Defining and Applying Risk Analysis: Excerpts from the Proceedings of the Fourth National Symposium on Biosafety

Last year, presenters at the Fourth National Symposium on Biosafety (January 27-31, Atlanta, GA) exposed attendees to the burgeoning field of risk analysis as it applies to a laboratory animal facility. The concept provides a practical approach to assessing and managing the variety of risks associated with the day-to-day operations of a facility.

The following excerpts, based on presentations at the symposium, include a definition of risk analysis that discusses the importance of good risk assessment. Also included is a discussion of face protection in laboratory animal facilities, increasingly of concern because decisions regarding face protection involve little or no risk assessment of the hazards involved. The author urges animal caretakers to be more proactive in making specific choices about face protection. An interactive dialogue following the face protection presentation brought out some interesting practical issues.

Risk Assessment

Presented By Michael McElvaine, DVM, MPH

Risk analysis is an umbrella term that includes the process of risk assessment, risk management, and risk communication.

The first principle of risk assessment is, "Before you can manage something, you must first be able to measure it." In the last couple of decades, the practice has been to apply formal risk assessment methods, first used in engineering and economics, to health risk studies and questions of biological risk, like those faced in an animal facility. Even more recently, there has been an emphasis on using cost-benefit analysis based on risk assessment.

Risk assessment is the process of identifying a hazard and evaluating the risk of the specific hazard in absolute or relative terms, either qualitatively or a quantitatively. In short, one can define risk assessment by asking three questions: What can go wrong? How likely is it? And what are the consequences?

Risk management is a pragmatic, decision-making process concerned with managing risks. It encompasses all the different variables that relate to the final decision made by the risk manager. For instance, policy, regulations, society, and sometimes politics come into play when you must deal with the risk of transferring a zoonotic disease or accident in the laboratory.

Risk communication leads to a better understanding and better

Michael McElvaine, who presented Risk Assessment, *is affiliated with the USDA-ORACBA, 1400 Independence Ave. SW, 5248-5, Washington, DC 20250. Martin S. Favero, who presented the first segment of* Face Protection, *is Director, Hospital Infections Program, Centers for Disease Control and Prevention, 1600 Clifton Road, MS A-07, Atlanta, GA 30333. Robert J. Mullan, Rapporteur for the Face Protection* Discussion *segment is Medical Officer, NIOSH/CDC, 1600 Clifton Road, F-40, Atlanta, GA 30333. Please address reprint requests to the appropriate author at the address listed above.*

risk management decisions by incorporating an open, two-way exchange of information and opinions about risk. The risk manager must evaluate the outcomes and make the final decision. To have a good outcome, one should incorporate risk communication from start to finish; communicating the decision to affected parties is very important.

Performing Risk Assessment

There are a variety of different methods for evaluating the likelihood and consequences of an unwanted event (**Fig. 1**), performing risk assessment, and a variety of methods for evaluating the risks—qualitative, semiquantitative, quantitative, and combination methods are among them.

The **qualitative method** uses language and words to describe the risk's magnitude and the probability that it will occur. The **semi-quantitative methods** apply numbers and scales to the qualitative risk assessment to help better prioritize the risks. A **quantitative** risk assessment uses the best numerical values available to estimate the risks, permitting great flexibility in prioritizing and measuring risks and in measuring the amount of risk reduction attributable to each risk mitigation method. **Combination methods** may include all of the above methods.

There is no single best method for assessing risk. It is important to select the method that will provide the best answer for the situation. Characteristics of any good risk assessment include:

1. a scientific basis;
2. consistency with methodologies generally accepted by the scientific community;
3. documentation of the decision-making process and the information that formed the basis for the decision (especially important when dealing with multiple risks);
4. flexibility, meaning selecting the best risk assessment method for each situation, the one that will provide the most useful information to the decision-maker;
5. transparency, meaning all the information is presented in a clear and orderly manner, so that another assessor can review the assessment, understand the rationale, and come up with similar conclusions.

Benefits of Good Risk Assessment

Good risk assessment provides several useful outcomes and helps to rank risks and develop priorities for management. The process should help identify where to invest time and financial resources. A facility may not be able to actively deal with all risks all the time—the brutal truth is that the so-called "zero risk" is not achievable.

Good risk assessment allows you to compare risks, which is especially helpful when considering situations with many possible risks and many different types of risk. Good risk assessment also highlights points for risk reduction. As one examines the whole risk pathway or series of events and the probabilities associated with each pathway, the process elucidates places for effective risk-reduction.

Similarly, a good risk assessment reveals the most important information for making a decision and areas where the investigators need more information. Good risk assessment will help managers with risk communication: it will identify important factors for communication with different audiences; and lend a better understanding of the risks involved and the management options.

