

# Homework 9

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1

$$h(x) = \frac{2x}{(1+x^2)}$$

Let  $H(x)$  be cumulative hazard function,  $S(x)$  be Survival function, and  $f(x)$  be density function.

$$\begin{aligned} H(x) &= \int_0^x h(t) dt \\ &= \int_0^x \frac{2}{1+t^2} dt = \left[ \log(1+t^2) \right]_0^x \\ &= \log(1+x^2) \end{aligned}$$

$$S(x) = \exp\{-H(x)\} = \exp\{-\log(1+x^2)\} = \frac{1}{1+x^2}$$

$$\begin{aligned} h(x) = \frac{f(x)}{S(x)} &\Rightarrow f(x) = h(x) \times S(x) = \frac{2x}{(1+x^2)} \times \frac{1}{(1+x^2)} \\ &= \frac{2x}{(1+x^2)^2} \end{aligned}$$

2

3

tongue data contains the following columns:

- type Tumor DNA profile (1 = Aneuploid Tumor, 2 = Diploid Tumor)
- time Time to death or on-study time, weeks
- delta Death indicator (0 = alive, 1 = dead)

Here we consider individuals with `delta = 0` as right censored ones.

```
# data import
data("tongue")

str(tongue)
```

```
## 'data.frame': 80 obs. of 3 variables:
```

```
## $ type : int 1 1 1 1 1 1 1 1 1 1 ...
## $ time : int 1 3 3 4 10 13 13 16 16 24 ...
## $ delta: int 1 1 1 1 1 1 1 1 1 1 ...
```

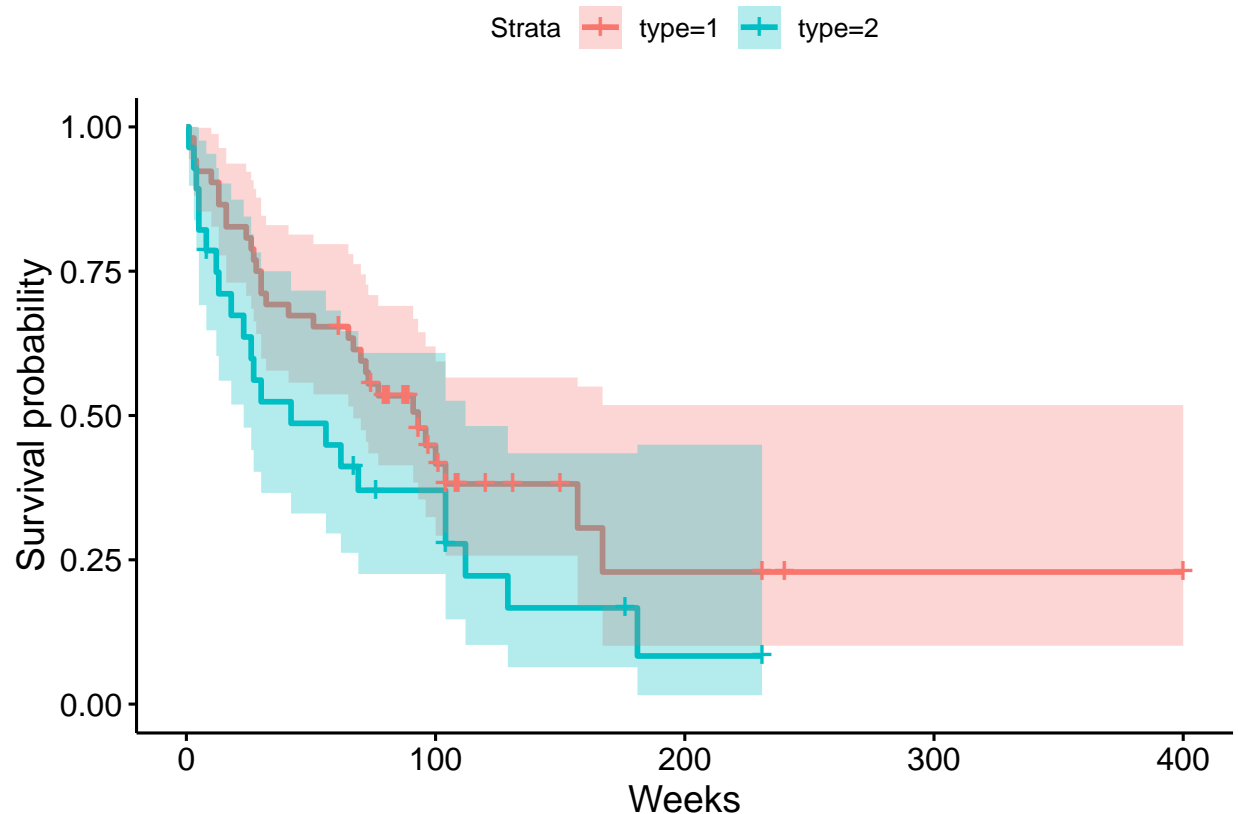
```
# check censored
```

```
Surv(tongue$time, tongue$delta, type = "right")
```

```
## [1] 1 3 3 4 10 13 13 16 16 24 26 27 28 30 30
## [16] 32 41 51 65 67 70 72 73 77 91 93 96 100 104 157
## [31] 167 61+ 74+ 79+ 80+ 81+ 87+ 87+ 88+ 89+ 93+ 97+ 101+ 104+ 108+
## [46] 109+ 120+ 131+ 150+ 231+ 240+ 400+ 1 3 4 5 5 8 12 13
## [61] 18 23 26 27 30 42 56 62 69 104 104 112 129 181 8+
## [76] 67+ 76+ 104+ 176+ 231+
```

```
# plot Kaplan-Meier curve of survival function
```

```
ggsurvplot(survfit(Surv(time, delta) ~ type, data = tongue, conf.type = "log"), conf.int = TRUE, xlab =
```



The Kaplan-Meier curve of survival function and its pointwise 95% CI using the log transformation is shown above.

```
# estimated 1-year (52 weeks) survival rate and 95% CI
```

```
KM <- survfit(Surv(time, delta) ~ type, data = tongue, conf.type = "log")
```

```
summary(KM, times = 52)
```

```
## Call: survfit(formula = Surv(time, delta) ~ type, data = tongue, conf.type = "log")
##
##               type=1
##      time      n.risk  n.event  survival  std.err lower 95% CI
##      52.000      34.000   18.000    0.654    0.066    0.537
## upper 95% CI
##      0.797
##
##               type=2
##      time      n.risk  n.event  survival  std.err lower 95% CI
##      52.0000     13.0000   14.0000   0.4864    0.0961    0.3302
## upper 95% CI
##      0.7164
```

Given the output, individuals with Aneuploid Tumor (`type = 1`) have an estimated 1-year (52 weeks) survival rate of 0.654 (95% CI: 0.537 - 0.797) and individuals with Diploid Tumor (`type = 2`) have that of 0.4864 (95% CI: 0.3302 - 0.7164).