

# bis630\_hw1

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## Question 1

Below are data from a study conducted on patients awaiting a heart transplant. The goal of the study was to describe the **survival of patients during their time on the heart transplant waiting list**, which we'll call "transplant-free survival." A patient remains on the heart transplant waiting list until they receive a heart transplant and is no longer on the transplant waiting list after they receive the transplant. The event of interest is **death before transplant**.

### Data description:

- birth.dt: birth date
- wtlist.dt: date patient is put on the heart transplant waiting list
- tx.date: transplant date
- fu.date: end of follow-up (Note: Equals date of death for those who died. For some patients, follow-up continued past date of transplant but we are only interested in their survival experience before transplant.)
- transplant: transplant indicator (1=yes)
- death: death indicator (1=yes)

### Create three new variables in this data set for these 20 patients:

- (1). Age at which the patient is put on the transplant waiting list (in years)
- (2). Appropriate survival time variable for the analysis of transplant-free survival (in days)

Since we are interested in the survival of patients during their time on the heart transplant waiting list, the time origin is *wtlist.dt*, while the ending event is patients is no longer on the waitlist and that is the time they receive a transplant *tx.date*. For patients who do not receive a transplant, the end date is *fu.date*.

- (3). Event indicator for the analysis of transplant-free survival During patients' time on the heart transplant waiting list, if the event of interest is **death before transplant** happens, then event indicator equals 1. Otherwise, 0.

Append the table above with the three new variables that you created and submit the table as your answer to this question.

ID	birth.dt	wtlist.dt	tx.date	fu.date	transplant	death	age_wtlist	survival_days	tf_survival
1	1937-01-10	1967-11-15	NA	1968-01-03	0	1	30.8	49	1
2	1916-03-02	1968-01-02	NA	1968-01-07	0	0	51.8	5	0
3	1913-09-19	1968-01-06	1968-01-06	1968-01-21	1	0	54.3	0	0
4	1927-12-23	1968-03-28	1968-05-02	1968-05-05	1	0	40.3	35	0
5	1947-07-28	1968-05-10	NA	1968-05-27	0	0	20.8	17	0
6	1913-11-08	1968-06-13	NA	1968-06-15	0	1	54.6	2	1
7	1917-08-29	1968-07-12	1968-08-31	1970-05-17	1	1	50.9	50	0

ID	birth.dt	wtlist.dt	tx.date	fu.date	transplant	death	age_wtlist	survival_days	tf_survival
8	1923-03-27	1968-08-01	NA	1968-09-09	0	1	45.3	39	1
9	1921-06-11	1968-08-09	NA	1968-11-01	0	0	47.2	84	0
10	1926-02-09	1968-08-11	1968-08-22	1968-10-07	1	1	42.5	11	0
11	1920-08-22	1968-08-15	1968-09-09	1969-01-14	1	0	48.0	25	0
12	1915-07-09	1968-09-17	NA	1968-09-24	0	0	53.2	7	0
13	1914-02-22	1968-09-19	1968-10-05	1968-12-08	1	0	54.6	16	0
14	1914-09-16	1968-09-20	1968-10-26	1972-07-07	1	1	54.0	36	0
15	1914-12-04	1968-09-27	NA	1968-09-27	0	0	53.8	0	0
16	1919-05-16	1968-10-26	1968-11-22	1969-08-29	1	1	49.4	27	0
17	1948-06-29	1968-10-28	NA	1968-12-02	0	1	20.3	35	1
18	1911-12-27	1968-11-01	1968-11-20	1968-12-13	1	1	56.8	19	0
19	1909-10-04	1968-11-18	NA	1968-12-24	0	1	59.1	36	1
20	1913-10-19	1969-01-29	1969-02-15	1969-02-25	1	0	55.3	17	0

## Question 2

A large number of individuals were enrolled in a study and were followed for 30 years after enrollment to assess age at which the disease symptom first appeared. The symptom could only be identified by a clinical exam and clinical testing and was assessed at yearly at scheduled follow-up visits. For ten selected individuals described below,

- determine if the individual is censored or not.
- If censored, what type of censoring is it (left, right, interval)?
- Report the value of the “time” variable for each participant (i.e., the censoring time or the event time, as appropriate). Note that time is the age of the individual. For interval censored data, you will have two values of time to define the interval. Assume the patients were followed for the full 30 years unless you are told that they died or moved.

*a. The first individual, enrolled in the study at age 45, entered the study with the symptom already present. The individual is censored. It's left censored because the event happened before the observation. The censoring time is 45.*

*b. The next two healthy (without symptom present) individuals enrolled in the study at ages 30 and 42 and never showed the symptom.*

Censored and right censored because the event happened to the right of the end of the study are not known precisely. The first individual's censoring time is  $30+30 = 60$  and the second is  $42+30 = 72$ .

*c. The next healthy individual, enrolled in the study at age 35, exhibited the symptom at the second exam after enrollment (2 years after enrollment). The symptom may have appeared between exams.*

Censored and it's interval censored because the event happened between two observations.  $(35+1, 35+2] = (36,37]$ .

