Risk-based strategy to establish a *trichinella* negligible risk compartment

M BRANAN*, L GUSTAFSON, M REMMENGA, M ANTOGNOLI

USDA APHIS VS Centers for Epidemiology and Animal Health, Surveillance Design and Analysis, 2150 Centre Ave, Fort Collins, CO, 80526-8117, United States

*matthew.a.branan@aphis.usda.gov

Abstract

Standard surveillance strategies to support *Trichinella* negligible risk status for compartments require extremely high volume testing to achieve target confidence in *Trichinella* absence. We describe an expert-elicitation risk-based model to establish confidence through a combination of risk-evaluation and standard testing. Results suggest the potential for substantial reductions in test volume without consequent loss in confidence. We describe the process and recommend future design of a formal elicitation and risk-based model.

Keywords: *trichinella, risk-based surveillance, disease freedom*

Introduction

Trichinellosis is a foodborne disease contracted through ingestion of raw or undercooked meat containing encysted larvae of *Trichinella ssp.* parasites. Though proper handling and cooking of meat products can prevent infection, its public health significance has led to import restrictions approaching zero tolerance in certain regions. OIE and CODEX Trichinae Guidelines (1,2) set international standards considered consistent with WTO rules (www.fao.org/fao-who-codexalimentarius/standards/en/). CODEX and efforts to standardise EU surveillance (3) recommend testing at levels sufficient to detect infection occurring at a prevalence of 1 per million animals. However, this extremely low detection threshold translates to an extremely large volume of testing that is difficult to sustain in practice. As *Trichinella* requires an intermediate host for transmission, mitigations that preclude exposure of swine to raw meat, rodents, or mortalities can reduce spread. Consequently, these same organisations support cessation or reduction in sampling for compartments that can establish a negligible risk status.

Negligible risk status applies to herds under controlled management conditions[1] in countries meeting reporting and oversight criteria described in the OIE Terrestrial Code[2], providing *Trichinella* freedom for the compartment has been demonstrated in accordance with OIE guidelines. After initial demonstration, negligible risk status can be maintained through annual audits of compartment practice. However, initial surveillance alone is estimated to demand upwards of five million tests per compartment, depending on the approach and test accuracy estimates. While this sample size presumes random sampling of swine within the compartment, risk-based surveillance strategies can offer credible alternatives. Chapter 1.4 of the OIE Terrestrial Code acknowledges that surveillance confidence in disease absence can be boosted through structured non-randomised data sources[3]. The Code further acknowledges the value of expert opinion obtained through formal, documented and scientifically valid methodologies in the analysis of surveillance data[4]. Recent developments in risk-based surveillance[5] capitalise on both non-random and expert-based designs, providing strategies for incorporating exposure risk and mitigations in disease freedom analyses (4,5). We here demonstrate a risk-based approach to *Trichinella* surveillance in which compartment confidence in freedom is modeled through a combination of slaughter surveillance and expert-defined measures of compartment risk.

Expert elicitation

Following methods previously described (6,7), a trial expert elicitation was conducted with four USDA APHIS VS subject matter experts in swine health to identify and weight risk factors impacting the probability of *Trichinella* occurrence in swine compartments.

Panelists met three times by phone or in person to (1) identify risk factors, (2) weight risk factors, (3) review results and revise factor weightings. In a full evaluation, a 4th step will validate the internal consistency of the results. Panelists discussed the OIE list of controlled management conditions as a starting set of factors and modified the list to resolve dependencies between factors and ensure coverage of all major pathways for *Trichinella* introduction.

Panelists weighted factors by imagining a set of hypothetical compartments in a *Trichinella* endemic region and estimating disease occurrence given presence or absence of each factor and then assigning counts of diseased compartments when

---

1 See OIE Terrestrial Code, Article 8.16.3 (website visited Aug 24, 2016)
2 See OIE Terrestrial Code, Article 8.16.4 (website visited Aug 24, 2016).

