August 2018

Preparing for Membership Exams in Epidemiology:

A study guide for groups

Australian and New Zealand College of Veterinary Scientists

This study guide is intended for groups of candidates studying for Membership in the Australian and New Zealand College of Veterinary Scientists, by examination in Epidemiology. Individuals studying for Membership exams may also find this guide useful in monitoring progress in their own study programs. This guide is an updated and revised version of the guide dated March 2006, which was compiled by examination candidates from 2005: Cameron Bell, Zoe Cannon, Katherine Clift and Mark Stevenson.

This updated and revised information has been compiled by Ashley Jordan, Clare Death, Corissa Miller, Corrie Croton, Joanne Taylor, Kara Dawson, Leigh Sinclair, Rahul Shakar, Tabita Tan, Thomas Teoh, Troy Laidlow, Emilie Vallee and Tu Tu Zaw (the 2017 Epidemiology examination cohort) using information from their respective study groups.

We would like to thank Tracey Bradley, Victoria Brookes, Beth Cookson, Brendan Cowled, Simon Firestone, Jane Heller, Marta Hernandez-Jover, John Morton, Jenny-Ann Toribio, Michael Ward and Anke Wiethoelter for reviewing the guide and providing valuable feedback.

If you have any comments, suggestions, erratum to report etc. then please contact Corissa Miller corissa.miller@agriculture.gov.au or Clare Death clare.death@ecodev.vic.gov.au. We are keen to receive any feedback that will assist to improve the study guide for future groups.

This guide is an informal resource created by members for membership candidates and must be read in conjunction with the most recent version of the following from the Australian and New Zealand College of Veterinary Scientists (ANZCVS) website:

- Membership guidelines – Veterinary Epidemiology **(provides the objective and learning outcomes by topic and definitions for levels of knowledge and levels of expertise required for candidates to be examined in Epidemiology)** https://www.anzcvs.org.au/membership/subject-guidelines/
- Membership Candidate Handbook https://www.anzcvs.org.au/membership/

Benefits of studying in groups

(Developed originally by Andrew Kelly, revised by Katherine Clift and John Morton)

Preparing for examination in groups has a number of advantages over individual preparation. In a group, some parts of the workload can be shared. Group membership encourages a steady, consistent pace of learning. Group members can learn from the experiences of others in the group as issues tend to be viewed from different perspectives by different people. Group discussions can help members understand concepts. Groups are a great way to get to know other vets with similar interests.

State and country representatives are available to help candidates connect with study groups. Study groups are encouraged to contact their state or country representative when the study group forms and to advise whether other candidates can be included in the study group.

Details of current state and country representatives can be found at the Chapter webpage: https://www.anzcvs.org.au/chapters/epidemiology+chapter/administration.

Using this guide

In general, it is recommended that candidates and groups prepare over 16 - 18 months. This study guide assumes that preparation begins in February with written and oral examinations undertaken in June and July, respectively, of the following year.

The topics suggested for study in this guide should be viewed only as a general recommendation. Not all 'potentially examinable' areas are addressed in this program. In addition, each candidate and each group will have particular requirements that should be addressed where appropriate during the course of study. ***Therefore, candidates and groups are strongly advised to use this document only as a guide. Material and issues covered should be modified after considering both the topics listed in the Epidemiology section of the 'Guidelines for Membership Candidates' and the particular requirements of individuals and groups.***

This amendment process needs to be considered on an ongoing basis during the preparatory period. Although many of the concepts/topics may be covered in a number of meetings there are no specific revision sessions. If the group is struggling with particular concepts then additional sessions may be required. It may also be advisable to have additional group revision sessions prior to the examinations.

Readings are listed for each topic. There are also suggestions for additional reading/resources. However, there may be more appropriate sources. So, participants should view the reading only as a suggested starting point. In addition, general reading is recommended in the Guidelines for Membership Candidates.

Other useful sources of information during the preparation process

Mentors and other helpers

Personal assistance is desirable during preparation. Intending candidates can request that the College appoint a mentor to assist during their preparation period. Other current members of the Epidemiology Chapter can also be approached for help.

Past examination papers

Past examination papers for Membership in the Australian College of Veterinary Scientists, by examination in Epidemiology are available from the Australian College of Veterinary Scientists Website http://www.acvs.org.au/.

Suggested learning activities as part of the group process

Before commencing the study meetings, it may be useful to have an initial meeting to develop a plan for the sessions. It may be based on those plans shown in this guide but should be amended to suit particular needs.

The items that may be covered in the preliminary meeting include:

- When and where the meetings should occur
- What duration and structure the meetings might have
- What people would like to get out of the group e.g. undertake exams or improve knowledge without being examined
- Appointment of a group coordinator(s)
- Identification of group mentors/assistants
- Identification of potential guest speakers or people with special expertise
- Setting of ground rules e.g. respect for all participants, punctuality
- Sourcing of required reading and journal articles/other resources

This preliminary meeting also provides an opportunity to gauge the level of interest and allow people to meet each other.

Some meeting plans will take less time than others. When arranging meetings, groups may wish to combine some plans suggested in this guide. Ideally, meetings should be planned to take approximately 5 - 6 hours including a break. It is difficult to cover topics adequately with meetings of less than 4 hours.

A number of distinct learning activities have been included in this guide for each meeting.

Prescribed minimum reading before group meetings

Prescribed reading should adequately cover required subject matter but extra reading should also be considered.

In this guide, Dohoo and Thrusfield are frequently recommended reading sources. These sources cover similar material for many topics. However, for some topics, there are other texts listed. There may be some duplication with readings. However, this was done because different candidates may prefer the different presentation styles.

Additional resources/reading

There is a wealth of information available on many of these topics, the additional resources/reading is designed to give you a guide as to where to start looking if you require more information on a topic or are seeking a different presentation style to assist your understanding.

Presentations at group meetings

Topics are generally subdivided into a number of presentations. Each of the previously nominated participants should be asked to present a short summary of the key points of one presentation.

The aims of presentations are to:

- Introduce the subject matter and stimulate group discussion,
- Highlight key and confusing points, and
- Provide a complete list of the key points.

It is suggested that each presenter prepare a brief (1 - 2 page) summary of their nominated presentation for circulation to candidates at the meeting. The presenter is not expected to be an expert on their part of the topic. Rather they should have simply made an attempt to identify all key issues and points.

Exercises

Relevant exercises are useful to both increase technical understanding and to improve examination technique. Within 3 months prior to written examinations, these problems could be attempted under 'real-life' written exam conditions.

Review papers

Reviewing papers is not an attempt to 'pull a paper to bits'. It is based on the concept that virtually all published papers can make some contribution to knowledge, but that many papers have some limitations which must be identified to place the paper's usefulness into perspective. The emphasis is on identifying areas in which a paper could have been improved, and on interpretation of study results using epidemiological skills.

Example exam questions

Relevant exam questions from previous years have been included in each meeting. These provide a guide as to the depth and breadth of knowledge required on this topic. The examination format used by the college and the style of the questions may change significantly from one exam to the next so please use the questions only as a guide to learning.

Role of group assistants and group mentors

The key role of group assistants or group mentors is to recommend reading, to suggest presentation areas, to present problems and to identify papers for review. They should also attend some group meetings but should not be required to lead meetings. It is suggested that group assistants or mentors do not lecture on specific topics nor accept the task of presenting, even for topics in which they are particularly expert. Participants will learn much more by being the presenter than by being presented to (see below under 'Key characteristics of successful groups'.)

Expertise for particular topics

Experts in various areas on epidemiology should be identified and use made of their expertise to assisting achieving learning objectives. Benefit from experts is maximised if candidates complete some preparatory reading before the meeting and if some interaction is possible during the meeting. So experts should be requested to suggest reading (and perhaps presentation of topics and problems) well before the meeting.

Key characteristics of successful groups

Some study groups in epidemiology are more successful than others. There appear to be some important characteristics that contribute to the success of groups as a learning method.

A common goal

Participants should define their expectations and targets early in the group's formation. Group success is more likely when participants have a common purpose. The simplest situation is where all candidates are aiming to gain membership in the same year. However, in some groups, participants have had varied aims (e.g. participants aiming for membership in different years or some participants aiming to improve their epidemiological knowledge without attempting membership while others in the same group are committed to attempting membership examinations). Also, some participants may need to begin the process before they are able to decide whether to attempt membership examinations. Groups can be successful in these situations provided there is adequate commitment to the learning process of the group by all members, regardless of their individual aims.

Attitudes

It is important that candidates take responsibility for their own learning. As such, the degree of success of the group process is in their hands.

This attitude may be reflected in:

- Candidates (rather than group assistants or mentors) chairing the group meetings
- Group assistants or mentors delivering very few, if any, presentations
- Candidates (rather than group assistants or mentors) taking responsibility for organisational issues (i.e. venue arrangement, circulating meeting details, providing copies of relevant papers for absent group participants etc.)

Commitment to the group

The group process depends on reasonable commitment from all members. This is reflected in presenters being prepared, members having completed the prescribed reading, getting to meetings on time etc. As the group process is quite time consuming, preparation and meeting time must be successfully balanced with the many other demands on each participant's time.

Interactive learning style

One of the key benefits of group learning over individual preparation is the interaction. Accordingly, groups should avoid excessive 'lecture' style approaches. The most useful presentations are those that move through a planned body of material but with ample opportunity for questions and discussion during as well as after the presentation.

Participation by all members at all meetings

Learning is generally more focused for those having a specific task at the next meeting. Accordingly, it is desirable that each group member is allocated a task before each meeting. These tasks might include doing a presentation, leading discussion about a problem or exercise, or commenting on a review paper. Tasks such as presentations should be rotated in larger groups.

Atmosphere

Learning is enhanced in an uncritical atmosphere. It is important that people feel comfortable about 'thinking out loud', expressing uncertainties, exploring topics, making mistakes and taking time to grasp new concepts. All group participants must feel comfortable about stopping the group from moving on until they have understood an issue.

Group coordinator

It is highly desirable necessary to have one person take on the role of group coordinator. This person should ensure that organisational issues are addressed. These issues include arranging meeting rooms, circulating meeting plans, allocating tasks to group members, ensuring that prescribed reading is available to all members and ensuring that absent members receive notes etc. from missed meetings. This role could be rotated during the preparation period.

Group size

Groups can be either too small or too large. It may be difficult to get a broad range of backgrounds and perspectives with a very small group. Stimulating discussion may be more difficult to encourage. Discussion can also be restricted in large groups where a more formal atmosphere seems to predominate. Individuals may be less likely to raise concerns in a large group. The ideal group size would appear to be between 4 and 6 committed participants.

Examples and references used in this guide

Many examples used in this guide are hypothetical or are based on 'real-world' data but with extensive modifications. Please don't assume that any of these examples reflect actual observations or data except where this is stated.

Journal articles are referenced in the usual fashion.

Problems cited by year are questions from past examination papers for Membership in the Australian College of Veterinary Scientists, by examination in Epidemiology.

The following texts have been cited in the suggested reading.

Texts referenced frequently that should be acquired by each candidate:

- Thrusfield (2018). *Veterinary Epidemiology, 4th Edition*. Blackwell Science, Oxford.
- Dohoo, Martin and Stryhn (2009). *Veterinary Epidemiologic Research, 2nd Edition*. (No. V413 DOHv). 2nd Edition. Charlottetown, Canada: AVC Incorporated.
- Sergeant and Perkins (2015). *Epidemiology for Field Veterinarians: An Introduction.* CABI. UK.
- EpiTools resources e.g. Cameron A (1999). Survey Toolbox, available from: http://epitools.ausvet.com.au/content.php?page=SurveyToolbox
- Pfeiffer DU (2010). Introduction to Veterinary Epidemiology. This textbook is out of print but copyright has been returned to the author and the text is available for free download here: https://www.researchgate.net/publication/305279557_Introduction_to_Veterinary_Epidemiology?channel=doi&linkId=5786613d08aef321de2c66c6&showFulltext=true

Texts referenced less frequently that the group should have access to:

- Dijkhuizen and Morris (1997). *Animal Health Economics: Principles and Applications.* PGFVS, University of Sydney.
- Petrie and Watson (2013). *Statistics for Veterinary and Animal Science*, John Wiley & Sons.

SUGGESTED PROGRAM FOR MEETINGS

CAUSATION

February Meeting 1: Overview of epidemiology (purpose and scope of epidemiology), causation (Learning outcome 4)

DISEASE ECOLOGY AND DESCRIPTIVE EPIDEMIOLOGY

March Meeting 2: Disease ecology and strategies for disease control (Learning outcome 6)

April Meeting 3: Regional animal health programmes (Learning outcome 2)

May Meeting 4: Investigation of disease outbreaks (Learning outcome 1)

FUNDAMENTAL EPIDEMIOLOGICAL PRINCIPLES

June Meeting 5: Measuring population health (Learning outcome 7)

July Meeting 6: Application of diagnostic tests (Learning outcome 8)

August Meeting 7: Surveillance and monitoring (Learning outcome 13)

EPIDEMIOLOGICAL STUDIES

September Meeting 8: Types of epidemiological studies (Learning outcome 9)

October Meeting 9: Aspects of epidemiological studies (Learning outcome 10)

November Meeting 10: Evidence evaluation (Learning outcome 3)

December Meeting 11: Description and analysis of epidemiological data, part 1 (Learning outcome 11)

January Meeting 12: Description and analysis of epidemiological data, part 2 (Learning outcome 11)

POPULATION-BASED APPLICATIONS

February Meeting 13: Animal health economics (Learning outcome 14)

March Meeting 14: Herd health, productivity or performance (Learning outcome 12)

April Meeting 15: Risk analysis (Learning outcome 15)

May Meeting 16: Modelling and spatial epidemiology (Learning outcome 16 & 17)

REVISION

June Meeting 17: Final revision

July Meeting 18: Preparation for oral examination

1. Investigation of disease outbreaks

1.1 The candidate will have sound knowledge of investigation of disease outbreaks.

1.2 The candidate will be able to do the following with sound expertise:

1.2.1. Undertake a structured investigation of a disease outbreak scenario involving a single farm/enterprise/event and on the basis of this investigation present a summary of key findings, hypothesis/es regarding cause/s of the outbreak, and recommendations for disease control and prevention and for further investigation.

1.2.2. Critically appraise investigations of several disease outbreaks that involved multiple farms/enterprises/events, and specify with justification the respective strengths and weaknesses of each investigation in terms of attainment of an objective of timely outbreak containment and/or eradication.

1.2.2.1. Essential components to be included in the investigation:

- *an explanation of the objectives of various disease outbreak investigations*
- *case definition*
- *confirmation that an outbreak is occurring*
- *epidemic curve*
- *creation of an epidemic curve from data provided; incorporate curve into a report with interpretation*
- *spatial distribution*
- *attack rate table*
- *hypothesis formulation*
- *specification of objective/s for disease control and prevention and further investigation*
- *Definition of trace forward and trace back, and prioritisation of tracing activities.*

Reading

1. Sergeant and Perkins: Chapter 3 – Investigating disease outbreaks
2. Thrusfield 4th Edition: Chapter 4 – Describing disease occurrence, pp. 58-85; Chapter 8 – Patterns of disease, pp. 168-188
3. Dohoo 2nd Edition: Chapter 1 – Introduction and causal concepts

Presentations

1. Summarise the steps followed in carrying out an outbreak investigation
2. Discuss the definition of an outbreak, e.g. sudden, increase/decrease above normal
3. List the key steps in an outbreak investigation (you may find it helpful to do a diagram noting that not all steps are necessarily included in an investigation nor do they always follow the same sequence)
4. Discuss the information that can be obtained from epidemic curves
5. Give examples of tracing backward and forward
6. Using an example, present the components of establishing a case definition
7. Create an attack rate table using a disease of your choice and explain to the group
8. Outline the steps of hypothesis formulation
9. Discuss potential patterns of disease in time, space and by animal characteristics
10. Outline the steps involved with implementation of emergency measures

Exercises

Work through one of the case studies below from Epidemiological Skills for Animal Health Professionals Volume 2: Epidemiological Problem Solving (make sure someone has a copy of the example answers):

- o Case study 5: Outbreak investigation – Fish deaths pp. 83-101
- o Case study 6: Outbreak investigation FMD village outbreak pp. 103-108
- o Case study 7: Outbreak investigation – Horse deaths pp. 109-110

Example exam questions

<u>1996</u>

- Recently a number of outbreaks of disease have occurred in wild or free living animals in Australia and NZ. Epidemiologists can play a central role in investigating these types of problems. Discuss the special challenges of investigating outbreaks of free living populations and outline how you would have advised either fisheries or wildlife authorities investigating one of the following recent outbreaks:
  a. death in pilchards
  b. blindness in kangaroos
  c. wobbly disease in possums.