*d. The next healthy individual, enrolled in the study at age 40, exhibited the symptom at the fifth exam after enrollment (5 years after enrollment). The symptom may have appeared between exams.*

Censored and it's interval censored. The reason is the same as c.  $(40+4, 40+5) = (44, 45)$ .

*e. The next two healthy individuals, enrolled in the study at ages 50 and 47, died from causes unrelated to the disease (the symptom was absent) at ages 61 and 65, respectively.*

Right censored. This is because the situation doesn't fit the other censoring definition. The censoring time is 61 and 65.

*f. The last three individuals, enrolled in the study at ages 36, 42, and 50, moved away from the area at ages 40, 55, and 60, respectively, never having showed the symptom.*

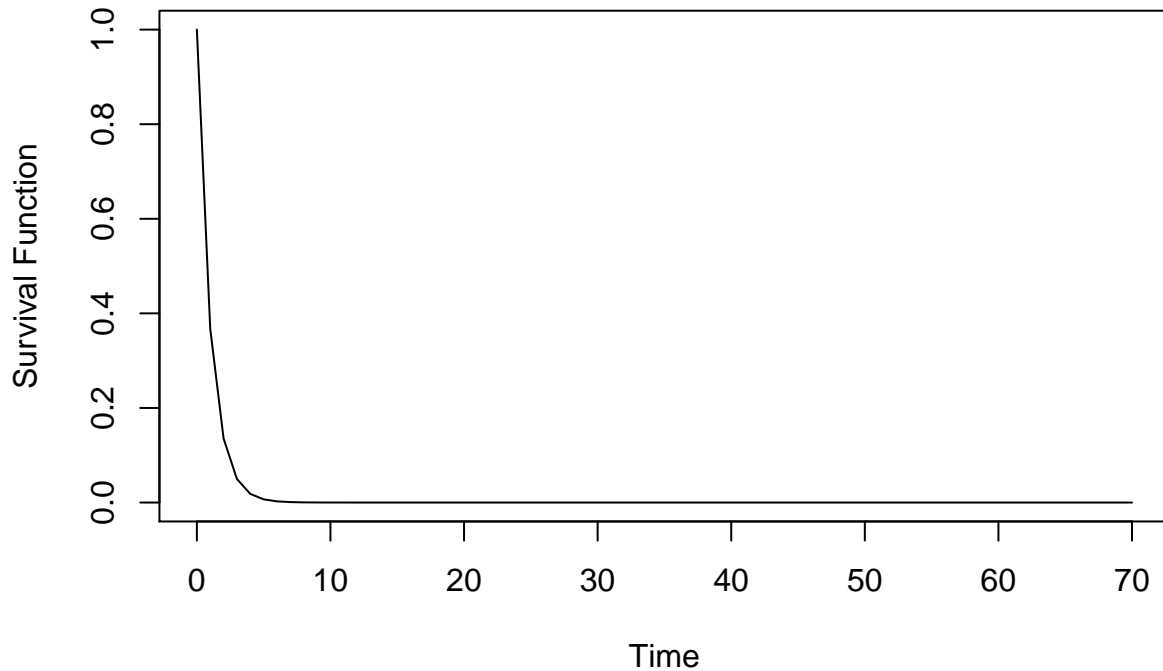
Right censored. Recall the similar example given in class. The censoring times are 40, 55, 60.

### Question 5

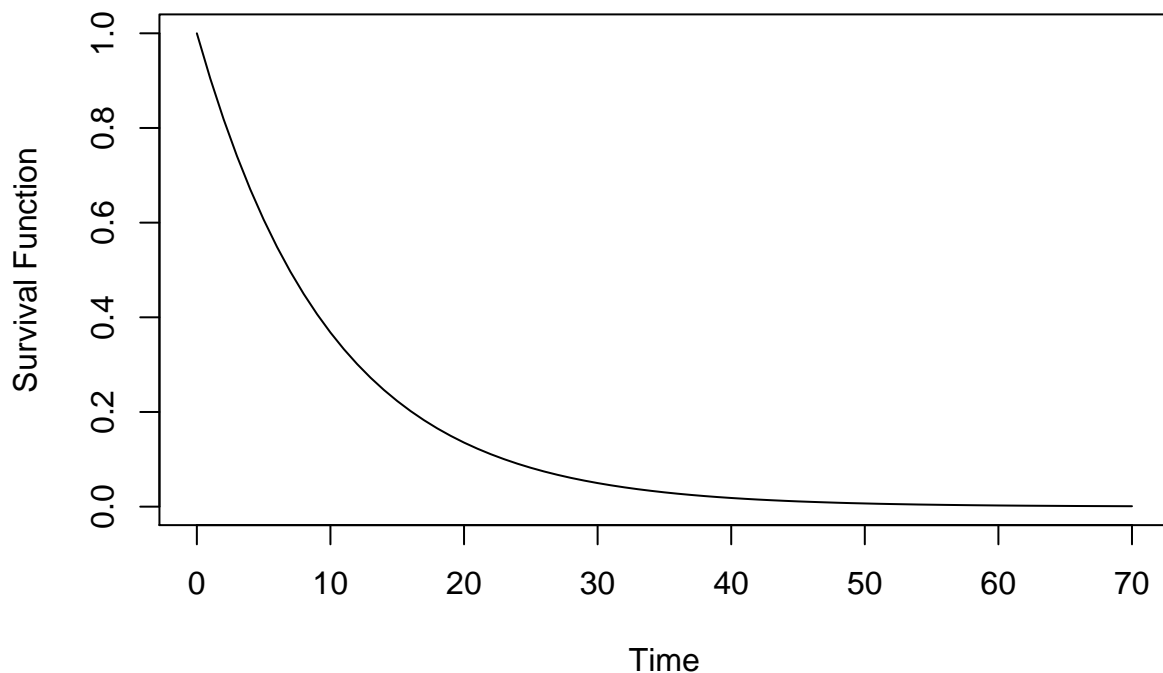
Plot the survival curves for the exponential model assuming  $\lambda = 1, 0.1, 0.01$  events/day over a range of time from 0 to 70 days.

