

# Kaplan-Meier estimate

SURVIVAL ANALYSIS IN R



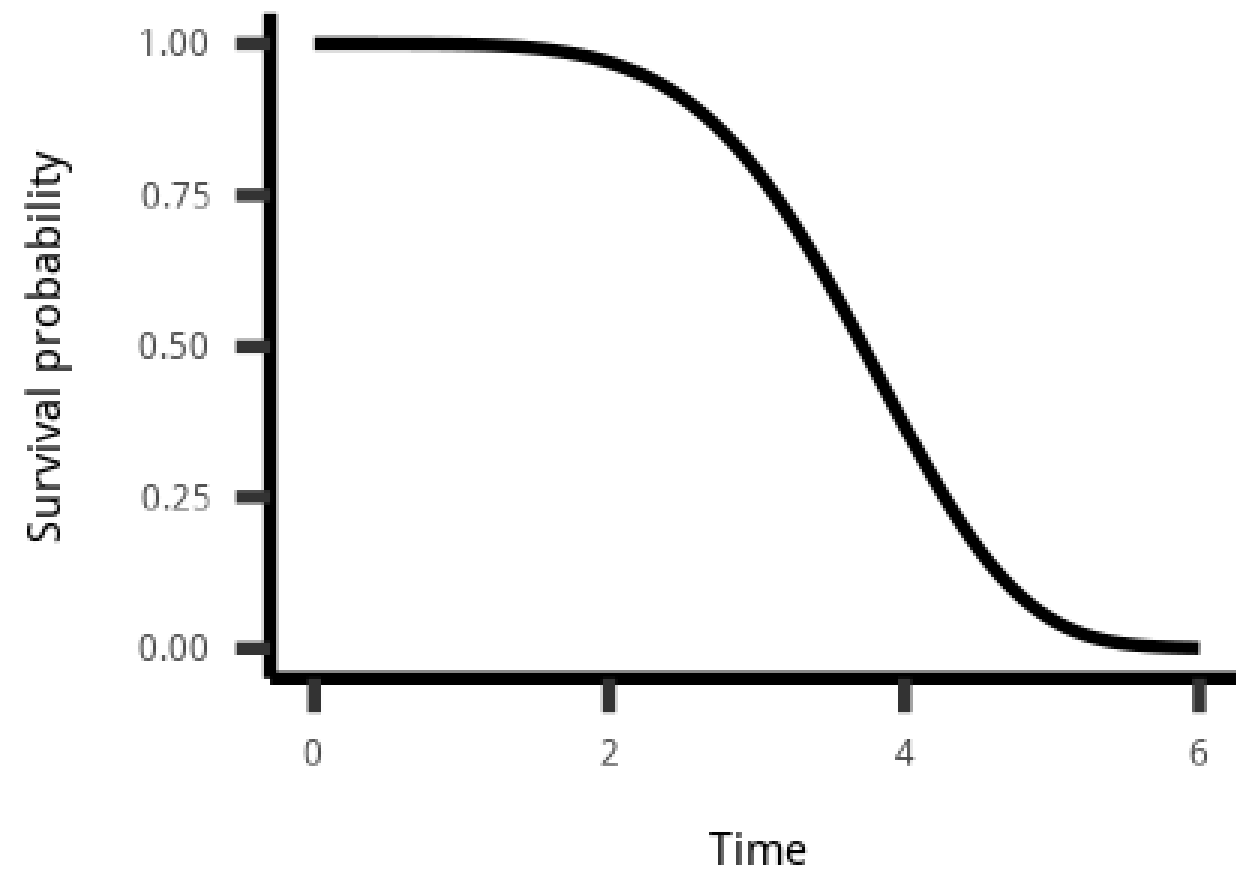
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# Survival function