<u>1997</u>

- A large turkey breeding company has, on two occasions in the last 12 months, experiences extremely high mortality in birds placed with contract growers a day-old poults. Each placement involved several thousand birds. Ten to fifteen percent of the birds died between the ages of three and seven days. The problem then appeared to resolve spontaneously. The outbreaks occurred on two different properties, several months apart. The other eight contract growing properties have not yet experienced the problem. The farm managers keep very good records.

  -> Describe in detail how you would investigate this problem and how you would prepare for a prospective investigation of similar outbreaks in the future.

<u>2001</u>

- You have just been asked to provide epidemiological assistance for the investigation of an unusual disease outbreak in a mink farm. The farm houses about 10,000 adult mink, and the owner has reported an increased number of mink becoming ill, and an increased death rate. The farm's veterinarian has been investigating the incident, but has been unable to arrive at a diagnosis or recommend action to prevent further losses. He has asked for your assistance in investigating this incident and providing advice to the owner to resolve the problem. Please describe your approach to this investigation.

<u>2005</u>

- You have been asked to provide epidemiological assistance to a prawn farming enterprise in Costa Rica (Central America). The farm consists of 30 prawn ponds on a 450-acre property. The ponds are stocked with post-larvals in March and June, and prawns are harvested in September and October. The farmer has noticed an increased number of birds over ponds preying on dead prawns. On questioning, you are told that survival levels are well below average but vary with the location of the pond.

Survival levels are as follows:

Ponds located on the north side of the enterprise – 39.5% (mean survival), south side 5%, west side 25%, east side 6%

Your experience in Australia is that survival rates of about 60% are normal. The farm has been operational for 7 years and is not the only farm in the area affected. There was a large variation in mortalities observed between ponds.

Notable similarities between ponds: water source, feed and feed practices (prawns are fed by broadcast), salinity, age and source of post-larvals.

Discernible differences between ponds: size, stocking density, average morning temperature and oxygen concentration, date of post-larval stocking.

Describe your approach to investigating these deaths.

2007
- Write brief notes to explain your understanding of the steps followed in an outbreak investigation.

- Write brief notes to explain your understanding of the information that can be obtained from an epidemic curve.

2010
- Write brief notes on your understanding about how knowledge of host-agent-environment is used in disease investigation and mitigation.

Additional reading and resources

- Sergeant E, Cameron A, Baldock C (2004) Epidemiological Skills for Animal Health Professionals Volume 2: Epidemiological Problem Solving pp. 1-36.
- Gay J (2003) Guide for Herd Problem Investigations. Available: http://www.vetmed.wsu.edu/courses-jmgay/OutBGuide.htm
- Den Boer JW et al (2002) A Large Outbreak of Legionnaires' Disease at a Flower Show, the Netherlands 1999. EID 8(1). Available: https://wwwnc.cdc.gov/eid/article/8/1/01-0176_article
- Ancelle T et al. A multifocal outbreak of trichinellosis linked to horsemeat imported from North America to France in 1993. American Journal of Tropical Medicine and Hygiene, 59(4): 615-619. Available: http://www.ajtmh.org/cgi/reprint/59/4/615
- Reintjes R et al. (2002) Tularemia Outbreak Investigation in Kosovo: Case Control and Environmental Studies. EID 8(1). Available: https://wwwnc.cdc.gov/eid/article/8/1/01-0131_article
- Reingold AL (1998) Outbreak Investigations—A Perspective EID 4(1). Available: https://wwwnc.cdc.gov/eid/article/4/1/98-0104_article
- CDC: Epidemiology in the Classroom: Steps of an Outbreak Investigation. Available: https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson6/section2.html
- Neumann GB (1990) Investigation of an Outbreak of Disease. In: Epidemiological skill. Proceedings 143, Postgraduate Committee in Veterinary Science, University of Sydney pp289-318.
- Gardner I (1990) Outbreak Investigation. In: Epidemiology at work. Proceedings 144, Postgraduate Committee in Veterinary Science, University of Sydney pp. 7-13.
- Herd outbreak investigation resources for veterinarians: http://www.vetmed.wsu.edu/courses-jmgay/OutBResources.htm

2. Regional Animal Health Programmes

2.1. The candidate will have sound knowledge of regional animal health programs.

2.2. The candidate will be able to do the following with sound expertise:

2.2.1. describe in detail the objective/s, structure, components and stages of several animal health programs that seek to control and/or eradicate a specific disease from a defined region, and specify with justification the respective strengths and weaknesses of each program in terms of ability to achieve its stated objective/s given known epidemiology of the disease in the region, available resources and other relevant issues

2.2.2. clearly elucidate the differences between control and eradication programs

2.2.3. describe the principles to be considered when embarking on a regional/national disease control program

2.2.4. appraise regional/national disease control and eradication programs

2.2.5. describe social, economic and welfare considerations in disease control programs and provide examples.

Reading

1. Sergeant and Perkins: Chapter 13 – Regional animal health programmes
2. Thrusfield 4th Edition: Chapter 27 – The control and eradication of disease, pp. 604-632

Presentations

1. Choose a disease (preferably one that has not been tackled before!) and outline the objective, structure, components and stages of your disease control programme.
2. Describe the factors you would consider before embarking on a regional animal health programme for 2-3 endemic diseases of your choice.
3. Explore previous animal health programmes: Brucellosis and Tuberculosis Eradication campaign in Australia; Ovine Johne's Disease in Australia; Bovine TB eradication in NZ – What made/ are making these programs successful/unsuccessful, and what issues were faced/are being faced during these programmes?
4. Social, economic and welfare considerations in disease control programs – discuss.

Exercises

1. You are tasked with assessing the feasibility of eradicating Bovine Viral Diarrhoea Virus (BVDV) from Australia (or New Zealand). Specify the strengths and weaknesses of undertaking such a program in regards to its ability to achieve the goal of eradication.
2. What is the difference between a control and an eradication program? Provide examples.

Example exam questions

2000

- A program to eradicate brucellosis from cattle in New Zealand has been in place for a number of years and the prevalence of infected herds has been substantially reduced and is now quite low. The program objective remains unchanged – to eradicate brucellosis from cattle in New Zealand.

Programs to eradicate contagious diseases from animal populations in regions *have specific features,* which can change during the course of such programs. Contrast the major issues associated with the design and implementation of such an eradication program between two stages: Stage 1 – early in such a program, and Stage 2 – once the disease prevalence has been reduced to a low level.

Explain why such changes are required. The emphasis in this question is not on the specific epidemiology of brucellosis but is on the *differing issues that need to be addressed* as a program to eradicate a contagious disease proceeds.

2003

- Select a disease for each of the following and write brief notes on the important features of its epidemiology and its control, management or eradication:

a) Zoonotic disease caused by a virus with an insect vector
b) Zoonotic disease caused by a bacterium
c) Parasitic disease with an intermediate host.

2015

- Nominate a zoonotic disease that is endemic in Australia or New Zealand. For this disease:

1. Identify the important features of the epidemiology in human and animal populations that are critical for its control and prevention.
2. Explain the features in 1 a) relate to control and management strategies that may be implemented in both human and animal populations.

- Veterinary authorities are often asked to evaluate the feasibility of wide scale control or eradication of an existing animal health problem. Using two (2) examples of endemic diseases in Australia or New Zealand for which control or eradication programmes might be justifiable, discuss the factors that should be considered when deciding on the feasibility of a control or eradication programme

2017

- Answer all parts of this question:

a) Nominate and explain the relevance of a regional, national, state or district animal health program that you are familiar with.
b) Describe in detail the objectives of this program.
c) State the reasons for it being either a control or eradication program.
d) Explain the key strengths and weaknesses of this program in relation to its ability to meet the stated objectives.

Additional reading and resources

- Guidelines for animal disease control https://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/A_Guidelines_for_Animal_Disease_Control_final.pdf

- Rinderpest: the veterinary perspective on eradication: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3720037/

- Bovine Tuberculosis eradication in Australia: https://pdfs.semanticscholar.org/82a7/7387aa6b74d9ce82a7a8d78857094f5c2b35.pdf

3. Evidence evaluation

3.1. The candidate will have sound knowledge of evidence evaluation.

3.2 The candidate will be able to do the following with sound expertise:

3.2.1 critically evaluate a standard example of each the following as reported in a peer-reviewed journal (evaluation should include learning outcomes from topics below that refer to epidemiological studies):

3.2.1.1 survey to measure prevalence

3.2.1.2 cross-sectional study

3.2.1.3 case-control study

3.2.1.4 cohort study

3.2.1.5 controlled trial.

Reading

1. Elwood (2007). Critical appraisal of epidemiological studies and clinical trials – Third edition. pp. 361-391
2. Bonita, R., Beaglehole, R., & Kjellström, T. (2006). Basic epidemiology. WHO. pp. 178-181 whqlibdoc.who.int/publications/2006/9241547073_eng.pdf
3. Examples of critical appraisal by Reginster J.Y. and Cooper H. (2000) in Student BMJ 8, pp. 328-329
4. Series of articles in BMJ by T. Greenhalgh on "How to read a paper"
   - Greenhalgh, T. (1997). How to read a paper: Getting your bearings (deciding what the paper is about). BMJ 315, 243-246
   - Greenhalgh, T. (1997). How to read a paper: Assessing the methodological quality of published papers. BMJ 315, 305-308
   - Greenhalgh, T. (1997). How to read a paper: Statistics for the nonstatistician. II: "Significant" relations and their pitfalls. BMJ 315, 422-425
   - Greenhalgh, T. (1997). How to read a paper: Papers that report diagnostic or screening tests. BMJ 315, 540-543
   - Greenhalgh, T. (1997). How to read a paper: Papers that tell you what things cost (economic analyses). BMJ 315, 596-599
   - Greenhalgh, T. (1997). How to read a paper: Papers that summarise other papers (systematic reviews and meta-analyses). BMJ 315, 672-675
   - Greenhalgh, T., Taylor, R. (1997). How to read a paper: Papers that go beyond numbers (qualitative research). BMJ 315, 740-743
5. Vandenbroucke, JP et al. 2007. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Explanation and Elaboration. Epidemiology, vol.18, no. 6, p. 805-835 – focus on Table 1.
6. Sargeant, JM et al. 2016. Methods and processes of developing the strengthening the reporting of observational studies in epidemiology − veterinary (STROBE-Vet) statement. Preventive Veterinary Medicine vol. 134, no. 6, p. 188–196 – focus on Table 1.
7. Sargeant, JM et al. 2010. The REFLECT Statement: Reporting Guidelines for Randomized Controlled Trials in Livestock and Food Safety: Explanation and Elaboration. Zoonoses and Public Health 57: 105–136 – focus on Table 1

Presentations

1. Internal validity and external validity
2. Evaluating bias, confounding and random error and their consequences
3. Critical appraisal of analytical studies
4. Critical appraisal of descriptive studies
5. Statistical significance vs. clinical significance

Exercises

1. Conduct a critical appraisal of a journal article for one of the study designs listed in the learning outcomes.
2. Discuss the effects of selection bias on the internal and external validity of a study.

Example examination questions

2017

- You have read a journal paper that reports a relative risk of 4.2. State, with justification, two (2) additional pieces of information that should be presented within the paper in order for you to accurately interpret this relative risk.

- The excerpts in attachment 1 on the following page, are from a study examining a disease of unknown aetiology, 'Grass Sickness' in horses in the United Kingdom, (The Veterinary Journal 1998, 156:7–14. Wood JLN, Milne EM and Doxey DL). The disease causes extensive and severe degeneration of the enteric and autonomic nervous system. The disease is generally fatal and can only be diagnosed at post mortem. The disease has been identified in a number of countries and there are several hypothesised risk factors.

Answer all parts of this question:

a) What type of study is this? Discuss whether this is an appropriate study design for the investigation of this condition. What are the advantages of this study design?
b) Briefly outline two (2) other possible observational study designs for the investigation of risk factors for this condition.
c) Referring to the materials and methods of this study, identify any possible sources of bias. Discuss how the identified biases can affect the validity of the study results and provide suggestions for how these biases could be removed.
d) Referring to the printed text under 'Results', comment on the return rate. How does the return rate affect the study validity? What can be done to improve the return rate in a study?
e) Provide an interpretation of the findings in Table III under 'Time since field change', in plain English for a lay audience. Discuss briefly any concerns you have with the interpretations of the findings you have provided.

Attachment 1

The Veterinary Journal 1998, 156:7–14. Wood JLN, Milne EM and Doxey DL

Material and Methods

Study design

The study was carried out between 1992 and 1995. During this period, owners of cases or veterinary surgeons attending cases of grass sickness in the United Kingdom were asked to contact one of the authors. The study was publicised in the veterinary and lay equine press by local television and radio and by word of mouth. All data from outside this period were excluded.

Upon contact, the study was briefly explained to the owner or veterinary surgeon and they were sent a set of three uniquely numbered questionnaires, a covering letter and a reply paid envelope. The recipient was asked to complete one questionnaire for the case of grass sickness, one for a healthy animal on the same premises and one for a healthy animal on a different premises.

The questionnaires requested information on (1) the animal (age, breed, sex, height, body condition); (2) its recent management and use (stabled or not, type of use, whether the animal had recently moved between fields and, if so, when, type of grazing, supplementary feeding, anthelmintic and tetanus vaccination history); (3) details of the premises where the animal was being kept (type of premises, how long the animal had been there, whether grass sickness had previously occurred on the premises and, if so, when, whether the animal had been in contact with the previous case of grass sickness or in the same field in which a previous case had occurred, the number of animals on the premises, in the same field and also the field size); (4) details of the weather conditions in the previous 2 weeks and (5) if a case, how the disease had been diagnosed and whether the animal had survived. All answers were requested to reflect the date of clinical onset of the case.

Results

Descriptive and univariate analyses

Questionnaires were returned from 183 cases from 154 incidents. However, control data were only returned from 124 incidents, representing 135 cases and 226 controls. A control of 281 questionnaires sets had been sent out. Although the overall return rate was 55%, the useable return rate was 44%.

Grass sickness was diagnosed after *post mortem* in 40% of cases and by veterinary surgeons on clinical grounds after death in a further 43% of cases. The remaining 17% of cases survived and were diagnosed as having grass sickness by veterinary surgeons.

Table III: Final multivariate conditional logistic regression model of the probability of grass sickness in equids, using dead cases and all controls.

Variable	*β*	*S.E.β*	*P-value*	*O.R*	*95% C.I.*
Age:					
≥10 years	Referent	—	—	—	—
6–9 years	1.659	0.468	<0.001	5.3	2.1–13.2
3–5 years	2.039	0.473	<0.001	7.7	3.0–19.4
<3 years	1.569	0.529	0.003	4.8	1.7–13.5
Sex:					
female	-1.059	0.361	0.003	0.3	0.18–0.7
Time since grass sickness last occurred on premises	0.780	0.271	0.004	2.2	1.3–3.7
In contact with previous grass sickness	-2.758	1.43	0.05	0.06	0.003–1.0
Time since field change:					
>3 months	Referent	—	—	—	—
2–3 months	1.655	0.822	0.044	5.2	1.0–26.2
2 months	1.310	0.883	0.138	3.7	0.7–20.9
1 month	0.815	0.831	0.327	2.3	0.4–11.5
2–4 weeks	1.677	0.800	0.036	5.3	1.1–25.6
<2weeks	3.209	0.803	<0.001	24.8	5.1–120

Additional reading/resources

- Elwood (2007). Critical appraisal of epidemiological studies and clinical trials – Third edition. (the whole book really)
- Dohoo (2014). Bias – Is it a problem, and what should we do?, Preventive Veterinary Medicine 113(3), 331-337
- The Cochrane network www.cochrane.org

4. The Purpose and Scope of Epidemiology

4.1. The candidate will have sound knowledge of the purpose and scope of epidemiology.

4.2. The candidate will be able to do the following with sound expertise:

4.2.1. Illustrate common purposes and scope of epidemiology of various applications of epidemiology in animal health.

Reading

- Dohoo 2nd Edition (2009): Chapter 1.1 – Introduction, p. 2
- Sergeant and Perkins (2015): Chapter 1 – What is epidemiology? pp. 1-10
- Thrusfield 4th Edition (2018): Chapter 1 – The development of veterinary medicine, p. 1; Chapter 2 – The scope of epidemiology, pp. 28-40
- OIE (1997) The Role of Epidemiology in Public Health: https://www.oie.int/doc/ged/D9139.PDF
- OIE (2017) One Heath "at a glance": http://www.oie.int/en/for-the-media/onehealth/
- Zinstag J, Scheeling E, Walter-Toews D and Tanner M. (2011) From "one medicine" to "one health" and systemic approaches to health and well-being. *Prev Vet Med* 101, 148-156.

