# Annexe A: New/Revised Course Content in OBTL+ Format

## Course Overview

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| Expected Implementation in Academic Year (New format) | AY2026-2027 |
| Semester/Trimester/Others (specify approx. Start/End date) | Semester 1 |
| Course Author<br>* Faculty proposing/revising the course | Xiang Liming |
| Course Author Email | lmxiang@ntu.edu.sg |
| Course Title | Survival Analysis |
| Course Code | MH4513 |
| Academic Units | 4 |
| Contact Hours | 51 |
| Research Experience Components | Not Applicable |

## Course Requisites (if applicable)

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| Pre-requisites | MH3500 and MH3510, or MH2510 and MH3510 |
| Co-requisites | |
| Pre-requisite to | |
| Mutually exclusive to | |
| Replacement course to | |
| Remarks (if any) | |

## 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 you to work closely with data and make inference nonparametrically and/or parametrically in the fields of study.

## Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

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| ILO 1 | Carry out exploratory non-parametric analysis of survival data |
| ILO 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 |
| ILO 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 |
| ILO 4 | Explore and analyze survival data using R |
| ILO 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.
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

## Reading and References (if applicable)


1. Lee E. and Wang W. (2013). Statistical Methods for Survival Data Analysis, 4th edition. John Wiley & Sons.
2. Collett, D. (2023). Modelling Survival Data in Medical Research. Chapman and Hall/CRC.
3. Kleinbaum, D.G. and Klein, M. (2011). Survival Analysis: A Self-Learning Text, 3rd edition. Springer-Verlag New York Inc.


NOTE: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they are available

## Planned Schedule

| Week or Session | Topics or Themes | ILO | Delivery Mode | Activities | Readings |
|---|---|---|---|---|---|
| 1 | Introduction to distribution functions of survival time and their inter-relationships, types of censoring | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 2 | Introduction to distribution functions of survival time and their inter-relationships, types of censoring | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 3 | Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 4 | Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |

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|---|---|---|---|---|---|
| 5 | Nonparametric Methods: K-M estimator, lifetime table and Log-rank tests for comparison | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 6 | Parametric distributions, Maximum likelihood estimation and graphic methods | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 7 | Parametric distributions, Maximum likelihood estimation and graphic methods | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 8 | Tests of Goodness of Fit: Asymptotic likelihood inference, families of distributions, AIC an BIC | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |

| Week or Session | Topics or Themes | ILO | Delivery Mode | Activities | Readings |
|---|---|---|---|---|---|
| 9 | Tests of Goodness of Fit: Asymptotic likelihood inference, families of distributions, AIC an BIC | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 10 | Parametric Regression Models (AFT ):population AFT models, asymptotic inference, goodness-of-fit | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 11 | Parametric Regression Models (AFT ):population AFT models, asymptotic inference, goodness-of-fit | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |
| 12 | Cox PH model: Assumptions of the model, Testing and estimation, Computing problems and interpreting results | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |

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|---|---|---|---|---|---|
| 13 | Cox PH model: Assumptions of the model, Testing and estimation, Computing problems and interpreting results | 1, 2, 3, 4, 5 | In-person | Lectures will consist of concept explanations, worked examples, class discussions, problem-solving exercises, and short quizzes to reinforce learning. | Lecture notes |

## Learning and Teaching Approach

| Approach | How does this approach support you in achieving the learning outcomes? |
|---|---|
| Lectures | Present the key ideas behind mathematical concepts. Present important steps used to solve different types of problems. |
| Tutorials | This will help to develop problem solving and computing skills, and reinforce the understanding of the concepts and notions. |

## Assessment Structure

Assessment Components (includes both continuous and summative assessment)

| No. | Component | ILO | Related PLO or Accreditation | Weightage | Description of Assessment Component | Team/Individual | Rubrics | Level of Understanding |
|---|---|---|---|---|---|---|---|---|
| 1 | Continuous Assessment (CA): Project(Group project) | 1, 2, 3, 4, 5 | 1.a,b,c, 2.b, 3.a | 20 | Students will collaborate in groups to analyze a real dataset using statistical techniques covered in the course. Each group will submit a report presenting the methodology, results, and conclusions, demonstrating their ability to apply statistical concepts to practical problems in survival analysis. | Team | Analytic | Relational |

