MA4M1-15 Epidemiology by Example

21/22

Department
: Warwick Mathematics Institute

Level
: Undergraduate Level 4

Module leader
: Kat Rock

Credit value
: 15

Module duration
: 10 weeks

Assessment
: 100% coursework

Study location
: University of Warwick main campus, Coventry

Description

Introductory description

This module is a practical course in learning and applying techniques in mathematical modelling of infectious disease dynamics. There is a strong emphasis on using programming and problem solving to address a series of key questions arising in the field of mathematical epidemiology.

Module aims

Students taking this module will acquire hands-on experience of manipulating mathematical models, implementing appropriate numerical methods and fitting models to data, all of which are essential components of modern-day modelling for research or industry. By the end of the course, students will have encountered a range of model types which can describe a broad range of important infection systems such as influenza, malaria, measles and soil transmitted helminths. Students will understand how to perform predictive analyses which could inform policy decision making - such as assessing future control interventions including adaptive strategies and health economic analyses.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

This 10-week programme will be partitioned into five, 2-week topics:

- Simple infectious disease model dynamics simulation and prediction
- Modelling fitting to data (frequentist and Bayesian methods)
- Deterministic vs stochastic modelling approaches (endemic vs outbreak or elimination)
- Adaptive management for improved intervention efficacy
- Health economics for dynamic models and decision making

Each fortnight students will learn about current real-world motivating problems and methodologies available to address them. There will be 2 lectures a week + 1 computer lab session with the lecturer + 1 TA-guided lab session. During these 10 weeks students will cover a range of different infections spanning contagion, vector-borne disease, and macroparasitic infections. Diseases of humans and animals will be covered.

Learning outcomes

By the end of the module, students should be able to:

- (a) adapt or create infection models within Matlab, and perform simulations
- By the end of the course the student will be able to:
- (b) perform fitting to data using both frequentist and Bayesian approaches
- (c) implement and explain deterministic and stochastic modelling approaches, and their situational appropriateness
- (d) demonstrate how modelling predictions can be performed and contrast future interventions including adaptive strategies
- (e) utilise basic health economic concepts (disability-adjusted life years, willingness to pay, etc.) and methodology
- (f) communicate modelling outcomes in a clear and informative manner
- (g) appraise the suitability of different models and their predictions for real-world decision making
- (h) evaluate the role of assumptions in influencing model outcomes

Indicative reading list

General reading:

- M.J. Keeling and P. Rohani Modeling Infectious Diseases in Humans and Animals, Princeton University Press, 2007 (ISBN 0691116172)

Health economics:

- Barton, G.R., Briggs, A.H. and Fenwick, E.A., 2008. Optimal cost-effectiveness decisions: the role of the cost-effectiveness acceptability curve (CEAC), the cost-effectiveness acceptability frontier (CEAF), and the expected value of perfection information (EVPI). Value in Health, 11(5), pp.886-897.

Vector-borne infections:

- Rock, K.S., Torr, S.J., Lumbala, C. and Keeling, M.J., 2017. Predicting the impact of intervention strategies for sleeping sickness in two high-endemicity health zones of the Democratic Republic of Congo. PLoS neglected tropical diseases, 11(1), p.e0005162.

Soil transmitted helminths:

- Turner, H.C., Truscott, J.E., Fleming, F.M., Hollingsworth, T.D., Brooker, S.J. and Anderson, R.M., 2016. Cost-effectiveness of scaling up mass drug administration for the control of soil-transmitted helminths: a comparison of cost function and constant costs analyses. The Lancet infectious diseases, 16(7), pp.838-846.

Adaptive management:

- Shea, K., Tildesley, M.J., Runge, M.C., Fonnesbeck, C.J. and Ferrari, M.J., 2014. Adaptive management and the value of information: learning via intervention in epidemiology. PLoS biology, 12(10), p.e1001970.

Research element

Students will be encouraged to engage with recent scientific articles connected to the topics they are studying to help expand their knowledge and see examples of modelling methodologies in practice.