Presentations

1. Define and briefly describe the scope of epidemiology.
2. List and explain (with examples) the objectives/uses of epidemiology.
3. What are the differences between clinical and epidemiological approaches to disease management?

Exercises

1. Define and explain what is meant by 'One Health'.
2. List and define types of epidemiological investigations/draw a diagram outlining groups of epidemiological investigations.

Example examination questions

2003
- Write brief notes to demonstrate your understanding of the meaning and scope of epidemiology.

2009
- Write brief notes to list and explain your understanding of the objectives of epidemiology.

2010
- Write brief notes to explain your understanding of 'One medicine – One Health'.

5. Causation

5.1. The candidate will have sound knowledge of causation.

5.2. The candidate will be able to do the following with sound expertise:

5.2.1. describe concepts and models of causality, and provide examples of application of these

5.2.2. describe considerations when making causal inference and provide examples of application of these.

Reading

1. Dohoo 2nd Edition: Chapter 1.5-1.10
2. Thrusfield 4th Edition: Chapter 3 – Causality, pp. 42-57.
3. Sergeant and Perkins (2015): Chapter 4 – Causality, pp. 46

Presentations

1. Causal models and considerations when making causal inference: indirect and direct causes, association, necessary and sufficient causes, confounding.
2. Formulating a causal hypothesis: methods of deriving hypothesis, causal webs, path analysis.
3. Criteria for assessing causality (including Koch's postulates, Hill's criteria and Evan's rules). Discuss how they have changed with history, especially how Koch's postulates are less relevant for multifactorial disease.

Exercises

1. John Snow - a brief history of his work. What judgement criteria did he use in his work with cholera (see Eyler JM. 2001. The changing assessment of John Snow's and William Farr's cholera studies. Soc Prev Med, 46(4): 225-232. Available: http://www.epidemiology.ch/history/papers/eyler-paper-1.pdf)
2. Criteria for causality
    a. There have been several outbreaks in cattle of a severe hepatopathy with high incidence and sometimes, high case fatality rate. The hepatic damage is apparently quite distinctive histologically. There is some speculation that the disease is due to ingestion of a weed known as Rough Dog's-Tail (*Cynosurus echinatus*).
    b. List the Criteria for causality.
    c. The following pieces of information have progressively accumulated. Which judgement criterion does each piece contribute to? How useful is each piece of information for determining causality?
        i. In the first fully investigated Victorian outbreak, Rough Dog's-Tail (RDT) was available and eaten by cattle in the affected mob.
        ii. In 2 subsequent outbreaks in Victoria, RDT has been available to cattle although it has not always comprised a large proportion of available pasture.
        iii. In a series of 10 Tasmanian outbreaks, cattle and sheep in all outbreaks have had access to RDT.
        iv. The hepatopathy has only been reported in areas where RDT exists.

v. The frequency of diagnosis of the hepatopathy has increased as the habitat of RDT has expanded.
vi. In a case-control study, apparently toxic paddocks were substantially more likely to contain RDT than apparently safe paddocks (OR = 5.1).
vii. In a 4 year cohort study, paddocks containing RDT were more likely to result in outbreaks than paddocks not containing RDT (RR = 3.6).
viii. In the same cohort study, the population of available pasture that was RDT in each paddock was categorised as nil, 1-50% and > 50%. The risk of an outbreak was greater in heavily infested paddocks (RR = 2.1 and 4.9 for 1-50% and >50%, respectively).
ix. Analysis of RDT reveals low levels of a hepatotoxin in some samples.
x. Feeding RDT to rats cause a mild hepatic disease.
xi. (Note: Pieces i to iv are actual observations. The remaining pieces are hypothetical.)

3. Draw a hypothetical causal web for a multifactorial disease or production deficit that you are familiar with.
4. Read the paper 'Cancer incidence and mortality and proximity to TV towers' and discus how it addresses the criteria for causation. The paper can be found at: http://www.teslabel.be/001/documents/Cancer%20incidence%20and%20mortality%20and%20proximity%20to%20TV%20towers.pdf. After you have done this read the article (at the same site) 'Cancer and TV towers: association but not causation'. Discuss this article with other group members.

Example examination questions

2000
- Using examples write brief notes on necessary and sufficient cause.

2001
- Using examples write brief notes on establishing a causal relationship.

2002
- Write brief notes to demonstrate your understanding on the criteria for judging causal relationships in epidemiological studies.

2003
- Briefly describe the essential features and application of path models for causation.

2013
- Causal criteria should be used to supplement statistical associations to assess causation during epidemiological studies. Describe briefly why causal criteria are required. In your answer, provide one (1) causal criterion and explain how it is used to assess causality.

2015
- Cohort studies are observational studies that can provide some evidence of causation. Justify why this study design is more suited to establishing causation than other designs.

- Provide an alternative explanation to an observed association being causal.

2016

- Describe at least five (5) of the Hill's criteria for making causal inferences and discuss their strengths and limitations.

- Using examples and causal diagrams, discuss the criteria used to determine if a variable is a potential confounder.

2017

(- abridged) You are investigating the cause of a newly-identified disease called jelly nail. You have received cross-sectional data of affected and exposed animals. What additional information is required to demonstrate a cause of this disease? Provide a list of criteria required to demonstrate the cause of a disease.

Additional reading and resources

- Austin Bradford Hill (1965) The Environment and Disease: Association or Causation? Proceedings of the Royal Society of Medicine, 58: 295-300. Available: http://www.edwardtufte.com/tufte/hill
- Chesterton RN, Pfeiffer DU, Morris RS and Tanner CM (1989) Environmental and behavioural factors affecting the prevalence of foot lameness in New Zealand dairy herds - a case-control study. NZ Vet J, 37: 135-142.

6. Disease Ecology and Strategies for Disease Control

6.1. The candidate will have sound knowledge of disease ecology and strategies for disease control.

6.2. The candidate will be able to do the following with sound expertise:

6.2.1. in relation to the occurrence of infectious disease, explain and provide examples of the following concepts:

6.2.1.1. transmission and maintenance of infection in a population of interest
6.2.1.2. methods of spread of disease
6.2.1.3. basic epidemic theory
6.2.1.4. basic reproduction rate (R0) for infectious diseases
6.2.1.5. herd immunity.

6.2.2. list major strategies used for infectious disease control, and explain how these affect disease frequency in the context of the concepts above.

6.2.3. identify and elucidate the epidemiological features critical to control and prevention of infectious and non-infectious diseases important in Australia or New Zealand selected by the candidate.

Reading

1. Dohoo 3rd Edition (2009): Chapter 27 – Concepts of infectious disease epidemiology, pp. 715-725
2. Thrusfield 4th Edition (2018): Chapter 6 – Transmission and maintenance of infection, pp. 115-136; Chapter 8 – Patterns of disease, pp. 168-187

Presentations

1. Transmission and maintenance of infection in a population of interest, methods of spread of disease
2. Basic epidemic theory, basic reproduction rate (R0) for infectious diseases, effective reproductive rate, herd immunity, SIR models
3. Major strategies used for infectious disease control, and how these affect disease frequencies in the context of disease transmission dynamics.

Exercises

1. Use an SIR model simulator such as the ones listed below in additional readings, and by changing input parameters determine the effects of:
    a. Increasing the transmissibility of the infectious organism
    b. Reducing the susceptibility of the population (e.g. by vaccination)
    c. Increasing the length of time an infected animal remains infectious before recovery
2. Find the R0 of some common human or animal diseases, and for each calculate the proportion of the population that would be required to be vaccinated to prevent the disease spreading.
3. Choose three infectious diseases and one non-infectious disease of importance in Australia and/or New Zealand. For each, describe the epidemiological features critical to control and prevention.

Example examination questions

2002

- Write brief notes to demonstrate your understanding of herd or population immunity.

- Using examples, write brief notes on methods of disease transmission.

2005

- Select a topical disease for three of the four options: bacterial food-borne, parasitic, congenital and viral. Explain how features of the epidemiology of each disease you have selected are relevant to its control, management or eradication.

2009

- Write brief notes to explain your understanding of maintenance of infection in populations.

2011

- Nominate an infectious disease of animals with which you are familiar. For that disease answer all subparts of the question:

a) Describe the methods of spread of the infectious agent – both within herd and between herd.
b) List any reservoirs of the infectious agent.
c) List the major strategies used for infectious disease control in animals.
d) Explain how one of these strategies reduces disease frequency in the context of either basic epidemic theory or transmission and maintenance of infection.

2013

- Explain what herd immunity means. Use the concept of herd immunity to explain why 100% vaccination coverage (i.e. every individual is fully immune) is not required for mass vaccination programs to prevent epidemics.

2015

- Nominate a zoonotic disease that is endemic in either Australia or New Zealand. For this disease:

- Identify the important features of the epidemiology in human and animal populations that are critical for its control and prevention
- Explain how these features relate to control and management strategies that may be implemented in both human and animal populations.

- The basic reproduction rate R0 is an important descriptor of an infectious disease outbreak.

- Define R0.
- Explain how the value of R0 can impact the progression of the outbreak.
- Explain three ways in which R0 can be estimated.

Additional reading and resources

- Introduction to disease dynamics and modelling of infectious disease https://pdfs.semanticscholar.org/presentation/936a/92e3aa915be587d1f5bbc27c2f1d7b85626c.pdf

- SIR model simulator: http://www.public.asu.edu/~hnesse/classes/sir.html
- SIR model simulator: http://252s-weblive.vet.unimelb.edu.au:3838/users/epi/sir.vanilla/
- Epidemiological Skills in Animal Health, PGFVS Proceedings 143; pp. 161-175 (Ecology of disease), pp. 239-254 (Patterns of disease).
- Jackson et al. (2005) Epidemiology of the 2003-2005 Epidemic of Avian Influenza H5N1 in Asia. In: Proceedings of the Food Safety & Biosecurity and Epidemiology Branches of the NZVA, pp. 87-99.
- Daszak P, Cunningham AA and Hyatt AD (2000) Emerging Infectious Diseases of Wildlife – Threats to Biodiversity and Human Health. Science, 287(5452): 443-449.
- Morse SS (1995) Factors in the Emergence of Infectious Diseases. EID 1(1). Available: https://wwwnc.cdc.gov/eid/article/1/1/95-0102_article
- 'Global Aspects of Emerging and Potential Zoonosis: a WHO perspective' Available: https://wwwnc.cdc.gov/eid/article/3/2/97-0220_article

7. Measuring Population Health

7.1. The candidate will have sound knowledge of measuring population health.

7.2. The candidate will be able to do the following with sound expertise:

7.2.1. calculate and interpret the following measurements from information provided:

7.2.1.1. measures of disease frequency — crude mortality or morbidity, prevalence, attack rate, incidence risk, incidence rate

7.2.1.2. measures of association — odds ratio, relative risk based on attack rate, prevalence ratio, incidence risk ratio, incidence rate ratio

7.2.1.3. measures of effect – attributable risk, attributable fraction, population attributable risk, population attributable fraction

7.2.1.4. measures of production and productivity — provide examples relevant to specific livestock production systems.

7.2.2. describe objectives of standardisation of measures of disease frequency.

Reading

1. Dohoo 2nd Edition: Disease frequency, 73-84; Standardisation, 85-88; Measures of association, pp. 135-144
2. Thrusfield 4th Edition: Chapter 4 – Measures of disease occurrence and standardisation, pp. 67-80.
3. An overview of measurements in epidemiology: http://www.med.mcgill.ca/epidemiology/ebss/resources/Docs/An%20overview%20of%20measurements%20in%20epi_v3_2007.pdf
4. Sergeant and Perkins: Chapter 6 – Measuring disease frequency, pp. 76-88
5. Schmidt, C.O. & Kohlmann, T. 2008, "When to use the odds ratio or the relative risk?", International Journal of Public Health, vol. 53, no. 3, pp. 165-167.

Presentations

1. Retained placenta in cattle is a well-defined risk factor for reduced fertility. Twin calvings are a frequent (indirect) cause of retained placenta. The magnitude of this latter effect was quantified using population data from Dutch dairy herds from 1982 to 1988 (*Nielen M et al. (1989). Twinning in dairy cattle: a study of risk factors and effects. Theriogenology 32: 845 - 862*). The following data was adapted from this report. For all 11,943 calvings that occurred over the period, 839 were followed by retained placenta (placenta not expelled by 24 hours after calving). Of these calvings, 369 were twin calvings. Of the twin calvings, 128 were followed by retained placenta. For our purposes, assume that no bias is present in these observations. Calculate the following measures and describe the meaning of each:
    - Risk ratio (relative risk), odds ratio, population risk ratio, population odds ratio, attributable risk, attributable fraction, estimated attributable fraction, population attributable risk, population attributable fraction, estimated population attributable fraction.
2. Incidence risk versus incidence rate; (incidence) risk ratio versus (incidence) rate ratio: Define these terms, show how each are calculated using examples, and interpret each. Describe when it is appropriate to use each of these. Define 'relative risk'.

3. Pick a major study design (e.g. cross sectional, case-control, cohort, controlled trial) and discuss what measures of association and effect can be calculated and compare this to other major study designs. Consider using example journal articles or studies to illustrate your points. If desired this exercise can be combined with a critical evaluation of a journal article (see topic 3)
4. Describe what a risk ratio is and compare this to an odds ratio. Explain the benefits and limitations of each measure of association and when you should use one over another.

Exercises

1. Pick a livestock production system you are familiar with or interested in and describe some major production measures and how they are used to monitor and assess herd performance.
2. Explain why standardisation may be used when comparing disease incidence between two populations. What is the difference between direct and indirect standardisation?

Example examination questions

Note: Some of the content below relates to other topics/sections.

2007

- Population-based measurements. Write brief notes to explain your understanding of direct and indirect standardisation of rates.

- Outbreak investigation – *methods for analysis*

Using the data in the table below:

a) Calculate and explain important epidemiologic measures of the strength of association between the exposure factor and disease in this group of animals.
b) Calculate and explain important epidemiologic measures of the effect of the factor on rate and proportion of disease in the group, and similar measures for the effect of the factor in the broader population.
c) Describe how you would determine the significance of these tabulated data. Note that numerical calculations are not required.
d) Describe how you would determine the significance of estimates of the strength of association. Note that numerical calculations are not required.
e) Which of the measures of association and effect are appropriate for the interpretation of a cohort study, a case-control study and an intervention study?

	Diseased	Not Diseased	Totals
Exposed	20	5	25
Not Exposed	10	10	20
Totals	30	15	45

- Outbreak investigation – *application*

You have been asked to investigate high piglet mortalities on a farm that has two farrowing sheds. One of these sheds is older, and has a less sophisticated cooling system. The other is newer and better controlled. The district in which the farm is located has been experiencing an extended period of unusually hot weather, and the owner believes that the older cooling system may be contributing to piglet stress.

Although the sheds are of the same size, the owner preferentially places relatively more of his higher-quality young breeding sows in the newer and better air-conditioned shed in the hope that more of their piglets will survive.

a) The owner has a total of 250 sows, evenly divided between the two sheds. The average number of piglets per sow throughout the farm (i.e., in both sheds) is 10 – for the purpose of this examination, you can assume that every sow has 10 piglets. Of the total of 2,500 piglets born on the farm, 250 have been found dead in the older shed and 200 have been found dead in the newer shed. Using these data, and a contingency table (2x2) table, calculate the relative risk or mortality for piglets in the older versus newer shed.
b) Explain how stratified analysis can be used to determine whether a third dichotomous variable (e.g. 'younger' vs 'older' sows) might confound or otherwise modify the effect of one dichotomous variable on another. Include in your answer, how you would use stratified analysis to delineate between confounding and effect modification. If only confounding is occurring, how might the data be re-analysed?
c) The owner now tells you that 75 of the 175 younger and higher quality sows farrowed in the older and poorly air-conditioned shed. Of the 750 piglets born to these 75 young sows, 180 have died. By comparison, only 150 of the piglets born to the young sows that farrowed in the newer shed have died. Use a stratified analysis and the data above to determine whether the age and quality of sows (i.e. young and high quality sows *versus* older and poorer quality sows) is likely to be confounding or otherwise modifying the effect of poor air conditioning on piglet mortality. Note that in answering this, you are not required to calculate an adjusted relative risk.

