

# Survival Bands

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2020-10-18

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## Overview

This package generates simultaneous confidence bands for a single survival curve and for the difference of two survival curves using the method proposed by Prazen et al (1997).

## Single Survival Curve

### Critical Value

In the following example,  $n = 10^2$  observations are drawn from a gamma distribution with shape  $\alpha = 1$ , rate  $\lambda = 1/2$ , and 20% independent right censoring. The critical value for a 95% equi-precision band is approximated using  $10^3$  simulated sample paths.

```
library(Temporal)
set.seed(2013)
data <- rGamma(n = 1e2, a = 1, l = 1/2, p = 0.2)
ep_band <- SurvBands(
  time = data$time,
  status = data$status,
  alpha = 0.05,
  paths = 1e3,
  method = "EP"
)
show(ep_band)
```

```
## 1 Sample Survival Band.
## Significance level: 0.05
## Critical value: 1.381
## Sample paths: 1000
```

The critical value of a Hall-Wellner band is also available:

```
hw_band <- SurvBands(
  time = data$time,
  status = data$status,
  alpha = 0.05,
  paths = 1e3,
  method = "HW"
)
show(hw_band)
```

```
## 1 Sample Survival Band.
## Significance level: 0.05
## Critical value: 1.353
## Sample paths: 1000
```

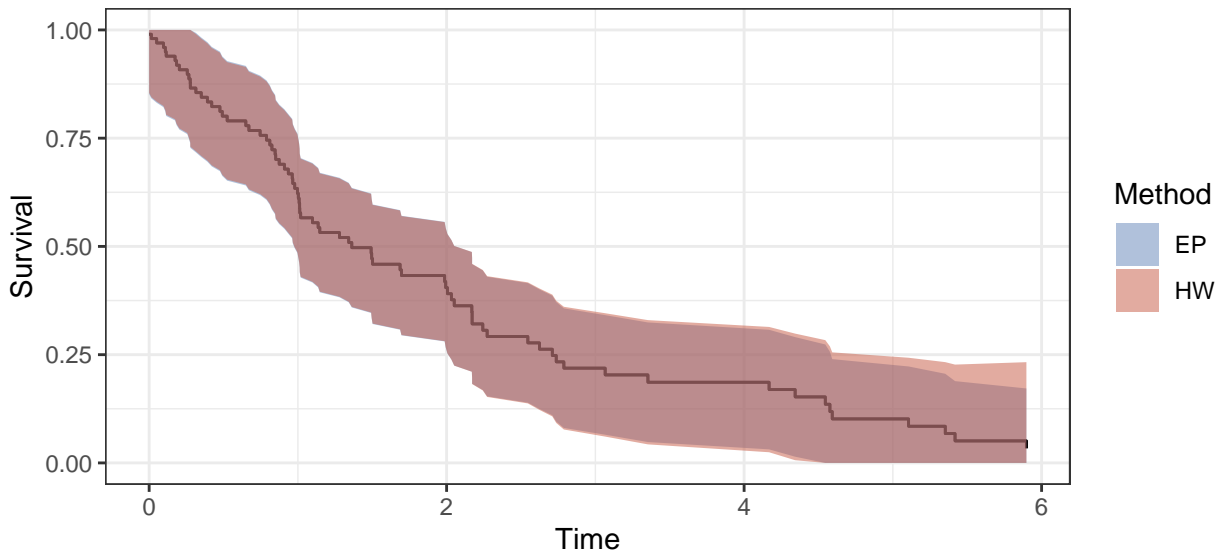
## Plotting

The resulting confidence bands may easily be plotted. For the simulated data, the equi-precision and Hall-Wellner bands are nearly identical until the end of follow-up.

```
library(cowplot)
library(ggplot2)

# Plotting frame.
ep_tab <- ep_band@Table
ep_tab$method = "EP"
hw_tab <- hw_band@Table
hw_tab$method = "HW"
df <- rbind(ep_tab, hw_tab)

# Plotting.
red <- rgb(198, 88, 66, maxColorValue = 255)
blue <- rgb(99, 133, 184, maxColorValue = 255)
q <- ggplot(data = df) +
  theme_bw() +
  geom_step(
    aes(x = time, y = surv, group = method)
  ) +
  geom_ribbon(
    aes(x = time, ymin = lower, ymax = upper, fill = method),
    alpha = 0.5
  ) +
  labs(
    x = "Time",
    y = "Survival",
    fill = "Method"
  ) +
  scale_fill_manual(
    values = c(blue, red)
  )
show(q)
```



## Difference of Survival Curves

### Critical Value

In the following example,  $n = 10^2$  observations are drawn from two distinct gamma distributions, representing a reference and treatment arm. For the reference arm, the shape parameter is  $\alpha = 1$ , the rate parameter is  $\lambda = 1/2$ , and the mean is 2. For the treatment arm, the shape parameter is again  $\alpha = 1$ , however the rate is  $\lambda = 1/4$ , for a mean of 4. The critical value of a 95% equi-precision band for the difference in survival curves is approximated using  $10^3$  simulated sample paths.

```
set.seed(2014)
data0 <- rGamma(n = 1e2, a = 1, l = 1/2, p = 0.2)
data0$arm <- 0
data1 <- rGamma(n = 1e2, a = 1, l = 1/4, p = 0.2)
data1$arm <- 1
data <- rbind(data0, data1)
ep_band <- SurvBands(
  time = data$time,
  status = data$status,
  arm = data$arm,
  alpha = 0.05,
  paths = 1e3,
  method = "EP"
)
show(ep_band)

## 2 Sample Survival Band.
## Significance level: 0.05
## Critical value: 2.671
## Sample paths: 1000
## P-value for difference of survival curves: 0.000999
```

## Plotting

Plotting the difference:

```
df <- ep_band@Table
df_indiv <- df[, c("time", "surv0", "surv1")]
df_indiv <- reshape2::melt(df_indiv, id.vars = "time")
colnames(df_indiv) <- c("time", "arm", "surv")

# Control arm.
q_indiv <- ggplot(data = df_indiv) +
  theme_bw() +
  theme(legend.position = "top") +
  geom_step(
    aes(x = time, y = surv, color = arm)
  ) +
  scale_color_manual(
    name = "Arm",
    labels = c(0, 1),
    values = c(blue, red)
  ) +
  labs(
    x = "Time",
    y = "Survival",
    title = "Individual Curves"
  )

# Difference.
q_diff <- ggplot(data = df) +
  theme_bw() +
  geom_step(
    aes(x = time, y = delta),
    color = blue
  ) +
  geom_ribbon(
    aes(x = time, ymin = lower, ymax = upper),
    fill = blue,
    alpha = 0.5
  ) +
  labs(
    x = "Time",
    y = expression(S[1] - S[0]),
    title = "Difference"
  )

# Final plot
q <- plot_grid(
  q_indiv,
  q_diff,
  ncol = 1
)
show(q)
```

## Individual Curves