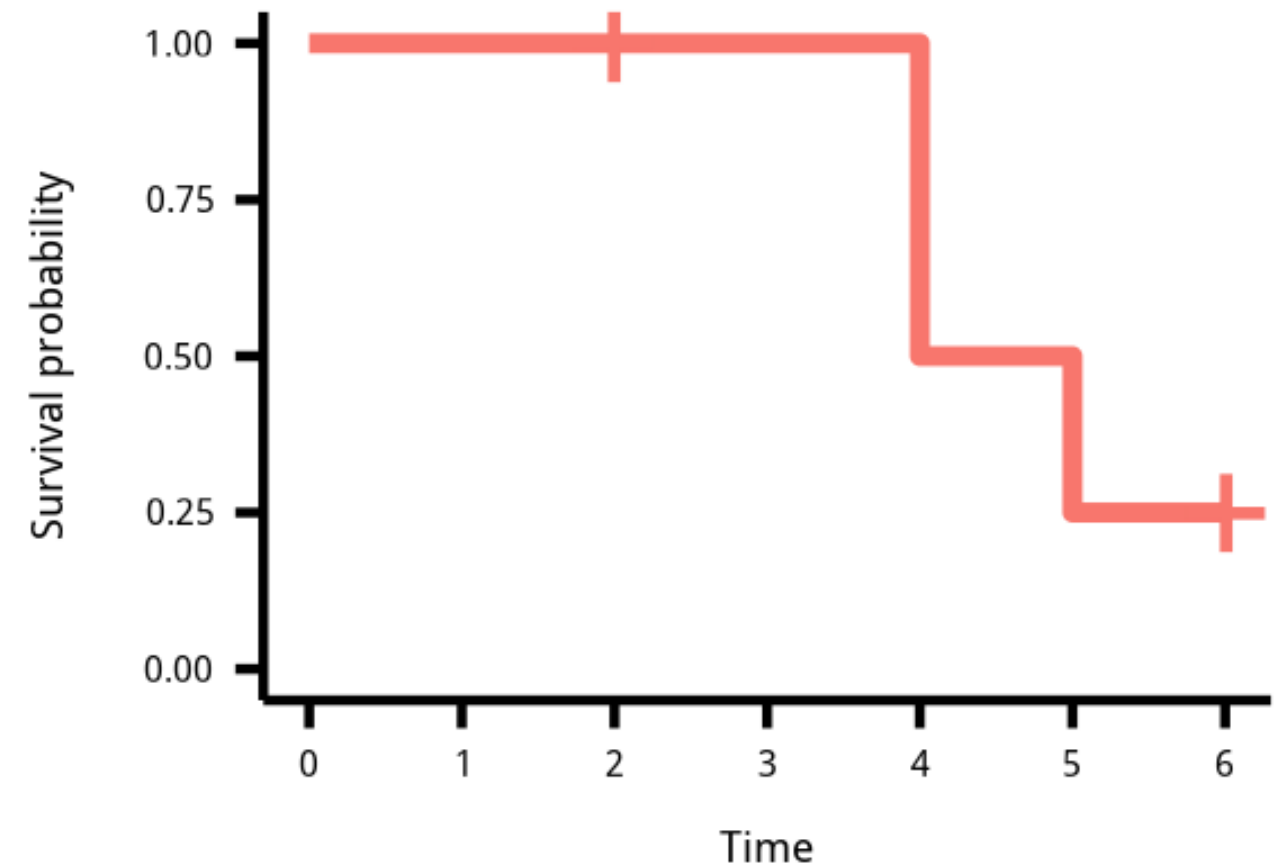
## Theory

$$S(t) = 1 - F(t) = P(T > t)$$



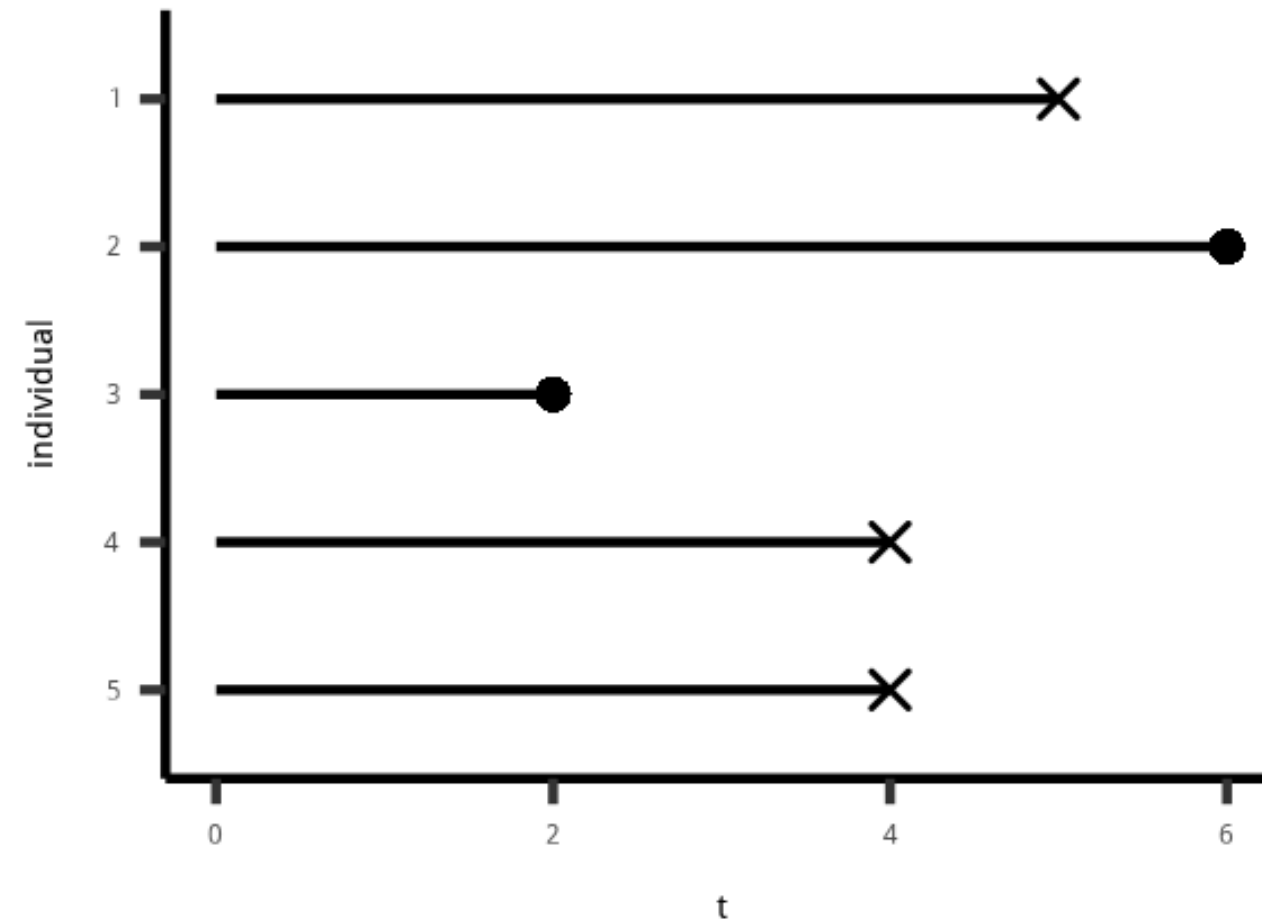
## Estimation

$$\hat{S}(t) = \prod_{i: t_i \leq t} \frac{n_i - d_i}{n_i}$$



