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CHAPTER 1

Disease Risk Analysis in Wildlife Health Field Studies

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Although risk may be defined many ways, it always denotes the possibility of loss or injury. In mathematical terms, a risk is calculated as the probability of an outcome multiplied by the impact if the outcome occurs. We calculate risks in all aspects of our lives. There are risks in walking across a highway (e.g., risk of being hit by a car) or putting money in the stock market (e.g., risk of losing money). With each of these actions, there is an uncertain possibility of injury or loss because the outcome cannot be known beforehand. Rather, we may have a subjective impression (qualitative) or use a calculated probability (quantitative) as an indicator of the risks associated with the action.

As zoological and wildlife veterinarians, we perform risk analyses daily. With each of our decisions, whether working with captive or free-living animals, we weigh the benefits versus risks (a form of risk analysis) for every diagnostic and therapeutic option. We do this knowing that no medical action is risk-free. For example, there are risks when we anesthetize an animal to perform diagnostics. However, there are also risks if we do not anesthetize the animal because we may not be able to collect the biomaterials necessary for making a sound diagnosis leading to proper treatment. Veterinarians are aware of these risks and must often defend their medical decisions to curators, park managers, and politicians based on the risks associated with each of their informed medical actions.

To calculate and manage risks better, the use of disease risk analysis has become an important tool in many areas of the veterinary sciences.[21] Disease issues are often complex and predictive models, using a disease risk analysis format, may be highly effective in dealing with these disease-related challenges. Within wildlife veterinary medicine, risk analysis has also become a highly valued tool.[1,2,20] Many wildlife health field studies are now directed at understanding the following: (1) diseases in wildlife populations; (2) links among wildlife, domestic animal, and human health; and (3) links between the health of captive and free-living wildlife species. Illustrative examples for each of these three areas of study include an understanding of the following: (1) the conservation implications of *Batrachochytrium dendrobatidis* in amphibian species; (2) tuberculosis in African wildlife and people; and (3) herpesviruses in captive and free-living elephants. Additionally, we often must make medical management decisions based on findings from wildlife health studies. For example, is vaccination a viable medical decision, or does one let nature take its course during a disease epidemic in a wild canid population? These risk management decisions may best be answered using disease risk analysis.

The growth in awareness, interests, and efforts directed at wildlife health field studies may be viewed as positive for biodiversity conservation; however, this growth is most likely the result of a significant increase in disease-related conservation challenges.[8] These field studies provide a scientific process that may better direct wildlife conservation initiatives. With the current extinction crisis, limited funds for wildlife health and conservation field projects, and the zoonotic connection of diseases found in many species of conservation concern, disease risk analyses should be used to direct and perform wildlife health field studies more effectively.

DISEASE RISK ANALYSIS

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.[23] Disciplines as diverse as economics, engineering, business, environmental science, and health all commonly apply this technique. In the health sciences,

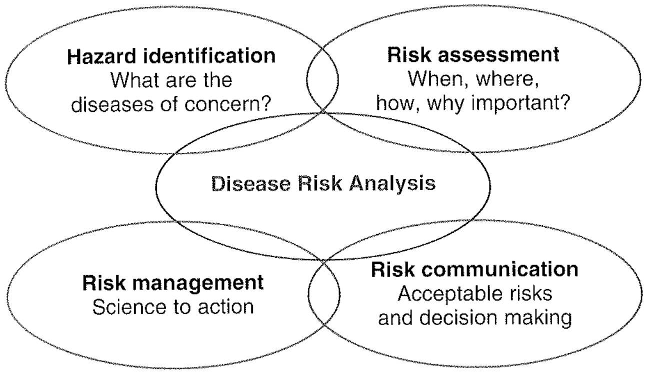

Figure 1-1

Disease risk analysis consists of four interconnected phases that include hazard identification, risk assessment, risk management, and risk communication.

a disease risk analysis is defined as a multidisciplinary process used to evaluate existing knowledge to prioritize risks associated with the spread or occurrence of diseases.

A risk analysis consists of four interconnected phases: (1) hazard identification; (2) risk assessment; (3) risk management; and (4) risk communication (Fig. 1-1). All the phases are interactive with the others—the process should not simply flow from phase 1 to phase 4 in chronologic order. A disease risk analysis is structured similar to that for other risk analyses.