Interdisciplinary

This module falls at the interface of Mathematics, Statistics, Biology and Health Economics. Students will utilise their quantitative background in Mathematics to investigate how modelling can shape our understanding of infectious diseases and guide their control.

International

This module encourages the students to consider infections from the global perspective: from controlling diseases with pandemic potential, to infections endemic to different geographies - especially ones present in tropical and/or developing countries. Through the health economic concepts, students will explore ideas surrounding the value of health and gain an international perspective on how health policy decisions are made.

Subject specific skills

- Implementation of ODE and stochastic dynamical systems in Matlab
- Improved understanding of how to develop models in epidemiology
- Understanding of model fitting (MLE and MCMC) methods (statistics)
- Ability to utilise key health economic concepts in epidemiological dynamic modelling
- Comprehension of practical optimisation methods for real-world decision making

Transferable skills

- Problem solving including creative solutions

- General programming skills
- General modelling skills
- Research skills (reading scientific articles and implementing/modifying models)
- Using LaTeX

Study

Study time

Type	Required	Optional
Lectures	20 sessions of 1 hour (16%)	
Practical classes	10 sessions of 1 hour (8%)	
Supervised practical classes	(0%)	10 sessions of 1 hour
Private study	95 hours (76%)	
Total	125 hours	

Private study description

Reading provided literature around the topic to assist with assessments.

Costs

Category	Description	Funded by	Cost to student
Books and learning materials	All content will be provided to students via lecture notes (also available online). Suggested reading will come from open access scientific articles, except for Keeling and Rohani which is available in the Library.		£0.00
IT and software	Students will be expected to use MatLab software to complete assignments which is available through the university and could be completed on either student-owned or university machines.	Department	£0.00

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group A

	Weighting	Study time
Worksheet 5	20%	5 hours

Assessment of the last 2 week topic (weeks 9 and 10). Worksheets are to be completed individually with a pdf of solutions and Matlab code (m-file) to be uploaded electronically. Submission will be in week 11 with individual written feedback given by the beginning of term 3.

Worksheet 3	20%	5 hours

Assessment of the third 2 week topic (weeks 5 and 6). Worksheets are to be completed individually with a pdf of solutions and Matlab code (m-file) to be uploaded electronically. Submission will be in week 7 with individual written feedback given in week 8.

Worksheet 4	20%	5 hours

Assessment of the fourth 2 week topic (weeks 7 and 8). Worksheets are to be completed individually with a pdf of solutions and Matlab code (m-file) to be uploaded electronically. Submission will be in week 9 with individual written feedback given in week 10.

Worksheet 1	20%	5 hours

Assessment of the first 2 week topic (weeks 1 and 2). Worksheets are to be completed individually with a pdf of solutions and Matlab code (m-file) to be uploaded electronically. Submission will be in week 3 with individual written feedback given in week 4.

Worksheet 2	20%	5 hours

Assessment of the second 2 week topic (weeks 3 and 4). Worksheets are to be completed individually with a pdf of solutions and Matlab code (m-file) to be uploaded electronically. Submission will be in week 5 with individual written feedback given in week 6.

Feedback on assessment

All feedback and marks will be given individually to students within one week after submission for the first 4 worksheets and by Term 3 for the last assessment. The time to receive feedback for the first four assessments is important so that students have the opportunity to learn from their previous success/mistakes. The final assessment is less critical in timescale as it marks the end of the course and also represents more summative assessment.

Availability

Courses

This module is Optional for:

- Year 1 of TMAA-G1PE Master of Advanced Study in Mathematical Sciences
- Year 1 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics

- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1PF Postgraduate Taught Mathematics of Systems
- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
    - Year 3 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics

This module is Option list A for:

- Year 2 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 2 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
    - Year 4 of FG31 Mathematics and Physics (MMathPhys)
    - Year 4 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)

This module is Option list B for:

- Year 2 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 2 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 4 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)

This module is Option list C for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 3 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
    - Year 4 of G106 Mathematics (MMath) with Study in Europe

This module is Option list E for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics