3.1 DISEASE RISK ANALYSIS

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Additional material from the following sources:
- Thursfield M (2007). Veterinary Epidemiology (3rd Ed) Blackwell Publishing
- Travis D (2005) Veterinary Risk Analysis Lecture notes. PASA 2005 veterinary workshop

Figure 1. Risk of disease occurs where you have a hazard, (we will mainly be talking about pathogens here, but this could equally be something non infectious, such as too much sugar in the diet), a vulnerable population, who are then exposed to that hazard.

3.1.1 What Is Risk?

Risk is the likelihood of the occurrence and the magnitude of the consequences (severity) of an adverse event – for this you need a vulnerable population and the possibility of exposure, to a particular hazard (Figure 1). That is, risk is a measure of the probability (likelihood) of harm and the severity of the impact of a hazard. In veterinary risk analyses, hazards are usually a pathogen (e.g virus) or a clinical sign (e.g pneumonia). Objective measurement and scientific repeatability are key features of risk evaluation. In risk studies it is common, especially when discussing the risk orally, to use the term ‘risk’ synonymously with the likelihood (probability or frequency) of the occurrence of a hazardous event. In such instances the magnitude (severity) of the event is assumed to be significant.
3.1.2 Risk Analysis and Uncertainty

There is often a large degree of uncertainty in deciding what is going to be a problem disease for your animals, and what may not be. Often information on disease risk and population health is scanty at best. By working through a risk analysis process, the aim is not only to highlight what we do know, or strongly suspect, but also where we need to focus our research efforts, to find out what we don’t know. Risk analysis is a formal procedure for estimating the likelihood and consequences of adverse effects occurring in a specific population, taking into consideration exposure to potential hazards and the nature of their effects. This includes the management (usually reduction) of the likelihood of exposure.

Risk analyses are used widely in finance (e.g. to control either an individual’s or companies chance of losing on an investment), in environmental science (e.g. to estimate hazards associated with contaminants or other environmental conditions, as they affect exposed humans, animals, or selected elements of an ecosystem), and in engineering (e.g. to study the safety of nuclear reactors).

Risk analysis is now applied to a wide range of veterinary issues. A major area is import risk analysis (reducing the risk of importing disease into an area). Examples include:

- Importation of Foot and Mouth Disease into the UK and South Africa (www.defra.gov.uk/animalh/diseases/monitoring/pdf/fmd_rsa.pdf)
- Importation of rabies into New Zealand (http://www.biosecurity.govt.nz/regs/imports/ihs/risk)
- Transmission of bovine tuberculosis from badgers to cattle in the UK (www.defra.gov.uk)
- Public health and animal health risks associated with Highly Pathogenic Avian Influenza around the world (Protocols in bundled notes on the workshop DVD under Avian Influenza)
This process has huge scientific merit when dealing with wildlife disease, as it provides a framework that can be followed when investigating disease.

3.1.3 Zero Risk in Veterinary Medicine?

No situation, in veterinary medicine especially, is without risk. Thus it is untenable to adopt a ‘zero risk’ approach. For example, it is unrealistic to aim for the absence of parasites in the primates in your sanctuary. So effective control of parasites must be tackled by identification of those animals that pose a risk, and management of the risk at critical stages through the year (or the parasites life cycle), and perhaps concentrating on biosecurity protocols to reduce spread of parasites.

Although we will be dealing primarily with infectious disease in this discussion, don’t forget non infectious disease risk (as part of your preventative health plan). For example, malnutrition from either too little food, or the wrong type of food, or too much food and getting like the guys in figure 4.
Veterinary risk analyses frequently report risk in terms of likelihood, but exclude severity from the assessment. This is often because severity may be very difficult to assess, due to the quality of the data available, or it is assumed that the severity will be high. For example, likelihood of diabetes in sanctuary gorillas may be negligible, but the likelihood of pneumonia in chimpanzees in the rainy season may be high. The severity of these two disease conditions may vary, but we often don’t have the data to be able to quantify this, so we are more likely to investigate issues with pneumonia in chimps, because that is more likely than diabetes in sanctuary gorillas.