Hazard identification is the identification of what may go wrong. We must identify what diseases have potential effects harmful enough to warrant inclusion in the risk analysis. Some criteria used for ranking infectious disease hazards include prevalence and incidence data, infectivity, pathogenicity (e.g., morbidity, mortality, fitness costs, reproductive costs), transmissibility (e.g., routes, rates, competent vectors), susceptibility (e.g., species, humans), and economic impacts associated with wildlife species, domestic animals, humans, and the ecosystem. Ranking of noninfectious diseases may include species susceptibility to injuries, physiologic stress, and genetic defects.

Risk assessment is the range of calculations required to estimate release, exposure, and consequence parameters for infectious diseases of concern. The process of assessing the risk will help understand the when, where, how, and why of a potential disease risk. With noninfectious diseases, it may involve calculations of the likelihood and consequences of the disease occurring (e.g., capture myopathy, toxicity) in a certain population or community. A subsequent estimate of the total risk may then be calculated based on the parameters for each of the identified hazards.

Risk management focuses on responses that may decrease the likelihood of an adverse outcome and reduce the consequences if such an outcome occurs. This element of risk analysis may best be viewed as the reason for performing the analysis so that science may move into action. Risk management may be the single most important component because it translates the identification of diseases and assessment of associated risks into management actions that may mitigate these risks.

Risk communication is a continuous process, necessitating respectful communication among the multiple stakeholders throughout the risk analysis.[21] Risk communication should occur among field staff (those on the ground collecting data), modelers (those using data for a quantitative risk analysis), managers, laypersons, politicians, and all potentially affected parties to ensure that management policies and efforts are equitably based on the risk assessment outcome. To be of value, this requires a real-time communications network. All stakeholders must know about and understand the risks and options, with a clear statement of acceptable risk. Additionally, it must be clear as to who makes the risk management decisions. Different stakeholders often hold very different views on which risks are acceptable and who is in charge.

Hazard identification and risk assessment are sometimes grouped together because they are clearly interrelated. The criteria used to identify diseases of concern may also be used to assess the level of their associated risks. In many risk analyses, hazard identification and risk assessment are performed based solely on expert opinion or literature review. One of the most valuable products of disease risk analysis is the identification of missing data points that if obtained, would enhance a broader understanding of disease risks for a population or project. For a disease risk analysis to provide the highest quality outputs, hazard identification and risk assessments should be based on scientific data collected from the field and pertinent to the analysis in question. Providing these necessary data points for disease risk analysis are best performed by implementing standardized disease surveillance and monitoring systems.[6,15,22]

Performing a disease risk analysis may involve data input from literature reviews, expert opinion, direct knowledge of the species, ecosystem, or project of interest, and extrapolation from other similar studies. It is often best to start with a specific question or hypothesis and to know the assumptions (e.g., data from the literature, expert opinion versus real data) used in the risk analysis. For example, prior to a pronghorn *(Antilocapra americana)* relocation project, the risks associated with the project should be analyzed. If the expert opinion (assumption) provided during the analysis is that pronghorns are not susceptible to capture myopathy, then the value of the risk analysis may be flawed from the start. It is also crucial to assess the reliability of the data to be used in the risk analysis. In the pronghorn example, do we have data on the capture technique, mode of transport, and personnel that will be used in the relocation effort? Each of these variables will influence the outcome of the project and need to be factored into the risk analysis to help determine whether to conduct the relocation. There are other factors that must be weighed into this decision—for example, why the pronghorns are being relocated and the health risks if the group is not moved.

Outputs of a disease risk analysis may include the following: (1) a visual representation (e.g., flow charts, tables, graphs) of the analysis; (2) identification of relationships that may not have been immediately obvious; (3) identification of missing data points necessary to better understand disease risks (e.g., need for further studies); and (4) identification of critical control points to facilitate the development of cost-effective management strategies. Critical control points are any location, practice, procedure, or process at which control may be implemented over one or more factors and, if controlled, may minimize or prevent a hazard.[23] Therefore, critical control points are important in the context of planning strategies that may minimize the risks of disease by identifying those actions that should be taken (e.g., risk management).

