COURSE OUTLINE: MH4513

Course Title	**Survival Analysis**		
Course Code	**MH4513**		
Offered	Study Year 4, Semester 1		
Course Coordinator	Xiang Liming (Assoc Prof)	lmxiang@ntu.edu.sg	6513 7451
Pre-requisites	MH2500 and MH3500 and MH3510		
AU	4		
Contact hours	Lectures: 39, Tutorials: 12		
Approved for delivery from	AY 2021/22 semester 1		
Last revised	24 Nov 2020, 10:19		

Course Aims

The course will introduce statistical methods used to analysis time-to-event data. Time-to-event or failure time data, and associated covariate data can be collected under a variety of sampling schemes and very commonly involves right censoring. The distribution of a time-to-event variable is often characterized in terms of its survival or hazard function. The course will cover fundamentals in survival analysis, with emphasis on statistical principal, methods and real life applications. The course will also motivate students to work closely with data and make inference nonparametrically and/or parametrically in the fields of study.

Intended Learning Outcomes

Upon successfully completing this course, you should be able to:

1. Carry out exploratory non-parametric analysis of survival data
2. Conduct more sophisticated analyses on survival data using parametric techniques and be aware of the variety of the statistical models and methods now available
3. Use common parametric distributions to model survival data, Construct parameter estimators using the maximum likelihood method subject to different types of censoring, and check the goodness-of-fit of the models
4. Explore and analyze survival data using R
5. Interpret the results of analyses

Course Content

Examples and functions of survival time: survival, hazard, cumulative hazard functions and their inter-relationships

Censoring: Right censoring, Left-censoring, Interval-censoring

Nonparametric Methods - One sample estimation (Estimating Survival Functions), product-limit (K-M) estimator and its properties, and life tables

Nonparametric Methods - Comparing survival distributions, two-sample testing and comparison of more than two samples

Some Parametric Survival Distributions such as the Exponential, Weibull, Log-normal, Gamma distributions.

Maximum likelihood estimation

Graphical Methods for Survival Distribution Fitting

Tests of Goodness of Fit - asymptotic likelihood inference, appropriateness of a family of distributions, AIC and BIC procedures

Identifying Prognostic Factors: Parametric Regression Models (AFT) - accelerate failure time model and asymptotic likelihood inference

Some popular AFT models - Exponential, Weibull, Lognormal, and Log-logistic regression models

Goodness-of-fit using likelihood ratio test

How to identify prognostic factors related to survival time: Cox Proportional Hazards Model, assumptions of the model, testing and estimation, and computing problems and interpreting results

Assessment

Component	Course ILOs tested	SPMS-MAS Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Lectures					
Group Project	1, 2, 3, 4, 5	**1.** a, b, c **2.** b **3.** a	20	team	See Appendix for rubric
Tutorials					
Assignment	1, 2, 3, 4, 5	**1.** a, b, c **2.** b **3.** a	5	individual	See Appendix for rubric
Mid-semester Quiz					
Midterm Examination	1, 2, 3, 4, 5	**1.** a, b, c **2.** b, d **3.** a	25	individual	See Appendix for rubric
Examination (2 hours)					
Final Examination	1, 2, 3, 4, 5	**1.** a, b, c **2.** b, d **3.** a	50	individual	See Appendix for rubric
		Total	**100%**		

These are the relevant SPMS-MAS Graduate Attributes.

1. **Competence**
   a. Independently process and interpret mathematical theories and methodologies, and apply them to solve problems
   b. Formulate mathematical statements precisely using rigorous mathematical language
   c. Discover patterns by abstraction from examples
2. **Creativity**
   b. Build on the connection between subfields of mathematics to tackle new problems
   d. Critically analyse data from a multitude of sources
3. **Communication**
   a. Present mathematics ideas logically and coherently at the appropriate level for the intended audience

Formative Feedback

Midterm test: Feedback on common mistakes and the level of difficulty of the problems is given.

Assignments: Students will receive individual feedback on their performance in the test, exercises during the tutorial sessions

Group project: Feedbacks on performance in the group project will also be given to each group of students.

Learning and Teaching Approach

Lectures (39 hours)	Present the key ideas behind mathematical concepts. Present important steps used to solve different types of problems.
Tutorials (12 hours)	This will help to develop problem solving and computing skills, and reinforce the understanding of the concepts and notions.

Reading and References

Lee, E., Statistical Methods for Survival Data Analysis, 3rd edition, ISBN: 9780471369974, John Wiley & Sons, 2003.

Collett D., Modelling Survival Data in Medical Research, ISBN: 9781439856789, Chapman&Hall, 1994.

Hosmer D W, Lemeshow S and May S. Applied survival analysis: Regression modeling of time-to-event data, ISBN: 9780471754992, Wiley-Interscience, 2008.

Kalbfleisch J. D. and Prentice R. L., The Statistical Analysis of Failure Time Data, 2nd Ed., ISBN: 9780471363576, Wiley, 2002.

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

If you are sick and not able to attend a quiz or midterm, you have to submit the original Medical Certificate (or another relevant document) to the administration to obtain official leave. In this case, the missed assessment component will not be counted towards the final grade. There are no make-up quiz or make-up midterm.

