Study Guide
Semester 2, 2015

Contents

Background ............................................................................................ 2
Objectives ............................................................................................... 2
Assumed Knowledge .............................................................................. 2
Unit Materials ......................................................................................... 3
Outline of Unit Modules .......................................................................... 4
Method of Delivery and Communication ................................................. 5
  eLearning ............................................................................................ 5
  Email and phone ................................................................................. 5
  Textbook and other reference books ...................................................... 6
Software ................................................................................................. 7
Timetable ................................................................................................ 8
Assessment ............................................................................................ 9
  Extensions ........................................................................................... 10
  Late penalty ......................................................................................... 10
Contact details ...................................................................................... 11
Background

A sound understanding of the basic principles of statistical inference, including the theory of statistical estimation and hypothesis testing, is necessary for students to gain a deeper understanding of methods used in the design and analysis of biomedical and epidemiological studies. An understanding of the theoretical basis for common biostatistical techniques is essential for practising biostatisticians to be able to assess the validity of these techniques for particular studies, and to be able to modify those techniques where appropriate. This unit of study (unit) provides the core prerequisite knowledge in statistical inference, which will subsequently be built upon in other subjects.

This unit will introduce and review core concepts of statistical inference, including estimators, confidence intervals, type I & II errors and p-values. The emphasis will be on the practical interpretation of these concepts in biostatistical contexts, including an emphasis on the difference between statistical and practical/clinical significance. Concepts in classical estimation theory, including bias and efficiency will be discussed. The unit will provide a general study of the likelihood function, which will be used as a basis for the study of likelihood based methodology, including maximum likelihood estimation and inference based on likelihood ratio, Wald and score test procedures. The Bayesian approach to statistical inference will be briefly studied and contrasted with the classical frequentist approach.

Objectives

At the completion of this unit the student will:

1. Have a deeper understanding of fundamental concepts in statistical inference and their practical interpretation and importance in biostatistical contexts;
2. Understand the theoretical basis for frequentist and Bayesian approaches to statistical inference; and
3. Be able to apply likelihood-based methods of inference, with particular reference to problems of relevance in biostatistical contexts.

Assumed Knowledge

PSI builds upon the material covered in Probability and Distribution Theory (PDT). You may find it useful to refer back to your PDT notes. The first two chapters and the appendix of the textbook contain information that will be helpful for PSI – it is recommended that you read those chapters early in the semester and refer to the appendix as required.
Unit Materials

The unit is divided into 6 modules, summarized in more detail below. Each module will involve approximately 2 weeks of study and will usually include the following materials:

1. A chapter from the textbook, which includes statistical theory and also an extended example illustrating the statistical theory covered.
2. A lecture on the theory and a lecture on the extended example
3. Practical exercises to be completed
4. A discussion board to ask lots of questions and post up solutions to non-assessed exercises.

Students should begin each module by reading through the relevant chapter of the text and work through the extended example in parallel with the exercises.

Lectures will be provided describing the material in each module and the extended examples where applicable. This year there have been substantial changes to PSI from previous deliveries of the unit. These include replacing module notes with a textbook, the introduction of new unit material and the re-ordering/numbering of the previous existing modules. We have recorded new lectures, but we are also re-using some previously recorded lectures, so please be aware that for these lectures that references to the module number and/or page numbers will not be directly applicable.

Each module contains a number of exercises, one of which is required to be submitted for assessment. Some of the exercises require computer simulations, and for these SAS and Stata code will be provided on eLearning (see further details below). You are welcome to use any other software you have available and are familiar with for the exercises, however code will not be provided and assistance may not be available.
Outline of Unit Modules

Each module of this unit corresponds to a chapter in the Marschner textbook (see below for details).

Module 1: Likelihood
- Likelihood function
- Sufficiency
- Nuisance parameters
- Approximate likelihood

Module 2: Estimation methods
- Maximum likelihood estimation
- Fisher information
- Properties of maximum likelihood estimation

Module 3: Hypothesis testing concepts
- Null and alternative hypotheses
- Test statistics
- P-values
- Type I & II errors, significance level and power
- Statistical significance and practical significance

Module 4: Likelihood based methods
- Likelihood ratio tests
- Score tests
- Wald tests
- Relationship between the three tests
- Interval estimation based on the three tests

Module 5: Bayesian methods
- Basic concepts: subjective probability
- Bayes’ rule, prior and posterior distributions
- Conjugate and non-informative prior distributions
- Analysis of simple binomial & normal models

Module 6: Further inference methods
- Exact methods
- Non-parametric methods
- Bootstrapping and other resampling methods
Method of Delivery and Communication

**eLearning**
We will use the BCA eLearning site (also known as *Learning Management System (LMS)* or Blackboard) as the main means of communication. An eLearning Guide, which gives basic information on how to use online eLearning is available from the Student Resources page [http://www.bca.edu.au/currentstudents.html](http://www.bca.edu.au/currentstudents.html) on the BCA website.

