                                     ((mean(0.042,0.041,0.043)-me
                                                                                     ((mean(0.041,0.399,0.046)-me
                                                                                     ((mean(0.123,0.042,0.135)-me
                                                                                     ((mean(0.191,0.209,0.229)-me
                                                                                     ((mean(0.392,0.43,0.41)-mean
                                                                                     ((mean(0.037,0.038,0.041)-me
                                                                                     ((mean(0.038,0.038,0.04)-mea
                                                                                     ((mean(0.039,0.038,0.039)-me
                                                                                     ((mean(0.042,0.042,0.043)-me
                                                                                     ((mean(0.041,0.385,0.077)-me
                                                                                     ((mean(0.169,0.042,0.193)-me
                                                                                     ((mean(0.224,0.247,0.264)-me
```

```
                                                                    ((mean(0.379,0.416,0.399)-m
                                                                    ((mean(0.037,0.037,0.043)-m
                                                                    ((mean(0.037,0.039,0.045)-m
                                                                    ((mean(0.038,0.038,0.039)-m
                                                                    ((mean(0.038,0.041,0.04)-mea
                                                                    ((mean(0.223,0.498,0.291)-m
                                                                    ((mean(0.47,0.109,0.54)-mean
                                                                    ((mean(0.456,0.335,0.497)-m
                                                                    ((mean(0.545,0.436,0.585)-m
                                                                    ((mean(0.037,0.038,0.04)-mea
                                                                    ((mean(0.037,0.038,0.039)-m
                                                                    ((mean(0.037,0.075,0.038)-m
                                                                    ((mean(0.037,0.039,0.039)-m
                                                                    ((mean(0.239,0.513,0.275)-m
                                                                    ((mean(0.482,0.234,0.527)-m
                                                                    ((mean(0.489,0.403,0.535)-m
                                                                    ((mean(0.557,0.507,0.673)-m
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp6 <- Bacillus_subtilis_3.125ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 3.125 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_3.125ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_3.
                ymax=Bacillus_subtilis_3.125ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_3.
print(bp6)
```




```
# Penicillin 1.5625
Bacillus_subtilis_1.5625ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep
                                                      Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125
                                                      Optical_density_mean_values =c(((mean(0.052,0.053,0.053)-
                                                                                      ((mean(0.053,0.053,0.052)-
                                                                                      ((mean(0.054,0.054,0.052)-
                                                                                      ((mean(0.052,0.054,0.054)-
                                                                                      ((mean(0.053,0.054,0.054)-
                                                                                      ((mean(0.053,0.053,0.054)-
                                                                                      ((mean(0.053,0.056,0.054)-
                                                                                      ((mean(0.054,0.054,0.054)-
                                                                                      ((mean(0.037,0.037,0.039)-
                                                                                      ((mean(0.037,0.375,0.038)-
                                                                                      ((mean(0.037,0.037,0.039)-
                                                                                      ((mean(0.041,0.041,0.042)-
                                                                                      ((mean(0.041,0.393,0.043)-
                                                                                      ((mean(0.115,0.044,0.116)-
                                                                                      ((mean(0.202,0.199,0.229)-
                                                                                      ((mean(0.387,0.421,0.398)-
                                                                                      ((mean(0.037,0.038,0.039)-
                                                                                      ((mean(0.038,0.364,0.038)-
                                                                                      ((mean(0.038,0.039,0.038)-
                                                                                      ((mean(0.042,0.042,0.041)-
                                                                                      ((mean(0.042,0.374,0.041)-
                                                                                      ((mean(0.165,0.043,0.171)-
                                                                                      ((mean(0.233,0.243,0.259)-
```

```
                                                                                ((mean(0.373,0.421,0.388)-m
                                                                                ((mean(0.037,0.037,0.04)-me
                                                                                ((mean(0.037,0.45,0.038)-me
                                                                                ((mean(0.038,0.038,0.038)-m
                                                                                ((mean(0.039,0.041,0.039)-m
                                                                                ((mean(0.235,0.476,0.266)-m
                                                                                ((mean(0.471,0.122,0.548)-m
                                                                                ((mean(0.47,0.321,0.503)-me
                                                                                ((mean(0.546,0.474,0.583)-m
                                                                                ((mean(0.037,0.038,0.038)-m
                                                                                ((mean(0.037,0.463,0.038)-m
                                                                                ((mean(0.037,0.038,0.037)-m
                                                                                ((mean(0.038,0.039,0.039)-m
                                                                                ((mean(0.261,0.495,0.341)-m
                                                                                ((mean(0.477,0.243,0.556)-m
                                                                                ((mean(0.488,0.393,0.532)-m
                                                                                ((mean(0.544,0.511,0.63)-me
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp7 <- Bacillus_subtilis_1.5625ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 1.5625 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_1.5625ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_1
                ymax=Bacillus_subtilis_1.5625ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_1
print(bp7)
```



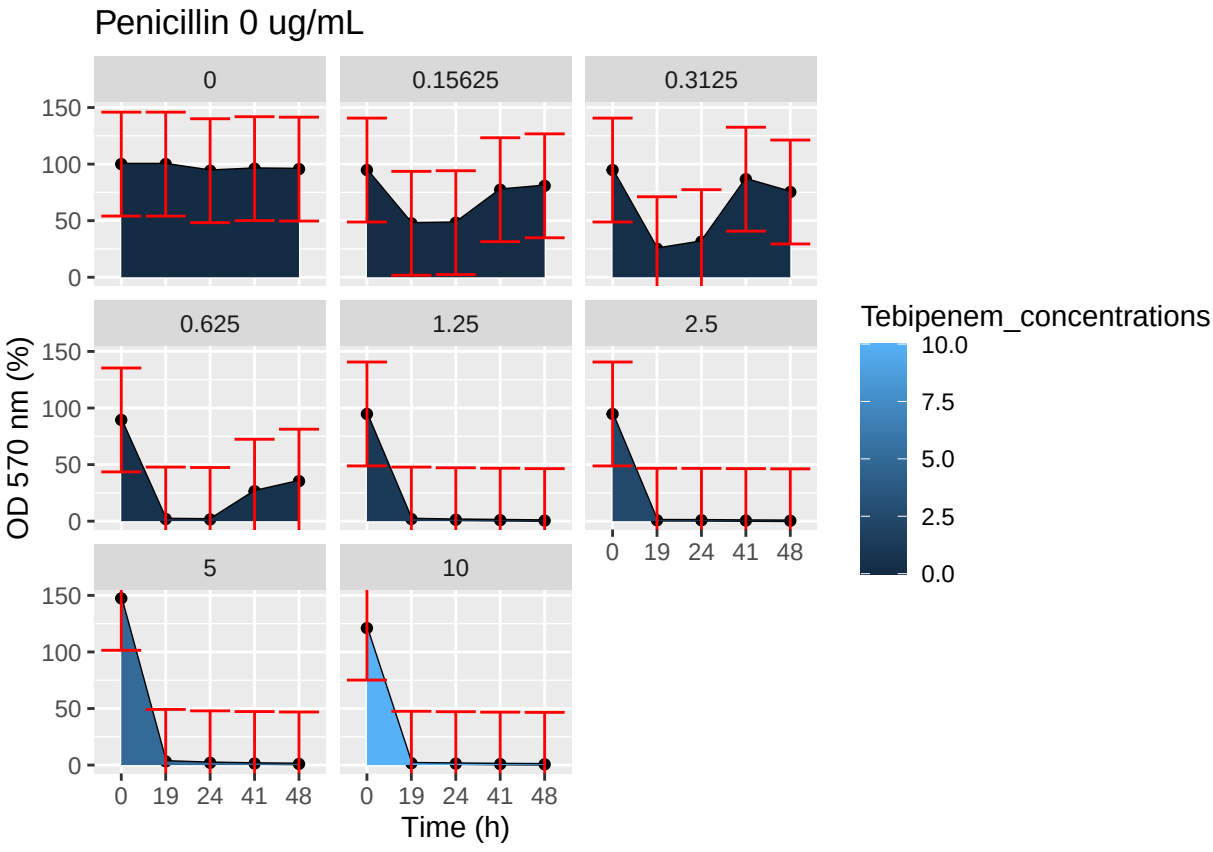

```
#Penicillin 0 ug/mL
Bacillus_subtilis_0ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
                                         Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                         Optical_density_mean_values =c(((mean(0.059,0.054,0.054)-0.036)
                                                                        ((mean(0.064,0.054,0.055)-0.036)
                                                                        ((mean(0.054,0.054,0.053)-0.036)
                                                                        ((mean(0.054,0.054,0.054)-0.036)
                                                                        ((mean(0.053,0.055,0.055)-0.036)
                                                                        ((mean(0.054,0.062,0.054)-0.036)
                                                                        ((mean(0.054,0.054,0.054)-0.036)
                                                                        ((mean(0.055,0.056,0.055)-0.036)
                                                                        ((mean(0.042,0.038,0.038)-mean(
                                                                        ((mean(0.048,0.038,0.039)-mean(
                                                                        ((mean(0.039,0.038,0.039)-mean(
                                                                        ((mean(0.043,0.041,0.045)-mean(
                                                                        ((mean(0.043,0.406,0.044)-mean(
                                                                        ((mean(0.128,0.041,0.127)-mean(
                                                                        ((mean(0.21,0.184,0.229)-mean(0
                                                                        ((mean(0.401,0.418,0.42)-mean(0
                                                                        ((mean(0.041,0.038,0.038)-mean(
                                                                        ((mean(0.044,0.039,0.039)-mean(
                                                                        ((mean(0.039,0.039,0.039)-mean(
                                                                        ((mean(0.041,0.042,0.042)-mean(
                                                                        ((mean(0.042,0.413,0.042)-mean(
                                                                        ((mean(0.16,0.044,0.189)-mean(0
                                                                        ((mean(0.226,0.233,0.266)-mean(
```

```
                                                                                ((mean(0.407,0.455,0.414)-mean(
                                                                                ((mean(0.04,0.038,0.038)-mean(0
                                                                                ((mean(0.043,0.038,0.04)-mean(0
                                                                                ((mean(0.038,0.039,0.038)-mean(
                                                                                ((mean(0.04,0.042,0.04)-mean(0.
                                                                                ((mean(0.186,0.52,0.277)-mean(0
                                                                                ((mean(0.529,0.093,0.567)-mean(
                                                                                ((mean(0.476,0.373,0.534)-mean(
                                                                                ((mean(0.582,0.531,0.606)-mean(
                                                                                ((mean(0.04,0.038,0.073)-mean(0
                                                                                ((mean(0.042,0.038,0.066)-mean(
                                                                                ((mean(0.038,0.039,0.092)-mean(
                                                                                ((mean(0.039,0.04,0.041)-mean(0
                                                                                ((mean(0.244,0.551,0.27)-mean(0
                                                                                ((mean(0.479,0.199,0.562)-mean(
                                                                                ((mean(0.511,0.432,0.592)-mean(
                                                                                ((mean(0.598,0.568,0.704)-mean(
print(Bacillus_subtilis_0ug_data)
```

```
##    Time Tebipenem_concentrations Optical_density_mean_values
## 1     0                 10.00000                  121.0526316
## 2     0                  5.00000                  147.3684211
## 3     0                  2.50000                   94.7368421
## 4     0                  1.25000                   94.7368421
## 5     0                  0.62500                   89.4736842
## 6     0                  0.31250                   94.7368421
## 7     0                  0.15625                   94.7368421
## 8     0                  0.00000                  100.0000000
## 9    19                 10.00000                    1.6438356
## 10   19                  5.00000                    3.2876712
## 11   19                  2.50000                    0.8219178
## 12   19                  1.25000                    1.9178082
## 13   19                  0.62500                    1.9178082
## 14   19                  0.31250                   25.2054795
## 15   19                  0.15625                   47.6712329
## 16   19                  0.00000                  100.0000000
## 17   24                 10.00000                    1.2690355
## 18   24                  5.00000                    2.0304569
## 19   24                  2.50000                    0.7614213
## 20   24                  1.25000                    1.2690355
## 21   24                  0.62500                    1.5228426
## 22   24                  0.31250                   31.4720812
## 23   24                  0.15625                   48.2233503
## 24   24                  0.00000                   94.1624365
## 25   41                 10.00000                    0.8771930
## 26   41                  5.00000                    1.4035088
## 27   41                  2.50000                    0.5263158
## 28   41                  1.25000                    0.8771930
## 29   41                  0.62500                   26.4912281
## 30   41                  0.31250                   86.6666667
## 31   41                  0.15625                   77.3684211
## 32   41                  0.00000                   95.9649123
## 33   48                 10.00000                    0.6802721
```

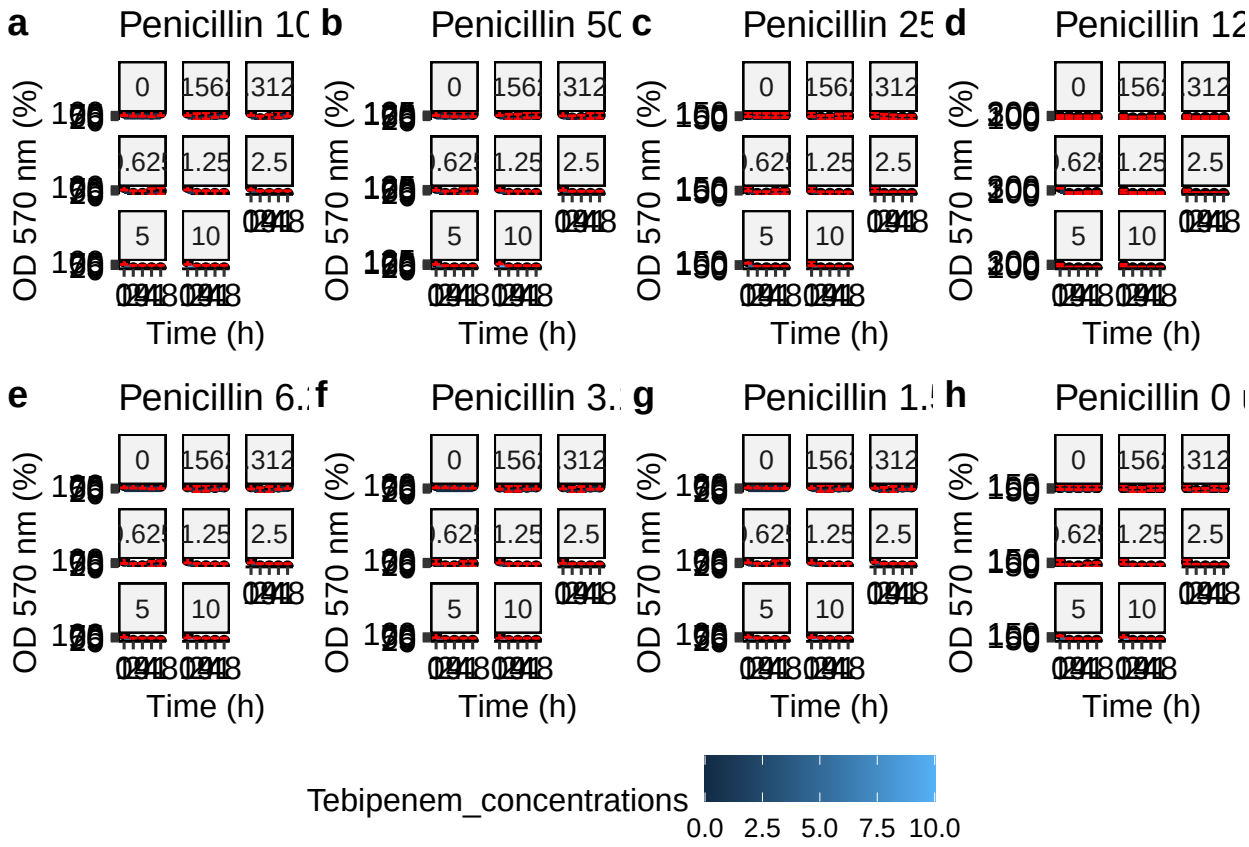
```
## 34   48                  5.00000                  1.0204082
## 35   48                  2.50000                  0.3401361
## 36   48                  1.25000                  0.5102041
## 37   48                  0.62500                 35.3741497
## 38   48                  0.31250                 75.3401361
## 39   48                  0.15625                 80.7823129
## 40   48                  0.00000                 95.5782313
```

```
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
bp8 <-Bacillus_subtilis_0ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 0 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Bacillus_subtilis_0ug_data$Optical_density_mean_values-sd(Bacillus_subtilis_0ug_da
                ymax=Bacillus_subtilis_0ug_data$Optical_density_mean_values+sd(Bacillus_subtilis_0ug_da
print(bp8)
```




```
#Align all graphs together
library(ggplot2)
library(ggpubr)
```

```
theme_set(theme_pubr())
figure <-
  ggarrange(bp1,bp2,bp3,bp4, bp5, bp6, bp7, bp8,
                        labels=c("a","b","c","d","e","f","g","h"),
                        ncol=4,nrow=2,
                        common.legend = TRUE,legend = "bottom")
print(figure)
```




```
#Final Plot and Data frame that conrain only values that inhibited the growth of the bacteria
Final_Bacillus_data <- data.frame(Time_f1=c("0","19","24","41","48"),
                                  Penicillin_concentrations= c(rep("PenV+Tebipenem (100 ug/mL+1.25 ug/
                                                               rep("PenV+Tebipenem (25 ug/mL+1.25 ug/m
                                                               rep("PenV+Tebipenem (6.25 ug/mL+1.25 ug
                                                               rep("PenV+Tebipenem (1.5625 ug/mL+1.25
                                  Optical_density_values= c(((mean(0.053,0.054,0.053)-0.38)/(mean(0.053
                                                            ((mean(0.041,0.04,0.041)-mean(0.037,0.038,0
                                                            ((mean(0.041,0.039,0.041)-mean(0.037,0.037,
                                                            ((mean(0.04,0.04,0.038)-mean(0.036,0.036,0.
                                                            ((mean(0.039,0.039,0.06)-0.036)/(mean(0.527
                                                            ((mean(0.052,0.056,0.053)-mean(0.036,0.036,
                                                            ((mean(0.04,0.04,0.041)-mean(0.035,0.282,0.
                                                            ((mean(0.043,0.042,0.044)-mean(0.037,0.402,
                                                            ((mean(0.042,0.041,0.041)-mean(0.037,0.548,
                                                            ((mean(0.039,0.041,0.041)-mean(0.037,0.632,
                                                            ((mean(0.051,0.053,0.053)-mean(0.035,0.035,
```