<u>2009</u>

- Outbreak investigation — fleece rot

You have been asked to investigate a severe outbreak of fleece rot caused by *Pseudomonas aeruginosa* on a New Zealand hill-country farm. This is the first year that the farmer has tried hogget mating and he has brought his hoggets in at the end of the mating period to remove the rams and give them a drench. He found that 183 of the 381 hoggets had severe fleece rot. It had been quite wet over the previous three weeks. The farmer once used Cheviots predominantly, but had been using Romney rams in the past couple of years, and the hoggets were the progeny of this cross-breeding program. The farmer was concerned that introducing the Romney breed may have been part of the reason for the problem. He asks you for your advice.

You decide to survey the condition in the region by attending the mid-week sheep sales at the nearby saleyards over the next three weeks. You examine the sheep in a selection of pens each sale day before the bidding starts. You record breed (Romney versus Cheviot), age (hoggets versus older ewes) and length of wool (short versus long). The combined results after the three weeks are presented in the following table:

Sheep type	**Affected**	**Clear**
Romney hoggets — short wool	8	104
Romney hoggets — long wool	20	56
Cheviot hoggets — short wool	12	218
Cheviot hoggets — long wool	9	42
Romney ewes — short wool	36	352
Romney ewes — long wool	81	173
Cheviot ewes — short wool	27	391
Cheviot ewes — long wool	69	241

Answer all of the following:

a) What type of study did you conduct?
b) Calculate the apparent prevalence in each group.
c) How would you determine whether the differences between the groups are significant?
d) What are some of the risk factors you might consider in a comprehensive study of this condition?
e) Using contingency tables, calculate the relative risk of fleece rot for each of the risk factors for which you have data.
f) Explain how you could further analyse the data.

2010

- Write brief notes to explain your understanding of the incidence of disease.

2013

- Define and explain the meaning of the term 'risk' as used in risk analysis, and contrast this with the meaning of the term 'risk' as used to describe disease frequency.

2015

- A (fictitious) cross-sectional study investigating the relationship between the feeding of liver treats (LT) to dogs and the occurrence of anterior cruciate ligament rupture (ACR) produced the following data:

	ACR +ve	ACR –ve	Total	Rate of ACR
LT +ve	20	1500	1520	13.16/1000
LT –ve	6	3200	3206	1.87/1000
Total	26	4700	4726	5.5/1000
Proportion LT+ve	0.77	0.32	0.32	

Using this data, calculate the following measures of association and, for each one, provide an explanatory interpretation of the result:

a) relative risk
b) odds ratio
c) attributable risk
d) population attributable risk.

2016

- You have been asked to provide epidemiological support to investigate an outbreak of mortalities that has occurred in a free-range chicken layer farm.

Answer all parts of this question:

a) Describe in detail the steps you would take to investigate this outbreak.
b) The producer provides you with the following data of mortalities in four sheds which house 12,500 birds each. For shed one only, calculate and interpret the cumulative mortality/mortality risk assuming a starting population of 12,500 birds in the shed.
c) Using the same data, calculate and interpret the mortality density/rate in shed one only. You may assume that the birds remained at risk up to and including the day of their death.

Day	Shed 1	Shed 2	Shed 3	Shed 4
1	80	2	0	0
2	245	110	2	1
3	213	435	0	0
4	42	890	1	1
5	38	1300	1	1
6	13	500	0	5
7	15	400	2	2
8	10	150	15	15

- The following is a modified excerpt from the abstract and method of a paper from the Veterinary Record, November 25, 2015 titled:
Prevalence factors associated with equine herpesvirus type 1 infection in equids with upper respiratory tract infection and/or acute onset of neurological signs from 2008 to 2014.

Abstract
The objective of the present case-control study was to determine factors associated with the detection of equine herpesvirus type 1 (EHV-1) by quantitative PCR (qPCR) in horses presented to veterinarians with clinical signs related to an acute upper respiratory tract infection and/or acute onset of neurological disease from March 2008 to December 2014. Statistical analyses were performed to determine the association between risk factors (demographic, geographic and management) and EHV-1 status.
A total of 117/4228 (2.7 per cent) equids meeting the case definition tested qPCR-positive for EHV-1.

Materials and methods – study population
Two hundred and thirty-nine equine veterinary practices located in 38 states of the USA were enrolled in a voluntary surveillance programme for equine respiratory pathogens. The participating veterinarians were asked to collect blood and nasal secretions from equine patients that presented with signs of acute upper respiratory tract infection and/or neurological deficits. The case definition of horses to be sampled included one or more of the following signs: unexplained fever (T>101.5°F), depression, nasal discharge, coughing and acute neurological signs (ataxia, weakness, urinary incontinence, recumbency). Acute onset of neurological disease was included in the case definition in order to sample horses with possible EHV-1 myeloencephalopathy. Case submission occurred over 82 months (March 2008 to December 2014). A diagnosis of EHV-1 infection was made based on the presence of clinical signs and the laboratory detection of EHV-1 via quantitative PCR (qPCR).

Answer all parts of this question:

a) The data in the table below have been adapted from the paper. Which measure/s of association and measure/s of effect would be used to evaluate association between gender and EHV-1 status? Justify your answer.
b) Based on the data provided in the table below, calculate and interpret one (1) measure of association you nominated above. Show the calculation.

	EHV-1 PCR negative	EHV-1 PCR positive	
Female	1505	47	1552
Male	2320	60	2380
Total	3825	107	3932

8. Application of diagnostic tests

8.1. The candidate will have sound knowledge of application of diagnostic tests and be able to explain the concepts behind the characteristics of diagnostic tests (For example why might a test be very sensitive, or very specific? How applicable are a test's characteristics in a different population?).

8.2. The candidate will be able to do the following with sound expertise:

8.2.1. calculate and interpret the following measurements from information provided:

8.2.1.1. measures of test validity — specificity, sensitivity

8.2.1.2. measures of prevalence based on test results — apparent prevalence and true prevalence

8.2.1.3. probability of individual status given test results — positive predictive value, negative predictive value.

8.2.2. compare application of diagnostic tests in series and in parallel and give examples of the appropriate application of each approach.

8.2.3. describe effects of prior probability on predictive value and interpret specific examples using these principles including:

8.2.3.1. discussing with justification the characteristics of a diagnostic test/s suitable for use in regional animal disease programs particularly when disease prevalence is moderate-high versus low-zero.

8.2.3.2. explaining how the interpretation of diagnostic test results will change over the course of a regional animal disease program that is aiming to reduce and then eradicate a disease.

8.2.4. define herd-level sensitivity and specificity, and describe major determinants of these.

Reading

1. Dohoo 2nd Edition: Chapter 5 – Screening and Diagnostic Tests, pp. 91-134.
2. Sergeant and Perkins: Chapter 7 – Diagnosis and screening, pp. 98-124
3. Thrusfield 4th Edition: Chapter 20 – Diagnostic testing, pp. 421-456.
4. Cameron: http://epitools.ausvet.com.au/docs/SurveyToolbox.pdf

Presentations

1. Construct a 2x2 table and be able to calculate sensitivity, specificity, apparent prevalence, true prevalence, positive predictive value and negative predictive value from the table.
2. Consider the relationship between sensitivity and specificity, i.e. for a test such as an ELISA (continuous values) there is an inverse relationship between Se and Sp and the selection of the optimum cut-off point depends on the diagnostic strategy (relative cost of false positives and false negatives). A receiver operating characteristic (ROC) curve is useful for understanding this relationship.
3. Comparing tests and selection of appropriate diagnostic tests.

4. Herd level sensitivity and specificity.
5. Interpretation of predictive values and their relationship with Se/Sp and pre-test probability.

Exercises

1. Diagnosis of fascioliasis in cattle – Two methods are being compared for the diagnosis of fascioliasis in cattle from the region around Hanoi in Vietnam. Between 3 and 8 samples are collected each week at a local abattoir from cattle of different age groups. These samples include whole liver and gall bladder for total counts of fluke, samples of faeces for fluke egg counts and blood for serum, to be used for an indirect antibody ELISA. So far, 95 livers have been collected, but of these, on 93 have matching serum samples and 65 have matching faecal samples. Of the animals with one or more fluke, 58 had positive and 15 negative results in the ELISA test, whereas in animals with no detectable fluke, 5 sera were positive and 15 negative for the ELISA. Similarly, 38 of the animals infected with fluke had positive egg counts for Fasciola species and 16 had zero counts. Eleven animals were not infected by fluke and all had zero counts for fluke eggs.
    - Calculate the sensitivity and specificity for both tests, determine the apparent and true prevalence of fascioliasis in this population and decide on the usefulness of these tests for the diagnosis of fascioliasis in this region.
2. Read journal article Dionysius DA, 1991, Pregnancy diagnosis in dairy goats and cows using progesterone assay kits, Australian Veterinary Journal, vol 68, no 1, pp 14-16.
    - For cattle calculate the positive and negative predictive values for diagnosis of pregnancy using the Enzygost Vet test kit (Table 3). Assume a normal conception rate of 55% and no follow up heat detection for determination of pregnancy status.
    - On the basis of these calculations how would you advise a farmer to interpret a positive and negative test?
3. A test with a sensitivity at the individual level of 99% is to be applied to a population, testing different numbers of animals according to the size of the herd:
    a. all the animals in herds of less than 20 head
    b. 50% of the animals in herds of 20-50 head
    c. 30% of the animals in herds of more than 50 head.
        - What is the probability of missing herds with a low level of infection (only 1 infected animal)?

Example examination questions

Note: Some of the content below relates to other topics/sections.

<u>2001</u>

- Using examples, write brief notes on attributes of a screening test.

<u>2002</u>

- Using examples, write brief notes on sensitivity, specificity and predictive values of a diagnostic test.

- Two tests for ovine paratuberculosis (*Mycobacterium avium* subsp*. paratuberculosis*) have been developed. One test is an absorbed enzyme-linked immunosorbent assay (ELISA) while the other is an agar-gel immuno-diffusion (AGID) test. You have been asked to evaluate these tests. To assist with the study, sheep have been made available from farms where ovine paratuberculosis is known to be present and from farms in a region thought to be free. Histologic examination of intestinal tissue is regarded as a definitive test for ovine paratuberculosis.
    a) Describe how you would evaluate the performance of these tests.
    b) Include in your answer a discussion of how you might compare the performance of the tests.

- Write brief notes to demonstrate your understanding of interpretation of:
    a) herd level sensitivity and specificity
    b) parallel and serial testing
    c) ROC curves.

<u>2009</u>
- Write brief notes to explain your understanding of establishing the parameters of a diagnostic test.

<u>2011</u>
- Answer the following:
    - List the major generic determinants of herd-level sensitivity; and for each of the determinants, note the direction of change in herd-level sensitivity following an increase in just that determinant.
    - List the major generic determinants of herd-level specificity; and for each of the determinants, note the direction of change in herd-level specificity following an increase in just that determinant.

- Diagnostic test validity and use – Two diagnostic tests are being used during a major livestock disease eradication program for an infectious disease, a PCR (polymerase chain reaction) test for viral DNA, and an ELISA (enzyme-linked immunosorbent assay) for antibodies. Test results are available for animals known to be infected (as demonstrated using a gold standard process), and animals in regions known to be free of the agent. Numbers of animals were as follows:

Animals known to be infected (as demonstrated using a gold standard process)

		ELISA	
		Positive	Negative
PCR	Positive	154	2
	Negative	23	7

Animals in regions known to be free of the agent

		ELISA	
		Positive	Negative
PCR	Positive	5	1
	Negative	39	263

Answer all subparts of this question:

- Based on these data, calculate each of the following:
  i. sensitivity of the PCR
  ii. specificity of the PCR
  iii. sensitivity of the ELISA
  iv. specificity of the ELISA
  v. relative sensitivity of the ELISA (relative to the PCR)
  vi. relative specificity of the ELISA (relative to the PCR)
- Describe in words the meaning of each of the six numbers calculated above.
- Assume an eradication program is about to commence and that the agent is very common in a region. If only one of these tests is to be used at any particular stage of the eradication program; based solely on the test sensitivities and specificities that you have calculated above, describe which test you would use in **each** of the following stages:
  i. early in the eradication program
  ii. near the end of the eradication program
  iii. to prove freedom to trading partners five years after the infectious agent was declared eradicated.

<u>2013</u>

- Application of diagnostic tests – Assume you are analysing data from equine influenza (EI) epidemic that occurred in Australia in 2007. You want to examine diagnostic aspects of the antibody enzyme-linked immunosorbent assay (ELISA) used during the outbreak.

Assume you have a data set of ELISA test results. These comprise test results from a total of 1798 horses (each horse was tested only once). Four hundred and seventy-five (475) of these horses tested positive to an EI polymerase chain reaction test (PCR) some weeks before the blood was collected for ELISA testing. It can be assumed that all of these animals were truly infected. Of these 475 infected horses, 4 horses tested negative with the ELISA. A further 1323 horses from areas remote from infected areas were tested and it can be assumed that these animals had never been infected with EI. Of these 1323 animals, 43 tested positive with the ELISA.

- Complete the following contingency table in the answer booklet you have been provided.

	True disease status		
	EI+	EI-	
ELISA+			
ELISA-			

- Calculate the sensitivity and specificity of this ELISA.
- Calculate the apparent and true prevalence of the disease (ie of being EI PCR positive).
- One horse is randomly selected from these 1798 study horses.
  i. Assume that horse's test was positive. What is the probability that the horse had been truly infected during the epidemic? That is, calculate the positive predictive value (PPV).
  ii. Assume the test was negative. What is the probability that the horse was truly uninfected during the epidemic? That is, calculate the negative predictive value (NPV).
  iii. State briefly what would happen to the PPV and the NPV of this test if the prevalence of EI in this 1798 horse study population had been lower.

iv. Define herd level specificity and list **two (2)** factors that influence herd level specificity.

2015

- A survey has been undertaken to detect the prevalence of Babe's disease in commercial pigs in a particular region of Australia. The sensitivity (Se) and specificity (Sp) of the test for Babe's disease is 95% and 99% respectively. If 50 out of a sample of 1,000 pigs test positive:
  - Calculate the apparent prevalence (AP) and true prevalence (TP) of Babe's disease in this population of pigs.
  - Explain the effect of varying test sensitivity and test specificity on estimates of TP.
  - Interpret what TP means in terms of the probability of disease in an individual animal from that population.

The following formula may be useful: TP=AP+(Sp−1)/Sp+(Se−1)

2016

- Answer **all** parts of this question:
  - Justify your choice of **two (2)** situations when you would prefer to select a test with high sensitivity while compromising on specificity.
  - Justify your choice of **two (2)** situations when you would prefer to select a test with high specificity while compromising on sensitivity.
  - If diagnostic tests with desired sensitivity or specificity are not available, how would you use information from multiple tests to improve the sensitivity and specificity of a combination of tests?

Additional reading and resources

- Stevenson, An introduction to veterinary epidemiology, pages 68-74: http://www.massey.ac.nz/massey/fms/Colleges/College%20of%20Sciences/Epicenter/docs/ASVCS/Stevenson_intro_epidemiology-web_2008.pdf
- Pfeiffer, Introduction to veterinary epidemiology, pages 110-141; alternatively online version available here: https://www.researchgate.net/publication/305279557_Introduction_to_Veterinary_Epidemiology?channel=doi&linkId=5786613d08aef321de2c66c6&showFulltext=true (pages 37-50)
- Greiner and Gardner, Application of diagnostic tests in veterinary epidemiologic studies Preventative Veterinary Medicine Volume 45, Issues 1–2, 30 May 2000, Pages 43-59

9. Types of epidemiological studies

9.1. The candidate will have sound knowledge of types of epidemiological studies.

9.2. The candidate will be able to do the following with sound expertise:

9.2.1. Correctly identify examples of each of the following types of epidemiological studies - *survey; case report and case series*; *cross sectional study*; *case control study; cohort study; randomised controlled trial.*

9.2.2. Explain the strengths and weaknesses of the different study types and applicability for particular research objectives and circumstances.

Reading

1. Cameron A (1999) Survey Toolbox, available from http://epitools.ausvet.com.au/docs/SurveyToolbox.pdf Part 1 Chapter 2 'General Principles of Animal Disease Surveillance' pp 11-36, Part II 'Survey design and analysis' Chapters 7,8,9 pp. 143-189.
2. Sergeant and Perkins, Epidemiology for Field Veterinarians: Chapter 1.6 – Types of Epidemiological Study.
3. Dohoo 2nd Edition: Chapter 7 – Introduction to observational studies; Chapter 8 – Cohort studies; Chapter 9 – Case-control studies; Chapter 10 – Hybrid study designs; Chapter 11 – Controlled studies
4. Thrusfield 4th Edition: Chapter 15 – Observational studies pp. 319-338; Chapter 16 – Design considerations for observational studies, pp. 339-360; Chapter 17 – Clinical trials, pp.361-383.
5. Committee for Proprietary Medicinal Products (CPMP) (2000). Points to consider on switch between superiority and non-inferiority. Available: http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2009/09/WC500003658.pdf

Presentations

1. Types of observational and intervention studies (including strengths and weaknesses)
2. Discuss the circumstances when a cross sectional study is most appropriate, the key design features and the statistics that can be calculated.
3. 'Is Vitamin D intake associated with the risk of Multiple Sclerosis?'. One member of the group should briefly research MS – occurrence, hypothesised risk factors etc and bring their findings to the session (5 minutes worth). At the meeting members of the group allocate themselves to different study types (cross-sectional, case-control, cohort and intervention/clinical trial) and discuss how they would conduct a trial examining this question using their nominated design. The design should include exposure and outcome and concentrate on the strengths and weaknesses of their study type.