Face Protection in Animal Research

Presented By Martin S. Favero, PhD

In an animal facility, the risk of environmental transmission is a major part of the protective strategy because zoonotic transmission

Evaluating likelihood and consequences of an event occurring.

9-Step Evaluation

1. State the question;
2. Identify the hazard of interest;
3. Develop a scenario tree, outlining the pathway of expected events and all the failures which could occur culminating in the occurrence of the identified hazard **(see diagram)**;
4. Label the scenario tree and assign units;
5. Gather and document evidence.
6. Assign values to the branches of the scenario tree;
7. Perform the calculations to summarize the likelihood of the hazard occurring;
8. Consider risk management options;
9. Prepare a written report.

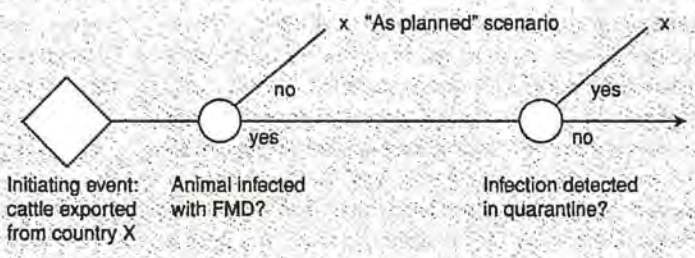

FIGURE 1. Left: 9-Step evaluation process; **Right:** Scenario tree, showing deviation from an "as planned" scenario. These deviations continue in the form of diagrams until they reach an endpoint where: the deviation results in the same outcome of the "as planned" scenario (*i.e.*, it does not pose an actual hazard); the deviation ends at a point which is neither the hazard of interest nor the "as planned" scenario; or the deviation culminates in the occurrence of the hazard of interest, in this case infection with foot and mouth disease (FMD).

FIGURE 2. Surgical masks are appropriate for surgery, yet ineffective against infectious airborne agents.

can, and does, occur. My experience has indicated that when managers and agencies consider a type of strategy to control environmental transmission within a laboratory or an animal facility, they tend to be conservative.

Face protection—the use of goggles, shields, and relative respiratory protection—forms the skeleton of biosafety levels, as described in the guidelines and publications produced by the CDC and NIH. The CDC/NIH also discuss agents and their levels, good laboratory practices, and safety equipment. Primary barriers included in these sections of the manual deal with protective equipment. No large sections include extensive writing about face protection. Even the other resource publication, the *Guide for the Care and Use of Laboratory Animals*, does not include many words about face protection. For respiratory protection, some specifications exist, but most biosafety strategies rely on common sense judgment.

Biosafety Levels One & Two

Primarily, biosafety level one and two situations require someone to make a judgment call. The agents listed under animal biosafety level one are not known to cause diseases in healthy humans. The procedure for primary barriers does not require special clothing, face, or respiratory protection, so, it is a matter of judgment. For example, if you care for ordinary animals, a problem with spitting and scratching might warrant wearing safety goggles.

The real gray area rests in biosafety level two, when animals may harbor agents associated with human disease, and there are hazards associated with percutaneous exposure, ingestion, or mucus membrane exposure.

Depending on the type of animal, splashed and spattered droplets can go through the air and end up in the caretaker's mucus membranes of the eyes, mouth, and nose. Years ago, before primate laboratories implemented the science and art of biosafety, the handlers (of animals used for hepatitis A or B research, or animals indigenously infected with the viruses) often tested seropositive for antibodies to these agents. They used the primary barriers—laboratory coats, gowns, gloves, and face and respiratory protection—as needed. To them, face protection meant sturdy face shields or perhaps safety glasses.

In general, for respiratory protection, the principle is that if the agent transmits by the airborne route, then implement respiratory protection. This does not mean just putting on a wraparound surgical mask—surgical masks are for performing surgery (**Fig. 2**). Respiratory protection means using respirators.

Biosafety Levels Three & Four

At biosafety level three in an animal facility, and especially level four, the risk for exposure to mucus membranes of the face and respiratory tract dictate protective measures.

Biosafety level three facilities house indigenous or exotic agents—including tularemia, mycobacterium tuberculosis, the hemorrhagic fever virus, and yellow fever virus—with a potential for aerosol transmission, and the disease may have serious health effects. The primary barriers are engineered controls: biological safety cabinets, ventilation, containment, and protective laboratory clothing (*i.e.*, wrap around gowns, scrub suits). Level three marks the first time the CDC/NIH manual specifically mentions goggles, masks, or face shields, and respiratory protection regarding unsafe, uncontainable aerosols. Under ordinary circumstances, the types of procedures performed with these animals are within a barrier: in other words, the risk is supposedly designed out. But Murphy's law often comes into play, so one cannot always assume that the design works: you might choose to employ a particular respirator.