```
                                                                ((mean(0.042,0.043,0.043)-mean(0.038,0.038,
                                                                ((mean(0.041,0.042,0.041)-mean(0.035,0.036,
                                                                ((mean(0.038,0.04,0.039)-mean(0.034,0.035,0
                                                                ((mean(0.036,0.038,0.037)-mean(0.034,0.036,
                                                                ((mean(0.057,0.058,0.058)-mean(0.038,0.039,
                                                                ((mean(0.042,0.043,0.043)-mean(0.037,0.038,
                                                                ((mean(0.044,0.044,0.044)-mean(0.037,0.038,
                                                                ((mean(0.041,0.042,0.042)-mean(0.037,0.039,
                                                                ((mean(0.039,0,04,0.041)-mean(0.037,0.038,0
                                                                ((mean(0.057,0.061,0.056)-mean(0.036,0.036,
                                                                ((mean(0.04,0.04,0.041)-mean(0.035,0.036,0.
                                                                ((mean(0.041,0.041,0.041)-mean(0.035,0.039,
                                                                ((mean(0.038,0.212,0.04)-mean(0.035,0.037,0
                                                                ((mean(0.037,0.216,0.038)-mean(0.039,0.037,
                                                                ((mean(0.055,0.056,0.054)-mean(0.037,0.037,
                                                                ((mean(0.042,0.041,0.043)-mean(0.036,0.308,
                                                                ((mean(0.042,0.042,0.043)-mean(0.036,0.383,
                                                                ((mean(0.038,0.041,0.04)-mean(0.036,0.421,0
                                                                ((mean(0.037,0.039,0.039)-mean(0.036,0.534,
                                                                ((mean(0.052,0.054,0.054)-mean(0.036,0.036,
                                                                ((mean(0.041,0.041,0.042)-mean(0.035,0.358,
                                                                ((mean(0.042,0.042,0.041)-mean(0.035,0.431,
                                                                ((mean(0.039,0.041,0.039)-mean(0.035,0.54,0
                                                                ((mean(0.038,0.039,0.039)-mean(0.036,0.607,
                                                                ((mean(0.054,0.054,0.054)-0.036)/(0.055-0.03
                                                                ((mean(0.043,0.041,0.045)-mean(0.036,0.036,
                                                                ((mean(0.041,0.042,0.042)-mean(0.036,0.037,
                                                                ((mean(0.04,0.042,0.04)-mean(0.035,0.037,0.
                                                                ((mean(0.039,0.04,0.041)-mean(0.036,0.038,0
print(Final_Bacillus_data)
```

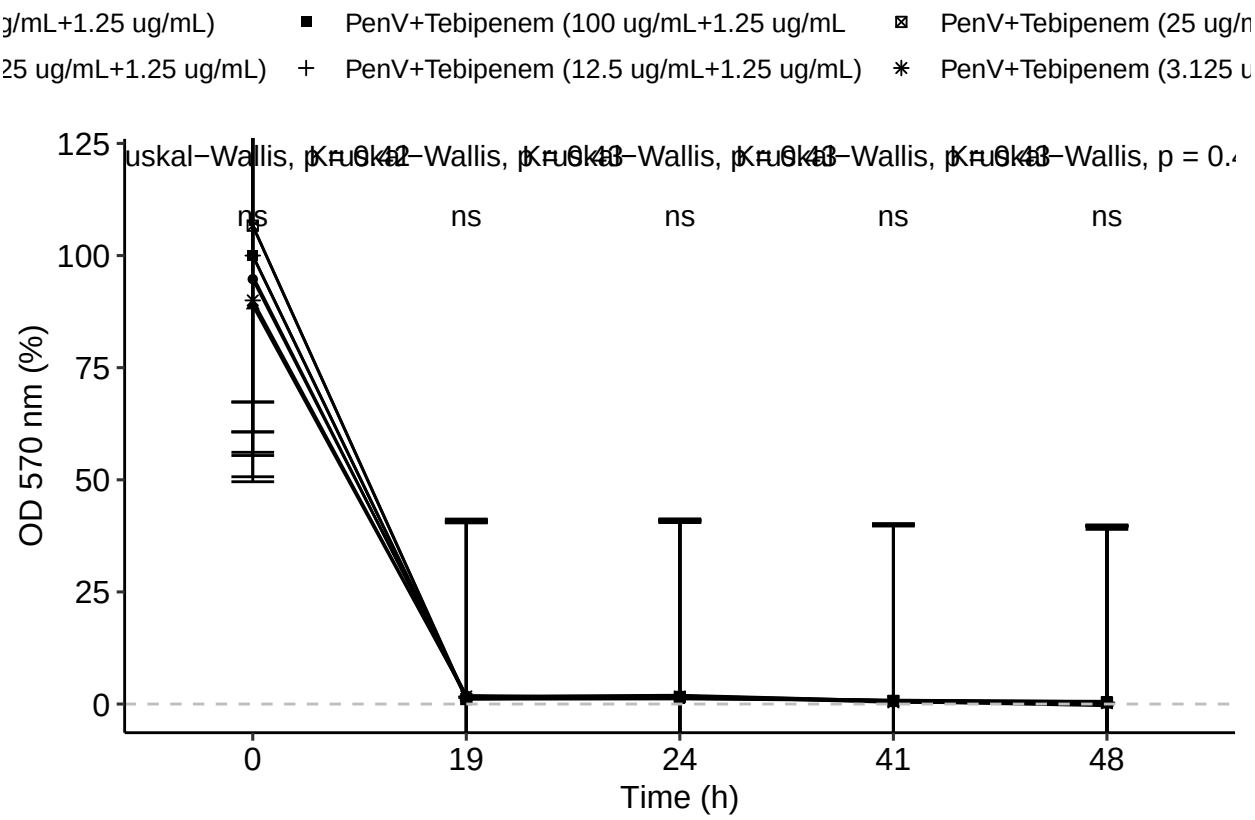
```
##    Time_f1                Penicillin_concentrations Optical_density_values
## 1        0     PenV+Tebipenem (100 ug/mL+1.25 ug/mL             100.0000000
## 2       19     PenV+Tebipenem (100 ug/mL+1.25 ug/mL               1.0840108
## 3       24     PenV+Tebipenem (100 ug/mL+1.25 ug/mL               1.1396011
## 4       41     PenV+Tebipenem (100 ug/mL+1.25 ug/mL               0.7633588
## 5       48     PenV+Tebipenem (100 ug/mL+1.25 ug/mL               0.6109980
## 6        0     PenV+Tebipenem (50 ug/mL+1.25 ug/mL)             106.6666667
## 7       19     PenV+Tebipenem (50 ug/mL+1.25 ug/mL)               1.3123360
## 8       24     PenV+Tebipenem (50 ug/mL+1.25 ug/mL)               1.4117647
## 9       41     PenV+Tebipenem (50 ug/mL+1.25 ug/mL)               0.8090615
## 10      48     PenV+Tebipenem (50 ug/mL+1.25 ug/mL)               0.3278689
## 11       0     PenV+Tebipenem (25 ug/mL+1.25 ug/mL)             106.6666667
## 12      19     PenV+Tebipenem (25 ug/mL+1.25 ug/mL)               1.1173184
## 13      24     PenV+Tebipenem (25 ug/mL+1.25 ug/mL)               1.5665796
## 14      41     PenV+Tebipenem (25 ug/mL+1.25 ug/mL)               0.6944444
## 15      48     PenV+Tebipenem (25 ug/mL+1.25 ug/mL)               0.3539823
## 16       0   PenV+Tebipenem (12.5 ug/mL+1.25 ug/mL)             100.0000000
## 17      19   PenV+Tebipenem (12.5 ug/mL+1.25 ug/mL)               1.3440860
## 18      24   PenV+Tebipenem (12.5 ug/mL+1.25 ug/mL)               1.8087855
## 19      41   PenV+Tebipenem (12.5 ug/mL+1.25 ug/mL)               0.7448790
## 20      48   PenV+Tebipenem (12.5 ug/mL+1.25 ug/mL)               0.3649635
## 21       0   PenV+Tebipenem (6.25 ug/mL+1.25 ug/mL)              95.4545455
```

```
## 22      19   PenV+Tebipenem (6.25 ug/mL+1.25 ug/mL)              1.4084507
## 23      24   PenV+Tebipenem (6.25 ug/mL+1.25 ug/mL)              1.6348774
## 24      41   PenV+Tebipenem (6.25 ug/mL+1.25 ug/mL)              0.5309735
## 25      48   PenV+Tebipenem (6.25 ug/mL+1.25 ug/mL)             -0.3731343
## 26       0  PenV+Tebipenem (3.125 ug/mL+1.25 ug/mL)             90.0000000
## 27      19  PenV+Tebipenem (3.125 ug/mL+1.25 ug/mL)              1.7045455
## 28      24  PenV+Tebipenem (3.125 ug/mL+1.25 ug/mL)              1.6853933
## 29      41  PenV+Tebipenem (3.125 ug/mL+1.25 ug/mL)              0.3656307
## 30      48  PenV+Tebipenem (3.125 ug/mL+1.25 ug/mL)              0.1814882
## 31       0 PenV+Tebipenem (1.5625 ug/mL+1.25 ug/mL)             88.8888889
## 32      19 PenV+Tebipenem (1.5625 ug/mL+1.25 ug/mL)              1.7094017
## 33      24 PenV+Tebipenem (1.5625 ug/mL+1.25 ug/mL)              1.9607843
## 34      41 PenV+Tebipenem (1.5625 ug/mL+1.25 ug/mL)              0.7259528
## 35      48 PenV+Tebipenem (1.5625 ug/mL+1.25 ug/mL)              0.3690037
## 36       0     PenV+Tebiepenem (0 ug/mL+1.25 ug/mL)             94.7368421
## 37      19     PenV+Tebiepenem (0 ug/mL+1.25 ug/mL)              1.9178082
## 38      24     PenV+Tebiepenem (0 ug/mL+1.25 ug/mL)              1.2690355
## 39      41     PenV+Tebiepenem (0 ug/mL+1.25 ug/mL)              0.8771930
## 40      48     PenV+Tebiepenem (0 ug/mL+1.25 ug/mL)              0.5102041
```

```
#Line graph
Final_Bac <- Final_Bacillus_data %>%
  ggplot(aes(x=Time_f1, y=Optical_density_values, group=Penicillin_concentrations, shape=Penicillin_con
  geom_line()+
  geom_point()+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  stat_compare_means(method = "kruskal.test", label.y =120)+
  stat_compare_means(label = "p.signif")+
  geom_errorbar(ymin=Final_Bacillus_data$Optical_density_values-sd(Final_Bacillus_data$Optical_density_
                ymax=Final_Bacillus_data$Optical_density_values+sd(Final_Bacillus_data$Optical_density_
                width=.2)+
  geom_hline(yintercept = 0, linetype="dashed", col="grey")
print(Final_Bac)
```

```
## Warning: The shape palette can deal with a maximum of 6 discrete values because
## more than 6 becomes difficult to discriminate; you have 8. Consider
## specifying shapes manually if you must have them.
```

```
## Warning: Removed 10 rows containing missing values (geom_point).
```



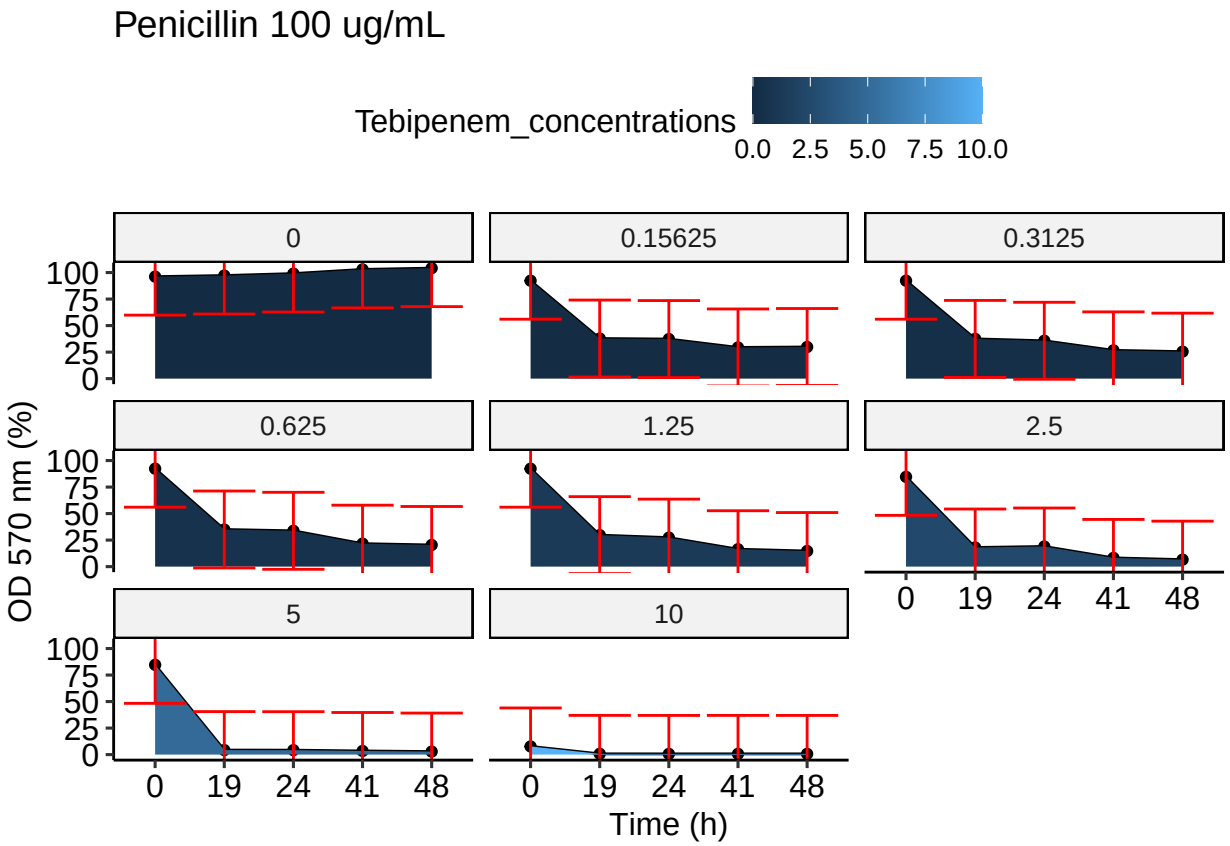

```
#PROTEUS MIRABILIS RESULTS AND PLOTS
#Penicillin 100 ug/mL
Proteus_mirabilis_100ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("4
                                                   Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.1
                                                   Optical_density_mean_values =c(((mean(0.04, 0.06, 0.806)-0.03
                                                                                  ((mean(0.06,0.061, 0.061)-0.03
                                                                                  ((mean(0.06,0.061,0.061)-0.038
                                                                                  ((mean(0.062,0.061,0.061)-0.03
                                                                                  ((mean(0.062,0.061,0.066)-0.03
                                                                                  ((mean(0.062,0.061,0.064)-0.03
                                                                                  ((mean(0.062,0.061,0.061)-0.03
                                                                                  ((mean(0.063,0.062,0.062)-0.03
                                                                                  ((mean(0.04,0.049,0.051)-mean
                                                                                  ((mean(0.05,0.06,0.054)-mean(
                                                                                  ((mean(0.089,0.1,0.093)-mean(
                                                                                  ((mean(0.122,0.127,0.121)-mean
                                                                                  ((mean(0.137,0.152,0.141)-mean
                                                                                  ((mean(0.144,0.159,0.146)-mean
                                                                                  ((mean(0.145,0.161,0.14)-mean
                                                                                  ((mean(0.313,0.319,0.321)-mean
                                                                                  ((mean(0.04,0.048,0.043)-mean
                                                                                  ((mean(0.051,0.052,0.051)-mean
                                                                                  ((mean(0.097,0.1,0.098)-mean(
                                                                                  ((mean(0.123,0.125,0.12)-mean
                                                                                  ((mean(0.143,0.149,0.139)-mean
                                                                                  ((mean(0.149,0.159,0.149)-mean
```

```
                                                                    ((mean(0.154,0.167,0.15)-mean
                                                                    ((mean(0.346,0.344,0.337)-mea
                                                                    ((mean(0.041,0.049,0.039)-mea
                                                                    ((mean(0.053,0.053,0.051)-mea
                                                                    ((mean(0.074,0.081,0.081)-mea
                                                                    ((mean(0.11,0.114,0.11)-mean(
                                                                    ((mean(0.133,0.152,0.14)-mean
                                                                    ((mean(0.155,0.182,0.157)-mea
                                                                    ((mean(0.167,0.201,0.165)-mea
                                                                    ((mean(0.49,0.494,0.416)-mean
                                                                    ((mean(0.041,0.048,0.036)-mea
                                                                    ((mean(0.051,0.051,0.052)-mea
                                                                    ((mean(0.068,0.075,0.085)-mea
                                                                    ((mean(0.105,0.109,0.111)-mea
                                                                    ((mean(0.131,0.144,0.141)-mea
                                                                    ((mean(0.154,0.176,0.161)-mea
                                                                    ((mean(0.174,0.206,0.186)-mea
                                                                    ((mean(0.513,0.501,0.49)-mean
print(Proteus_mirabilis_100ug_data)
```

```
##    Time Tebipenem_concentrations Optical_density_mean_values
## 1     0                 10.00000                   7.6923077
## 2     0                  5.00000                  84.6153846
## 3     0                  2.50000                  84.6153846
## 4     0                  1.25000                  92.3076923
## 5     0                  0.62500                  92.3076923
## 6     0                  0.31250                  92.3076923
## 7     0                  0.15625                  92.3076923
## 8     0                  0.00000                  96.1538462
## 9    19                 10.00000                   0.7067138
## 10   19                  5.00000                   4.2402827
## 11   19                  2.50000                  18.0212014
## 12   19                  1.25000                  29.6819788
## 13   19                  0.62500                  34.9823322
## 14   19                  0.31250                  37.4558304
## 15   19                  0.15625                  37.8091873
## 16   19                  0.00000                  97.1731449
## 17   24                 10.00000                   0.6430868
## 18   24                  5.00000                   4.1800643
## 19   24                  2.50000                  18.9710611
## 20   24                  1.25000                  27.3311897
## 21   24                  0.62500                  33.7620579
## 22   24                  0.31250                  35.6913183
## 23   24                  0.15625                  37.2990354
## 24   24                  0.00000                  99.0353698
## 25   41                 10.00000                   0.6833713
## 26   41                  5.00000                   3.4168565
## 27   41                  2.50000                   8.2004556
## 28   41                  1.25000                  16.4009112
## 29   41                  0.62500                  21.6400911
## 30   41                  0.31250                  26.6514806
## 31   41                  0.15625                  29.3849658
## 32   41                  0.00000                 102.9612756
```