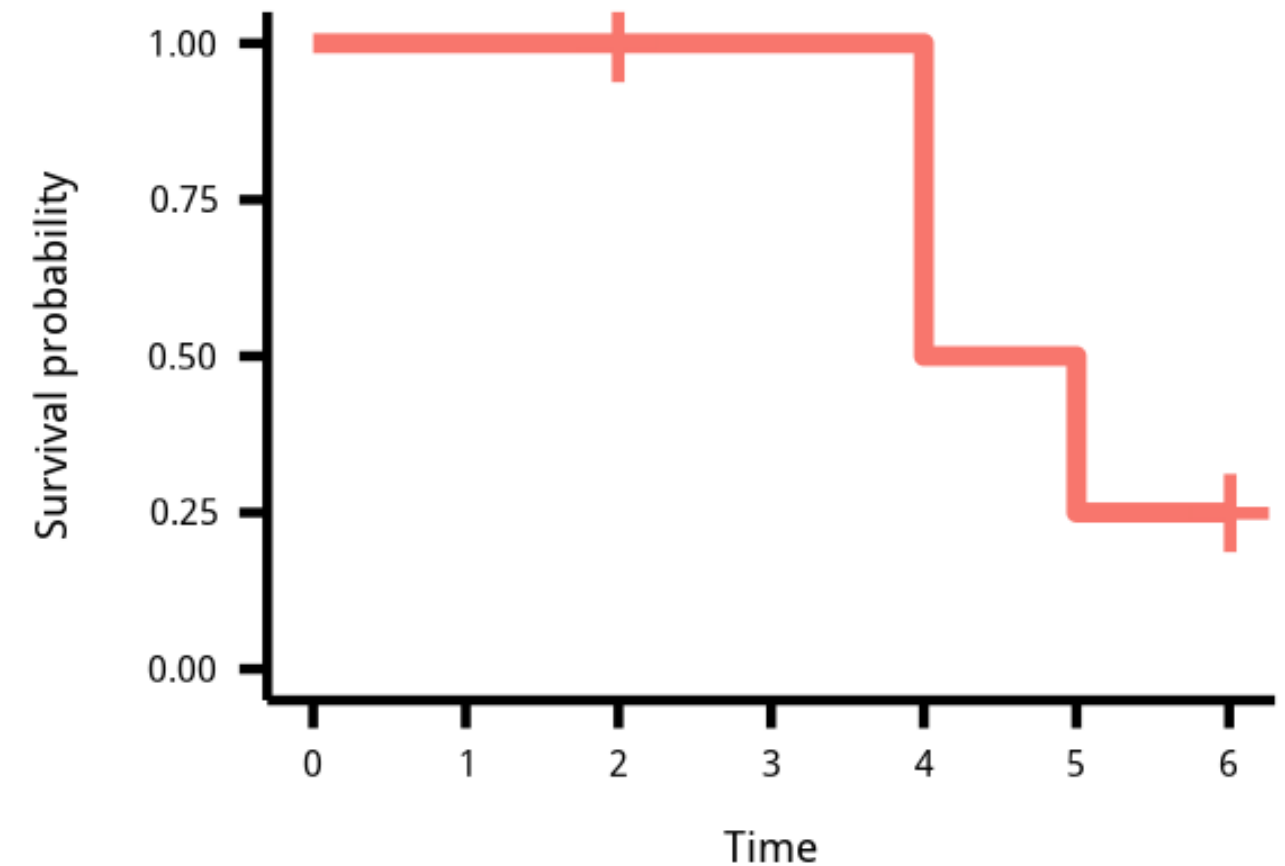
# Survival function estimation

## Data



## Estimation

$$\hat{S}(t) = \prod_{i: t_i \leq t} \frac{n_i - d_i}{n_i}$$