The survival function under the exponential model is  $S(t) = \exp(-\lambda t)$ . We will plot 3 curves. They are  $S(t) = \exp(-t)$ ,  $S(t) = \exp(-0.1t)$  and  $S(t) = \exp(-0.01t)$ .

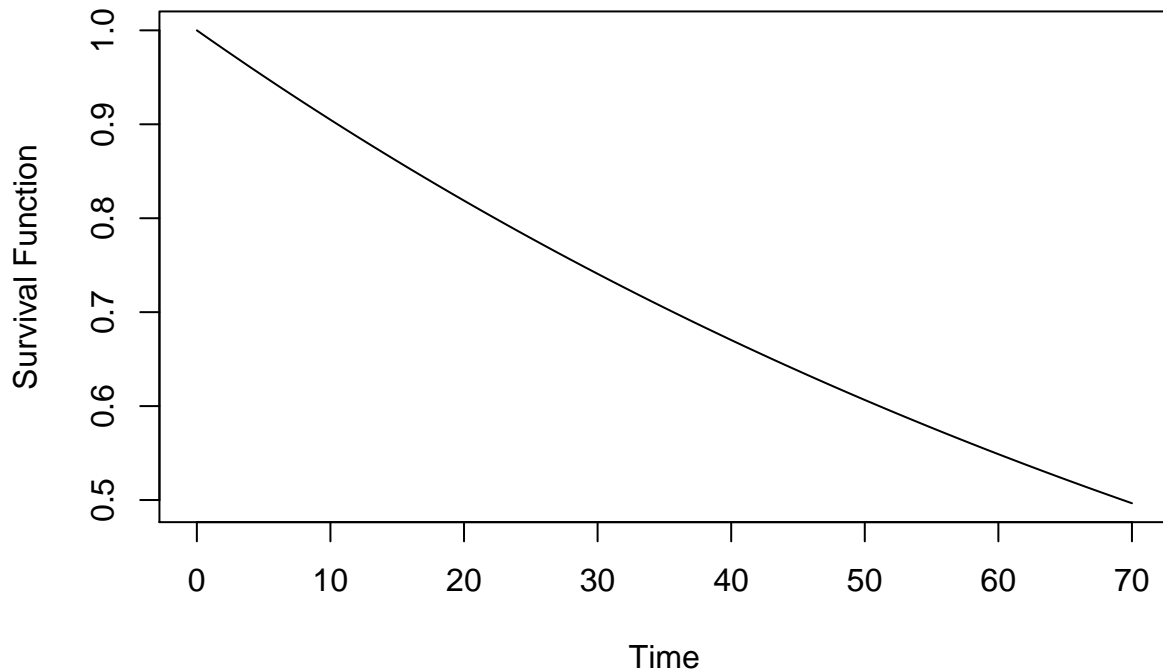
#### survival curves for the exponential model assuming lambda = 1



#### survival curves for the exponential model assuming lambda = 0.1



## survival curves for the exponential model assuming lambda = 0.01



*Does the relative positioning of the survival curves make sense given the hazard rates? Explain.*

Yes. We know that the survival function focuses on not failing, while the hazard rate focuses on failing. So the larger the hazard rate (the instantaneous rate of failure) is, the quicker the survival curve decaying. The smaller the hazard rate is, the slower the survival curve decaying (less failing and survive longer).

*Assuming the event of interest is death, which hazard corresponds to the better survival?*

The one with lambda 0.01 one is the better survival. It shows a steady decrease in survival probabilities throughout the time range.

*Report the median survival time for each model.*

for the model with lambda = 1,  $\exp(-t) = 0.5$  gives  $t = -\ln(0.5)$ .

for the model with lambda = 0.1,  $\exp(-0.1t) = 0.5$  gives  $t = \frac{-\ln(0.5)}{0.1}$

for the model with lambda = 0.01,  $\exp(-0.01t) = 0.5$  gives  $t = \frac{-\ln(0.5)}{0.01}$