```
## 33   48                10.00000                0.6578947
## 34   48                 5.00000                2.8508772
## 35   48                 2.50000                6.5789474
## 36   48                 1.25000               14.6929825
## 37   48                 0.62500               20.3947368
## 38   48                 0.31250               25.4385965
## 39   48                 0.15625               29.8245614
## 40   48                 0.00000              104.1666667
```

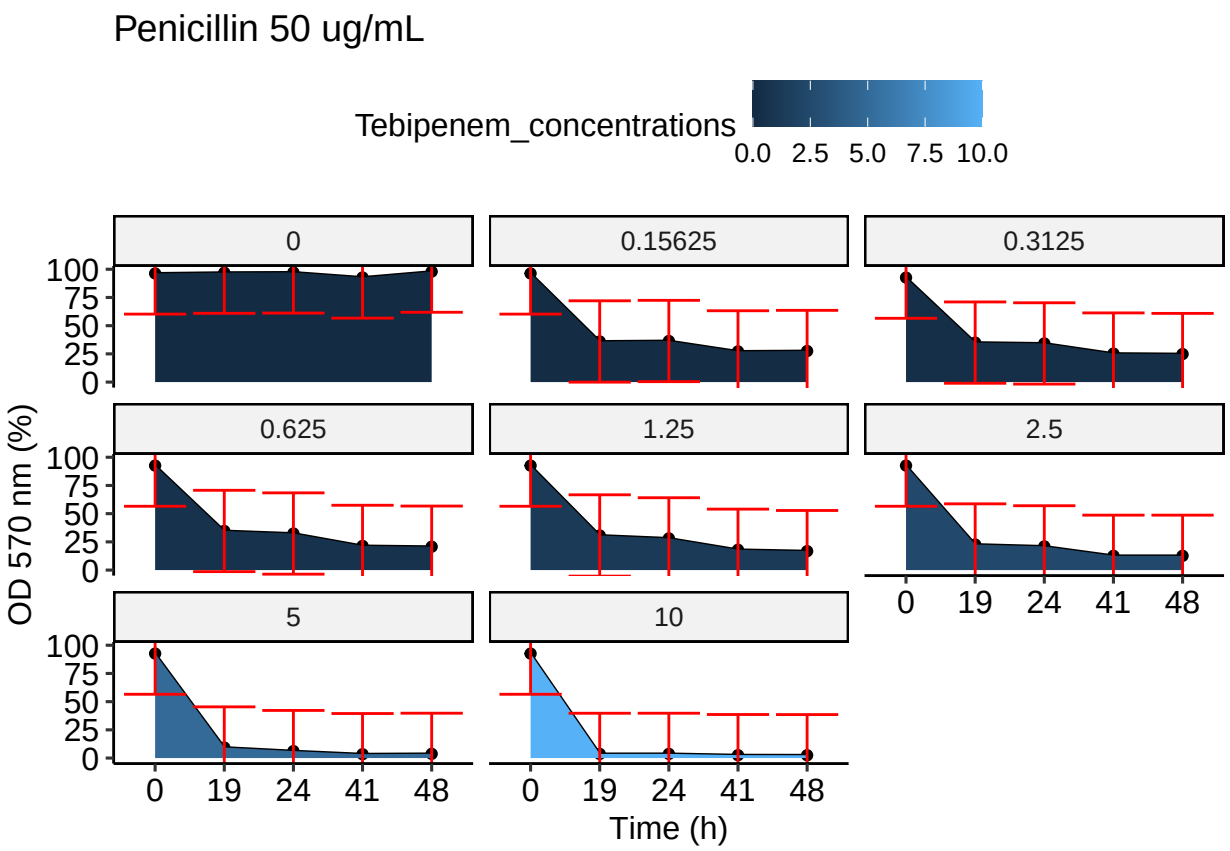
```
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp1 <- Proteus_mirabilis_100ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area()+
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 100 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_100ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_100u
                ymax=Proteus_mirabilis_100ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_100u
print(Pp1)
```




```
#Penicillin 50 ug/mL
Proteus_mirabilis_50ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
```

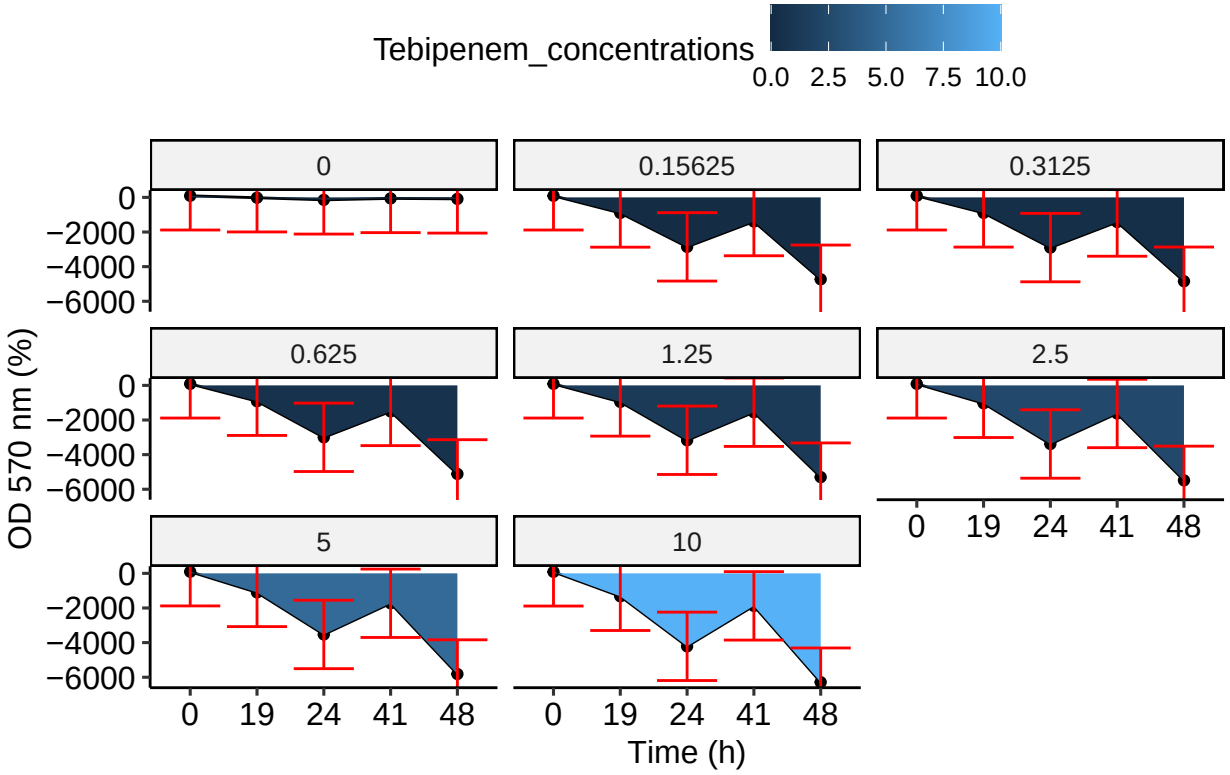
```
                                    Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                    Optical_density_mean_values =c(((mean(0.06,0.06,0.04)-mean(0.
                                                                   ((mean(0.06,0.06,0.06)-mean(0.
                                                                   ((mean(0.06,0.061,0.06)-mean(0
                                                                   ((mean(0.06,0.06,0.061)-mean(0
                                                                   ((mean(0.06,0.06,0.06)-mean(0.
                                                                   ((mean(0.06,0.06,0.061)-mean(0
                                                                   ((mean(0.061,0.06,0.059)-mean(
                                                                   ((mean(0.061,0.06,0.06)-mean(0
                                                                   ((mean(0.046,0.048,0.194)-mean
                                                                   ((mean(0.063,0.097,0.069)-mean
                                                                   ((mean(0.103,0.108,0.106)-mean
                                                                   ((mean(0.127,0.129,0.124)-mean
                                                                   ((mean(0.139,0.143,0.137)-mean
                                                                   ((mean(0.14,0.15,0.138)-mean(0
                                                                   ((mean(0.143,0.154,0.143)-mean
                                                                   ((mean(0.326,0.341,0.327)-mean
                                                                   ((mean(0.049,0.051,0.239)-mean
                                                                   ((mean(0.057,0.1,0.067)-mean(0
                                                                   ((mean(0.105,0.11,0.11)-mean(0
                                                                   ((mean(0.128,0.129,0.127)-mean
                                                                   ((mean(0.142,0.145,0.144)-mean
                                                                   ((mean(0.148,0.156,0.147)-mean
                                                                   ((mean(0.155,0.166,0.154)-mean
                                                                   ((mean(0.352,0.346,0.337)-mean
                                                                   ((mean(0.05,0.052,0.239)-0.038
                                                                   ((mean(0.054,0.082,0.056)-0.038
                                                                   ((mean(0.097,0.104,0.104)-0.038
                                                                   ((mean(0.122,0.125,0.12)-0.038)
                                                                   ((mean(0.138,0.149,0.145)-0.038
                                                                   ((mean(0.156,0.176,0.159)-0.038
                                                                   ((mean(0.165,0.19,0.162)-0.038)
                                                                   ((mean(0.471,0.504,0.413)-0.038
                                                                   ((mean(0.05,0.051,0.168)-0.038)
                                                                   ((mean(0.056,0.083,0.061)-0.038
                                                                   ((mean(0.099,0.107,0.109)-0.038
                                                                   ((mean(0.119,0.121,0.12)-0.038)
                                                                   ((mean(0.138,0.148,0.147)-0.038
                                                                   ((mean(0.158,0.177,0.162)-0.038
                                                                   ((mean(0.171,0.2,0.171)-0.038),
                                                                   ((mean(0.511,0.525,0.474)-0.038
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp2 <- Proteus_mirabilis_50ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 50 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_50ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_50ug_
                ymax=Proteus_mirabilis_50ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_50ug_
```

```
print(Pp2)
```




```
#Penicillin 25 ug/mL
Proteus_mirabilis_25ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
                                                  Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                                  Optical_density_mean_values =c(((mean(0.058,0.057,0.056)-0.035
                                                                                 ((mean(0.06,0.057,0.06)-0.035),
                                                                                 ((mean(0.058,0.056,0.058)-0.035
                                                                                 ((mean(0.058,0.057,0.059)-0.035
                                                                                 ((mean(0.058,0.058,0.058)-0.035
                                                                                 ((mean(0.059,0.062,0.057)-0.035
                                                                                 ((mean(0.059,0.057,0.057)-0.035
                                                                                 ((mean(0.059,0.058,0.057)-0.035
                                                                                 ((mean(0.05,0.05,0.05)-mean(0.3
                                                                                 ((mean(0.095,0.09,0.094)-mean(0
                                                                                 ((mean(0.108,0.106,0.109)-mean
                                                                                 ((mean(0.124,0.127,0.12)-mean(0
                                                                                 ((mean(0.132,0.137,0.133)-mean
                                                                                 ((mean(0.136,0.144,0.132)-mean
                                                                                 ((mean(0.135,0.144,0.136)-mean
                                                                                 ((mean(0.311,0.333,0.32)-mean(0
                                                                                 ((mean(0.048,0.048,0.046)-mean
                                                                                 ((mean(0.096,0.089,0.098)-mean
                                                                                 ((mean(0.106,0.103,0.109)-mean
                                                                                 ((mean(0.121,0.124,0.122)-mean
```

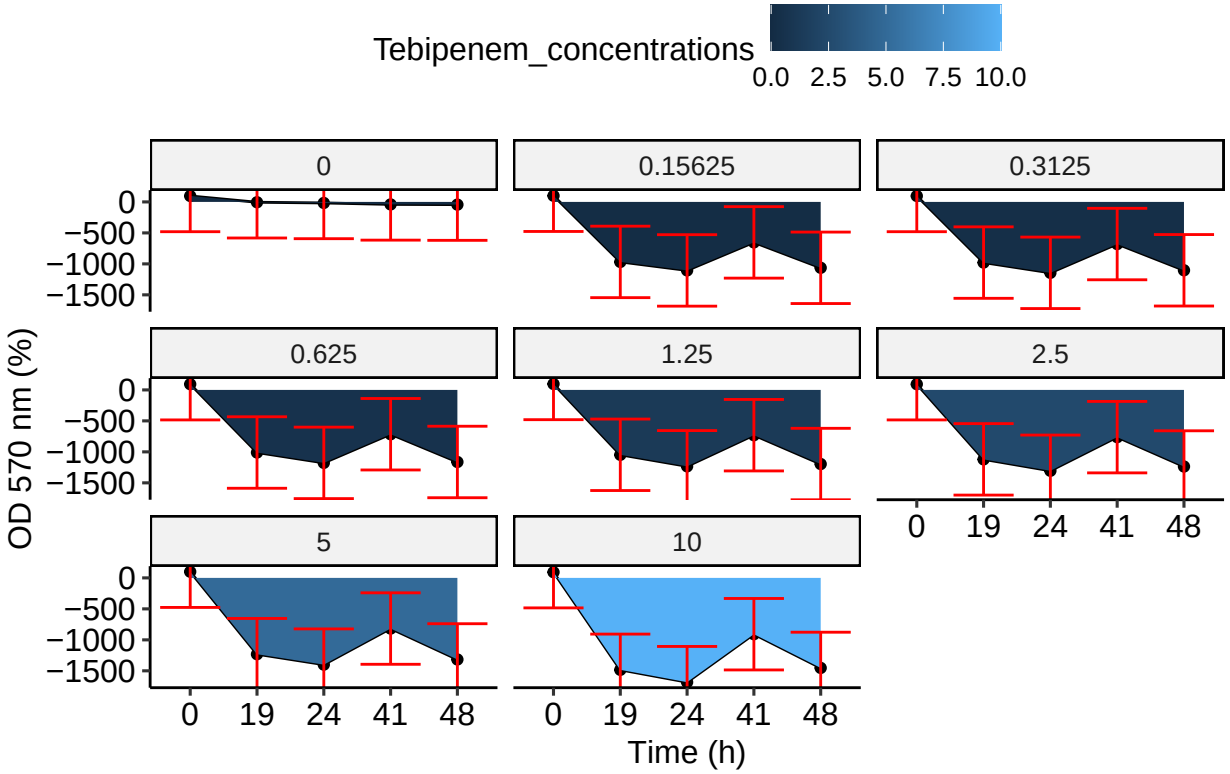
```
                                                                    ((mean(0.133,0.136,0.136)-mean
                                                                    ((mean(0.14,0.146,0.135)-mean(
                                                                    ((mean(0.143,0.152,0.144)-mean
                                                                    ((mean(0.333,0.335,0.324)-mean
                                                                    ((mean(0.047,0.048,0.046)-mean
                                                                    ((mean(0.08,0.055,0.088)-mean(
                                                                    ((mean(0.103,0.102,0.104)-mean
                                                                    ((mean(0.119,0.12,0.117)-mean(
                                                                    ((mean(0.129,0.137,0.135)-mean
                                                                    ((mean(0.147,0.162,0.147)-mean
                                                                    ((mean(0.153,0.175,0.152)-mean
                                                                    ((mean(0.447,0.489,0.399)-mean
                                                                    ((mean(0.048,0.048,0.046)-mean
                                                                    ((mean(0.081,0.057,0.09)-mean(
                                                                    ((mean(0.104,0.104,0.108)-mean
                                                                    ((mean(0.117,0.117,0.117)-mean
                                                                    ((mean(0.13,0.137,0.137)-mean(
                                                                    ((mean(0.149,0.163,0.149)-mean
                                                                    ((mean(0.157,0.179,0.157)-mean
                                                                    ((mean(0.482,0.495,0.45)-mean(
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp3 <- Proteus_mirabilis_25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_25ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_25ug_
                ymax=Proteus_mirabilis_25ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_25ug_
print(Pp3)
```