Academic Integrity & Collaboration Policy

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.
Collaboration is encouraged for your homework because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. As part of academic integrity, crediting others for their contribution to your work promotes ethical practice.
You must write up your solutions by yourself and understand anything that you hand in.
If you do collaborate, you must write on your solution sheet the names of the students you worked with. If you did not collaborate with anyone, please explicitly write, "No collaborators." Failure to do so constitutes plagiarism.

Use of materials outside the course is strongly discouraged. If you use outside source, you must reference it in your solution.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the Academic Integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Xiang Liming (Assoc Prof)	SPMS MAS04-11	6513 7451	lmxiang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Introduction to distribution functions of survival time and their inter-relationships, types of censoring	1, 2, 3, 4, 5	Lecture notes
2	Introduction to distribution functions of survival time and their inter-relationships, types of censoring	1, 2, 3, 4, 5	Lecture notes
3	Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison	1, 2, 3, 4, 5	Lecture notes
4	Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison	1, 2, 3, 4, 5	Lecture notes
5	Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison	1, 2, 3, 4, 5	Lecture notes
6	Parametric distributions, Maximum likelihood estimation and graphic methods	1, 2, 3, 4, 5	Lecture notes
7	Parametric distributions, Maximum likelihood estimation and graphic methods	1, 2, 3, 4, 5	Lecture notes
8	Tests of Goodness of Fit: Asymptotic likelihood inference, families of distributions, AIC an BIC	1, 2, 3, 4, 5	Lecture notes
9	Tests of Goodness of Fit: Asymptotic likelihood inference, families of distributions, AIC an BIC	1, 2, 3, 4, 5	Lecture notes
10	Parametric Regression Models (AFT):population AFT models, asymptotic inference, goodness-of-fit	1, 2, 3, 4, 5	Lecture notes
11	Parametric Regression Models (AFT):population AFT models, asymptotic inference, goodness-of-fit	1, 2, 3, 4, 5	Lecture notes
12	Cox PH model: Assumptions of the model, Testing and estimation, Computing problems and interpreting results	1, 2, 3, 4, 5	Lecture notes
13	Cox PH model: Assumptions of the model, Testing and estimation, Computing problems and interpreting results	1, 2, 3, 4, 5	Lecture notes

Appendix 1: Assessment Rubrics

Rubric for Lectures: Group Project (20%)

MH4513 Rubric for Tutorials: Group Project (20%)

Grading Criteria	Exceptional	Effective	Acceptable	Developing
Accuracy	Data exploration: the data are properly visualized and summarized in a way that helps to get meaningful insights of the data. The interpretation is highly accurate, concise and precise.	There are preliminary data summary and visualizations but not completely perfect. The interpretation is mostly accurate. Some parts can be better explained or more succinct.	There are incomplete data exploration, either the summary or the visualization is missing. The interpretation is somewhat accurate. However, it contains some inaccuracies, missing points or ideas that are not related to the interpretation.	There is an improper data exploration. It does not help the reader to understand the data at all. The interpretation are mostly inaccurate.
Thoroughness	There is a comprehensive explanation of the problem background (literature review). The problem is either particularly challenging or particularly important for society ≥3 analysis methods have been chosen with reasons for the choice and comparison between results from different methods. Limitation has been well addressed.	There is a comprehensive explanation of the problem background (literature review). It can improve in terms of the selection of the works relating to the topic. ≥3 analysis methods have been chosen with either incomplete reasons for the choice or improper comparison between results from different methods.	The students made a minimal effort to research the problem's background. The literature review was adequate. ≥3 analysis methods have been chosen with serious improper use of methods or consistencies in results from methods chosen or without addressing the comparison between results from different methods.	The problem was chosen randomly without a thorough literature review. It is based on a single source of information and/or inaccurate or unreliable secondary sources. Fewer methods or models than required are used, or method are applied wrongly
Presentation	Very clear and organized. It is easy to follow your train of thought	Mostly clear and organized. Some parts can have better transitions.	Somewhat clear. It requires some careful reading to understand what you are writing.	Mostly unclear and messy. It is difficult to understand what you are writing as there is no clear flow of ideas.
Originality	Evidence of extensive synthesis of ideas from different perspectives such that there is a very convincing original interpretation and that goes beyond what is already discussed in literature.	Evidence of some synthesis of ideas which lead to an original interpretation. The interpretation is good original summary of what is discussed in literature.	Evidence of an attempt to synthesis ideas. However, the attempt contains some misunderstandings.	No synthesis of ideas or originality. It is a repetition of what people have said or a laundry list of ideas with little interpretation.

Please Note: In principle, students in the same group share the same group marks. However, there can be some individual variation within a group, depending on the evaluation of the tutor and the feedback from the peers. Students may be awarded more marks for showing exemplary contribution to other team members' learning that goes beyond what is required, whereas students who have not contributed sufficiently may receive lower marks than the rest of the team members.

Rubric for Tutorials: Assignment (5%)
Point-based marking (not rubrics-based)

Rubric for Mid-semester Quiz: Midterm Examination (25%)
Point-based marking (not rubrics-based)

Rubric for Examination: Final Examination (50%)
Point-based marking (not rubrics-based)