Exercises

1. Advantages and disadvantages of case-control studies.
2. Advantages and disadvantages of retrospective and prospective cohort studies.
3. Hybrid study designs (for example, nested case-control studies).
4. Select two (or more) of the following papers and discuss their design and conduct:
   a) Schouten J et al (2004) Prevalence estimation and risk factors for Escherichia coli O157 on Dutch dairy farms. Prev Vet Med 64:49 - 61.

b) Jackson R et al (2004) Survey of the seroprevalence of brucellosis in ruminants in Kosovo. Veterinary Record 154(24): 747 - 751.
c) Cole FL et al. (2004) Prevalence and demographic characteristics of exertional rhabdomyolysis in horses in Australia. Veterinary Record 155: 625-630.
d) Garner MG et al. (1997) A national serological survey to verify Australia's freedom from porcine reproductive and respiratory syndrome. AVJ 75: 596-600.
e) Small L and Pinch DS. (2003) Survey for hydatidosis in cattle bred in the northern region of the Northern Territory of Australia. AVJ 81: 355-358.

5. Critically appraise a selection of the following papers. What are the positive and negative features of the study design used in each study?
   a) Chesterton, R., Pfeiffer, D., Morris, R., Tanner, C. (1989) Environmental and behavioural factors affecting the prevalence of foot lameness in New Zealand dairy herds - a case-control study. NZ Vet J 37: 135 - 142.
   b) Johansen C, Boise J, McLaughlin J, Olsen J (2001). Cellular telephones and cancer --- a nationwide cohort study in Denmark. Journal of the National Cancer Institute, 93: 203 - 237.
   c) Muscat JE, Malkin MG, Thompson S, Shore RE, Stellman SD, McRee D et al. (2000). Handheld cellular telephone use and risk of brain cancer. Journal of the American Medical Association, 284: 3001 - 3007.
   d) Parsonnet J, Friedman GD, Vandersteen DP, Chang Y, Vogelman JH, Orentreich N, Sibley RK (1991). Helicobacter pylori infection and the risk of gastric-carcinoma. New England Journal of Medicine, 325(16): 1127 - 1131.
   e) Neilen M (1989) Twinning in dairy cattle: a study of risk factors and effects. Theriogenology 32(5):845-861.
   f) Steenholdt C and Hernandez J (2004) Risk factors for umbilical hernia in Holstein heifers during the first two months after birth. JAVMA 224(9):1487-1490.
   g) Wilesmith JW et al (1997) A cohort study to examine maternally associated risk factors for bovine spongiform encephalopathy. Veterinary Record, 141: 239-243.
   h) Healy AM et al (2004) A paired case-control study of risk factors for scrapie in Irish sheep flocks. Prev Vet Med 64: 73-83.

Example examination questions

Note: Some of the content below relates to other topics, particularly the section aspects of epidemiological studies.

<u>1999</u>

- Crohn's disease is a disease of humans with many similarities to Johne's disease in ruminants. It is a chronic inflammatory condition of the intestines that is histologically similar to Johne's disease. Mycobacterium paratuberculosis has also been isolated from some cases of Crohn's disease, but this is not a consistent finding. There is increasing concern that exposure to M. paratuberculosis is a cause of Crohn's disease, but existing evidence for causality is limited. There is particular concern about risks to people exposed to dairy cattle infected with M. paratuberculosis.

You are part of a research team of epidemiologists that has been asked to investigate this issue on an epidemiological, rather than bacteriological basis, focussing on risks to people exposed to infected dairy cattle. You have reasonable resources at your disposal. Describe how you would proceed.

<u>2000</u>

- A veterinary practitioner asks you for epidemiological advice about an apparent problem amongst Huntaway dogs (a breed of sheep dog). On the basis of dogs presented to his clinic the practitioner suspects that Huntaways have a higher incidence of hip dysplasia (HD). This

concern is of some importance as many sheep dogs in New Zealand are Huntaways. How would you advise this veterinarian to go about determining in Huntaways are, in fact, at greater risk than other breeds of dog of being affected by HD?

2001
- Write brief notes to demonstrate your understanding of case-control studies.

2002
- Canine coronavirus is becoming an agent of concern to small animal practitioners. In particular there is some controversy regarding the prevalence of seropositive dogs and the role that the virus may play in canine gastroenteritis. As a consultant epidemiologist you have been asked to design and carry out a cross-sectional study to investigate these problems. Describe how you would proceed with planning the study, including discussion of important factors affecting study design.

- *Salmonella enteritidis* (SE) is a common cause of food poisoning in many countries, with the main source of infection being raw or partly cooked eggs and egg products. For example human illness from SE positive eggs in the United States is now approximately 637 000 cases per year. SE in chickens causes a silent systemic infection that can be detected by both bacteriological and serological techniques. Prevalence of infection in naturally infected commercial layers has been found to be very low.

The Australian and New Zealand egg industries are thought to be free of SE infection and relatively few human cases occur in either country compared to overseas. No human cases of SE due to consumption of Australian or New Zealand eggs have been reported. You have been engaged by the egg industry in your country (Australia or New Zealand) to plan an epidemiological study to demonstrate freedom from SE. Describe how you would proceed with this project and discuss the key issues affecting study design.

- A pharmaceutical company has commissioned you as an epidemiologist to identify the major health issues associated with pet dogs in NZ/Australia to help them review the direction of the R & D program. You have one year in which to complete the project and a generous, although not unlimited budget available to you.
Describe how you would go about fulfilling this task, giving details of:

a) The different sources of information on dog health that you might use.
b) The way in which you would collect data from these sources.
c) The strengths and weaknesses of each with respect to data quality and ease with which the information can be collected.

- Infectious bovine rhinotracheitis (IBR) is a viral infection of cattle that is endemic in Australian herds. The virus occurs worldwide, but strains overseas appear to be more pathogenic and have been subject to eradication programs in some countries. Although we now that IBR occurs in Australia, and that Australian strains are less pathogenic than overseas strains, we know very little about the prevalence or distribution. You have been asked to design a survey to estimate the prevalence of IBR infected herds in the country. Describe how you would proceed with designing such a survey and discuss factors that influence your decisions at each major step of the design.

Additional reading and resources

- East IJ et al (2004) Survey for the presence of White Spot Syndrome Virus in Australian crustaceans. AVJ 82:4, 236-239.

- Black PF et al (2001) Serological examination for evidence of infection with Hendra and Nipah viruses in Queensland piggeries. AVJ 79:6, 424-426.
- Dohoo IR and Thomas FC (1989) Clinical trials in veterinary medicine Can Vet J, 30: 291- 303.

10. Aspects of epidemiological studies

10.1. The candidate will have sound knowledge of aspects of epidemiological study design.

10.2. The candidate will be able to do the following with sound expertise:

10.2.1. describe major sampling methods, provide and recognise examples of each method, and compare and contrast the respective strengths and weaknesses of each method.

10.2.2. explain the determinants of sample size and how each affects sample size when:

10.2.2.1. estimating a proportion
10.2.2.2. estimating a mean
10.2.2.3. comparing two independent proportions
10.2.2.4. comparing two independent means
10.2.2.5. detecting disease.

10.2.3. appraise a questionnaire for potential introduction of information bias and selection bias, and propose appropriate improvements to reduce potential biases

10.2.4. describe key principles of data management, and recognise examples of inappropriate data management

10.2.5. identify examples of potential selection bias, information bias and confounding bias, explain why each identified potential bias may have occurred, discuss the respective impact of each on internal validity and external validity (if applicable), and propose alternate methods for controlling each identified form of potential bias.

10.2.6. identify examples of interaction, and interpret results in the presence of interaction.

10.3. design of an Epidemiological Study demonstrated by candidate being able to, for a given scenario:

10.3.1. outline the essential design features of an appropriate epidemiological study (survey, cross-sectional study, case-control study, cohort study or controlled trial)

10.3.2. describe and compare alternate options for essential design features where these exist, and explain justification for choice of particular alternatives.

10.3.3. essential features to be included in the outline of the epidemiological study:

- *hypothesis formulation*
- *setting objective/s*
- *choice of study type*
- *unit of study*
- *target/reference and study populations*
- *defining outcome and exposure variables*
- *sampling methods*
- *sample size estimation*
- *design strategies to minimise bias*

Reading

1. Sergeant and Perkins: Chapter 8 – Sampling populations; Chapter 9 – Data Collection and Management
2. Dohoo 2nd Edition: Chapter 2 – Sampling; Chapter 3 – Questionnaire design; Chapter 12 – Validity in observational studies; Chapter 13 – Confounding: Detection and Control; Chapter 30 – A structured approach to data analysis
3. Thrusfield 4th Edition: Chapter 11 – Data collection and management, pp. 219-250; Chapter 13 – Surveys, pp. 270-295.
4. Baldock FC. (1998) What constitutes freedom from disease in livestock? AVJ 76: 544-545.

Presentations

1. Probability and non-probability sampling methods
2. Creating sampling frames and sampling techniques
3. Sources of error when sampling and strategies to reduce error
4. I'm designing a study - how many samples should I take?
5. Estimating population parameters on the basis of a sample
6. Control of biases – what type/s of bias does randomisation reduce? blinding reduce?

Exercises

1. Carefully read the following examples and then choose your preferred sampling unit. Explain your choice:
    a) You wish to estimate the economic losses arising from lameness in sheep in a region. You decide to conduct a survey to estimate the prevalence of lameness in sheep in the region.
    b) You wish to conduct a survey to determine the incidence of foot-and-mouth disease (FMD) outbreaks in pigs from an intensively farmed endemic region of a country during the last year.
    c) You believe that poor stockyards and overcrowding of cattle in abattoirs before slaughter is contributing to carcass bruising. You plan to conduct a study to investigate this proposed risk factor.

2. It is frequent in animal production systems to divide animals into separate groups. Dairy farms (for example) manage lactating and non-lactating stock as separate groups. These divisions can make the collection of a representative sample from a population difficult.
    a) Give three examples from livestock enterprises where free mixing of animals is prevented.
    b) List all of the sub-groups that may be present in each.
    c) How would you obtain a representative sample from each enterprise?

3. Suppose you wish to determine the prevalence of disease within the pig population of a region. Previous surveys have indicated that 70% of the region's pigs are located in very large, intensive specialised pig farms, 20% of pigs are found within smaller farming units (frequently as a secondary industry on large dairy farms), and 10% of pigs are kept singly within small plots around towns (by people whose major occupation is not farming). With proportional stratification, a sample would be selected at random from within each stratum such that the aggregated sample would consist of 70% pigs obtained from the large intensive farms, 20% pigs obtained from

the smaller pig farms, and 10% pigs obtained from small plots near towns. Explain why it is important for each stratum of pigs to be represented in this sample for the prevalence survey.

Assume that the disease that you are investigating is leptospirosis: combine your knowledge of leptospirosis with the description of the farming systems. Is the epidemiology of leptospirosis likely to vary between the different strata?

4. It is decided to do a survey to estimate the prevalence of disease X in a population of cattle. Three experts are asked for their opinions about the expected prevalence and they reply: 75%, 50% and 25%. Assuming that there are 1 million head of cattle in the study area, a desired precision of 5% and a desired confidence level of 95%. Calculate the needed sample size according to the three expert opinions. When prevalence is unknown and you have absolutely no idea about its expected value, what prevalence estimate should you use for the sample size calculation?

5. Serological surveillance for a disease of poultry is to be conducted in a population of 15,000 villages. Each village contains between 10 and 2100 eligible birds. The mean number of birds per village is 750. The requirement is to be 95% certain of declaring a village positive for disease if the within-village prevalence is greater than or equal to 5% and the between-village prevalence is greater than or equal to 1%. If all birds were tested in sampled villages, how many villages would need to be sampled to achieve the required probability of detection?

6. Using the following structure, answer the question below (also use this structure to answer the previous exam question below on respiratory disease in feedlot cattle):
    1. Introduction (show how you have interpreted the problem)
    2. State the objectives of your particular study.
    3. State your hypotheses
    4. Define the external population
    5. Define the target population. If there is a sampling frame state what this is or how it would be developed.
    6. Define the study population (including eligibility criteria, case definitions, sampling methodology, sample sizes – and how you would calculate them).
    7. State what you would measure and how you would do it (i.e. survey instrument). This could be a diagnostic test(s) or questionnaire based, or both. State how would you ensure minimal loss to follow up and maximise response rates, etc.
    8. Note any sources of error, including bias (confounding, information or selection bias) and interaction, and alternative study approaches which might avoid these. Make sure to highlight the strengths of your study in this section.
    9. Discuss how would analyse the results.

Example examination questions

Note: Some of the content below relates to other topics, particularly the section types of epidemiological studies and evidence evaluation.

<u>2001</u>

- Using examples, write brief notes on sampling methods used to select participants in epidemiological studies.

2002

- Briefly describe the essential features and application of stratified random sampling.

- Using examples, write brief notes on selection bias in epidemiological studies.

2003

- *Babesia gibsoni* has recently been found in Pit Bull terriers in Victoria. However, little is known about its distribution or prevalence in Australia. You have therefore been asked to design a study to identify the prevalence of *Babesia gibsoni* in the Australian dog population.

a) What type of study would you use and what are the strengths and weaknesses of your chosen type of study?
b) Describe the study design, including the study objectives, hypothesis, unit of interest, reference and study populations.
c) What sampling methods you would use and how you would select your sample size?
d) Discuss possible means of data collection and the advantages and disadvantages of alternative sources of data.
e) Describe any potential biases and how you may control these.
f) Discuss how you would analyse and interpret the results.

2005

- Briefly describe the essential features, application and limitations of:

a) stratified analysis
b) longitudinal studies.

- Using examples, write brief notes on:

a) handling confounding at the design and analysis stages of a study
b) selection of subjects for a cross-sectional study.

- Acute Bovine Liver Disease (ABLD) is a disease of sudden onset that affects beef and dairy cattle in south-eastern Australia. ABLD causes high morbidity and significant mortality on affected properties. Clinical signs include severe depression, milk drop, fever over 40^{o}C, jaundice and photosensitivity of unpigmented areas. Little is known of the possible cause of the disease, although it appears to be associated with warm, balmy Autumn weather. Liver histopathology is pathognomonic, with hyperacute periportal necrosis.

a) How would you investigate this problem?
b) Include in your answer the strengths and weaknesses of the chosen study design, the study hypothesis, sampling method and how you would determine sample size. What potential biases would you encounter and how would you control for these? Also provide full details of data collection, analysis and interpretation.

- Transporters of live dairy cattle to the Middle East have reported an increased number of deaths. These appear to be in the absence of significant mechanical or logistics difficulties. Exporters have approached you to investigate the problem, with a view to identifying management measures for key risk factors.

a) How would you investigate possible causes of this disease?
b) Include in your answer the strengths and weaknesses of the chosen study design, the study hypothesis, sampling method and how you would determine sample size.
c) What potential biases would you encounter and how would you control for these?
d) Also provide full details of data collection, analysis and interpretation.

2007

- Write brief notes to explain your understanding of:
    - cluster sampling
    - common sources of bias in epidemiological studies
    - the characteristics, analysis and limitations of cross-sectional studies.

2009

- Write brief notes to list and explain your understanding of:
    - the types of epidemiological investigations
    - issues to consider when calculating sample sizes for assessing the presence or absence of disease in a population, versus estimating prevalence
    - confounding and how it can be controlled
    - the characteristics, analysis and limitations of case-control studies.

- Disease investigation — bearded dragon mortality

You have been asked to provide epidemiological assistance to a wildlife agency that is concerned about adenovirus mortality in bearded dragons (Pogona vitiiceps).

A reptile park has recently reported mortalities in 10 out of 23 bearded dragons. Laboratory investigation has confirmed the diagnosis of adenoviral hepatitis (histopathology, electron microscopy and viral culture). This virus has not previously been reported in bearded dragons in Australia, although similar adenoviral disease has been reported overseas in Pogona spp. Animals across the age spectrum have been affected and die acutely in good body condition with minimal ante-mortem morbidity.