```
#Penicillin 12.5 ug/mL
Proteus_mirabilis_12.5ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep(
                                            Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.15
                                            Optical_density_mean_values =c(((mean(0.063,0.065,0.062)-0.038
                                                                           ((mean(0.065,0.065,0.064)-0.038
                                                                           ((mean(0.063,0.064,0.064)-0.038
                                                                           ((mean(0.064,0.063,0.064)-0.038
                                                                           ((mean(0.063,0.064,0.063)-0.038
                                                                           ((0.064-0.038)/(mean(0.065,0.06
                                                                           ((mean(0.065,0.064,0.063)-0.038
                                                                           ((mean(0.064,0.063,0.063)-0.038
                                                                           ((mean(0.052,0.053,0.053)-mean
                                                                           ((mean(0.1,0.104,0.103)-mean(0
                                                                           ((mean(0.121,0.117,0.114)-mean
                                                                           ((mean(0.135,0.137,0.131)-mean
                                                                           ((mean(0.142,0.149,0.143)-mean
                                                                           ((mean(0.148,0.153,0.148)-mean
                                                                           ((mean(0.15,0.157,0.15)-mean(0
                                                                           ((mean(0.333,0.35,0.331)-mean(
                                                                           ((mean(0.052,0.053,0.051)-mean
                                                                           ((mean(0.103,0.105,0.107)-mean
                                                                           ((mean(0.12,0.117,0.117)-mean(
                                                                           ((mean(0.133,0.135,0.134)-mean
                                                                           ((mean(0.143,0.148,0.147)-mean
                                                                           ((mean(0.149,0.156,0.151)-mean
                                                                           ((mean(0.156,0.167,0.158)-mean
```

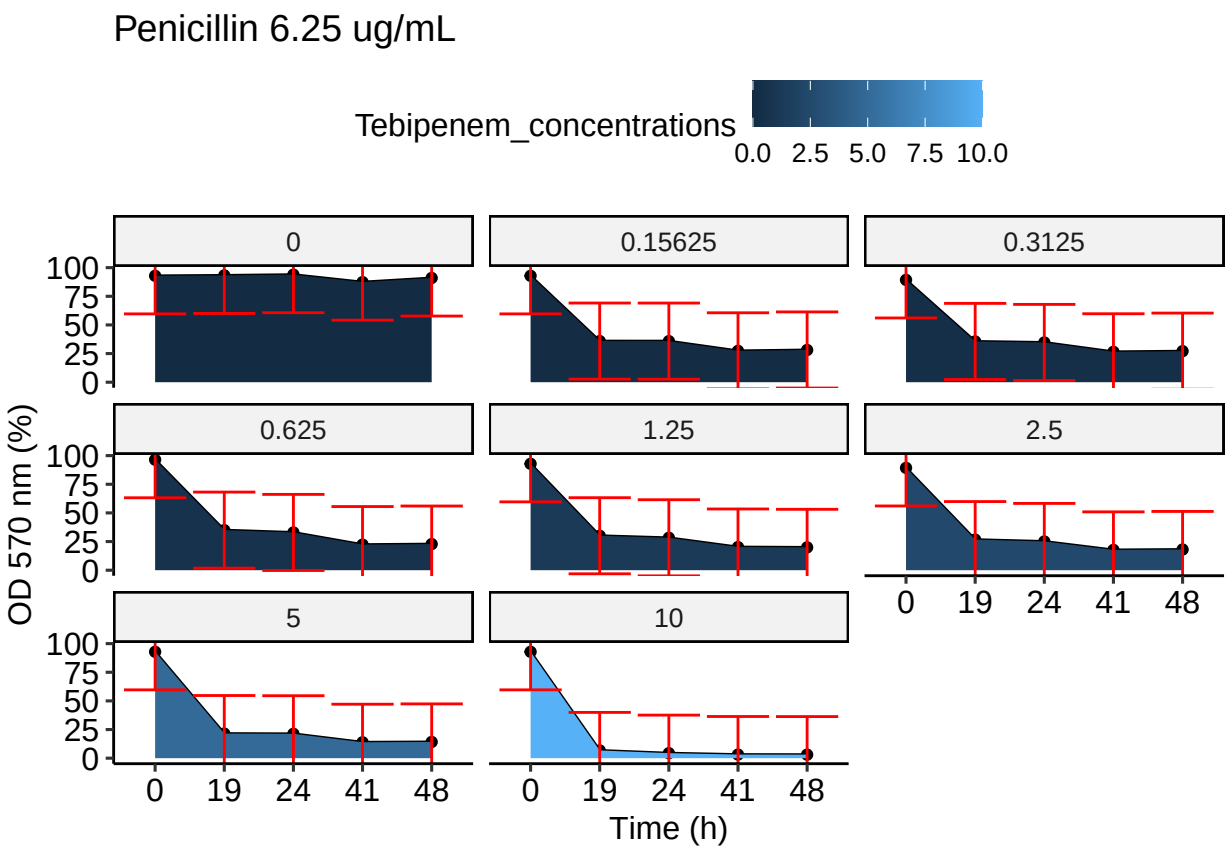
```
                                                                    ((mean(0.352,0.351,0.334)-mean
                                                                    ((mean(0.053,0.054,0.053)-mean
                                                                    ((mean(0.094,0.091,0.104)-mean
                                                                    ((mean(0.119,0.115,0.111)-mean
                                                                    ((mean(0.133,0.132,0.129)-mean
                                                                    ((mean(0.14,0.148,0.149)-mean(
                                                                    ((mean(0.156,0.169,0.16)-mean(
                                                                    ((mean(0.168,0.185,0.166)-mean
                                                                    ((mean(0.444,0.492,0.405)-mean
                                                                    ((mean(0.054,0.054,0.055)-mean
                                                                    ((mean(0.095,0.093,0.103)-mean
                                                                    ((mean(0.119,0.117,0.115)-mean
                                                                    ((mean(0.131,0.13,0.128)-mean(
                                                                    ((mean(0.141,0.149,0.15)-mean(
                                                                    ((mean(0.159,0.171,0.162)-mean
                                                                    ((mean(0.171,0.187,0.171)-mean
                                                                    ((mean(0.477,0.501,0.447)-mean
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp4 <- Proteus_mirabilis_12.5ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 12.5 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_12.5ug_data $Optical_density_mean_values-sd(Proteus_mirabilis_12
                ymax=Proteus_mirabilis_12.5ug_data $Optical_density_mean_values+sd(Proteus_mirabilis_12
print(Pp4)
```

Penicillin 12.5 ug/mL



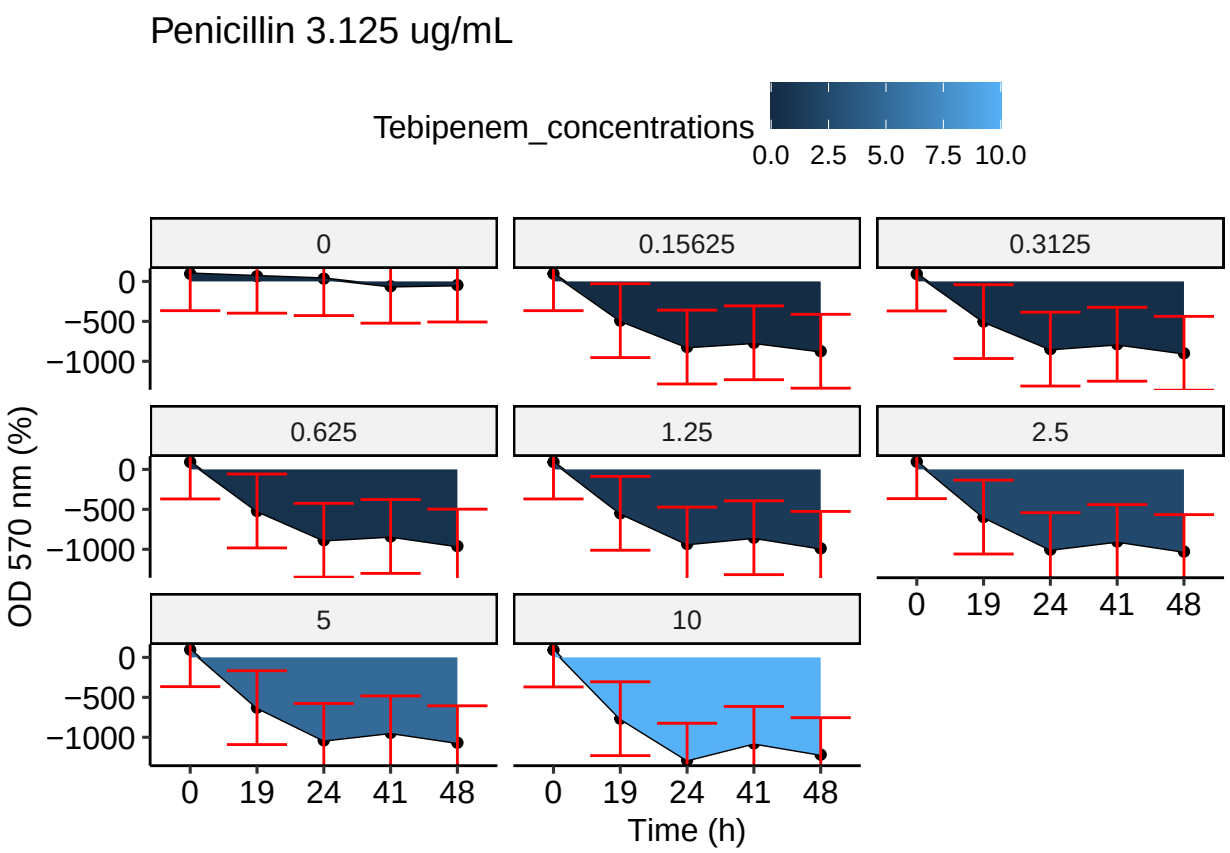

```
#Penicillin 6.25 ug/mL
Proteus_mirabilis_6.25ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep(
                                                    Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0
                                                    Optical_density_mean_values =c(((mean(0.062,0.063,0.061)-0.
                                                                                   ((mean(0.062,0.065,0.062)-0.
                                                                                   ((mean(0.061,0.062,0.062)-0.
                                                                                   ((mean(0.062,0.063,0.063)-0.
                                                                                   ((mean(0.063,0.062,0.063)-0.
                                                                                   ((mean(0.061,0.062,0.062)-0.
                                                                                   ((mean(0.062,0.062,0.061)-0.
                                                                                   ((mean(0.062,0.062,0.063)-0.
                                                                                   ((mean(0.057,0.057,0.05)-mea
                                                                                   ((mean(0.105,0.106,0.107)-mea
                                                                                   ((mean(0.122,0.121,0.117)-mea
                                                                                   ((mean(0.133,0.143,0.135)-mea
                                                                                   ((mean(0.149,0.155,0.149)-mea
                                                                                   ((mean(0.151,0.156,0.153)-mea
                                                                                   ((mean(0.152,0.165,0.157)-mea
                                                                                   ((mean(0.339,0.351,0.349)-mea
                                                                                   ((mean(0.05,0.051,0.05)-mean
                                                                                   ((mean(0.108,0.106,0.109)-mea
                                                                                   ((mean(0.121,0.122,0.119)-mea
                                                                                   ((mean(0.132,0.141,0.138)-mea
                                                                                   ((mean(0.148,0.154,0.153)-mea
                                                                                   ((mean(0.154,0.16,0.156)-mea
                                                                                   ((mean(0.158,0.173,0.164)-mea
```

```
                                                                                ((mean(0.357,0.353,0.342)-mea
                                                                                ((mean(0.051,0.052,0.052)-mea
                                                                                ((mean(0.102,0.097,0.111)-mea
                                                                                ((mean(0.12,0.121,0.115)-mean
                                                                                ((mean(0.132,0.135,0.131)-mea
                                                                                ((mean(0.142,0.151,0.152)-mea
                                                                                ((mean(0.162,0.172,0.164)-mea
                                                                                ((mean(0.166,0.189,0.169)-mea
                                                                                ((mean(0.451,0.475,0.407)-mea
                                                                                ((mean(0.051,0.052,0.055)-mea
                                                                                ((mean(0.105,0.101,0.113)-mea
                                                                                ((mean(0.124,0.125,0.121)-mea
                                                                                ((mean(0.133,0.135,0.134)-mea
                                                                                ((mean(0.147,0.154,0.157)-mea
                                                                                ((mean(0.168,0.178,0.171)-mea
                                                                                ((mean(0.173,0.194,0.177)-mea
                                                                                ((mean(0.479,0.493,0.453)-mea
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp5 <- Proteus_mirabilis_6.25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 6.25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_6.25ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_6.25
                ymax=Proteus_mirabilis_6.25ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_6.25
print(Pp5)
```



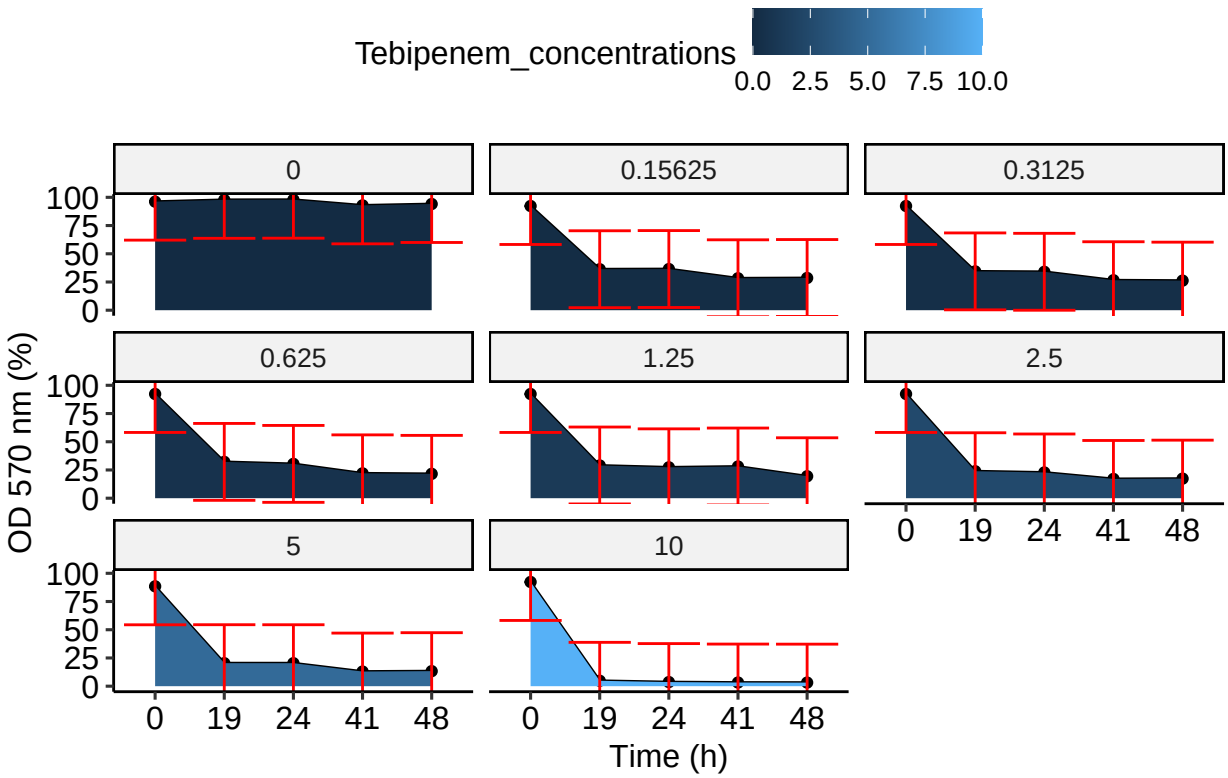

```
#Penicillin 3.125 ug/mL
Proteus_mirabilis_3.125ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep
                                                     Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0
                                                     Optical_density_mean_values =c(((mean(0.061,0.063,0.06)-mean
                                                                                    ((mean(0.062,0.062,0.062)-mean
                                                                                    ((mean(0.062,0.061,0.062)-mean
                                                                                    ((mean(0.061,0.062,0.062)-mean
                                                                                    ((mean(0.061,0.062,0.063)-mean
                                                                                    ((mean(0.061,0.061,0.063)-mean
                                                                                    ((mean(0.062,0.061,0.061)-mean
                                                                                    ((mean(0.062,0.06,0.063)-mean
                                                                                    ((mean(0.057,0.054,0.052)-mean
                                                                                    ((mean(0.104,0.106,0.105)-mean
                                                                                    ((mean(0.115,0.118,0.114)-mean
                                                                                    ((mean(0.131,0.137,0.131)-mean
                                                                                    ((mean(0.141,0.151,0.141)-mean
                                                                                    ((mean(0.147,0.151,0.143)-mean
                                                                                    ((mean(0.151,0.159,0.151)-mean
                                                                                    ((mean(0.34,0.352,0.339)-mean
                                                                                    ((mean(0.05,0.052,0.052)-mean
                                                                                    ((mean(0.107,0.107,0.108)-mean
                                                                                    ((mean(0.115,0.12,0.118)-mean
                                                                                    ((mean(0.131,0.136,0.134)-mean
                                                                                    ((mean(0.142,0.151,0.146)-mean
                                                                                    ((mean(0.151,0.158,0.15)-mean
                                                                                    ((mean(0.157,0.169,0.159)-mean
```

```
                                                                    ((mean(0.354,0.347,0.332)-mea
                                                                    ((mean(0.051,0.053,0.052)-mea
                                                                    ((mean(0.101,0.099,0.111)-mea
                                                                    ((mean(0.117,0.122,0.116)-mea
                                                                    ((mean(0.135,0.135,0.131)-mea
                                                                    ((mean(0.141,0.153,0.149)-mea
                                                                    ((mean(0.161,0.171,0.162)-mea
                                                                    ((mean(0.168,0.185,0.168)-mea
                                                                    ((mean(0.437,0.475,0.402)-mea
                                                                    ((mean(0.052,0.053,0.053)-mea
                                                                    ((mean(0.104,0.103,0.112)-mea
                                                                    ((mean(0.118,0.122,0.12)-mean
                                                                    ((mean(0.132,0.132,0.13)-mean
                                                                    ((mean(0.142,0.154,0.151)-mea
                                                                    ((mean(0.163,0.176,0.164)-mea
                                                                    ((mean(0.172,0.185,0.171)-mea
                                                                    ((mean(0.462,0.482,0.437)-mea
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp6 <- Proteus_mirabilis_3.125ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 3.125 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_3.125ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_3.
                ymax=Proteus_mirabilis_3.125ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_3.
print(Pp6)
```