3 OIE Terrestrial Code acknowledges that contributions from structured non-random sources can improve surveillance confidence in Article 1.4.5 item 4, and Article 1.4.6 item 5 (website visited Aug 24, 2016).
4 See OIE Terrestrial Code, Article 1.4.5, item 3 (website visited Aug 24, 2016).
5 One of the objectives of the CODEX *Trichinella* guidelines (section 2) is to provide guidance for risk-based surveillance (website visited Sept 1, 2016).

a factor was present and comparative counts of diseased compartments when that same factor was absent. We followed an estimate-talk-revise process, wherein experts could pose independent estimates, discuss within the group, and revise their estimates, if needed.

Model development and comparison

Two Bayesian models were compared for *Trichinella* freedom assessment, using models in the literature as a base model (8). A naïve model was informed using sample size and test sensitivity estimates. A risk-adjusted model was further informed by compartment management factors judged predictive of *Trichinella* risk and weighted by expert panel. Sample sizes required for initial freedom demonstration were calculated for a hypothetical controlled management compartment under each model.

The data from slaughter-based surveillance, test performance metrics, and expert elicited judgments regarding the impact of *Trichinella* risk factors are combined in the risk-adjusted model. The expert elicitations are combined with surveillance information on the presence or absence of *Trichinella* risk factors via a logistic regression model used to estimate *Trichinella* prevalence. This model output is then used as input to a beta-binomial model that combines the test characteristics and slaughter surveillance information to estimate prevalence of *Trichinella* in the compartment. Simulations from this combined model are used to estimate sample sizes required to meet surveillance goals.

Results and discussion

Our key objective was to trial a method. Thus, results are not intended for formal use but are instructive for future modeling efforts. Trial results suggest a model capable of strong reductions in sampling for compartments meeting controlled management conditions (Table 1).

Table 1. Comparison of sample size requirements under a standard versus an example risk-based surveillance model. Both models define disease freedom at one per million detection prevalence and 95% confidence levels. Imperfect low versus high assumes a diagnostic test sensitivity with a mode of 40% or 73% respectively, while perfect assumes a test sensitivity of 100%. The risk-based results are based on no farms having any risk factors and an informed prior prevalence distribution.

Surveillance Model	Diagnostic test sensitivity estimate	Mock sample size requirement
Standard	Imperfect low	17,500,000
	Imperfect high	5,500,000
	Perfect	3,000,000
Risk-based	Imperfect low	1,250,000
	Imperfect high	750,000
	Perfect	450,000

Trial results found general agreement in ranking of *Trichinella* risk factors across experts. The top scoring factors included those relating to outdoor stages of production, audits, and exposure to raw or uncooked meat waste. However, weight magnitudes varied substantively across experts, perhaps in part because expertise was predominantly literature, as opposed to field. We here used the square-root of averaged responses, a variance stabilising transformation, to demonstrate model application and impact.

This trial method suggests strong potential value in risk-based modeling for *Trichinella* negligible risk substantiation. As the risk-adjusted model offsets surveillance through biosecurity mitigations, an expected corollary to this approach would be the inclusion of routine audits to verify the biosecurity mitigations described. Future elicitations will ensure diverse field and international representation in panel composition.

References

1. **Codex.** 2015 www.fao.org/input/download/standards/13896/CXG_086e_2015.pdf.
2. **OIE.** 2016 http://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.01.20 _TRICHINELLOSIS.pdf.
3. **Alban L *et al*.** *Preventative Veterinary Medicine* 99, 148-160, 2011
4. **Cameron A.** *Preventive Veterinary Medicine* 105, 280-286, 2012
5. **Gustafson L *et al*.** *Preventive Veterinary Medicine* 114, 174-187, 2014
6. **VHSV Expert Panel and Working Group.** *Preventive Veterinary Medicine* 94, 128-139, 2010
7. **Gustafson L *et al*.** *Preventive Veterinary Medicine* 109, 1-9, 2012
8. **Kostoulas *et al*.** *Preventative Veterinary Medicine* 89, 155-162, 2009