3.1.4 What Level Of Risk Is Acceptable?

This will vary with the assessment of each pathogen or group of pathogens. Thus, the results of risk assessments need to be meaningfully interpreted so that appropriate risk management strategies can be adopted.

We MUST be aware of the limitations of risk analysis which may pose more questions than it answers – indeed it is an important function of risk analysis to identify what is not known. The results of risk analyses may be founded on invalid assumptions, and frequently there may be uncertainty attached to the hazards and processes for which risk is being assessed. Moreover, because the severity of a potential risk is often difficult to quantify, it is often only possible to produce a relative ranking of the likelihood of the events, rather than accurate assessments.

Nevertheless, risk analysis has a valuable role to play in identifying and managing risk in many areas of veterinary medicine, rather than attempting to pursue a ‘zero-risk’ strategy, which would not be amenable to changes in the light of new knowledge, economic circumstances, or political requirements.
3.1.5 Risk Analysis Basics

Figure 5. In its most basic form, a risk analysis consists of assessment to base management on, all of which is communicated to relevant parties effectively. This structure follows the OIE model of how the components of the risk analysis relate to each other. For more information on this, visit the OIE website www.oie.int

Figure 6. Feedback model to help inform policy decisions

Figure 6 illustrates a basic feedback model to help inform policy decisions. For example, the policy may be ‘your sanctuary is proposing to minimise the risk
of diseases of concern in release chimpanzees’. By working through this model you can help pinpoint areas to help that policy become successful. The same would apply if you were updating the biosecurity protocols for your sanctuary, where the policy may be ‘your sanctuary minimises parasite burdens to reduce the risk of clinical disease’. Thus, you want what you do to be scientifically based, for it to be best effective ‘in the real world’. A risk analysis provides a framework to work through a disease issue scientifically. However, for it to inform a model that allows accurate and useful decision making, data is required. For veterinary disease investigations this data comes from surveying and monitoring your animals for your diseases and health issues of concern. This information can also be enhanced from local public health, conservation and agricultural projects.

WHAT ARE SOME OF THE POLICIES/ VETERINARY ISSUES AT YOUR SANCTUARY THAT MAY BENEFIT FROM THIS PROCESS?

Mapping the Pathway

WILD

CONFISCATION/RESCUE

SANCTUARY

PRE-RELEASE

RELEASE

Figure 7. Mapping the pathway of a primate from the wild, to a sanctuary, and back into the wild via a release programme
As a first step – mapping the pathway of the policy you are trying to perform is essential. In the basic example of figure 7, a chimpanzee going from the wild, through rehabilitation, to release could be said to follow a pathway to release. By going through this process, you can remain focused on what areas may need monitoring for disease. You can also highlight where diseases (hazards) might crop up and cause a problem for your policy, but more on that later. PASA examples of mapping the pathway are shown at the end of this section (3.1.11)

3.1.6 Data Input – Qualitative Vs. Quantitative

The data that will be inputted into your model, and thus reduce the uncertainty of your analysis will be either qualitative or quantitative.

Qualitative data is information that is difficult to measure, count, or express in numerical terms. For example, data which measures intangible or objective data, such as peoples’ attitudes and opinions, is qualitative.

Quantitative data is numeric information including quantities, percentages, and statistics.

When embarking on a disease investigation and risk analysis in non human primates, most of the data we have will be qualitative. However, as diseases are investigated more methodically (thanks to your good work!), the data gathered becomes more quantitative, thus reducing the uncertainty in any risk analysis we are performing. This also makes the risk analysis more precise – but does this also mean quantitative data will increase its accuracy? As sanctuary vets, you are on the cutting edge for obtaining this more quantitative data!

3.1.7 Risk Analysis – Asking The Right Questions.

Risk Assessment
   What are the potential problems (hazards)?
   How important are they?
   When, where and how likely are they to occur?
Risk Management
   What can we do about them?
   How well will it work?
   How sure are we about our predictions?
Risk Communication
   Do the relevant people know about the risks and options?

The questions above outline the basic components of a risk analysis. Figure 12 specifically relates these questions to a disease investigation scenario. Note that the data for the actual assessment may be either qualitative (high, medium or low) or quantitative (probabilities, percentages etc). It also highlights that management of diseases need not only be of a medical origin. Wildlife law and regulation also have a role to play, especially in managing exotic disease.
3.1.8 Hazard Identification and Risk Assessment

What follows are the steps involved in hazard identification and risk assessment.