```
#Penicillin 1.5625 ug/mL
Proteus_mirabilis_1.5625ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep
                                                      Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,
                                                      Optical_density_mean_values =c(((mean(0.06,0.063,0.059)-0.
                                                                                      ((mean(0.059,0.062,0.06)-0.
                                                                                      ((mean(0.06,0.06,0.06)-0.03
                                                                                      ((mean(0.06,0.06,0.061)-0.0
                                                                                      ((mean(0.06,0.06,0.061)-0.0
                                                                                      ((mean(0.06,0.06,0.061)-0.0
                                                                                      ((mean(0.06,0.06,0.06)-0.03
                                                                                      ((mean(0.061,0.06,0.061)-0.
                                                                                      ((mean(0.051,0.054,0.051)-0
                                                                                      ((mean(0.1,0.106,0.102)-0.0
                                                                                      ((mean(0.111,0.115,0.112)-0
                                                                                      ((mean(0.127,0.133,0.127)-0
                                                                                      ((mean(0.137,0.139,0.345)-0
                                                                                      ((mean(0.144,0.152,0.138)-0
                                                                                      ((mean(0.15,0.157,0.142)-0.
                                                                                      ((mean(0.343,0.349,0.341)-0
                                                                                      ((mean(0.049,0.051,0.053)-me
                                                                                      ((mean(0.104,0.108,0.112)-me
                                                                                      ((mean(0.112,0.117,0.116)-me
                                                                                      ((mean(0.127,0.133,0.13)-mea
                                                                                      ((mean(0.137,0.14,0.337)-mea
                                                                                      ((mean(0.149,0.158,0.147)-me
                                                                                      ((mean(0.157,0.167,0.154)-me
```

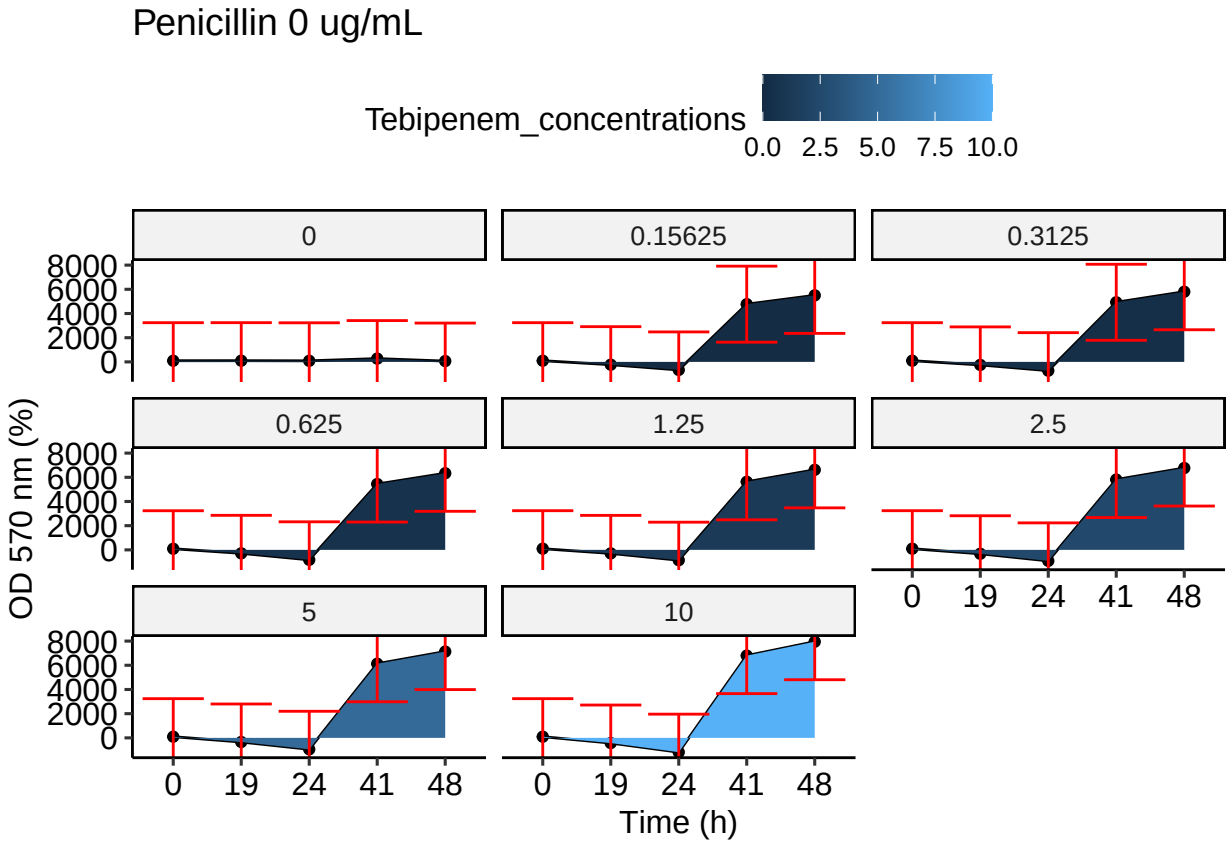
```
                                                                                ((mean(0.359,0.347,0.335)-m
                                                                                ((mean(0.052,0.053,0.053)-m
                                                                                ((mean(0.097,0.102,0.111)-m
                                                                                ((mean(0.116,0.119,0.116)-m
                                                                                ((mean(0.13,0.132,0.129-mea
                                                                                ((mean(0.139,0.138,0.406)-m
                                                                                ((mean(0.16,0.173,0.158)-mea
                                                                                ((mean(0.168,0.183,0.163)-m
                                                                                ((mean(0.467,0.502,0.408)-m
                                                                                ((mean(0.052,0.052,0.052)-m
                                                                                ((mean(0.1,0.105,0.109)-mea
                                                                                ((mean(0.119,0.123,0.119)-m
                                                                                ((mean(0.129,0.13,0.13)-mea
                                                                                ((mean(0.139,0.136,0.427)-m
                                                                                ((mean(0.161,0.174,0.16)-mea
                                                                                ((mean(0.172,0.187,0.166)-m
                                                                                ((mean(0.482,0.478,0.44)-mea
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp7 <- Proteus_mirabilis_1.5625ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 1.5625 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_1.5625ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_1
                ymax=Proteus_mirabilis_1.5625ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_1
print(Pp7)
```



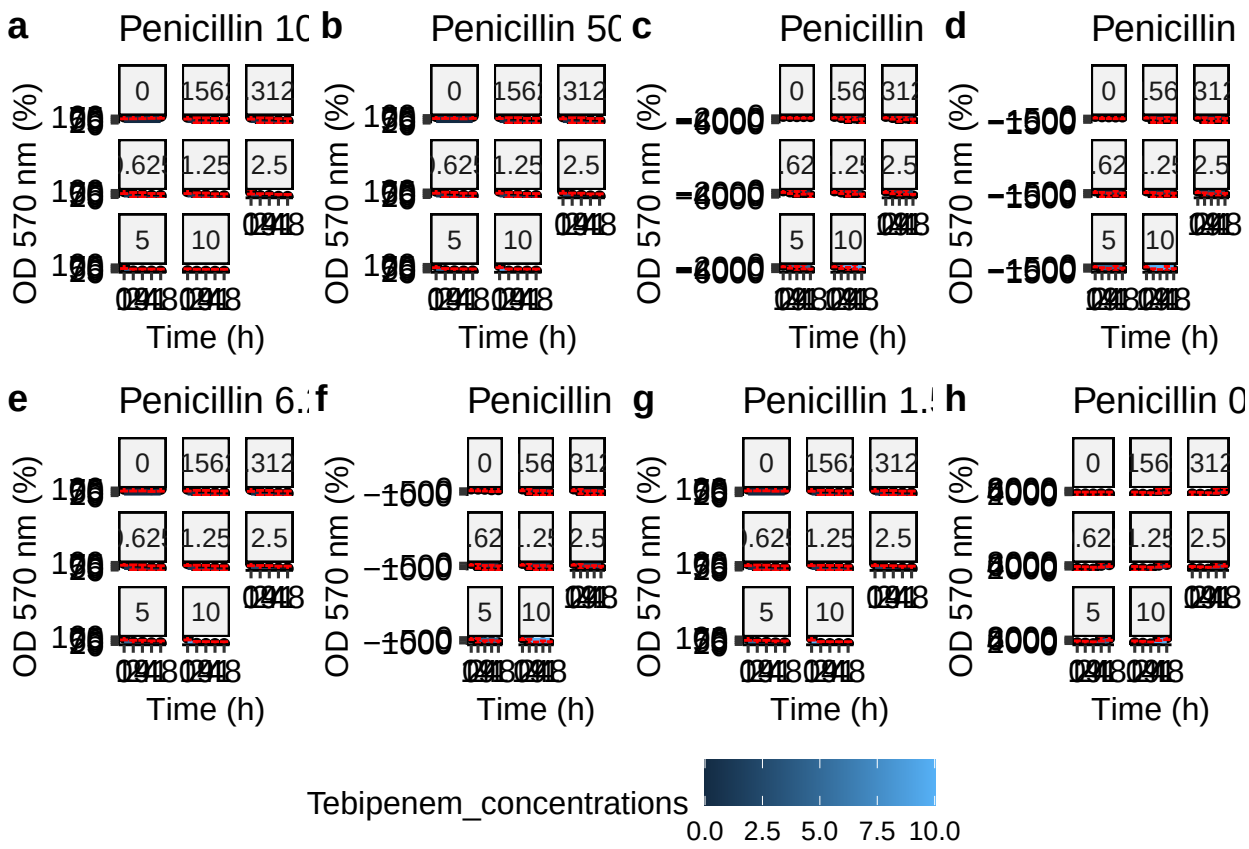

```
#Penicillin 0 ug/mL
Proteus_mirabilis_0ug_data <- data.frame(Time= c(rep("0",8),rep("19",8),rep("24",8),rep("41",8),rep("48
                                                 Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125
                                                 Optical_density_mean_values =c(((mean(0.062,0.066,0.062)-m
                                                                                ((mean(0.062,0.064,0.062)-m
                                                                                ((mean(0.062,0.063,0.063)-m
                                                                                ((mean(0.062,0.062,0.063)-m
                                                                                ((mean(0.061,0.061,0.063)-m
                                                                                ((mean(0.062,0.063,0.063)-m
                                                                                ((mean(0.062,0.061,0.062)-m
                                                                                ((mean(0.062,0.061,0.063)-m
                                                                                ((mean(0.055,0.055,0.051)-m
                                                                                ((mean(0.107,0.108,0.104)-m
                                                                                ((mean(0.12,0.12,0.116)-mea
                                                                                ((mean(0.139,0.139,0.137)-m
                                                                                ((mean(0.142,0.157,0.375)-m
                                                                                ((mean(0.164,0.168,0.162)-m
                                                                                ((mean(0.176,0.183,0.165)-m
                                                                                ((mean(0.377,0.38,0.375)-me
                                                                                ((mean(0.051,0.054,0.053)-m
                                                                                ((mean(0.113,0.109,0.11)-me
                                                                                ((mean(0.122,0.122,0.121)-m
                                                                                ((mean(0.137,0.139,0.14)-me
                                                                                ((mean(0.145,0.16,0.357)-me
                                                                                ((mean(0.17,0.176,0.169)-me
                                                                                ((mean(0.186,0.196,0.174)-m
```

```
                                                                                ((mean(0.382,0.376,0.359)-m
                                                                                ((mean(0.052,0.054,0.053)-m
                                                                                ((mean(0.099,0.1,0.112)-mea
                                                                                ((mean(0.121,0.121,0.12)-me
                                                                                ((mean(0.134,0.134,0.137)-m
                                                                                ((mean(0.147,0.164,0.422)-m
                                                                                ((mean(0.183,0.192,0.181)-m
                                                                                ((mean(0.194,0.215,0.188)-m
                                                                                ((mean(0.509,0.562,0.426)-m
                                                                                ((mean(0.052,0.053,0.052)-m
                                                                                ((mean(0.101,0.104,0.113)-m
                                                                                ((mean(0.123,0.126,0.124)-m
                                                                                ((mean(0.132,0.137,0.137)-m
                                                                                ((mean(0.149,0.168,0.445)-m
                                                                                ((mean(0.181,0.194,0.184)-m
                                                                                ((mean(0.199,0.23,0.199)-me
                                                                                ((mean(0.525,0.519,0.471)-m

#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Pp8 <- Proteus_mirabilis_0ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 0 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Proteus_mirabilis_0ug_data$Optical_density_mean_values-sd(Proteus_mirabilis_0ug_dat
                ymax=Proteus_mirabilis_0ug_data$Optical_density_mean_values+sd(Proteus_mirabilis_0ug_dat
print(Pp8)
```




```
#Align all graphs together
library(ggplot2)
library(ggpubr)
theme_set(theme_pubr())
figure_2 <- ggarrange(Pp1,Pp2,Pp3,Pp4, Pp5, Pp6, Pp7, Pp8,
                      labels=c("a","b","c","d","e","f","g","h"),
                      ncol=4,nrow=2,
                      common.legend = TRUE,legend = "bottom")
print(figure_2)
```



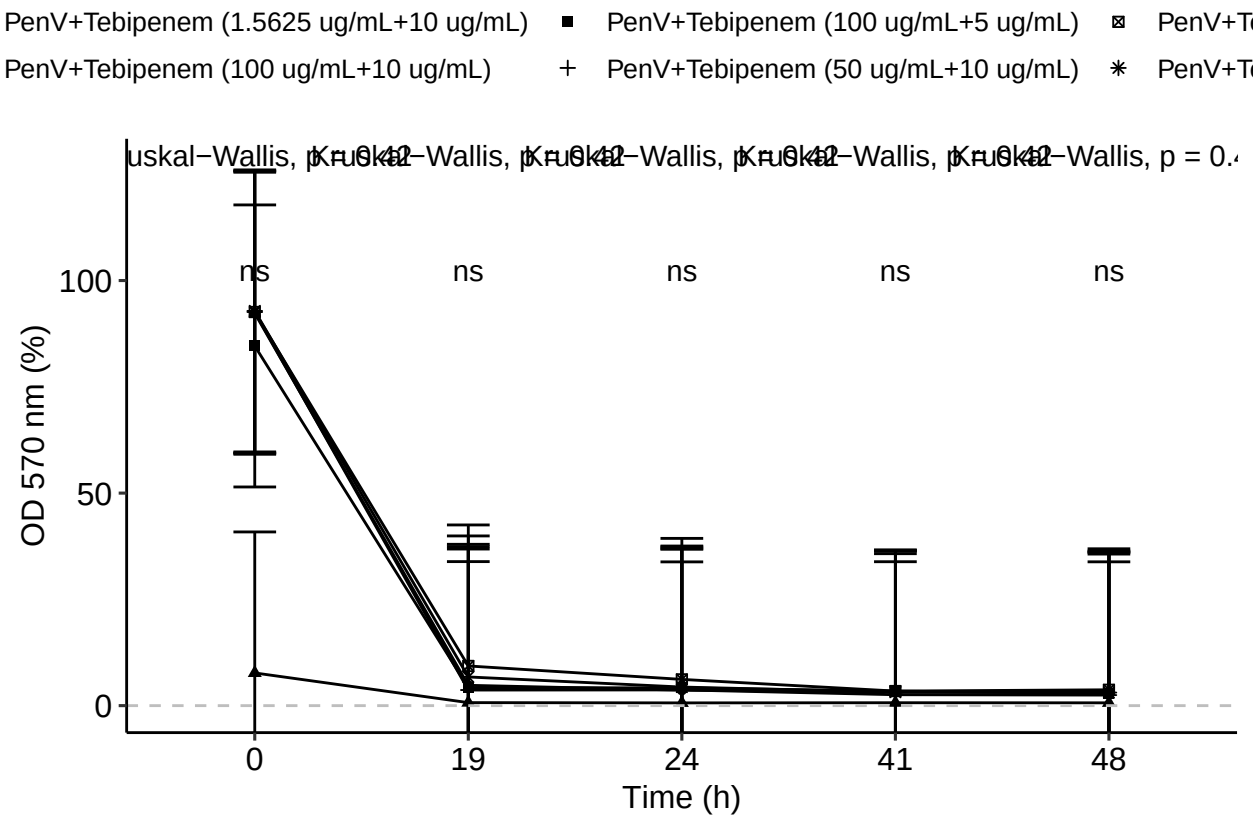

```
#Compare concentrations that inhibt the bacterial growth
Final_Proteus_data <- data.frame(Time_f2 =c("0","19","24","41","48"),
                                 Concentrations= c(rep("PenV+Tebipenem (100 ug/mL+10 ug/mL)",5),rep("Pen
                                                   rep("PenV+Tebipenem (50 ug/mL+10 ug/mL)",5),rep("PenV
                                                   rep("PenV+Tebipenem (6.25 ug/mL+10 ug/mL)",5),rep("Pe
                                 Optical_density=c(((mean(0.04,0.06,0.806)-0.038)/(mean(0.064,0.063,0.0
                                                   ((mean(0.04,0.049,0.051)-mean(0.038,0.037,0.037))/(me
                                                   ((mean(0.04,0.048,0.043)-mean(0.038,0.037,0.038))/(me
                                                   ((mean(0.041,0.049,0.039)-mean(0.038,0.036,0.037))/(m
                                                   ((mean(0.041,0.048,0.036)-mean(0.038,0.036,0.036))/(m
                                                   ((mean(0.06,0.061,0.061)-0.038)/(mean(0.064,0.063,0.0
                                                   ((mean(0.05,0.06,0.054)-mean(0.038,0.037,0.037))/(mea
                                                   ((mean(0.051,0.052,0.051)-mean(0.038,0.037,0.038))/(m
                                                   ((mean(0.053,0.053,0.051)-mean(0.038,0.036,0.037))/(m
                                                   ((mean(0.051,0.051,0.052)-mean(0.038,0.036,0.036))/(m
                                                   ((mean(0.06,0.06,0.04)-mean(0.035,0.036,0.037))/(mean
                                                   ((mean(0.046,0.048,0.194)-mean(0.035,0.036,0.037))/(m
                                                   ((mean(0.049,0.051,0.239)-mean(0.037,0.038,0.038))/(m
                                                   ((mean(0.05,0.052,0.239)-0.038)/(mean(0.505,0.514,0.4
                                                   ((mean(0.05,0.051,0.168)-0.038)/(mean(0.521,0.515,0.4
                                                   ((mean(0.06,0.06,0.06)-mean(0.035,0.036,0.037))/(mean
                                                   ((mean(0.063,0.097,0.069)-mean(0.035,0.036,0.037))/(m
                                                   ((mean(0.057,0.1,0.067)-mean(0.037,0.038,0.038))/(mea
                                                   ((mean(0.054,0.082,0.056)-0.038)/(mean(0.505,0.514,0.
                                                   ((mean(0.056,0.083,0.061)-0.038)/(mean(0.521,0.515,0.
                                                   ((mean(0.062,0.063,0.061)-0.036)/(mean(0.064,0.065,0.
```

```
                                                    ((mean(0.057,0.057,0.05)-mean(0.035,0.035,0.338))/(me
                                                    ((mean(0.05,0.051,0.05)-mean(0.035,0.037,0.366))/(mea
                                                    ((mean(0.051,0.052,0.052)-mean(0.036,0.037,0.469))/(m
                                                    ((mean(0.051,0.052,0.055)-mean(0.036,0.037,0.49))/(me
                                                    ((mean(0.06,0.063,0.059)-0.036)/(mean(0.062,0.061,0.0
                                                    ((mean(0.051,0.054,0.051)-0.036)/(mean(0.35,0.362,0.3
                                                    ((mean(0.049,0.051,0.053)-mean(0.037,0.036,0.037))/(m
                                                    ((mean(0.052,0.053,0.053)-mean(0.037,0.037,0.036))/(m
                                                    ((0.052- mean(0.037,0.037,0.036))/(mean(0.51,0.503,0.
print(Final_Proteus_data)
```

```
##    Time_f2                          Concentrations Optical_density
## 1        0    PenV+Tebipenem (100 ug/mL+10 ug/mL)       7.6923077
## 2       19    PenV+Tebipenem (100 ug/mL+10 ug/mL)       0.7067138
## 3       24    PenV+Tebipenem (100 ug/mL+10 ug/mL)       0.6430868
## 4       41    PenV+Tebipenem (100 ug/mL+10 ug/mL)       0.6833713
## 5       48    PenV+Tebipenem (100 ug/mL+10 ug/mL)       0.6578947
## 6        0     PenV+Tebipenem (100 ug/mL+5 ug/mL)      84.6153846
## 7       19     PenV+Tebipenem (100 ug/mL+5 ug/mL)       4.2402827
## 8       24     PenV+Tebipenem (100 ug/mL+5 ug/mL)       4.1800643
## 9       41     PenV+Tebipenem (100 ug/mL+5 ug/mL)       3.4168565
## 10      48     PenV+Tebipenem (100 ug/mL+5 ug/mL)       2.8508772
## 11       0     PenV+Tebipenem (50 ug/mL+10 ug/mL)      92.5925926
## 12      19     PenV+Tebipenem (50 ug/mL+10 ug/mL)       3.6666667
## 13      24     PenV+Tebipenem (50 ug/mL+10 ug/mL)       3.7037037
## 14      41     PenV+Tebipenem (50 ug/mL+10 ug/mL)       2.5695931
## 15      48     PenV+Tebipenem (50 ug/mL+10 ug/mL)       2.4844720
## 16       0      PenV+Tebipenem (50 ug/mL+5 ug/mL)      92.5925926
## 17      19      PenV+Tebipenem (50 ug/mL+5 ug/mL)       9.3333333
## 18      24      PenV+Tebipenem (50 ug/mL+5 ug/mL)       6.1728395
## 19      41      PenV+Tebipenem (50 ug/mL+5 ug/mL)       3.4261242
## 20      48      PenV+Tebipenem (50 ug/mL+5 ug/mL)       3.7267081
## 21       0   PenV+Tebipenem (6.25 ug/mL+10 ug/mL)      92.8571429
## 22      19   PenV+Tebipenem (6.25 ug/mL+10 ug/mL)       6.7484663
## 23      24   PenV+Tebipenem (6.25 ug/mL+10 ug/mL)       4.3731778
## 24      41   PenV+Tebipenem (6.25 ug/mL+10 ug/mL)       3.1578947
## 25      48   PenV+Tebipenem (6.25 ug/mL+10 ug/mL)       3.0800821
## 26       0 PenV+Tebipenem (1.5625 ug/mL+10 ug/mL)      92.3076923
## 27      19 PenV+Tebipenem (1.5625 ug/mL+10 ug/mL)       4.7770701
## 28      24 PenV+Tebipenem (1.5625 ug/mL+10 ug/mL)       3.6474164
## 29      41 PenV+Tebipenem (1.5625 ug/mL+10 ug/mL)       3.2397408
## 30      48 PenV+Tebipenem (1.5625 ug/mL+10 ug/mL)       3.1712474
```

