UNSW Course Outline

ACTL5104 Survival Analysis and Prediction of Life and Health Related Risks - 2024

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General Course Information

Course Code : ACTL5104
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : UNSW Business School
Academic Unit : School of Risk and Actuarial Studies
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

This course covers the actuarial profession syllabus for survival models– with a focus on the

understanding and prediction of mortality, morbidity, and longevity risks and on applications of the techniques to areas such as life, health, disability insurance, superannuation, finance, and epidemiology. Such models can be used to understand and forecast risks relating to contingent events (eg mortality, health status changes, credit defaults) - leading to more accurate quantification, pricing, and management of these risks. Topics covered include: survival models and actuarial notation; estimation of lifetime distributions; maximum likelihood estimation of transition intensities in multiple state models and intensities dependent on age and duration; graduation of crude estimates and tests of fidelity and smoothness; and models for the projection of mortality trends. The course will emphasize the implementation of the concepts using numerical computer packages. Issues around ethics and discrimination will also be considered.

Course Aims

The primary aim of this course is for students to acquire the ability to develop appropriate insurance, credit risk and demographic statistical assumptions for use in life, general and health insurance, superannuation and banking applications. These assumptions are used in the determination of premium rates and reserves for life and general insurance as taught in ACTL3002/5105 Life Insurance and Superannuation Models and in ACTL3003/5106 Insurance Risk Models respectively. A thorough understanding of the assumptions is also necessary for the application of the models taught in parts II and III of the professional examinations.

Students will learn how to determine appropriate transition and survival rates from raw data; select appropriate models and calibrate as necessary. They will gain some appreciation of applications in medical research. Students will develop a detailed Excel workbook during the course to enable them to produce graduated tables from raw data, and to comment on their suitability for various purposes.

Relationship to Other Courses

At the end of the course students should be able to:

- Assess the properties of a model involving survival or transition intensities and apply to real-life data for insurance and finance applications.
- Use actuarial statistics techniques to assess probability models and data.
- Understand and discuss ethical issues and implications of the modelling introduced in the course.

This course covers the development and application of statistical techniques to practical

actuarial problems. Examples will be drawn from the insurance and financial markets as well as from the ongoing COVID-19 pandemic. Students are assumed to have a good knowledge of ACTL5101, ACTL5103.and ACTL5110

Particularly important is the material on statistical estimation and regression techniques covered in ACTL5110 . If your knowledge on this topic area requires revision it is important that you revise this material as soon as possible. The assumed knowledge of the course includes a good understanding of mathematics in calculus and linear algebra.

Course Learning Outcomes

Course Learning Outcomes	Program learning outcomes
CLO1 : Explain the concept of survival models	• PLO1 : Business Knowledge • PLO3 : Business Communication
CLO2 : Describe estimation procedures for lifetime distributions	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO3 : Describe statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO4 : Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO5 : Describe the Binomial model of mortality, derive a maximum likelihood estimator for the probability of death and compare the Binomial model with the multiple state models	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO6 : Describe how to estimate transition intensities depending on age, exactly or using the census approximation	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO7 : Describe how to test crude estimates for consistency with a standard table or a set of graduated estimates, and describe the process of graduation	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO8 : Describe the principal forms of mortality and morbidity heterogeneity in a population and the main forms of selection	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO9 : Describe the main methods of projecting/forecasting mortality rates	• PLO1 : Business Knowledge • PLO2 : Problem Solving
CLO10 : Understand and discuss the ethical dimensions and implications of the modelling introduced in the course	• PLO5 : Responsible Business Practice • PLO6 : Global and Cultural Competence

Course Learning Outcomes	Assessment Item
CLO1 : Explain the concept of survival models	• Assignment • Final Examination
CLO2 : Describe estimation procedures for lifetime distributions	• Assignment • Final Examination
CLO3 : Describe statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities	• Assignment • Final Examination
CLO4 : Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities	• Assignment • Final Examination
CLO5 : Describe the Binomial model of mortality, derive a maximum likelihood estimator for the probability of death and compare the Binomial model with the multiple state models	• Assignment • Final Examination
CLO6 : Describe how to estimate transition intensities depending on age, exactly or using the census approximation	• Assignment • Final Examination
CLO7 : Describe how to test crude estimates for consistency with a standard table or a set of graduated estimates, and describe the process of graduation	• Assignment • Final Examination
CLO8 : Describe the principal forms of mortality and morbidity heterogeneity in a population and the main forms of selection	• Assignment • Final Examination
CLO9 : Describe the main methods of projecting/ forecasting mortality rates	• Assignment • Final Examination
CLO10 : Understand and discuss the ethical dimensions and implications of the modelling introduced in the course	• Weekly formative activities • Final Examination