**Hazard Identification** – To start the process you first need to know what hazards (pathogens) are relevant. This process is of course ongoing, as new information becomes available. Your hazard list will be based on published material, discussion with experts, sanctuary records, what is found in the local area etc.

**Hazard characterisation** – Using your qualitative and quantitative data to characterise the hazard to the maximal level of precision known. For example, if the hazard is tuberculosis, can you say that the risk of TB in your sanctuary is low, or that the risk of importing TB into your sanctuary is high because the prevalence in the local area is 20%, or can you say 2 of the last 100 animals imported had confirmed TB, therefore the risk is moderate.

**Release assessment** – What happens when the pathogen gets out into the world? That is, what would be the consequences of you missing this hazard and it then being released in the wild? This where scenario trees, (a simple example is given in Figure 9), can come in useful.
**Risk Assessment**

**Decision Tree Analysis for Assessing Potential Pathogen Introduction Through Reintroduction of Primates**

1. **Hazard (A)**: Does it cause high mortality in spp. of concern?
   - Yes: Examine for potential introduction.
   - No: Proceed to next step.

2. **Hazard (B)**: Does it cause high morbidity in spp.?
   - Yes: Examine for potential introduction.
   - No: Proceed to next step.

3. **Hazard (C)**: Does it cause disease in primates? Is it zoonotic?
   - Yes: Examine for potential introduction.
   - No: Proceed to next step.

**Potential Hazard:**

- Yes: Identify as a hazard.
- No: Not identified as a hazard for this assessment.

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**Exposure assessment** – This means using whatever data you have to be able to assess the magnitude, frequency, duration and route of exposure of humans or animals to hazards. The assessment should also describe the size and nature of the population at risk. An assessment of the risk associated with the unrestricted importation of animals into the sanctuary for example, would consider the prevalence of pathogens in the source population, the probability of the pathogens surviving during importation, and the probability of the pathogens coming into contact with the animals and workers in the sanctuary. This information assists with mapping the pathway, because you can highlight points of entry for each disease of concern (see figure 15 and section 2.11).

**Risk characterisation** – This is the final part of the assessment and is a description of the nature and magnitude of risk, either to health or the environment. The description combines results of hazard identification, hazard characterisation, release assessment and exposure assessment.
Figure 10. Primate diseases of Concern, categorised as high, medium, or minimal threats using a ‘traffic light’ colour system, based on the epidemiological assessment questions. The ranking of each category is from 1 (lowest significance) to 5 (highest significance) and is based on literature reviews and field data.

Many of you will be familiar with the list of diseases of concern in Figure 10, which is an example of combining hazard identification, hazard characterisation and exposure assessment to provide a risk characterisation by ranking, providing the sanctuary with a ranked ‘Diseases of Concern’ list.
WHAT ARE SOME OF THE DISEASES OF CONCERN FOR YOUR SANCTUARY?

WHY HAVE YOU CHOSEN THESE DISEASES?

WHAT IS THE EVIDENCE FOR THEM BEING A RISK?

By going through this risk analysis process, 3 areas for error can be highlighted – variability, uncertainty and subjectivity.

**Variability** – is the inherent variation in biological systems (which can be managed by statistical manipulation). Variability will exist, even if there is complete knowledge of a situation. For example, it may be known that disease is present in the country, but the prevalence may be based on a sample survey, (a subset of the population), giving rise to a point estimate and a confidence interval for the prevalence of disease in the population as a whole. Thus while studies show a country may have a 20% prevalence for TB for instance, it is acknowledged that there will be a local variability of the risk of TB within a country or region. For example TB prevalence in Africa is assessed in this way.

![Figure 11. TB prevalence around the world – data based on surveys, rather than whole population census.](image)

**Uncertainty** – this indicates ignorance. That is, a lack of knowledge of the disease status of a country. So this can be reduced with time as more data are collected and more research is conducted. For example – We are still uncertain as to the identification of the definitive hosts of ebola.