# Survival function estimation: Kaplan-Meier estimate

$$\hat{S}(t) = \prod_{i: t_i \leq t} \frac{n_i - d_i}{n_i}$$

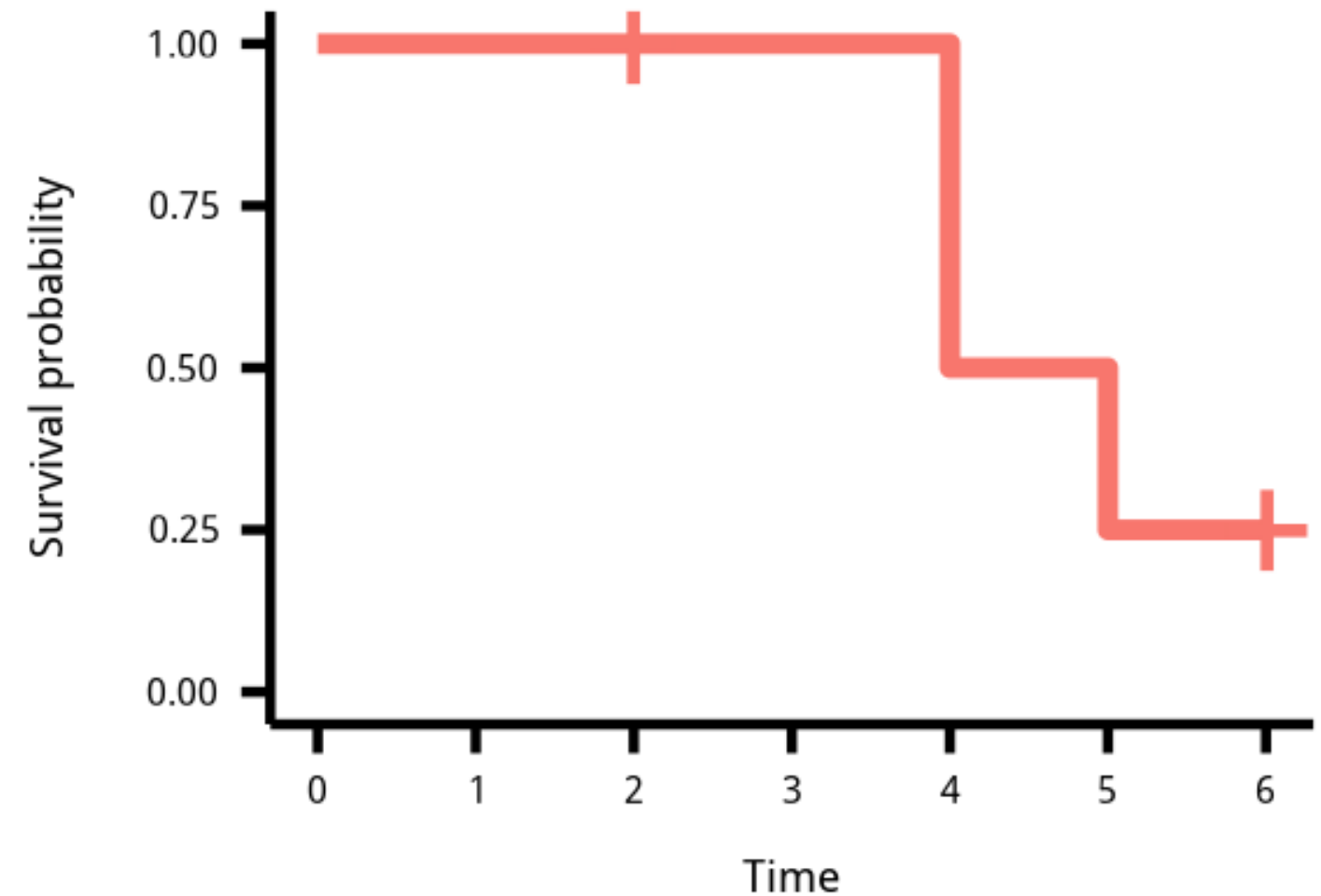
$$\hat{S}(2) = \frac{5-0}{5} = \frac{5}{5} = 1$$

