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An analysis of an early-warning system to reduce abortions in dairy cattle in Denmark incorporating both financial and epidemiologic aspects

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Abstract

Emergency preparedness relies on the ability to detect patterns in rare incidents in an early stage of an outbreak in order to implement relevant actions. Early warning of an abortion storm as a result of infection with a notifiable disease, e.g. brucellosis, bovine viral diarrhea (BVD) or infectious bovine rhinotracheitis (IBR), is a significant surveillance tool. This study used data from 507 large Danish dairy herds. A modified two-stage method for detecting an unusual increase in the abortion incidence was applied to the data. An alarm was considered true if an abortion were detected in the month following the alarm month, otherwise false. The total number of abortions that could potentially be avoided if effective action were taken ranged from 769 (22.9%) to 10 (0.3%), as the number of abortions required to set the alarm increased from 1 to 6. The vast majority of abortions could, however, not be predicted, much less prevented, given this early-warning system. The false to true alarm ratio was reduced when the number of abortions that set the alarm increased. The financial scenarios evaluated demonstrated that the value of an abortion, the cost of responding to an alarm and the efficiency of the actions are important for decision making when reporting an alarm. The presented model can readily be extended to other disease problems and multiple-time periods.

Keywords: Financial; Early-warning system; Economic; Abortion; Dairy cattle; Denmark

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1. Introduction

Early-warning systems provide ways to detect a problem at a relatively early point in time, in an attempt to reduce or eliminate future problems. An example is an early-warning system for a manufacturer who is concerned with machinery malfunction. While the machine produces a product with an acceptable level of variability, once the machine becomes worn or out of alignment, this variability increases to the point that the product is unacceptable. Given the machine requires periodic adjustments or parts replacements, the question is how frequently should machine maintenance be performed to avoid this unacceptable variation? The answer depends on the cost of maintenance, loss due to producing an unacceptable product, the opportunity cost of not producing salable product and the probability that said maintenance will effectively reduce the product variability.

The World Health Organization (WHO) defines early-warning systems as "... timely surveillance systems that collect information on epidemic-prone diseases in order to trigger prompt public health interventions" (http://www.who.int/csr/labepidemiology/projects/earlywarnsystem/en/; accessed 12/21/2004). The WHO notes these systems rarely apply statistical methods and instead rely on a non-systematic review done by epidemiologists of the data coming in. The WHO further states that, "This process should be guided by statistical tests that will allow the epidemiologist to focus on data cells (defined by time, place and disease) where a significant change has occurred, and ignore cells where nothing significant has happened. In other words, statistics should be used to extract significant changes drowned in routine tables of weekly data." (http://www.who.int/csr/labepidemiology/projects/ewarn/en/index.html; accessed 12/21/2004).

Early-warning systems for human and animal health have been developed and implemented around the world. Examples include a nationwide human health system called the Global Public Health Intelligence Network (GPHIN and recently GPHIN II), developed by the staff of Health Canada (now the Public Health Agency of Canada) (http://www.phac-aspc.gc.ca/media/nr-rp/2004_gphin-rmisp_e.html; accessed 12/21/2004); a system that combines satellite images with mathematical algorithms to detect outbreaks of malaria (Wood et al., 1991; Beck et al., 1994), Dengue Fever, hantavirus, West Nile Fever, Rift Valley Fever (Linthicum et al., 1999) and plague (http://science.nasa.gov/headlines/y2004/12mar_disease.htm?list962987; accessed 12/21/2004); a weather and Poisson regression model-based early detection system for malaria in Ethiopia, developed Harvard School of Public Health (Teklehaimanot et al., 2004); and a bipartite system between the U.S. and Mexico, funded by the U.S. Department of Human Health Services, for both naturally and potentially bioterrorist-introduced infectious diseases (http://www.hhs.gov/news/press/2003pres/20031212.html; accessed 12/21/2004). Such systems are typically developed not for exotic diseases, rather for endemic or epidemic diseases. A financial analysis of the operation performance of early-warning systems is possible in a decision analysis framework.

Early-warning systems should be designed differently depending on, among other things, the contagious nature of the causative agent. Hovingh (2002) reported that most abortions will be due to one of the causes discussed in Virginia Cooperative Extension [VCE] Publication 404–288, "Abortion in Dairy Cattle—I: causes of bovine abortion that are not highly contagious and can be considered to be isolated incidents. However, there is