![Figure 12: We are still uncertain as to the definitive host of ebola. Here are some potential candidates.](image)
Subjectivity - Risk Analyses are always subjective, as the questions to be asked in risk analysis involve judgement, which is subjective. Therefore, to reduce subjectivity, all risk analyses should be fully documented and independently peer reviewed.

Figure 13. Deciding on who is most evolved will depend on your subjective point of view
3.1.8.2 Uncertainty
Revisited

One of the major objectives of a risk analysis is to highlight areas of uncertainty

Table: Parasitology findings

<table>
<thead>
<tr>
<th>Group</th>
<th>Adult (release group) (7-19yrs)</th>
<th>Petit (4.5-8.5yrs)</th>
<th>Quarantine (1.5-8yrs)</th>
<th>Nursery (1.5-2.5yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

Fasciola spp: 10% 40% 100% 100%
Entamoeba coli: 0% 75% 10% 0%
Troglodytella spp: 20%
Entamoeba spp: 42%
Giardia: 3/15 scanty
Hookworm: 2/15 scanty

FINDING OF UNDETERMINED SIGNIFICANCE – change in risk analysis required. *Dientamoeba fragilis*, a potential pathogen thought to be associated with irritable bowel syndrome in humans, was found in one member of the petit group (not for release), and 1 staff member.

Figure 14. Slide highlighting parasitological findings from a survey conducted at the Centre for Chimpanzee Conservation

Figure 14 highlights some of the parasitological findings from the Centre for Chimpanzee Conservation in Guinea. It indicates that a protozoa of uncertain significance, *Dientamoeba fragilis*, was found. It also highlights UNCERTAINTY in the significance of the protozoa. This parasite could pose a major threat to the CCC reintroduction plans (it doesn’t!). This new potential hazard can be inserted into the model, and further data gathered on what is known about the parasite (hazard characterization). It can then be integrated into, or discarded from, the diseases of concern list.
3.1.9 Risk Management

Risk management can be prioritised by creating a risk matrix (Figure 15). For example, for the new Gorilla Rehabilitation Centre near the Tayna Nature Reserve in DRC, the likelihood of Ebola at the Centre might be considered medium or high, and the severity would also be high, based on what we know about the pathology of this disease. Therefore it is a disease of high concern. However, if this matrix was at Chester Zoo in the UK, although the severity for Ebola would still be very high, the likelihood would be very low (we don’t currently import animals from ebola areas!). There is software available to assist in the development of risk matrices. For now, it is enough for you to know that risk matrices exist, and they may be a useful tool in risk management.

Figure 15. Risk Matrix for various primate diseases
Disease Category | Antigen | Species | Clinical Signs | Diagnostics | For each sample, what type of conservation? | For each sample, what type of conservation? | Test as part of normal protocol (T), test in face of outbreak (S) | Notes
---|---|---|---|---|---|---|---|---
Viral Hepatitis A,B,C | All | L | Various, liver associated | Serology | Serum/plasma (EDTA) | Freezing, months | N/A | T (Hep A and B only)
Encephalomyocarditis virus | All | M | Sudden death | Histopathology | N/A | Formalin, months | N/A | More info?? S
SIV/HIV | Chimpanzees | L | Usually asymptomatic | Serology | Serum/plasma (EDTA) | Freezing, months | N/A | T
STLV | Chimpanzees | L | Usually asymptomatic | Serology | Serum/plasma (EDTA) | Freezing, months | N/A | T
Ebola/ Marburg | All | M | Sudden death | Serology | Serum/plasma (EDTA) | Freezing, months | CIRMF/GAHMU | S
Measles (morbillivirus) | All | L | Maculopapular exanthema | Clinical signs, isolation, environment | Serum/plasma (EDTA) | Freezing, months | N/A | Vaccination S
Polio (enterovirus) | All | L | Asymptomatic, CNS | Clinical signs | Serum/plasma (EDTA) | Freezing, months | N/A | Vaccination S

Blood sample - minimum 10 mL - 6 mL serum, 4 mL EDTA, plus enough for 3 smears minimum, and several drops for filter paper. All samples to be duplicated.