The eLearning website should be the primary mode for asking questions, via the Discussion Board. We encourage you to use the Discussion Board as a forum for asking questions, posting comments and answering other students’ questions. Interaction between students has been very successful in the past. Students are often able to resolve issues amongst themselves and pedagogic research suggests that this is often a better form of learning than relying solely on the instructors. The instructors will regularly monitor the discussions and contribute when needed.

Instructors will respond when required in a timely manner between Monday and Friday (within 48 hours from posting). Please note that instructors will not be available to reply to email or Discussion Board postings during the weekends.

The eLearning website will also be used for posting additional course materials.

**Email and phone**
The unit coordinator will be available by e-mail and phone to answer any queries. Queries related to the module notes and practical exercises which are posted on eLearning will be given priority over those sent via e-mail.

To assist in keeping track of e-mails, please use “PSI” in the subject line of your email.
Textbook and other reference books

The textbook for this unit is:

Marschner I.C.
Inference Principles for Biostatisticians.
ISBN 9781482222234
http://www.crcpress.com/product/isbn/9781482222234
It contains all the material that will be covered in this unit.

Other reference books you may find useful include:


Many statistical textbooks are not entirely devoted to inference, but have several sections on inference, which may not be as theoretical as the books above. Two of many are:

Altman DG. *Practical Statistics for Medical Research* Chapman and Hall, 1991
Software

The purpose of the course is not to teach statistical computing. However, there are several exercises that rely on the use of simulation to help understand the concepts being taught.

The recommended and supported software for this unit is either SAS or STATA. Whenever you will be required to use statistical software, the necessary code will be downloadable from the PSI eLearning website. The code can be run on your computer, and usually you will only need to change input values for exercises and assignments.

Some students sometimes struggle with the software. Please do not be afraid to ask for help from the other students and instructors on the Discussion Board. Try not to allow any difficulties with software to obscure the basis of the course, which is to understand the principles of statistical inference.
## Timetable

The following timetable describes the timing of the study modules and assessment tasks for Principles of Statistical Inference. It is the intention that students will work through the material for each module, including completion of practice exercises by the due date of the module assessment task. **All assessment tasks are due by 11:59pm on the Tuesday stated date.**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Tuesday date</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Module 1</td>
<td>26 July</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2 August</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Module 2</td>
<td>9 August</td>
<td>Module 1 exercise due</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>16 August</td>
<td></td>
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<tr>
<td>5</td>
<td>Module 3</td>
<td>23 August</td>
<td>Module 2 exercise due</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>30 August</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Module 4</td>
<td>6 September</td>
<td>Module 3 exercise due</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assignment 1 handed out</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>13 September</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>20 September</td>
<td>Assignment 1 due</td>
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<tr>
<td></td>
<td>Mid-semester Break</td>
<td>27 September</td>
<td></td>
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<tr>
<td>10</td>
<td>Module 5</td>
<td>4 October</td>
<td>Module 4 exercise due</td>
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<tr>
<td>11</td>
<td></td>
<td>11 October</td>
<td></td>
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<tr>
<td>12</td>
<td>Module 6</td>
<td>18 October</td>
<td>Module 5 exercise due</td>
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<tr>
<td>13</td>
<td></td>
<td>25 October</td>
<td></td>
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<tr>
<td>14</td>
<td></td>
<td>1 November</td>
<td>Module 6 exercise due</td>
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<tr>
<td>15</td>
<td></td>
<td>8 November</td>
<td>Assignment 2 handed out</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>15 November</td>
<td>Assignment 2 due</td>
</tr>
</tbody>
</table>
Assessment

There are two assignments worth 40% each. In addition, one designated exercise from each module will be required to be submitted as part of the unit assessment. These assessable exercises are worth 20% in total. Your best five assessed exercises, from six, will count towards the 20%, i.e. your best five modules assessments will be worth 4% each. Your lowest scoring module assessment will not count towards your final assessment.