Disease risk analyses may be qualitative or quantitative. Qualitative analyses indicate the likelihood of an outcome expressed in terms such as high, medium, low, or negligible. Quantitative analyses indicate an outcome expressed numerically (e.g., there is a 10% chance that 5% of the pronghorns will develop capture myopathy). A quantitative disease risk analysis may be time-consuming and require large amounts of resources and possibly advanced training in modeling and epidemiology. Fortunately, there are a number of quantitative risk analysis software programs that go beyond deterministic models, providing stochastic capabilities (Table 1-1). In quantitative analyses, numeric values are attached to various stages of release, exposure, and consequence pathways to generate a numeric estimate of total risk.

If it is not possible or desired to perform a quantitative analysis, a qualitative disease risk analysis is often adequate. A qualitative analysis may simply demand paper and pen and some time for analytic thought. Every good quantitative analysis begins with a qualitative visual representation. In many cases, just the process of specifying the model provides insights that might have been previously missed. It provides a visual summary of what we believe the relationships to be in a complex situation and may stimulate discussion, among all the stakeholders, about the problem being modeled.

Semiquantitative disease risk analyses, in which scores are assigned based on expert opinion, are also available and have the advantage of quantitative analyses but, like qualitative analyses, are easier to perform.[19] However, the limitations of semiquantitative approaches, because of a possible lack of transparency if numbers are assigned and because the method of combination is arbitrary, should be minimized when performing semiquantitative analyses.

Finally, it is important to know how the findings from a qualitative, quantitative, or semiquantitative disease risk analysis will be used. There is both art and science to the proper application of results from the hazard identification and risk assessment phases to direct effective risk management and risk communication. For example, if a risk is determined with a large potential loss and a low probability of occurring (e.g., there is a 2% chance that all 50 pronghorns will develop capture myopathy during translocation), it is often treated differently from a risk determined with a low potential loss and a high likelihood of occurring (e.g., 75% chance of two pronghorns developing capture myopathy during translocation). A risk matrix shows the probability of a risk occurring in relationship to the severity (impact) of its consequences and helps in deciding how findings should direct risk management actions.[23]

EXAMPLES OF DISEASE RISK ANALYSIS IN WILDLIFE HEALTH FIELD STUDIES

The following examples demonstrate the application of disease risk analysis in wildlife health field studies. The overall objective of each of these examples is to understand disease risks for wildlife species, domestic animals, humans and/or ecosystems better and to ensure proper disease management.

TABLE 1-1 Software for Performing Quantitative Disease Risk Analyses

Package	Cost ($)	Software Developer	URL	Description
Outbreak	None	Conservation Breeding Specialist Group	http://www.vortex9.org/outbreakinstall.zip	Made specifically for the wildlife health community; may stand alone or work within Vortex
Stella	2000	High Performance Systems	http://www.hps_inc.com/edu/stella/stella.htm http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx	Highlights critical data points; predicts consequences; evaluates effectiveness of interventions
Vensim	0-2000	Ventana Systems	http://www.vensim.com	Highlights critical data points; predicts consequences; evaluates effectiveness of interventions
@Risk	2000	Palisade Corporation	http://www.palisade.com/risk	Monte Carlos simulation modeling
Precision Tree	2000	Palisade Corporation	http://www.palisade.com/precisiontree/	Add-in to Microsoft Excel; relatively easy to use
Risk Matrix	Free	MITRE Corporation	http://www.mitre.org/work/sepo/toolkits/risk/ToolsTechniques/RiskMatrix.html	Construction of risk matrices to identify, prioritize, and manage key risks

Conservation Breeding Specialist Group Workbooks

The Conservation Breeding Specialist Group (CBSG) workbook on animal movements and associated disease risks provides a thorough overview of how to perform a disease risk analysis, introduction to quantitative software programs, and real case study examples (e.g., mountain gorilla and tracker health; wildlife disease issues on islands). This workbook may be downloaded[1] or a hard copy may be ordered from CBSG. A separate CBSG workbook on disease risks associated with biomaterial transportation may also be downloaded.[17] This workbook provides an overview of the disease risk analysis method and examples related to biomaterial transportation, such as the international transport of semen. As noted by Miller,[20] the tools provided by the CBSG were designed to enable professionals to incorporate not only published, statistically valid data, but also to make reasonable decisions under conditions of uncertainty and to capture valuable information from more basic field or clinical experiences.