```
#Make up a line graph
Final_Prot <- Final_Proteus_data %>%
  ggplot(aes(x=Time_f2, y=Optical_density,group=Concentrations, shape=Concentrations))+
  geom_line()+
  geom_point()+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Final_Proteus_data$Optical_density-sd(Final_Proteus_data$Optical_density),
                ymax=Final_Proteus_data$Optical_density+sd(Final_Proteus_data$Optical_density),
                width=.2)+
```

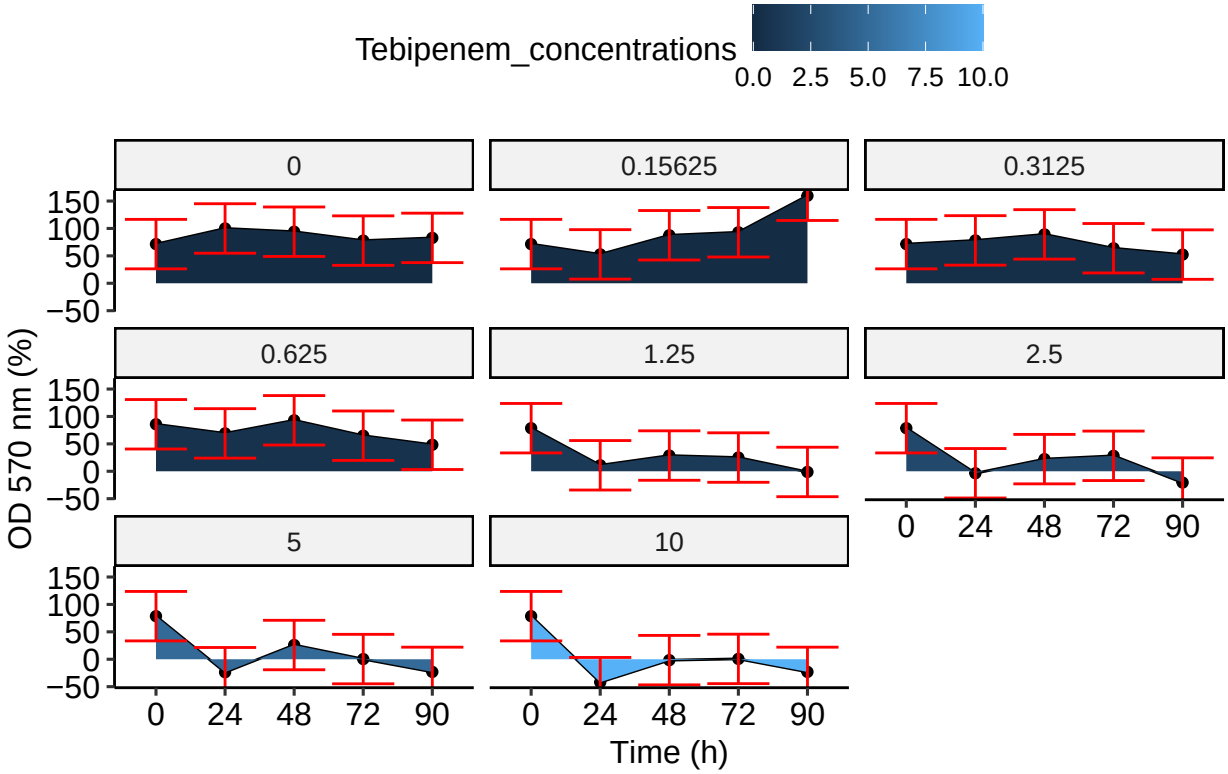
```
  stat_compare_means(method = "kruskal.test", label.y =127)+
  stat_compare_means(label = "p.signif", label.y = c(100,100,100,100,100), label.x = 10)+
  geom_hline(yintercept = 0, linetype="dashed", col="grey")
print(Final_Prot)
```




```
#Mycobacterium smegmatis RESULTS AND PLOTS
#Penicillin 100 ug/ml
Mycobacterium_smegmatis_100ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8)
                                                 Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3125,0.1
                                                 Optical_density_mean_values =c(((mean(0.047,0.053,0.049)-mean
                                                                                 ((mean(0.047,0.051,0.047)-mean
                                                                                 ((mean(0.047,0.046,0.046)-mean
                                                                                 ((mean(0.047,0.047,0.047)-mean
                                                                                 ((mean(0.048,0.045,0.045)-mean
                                                                                 ((mean(0.046,0.045,0.045)-mean
                                                                                 ((mean(0.046,0.044,0.046)-mean
                                                                                 ((mean(0.046,0.044,0.046)-mean
                                                                                 ((mean(0.057,0.064,0.047)-mean
                                                                                 ((mean(0.067,0.076,0.101)-mean
                                                                                 ((mean(0.078,0.075,0.126)-mean
                                                                                 ((mean(0.086,0.114,0.125)-mean
                                                                                 ((mean(0.118,0.103,0.146)-mean
                                                                                 ((mean(0.123,0.144,0.138)-mean
                                                                                 ((mean(0.109,0.106,0.152)-mean
                                                                                 ((mean(0.135,0.12,0.163)-mean
```

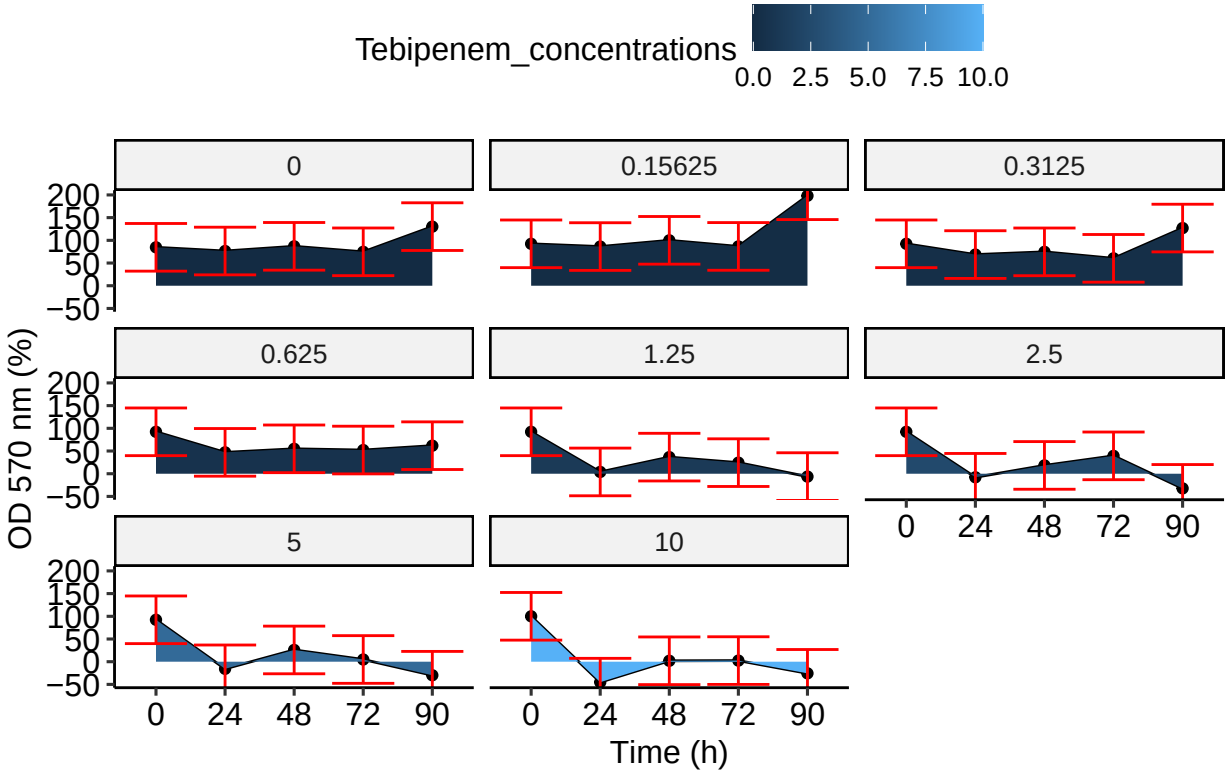
```
                                                                    ((mean(0.049,0.044,0.08)-mean
                                                                    ((mean(0.1,0.065,0.119)-mean(
                                                                    ((mean(0.093,0.068,0.084)-mea
                                                                    ((mean(0.105,0.226,0.182)-mea
                                                                    ((mean(0.224,0.138,0.183)-mea
                                                                    ((mean(0.217,0.263,0.163)-mea
                                                                    ((mean(0.214,0.174,0.237)-mea
                                                                    ((mean(0.226,0.201,0.25)-mean
                                                                    ((mean(0.049,0.058,0.043)-mea
                                                                    ((mean(0.048,0.044,0.128)-mea
                                                                    ((mean(0.136,0.066,0.048)-mea
                                                                    ((mean(0.126,0.32,0.153)-mean
                                                                    ((mean(0.252,0.187,0.302)-mea
                                                                    ((mean(0.249,0.368,0.209)-mea
                                                                    ((mean(0.341,0.292,0.315)-mea
                                                                    ((mean(0.293,0.326,0.34)-mean
                                                                    ((mean(0.044,0.045,0.041)-mea
                                                                    ((mean(0.044,0.046,0.14)-mean
                                                                    ((mean(0.052,0.088,0.083)-mea
                                                                    ((mean(0.115,0.587,0.137)-mea
                                                                    ((mean(0.276,0.245,0.373)-mea
                                                                    ((mean(0.289,0.44,0.281)-mean
                                                                    ((mean(0.638,0.462,0.637)-mea
                                                                    ((mean(0.388,0.418,0.498)-mea
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp1 <- Mycobacterium_smegmatis_100ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 100 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_100ug_data $Optical_density_mean_values-sd(Mycobacterium_s
                ymax=Mycobacterium_smegmatis_100ug_data $Optical_density_mean_values+sd(Mycobacterium_s
print(Mp1)
```

Penicillin 100 ug/mL



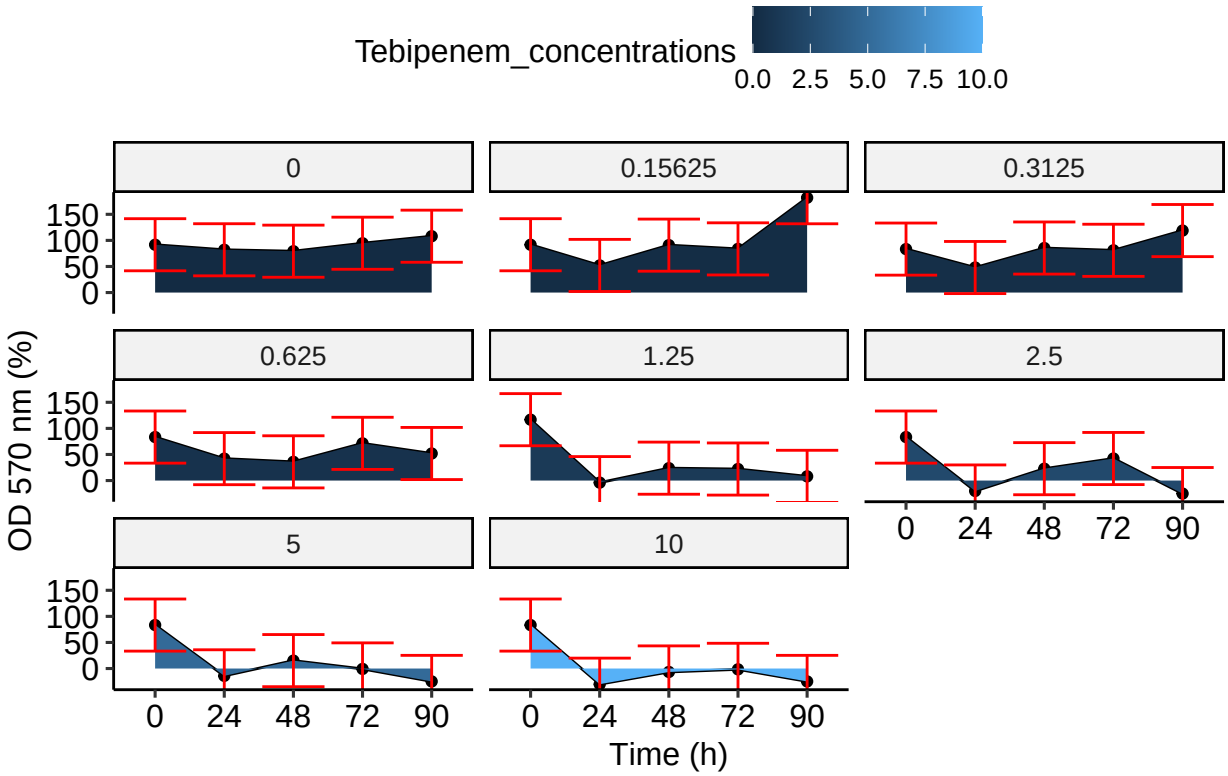

```
#Penicillin 50 ug/mL
Mycobacterium_smegmatis_50ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8),r
                                                Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3
                                                Optical_density_mean_values =c((mean(0.049,0.05,0.049)
                                                                               ((mean(0.048,0.048,0.064
                                                                               ((mean(0.048,0.047,0.05
                                                                               ((mean(0.048,0.047,0.04
                                                                               ((mean(0.048,0.046,0.04
                                                                               ((mean(0.048,0.046,0.04
                                                                               ((mean(0.048,0.047,0.04
                                                                               ((mean(0.047,0.047,0.04
                                                                               ((mean(0.067,0.074,0.05
                                                                               ((mean(0.082,0.082,0.05
                                                                               ((mean(0.086,0.085,0.10
                                                                               ((mean(0.092,0.101,0.14
                                                                               ((mean(0.114,0.106,0.15
                                                                               ((mean(0.125,0.106,0.15
                                                                               ((mean(0.134,0.114,0.16
                                                                               ((mean(0.129,0.142,0.17
                                                                               ((mean(0.053,0.049,0.07
                                                                               ((mean(0.1,0.063,0.088)
                                                                               ((mean(0.085,0.09,0.093)
                                                                               ((mean(0.121,0.151,0.17
                                                                               ((mean(0.157,0.159,0.20
                                                                               ((mean(0.196,0.169,0.16
                                                                               ((mean(0.246,0.201,0.21
```

```
                                                                                ((mean(0.22,0.253,0.273)
                                                                                ((mean(0.057,0.051,0.053
                                                                                ((mean(0.065,0.048,0.040
                                                                                ((mean(0.178,0.074,0.054
                                                                                ((mean(0.129,0.217,0.193
                                                                                ((mean(0.22,0.209,0.278)
                                                                                ((mean(0.247,0.291,0.229
                                                                                ((mean(0.333,0.299,0.303
                                                                                ((mean(0.294,0.354,0.323
                                                                                ((mean(0.062,0.061,0.040
                                                                                ((mean(0.05,0.066,0.094)
                                                                                ((mean(0.043,0.043,0.071
                                                                                ((mean(0.117,0.207,0.22)
                                                                                ((mean(0.311,0.272,0.245
                                                                                ((mean(0.497,0.427,0.301
                                                                                ((mean(0.7,0.498,0.581)+
                                                                                ((mean(0.506,0.521,0.543
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp2 <- Mycobacterium_smegmatis_50ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 50 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_50ug_data$Optical_density_mean_values-sd(Mycobacterium_smeg
                ymax=Mycobacterium_smegmatis_50ug_data$Optical_density_mean_values+sd(Mycobacterium_smeg
print(Mp2)
```