$$\hat{S}(3) = \frac{4-0}{4} = \frac{4}{4} = 1$$

$$\hat{S}(4) = \frac{4-2}{4} = \frac{2}{4} = \frac{1}{2} = 0.5$$

$$\hat{S}(5) = \frac{1}{2} \cdot \frac{2-1}{2} = \frac{1}{4} = 0.25$$

$$\hat{S}(6) = \frac{1}{4} \cdot \frac{1-0}{1} = \frac{1}{4} = 0.25$$

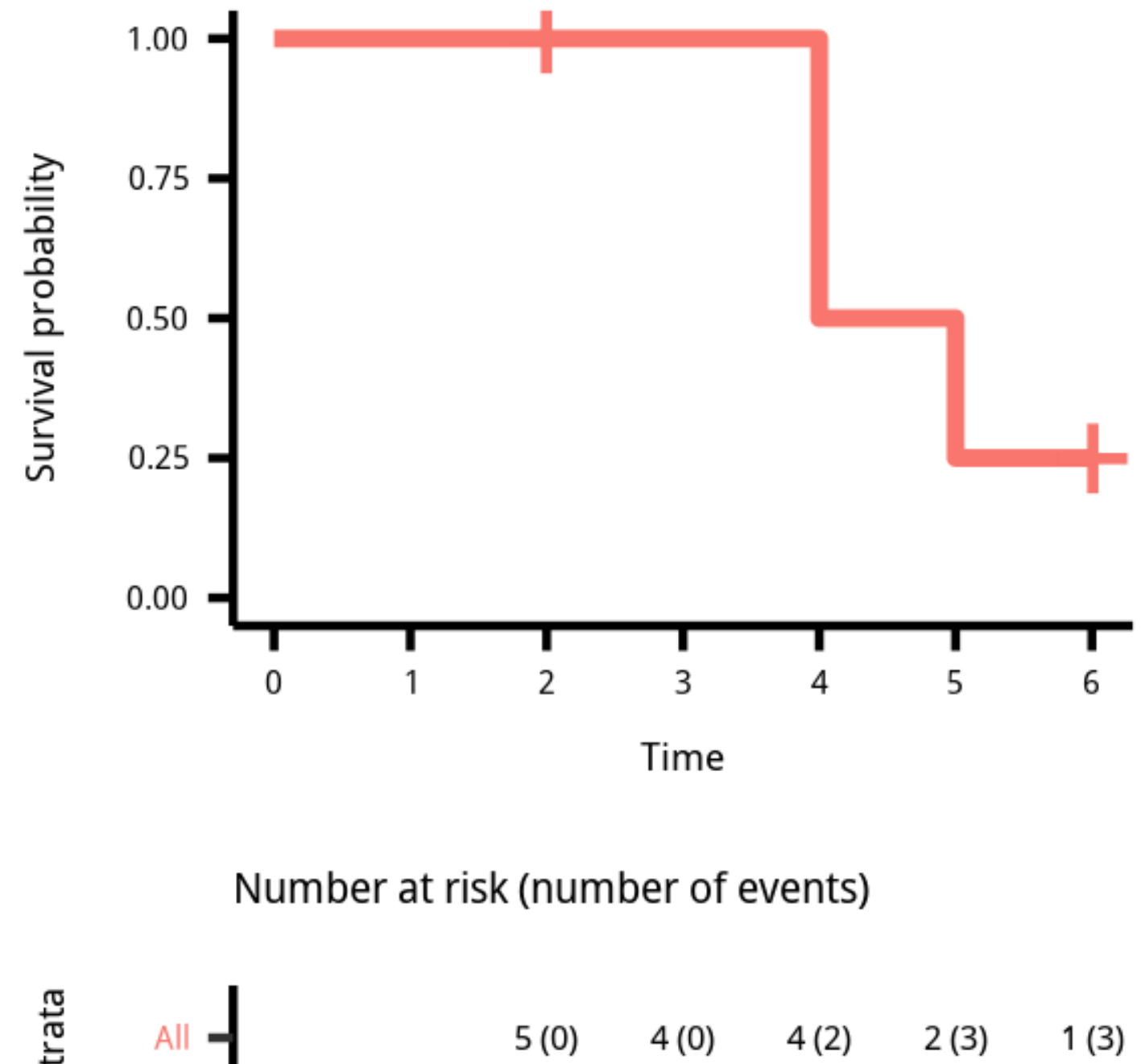


Number at risk (number of events)



