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# Parametric Uncertainty in Intra-Herd Foot-and-Mouth Disease Epidemiological Models

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## Objective

The objective of this project is to understand how parametric uncertainty within intra-herd Foot-and-Mouth disease epidemiological models affects the outbreak simulations and what implications this has on surveillance and control strategy and policy.

## Introduction

The rapid transmission and poor control policy response during recent Foot-and-Mouth disease (FMD) outbreaks have underscored the need for better decision support tools. At the foundation of these decision support tools are the epidemiological models that are parameterized with the data generated from pathogenesis studies of the FMD virus that contain contact transmission data. These values being used to parameterize the model, contrary to assumption, contain a significant amount of uncertainty, which propagates throughout the model affecting output. To understand how parametric uncertainty might affect output, a variety of disease transmission parameters were generated from contact transmission data and parameterized to an intra-herd model.

## Methods

Data was initially collected and analyzed for papers that could meet several criteria: they must be contact transmission studies, they must measure viremia (the level of virus in the blood), and they must observe clinical signs.

For the studies that met the criteria, tables were constructed and the following information from each paper was collected: serotype, strain, animal species, unique animal identifier, unit of measurement utilized by virus quantification, duration and quantity of viremia, and the time to first report of clinical signs.

Three different durations of disease states for the latent, sub-clinically infectious, and clinically infectious periods were generated from the viremia data for each individual animal and grouped in three ways: by strain of virus, by similar experimental design, and all together. Gamma, weibull, and normal distributions were fitted to the data in each group.

The distributions for each group were then used to parameterize a stochastic, state transition intra-herd model. Output from the model was analyzed by examining the uncertainty and variance in time to 50% herd infected, time to 2% herd clinically infected, and percentage of herd infected at 2% herd clinically infected for each distribution and group.

## Results

There is a lack of a standardized definition for disease state durations of the Foot-and-Mouth Disease virus in the literature. As a result, many different models utilize slightly differing values generated from the same data. This project discovered that depending on the definitions used to determine the disease state durations, the model output varied significantly. Additionally, durations of the disease state periods do not follow a normal distribution as may be assumed by many modelers, and are more accurately described by distributions that allow for non-zero skewness.

## Conclusions

The data being used to parameterize intra-herd Foot-and-Mouth disease models contains a significant amount of uncertainty that can cause the model output to vary significantly. This uncertainty needs to be clearly communicated to decision makers who use results generated from FMD intra-herd models and illustrates the need for more resources to be put into addressing the issue of basic parameters such as contact rate and disease state duration. Currently no studies have been conducted on the contact rate of animals on farms and the current values used for disease state durations vary drastically depending on the data and methods used. Without a better understanding of the basic parameters, even the most advanced models will not be accurate.

## Keywords

Control; Foot and Mouth Disease; Epidemiological Model; Uncertainty; Parameters

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