The park is a tourist facility with a variety of reptile species on display, used in show, and for public handling. It also operates as a rehabilitation facility for sick, injured and orphaned wild reptiles. There is effectively no separation between wild and captive animals, and husbandry procedures would allow for horizontal disease transmission.

Potential sources of introduction include captive animals exposed through the reptile trade (legal and illegal), animal handling, or contact with wild animals undergoing rehabilitation.

An experimental serological test has been developed in anticipation of a field study.

You are asked to investigate whether adenovirus is present in the wild population.

- Discuss how you would select a cut off for using the test, assuming you have some sera available from infected and non-infected lizards.
- What type of study would you use to decide whether the virus is present in the wild population of lizards, and what are the strengths and weaknesses of your chosen type of study?
- What sampling methods would you use and how would you select your sample size?
- Describe any potential biases.

2010

- Write brief notes to explain your understanding of:
    - multi-stage random sampling
    - pooling of samples for detection of disease
    - characteristics and limitations of cohort studies.

- Disease investigation – pig weaner mortality

A veterinary pig practitioner has been investigating a 900-sow herd of pigs with increased rates of mortality amongst weaners from four to ten weeks of age. Some pigs die acutely in very good condition, showing signs of respiratory distress. Others die over a period of time, with some loss of condition. Although a variety of organisms have been isolated from specimens submitted, treatment with antibiotics has not provided much improvement.

The pig farmer does not keep count (inventory) records of animals beyond weaning. In the period from January to June 2006 a total of 7,706 pigs were weaned, and abattoir records showed that 6,870 pigs were slaughtered at 20 weeks post-weaning (June-November 2006). A number of gilts were retained (estimated 3% of killings) as replacement sow breeding stock. As a veterinary epidemiologist you have been asked to assist with the investigation.

Answer all of the following:

a) Calculate and describe the apparent morality rate in this herd.
b) List the additional information you would need to progress the investigation and how this information might be obtained.
c) What type of study could be used to determine the cause of these types mortalities and what are the strengths and weaknesses of the chosen study design?
d) Briefly describe the study design including objectives, hypothesis, unit of interest, sample size, reference and study population.
e) Describe any potential or actual bias in the calculated mortality rate and in the results of your study.

<u>2011</u>

- Respiratory disease vaccination in feedlot cattle

In Australian feedlots, cattle from various sources are trucked to the feedlot, held for various periods of time in paddocks or pens and fed hay; then on a single day, are placed in groups of between 100 and 500 (depending on the physical size of the pen). They typically remain together in the same pen until removed for slaughter after 60 to 250 days. Each feedlot typically consists of between 10 and 100 pens. Most pens have other pens adjoining. Feedlot staff visually assess cattle each day and remove cattle thought to be unwell for detailed examination and treatment elsewhere. Bovine respiratory disease is the most important disease in most large beef cattle feedlots. Cattle must have been infected with one or more of several infectious and contagious agents before clinical bovine respiratory disease develops. Three vaccines are available in Australia that target the pathogens thought to be contributors to clinical bovine respiratory disease; (all of these vaccines are killed and so are not transmitted between animals). You have been asked to design a controlled trial to assess the effectiveness of these under Australian conditions. Managers of five feedlots have approved implementation of a controlled trial for this purpose in their feedlots. Describe in detail the design of a controlled trial that will provide precise and unbiased estimates of the effectiveness of these three vaccines in preventing clinical bovine respiratory disease in feedlot cattle. Explain why each element of your design is important and necessary.

<u>2015</u>

- Cohort studies are observational studies which can provide some evidence of causation:

a) Define what is meant by a cohort study.
b) Outline the essential design features of such a study.
c) Explain the measures of association that can be evaluated from a cohort study and describe how these can be interpreted.
d) Justify why this study design is more suited to establishing causation than other designs.

2016

- Explain confounding bias in epidemiological studies.

- Using examples and causal diagrams, discuss the criteria used to determine if a variable is a potential confounder.

- Differentiate between confounding and interaction (effect modification).

Additional reading and resources

- EpiTools – Epidemiological calculators
  http://epitools.ausvet.com.au/content.php?page=home

11. Description and Analysis of Epidemiological Data

** Below: Learning outcomes and recommended reading combined*

11.1. The candidate will have sound knowledge of description and analysis of epidemiological data.

11.2. The candidate will be able to do the following with sound expertise:

11.2.1. outline the characteristic features of different data types (binary/dichotomous, nominal, ordinal, continuous (interval and ratio))

- Thrusfield 4th Edition: Chapter 10 – The nature of data, Classification of data, Scales (levels) of measurement, pp. 201-205.
- Petrie and Watson 3rd Edition: 1 – The whys and wherefores of statistic ; 1.6 – Types of Variable

11.2.2. describe and compare alternate methods for summarising and presenting each data type, and explain justification for preference for particular alternative/s

- Thrusfield 4th Edition: Chapter 12 – Presenting numerical data, pp.251-269.
- Petrie and Watson 3rd Edition: Chapter 2 – Descriptive statistics
- Sergeant and Perkins: Chapter 10 – Exploratory Data Analysis

11.2.3. calculate and interpret confidence intervals for common population measures (proportion/prevalence, mean, odds ratio, relative risk based on attack rate, prevalence ratio, incidence risk ratio, incidence rate ratio)

- Thrusfield 4th Edition: Chapter 12 – Presenting numerical data – confidence intervals, pp. 257-262; Chapter 15 – Observational Studies – Measures of association, pp. 321-328.
- Sergeant and Perkins: Chapter 6 – Measuring of disease frequency
- Dohoo 2nd Ed: Chapter 6 – Measures of association; 6.5 Hypothesis testing and confidence intervals

11.2.4. explain using examples hypothesis testing, p-values, statistical power, Type I and Type II errors, and interpret specific examples of p-values and statistical power

- Thrusfield 4th Edition: Chapter 14 – Demonstrating association – Some basic principles, The principles of a significance test, The null hypothesis, Errors of inference, One- and two-tailed tests, pp. 296-301.
- Petrie and Watson 3rd Edition: Chapter 6 – An introduction to hypothesis testing
- Sergeant and Perkins: Chapter 11 – Introduction to statistical principles
- Dohoo et al 2nd Ed: Chapter 6 – Measures of association; 6.5 Hypothesis testing and confidence intervals; Chapter 2 – Sampling; 2.1.6 Introduction - Types of error; 2.11.4 Sample-size determination – Power

11.2.5. specify with justification the appropriate parametric or non-parametric statistical approaches when comparing two groups with straightforward data types and structures (binary/dichotomous, nominal, ordinal, continuous; independent, paired/dependent)

- Petrie and Watson 3rd Edition: Chapter 7 – Hypothesis tests 1 – the t-test (comparing one or two means); Chapter 9 – Hypothesis tests 3 – the Chi-squared tests (comparing proportions); Chapter 12 – Non-parametric statistical methods; Appendix E: Flowcharts for selection of appropriate tests

11.2.6. explain the uses and basic concepts of linear regression, logistic regression and survival analysis as tools to analyse data in epidemiological studies, and be able to interpret output from standard examples of each

- Petrie and Watson 3rd Edition: Chapter 10 – Linear correlation and regression; Chapter 11 – Further regression analysis; Chapter 14 – Additional techniques – 14.6 survival analysis
- Dohoo 2nd Ed: Chapter 14 – Linear regression; Chapter 16 – Logistic regression; Chapter 19 – Modelling survival data
- Bennett, D (2001) Logistic regression analysis: an epidemiological perspective. Australasian Epidemiologist 8: 38-44

11.2.7. define hierarchical data and clustering, and provide and recognise examples of each.

- Sergeant and Perkins: Chapter 8 – Sampling populations – 8.6.5 Cluster Sampling
- Dohoo 2nd Ed: Chapter 20 – Clustering

Presentations

1. Presentation on displaying data: measures of centrality and dispersions, confidence intervals.
2. Summarise the different types of data. For each type provide a definition and example.
3. Write on a whiteboard a 2x2 attack rate table and calculate: proportion/prevalence, odds ratio, relative risk based on attack rate, prevalence ratio, incidence risk ratio, incidence rate ratio
4. Present on hypothesis testing, power, confidence and type 1 and 2 errors
5. Present on:
    a) basic statistical tests
    b) unit of analysis independence
    c) parametric and non-parametric tests (including underlying assumptions, applications and limitations)
    d) tests for different data types
    e) stratified analysis and the Mantel-Haenzel procedure.
6. Describe linear regression. Imagine that you are to give a 20 minute presentation about this technique to a group of colleagues who know very little about epidemiology or statics. Your talk should include:
    a) A description of what linear regression is used for and what it is.
    b) A brief description of the principles and assumptions that underpin the technique.
    c) Examples of where the technique has been used to provide insight into an animal problem.
    d) What to look out for when evaluating studies that have used the technique.
    e) Compare the method to logistic regression and survival analysis and note the major differences. Especially note what outcome measure the methods use and the differences in the measures of association derived from the models.

Exercises

1. Critically appraise some of the following studies - describe the following:
    a) Objectives of the data analysis
    b) The unit(s) of analysis
    c) Types of data (outcome and exposure variables)

d) The type of analysis used (linear regression, logistic regression, survival analysis) and why that approach was appropriate
e) Any potential sources of clustering

i. Arunvipas P1, Dohoo IR, VanLeeuwen JA, Keefe GP. (2003) The effect of non-nutritional factors on milk urea nitrogen levels in dairy cows in Prince Edward Island, Canada. Prev Vet Med. 2003 May 30;59(1-2):83-93.
ii. Borges VF1, Bernardi ML, Bortolozzo FP, Wentz I. (2005) Risk factors for stillbirth and foetal mummification in four Brazilian swine herds. Prev Vet Med. 2005 Sep 12;70(3-4):165-76. Epub 2005 Apr 18. [Logistic Regresson]
iii. Matsuda R, Morizane T, (2005) Helicobacter pylori infection in dental professionals:A 6-yprospective study. Helicobacter 10, 307 – 311 [logistic regression]
iv. Proudman C, Smith J, Edwards G, French N (2002) Long-term survival of equine surgical colic cases. Part 1: Patterns of mortality and morbidity. Equine Veterinary Journal 34, 432-437 [survival analysis]
v. M. A. Stevenson, R. S. Morris, J. W. Lockhart, D. Lin, R. Jackson, J. W. Wilesmith, , J. B. M. Ryan. Temporal aspects of the epidemic of bovine spongiform encephalopathy in Great Britain: individual animal-associated risk factors for the disease. Veterinary Record 141 (12):319-325

2. Read the following papers and discuss how clustering was accounted for during the design and analysis stages of the studies:
   a) Gitau GK, Perry BD, Katende JM, McDermott JJ, Morzaria SP and Young AS (1997) The prevalence of serum antibodies to tick-borne infections in cattle in small holder dairy farms in Murang'a District, Kenya; a cross-sectional study. Prev Vet Med 30: 95-107.
   b) Haine D, Boelaert F, Pfeiffer D, Saegerman C, Lonneux J-F, Losson B, Mintiens K (2004) Herd level seroprevalence and risk mapping of bovine hypodermosis in Belgian cattle herds. Prev Vet Med 65: 93-104.

Example examination questions

Note: Some of the content below relates to other topics, particularly the sections types of epidemiological studies, aspects of epidemiological study design and evidence evaluation.

<u>2002</u>
- Briefly describe the essential features and application of the Chi-squared test.

<u>2003</u>
- Using examples, write brief notes on P-values and significance testing.

- You have been asked to provide some assistance with the analysis of data from a pilot cross-sectional study of cattle from a number of herds and a number of geographic regions. The objective of the study was to identify possible risk factors for a particular disease. The investigators plan to use the results of the study as the basis for a more searching and expensive case-control study. Explain the steps you would follow in analysing these data. Include in your answer the assumptions of any models, and reasons why you would choose them.

Outcome variable: Disease present or absent
Explanatory variables:

Sex	Male (bulls and steers) or Female
Breed	Poll Hereford, Black Angus, Santa Gertrudis, crossbred
Age	Months

Weight	Kilograms
Herd size	Number of head of cattle
Region	Temperate, subtropical, semi-arid

2007

- Write brief notes to explain your understanding of the following:
    a) The application and assumptions underpinning linear regression analysis
    b) Interpretation of confidence limits for calculated statistics.

2009

- Write brief notes to explain your understanding of:
    a) Type I and type II errors
    b) The application and assumptions of parametric tests and non-parametric tests
    c) survival analysis.

2010

- Write brief notes to explain your understanding of the following:
    a) Descriptive analysis of different types of data
    b) The application and assumptions underpinning logistic regression analysis.

2011

- Answer all subparts of this question; for subparts b and c assume all individuals are statistically independent of each other, other than the similarity of individuals due to being in the same group:
    a) Define and give examples of outcome variables of each major data type such as might be measured in an epidemiological study of your choice.
    b) Describe a statistical approach for comparing the means of a continuous outcome variable between two groups.
    c) Describe a statistical approach for comparing the distribution of a binary variable between two groups.

2013

- Define statistical power. List three factors that affect statistical power, and describe how each can be manipulated to increase power of an epidemiological study.

- Identifying associations: Salmonellosis in feral pigs (*Sus scrofa*)

Feral pigs are an invasive animal in New Zealand and Australia, and can transmit infectious organisms including *Salmonella* spp. In an effort to understand the ecology of *Salmonella* spp. in this species, you conduct a cross sectional survey of feral pigs in Northern Australia. You determine the condition score of each sampled pig (fat or thin) and the *Salmonella* spp. carrier status (infected or uninfected) of each pig. Assume condition scores and *Salmonella* spp. carrier statuses were determined with no classification errors.

Five hundred and forty three (543) pigs were sampled. Two hundred and eight pigs (208) were infected with *Salmonella* spp. One hundred (100) infected pigs were categorised as fat and one hundred and eight (108) infected pigs were categorised as thin. Two hundred and five (205) uninfected pigs were categorised as thin.

a) Construct a two-way contingency table summarising these data with infection status and condition score as the dependent and independent variable respectively.
b) Calculate an appropriate measure of disease frequency in this study population and

calculate a 95% confidence interval for the measure of disease frequency. Interpret the confidence interval in words.

You may find the following approximate formulae useful:
SE = sqrt [p(1-p)/N] where *p* = a proportion and N=sample size
95% CI = $\theta \pm Z$ (SE) where θ = the observed proportion and Z = 1.96

c) Calculate an appropriate measure of association to assess whether the condition score of feral pigs is associated with infection with *Salmonella* spp. Interpret the measure of association. (Confidence intervals are not required.)
d) Suppose that pig gender is associated with condition score and is a determinant of infection status. Assuming condition score is not an effect modifier; explain briefly the effect that gender may have on the measure of association between condition score and infection status as calculated from the study data.
e) Briefly explain how a multivariable analyses could be used to prevent the potential problem identified in part 1 d) (above).
f) Examine the following table and formula. These present details of a multivariable analysis for the data above.

Table 1: Results from a regression model.

Variable	Estimate (β)	Probability	Odds ratio (e^{β})	95% confidence interval (odds ratio)
Intercept	-0.39	<0.01	0.67	0.51-0.90
Gender	-0.26	0.13	0.77	0.54-1.08
Condition score	0.34	0.06	1.40	0.99-1.97

These results can also be described using this formula:

$$\log\left(\frac{\mathbf{P}}{\mathbf{1-P}}\right) = -0.39 - 0.26Gender + 0.34Condition\ score$$

where P is the predicted probability that the animal is a *Salmonella* spp. carrier.

i. State the type of multivariable model that has been used.
ii. Identify the outcome variable.
iii. Identify the explanatory variables.
iv. Describe whether the analysis identified any risk factors for the outcome that are significant at the 0.05 level. Justify your answer.

<u>2015</u>
- Answer **all** parts of this question:
    a) Explain the difference between parametric and non-parametric data. variables categorical).
    b) Give **two (2)** examples of appropriate statistical tests for **each** of these types of data and the relevant assumptions that apply.
    c) Specify the potential problems which may be associated with applying tests suitable for parametric data to non-parametric data.

2016

- Answer **both** parts of this question:
    a) List the types of outcome and explanatory variables that can be analysed using linear and binomial logistic regression. Describe how you would interpret coefficients from univariable linear and binomial logistic regression models for an explanatory variable of your choice.
    b) Define the term clustering. Give **two (2)** examples of clustered data and explain why veterinary epidemiologic data is often clustered.