# Survival function estimation: Kaplan-Meier estimate

```
km <- survfit(Surv(time, event) ~ 1)
ggsurvplot(km, conf.int = FALSE,
  risk.table = "nrisk_cumevents",
  legend = "none")
```



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# Understanding and visualizing Kaplan- Meier curves

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# The ggsurvplot function

```
library(survminer)
```

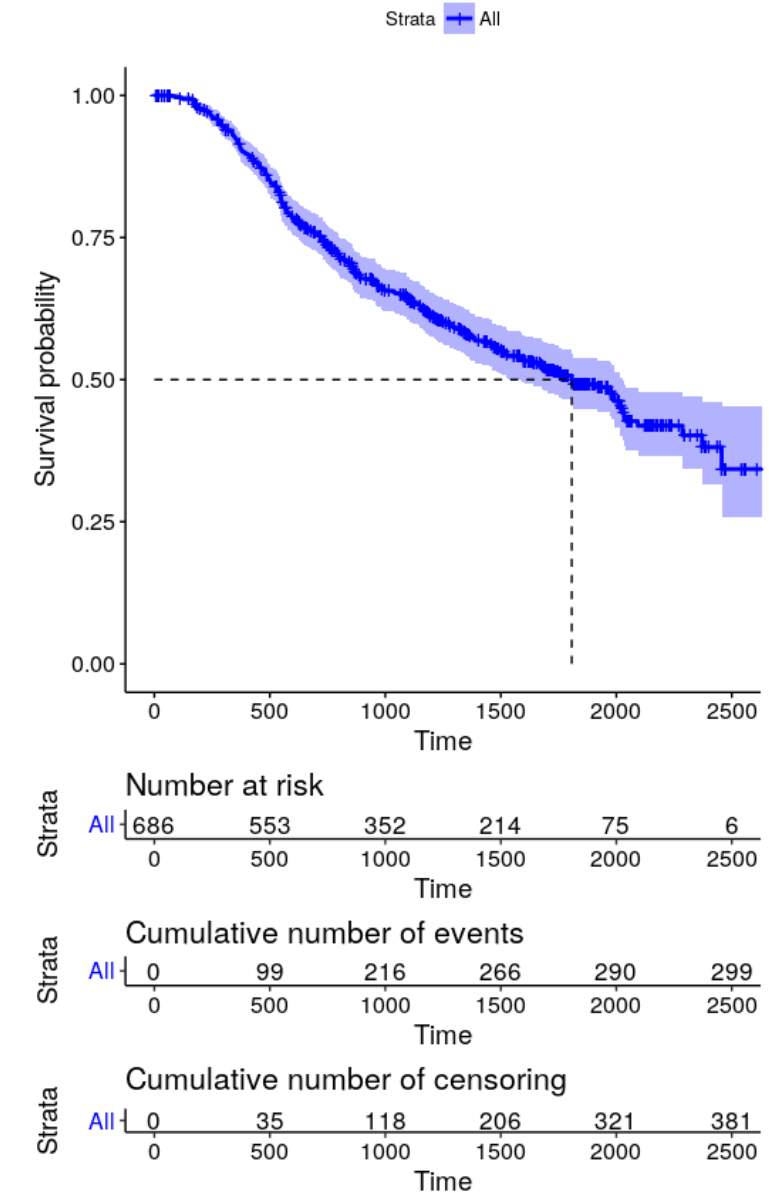
```
ggsurvplot(fit)
```

```
ggsurvplot(  
  fit, palette = NULL, linetype = 1,  
  surv.median.line = "none", risk.table = FALSE,  
  cumevents = FALSE, cumcensor = FALSE,  
  tables.height = 0.25,  
  ...  
)
```



# The ggsurvplot function

```
ggsurvplot(  
  fit = km,  
  palette = "blue",  
  linetype = 1,  
  surv.median.line = "hv",  
  risk.table = TRUE,  
  cumevents = TRUE,  
  cumcensor = TRUE,  
  tables.height = 0.1  
)
```



# The survfit function

```
survfit(object)
```

- If `object` is a `formula` : Kaplan-Meier estimation
- Other options for `object` (see upcoming chapters):
  - `coxph`
  - `survreg`

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# The Weibull model for estimating smooth survival curves