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360 | EdStem

Learning and Teaching in this course

The approach adopted in this course is one of assisted self-study. This approach is called flipped and blended classroom and differs from the traditional lecture. While reading this subsection, please refer to the detailed curse scheduled that will be posted on Moodle during the first week

of the session.

The main rationale for this flipped and blended structure is twofold. First, it frees up class time which can now be used to do inclass exercises and learning-by doing activities, which aim at enhancing students long-lasting (deep) learning. Second, it brings a significant portion of the synchronous time later in the learning process, when students are more comfortable with the materials, and more likely to interact and ask questions.

In this flipped and blended approach, the first conceptual encounter with the materials of a given module happens in class through a learn-by-doing activity to spark the students interest in the topic and to provide a context for the subsequent video lectures. The second conceptual encounter with the materials happens at home when students watch video lectures. These video lectures are accompanied by online quizzes and discussion forums which provide the students with an immediate opportunity for getting feedback and asking questions on their understanding of the material. Consultation is also available. Then, everyone gathers in the online lecture room for a lectorial. The word combines lecturesbecause they are run by the lecturer, and with the whole group, and tutorialbecause their goal is not to lecture students. By contrast, in this lectorial, the lecturer first provides a high level summary of the key concepts of the module and then moves on to other activities (such as discussions, advanced exercises, guest lectures, real life applications) that aim to cement students learning. Finally, the students move on to practicing their knowledge with tutorial exercises and computer exercises in R. Tutorial sessions aim to provide some additional face-to-face or online and personalised help.

Course materials are organised in 9 modules

1. Survival Models and The Life Table
2. Non-parametric models: Kaplan-Meier, Nelson-Aalen and the comparison of survival functions
3. Semi-parametric models: The Cox regression model
4. Binomial and Poisson Models
5. Exposed to risk
6. Graduation methods
7. Ethics and mortality heterogeneity
8. Mortality projection models
9. Markov models

This course consists of:

- Self-study video recordings available on the course Moodle website and organised in 9 modules;

- 1 hour consultation every week (2 to 10);
- 1.5 hour tutorial every week (1 to 10, except week 6); and
- 2 hour lectorials every week (1 to 10, except weeks 6 and 8).

Students are responsible to learn topics with the following materials:

- Prescribed books (and recommended books for additional support)
- Topic video lectures available on the course website
- Tutorial exercises with solutions
- Self-study R tutorials
- Past quizzes and exams for advanced exercises

It is expected the students will take a pro-active approach to learning. On average, students have one week to cover the contents of a given module. It is recommended to have read all prescribed readings, watched the associated videos, attempted the tutorial exercises and gone through the self-study R tutorials prior to the associated modules lectorial.

It is expected that you will spend at least ten hours per week studying this course. In periods where you need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment (to extra-curricular activities) has been a cause of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities. In the past, students have found the amount of contents particularly challenging. Dont allow yourself to fall behind the schedule!

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates	Program learning outcomes
Weekly formative activities Assessment Format: Individual	10%	Due Date: Not Applicable	• PLO1 : Business Knowledge • PLO3 : Business Communication • PLO5 : Responsible Business Practice • PLO6 : Global and Cultural Competence
Assignment Assessment Format: Individual	30%	Start Date: Not Applicable Due Date: Not Applicable	• PLO1 : Business Knowledge • PLO2 : Problem Solving • PLO3 : Business Communication • PLO5 : Responsible Business Practice • PLO6 : Global and Cultural Competence
Final Examination Assessment Format: Individual	60%	Due Date: Not Applicable	• PLO1 : Business Knowledge • PLO2 : Problem Solving • PLO5 : Responsible Business Practice • PLO6 : Global and Cultural Competence

Assessment Details

Weekly formative activities

Assessment Overview

The course offers discussions to practice the concepts you have learned each week. The discussions will reinforce your learning and help you identify the areas you need to focus on. Please see more information about the discussion questions on the course Moodle page.

