Risk Analysis Team Helps Guide Surveillance Plans
Through Pathways Analysis, Risk Assessment

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The Risk Analysis Team (RAT) within the Center for Animal Disease Information and Analysis (CADIA) develops and applies risk analysis approaches and computer-based models to support regulatory and strategic decision-making for animal health. This article describes the pathways analysis and risk assessment process and presents examples of each that RAT has recently completed to help the National Surveillance Unit (NSU) formulate domestic disease surveillance plans.

Pathways Analysis

A pathways analysis is a systematic assessment of the paths along which an exotic disease agent (also referred to as the *hazard*) might enter the United States and establish an outbreak of the disease. This technique is also used to delineate the paths along which a disease agent that is present domestically might spread to one or more new States or regions and establish an outbreak of disease. A pathways analysis, in turn, is integral to a risk assessment that is designed to estimate, in qualitative or quantitative terms, the likelihood of an outbreak of disease occurring from the identified pathway(s) and its consequences.

Several steps must be followed to complete a pathways analysis. First, a systematic knowledge of the biology and distribution of the disease agent must be gained as well as knowing the import sources and quantities of animals and/or their products at risk, immigration and tourist flow, and the livestock production and distribution systems at risk. Second, a careful search of the scientific literature, government data, and other sources of information must be undertaken to identify all available data and information relating to the disease agent and livestock population of interest (and human population if the disease is zoonotic). Finally, this information must be critically evaluated to assess its quality and reliability and then it must be integrated into the pathways analysis.

Example: Rift Valley fever virus

During fall 2005, RAT began work for NSU to identify the important pathways for releasing Rift Valley fever virus (RVFV) in the United States. First reported in the Rift Valley of Kenya, this *phlebovirus* is endemic in most African countries, Saudi Arabia, and Yemen. Although a large number of animal species can be infected with RVFV, domestic ruminants, particularly sheep and cattle, are the primary species associated with natural infection. It is also a zoonotic disease. The virus is usually transmitted to susceptible animals and people by mosquitoes.

Four potentially viable pathways were identified for release (i.e., introduction) of RVFV into the United States: (1) importation of RVFV-infected domestic or wild animal species, (2) entry of RVFV-infected people, (3) mechanical transport (in containers carrying commodities or in hull of ship or aircraft) of RVFV-infected insect vectors, and (4) smuggling of live virus.

Using USDA databases and public data sources to assess the viability of each pathway, it was found that, with the exception of primates, importations of other RVFV-susceptible animal species from RVFV-endemic countries into the United States are not taking place. Other notable findings were that 17 airports in the United States received more than 1 million people on direct flights from 16 RVFV-endemic countries and 46 RVFV-endemic countries exported 98 commodities in containers carried aboard ship or aircraft or bulk by ship into the United States during the time of this pathways analysis, 2000-2005. The importance of smuggling live virus as a pathway compared with the others could not be adequately assessed.

The animal and human populations in California, Florida, Georgia, Massachusetts, Maryland, Minnesota, New Jersey, New York, Pennsylvania, South Carolina, Texas, and Virginia could be the first to be exposed to RVFV, should it be released in the United States. These 12 States logged the highest volume of pathway activities with RVFV-endemic countries, with New York experiencing the greatest activity. The 12 States have more than one-third of all the farms and ruminants (cattle, sheep, goats) in the United States, and large populations of wild ruminants. These States also contain more than half of the U.S. population and have 125 cities with 100,000 or more people. Seven cities—Los Angeles, San Diego, New York City, Philadelphia, Dallas, Houston, and San Antonio— in four of the States are among the largest in the nation, each with a population greater than 1 million.