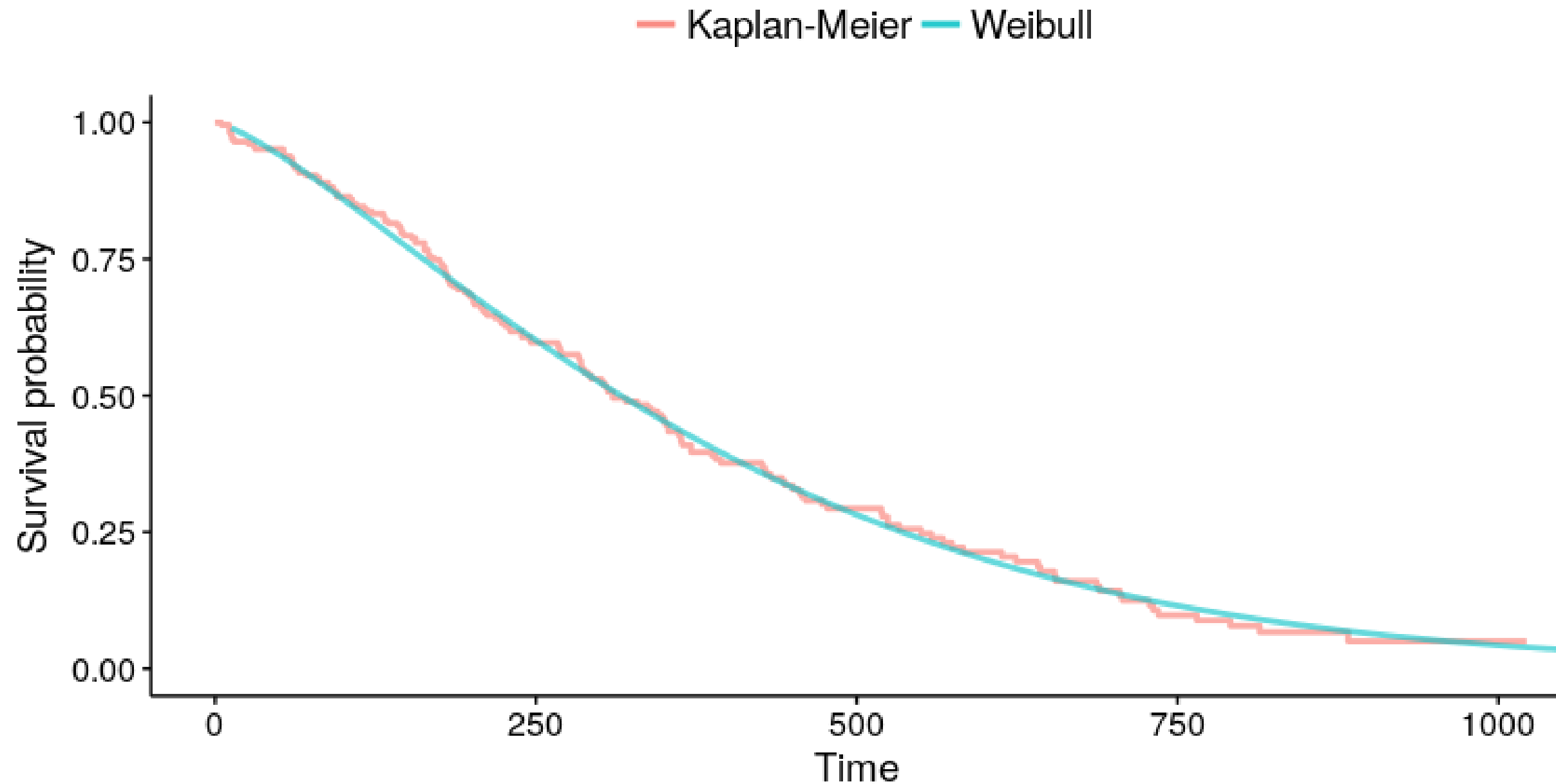
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# Why use a Weibull model?



# Computing a Weibull model in R

Weibull model:

```
wb <- survreg(Surv(time, event) ~ 1, data)
```

# Computing a Weibull model in R

Weibull model:

```
wb <- survreg(Surv(time, event) ~ 1, data)
```

Kaplan-Meier estimate:

```
km <- survfit(Surv(time, event) ~ 1, data)
```

# Computing measures from a Weibull model

```
wb <- survreg(Surv(time, cens) ~ 1, data = GBSG2)
```

90 Percent of patients survive beyond time point:

```
predict(wb, type = "quantile", p = 1 - 0.9, newdata = data.frame(1))
```

```
1  
384.9947
```

`p = 1 - 0.9` because the distribution function is 1 - the survival function.



```
wb <- survreg(Surv(time, cens) ~ 1, data = GBSG2)
```

Survival curve:

```
surv <- seq(.99, .01, by = -.01)
t <- predict(wb, type = "quantile", p = 1 - surv, newdata = data.frame(1))
head(data.frame(time = t, surv = surv))
```

	time	surv
1	60.6560	0.99
2	105.0392	0.98
3	145.0723	0.97
4	182.6430	0.96
5	218.5715	0.95
6	253.3125	0.94

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# Visualizing the results of a Weibull model

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# Visualizing a Weibull model

Visualization tools often focus on step functions.