**NOTES:** On site veterinarian, in house laboratory. Note that this refers to the apes only. A second sheet for monkeys will need to be completed (SEE: CERCOP)

**Limbe Wildlife Centre**

Blood sample - minimum 10 mL - 6 mL serum, 4 mL EDTA, plan enough for 3 smears minimum, and several drops for filter paper. All samples to be duplicated.

**THIS IS A LIVING DOCUMENT AND WILL NEED TO BE UPDATED ON A REGULAR BASIS.** THE SAMPLES HERE A A MINIMUM. ALL SANCTUARIES MUST HAVE ACCESS TO BLOOD EQUIPMENT AND FORMULAE AS A MAISON MINIMUM. TRAINING IN THE CORRECT USE OF THESE EQUIPMENT WILL ALSO BE REQUIRED FOR SEVERAL SANCTUARIES.

**Blood sample - minimum 10 mL - 6 mL serum, 4 mL EDTA, plan enough for 3 smears minimum, and several drops for filter paper. All samples to be duplicated.

**NOTES:** On site veterinarian, in house laboratory. Note that this refers to the apes only. A second sheet for monkeys will need to be completed (SEE: CERCOP)

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Figure 16 Part of a disease management chart – Limbe Wildlife Centre

Figure 16 shows part of a disease management chart, this one an example from Limbe Wildlife Centre. For a full list, please refer to Appendix 1. For each disease of concern, diagnostic methods and potential management strategies are given, both what is done, and what is ideal. Collation of this data is helpful so risk can be managed, in this case, across PASA, by highlighting, for example, what everyone considers important to test for, and highlighting potential laboratories to assist in investigating those pathogens.

**Critical Control Points for Pathogen Introduction/Release**

Returning to the Release Pathway, **critical control points** can be highlighted (Figure 17), to manage the risk of disease importation so resources can be utilized to best effect, (see section 3.1.11 for PASA examples). Remember however that the pathway isn’t only about release situations. This sort of diagram is useful to draw up in any situation animals are moving, to allow you to highlight critical control points for disease management.

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Figure 17. Critical Control Points on the Release Pathway
3.1.10 RISK COMMUNICATION

The most important step in the risk analysis process is communication of the risk to all interested parties (your manager, your staff, other vets, your government, peer reviewed journals, BBC etc.), AND encouraging dialogue between them. Risk communication is particularly important because the perception of risk by people who do risk analyses is often very from that of the general public – such as the local village elders, or your manager (!). The former (us) may argue that risk should be determined objectively by the ‘data alone’, whereas the latter may ‘irrationally’ colour their perception of risk by subjective factors – often called ‘outrage factors’. Reality is usually somewhere in the middle.

Since society generally reacts more to outrage than ‘mere hazard’, an important part of risk communication is to make serious hazards ‘more outrageous’, and modest hazards less so. Gruesome graphic government campaigns highlighting the dangers associated with driving under the influence of drinking or drugs, or some of the educational material used to inform on the transmission of ebola (Figure 18) are examples of increasing outrage. The extent to which the ‘public’ accepts risks is clearly related to the degree of outrage.

Figure 18. Image from a series of educational cartoons on the spread of ebola in the Republic of Congo (Thanks to Ken Cameron, WCS Field Vet Programme)

So, risk communication should not be an afterthought. Consideration of communication of the results of a risk assessment is essential in both defining
the hazard and the risk question, as well as formulating the approach to the whole risk analysis. Otherwise the whole exercise will be rendered useless.
3.1.11 RISK ANALYSIS OVERVIEW

**Hazard Identification**
A process that defines criteria by which all possible diseases important in this system are prioritized. Define criteria for ranking.

**Risk Assessment**
The use of a qualitative or quantitative model to characterize risks associated with the hazards identified above.

**Risk Communication**
The process of communicating with all stakeholders.

**Risk Management**
The process of changing pieces of the model (sensitivity analysis) in order to find ways to minimize consequences.
PASA VET CONFERENCE 2005

RISK ASSESSMENT

Group 1

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Summary

At the moment there are 3 sanctuaries within Cameroon working with chimpanzees of the subspecies *troglodytes* and *vellarosus*. These are the Limbe Wildlife Centre, Sanaga-Yong Chimpanzee Rescue Centre and the Cameroon Wildlife Aid Fund. Our risk assessment covers a possible inter-sanctuary collaboration for a possible release site for the chimpanzees kept within these sanctuaries. The site will be subspecies specific and the risk assessment would work for both subspecies.