Course Learning Outcomes

- CLO10 : Understand and discuss the ethical dimensions and implications of the modelling introduced in the course

Detailed Assessment Description

Online discussion questions

The course offers discussions to practice the concepts you have learned each week. The discussions will

reinforce your learning and help you identify the areas you need to focus on. Please see more

information
about the discussion questions on the course Moodle page.

R mini assignments

The R mini assignments relate to the R content of course, and aims at encouraging students to keep up
with the course materials. There will be 5 R mini assignments covering different parts of the course. In
each mini assignment students will be required to solve a number of exercises using the R software. Each
mini-assignment should take around 90 minutes to complete. Students are required to submit solutions
for all of the five R mini assignments.

Assignment submission Turnitin type

Not Applicable

Assignment

Assessment Overview

There will be one major assignment for this course. An important component of this will be ethical dimension of the course materials.

Course Learning Outcomes

- CLO1 : Explain the concept of survival models
- CLO2 : Describe estimation procedures for lifetime distributions
- CLO3 : Describe statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities
- CLO4 : Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities
- CLO5 : Describe the Binomial model of mortality, derive a maximum likelihood estimator for the probability of death and compare the Binomial model with the multiple state models
- CLO6 : Describe how to estimate transition intensities depending on age, exactly or using the census approximation
- CLO7 : Describe how to test crude estimates for consistency with a standard table or a set of graduated estimates, and describe the process of graduation
- CLO8 : Describe the principal forms of mortality and morbidity heterogeneity in a population and the main forms of selection
- CLO9 : Describe the main methods of projecting/forecasting mortality rates

Detailed Assessment Description

Full information about the major assignment will be released early in the session.

Final Examination

Assessment Overview

The final examination will assess students understanding of the concepts covered in the course and readings and their ability to apply them to practical problems. Details on the final examination will be available in the course Moodle page.

Course Learning Outcomes

- CLO1 : Explain the concept of survival models
- CLO2 : Describe estimation procedures for lifetime distributions
- CLO3 : Describe statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities
- CLO4 : Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities
- CLO5 : Describe the Binomial model of mortality, derive a maximum likelihood estimator for the probability of death and compare the Binomial model with the multiple state models
- CLO6 : Describe how to estimate transition intensities depending on age, exactly or using the census approximation
- CLO7 : Describe how to test crude estimates for consistency with a standard table or a set of graduated estimates, and describe the process of graduation
- CLO8 : Describe the principal forms of mortality and morbidity heterogeneity in a population and the main forms of selection
- CLO9 : Describe the main methods of projecting/forecasting mortality rates
- CLO10 : Understand and discuss the ethical dimensions and implications of the modelling introduced in the course

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Module	Module 1: Survival Models and The Life Table
Week 2 : 19 February - 25 February	Module	Module 2: Non-parametric models: Kaplan-Meier, Nelson-Aalen and the comparison of survival functions
Week 3 : 26 February - 3 March	Module	Module 3: Semi-parametric models: The Cox regression model
Week 4 : 4 March - 10 March	Module	Module 4: Binomial and Poisson Models Module 5: Exposed to risk
Week 5 : 11 March - 17 March	Module	Module 5: Exposed to risk
Week 6 : 18 March - 24 March	Other	Flexibility week
Week 7 : 25 March - 31 March	Module	Module 6: Graduation methods
Week 8 : 1 April - 7 April	Module	Easter Monday: No Lectorial Module 7: Ethics and Mortality heterogeneity
Week 9 : 8 April - 14 April	Module	Module 8: Mortality projection models
Week 10 : 15 April - 21 April	Module	Module 9: Markov models

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Resources

Prescribed Resources

There is no prescribed textbook for the course. However, some recommended references are:

- Klein, J. P., and Moeschberger, M. L. Survival Analysis: Techniques for Censored and Truncated Data, Springer-Verlag, New York, 1997 (2nd edition 2003).
  - Chapter 2 Basic Quantities and Models, Chapter 3 Censoring and Truncation, Chapter 4 Nonparametric estimation, Chapter 8 Semiparametric proportional hazards regression and Chapter 9 Refinements of Semi-parametric proportional hazards.
- Gareth M. James, Daniela Witten, Trevor Hastie, Robert Tibshirani. An Introduction to Statistical Learning (2nd edition 2021) . Available at https://www.statlearning.com/
  - Chapter 3 on Linear Regression
  - Chapter 11 on Survival Analysis and Censored Data
- Benjamin, B., and Pollard, J.H., The Analysis of Mortality and Other Actuarial Statistics, The Institute of Actuaries, 1993.
  - Chapter 1 on Mortality Measures, Chapters 11, 12, 14, 15 and 16 on Graduation topics, Chapter 19 on Social and Economic Factors Affecting Mortality, and Chapter 9 on Trend and Forecasting.
- Pitacco, E., Denuit, M., Haberman, S., and Olivieri, A.. Modelling longevity dynamics for

pensions and annuity business, Oxford University Press, Oxford, 2009.

- Chapters 4 and 5 on forecasting mortality.

Course website

The course Moodle website is available from UNSW Moodle Page.

To access the Moodle online support site for students, follow the links from that website to UNSW Moodle Support/Support for Students. Additional technical support can be obtained from itservicecentre@unsw.edu.au (02 9385 1333). All course contents will be available from the course website. It is essential that you visit the site regularly (at least weekly) to see any notices posted there by the course coordinator.

The Actuaries Institute

The Actuaries Institute allows students to become University Subscribers free of charge. Full time undergraduates studying at an Institute accredited university who are members of a university student actuarial society are eligible. To sign up.

Course Evaluation and Development

Feedback is regularly sought from students and continual improvements are made based on this feedback. At the end of this course, you will be asked to complete the myExperience survey, which provides a key source of student evaluative feedback. Your input into this quality enhancement process is extremely valuable in assisting us to meet the needs of our students and provide an effective and enriching learning experience. The results of all surveys are carefully considered and do lead to action towards enhancing educational quality.

The model of teaching for this course has been successfully run for several years with good feedback from the students. However, upon reflection on the student feedback from previous years we have implemented some adjustments. This include

- A revised tutorial exercise book with exercises for some modules revised to better reflect the current content of the course
- A much earlier deadline for the main assignment to allow for more study time for the final exam

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Lecturer	Andres Villegas					Yes	Yes

Other Useful Information

Academic Information

COURSE POLICIES AND SUPPORT

The Business School expects that you are familiar with the contents of this course outline and the UNSW and Business School learning expectations, rules, policies and support services as listed below:

- Program Learning Outcomes
- Academic Integrity and Plagiarism
- Student Responsibilities and Conduct
- Special Consideration
- Protocol for Viewing Final Exam Scripts
- Student Learning Support Services

Further information is provided on the key policies and support page.

Students may not circulate or post online any course materials such as handouts, exams, syllabi or similar resources from their courses without the written permission of their instructor.

STUDENT LEARNING OUTCOMES

The Course Learning Outcomes (CLOs) – under the Outcomes tab – are what you should be able to demonstrate by the end of this course, if you participate fully in learning activities and successfully complete the assessment items.

CLOs also contribute to your achievement of the Program Learning Outcomes (PLOs), which are developed across the duration of a program. PLOs are, in turn, directly linked to UNSW graduate capabilities. More information on Coursework PLOs is available on the key policies and support page. For PG Research PLOs, including MPDBS, please refer to the UNSW HDR Learning Outcomes.

Academic Honesty and Plagarism

As a student at UNSW you are expected to display academic integrity in your work and interactions. Where a student breaches the UNSW Student Code with respect to academic integrity, the University may take disciplinary action under the Student Misconduct Procedure. To assure academic integrity, you may be required to demonstrate reasoning, research and the process of constructing work submitted for assessment.

To assist you in understanding what academic integrity means, and how to ensure that you do comply with the UNSW Student Code, it is strongly recommended that you complete the Working with Academic Integrity module before submitting your first assessment task. It is a free, online self-paced Moodle module that should take about one hour to complete.

Submission of Assessment Tasks

SPECIAL CONSIDERATION

You can apply for special consideration when illness or other circumstances beyond your control interfere with your performance in a specific assessment task or tasks, including online exams. Students studying remotely who have exams scheduled between 10pm and 7am local time, are also able to apply for special consideration to sit a supplementary exam at a time outside of these hours.

Special consideration is primarily intended to provide you with an extra opportunity to demonstrate the level of performance of which you are capable. To apply, and for further information, see Special Consideration on the UNSW Current Students page.

