Using a Portfolio Approach to Evaluate Animal Health Surveillance Portfolios in the United States

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Abstract

Selecting the optimal level of surveillance to implement for an animal disease is important when decision-makers are allocating resources within a surveillance portfolio (collection of all surveillance activities for a species). Decision-makers should consider economically efficient options that meet effectiveness requirements of a surveillance system (i.e., disease detection capability, timeliness, etc.). In this research, we look at components in two disease surveillance systems within a species portfolio and compare current surveillance testing levels with four other optional levels. Option 1 does not meet the detection capability thresholds, while option 2 meets thresholds for one disease but not the other. Options 3 and 4 meet the detection capability thresholds and result in a cost savings compared to current levels. We conclude that Option 3 would be the optimum level of surveillance as it has a lower cost-effectiveness ratio compared to option 4 and the current level, as well as a cost savings of $637,500.

Keywords

Surveillance, portfolio theory, livestock disease, risk

Introduction

Reduced and flat budgets are constraining resources for programs throughout all levels of government, including animal health surveillance systems. Federal and State governments, livestock owners, and livestock organizations invest resources to conduct surveillance for livestock diseases to meet certain surveillance objectives. These surveillance objectives most often include but are not limited to demonstration of freedom from disease, rapid detection of new and emerging diseases, and determination of disease frequency (prevalence). Decision-makers should use a comprehensive and integrated approach when deciding which diseases to look for, where to look (i.e., risk-based strategies), how much to sample within a population, how often, what type (active vs passive vs observational), and when to stop or reduce surveillance. Economic analyses should be a part of this comprehensive approach, to assist in optimizing resource allocation decisions (Guo et al., 2014a; Howe, Hasler, and Stark, 2013; Hasler et al., 2013; Scott, Forsythe, Johnson, 2012, OIE, 2007).

A surveillance portfolio focuses on one livestock species and is comprised of multiple surveillance systems that target a specific hazard or disease (Guo et al., 2015). Surveillance systems collect information from different system components (e.g., test results, epidemiology records, and clinical observations) from a specific population typically identified as a target due to higher risk of having at least one but possibly multiple diseases. Several institutions have developed approaches to evaluating surveillance portfolios/systems/components with the common goal of developing recommendations to improve disease surveillance (Calba et al., 2015). Some notable peer-reviewed and published surveillance evaluation frameworks include the RISKSUR Evaluation Support Tool, also referred to as the EVA tool (RISKSUR 2013), SERVAL (Drewe et al. 2013, Drewe et al. 2011), and the OASIS assessment tool (Hendrikx et al. 2011). More recently these framework approaches have been extended into the economics of zoonosis surveillance, fitting the "one health" approach (incorporating both human and animal health considerations) to disease surveillance (Babo Martins, Rushton, and Stark, 2015). These frameworks have been applied to several livestock disease surveillance systems, evaluating a component's or system's contributions to meeting the identified surveillance objective(s). Some examples include: Fernanda et al., 2016; Amat et al., 2015; Pinior et al., 2015; Guo et al., 2014b; Drewe et al., 2013; El Allaki, Bigras-Poulin, and Ravel 2013; and Hendrikx et al. 2011. In addition, some studies have estimated the overall cost and benefits of surveillance systems in the United States (NRC, 1994; Paarlberg, Seitzinger, and Lee, 2008; Seitzinger, Paarlberg, and Mathews, 2010; USDA-APHIS, 2010). However, there has not been a study that evaluates the entire surveillance portfolio in a comprehensive manner.

The objective of our research is to apply surveillance evaluation frameworks to multiple surveillance components, systems, and portfolios in the United States. The overall goal is to utilize the evaluation results to influence decisions that maximize the effectiveness and efficiency (cost saving) of U.S. livestock surveillance portfolios.

Methodology

This research uses data from USDA-APHIS and livestock industries to estimate the cost-effectiveness of surveillance components designed to support a surveillance objective.

Cost-effectiveness analysis uses non-monetary effects to express the benefits and compare program choices by using the same units of effectiveness (Babo Martins & Rushton, 2014). The cost-effectiveness analysis allows decision-makers to evaluate different sampling options that meet effectiveness thresholds while minimizing costs.

In this evaluation, we completed the cost-effectiveness analysis by estimating a cost-effectiveness ratio (CER). The equation for the CER is:

$$CER = \frac{component\ costs}{component\ effectiveness}.$$

We provide the component costs by conducting a cost analysis of the surveillance system component and we determine the component effectiveness by measuring the estimated effectiveness of the component, which is the component detection capability in this research. The cost analysis estimates all expenses associated with the component, such as labor, supplies, shipping and handling, laboratory fees, etc. The component detection capability, estimated using Bayesian statistical modeling methods, is the probability that prevalence is less than a desired threshold (design prevalence) given no confirmed positive findings. The component detection capability can readily be computed from the estimated prevalence distribution (the Bayesian posterior distribution).