The due dates for assessments are outlined below, as well as in the semester timetable.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Due Date</th>
<th>% marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1 exercise</td>
<td>9 August</td>
<td>4*</td>
</tr>
<tr>
<td>Module 2 exercise</td>
<td>23 August</td>
<td>4*</td>
</tr>
<tr>
<td>Module 3 exercise</td>
<td>4 September</td>
<td>4*</td>
</tr>
<tr>
<td>Assignment 1</td>
<td>20 September</td>
<td>40</td>
</tr>
<tr>
<td>Module 4 exercise</td>
<td>4 October</td>
<td>4*</td>
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<tr>
<td>Module 5 exercise</td>
<td>18 October</td>
<td>4*</td>
</tr>
<tr>
<td>Module 6 exercise</td>
<td>4 November</td>
<td>4*</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>15 November</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Your best five modules from six will be worth 4% each.

Module exercises are located within the eLearning Module folder. Assignments will be posted online. All assessments are due on **Tuesday by 11:59pm**.

Assessed exercises and assignments should be submitted on the eLearning website. Please consult the [BCA Assessment Guide](#) for details about submitting your assignments, and guidelines for written work. For PSI submissions:

- Your assessment submission should be **one** WORD or PDF document. Multiple files/documents will **not** be accepted.
- Do **not** send EXCEL spreadsheets.
- Solutions for both exercises and assignments should include any formulae that you have used to arrive at your conclusion. Marks are awarded for correct formulae and working.
- If using WORD, please use the **equation editor** for writing mathematical formulae.
- Hand written solutions are acceptable.
- Marks will be deducted if incorrect notation is used.
Some exercises require the creation of graphs – these can be done in statistical software or a spreadsheet and must comply with the guidelines for reporting of statistical results found on the BCA website: http://www.bca.edu.au/currentstudents.html.

All material submitted for assessment must be entirely your own work. See the section on Academic Dishonesty and Plagiarism of the BCA Assessment Guide. Students are reminded that plagiarism is not acceptable. Please ensure that you understand what plagiarism means and that you have read and understood the policy associated with the university in which you are enrolled.

Acknowledgment of receipt of submitted exercises/assignments will be automatically generated in eLearning or via e-mail for e-mailed exercises. It is the responsibility of the student to ensure that the assessment item is received by the unit coordinator by the due date.

We strongly recommend that you keep a copy of your assignments.

Extensions
Request for an extension of the due date for an assessment may be made in advance of the due date. This request must be made directly to the unit coordinator by email. The unit coordinator will reply by email with the decision as to whether an extension has been given and the new due date.

Where a student is so incapacitated by a medical or other condition that he or she is unable to request an extension in advance, medical or other certification should explicitly note the severity of the disabling condition that precluded the advance request being made.

Late penalty
If no extension has been granted, late submissions will incur a penalty. Five percent of the total marks for the assessment will be deducted for each day the assessment is late, up to a maximum of 50%. It is not the intention of this late penalty policy to cause a student to fail the unit when otherwise they would have passed. If deductions for late assignments result in the final unit mark for a student being less than 50, when otherwise it would have been 50 or greater, the student's final mark will be exactly 50.
Contact details

For **all enquiries about this unit**, contact the unit coordinator:

Associate Professor Patrick Kelly  
Sydney School of Public Health  
Edward Ford Building (A27), University of Sydney, NSW 2006  
email: p.kelly@sydney.edu.au  
phone: 02 9036 5337  
fax: 02 9351 5049  

In case of illness or extended absence of the unit coordinator, the deputy coordinator is:

Professor Judy Simpson  
Sydney School of Public Health  
Edward Ford Building (A27), University of Sydney, NSW 2006  
email: judy.simpson@sydney.edu.au  
phone: 02 9351 4369  
fax: 02 9351 5049  

For **enquiries about the BCA** and about the various degrees towards which this unit contributes, contact the BCA Executive Officer:

Erica Jobling  
NHMRC Clinical Trials Centre, University of Sydney, NSW 2006  
email: bca@ctc.usyd.edu.au  
phone: 02 9562 5076  
fax: 02 9565 1863  

For **enquiries about your degree program**, contact the university through which you are enrolled.