Syllabus

Overview

This course surveys modern statistical methods for analyzing **censored** time-to-event data arising in clinical, epidemiological, sociological, and engineering studies. We emphasize intuitive explanations of statistical theory, such as counting-process martingales, to address real-world problems and develop practical problem-solving skills. The course combines methodological exposition with extensive case studies, primarily drawn from the health sciences. Sample R and SAS code will be provided throughout.

The primary focus is on the **application** of statistical methods to data analysis and study design, with careful attention to interpretation and assumptions.

Course Structure

The course consists of three parts. The first part covers methods for univariate event times, including the Kaplan–Meier estimator, log-rank tests, and the Cox proportional hazards model. The second part extends these ideas to more complex outcomes, such as recurrent events, multivariate events, (semi-)competing risks, joint modeling of survival and longitudinal data, multistate processes, and composite endpoints. The third part introduces selected modern topics, including causal inference and machine learning for censored data.

Learning Outcomes

By the end of the course, students will be able to

- Understand the defining features of censored data and their implications for statistical inference
- Select appropriate nonparametric and semiparametric methods for different types of time-to-event data
- Evaluate and assess modeling assumptions for estimation and inference
- Apply statistical procedures to real-world problems using R (or SAS)

- Clearly interpret and communicate analytical results in response to substantive scientific questions

Prerequisites

Students should have foundational knowledge of random variables, expectation, variance, and maximum likelihood estimation, as well as introductory coursework in hypothesis testing (e.g., *t*-tests and ANOVA) and (generalized) linear regression models. Prior experience with R or SAS is helpful but not required.

Time and Location

MW 2:35–3:45pm; Health Sciences Learning Center (HSLC) – Room 2158

Instructors

Main Instructor

Lu Mao, PhD
https://lmaowisc.github.io
WARF 207A, 610 Walnut St
Madison, WI 53726
Email lmao@biostat.wisc.edu
Phone 608-263-5674
Office hours T&Th 3–4pm, or by appointment
Zoom link provided on Canvas

Teaching Assistant

Heeyeong Jung
Email hjung96@wisc.edu
Office hours TBD, or by appointment
Zoom link provided on Canvas

Readings

- **Required**
  Applied Survival Analysis: From Univariate to Complex Time-to-Event Outcomes (posted on Canvas by chapter)

- *Methodological focus*
  Kalbfleisch JD, Prentice RL (2002). *The Statistical Analysis of Failure Time Data*, 2nd ed. John Wiley & Sons
- *Applied focus*
  Klein JP, Moeschberger ML (2003). *Survival Analysis: Techniques for Censored and Truncated Data*, 2nd ed. Springer
- *Theoretical depth* Fleming TR, Harrington DP (1991). *Counting Processes and Survival Analysis*. John Wiley & Sons

Course Schedule

Kickoff

Date	Topic	Notes
1/21	Lecture	Overview
	Reading	Syllabus

Part I: Univariate Events

Date	Topic	Notes
1/26	Introduction	Chapter 1
1/28	Mathematical Foundations	Chapter 2
2/2	Nonparametric Estimation of the Survival Curve	Chapter 3
2/4	Comparing Survival Rates Between Groups	Chapter 3
2/9	Cox Proportional Hazards Model – Assumptions and Inference	Chapter 4
2/11	Cox Proportional Hazards Model – Residual Analysis	Chapter 4
2/16	Cox Proportional Hazards Model – Time-Varying Covariates	Chapter 4
2/18	Other Non- and Semi-parametric Methods	Chapter 5
2/23	Study Design and Sample Size Calculation	Chapter 6
2/25	Left Truncation	Chapter 7
3/2	Interval Censoring	Chapter 7

Part II: Complex Outcomes

Date	Topic	Notes
3/4	Multivariate Events – Conditional (Frailty) Models	Chapter 8
3/9	Multivariate Event Times – Marginal Models	Chapter 8
3/11	Recurrent Events	Chapter 9
3/16	Competing and Semi-competing Risks	Chapter 10
3/18	Joint Analysis of Longitudinal and Survival Data	Chapter 11
3/23	Multistate Models – Introduction	Chapter 12
3/25	Multistate Models – Cox-Type Markov and Semi-Markov Models	Chapter 12
4/6	Composite Endpoints – Nonparametric Estimation	Chapter 13
4/8	Composite Endpoints – Semiparametric Regression	Chapter 13

Part III: Special Topics

Date	Topic	Notes
4/13	Causal Inference with Censored Data – IPTW and Standardization	Chapter 14
4/15	Causal Inference with Censored Data – Marginal Structural Models	Chapter 14
4/20	Machine Learning with Censored Data – Regularized Cox Models	Chapter 15
4/22	Machine Learning with Censored Data – Tree-based methods	Chapter 15
4/27	Guest lecture	
4/29	Course recap	

Homework and Exams

- Homework assigned on a biweekly basis
- In-class quizzes
- Final data analysis project

Grading

- **30%** Attendance and in-class quizzes
- **30%** Homework
- **20%** Midterm

- **20%** Final project