Additional reading and resources

- Shott S (1990) Statistics simplified – Confidence intervals, Journal of the American Veterinary Medical Association, 197(5): 576-578
- Shott S (1990) Statistics simplified – Association, Journal of the American Veterinary Medical Association, 198(3): 404-407
- Shott S (1990) Statistics simplified – Nonparametric statistics, Journal of the American Veterinary Medical Association, 198(7): 1126-1128.
- Epidemiological Skills in Animal Health, PGFVS Proceedings 143; 215-222 (data types and descriptive statistics)
- Cameron A. et. al. (2004) Data management for animal health. AusVet Animal Health Services, Brisbane, Australia
- Salman MD et al. (1990). Data description. Journal of American Veterinary Medical Association 197: 36-38
- Shott S (1990). Confidence intervals. Journal of American Veterinary Medical Association 197: 576-578
- Epidemiological Skills in Animal Health, PGFVS Proceeding 143; pp 222-236 (analysing epidemiologic data)
- McDermott JJ, Schukken YH and Shoukri MM. Study design and analytic methods for data collected from clusters of animals. Prev Vet Med 18: 175-191
- McDermottt JJ. Schukken YH. A review of methods used to adjust for cluster effects in explanatory epidemiological studies of animal populations. Prev Vet Med 18:155-173
- Noordhuizen J, Frankena K, van der Hoofd C, Graat E (1997) Application of Quantitative Methods in Veterinary Epidemiology. Wageningen Pers, Wageningen pp 135 – 178 [logistic regression]
- Ottenbacher K, Ottenbacher H, Tooth L, Ostir G (2004) A review of two journals found that articles using multivariable logistic regression frequently did not report commonly recommended assumptions. Journal of Clinical Epidemiology 57, 1147 – 1152 [logistic regression]
- Noordhuizen J, Frankena K, van der Hoofd C, Graat E (1997), Application of Quantitative Methods in Veterinary Epidemiology. Wageningen Pers, Wageningen pp 179 – 214 [survival analysis]

12. Herd Health and Productivity or Performance

('herd' refers to a group of any domestic animals kept or reared together)

12.1. The candidate will have sound knowledge of herd health and productivity or performance.

12.2. The candidate will be able to do the following with sound expertise:

12.2.1. explain the links between health, productivity or performance and economics for a livestock enterprise

12.2.2. explain, using an example, the process involved in investigating unsatisfactory herd productivity or performance

12.2.3. for specific types of livestock enterprises, specify relevant health and productivity or performance indices and provide examples of how they are used practically

12.2.4. explain how to set and monitor health and productivity targets including critical points for decision making

12.2.5. describe and provide examples of quality assurance systems at the herd level

12.2.6. describe data collection processes for managing herd health, and provide an example in an industry nominated by the candidate.

Reading

1. Thrusfield 4th Edition: Chapter 26 – Health Schemes, pp. 586-603.
2. Green, M., Bradley, A., Breen, J., Higgins, H., Hudson, C., Huxley, J., Statham, J., Green, L., Hayton, A. (Eds.). (2012). Dairy herd health. Wallingford, UK: CAB International. Chapter 1 (generalizable to herd health for other farmed animals)

Presentations

(Recommend a whole meeting on this topic, or link with the economics meeting)

1. Rationale behind herd health programs: Describe links between health, productivity/performance and economics for livestock enterprises
   - Include application of examples on how to justify implementing a herd health program for pigs, beef, dairy, poultry, wool
2. Herd health principles: Basic principles for design, strategies, limitations and methods of monitoring success/progress
   - Include application to an example industry
3. Steps and principles to consider when investigating poor productivity in a herd
   - Include application to an example industry
4. Methods of collecting data, monitoring, and setting action points for herd health performance
   - Include example application to pig, beef, dairy, poultry and wool industries
5. Quality assurance systems at the herd level
   - Include application to an example industry

Exercises

1. As a veterinary practitioner, you are asked by a client to develop a herd health program for a farm in an industry of your choice. Provide an overview of how you

would do this, including design features and implementation. Focus on the epidemiological principles.
2. Describe and provide examples of quality assurance systems at the herd level for an industry of your choice.
3. Explain how to set and monitor health and productivity targets including critical points for decision-making, using examples from an industry of your choice.

Example examination questions

2013

- Disease can reduce productivity and profitability in livestock enterprises in many different ways. Using examples, describe at least five different ways that the productivity and profitability of a livestock enterprise may be compromised by disease.

2017

- Briefly describe a herd health program for an animal species/industry that you are familiar with. Explain in detail how data is collected and used in this herd health program including specific examples of performance or production indices.

Additional reading and resources

Species specific suggestions:

- Green, M., Bradley, A., Breen, J., Higgins, H., Hudson, C., Huxley, J., Statham, J., Green, L., Hayton, A. (Eds.). (2012). Dairy herd health. Wallingford, UK: CAB International.
- Youngquist, R. S., & Threlfall, W. R. (Eds.). (2007). Current therapy in large animal theriogenology (2nd ed.). St Louis, MO: Saunders Elsevier.

    - Ch 82 for Goats- pages 597-602
    - Ch 93 for sheep pages 701-714
    - Ch 61 for dairy cattle pages 473- 489
    - Ch 62 for beef cattle pages 490-496
    - Ch 110 for pigs pages 816-821

Industry examples and KPIs

- Industry specific websites: MLA, Dairy Australia, APL, ACMF

Quality assurance

Australian industry specific examples:

- www.apiq.com.au/
- https://www.mla.com.au/meat-safety-and-traceability/red-meat-integrity-system/about-the-livestock-production-assurance-program/lpa-quality-assurance/
- https://www.australianeggs.org.au/for-farmers/egg-quality-standards/

Food-safety specific examples:

- The seven principles of HACCP: https://www.foodsafety.com.au/blog/the-seven-principles-of-haccp
- Dairy Australia Food Safety Guide (2014), Dairy Australia
- OIE Guide to good farming practices for animal production food safety http://www.oie.int/fileadmin/Home/eng/Current_Scientific_Issues/docs/pdf/eng_guide.pdf

13. Surveillance and monitoring

13.1. The candidate will have sound knowledge of surveillance and monitoring.

13.2. The candidate will be able to do the following with sound expertise:

13.2.1. describe the various functions of monitoring and surveillance

13.2.2. explain key considerations when interpreting passively collected incident or prevalence data

13.2.3. provide examples of surveillance activities that contribute to early detection, to evaluation of current regional disease control programs, and to demonstration of disease freedom for diseases important in Australia or New Zealand selected by the candidate.

13.2.3.1. In these examples, describe the key components of the monitoring or surveillance activities that contribute to each function.

Reading

1. Thrusfield 4th Edition: Chapter 21 – Surveillance, pp. 457-492.
2. Cameron A (1999) Survey Toolbox, available from: http://resources.ausvet.com.au.s3.amazonaws.com/resources/Toolbox.pdf; Part 1 Chapter 2 'General principles of Animal Disease Surveillance', pp. 13-17
3. Sergeant & Perkins (2015): Chapter 12 – Animal health surveillance, pp. 192

Presentations

1. The definition of monitoring and surveillance, and a description of the various functions of each.
2. Passive and active surveillance: examples of types, advantages and disadvantages.
3. Interpreting passively collected incident or prevalence data and outline key considerations of each.
4. Evaluate current regional disease control programs to demonstrate freedom for diseases important in Australia and New Zealand. Describe key components of the monitoring or surveillance activities that contribute to each.

Exercises

1. Discuss national disease monitoring and surveillance programs (e.g. NTSESP, NAMP)
    a. https://www.animalhealthaustralia.com.au/wp-content/uploads/2015/11/NTSESP-Field-Guidelines-2015-16.pdf
    b. https://www.animalhealthaustralia.com.au/what-we-do/disease-surveillance/tse-freedom-assurance-program/surveillance-of-tses/
2. Discuss strengths and weaknesses of these examples of global animal disease surveillance systems:
    a. OIE WAHIS: http://www.oie.int/animal-health-in-the-world/the-world-animal-health-information-system
    b. FAO EMPRESi: http://empres-i.fao.org/eipws3g/

Example examination questions

2011

- Select an infectious disease exotic to either Australia or New Zealand and of importance to that country. Briefly describe surveillance activities that could be used to provide evidence

that the infectious agent(s) necessary for occurrence of your selected disease is/are not present in animals in that country. In your answer considering the key determinants of degree of confidence that an infectious agent is not present in animals in a region, identify both the key aspects of the agent(s) and the key features of the surveillance activities that affect the degree of confidence of freedom. Explain how these affect degree of confidence of freedom.

2016

- Discuss the differences between active and passive surveillance. Identify the advantages and disadvantages of both active and passive surveillance.

Additional reading and resources

- Animal Health Australia (2017). Disease Surveillance. Available from: https://www.animalhealthaustralia.com.au/what-we-do/disease-surveillance/ FAO-OIE-WHO (2017). The Global Livestock Early Warning System (GLEWS).
- Pfeiffer D (2009). Veterinary Epidemiology An Introduction. Chapter 9 'Disease surveillance and monitoring' pp 150-152
- Pharo H (2002). New Zealand declares 'provisional freedom' from hydatids. Surveillance
- Calba C et al. (2015). Surveillance systems evaluation: a systematic review of the existing approaches https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4418053/
- FAO, 2014. Risk-based disease surveillance – A manual for veterinarians on the design and analysis of surveillance for demonstration of freedom from disease. FAO Animal Production and Health Manual No. 17. Rome, Italy. http://www.fao.org/publications/card/en/c/1440fee4-be47-4d38-8571-4dad3f3036d6/
- OIE. Training Manual on Surveillance and international reporting of diseases in wild animals http://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Training_Manual_Wildlife_2.pdf

14. Animal Health Economics

14.1. The candidate will have basic knowledge of animal health economics.

14.2. The candidate will be able to do the following with basic expertise:

14.2.1. explain and give examples of the following economic methods/concepts: partial farm budgets, gross margin analysis, decision trees and payoff tables

14.2.2. describe the key steps and relevant concepts in conducting a cost-benefit analysis of an animal health program.

Reading

1. Dijkhuizen AA and Morris RS (1997) Animal Health Economics: Principles and Applications. PGFVS, University of Sydney, Chapters 1-4.
2. Thrusfield 4th Edition: Chapter 25 – Economics and veterinary epidemiology, pp. 565-586..

Presentations

1. Partial farm budgeting
2. Gross margins analysis
3. Decision trees and pay-off tables
4. Cost benefit analysis and cost effectiveness analysis
5. Describe the purpose and methods of a) sensitivity analysis and d) discounting in economic analyses

Exercises

1. Choose a management situation on a farm and as a group work out a partial farm budget for a particular change. Example: mastitis control program in a dairy herd.
2. Choose an animal disease and as a group work through a pay-off table or decision tree for different treatment options. Example: vaccination against clostridial diseases to prevent an outbreak of enterotoxaemia.
3. An exercise in Decision Analysis: When is Coronary Angiography required in aortic valve replacement? Available: https://www.med.illinois.edu/m2/epidemiology/DecisionAnalysis/

Example examination questions

2002

- Briefly describe the essential features and application of gross-margin analysis.

2007

- Write brief notes to explain your understanding of: The use of discounting in benefit cost analyses and Economic issues that may arise in large-scale national disease control programs.

2009

- Write brief notes to explain your understanding of: The internal rate of return of a project and Partial farm budgets.

2010
- Write brief notes to explain your understanding of: Net present value and Pay-off matrices

2011
- Using examples, briefly describe when partial farm budgets are an appropriate tool for economic evaluation of an intervention within a farm.

2013
- Discounting is used in some economic analyses. Define discounting and briefly describe why discounting is used in such analyses.

2015
- Disease can reduce productivity and profitability in livestock enterprises in many different ways. Using examples, describe at least five (5) different ways that the productivity and profitability of a livestock enterprise may be compromised by disease.

2016
- Explain the method of cost benefit analysis. Describe how a cost benefit analysis could be used for evaluating an animal health programme.

2017
- Nominate and describe an economic method that could be used to evaluate if a change in management practice for the herd health program of your choice is economically beneficial. Explain the basic steps and information needed to perform your economic analysis.

Additional reading and resources

- Rushton, J. (2009) The Economics of Animal Health and Production. CABI, UK.
- Rushton, J. et al (2016). Economics of Production Animal Health. http://www.oie.int/eng/vet-education-conf2016/Papers/3.1.%20Rushton.pdf
- Norton S, Groenendaal H and Heuer C (2005) Simulating control strategies for Johne's Disease on NZ dairy farms: effects on the prevalence and economic impact of disease. Proceedings of the Food Safety and Biosecurity and Epidemiology Branches of the NZVA, p.193-204. Available: http://www.albanyrecreation.ac.nz/massey/fms/Colleges/College%20of%20Sciences/Epicenter/docs/ASVCS/Norton_et_al_2005.pdf
- Swinkels JM, Zadoks RN and Hogeveen H (2005) Use of partial budgeting to determine the economic benefits of antibiotic treatment during lactation of chronic subclinical mastitis caused by *Staphylococcus aureus*. In: Mastitis in dairy production – current knowledge and future solutions, p. 217-223.
- Otte MJ and Chilonda P. Animal Health Economics: an Introduction. Available: http://www.albanyrecreation.ac.nz/massey/fms/Colleges/College%20of%20Sciences/Epicenter/docs/ASVCS/Otte_Chilonda_2000.pdf
- Martin, Meek and Willeberg Chapter 9 (animal health economics)
- Stevenson MA, Frey B and Morris RS (1996) Decision Making in Veterinary Practice: Economics made easy. AAPV- NZPVS 2nd Pan Pacific Program; pp 57-64.

- Dijkhuizen, A. A., R. B. M. Huirne, and A. W. Jalvingh (1995) Economic analysis of animal diseases and their control. Preventive Veterinary Medicine 25.2, 135-149.

15. Risk Analysis

15.1 The candidate will have sound knowledge of risk analysis.

15.2 The candidate will be able to do the following with sound expertise:

15.2.1 Describe the major steps in undertaking a risk analysis

15.2.2 Outline the key differences between qualitative, semi-quantitative and quantitative risk analysis and the main strength and weaknesses of the different approaches

15.2.3 Apply the principles of risk analysis to many specific scenarios – regional risk analysis; application of biosecurity to regions/localities/individual enterprises/components within an enterprise.

Reading

1. Sergeant (2015) Chapter 14 (Introduction to Risk Analysis), pp. 247 – 273.
2. OIE (2015) Chapter 2.1 (Import Risk Analysis), pp. 1-5: http://www.oie.int/fileadmin/Home/eng/Health_standards/aahc/2010/chapitre_import_risk_analysis.pdf
3. Australian animal import risk analyses: varied disease/commodities http://www.agriculture.gov.au/biosecurity/risk-analysis/animal (The pig and chicken meat are good examples of IRA)
4. Department of Agriculture and Water Resources; June 2016. Available at: http://www.agriculture.gov.au/biosecurity/risk-analysis/guidelines
5. Qualitative risk assessment: risk of chronic wasting disease being introduced into Great Britain (2018) https://www.gov.uk/government/publications/qualitative-risk-assessment-risk-of-chronic-wasting-disease-being-introduced-into-great-britain
6. Hernandez-Jover M et al. (2015). Evaluating the risk of avian influenza introduction and spread among poultry exhibition flocks in Australia. Prev Vet Med 118: 128-141

Presentations

1. List and describe the major steps in undertaking a risk analysis.
2. List and describe the four phases of risk assessment in risk analysis.
3. Define, briefly describe their use, and list the advantages and disadvantages of the following:
    a. Qualitative risk analysis
    b. Semi-quantitative risk analysis
    c. Quantitative risk analysis

Exercise

Using an example, draw a release and exposure scenario for the importation of a live animal/commodity.

Example examination questions

2002

- As a government epidemiologist, you have been asked to undertake an import risk assessment for the importation of horse semen from South America. Describe how you would proceed.

2003

- Using examples, write brief notes on the advantages and constraints of quantitative risk analysis models.

2005

- The risk of animal or zoonotic disease is an important consideration for countries importing agricultural products. Under the WTO-SPS Agreement, it is important that any restrictions placed on trade for animal, plant or human health are based on international standards or on the outcomes of a scientifically sound import risk analysis. It is also important that countries considering health risks do so in a way that is consistent across all imports.

  - The OIE Terrestrial Animal Health Code (the Terrestrial Code) provides protocols relating to the management of the risks associated with a range of important diseases. The Terrestrial Code also provides an explanation of the steps required for a scientifically sound import risk analysis, for those cases where disease-specific protocols do not exist or are not considered sufficient to meet an importing countries accepted level of risk. Explain the key steps in carrying out an import risk analysis, as described in the Terrestrial Code.
  - One of the questions facing import risk analysts is the decision to carry out qualitative or quantitative assessment of likelihood. What do you see to be the advantages and constraints of each approach, and in what situations might each be most appropriate?
  - A critical step in any import risk analysis is the evaluation of a risk estimate. What do you feel to be the important components of an import risk estimate? How might these components be combined? How might the import risk estimate be evaluated? In answering these questions, consider methods or approaches for qualitative and quantitative components, as you see relevant.
  - A final step in many import risk analyses is the specification of risk management options. What do you understand by the principle of 'least trade restrictive' measures, and how would you ensure that these were specified? What do you understand by the principle of equivalence?

