



# Program L2 in-class

- **Censoring and truncation**
- **Likelihood for censored and truncated data**
- Online lecture follow-up
- Review questions
- Exercises



# Review question

What is censoring?

How is censored data taken into account in the likelihood function?



# Review question

What is truncation?

How is truncated data taken into account in the likelihood function?

How does truncation affect the analysis of time to event?



## Exercise 3.1

Describe, in detail, the types of censoring which are present in the following studies.

- a) The example dealing with remission duration in a clinical trial for acute leukemia described in section 1.2.



## 1.2 Remission duration from a clinical trial for acute leukemia

A clinical trial of a drug 6-mercaptopurine (6-MP) versus a placebo in 42 children with acute leukemia.

The trial was conducted at 11 American hospitals.

Patients were selected who had a complete or partial remission of their leukemia induced by treatment with the drug prednisone. (A complete or partial remission means that either most or all signs of disease had disappeared from the bone marrow).

Patients were followed until their leukemia returned (relapse) or until the end of the study (in months).

The patients entered the study at different time points, and the study ended at the same date for all patients.



## Exercise 3.3

An investigator, performing an animal study designed to evaluate the effects of vegetable and vegetable-fiber diets on mammary carcinogenesis risk, randomly assigned female Sprague-Dawley rats to five dietary groups

- 1: control diet
- 2: control diet plus vegetable mixture 1
- 3: control diet plus vegetable mixture 2
- 4: control diet plus vegetable-fiber mixture 1
- 5: control diet plus vegetable-fiber mixture 2



## Exercise 3.3

Mammary tumors were induced by a single oral dose of 7,12-dimethylbenz( $\alpha$ )anthracene (DMBA) (5 mg dissolved in 1.0 ml corn oil).

The dose was administered by intragastric intubation and the starting point for this study is when DMBA was given.

Starting 6 weeks after DMBA administration, each rat was examined once weekly for 14 weeks (post DMBA administration) and the time (in days) until onset of the first palpable tumor was recorded.



## Exercise 3.3

We wish to make inference about the marginal distribution of the time until a tumor is detected.

Describe, in detail, the types of censoring that are represented by the following rats.

First: any type(s) of censoring and/or truncation that applies to the whole study?



## Exercise 3.3

- a) A rat who had a palpable tumor at the first examination at 6 weeks after intubation with DMBA.
- b) A rat that survived the study without having any tumors.
- c) A rat which did not have a tumor at week 12 but which had a tumor at week 13 after intubation with DMBA.
- d) A rat which died (without tumor present and death was unrelated to the occurrence of cancer) at day 37 after intubation with DMBA.
- e) Confining our attention to the four rats described above, write down the likelihood for this portion of the study.



## Exercise 3.2

A large number of disease-free individuals were enrolled in a study beginning January 1, 1970, and were followed for 30 years to assess the age at which they developed breast cancer.

Individuals had clinical exams every 3 years after enrollment.

For four selected individuals described below, discuss the types of censoring that are represented.

First: any type(s) of censoring and/or truncation that applies to the whole study?



## Exercise 3.2

- a) A healthy individual, enrolled in the study at age 30, never developed breast cancer during the study.
- b) A healthy individual, enrolled in the study at age 40, was diagnosed with breast cancer at the fifth exam after enrollment (i.e., the disease started sometime between 12 and 15 years after enrollment).
- c) A healthy individual, enrolled in the study at age 50, died from a cause unrelated to the disease (i.e., not diagnosed with breast cancer at any time during the study) at age 61.



## Exercise 3.2

- d) An individual, enrolled in the study at age 42, moved away from the community at age 55 and was never diagnosed with breast cancer during the period of observation.
- e) Confining your attention to the four individuals described above, write down the likelihood for this portion of the study.



## Exercise 3.4

In section 1.2, a clinical trial for acute leukemia is discussed. In this trial, the event of interest is the time from treatment to leukemia relapse.

Using the data for the 6-MP group and assuming that the time to relapse distribution is exponential with hazard rate  $\lambda$ , construct the likelihood function.

Using the likelihood function, find the maximum likelihood estimator of which  $\lambda$  maximizes this likelihood.



<i>Pair</i>	<i>Remission Status at Randomization</i>	<i>Time to Relapse for Placebo Patients</i>	<i>Time to Relapse for 6-MP Patients</i>
1	Partial Remission	1	10
2	Complete Remission	22	7
3	Complete Remission	3	32 <sup>+</sup>
4	Complete Remission	12	23
5	Complete Remission	8	22
6	Partial Remission	17	6
7	Complete Remission	2	16
8	Complete Remission	11	34 <sup>+</sup>
9	Complete Remission	8	32 <sup>+</sup>
10	Complete Remission	12	25 <sup>+</sup>
11	Complete Remission	2	11 <sup>+</sup>
12	Partial Remission	5	20 <sup>+</sup>
13	Complete Remission	4	19 <sup>+</sup>
14	Complete Remission	15	6
15	Complete Remission	8	17 <sup>+</sup>
16	Partial Remission	23	35 <sup>+</sup>
17	Partial Remission	5	6
18	Complete Remission	11	13
19	Complete Remission	4	9 <sup>+</sup>
20	Complete Remission	1	6 <sup>+</sup>
21	Complete Remission	8	10 <sup>+</sup>

<sup>+</sup> Censored observation



# Home assignments

Work in groups of 2-3 persons. Choose groups at Studium today.

Find your own data for home assignments 1+2!  
Data description to be handed in on Tuesday.

More information at Studium.