Risk Assessment

It is not unusual to hear the terms *risk assessment* and *risk analysis* used interchangeably. However, a risk assessment should be viewed as one component of a risk analysis. Each risk assessment developed by RAT conforms to World Organization for Animal Health (OIE) Code Requirements for Risk Analysis. The OIE guidelines state that a risk analysis must start with identification of a hazard (disease agent) and then proceed to a risk assessment. A risk assessment consists of four interrelated steps: release assessment, exposure assessment, consequence assessment, and risk estimation. These steps clarify the likelihood of entry, establishment, and spread of a disease on a local, regional, State, or national scale, plus the associated potential biological and economic consequences to the indigenous livestock population and public health. The output of the risk assessment is a report used to complete the final steps in a risk analysis, namely risk communication—the sharing of risk information—and risk management, a process of determining appropriate mitigation measures to reduce risk.

Example: Swine Pseudorabies

During spring 2005, RAT received a request from NSU to help formulate a domestic surveillance plan for swine pseudorabies. Specifically, the request asked for a risk assessment that would determine for each State the likelihood for re-exposure of their commercial production swine herds to pseudorabies virus (PRV). In 2004, the State-Federal-Industry PRV eradication program had succeeded in its efforts to get every State to Stage V: PRV-Free status.

Feral (or wild) swine and transitional production swine herds are sources of PRV infection for commercial production swine herds in the United States. A commercial production swine herd is defined as those swine that are continuously managed, with adequate facilities and practices to prevent exposure to either transitional production or feral swine. Feral swine are defined as those swine that are free-roaming. Transitional production swine are those feral swine that are captive or swine with reasonable opportunities to be exposed to feral swine.

A pathways analysis identified several risk factors that would be used in the risk assessment model. These included swine demographics, movement patterns of swine, farm-level and off-farm biosecurity management practices, and feral pig contact. In States with feral pig populations, the greatest opportunities for exposure of PRV-negative commercial production swine to PRV-infected feral and/or transitional production swine involve (1) a breach in biosecurity that allows direct contact between PRV-infected swine and PRV-susceptible swine and (2) activities that provide an opportunity for mechanical transmission of PRV to susceptible pigs. In States that do not support feral pig populations, movement patterns between PRV-infected and PRV-negative commercial production swine were presumed to be the predominant risk factor for spread of virus, particularly when sub-optimal farm-level biosecurity management practices exist. Transport of feral swine by hunters or other parties into States with no populations of these animals, but with commercial production swine, was also considered a mode of introduction of PRV into susceptible commercial production swine. A recrudescence of PRV from latently infected commercial production swine may also be a source of infection to their herd mates.

An electronic spreadsheet (Excel®– Microsoft Corp.) was used to construct the model. It was divided into two components. The *re-exposure component* of the model dealt with 14 risk factors associated with the introduction of PRV into transitional and commercial production swine herds. The *spread component* of the model dealt with 10 risk factors that facilitated the spread of PRV among commercial production swine herds. States were then ranked against each other for each of the risk factors in the *re-exposure component* and *spread component* of the model. A rank of “1” indicated highest rank whereas “50” indicated lowest rank. The utility of the model was enhanced by allowing a decision-maker to rank risk factors equally or differently as to their importance in re-exposing commercial and transitional production swine herds to PRV and spread of PRV among these herds. Thus, the ranking of each State depended on the importance that a decision-maker placed upon each of the 24 risk factors. For each of the 50 States, their respective weighted rankings for the 14 risk factors on the *re-exposure component* of the model was then summed to yield one number for final ranking. The same procedure was followed for the 10 risk factors of the *spread component* of the model.

For presentation of results, each State’s *risk of re-exposure* and *risk of spread* ranking was entered into an X:Y scatter plot, whereby the X-axis (*risk of spread* rank) and Y-axis (*risk of re-exposure* rank) was scaled 1-50 to account for all States. A rank of “1” indicated lowest risk and a rank of “50” indicated highest risk. This method of presentation clustered States into the following quadrants: low re-exposure and low spread, low re-exposure and high spread, high re-exposure and low spread, and high re-exposure and high spread. Depending upon the nature of the surveillance decision to be made, the size of the quadrants could be adjusted (by a cross-hair) by decision-makers to focus more attention on either the re-exposure or spread component of the model, and thus the clustering of States within.

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