2007

- Write brief notes to explain your understanding of the advantages and limitations of qualitative risk analysis.

2010

- Write brief notes to explain your understanding of risk assessment.

2011

- Briefly explain, with diagrams as appropriate, the purpose of risk analysis for the importation of animals into Australia or New Zealand, and steps involved in undertaking such a risk analysis.

2017

- List and describe the steps required to conduct an import risk analysis (IRA). Use one (1) example of an IRA to aid your description.

Additional reading and resources

- World Organisation for Animal Health (OIE) (2010). Handbook on Import Risk Analysis for animals and animal products, Volume 1: Introduction and qualitative risk analysis
- Hernández-Jover M, Schembri N, Holyoake PK, Toribio J-ALML and Martin PAJ (2016). A Comparative Assessment of the Risks of Introduction and Spread of Foot-and-Mouth Disease among Different Pig Sectors in Australia. Front. Vet. Sci. 3:85. doi: 10.3389/fvets.2016.00085
- Santman-Berends IMGA et al (2017). A quantitative risk-analysis for introduction of Bovine Viral Diarrhoea Virus in the Netherlands through cattle imports. Prev Vet Med 146: 103-113

16. Epidemiological Modelling

16.1 The candidate will have basic knowledge of epidemiological modelling.

16.2 The candidate will be able to do the following with basic expertise:

16.2.1 Outline the key differences between different types of disease-spread models

16.2.2 Describe the stages in model development and assessment

16.2.3 Describe the strengths and weaknesses of commonly used epidemiological models for particular purposes

16.2.4 Provide examples of applications of commonly used epidemiological models and explain the purposes of these models

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Reading

1. Garner, M.G. and Hamilton, S.A. (2011) Principles of epidemiological modeling. *Rev. sci. tech. Off. int. Epiz.(OIE)*, 30 (2), 407-416.
2. Thrusfield 4th Edition: Chapter 23 – Mathematical modelling, pp. 520-539.
3. Dohoo 2nd Edition: Mathematical modeling of infectious disease transmission, pp. 721 – 724.0.
4. Ward, M.P., Garner, M.G., Potts, J.M., Cowled, B.D. (2017) Chapter 7 Models for Understanding Disease Dynamics. In: A.P. Robinson, T. Walshe, M.A. Burgman, M. Nunn (Eds). *Invasive Species*. Cambridge University Press, ISBN 978-0-521-76596-1, pp. 152–180.

Presentations

1. List and describe examples of where modeling has been useful in devising methods to control disease or conduct surveillance in animal populations (e.g. foot-and-mouth disease, classical swine fever, rabies, bluetongue virus, screw-worm fly).
2. Discuss advantages and disadvantages of modelling approaches (noting categories are not mutually exclusive), with examples:
    a. Mathematical vs simulation models
    b. Deterministic vs stochastic models
    c. Spatial vs non-spatial models
    d. Network vs non-network models.
3. Discuss, with examples, this comment by Thrusfield: “Models cannot stand alone in determining efficient control strategies, but should be used in conjunction with accurate field data and experimentally derived data relating to the diseases natural history”.

Exercises

1. A ten-stage process for developing models is proposed by Garner and Hamilton (2011). Using this process, develop (on paper/whiteboard) a model for the spread of disease of an infectious disease relevant to your work. What inputs need to be included, what outputs would you like to generate and how could the model assist you to make decisions?
2. Consider a pest or disease scenario with which you are familiar:
    a) For your chosen scenario, choose a modelling approach
        i. Mathematical model

- Reed-Frost model
- Differential equation model

ii. Simulation model
- Individual based model
- Meta-population based (hybrid) model

iii. Spatial model
- Cellular automata
- Spatial kernel based model

iii. Social contact networks model

b) Describe one or more research questions that could be addressed using this approach
   i. What do you see to be the strengths of your chosen approach?
   ii. What do you see to be its pitfalls or weaknesses?
   iii. Could other modelling approaches have been used to address the same questions?

3. Compare the potential uses and limitations of a Reed-Frost model with a hybrid model like the Australian Animal Disease model (AADIS) discussed in the paper below by Bradhurst et al (2015).
4. What is sensitivity analysis and how is this used in disease modelling? What are the practical applications of a model sensitivity analysis?
5. Give an example of how a model is used to:
   a) test 'what if' questions
   b) provide advice on risks associated with emerging and foreign animal diseases
   c) assess the potential size and economic impact of diseases
   d) evaluate control strategies
   e) assess the effectiveness of surveillance programmes
   f) provide inputs for training activities.

Example examination questions

2005
- Briefly describe the essential features, applications and limitations of epidemiological simulation models.

2007
- Write brief notes to explain your understanding of Reed-Frost models.

2010
- Write brief notes to explain your understanding of **one (1)** of the following:
  a) sensitivity analysis of epidemiological simulation models
  b) the application and limitations of decision analysis.

2013
- Simulation models are commonly used in epidemiology. Various approaches can be used when constructing such models, and simulation models can be categorised based on the ways they are constructed. Discuss categorisation of simulation models based on the ways they are constructed.

2015
- Sensitivity analysis is commonly used during the development of epidemiological simulation modelling:
  a) Define simulation modelling

b) Define sensitivity analysis
c) Explain why sensitivity analysis is used in simulation modelling.

Additional reading and resources

- Bradhurst et al (2015) A hybrid modeling approach to simulating foot-and-mouth disease outbreaks in Australian livestock. *Frontiers in Environmental Science.* 3:17. doi: 10.3389/fenvs.2015.00017.
- Johnstone-Robertson SP, Fleming PJ, Ward MP, Davis SA (2017) Predicted spatial spread of canine rabies in Australia. *PLoS Neglected Tropical Diseases*. ; 11(1): e0005312. doi:10.1371/journal.pone.0005312
- Kelso JK and Milne GJ (2014) A spatial simulation model for the dispersal of the Bluetongue vector *Culicoides brevitarsis* in Australia. *PLoS ONE* 9(8): e104646. doi:10.1371/journal.pone.0104646
- Stevenson et al (2013). InterSpread Plus: a spatial and stochastic simulation model of disease in animal populations. *Preventive Veterinary Medicine*, *109*(1-2), 10-24.
- Review of the use of epidemiological models in informing disease control policy development and adjustment (London, DEFRA, 2003). URL: https://pdfs.semanticscholar.org/c8dc/8214ec760f8cd73f164e83aea403a98e54bb.pdf
- De Jong M (1995) Mathematical modelling in veterinary epidemiology: why model building is important. *Preventive Veterinary Medicine* 25: 183-193.
- Hurd H and Kaneene J (1993) The application of simulation models and systems analysis in epidemiology: a review. *Preventive Veterinary Medicine* 15: 81 - 99.
- The World Organisation for Animal Health (OIE). Models in the management of animal disease (2011). P. Willeberg (ed). Rev. sci. tech. Off. Int. Epiz, volume 30, number 2, pp. 1-643.

17. Spatial Epidemiology

17.1. The candidate will have basic knowledge of spatial epidemiology.

17.2. The candidate will be able to do the following with basic expertise:

17.2.1. describe the components of a geographic information system (GIS)

17.2.2. describe several applications of GIS for epidemiological purposes.

Reading

1. P Durr and T Gatrell (2004). GIS and Spatial Analysis in Veterinary Science. Chp. 1 The Tools of Spatial Epidemiology: GIS, Spatial Analysis and Remote Sensing. Pp. 1-33. (https://www.cabi.org/cabebooks/FullTextPDF/2004/20043183502.pdf)
2. Dohoo 2nd Edition: Chapter 25 – Analysis of spatial data: Introduction and Visualisation, pp. 663-704; Chapter 26 – Analysis of spatial data.
3. Thrusfield 3rd Edition: Chapter 4 – Describing disease occurrence - Mapping; Chapter 8 – Patterns of disease - Trends in the spatial and temporal distribution of disease.
4. Sergeant and Perkins: Chapter 15 – Spatial epidemiology, pp. 274-285.

Please note that only basic knowledge and skills are required for Spatial Epidemiology and it is not expected that the candidate will have the ability to conduct a spatial analysis. The readings should be considered only as they relate to understanding and knowledge on spatial analysis but not for demonstrating spatial analysis skills.

Presentations

1. Describe, using an exotic disease, how different types of spatial data could be visualised and used in a GIS to produce risk-maps, and how this could assist with:
    a. preparedness and response policy development during 'peace-time'
    b. decision-support during an outbreak (including limitations).
2. Discuss, using an endemic disease example, ways to identify spatial and temporal clustering using a GIS, and how this knowledge could assist with surveillance program design.
3. Choose a pest or disease issue that you are reasonably familiar with. Discuss an approach to identify significant spatial risk factors in an investigation.

Exercises

1. Imagine if John Snow had been able to use a modern GIS during his 1854 cholera outbreak investigation in London: describe the basic components of a GIS to him, and explain the types of data layers and spatial queries he could have used.
2. Using one of the listed peer-reviewed papers, explain how the use of a GIS assisted with the disease investigation. Describe the types of data used in different layers, and whether querying areas of intersection (overlay analysis) identified anything of interest.

Example examination questions

2003
- Briefly describe the essential features and application of geographic information systems.

2009
- Write brief notes to explain your understanding of how spatial mapping of disease is used in disease investigation and mitigation.

2011
- List three (3) main applications of spatial analysis in veterinary epidemiology. For one (1) of these applications, explain the objective of the analysis. Describe an example of the use of spatial analysis for this application.

2013
- Briefly describe two (2) examples of how geographic information systems (GIS) have been or could be applied for epidemiological purposes.

Additional reading and resources

- Dougherty et al (2018). Going through the motions: incorporating movement analyses into disease research. *Ecology letters*, *21*(4), 588-604. https://www.biorxiv.org/content/biorxiv/early/2017/12/22/237891.full.pdf
- Rahman et al (2017). Fascioliasis risk factors and space-time clusters in domestic ruminants in Bangladesh. *Parasites & Vectors*, *10*(1), 228. https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-017-2168-7
- Martin et al (2016). Climatic suitability influences species-specific abundance patterns of Australian flying foxes and risk of Hendra virus spillover. *One Health,* 2**,** 115-121. https://www.sciencedirect.com/science/article/pii/S2352771416300015
- Plowright et al (2015) Ecological dynamics of emerging bat virus spillover. *Proceedings of the Royal Society B*, 282, pp. 2014 - 2124; DOI: 10.1098/rspb.2014.2124. http://rspb.royalsocietypublishing.org/content/282/1798/20142124.full
- Selemetas et al (2015). Spatial analysis and risk mapping of *Fasciola hepatica* infection in dairy herds in Ireland. *Geospatial Health*, *9*(2), 281-291.
- Stevens, K. B., & Pfeiffer, D. U. (2015). Sources of spatial animal and human health data: casting the net wide to deal more effectively with increasingly complex disease problems. *Spatial and Spatio-temporal Epidemiology*, *13*, 15-29.
- Ward, M.P. et al (2013) Salmonella infection in a remote, isolated wild pig population. *Veterinary Microbiology* 162, 921-929.
- Pfeiffer, D.U., Robinson, T.P., Stevenson, M., Stevens, K.B., Clements, A.C.A. and Rogers, D. (2008) *Spatial analysis in Epidemiology.* Oxford University Press, Oxford, U.K.

Meeting 18: Preparation for oral examination

Preparation for oral exams is difficult. It is suggested that you go through all the questions in the written papers that you have just attempted. The aim of this is to prepare for any questions at the oral that may arise from the written papers. Examiners may raise areas in the written exam where the answers were confused or incomplete and require clarification so that the examiners may fully assess the candidate's knowledge.

A series of practice questions are below. These could be photocopied and cut into separate strips. Questions could then be randomly selected for individual group members to attempt.

Oral examination practice questions:

1. Give a definition of test Se, Sp, PPV, NPV and describe the effect of the prevalence of disease on these values.
2. How can you improve the PPV or NPV?
3. Describe the important attributes of screening tests
4. What are the important features of tests used at the beginning and the end of an eradication program? How might you improve the test performance at the end of the eradication program?
5. How would you compare two diagnostic tests?
6. What is the difference between precision and accuracy of diagnostic tests?
7. What is an ROC curve and what is it used for?
8. Define and give an example of a risk, rate, ratio and proportion.
9. Discuss the various sampling methods that can be used, their application, advantages and disadvantages?
10. What are the different types of data that may be collected? What are the most appropriate methods of presenting each type?
11. What are the application, advantageous and limitations of parametric and non-parametric test? Give 2 examples of each type of test.
12. Describe the application, advantages and limitations of meta-analysis.
13. Describe the application, advantages and limitations of survival analysis.
14. Describe the application, advantages and limitations of sensitivity analysis.
15. Describe the circumstances where collection of data on disease occurrence from an abattoir would be appropriate. What are the limitations of this method?
16. What response rate would you expect from a mailed-out survey? How could this be improved?
17. What type of bias is most likely to affect case-control studies?
18. What type of bias is most likely to affect cohort studies?

19. When perusing the AVJ or another veterinary journal what criteria do you use to critically assess the articles?

20. Define the null and alternative hypothesis.

21. What is a p value and how is it determined?

22. Define selection bias and what actions can be undertaken to prevent it?

23. Using the 2 X 2 table (below) show how to calculate RR, OR, AR and AF.

	D+	**D-**
E+	**a**	**b**
E-	**c**	**d**

24. What roles might an epidemiologist play on an Animal Ethics Experimentation Committee?

25. Your help has been sought to evaluate the efficacy of a new ovine footrot vaccine. The new vaccine has performed well in experimental challenge studies. What issues would you consider?

26. You are interested in the usefulness of leptospirosis serology in detecting renal colonisation with leptospires at the time of blood sampling. Consider the following data from a cross- sectional study of chopper dairy cows from Victoria. Cows were blood sampled at slaughter for leptospirosis serology and kidneys removed for extensive culture and other bacteriology for detection of leptospires**:**

Number of cows by serological result and renal leptospirosis status

Serological result	Renal leptospirosis status		
	+	-	Total
+	550	250	800
-	70	130	200
Total	620	380	1,000

a) Calculate the following for the serological test: positive predictive value, negative predictive value, true prevalence, apparent prevalence, sensitivity, and specificity.

b) How would you expect the negative predictive value and positive predictive value of the serological test to change if the true prevalence was 1/10 of that observed in the current study? Recalculate both of these using the table for 1,000 cattle as above, with the true prevalence 1/10 of that shown above.

27. Authorities in Australia plan to introduce a valuable bull from a country where several diseases exotic to Australia occur either sporadically or endemically. Diagnostic tests will be used to assess the bull's status for each disease of concern. How important are positive predictive value and negative predictive value to the Australian authorities.

28. How might an importing country reduce the risk of introducing infectious disease in

imported animals?

29. Despite accepting horses from countries where equine influenza has occurred, Australia does not want to introduce the virus. What issues do you need to consider before undertaking a risk analysis for the importation of horses from such countries?

30. Farmers consider that more cancer eyes are occurring in cattle in their region and are blaming the coal dust from the local coal mine. How would you investigate this?

31. How would you monitor the frequency of Johne's disease in a cattle population in a region of Victoria?

32. How might you prove that a region of Western Australia is free of ovine Johne's disease?

33. What are the pieces of information required to calculate sample sizes for: a) Estimating the prevalence of a disease in a population b) Detection of disease in a population, and c) A proposed observational study to investigate the association between a dichotomous exposure and a dichotomous outcome?

34. Some kangaroos in the Grampians National Park in Victoria are regularly fed bread by well- meaning tourists. Government rangers suspect that they see excess lumpy jaw amongst kangaroos fed bread. The results shown below are from a cohort study assessing the effect of bread feeding of kangaroos on the incidence of lumpy jaw. A total of 982 initially unaffected kangaroos were all observed for a 2 year period

    a) Which of the following indices can be appropriately calculated from this data? Odds ratio, relative risk, attributable rate, population attributable risk
    b) Where calculation is appropriate, calculate them.

Number of kangaroos observed and affected by lumpy jaw in a cohort study

		Number enrolled	**New cases of lumpy jaw**
Fed bread?	**+**	**213**	**9**
	-	**769**	**7**

c) What statistical test(s) would be appropriate for analysis of this data?