Very few laboratories in this country, and indeed the world, practice animal biosafety level four, which covers dangerous exotic agents that pose an extraordinarily high risk of life-threatening disease. Level four agents—including Marburg, Lassa virus, ebola, Russian spring, and summer encephalitis virus—are transmitted by aerosol, contact, or unknown means. The current protective strategy is to use maximum containment or partial containment with full-body air supply, positive pressure suits. Goggles, face shields, and choosing to wear a particular respirator do not even apply in this case, because the degree of containment and protection are several orders of magnitude greater, and the situation does not warrant a respirator.

Many acute care hospitals have conducted an exercise for the last four or five years to protect health care workers from exposure to *Mycobacterium tuberculosis*. Industrial hygienists have known about tuberculosis transmission for a long time, and, although these two groups tend to hold polarized views, they had a meeting of the minds regarding tuberculosis. If the risk of true airborne transmission (the

generation of viable particularities in the 0.5-1.0 micron range) exists, any worker dealing with infected animals needs to wear face protection that covers the mucus membranes of the eyes, nose, and mouth, and some sort of respiratory protective device.

In summary, face protection with goggles, safety glasses, or visors can prevent eye and mucus membrane exposures (**Fig. 3**). Animal caretakers should use respirators when caring for animals with infections that transmit by the airborne route.

Discussion Session

Presented By Robert J. Mullan

Staff use of respiratory protection is by far the most controversial aspect of my work with occupational tuberculosis.

Masks are FDA-approved devices, generally referred to as surgical masks. They are designed for protecting patients (or animals) primarily against splashes of potentially infectious materials. They are not designed or meant for protecting workers against aerosol exposures. Respirators, on the other hand, are NIOSH-certified, and are designed to protect workers against aerosols. When concerned about transmission of infectious aerosols, one must use a respirator, not a mask.

Respirators may serve as more than protection against infectious diseases: for example, they provide protection from chemical explosions that occur during cage cleaning and other procedures involving sterilization. Take care that the chosen respirator will protect against those situations, as well. Manufacturers can help the purchaser choose the most appropriate respirator.

Simultaneous Use of Respirators and Eyewear

Discussion in our session included concerns about concurrent use of contact lenses and eyewear. If wearing contact lenses and protective eyewear together is permitted, the facility should ensure that this does not put the worker at risk. Furthermore, workers who wear contact lenses in an area that houses other chemical toxic exposures have to consider that these various chemicals may cause distortion or breakdown of the contact lens itself.

Participants also discussed the problem of fogging eyewear. Most felt that the market failed to provide any really good remedies, and fogging still remains a problem. I suggest choosing eyewear carefully: the marketplace does provide a lot of different designs, and some of them work better than others to prevent fogging.

Allergies Caused by Respirators

The problem of allergic reactions has arisen with the use of respirators. Many of the currently available respirators use a latex seal around the edge of the mask to make sure that the mask fits tightly on the face. With the products that use natural rubber latex, the person using the respirator is at risk for developing an allergy to the latex. Choosing respirators that use some artificial compound for the face seal can minimize this problem. A similar problem evolves when aerosol danders of the various laboratory animals become lodged around the edge of the respirator, and then become contact allergens.

FIGURE 3. A technician stands near an eye wash station, a place to flood an injured eye with water in case of toxic exposure. Face protection with goggles, safety glasses, or visors can prevent eye exposures.

Beards

The last, and perennial, question involved workers with beards. According to OSHA (Occupational Safety and Health Agency), a negative-pressure respirator cannot adequately protect workers with beards. An alternative, without making the worker shave, is to use a loose-fitting, powered air-supply respirator that does not require a tight face seal.

Cost-Saving Respirators

The NIOSH has recently undergone a change in the way it certifies respirators. Instead of dust-mist and HEPA (high-efficiency particulate air) respirators, the terminology has changed—the agency now talks about N-, R-, and P-series. Each of these various N-, R-, and P-series respirators are available in three levels of efficiency: 95%, 99%, and what we call 100% (which has an efficiency of at least 99.97%). All have been tested with a particle size of 0.3 microns, which is the most penetrable size particle. The one that facilities are likely to be most interested is the N-95 respirator: it is the least complicated, and will protect in most situations involving tuberculosis. These respirators are in general much cheaper than what we had under the old certification process. In the past, we recommended HEPA respirators, which cost about six dollars each. The N-95 respirator costs about sixty cents, providing considerable cost-savings.