```
#Penicillin 25 ug/mL
Mycobacterium_smegmatis_25ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8),
                                                Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.31
                                                Optical_density_mean_values =c(((mean(0.044,0.044,0.044)
                                                                               ((mean(0.044,0.046,0.045)
                                                                               ((mean(0.044,0.044,0.043)
                                                                               ((mean(0.048,0.042,0.043)
                                                                               ((mean(0.044,0.043,0.044)
                                                                               ((mean(0.044,0.043,0.042)
                                                                               ((mean(0.045,0.043,0.044)
                                                                               ((mean(0.045,0.044,0.043)
                                                                               ((mean(0.071,0.068,0.048)
                                                                               ((mean(0.079,0.085,0.062)
                                                                               ((mean(0.076,0.079,0.104)
                                                                               ((mean(0.084,0.089,0.111)
                                                                               ((mean(0.107,0.101,0.144)
                                                                               ((mean(0.11,0.102,0.133)
                                                                               ((mean(0.112,0.105,0.172)
                                                                               ((mean(0.127,0.127,0.163)
                                                                               ((mean(0.043,0.042,0.075)
                                                                               ((mean(0.086,0.053,0.106)
                                                                               ((mean(0.101,0.091,0.106)
                                                                               ((mean(0.103,0.147,0.127)
                                                                               ((mean(0.127,0.144,0.235)
                                                                               ((mean(0.225,0.187,0.144)
                                                                               ((mean(0.236,0.181,0.209)
```

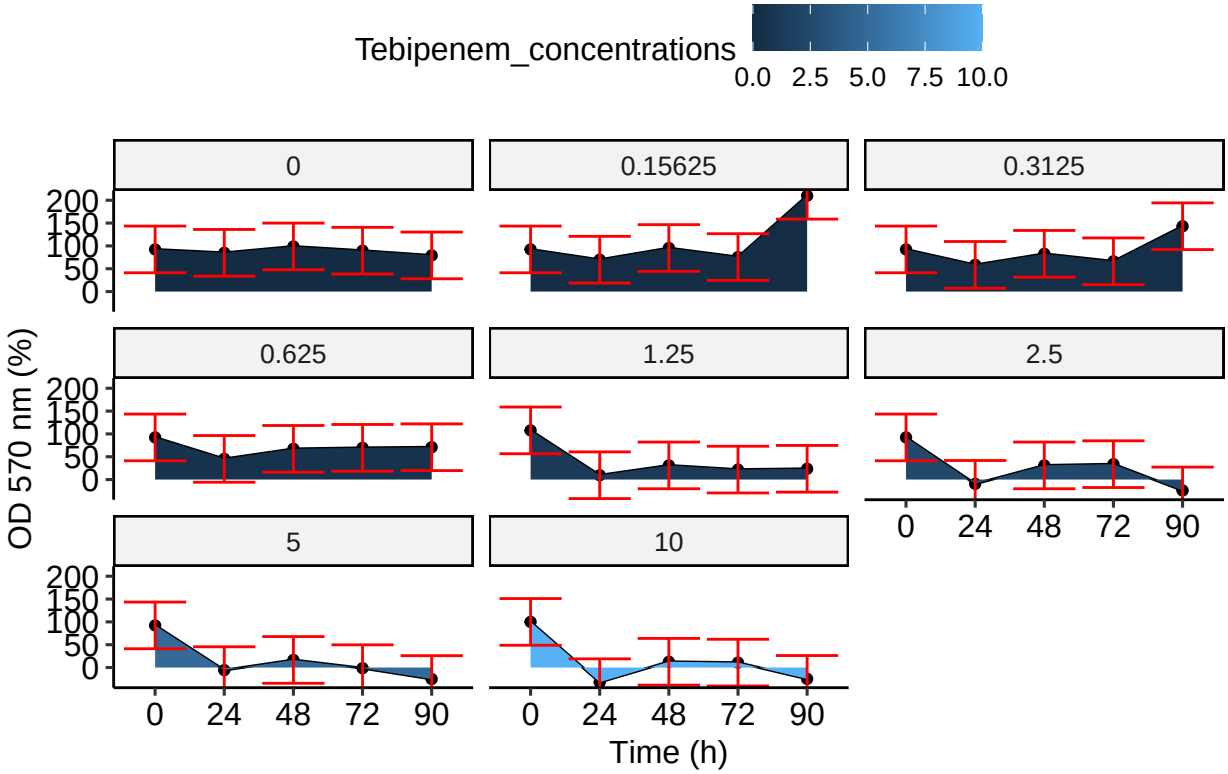
```
                                                                                ((mean(0.213,0.228,0.241
                                                                                ((mean(0.051,0.052,0.049
                                                                                ((mean(0.053,0.04,0.044)-
                                                                                ((mean(0.164,0.041,0.054
                                                                                ((mean(0.112,0.251,0.14)-
                                                                                ((mean(0.239,0.187,0.311
                                                                                ((mean(0.264,0.284,0.188
                                                                                ((mean(0.271,0.297,0.256
                                                                                ((mean(0.299,0.302,0.302
                                                                                ((mean(0.041,0.046,0.05)-
                                                                                ((mean(0.041,0.079,0.059
                                                                                ((mean(0.04,0.04,0.057)-m
                                                                                ((mean(0.147,0.243,0.165
                                                                                ((mean(0.289,0.294,0.677
                                                                                ((mean(0.506,0.455,0.358
                                                                                ((mean(0.71,0.486,0.542)-
                                                                                ((mean(0.471,0.468,0.603
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp3 <- Mycobacterium_smegmatis_25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_25ug_data$Optical_density_mean_values-sd(Mycobacterium_smeg
                ymax=Mycobacterium_smegmatis_25ug_data$Optical_density_mean_values+sd(Mycobacterium_smeg
print(Mp3)
```




```
#Penicillin 12.5 ug/mL
Mycobacterium_smegmatis_12.5ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8
                                                  Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.31
                                                  Optical_density_mean_values =c(((mean(0.049,0.05,0.047)
                                                                                 ((mean(0.048,0.048,0.048)
                                                                                 ((mean(0.048,0.047,0.048)
                                                                                 ((mean(0.05,0.046,0.049)
                                                                                 ((mean(0.048,0.046,0.048)
                                                                                 ((mean(0.048,0.048,0.047)
                                                                                 ((mean(0.048,0.046,0.047)
                                                                                 ((mean(0.048,0.047,0.047)
                                                                                 ((mean(0.071,0.072,0.053)
                                                                                 ((mean(0.085,0.081,0.063)
                                                                                 ((mean(0.083,0.08,0.122)
                                                                                 ((mean(0.093,0.088,0.125)
                                                                                 ((mean(0.112,0.105,0.153)
                                                                                 ((mean(0.119,0.114,0.135)
                                                                                 ((mean(0.125,0.119,0.16)
                                                                                 ((mean(0.133,0.129,0.165)
                                                                                 ((mean(0.076,0.055,0.082)
                                                                                 ((mean(0.083,0.056,0.119)
                                                                                 ((mean(0.108,0.107,0.119)
                                                                                 ((mean(0.108,0.13,0.147)
                                                                                 ((mean(0.171,0.178,0.148)
                                                                                 ((mean(0.198,0.221,0.157)
                                                                                 ((mean(0.22,0.198,0.213)
```

```
                                                                                ((mean(0.226,0.231,0.247
                                                                                ((mean(0.083,0.05,0.048)-
                                                                                ((mean(0.049,0.044,0.052
                                                                                ((mean(0.147,0.048,0.065
                                                                                ((mean(0.114,0.172,0.147
                                                                                ((mean(0.247,0.293,0.258
                                                                                ((mean(0.238,0.34,0.222)-
                                                                                ((mean(0.264,0.316,0.266
                                                                                ((mean(0.303,0.3,0.397)-m
                                                                                ((mean(0.046,0.061,0.048
                                                                                ((mean(0.045,0.05,0.057)-
                                                                                ((mean(0.049,0.08,0.048)-
                                                                                ((mean(0.202,0.19,0.155)-
                                                                                ((mean(0.354,0.304,0.433
                                                                                ((mean(0.587,0.504,0.291
                                                                                ((mean(0.802,0.45,0.489)-
                                                                                ((mean(0.381,0.484,0.508
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp4 <- Mycobacterium_smegmatis_12.5ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concent
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 12.5 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_12.5ug_data$Optical_density_mean_values-sd(Mycobacterium_sm
                ymax=Mycobacterium_smegmatis_12.5ug_data$Optical_density_mean_values+sd(Mycobacterium_sm
print(Mp4)
```

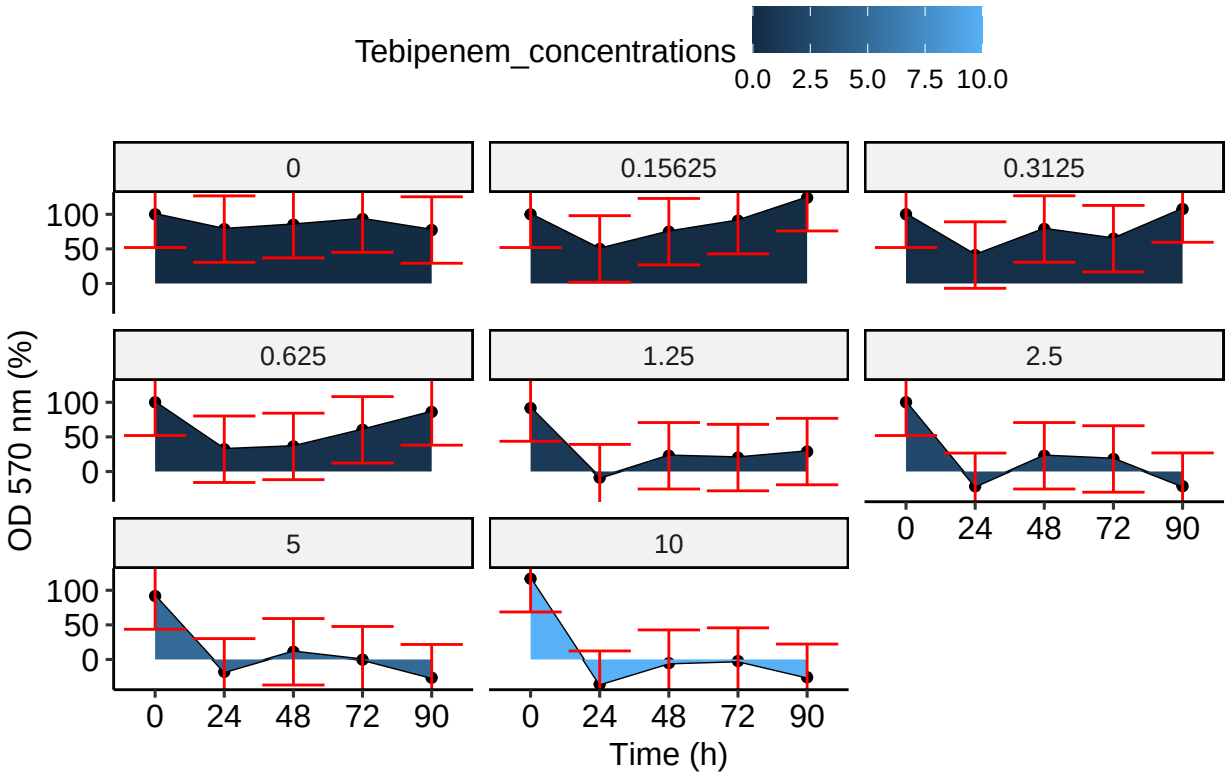
Penicillin 12.5 ug/mL




```
#Penicillin 6.25 ug/mL
Mycobacterium_smegmatis_6.25ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8)
                                                  Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3
                                                  Optical_density_mean_values =c(((mean(0.049,0.048,0.04
                                                                                 ((mean(0.046,0.047,0.04
                                                                                 ((mean(0.047,0.045,0.04
                                                                                 ((mean(0.046,0.046,0.04
                                                                                 ((mean(0.047,0.046,0.04
                                                                                 ((mean(0.047,0.045,0.04
                                                                                 ((mean(0.047,0.045,0.04
                                                                                 ((mean(0.047,0.046,0.04
                                                                                 ((mean(0.073,0.071,0.04
                                                                                 ((mean(0.083,0.078,0.06
                                                                                 ((mean(0.081,0.081,0.1
                                                                                 ((mean(0.088,0.091,0.13
                                                                                 ((mean(0.111,0.114,0.14
                                                                                 ((mean(0.116,0.118,0.13
                                                                                 ((mean(0.121,0.121,0.14
                                                                                 ((mean(0.137,0.143,0.20
                                                                                 ((mean(0.05,0.048,0.07
                                                                                 ((mean(0.084,0.085,0.1
                                                                                 ((mean(0.108,0.104,0.14
                                                                                 ((mean(0.108,0.134,0.15
                                                                                 ((mean(0.136,0.179,0.16
                                                                                 ((mean(0.224,0.199,0.14
                                                                                 ((mean(0.216,0.221,0.20
```

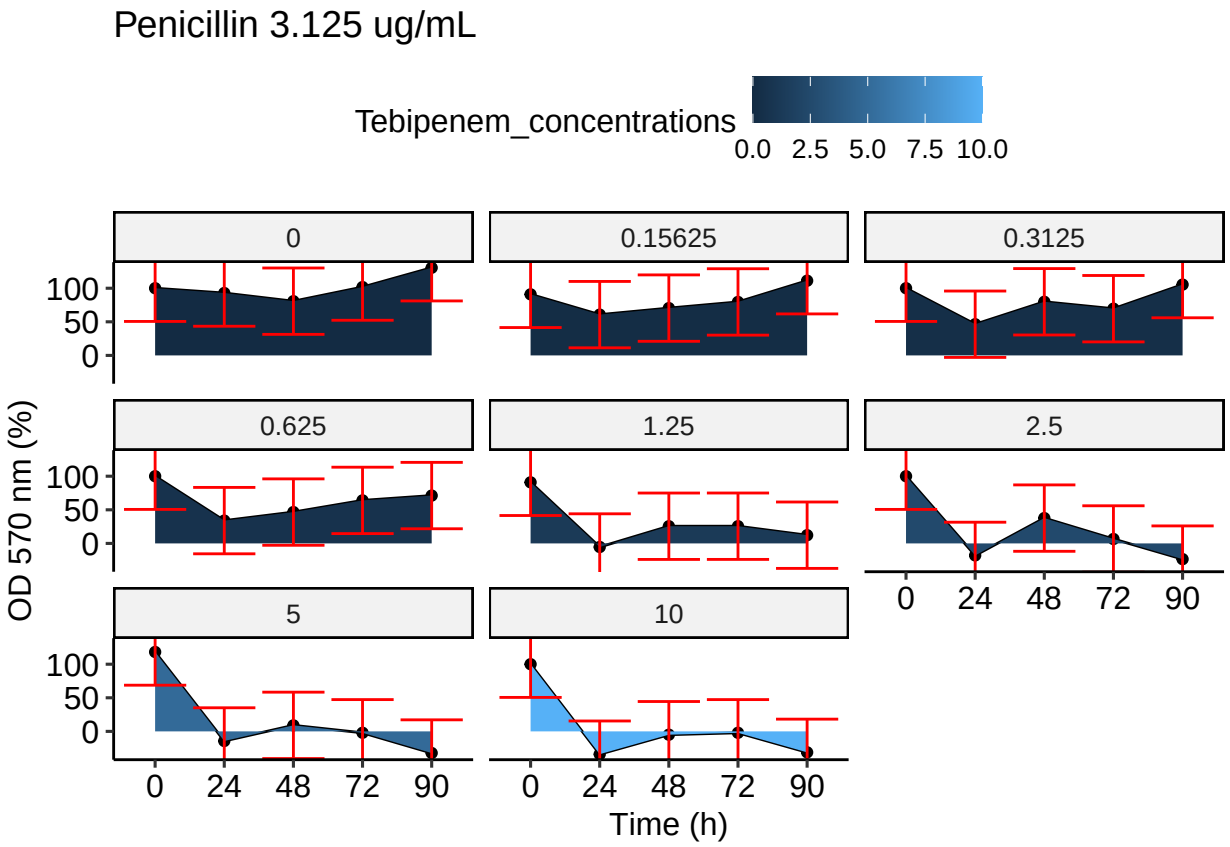
```
                                                                                ((mean(0.237,0.256,0.2
                                                                                ((mean(0.051,0.047,0.0
                                                                                ((mean(0.057,0.039,0.0
                                                                                ((mean(0.113,0.051,0.0
                                                                                ((mean(0.119,0.215,0.1
                                                                                ((mean(0.241,0.279,0.2
                                                                                ((mean(0.255,0.306,0.2
                                                                                ((mean(0.334,0.355,0.2
                                                                                ((mean(0.341,0.304,0.3
                                                                                ((mean(0.045,0.044,0.0
                                                                                ((mean(0.043,0.044,0.0
                                                                                ((mean(0.06,0.132,0.04
                                                                                ((mean(0.225,0.135,0.1
                                                                                ((mean(0.414,0.364,0.2
                                                                                ((mean(0.485,0.542,0.3
                                                                                ((mean(0.539,0.499,0.3
                                                                                ((mean(0.385,0.458,0.4
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp5 <- Mycobacterium_smegmatis_6.25ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 6.25 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_6.25ug_data$Optical_density_mean_values-sd(Mycobacterium_s
                ymax=Mycobacterium_smegmatis_6.25ug_data$Optical_density_mean_values+sd(Mycobacterium_s
print(Mp5)
```

Penicillin 6.25 ug/mL



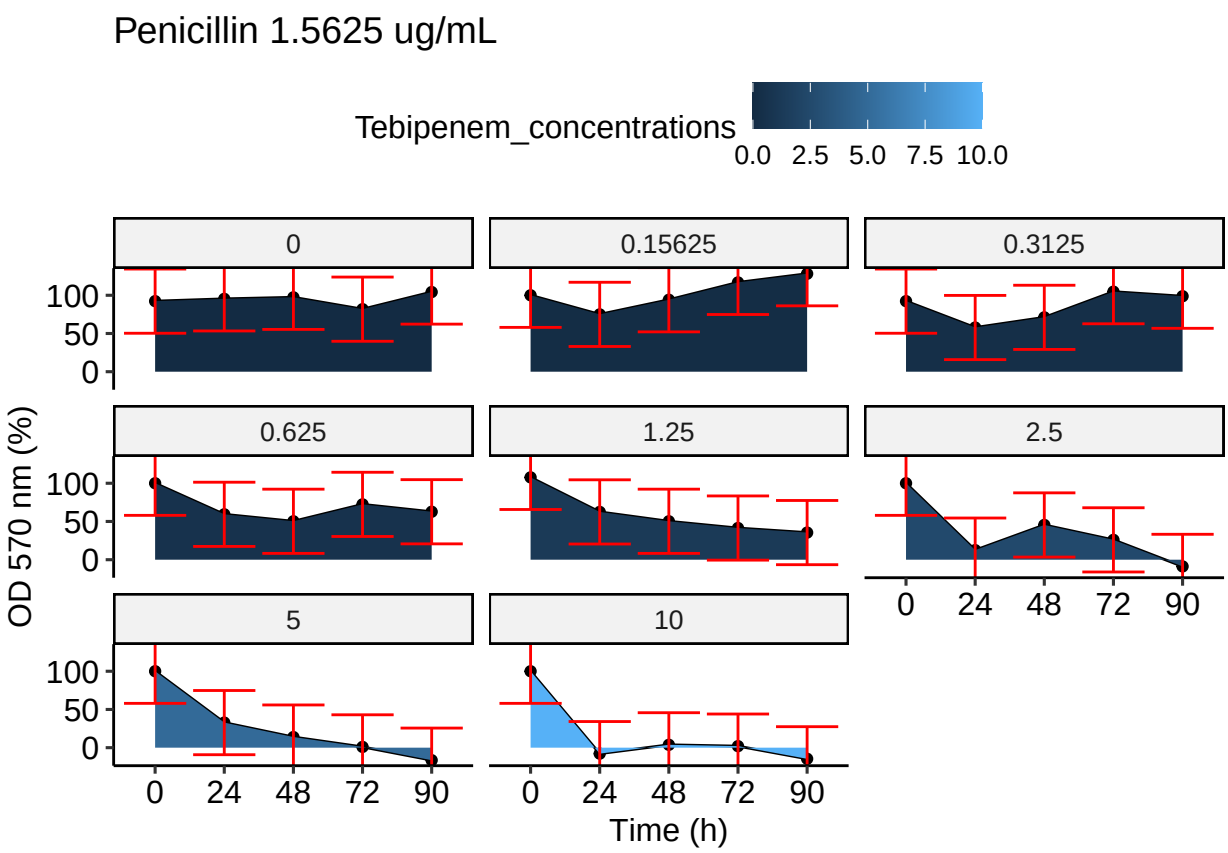