So the following code does NOT work:

```
wb <- survreg(Surv(time, cens) ~ 1)  
ggsurvplot(wb)
```



# Visualizing a Weibull model

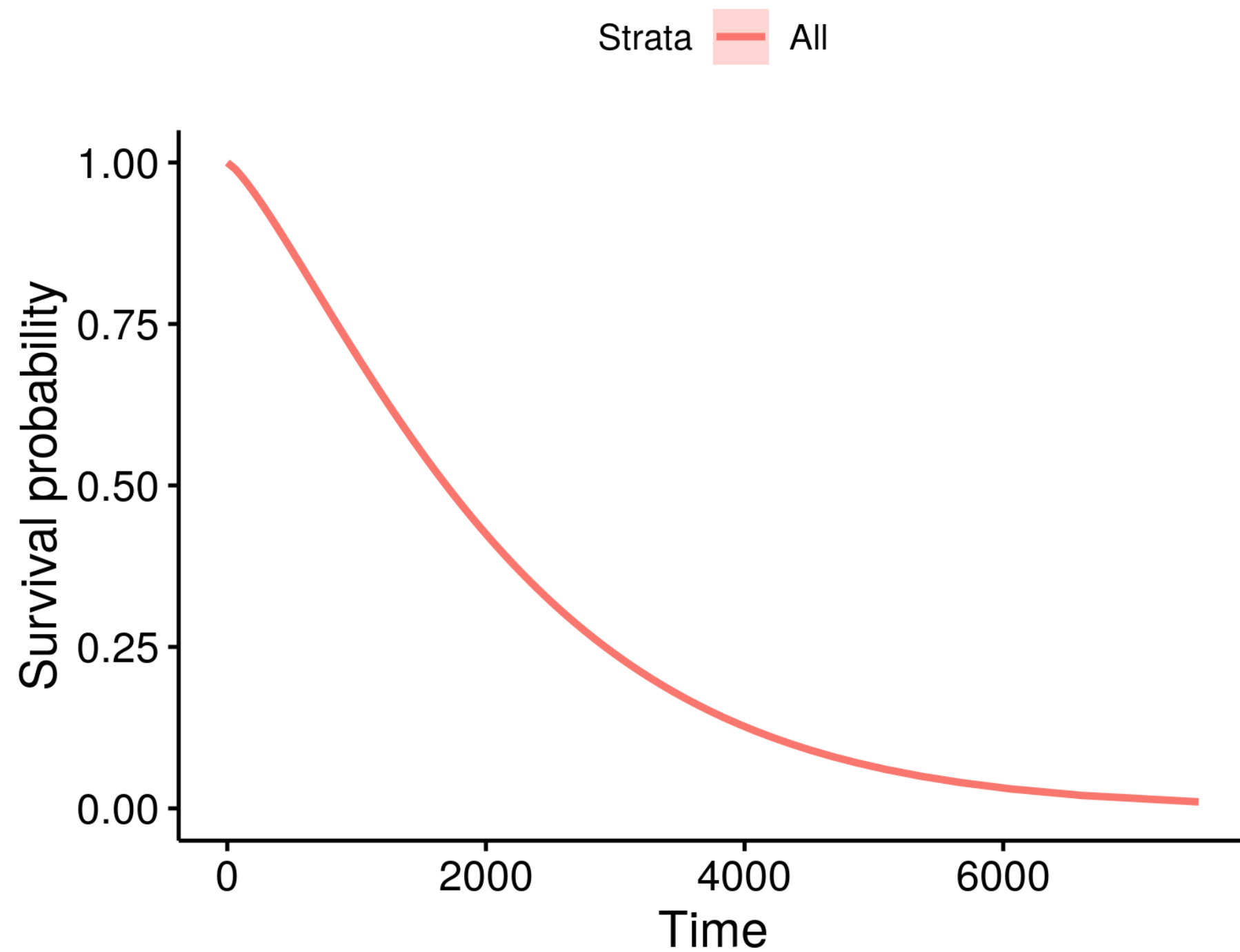
```
wb <- survreg(Surv(time, cens) ~ 1)
```

Survival curve:

```
surv <- seq(.99, .01, by = -.01)
t <- predict(wb, type = "quantile", p = 1 - surv, newdata = data.frame(1))
surv_wb <- data.frame(time = t, surv = surv,
                      upper = NA, lower = NA, std.err = NA)
```

Plot:

```
ggsurvplot_df(fit = surv_wb, surv.geom = geom_line)
```



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