| No. | Component | ILO | Related PLO or Accreditation | Weightage | Description of Assessment Component | Team/Individual | Rubrics | Level of Understanding |
|---|---|---|---|---|---|---|---|---|
| 2 | Continuous Assessment (CA): Assignment(Tutorial - Assignment) | 1, 2, 3, 4, 5 | 1.a,b,c, 2.b, 3.a | 5 | Students will complete individual assignments involving statistical concepts, methods, and data analysis in survival data settings. The assignments are designed to assess understanding of course material, problem-solving skills, and the ability to interpret and communicate statistical results. | Individual | Analytic | Relational |
| 3 | Continuous Assessment (CA): Test/Quiz(Mid-semester Quiz - Midterm Examination) | 1, 2, 3, 4, 5 | 1.a,b,c, 2.b,d, 3.a | 25 | An individual restricted open-book assessment designed to evaluate students' understanding of the concepts, methods, and techniques covered in the first part of the course. | Individual | Analytic | Relational |

| No. | Component | ILO | Related PLO or Accreditation | Weightage | Description of Assessment Component | Team/Individual | Rubrics | Level of Understanding |
|---|---|---|---|---|---|---|---|---|
| 4 | Summative Assessment (EXAM): Final exam(Final Examination) | 1, 2, 3, 4, 5 | 1.a,b,c, 2.b,d, 3. a | 50 | A comprehensive written examination assessing students' understanding of the concepts, methods, and techniques for the analysis of survival data covered in the course, as well as their ability to apply these methods to solve real data problems and interpret results. | Individual | Analytic | Relational |

Description of Assessment Components (if applicable)

Formative Feedback

Midterm test: Feedback on common mistakes and the level of difficulty of the problems is given.
Assignments: You will receive individual feedback on your performance in the test, exercises during the tutorial sessions
Group project: Feedback on performance in the group project will also be given to each group.

## NTU Critical Core Skills+ Mapping

This course intends to develop the following Critical Core Skills+ (maximum 5 most relevant)

| Critical Core Skills+ | Level |
|---|---|
| Problem Solving | Intermediate |
| Decision Making | Intermediate |
| Collaboration | Basic |

# Course Policy

Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

Nil

Policy (Absenteeism)

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. In general, there is no make-up for absentees in the midterm test. However, offering a make-up test to students absent with valid reasons. Midterm make-up test is generally not provided. However, exceptions may be considered for absentees who miss the test with valid reasons.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

## Technical Skills To Be Developed

### All skills to be developed for this course:

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| Analysis of Research Data |
| Analytical Method Validation |
| Analytics and Computational Modelling |

**Appendix 1: Assessment Rubrics**

**Rubric for Lectures: Group Project (20%)**

**MH4513 Rubric for Tutorials: Group Project (20%)**

**Rubric for Group Project: Instructor Evaluation (15%)**

| 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 is 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 | 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 | 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 | 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 |

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| | between results from different methods. Limitation has been well addressed. | comparison between results from different methods | from different methods. | 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 discuss | 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 synthesize 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 Group Project: Peer Evaluation (5%)**

| Grading Criteria | Exceptional | Effective | Acceptable | Developing |
|---|---|---|---|---|
| Data Handling & Coding | Expertly handled censoring; wrote flawless R code for methods, e.g., log-rank | Successfully set up the survival data layout; executed models with | Completed basic programming tasks but required help. | Contributed very little usable code, survival data structure or model syntax |

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| | tests, or Cox models. | minimal guidance. | | had to be fixed by teammates. |
| Model Selection & Assumptions | Thoroughly evaluated and resolved survival models assumptions | Correctly checked standard model assumptions | Understood the need for diagnostics but struggled to address assumption violations. | Ignored or incorrectly evaluated models or draw incorrect conclusions. |
| Survival Interpretation & Translation | Flawlessly translated important concepts (hazard ratios & survival curves) into practical insights. | Accurately interpreted survival curves and model coefficients for research questions. | Understands general findings but struggled to clearly explain the concepts of hazard. | Provided weak or incorrect interpretations; confused odds ratios with hazard ratios or misread curves. |
| Collaboration & Reliability | Always met internal deadlines; communicated proactively; actively supported teammates on difficult theoretical concepts. | Highly reliable; completed all assigned tasks on time and attended all scheduled group meetings. | Generally reliable but occasionally missed deadlines or required communication reminders. | Frequently late with work; rarely participated in discussions or missed team meetings without a valid reason. |

**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)