```
#Penicillin 3.125 ug/mL
Mycobacterium_smegmatis_3.125ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8
                                                   Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0.3
                                                   Optical_density_mean_values =c(((mean(0.047,0.049,0.04
                                                                                  ((mean(0.049,0.046,0.04
                                                                                  ((mean(0.047,0.045,0.04
                                                                                  ((mean(0.046,0.045,0.04
                                                                                  ((mean(0.047,0.047,0.04
                                                                                  ((mean(0.047,0.046,0.04
                                                                                  ((mean(0.046,0.045,0.04
                                                                                  ((mean(0.047,0.046,0.04
                                                                                  ((mean(0.078,0.088,0.04
                                                                                  ((mean(0.089,0.111,0.06
                                                                                  ((mean(0.087,0.085,0.09
                                                                                  ((mean(0.094,0.094,0.11
                                                                                  ((mean(0.116,0.108,0.15
                                                                                  ((mean(0.123,0.116,0.15
                                                                                  ((mean(0.131,0.12,0.167
                                                                                  ((mean(0.149,0.153,0.18
                                                                                  ((mean(0.046,0.05,0.054
                                                                                  ((mean(0.077,0.052,0.11
                                                                                  ((mean(0.141,0.077,0.14
                                                                                  ((mean(0.114,0.172,0.14
                                                                                  ((mean(0.161,0.186,0.17
                                                                                  ((mean(0.235,0.203,0.16
                                                                                  ((mean(0.214,0.205,0.22
```

```
                                                                                ((mean(0.237,0.266,0.2
                                                                                ((mean(0.046,0.047,0.0
                                                                                ((mean(0.046,0.042,0.0
                                                                                ((mean(0.071,0.041,0.0
                                                                                ((mean(0.126,0.198,0.1
                                                                                ((mean(0.237,0.252,0.2
                                                                                ((mean(0.253,0.369,0.2
                                                                                ((mean(0.282,0.278,0.2
                                                                                ((mean(0.346,0.322,0.3
                                                                                ((mean(0.045,0.044,0.0
                                                                                ((mean(0.042,0.044,0.0
                                                                                ((mean(0.068,0.05,0.04
                                                                                ((mean(0.173,0.186,0.2
                                                                                ((mean(0.347,0.316,0.3
                                                                                ((mean(0.448,0.411,0.3
                                                                                ((mean(0.465,0.319,0.3
                                                                                ((mean(0.522,0.592,0.4
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp6 <- Mycobacterium_smegmatis_3.125ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 3.125 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_3.125ug_data$Optical_density_mean_values-sd(Mycobacterium_s
                ymax=Mycobacterium_smegmatis_3.125ug_data$Optical_density_mean_values+sd(Mycobacterium_s
print(Mp6)
```



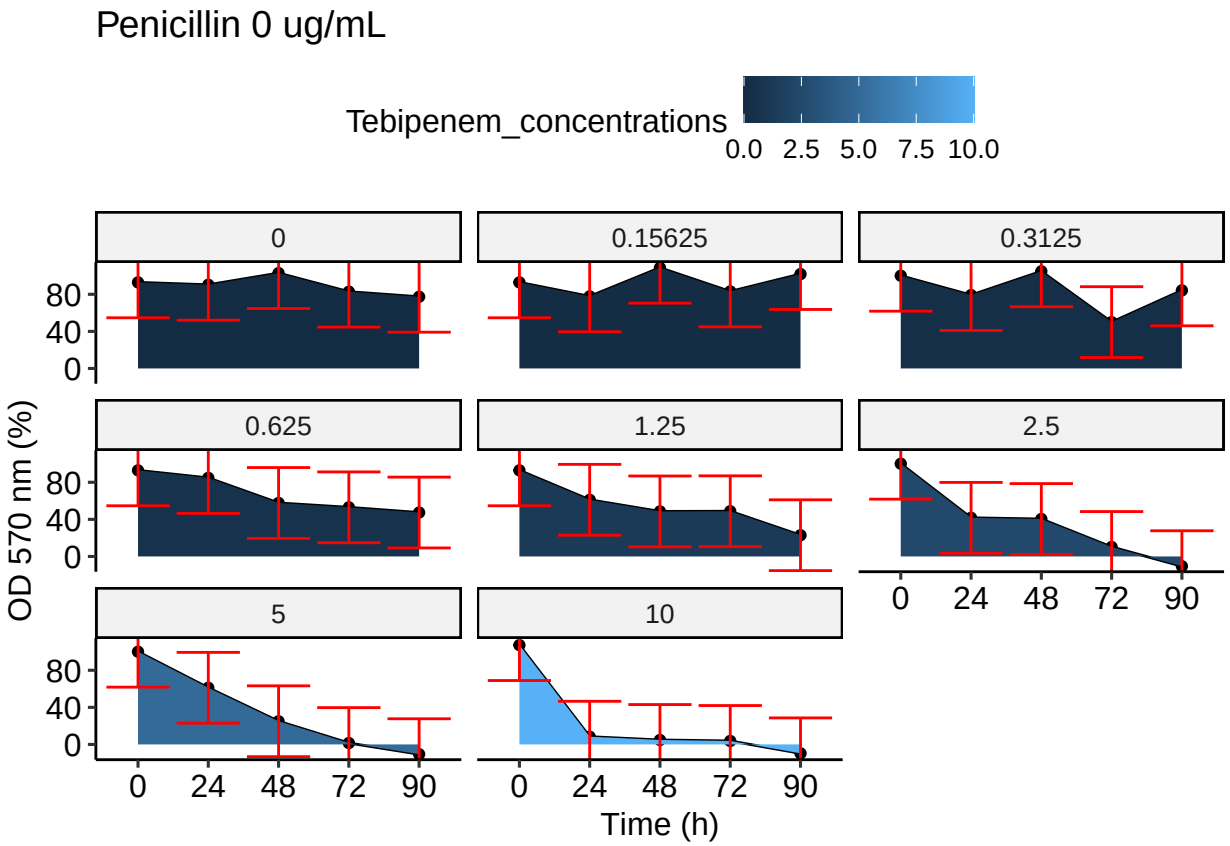

```
#Penicillin 1.5625 ug/mL
Mycobacterium_smegmatis_1.5625ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72"
                                                    Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,0
                                                    Optical_density_mean_values =c((mean(0.047,0.049,0.0
                                                                                   ((mean(0.047,0.047,0.0
                                                                                   ((mean(0.047,0.047,0.0
                                                                                   ((mean(0.048,0.045,0.0
                                                                                   ((mean(0.047,0.047,0.0
                                                                                   ((mean(0.046,0.045,0.0
                                                                                   ((mean(0.047,0.045,0.0
                                                                                   ((mean(0.046,0.045,0.0
                                                                                   ((mean(0.068,0.07,0.05
                                                                                   ((mean(0.094,0.084,0.0
                                                                                   ((mean(0.081,0.081,0.1
                                                                                   ((mean(0.113,0.094,0.1
                                                                                   ((mean(0.111,0.111,0.1
                                                                                   ((mean(0.11,0.139,0.14
                                                                                   ((mean(0.121,0.12,0.10
                                                                                   ((mean(0.134,0.153,0.1
                                                                                   ((mean(0.053,0.048,0.0
                                                                                   ((mean(0.072,0.05,0.10
                                                                                   ((mean(0.131,0.105,0.1
                                                                                   ((mean(0.14,0.165,0.12
                                                                                   ((mean(0.14,0.201,0.17
                                                                                   ((mean(0.179,0.216,0.1
                                                                                   ((mean(0.222,0.222,0.2
```

```
                                                                                ((mean(0.228,0.258,0.1
                                                                                ((mean(0.047,0.049,0.0
                                                                                ((mean(0.044,0.042,0.0
                                                                                ((mean(0.118,0.044,0.0
                                                                                ((mean(0.164,0.209,0.1
                                                                                ((mean(0.256,0.271,0.3
                                                                                ((mean(0.352,0.296,0.1
                                                                                ((mean(0.388,0.281,0.1
                                                                                ((mean(0.284,0.284,0.3
                                                                                ((mean(0.05,0.045,0.04
                                                                                ((mean(0.044,0.043,0.0
                                                                                ((mean(0.069,0.042,0.0
                                                                                ((mean(0.215,0.219,0.1
                                                                                ((mean(0.305,0.322,0.5
                                                                                ((mean(0.424,0.465,0.1
                                                                                ((mean(0.521,0.322,0.4
                                                                                ((mean(0.442,0.349,0.3
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp7 <- Mycobacterium_smegmatis_1.5625ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 1.5625 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_1.5625ug_data$Optical_density_mean_values-sd(Mycobacterium_
                ymax=Mycobacterium_smegmatis_1.5625ug_data$Optical_density_mean_values+sd(Mycobacterium_
print(Mp7)
```

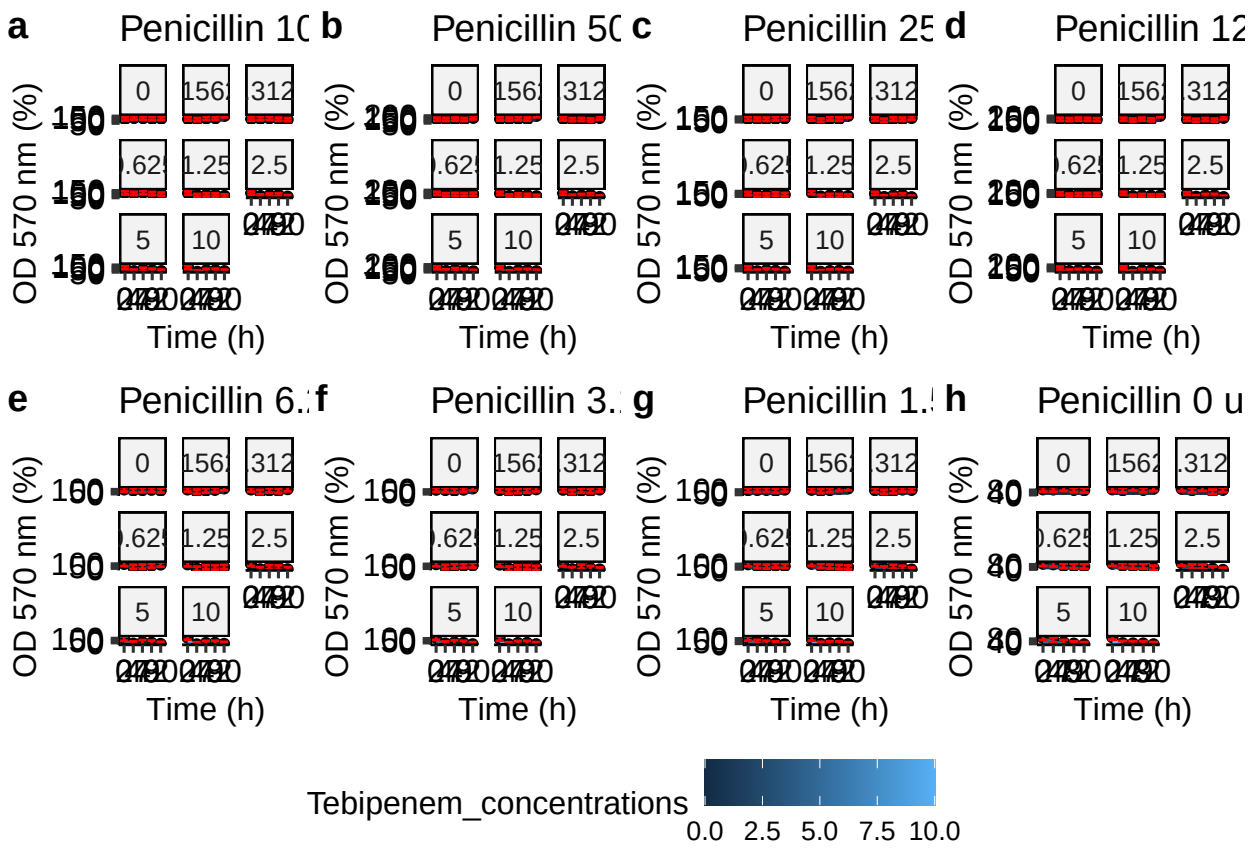



```
#Penicillin 0 ug/mL
Mycobacterium_smegmatis_0ug_data <- data.frame(Time= c(rep("0",8),rep("24",8),rep("48",8),rep("72",8),re
                                                       Tebipenem_concentrations=c(10.0,5.0,2.5,1.25,0.625,
                                                       Optical_density_mean_values =c(((mean(0.05,0.052,0.
                                                                                      ((mean(0.049,0.051,0
                                                                                      ((mean(0.049,0.049,0
                                                                                      ((mean(0.048,0.048,0
                                                                                      ((mean(0.048,0.047,0
                                                                                      ((mean(0.049,0.048,0
                                                                                      ((mean(0.048,0.046,0
                                                                                      ((mean(0.048,0.048,0
                                                                                      ((mean(0.07,0.084,0.
                                                                                      ((mean(0.108,0.098,0
                                                                                      ((mean(0.094,0.093,0
                                                                                      ((mean(0.108,0.109,0
                                                                                      ((mean(0.125,0.118,0
                                                                                      ((mean(0.121,0.144,0
                                                                                      ((mean(0.12,0.127,0.
                                                                                      ((mean(0.129,0.152,0
                                                                                      ((mean(0.051,0.052,0
                                                                                      ((mean(0.093,0.046,0
                                                                                      ((mean(0.125,0.064,0
                                                                                      ((mean(0.142,0.178,0
                                                                                      ((mean(0.161,0.179,0
                                                                                      ((mean(0.259,0.244,0
                                                                                      ((mean(0.267,0.229,0
```

```
                                                                                ((mean(0.255,0.277,0
                                                                                ((mean(0.053,0.048,0
                                                                                ((mean(0.044,0.065,0
                                                                                ((mean(0.079,0.042,0
                                                                                ((mean(0.234,0.062,0
                                                                                ((mean(0.251,0.287,0
                                                                                ((mean(0.239,0.391,0
                                                                                ((mean(0.372,0.238,0
                                                                                ((mean(0.371,0.315,0
                                                                                ((mean(0.048,0.049,0
                                                                                ((mean(0.044,0.047,0
                                                                                ((mean(0.044,0.042,0
                                                                                ((mean(0.19,0.183,0.1
                                                                                ((mean(0.297,0.297,0
                                                                                ((mean(0.458,0.447,0
                                                                                ((mean(0.535,0.454,0
                                                                                ((mean(0.428,0.521,0
#Make a line graphs for changing in OD with time according to Tebipenem concentrations
Mp8 <- Mycobacterium_smegmatis_0ug_data %>%
  ggplot(aes(x=Time,y=Optical_density_mean_values,group=Tebipenem_concentrations, fill=Tebipenem_concen
  geom_line()+
  geom_point()+
  geom_area() +
  facet_wrap(~Tebipenem_concentrations)+
  ggtitle("Penicillin 0 ug/mL")+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Mycobacterium_smegmatis_0ug_data$Optical_density_mean_values-sd(Mycobacterium_smegm
                ymax=Mycobacterium_smegmatis_0ug_data$Optical_density_mean_values+sd(Mycobacterium_smegm
print(Mp8)
```




```
#Align all graphs together
library(ggplot2)
library(ggpubr)
theme_set(theme_pubr())
figure_3 <- ggarrange(Mp1,Mp2,Mp3,Mp4, Mp5, Mp6, Mp7, Mp8,
                      labels=c("a","b","c","d","e","f","g","h"),
                      ncol=4,nrow=2,
                      common.legend = TRUE,legend = "bottom")
print(figure_3)
```




```
#Compare concentrations that inhibt the bacterial growth
Final_Myco_data <- data.frame(Time_f3 =c("0","24","48","72","96"),
                              Concentrations= c(rep("PenicillinV 100 ug/mL + Tebip 1.25 ug/mL",5),
                                                rep("PenicillinV 50 ug/mL + Tebip 1.25 ug/mL",5),
                                                rep("PenicillinV 1.5625 ug/mL + Tebip 2.5 ug/mL",5),
                                                rep("PeenicillinV 0 ug/mL + Tebip 2.5 ug/mL",5)),
                              Optical_density_value=c(((mean(0.047,0.047,0.047)-mean(0.036,0.036,0.03
                                                       ((mean(0.086,0.114,0.125)-mean(0.08,0.065,0.04)
                                                       ((mean(0.105,0.226,0.182)-mean(0.052,0.047,0.03
                                                       ((mean(0.126,0.32,0.153)-mean(0.047,0.049,0.04
                                                       ((mean(0.115,0.587,0.137)-mean(0.119,0.097,0.04
                                                       ((mean(0.048,0.047,0.047)-mean(0.036,0.035,0.03
                                                       ((mean(0.092,0.101,0.146)-mean(0.09,0.075,0.04
                                                       ((mean(0.121,0.151,0.175)-mean(0.049,0.046,0.03
                                                       ((mean(0.129,0.217,0.193)-mean(0.049,0.05,0.04)
                                                       ((mean(0.117,0.207,0.22)-mean(0.135,0.118,0.057
                                                       ((mean(0.047,0.047,0.046)-mean(0.034,0.034,0.03
                                                       ((mean(0.081,0.081,0.126)-mean(0.073,0.061,0.04
                                                       ((mean(0.131,0.105,0.143)-mean(0.046,0.043,0.03
                                                       ((mean(0.118,0.044,0.048)-mean(0.041,0.04,0.037
                                                       ((mean(0.069,0.042,0.066)-mean(0.098,0.084,0.04
                                                       ((mean(0.049,0.049,0.049)-mean(0.035,0.035,0.03
                                                       ((mean(0.094,0.093,0.091)-mean(0.064,0.053,0.03
                                                       ((mean(0.125,0.064,0.152)-mean(0.041,0.039,0.03
                                                       ((mean(0.079,0.042,0.084)-mean(0.038,0.038,0.03
                                                       ((mean(0.044,0.042,0.07)-mean(0.09,0.08,0.044))
```

```r
#Make up a line graph
Final_Myco<- Final_Myco_data %>%
  ggplot(aes(x=Time_f3, y=Optical_density_value,group=Concentrations, shape=Concentrations))+
  geom_line()+
  geom_point(size=2)+
  xlab("Time (h)")+
  ylab("OD 570 nm (%)")+
  geom_errorbar(ymin=Final_Myco_data$Optical_density_value-sd(Final_Myco_data$Optical_density_value),
                ymax=Final_Myco_data$Optical_density_value+sd(Final_Myco_data$Optical_density_value),
                width=.2)+
  stat_compare_means(method = "kruskal.test", label.y =140)+
  stat_compare_means(label = "p.signif", label.y = c(110,100,90,70,50))+
  geom_hline(yintercept = 0, linetype="dashed", col="grey")
print(Final_Myco)
```