Special consideration applications will be assessed centrally by the Case Review Team, who will update the online application with the outcome and add any relevant comments. The change to the status of the application immediately sends an email to the student and to the assessor with the outcome of the application.

Please note the following:

1. Applications can only be made through Online Services in myUNSW (see the UNSW Current Students page). Applications will not be accepted by teaching staff. The lecturer-in-charge/ course coordinator will be automatically notified when your application is processed.
2. Applying for special consideration does not automatically mean that you will be granted a

supplementary exam or other concession.
3. If you experience illness or misadventure in the lead up to an exam or assessment, you must submit an application for special consideration, either prior to the examination taking place, or prior to the assessment submission deadline, except where illness or misadventure prevent you from doing so.
4. If your circumstances stop you from applying before your exam or assessment due date, you must apply within 3 working days of the assessment or the period covered by your supporting documentation.
5. Under the UNSW Fit To Sit/Submit rule, if you sit the exam/submit an assignment, you are declaring yourself well enough to do so and are cannot subsequently apply for special consideration.
6. If you become unwell on the day of – or during – an exam, you must stop working on your exam, advise your course coordinator or tutor and provide a medical certificate dated within 24 hours of the exam, with your special consideration application. For online exams, you must contact your course coordinator or tutor immediately via email, Moodle or chat and advise them you are unwell and submit screenshots of your conversation along with your medical certificate and application.
7. Special consideration requests do not allow the awarding of additional marks to students.

Further information on Business School policy and procedure can be found under "Special Consideration" on the key policies and support page.

LATE SUBMISSION PENALTIES

For assessments other than examinations, late submission will incur a penalty of 5% per day or part thereof (including weekends) from the due date and time. An assessment will not be accepted after 5 days (120 hours) of the original deadline unless special consideration has been approved. An assignment is considered late if the requested format, such as hard copy or electronic copy, has not been submitted on time or where the 'wrong' assignment has been submitted.

For assessments which account for 10% or less of the overall course grade, and where answers are immediately discussed or debriefed, the LIC may stipulate a different penalty. Details of such late penalties will be available on the course Moodle page.

FEEDBACK ON YOUR ASSESSMENT TASK PERFORMANCE

Feedback on student performance from formative and summative assessment tasks will be provided to students in a timely manner. Assessment tasks completed within the teaching period of a course, other than a final assessment, will be assessed and students provided with

feedback, with or without a provisional result, within 10 working days of submission, under normal circumstances. Feedback on continuous assessment tasks (e.g. laboratory and studio-based, workplace-based, weekly quizzes) will be provided prior to the midpoint of the course.

Faculty-specific Information

PROTOCOL FOR VIEWING FINAL EXAM SCRIPTS

UNSW students have the right to view their final exam scripts, subject to a small number of very specific exemptions. The UNSW Business School has set a protocol under which students may view their final exam script. Individual schools within the Faculty may also set up additional local processes for viewing final exam scripts, so it is important that you check with your School.

If you are completing courses from the following schools, please note the additional school-specific information:

- Students in the **School of Accounting, Auditing & Taxation** who wish to view their final examination script should also refer to this page.
- Students in the **School of Banking & Finance** should also refer to this page.
- Students in the **School of Information Systems & Technology Management** should also refer to this page.

COURSE EVALUATION AND DEVELOPMENT

Feedback is regularly sought from students and continual improvements are made based on this feedback. At the end of this course, you will be asked to complete the myExperience survey, which provides a key source of student evaluative feedback. Your input into this quality enhancement process is extremely valuable in assisting us to meet the needs of our students and provide an effective and enriching learning experience. The results of all surveys are carefully considered and do lead to action towards enhancing educational quality.

QUALITY ASSURANCE

The Business School is actively monitoring student learning and quality of the student experience in all its programs. A random selection of completed assessment tasks may be used for quality assurance, such as to determine the extent to which program learning goals are being achieved. The information is required for accreditation purposes, and aggregated findings will be used to inform changes aimed at improving the quality of Business School programs. All material used for such processes will be treated as confidential.

TEACHING TIMES AND LOCATIONS

Please note that teaching times and locations are subject to change. Students are strongly advised to refer to the Class Timetable website for the most up-to-date teaching times and locations.