Carnivore Conservation

Diseases challenging the conservation of wild ungulate and carnivore populations have been identified as a primary threat to a number of these species; possibly due to the close genetic relationship between these taxa and their domestic relatives.[4] The critically endangered Ethiopian wolf *(Canis simensis)* is one canid species in which diseases (e.g., canine distemper and rabies viruses) have been shown to have significant conservation implications.[14] A population viability assessment (PVA) Vortex-based model performed in the 1990s only included disease as a single mortality factor.[18] Improving on this model, diseases were incorporated directly into a PVA that provided a much more reliable estimate of viability because diseases are known to be a key factor affecting the viability of this species.[11]

Human Activities and Health

A number of qualitative and semiquantitative disease risk analyses have been performed to understand the implications of human activities as related to the health of domestic animals, wildlife, and humans.[3,5,19] Using relatively simple analyses, each of these examples demonstrates how we may direct risk management better to minimize or mitigate disease threats challenging wildlife conservation, agricultural production, and public health.

Galapagos Avifauna

In the Galapagos Islands, a primary threat to endemic bird conservation is the introduction of novel pathogens.[24] Disease risk analyses provide a means to understand these disease-related threats. A qualitative disease risk assessment, based on literature review and expert opinion, was performed as a first step to inform decision makers and direct risk management.[7] This basic qualitative analysis allowed ranking of pathogens based on potential harm and determination of missing data to direct future studies better, especially for those diseases of high conservation concern (e.g., *Philornis downsi*, avian pox virus; *Plasmodium* sp.).

A quantitative analysis was performed to explore the most likely routes of introduction of West Nile virus into the Galapagos Islands.[13] The findings from this study, which demonstrated air transport as the most likely route, were instrumental in improving risk management, including the requirement of disinsection of all planes entering Galapagos.

Great Ape Conservation

A number of disease risk analyses for free-living primate populations are available in the literature. One example is an analysis using retrospective health data from the long-running Gombe chimpanzee study.[16] This study provides an excellent example of how retrospective data may be used within a disease risk analysis framework. The analysis enumerates various factors, including a better understanding of disease threats to an endangered species, a guide to improve health data collection, and proper risk communication to advance high-quality health care standards.

A second example is a study derived from a workshop on Southeast Asian Macaque Risk Analysis. Field and laboratory data and expert opinion were combined to develop a model to predict transmission of simian foamy virus between temple macaques and humans accurately.[9] This study provides an example of integrating real data with expert opinion for a better understanding of zoonotic pathogens at the interface of semiwild primates and humans.

Translocation Projects

A number of translocation and reintroduction studies have used disease risk analysis.[10,12] These studies demonstrate the application of disease risk analysis, prior to animal movements, that may help minimize the inherent risks and disease-related causes of past translocation failures.[25]

CONCLUSIONS

Health professionals conducting wildlife field studies are constantly confronted with uncertainty related to the complexity of disease issues and the ecology of study populations. The use of disease risk analysis provides a tool for directing these studies better and for understanding these complex disease issues. Disease risk analysis offers a theory to field and field to theory connection. Whether the disease risk analysis output is descriptive or analytic, the underlying objective should be to ensure management actions that are based on scientific evidence.

To be most effective, a disease risk analysis should be performed based on epidemiologic standards, including monitoring, surveillance, and real data. However, expert opinion and literature review may be the only source for some analyses; these often provide the stimulus for additional field studies to gather the missing, but important, real data.

The science in disease risk analysis is only one factor, because management and communication skills are equally important. The need for clear communication and agreement among all stakeholders about the level of risk that is acceptable and identification of the decision maker(s) must be discussed from the start, and possibly continually revised throughout the project.

In this day of increasingly complex conservation challenges that are often associated with disease threats, limited conservation funds, and the zoonotic link of many wildlife diseases, the use of disease risk analyses may direct our efforts more effectively. Whether we perform a qualitative risk analysis with pencil, paper, and a few minutes of thought, or a quantitative analysis using one of the available software packages, risk analysis offers a visual representation, with determination of critical control points that could translate science into conservation action.

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