Questions

Probability of introducing chimpanzee x into the wild with disease y

1) Probability of chimpanzee x leaving critical control point 1 a, b and c with disease y.

   a) Probability of chimpanzee x arriving at one of the sanctuaries with disease y.
   b) Probability of chimpanzee x contracting disease y while in quarantine.
   c) Probability of disease y going undetected while in quarantine
2) Probability of previous infection surviving transport or introduction of the agent during transport from critical control point 1 a, b and c.

a) Probability of the agent survival.
b) Probability of the introduction of the agent during transport.
c) Probability of the hosts survival.

3) Probability of chimpanzee x leaving the field site with disease y.

a) Probability of a FN at critical control point 1.
b) Probability of a FN at critical control point 2.
c) Probability of an introduction of a new infection or a FN at the field site.

4) Probability of a previous infection surviving transport or an introduction of a new infection during transport from the field site to the release site.

a) Probability of the agent survival.
b) Probability of the introduction of the agent during transport.
c) Probability of the hosts survival.
Cameroon Sanctuary Release Pathway

LWC = Limbe Wildlife Centre
CWAF = Cameroon Aid Fund
SY = Sanaga Yong
CCP = Critical Control Point

Key:
- Q = Quarantine
- LWC = Limbe Wildlife Centre
- CWAF = Cameroon Aid Fund
- SY = Sanaga Yong
- CCP = Critical Control Point

Field Site
- Permits
- Survey work
- Fund Raising
- Staff Screening

Pre-Release Holding
- Monitoring
- Post Release
- CCP8

Released
- Pre-release
- Screening
- CCP7

Transport
- CCP5

Integration
- On-going screening
- CCP4

Transport
- CCP2

Q = Quarantine

LWC = Limbe Wildlife Centre
CWAF = Cameroon Aid Fund
SY = Sanaga Yong
CCP = Critical Control Point
Group 2.

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Catherine Sourmail (HELP Congo)

Summary: Using Tchimpounga Sanctuary as a model, we examined the existing flow structure of animals passing through Tchimpounga in relation to a theoretical chimpanzee release program. In the diagram below, critical control points for disease are marked with a red number. We asked the primary question:

What is the chance that an infected animal will be released into the wild?

A. What is the probability that an infected animal will leave quarantine infected?
   1. What is the probability that an animal will be caught infected?
   2. What is the probability that an animal will become infected in captivity prior to confiscation?
   3. What is the probability that an animal will become infected at the MEFE (Ministry of Forest Economy and Environment) office?
   4. What is the probability that an animal will become infected in quarantine?
   5. What is the probability that quarantine testing will miss something?

B. What is the probability that an infected animal will leave the sanctuary infected?
   1. What is the probability that an infected animal will leave quarantine infected?
   2. What is the probability that an animal will become infected in the sanctuary?
   3. What is the probability that testing prior to leaving the sanctuary will miss something?

C. What is the probability that an infected animal will leave the “Boot Camp” infected?
   1. What is the probability that an infected animal will leave the sanctuary infected?
   2. What is the probability that the animal becomes infected in the “Boot Camp”?
   3. What is the probability that testing prior to leaving “Boot Camp” will miss something?

D. What is the chance that an infected animal will be released into the wild?
   1. What is the probability that an infected animal will leave the “Boot Camp” infected?
   2. What is the probability that an animal will become infected during transport and release?
CONFISCATIONS by Congolese Government (markets, poachers, etc.)

PRIVATELY HELD CHIMPS (held in private hands for significant time)

OTHER COUNTRIES

OTHER SANCTUARIES OR ZOOS

MEFE (Ministry of Forest Economy and Environment) OFFICE

TCHIMPOUNGA SANCTUARY
- integration with other chimps
- exposure to staff, visitors, villagers, researchers, volunteers

QUARANTINE

FOREST

FOREST

FOREST

FOREST

FOREST

FOREST

FOREST