CERs can be calculated for a variety of herd level-design prevalence levels. To apply the CER in decision-making, a herd-level design prevalence and detection capability threshold must be chosen to compare options for testing levels that will satisfy standards and guidelines. The standards and guidelines may be developed by the World Organization for Animal Health (OIE), industry, other government entities, etc. In this analysis, for comparison across surveillance options, we first chose herd-level design prevalence values that met and exceeded guidelines of 1 percent. Next, we selected an appropriate surveillance system effectiveness level to meet trade partners' standards, i.e., a detection capability of 95 percent. When comparing two equivalent options with respect to detection capability and herd-level design prevalence, a lower CER is desirable as it implies that the component is meeting or exceeding desired effectiveness at a lower cost. For example, when comparing sampling options with at least 95 percent surveillance system effectiveness the option with the lowest CER is the most desirable.

Several other attributes of the components were evaluated using the EVA tool (RISKSUR 2013); however, this paper focuses on the cost-effectiveness measure. The financial portfolio theory concepts used in this research include: applying risk-based strategies to reach surveillance objectives (diversification), making decisions while optimizing multiple objectives (minimizing component cost while maximizing detection capability), and considering risk levels of undesirable events compared to the level of investment(s) made in surveillance systems (expected return).

Data

The data used in this research are sampling levels for two endemic diseases determined by a national surveillance plan for each disease. The surveillance plan for disease A includes 10 components, while the surveillance plan for disease B includes four components. Surveillance samples from the 14 total components are collected, shipped, and tested at U.S. laboratories. We used USDA-APHIS budget reports, activity reports, labor estimations, laboratory testing fee catalogs, and personal communication to complete the cost analysis.

Results

The results from the cost analysis, effectiveness analysis, and cost-effectiveness ratios for a component in two disease surveillance systems within a species portfolio are presented in Table 1. In these two components, surveillance is conducted for two different diseases but the samples are collected at the same time. Table 1 presents the component costs, detection capabilities, CERs, and the total cost savings of the current surveillance implementation level compared to four other options with varied testing levels. The cost analysis covers all labor, supplies, and fees to collect, ship, test, and transmit test results for all samples from both components. The effectiveness levels meet the herd-level design prevalence value of 1 percent for one disease, which is also applied to the other disease. While all four options result in cost savings compared to current testing levels, not all options meet the 95 percent detection capability threshold desired for these surveillance systems. Option 1 does not meet the detection capability threshold for both surveillance systems, while option 2 meets it for one but not the other. Options 3 and 4 meet the detection capability threshold for both surveillance systems and save costs compared to the current levels. Thus, options 3, 4, and current levels are the efficient levels we can select from, as they meet the effectiveness criteria. Option 3 would be the optimum surveillance implementation level for these two components, as it has a lower CER compared to option 4 and the current level and results in a cost savings of $637,500.

Conclusions

Finding the optimal level of surveillance to implement in a component and system is important when allocating resources within a surveillance portfolio. Incorporating financial portfolio concepts emphasizes the economic considerations important in making livestock disease surveillance decisions, while also considering the effectiveness requirements of a surveillance system (i.e., disease detection capability, timeliness, etc.). Industry and government entities will be able to use this information to make short- and long-term surveillance investment decisions.

By following international frameworks, the results presented are consistent with other countries using the same frameworks to conduct analyses. This consistency allows for discussion, feedback, and communication with trading partners. Future research will include evaluations that compare current surveillance systems to other options including changes in sample types and tests (i.e., pen-level tests using ropes to collect oral fluid in commercial swine), appropriate testing levels to meet surveillance objectives, the surveillance components included in a system, and possibly the systems included in a portfolio. For example, in aquatic disease surveillance, data is currently being collected to evaluate the ability to demonstrate disease freedom using a surveillance zone instead of an individual mollusk farm. This framework is being considered for application to such foreign animal diseases as classical swine fever, foot-and-mouth disease, and highly pathogenic avian influenza, as well as endemic diseases like equine infectious anemia and bovine brucellosis.

Table 1: Component cost, effectiveness, CERS, and total cost savings for 2 components for the current testing level compared to 4 options with varied testing levels

		Component Cost		Effectiveness		CER		
Options	**Number of samples**	**Component 1**	**Component 2**	**Component 1**	**Component 2**	**Component 1**	**Component 2**	**Total cost savings**
1	80,000	$ 200,000	$ 140,000	0.9312	0.9108	214,777	153,711	$ 722,500
2	90,000	$ 225,000	$ 157,500	0.9514	0.9347	236,494	168,503	$ 680,000
3	100,000	$ 250,000	$ 175,000	0.9639	0.9506	259,363	184,094	$ 637,500
4	150,000	$ 375,000	$ 262,500	0.9929	0.9883	377,682	265,608	$ 425,000
Current	250,000	$ 625,000	$ 437,500	0.9994	0.9993	625,375	437,806	

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