Modelling study: certification-and-monitoring program to control herd infection by *Mycobacterium avium* subsp. *paratuberculosis*

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INTRODUCTION

MAP infection is a cause of economic losses for cattle farmers. MAP-free herds are sources of cattle for trade. However, repetitive herd testing performed to determine herds status are based on poorly sensitive tests. Infected but undetected herds may remain among certified MAP-free herds. The objective of the present study is to determine if truly MAP-free herds can be certified and stay certified over time if infected but undetected herds remain among certified herds. The Dutch certification-and-monitoring program is used to construct a model of the evolution of herds health states. A sensitivity analysis is carried out to test if an alternative control strategy could improve the results and to determine the limits of the present program.

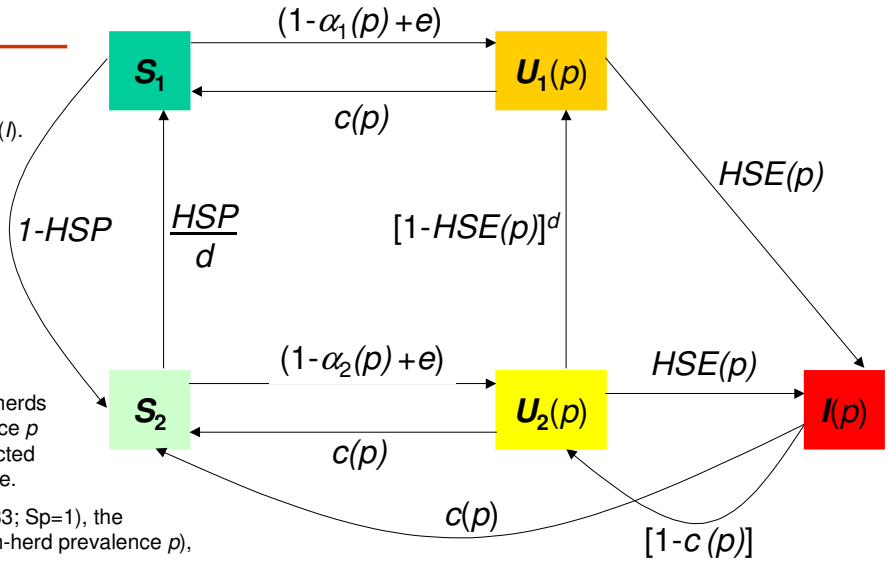
MODEL DESCRIPTION

State variables

Herds can be susceptible (S), undetected but infected (U) or infected (I).

Herds in groups S and U are either in the lowest (S_2, U_2) or in the highest (S_1, U_1) level of certification.

Undetected herds (U_1, U_2) are ordered by their prevalence p.



Parameters

Parameters are: the duration of the certification scheme (d; 4 years), the environmental charge of infection (e; 0.001 herd^{-1}yr^{-1}), the within-herd prevalence (p; β-distributed B(1.71,14.49) in group 2), the herd sensitivity ($HSE(p)$) of a test with sensitivity 0.33 if performed in herds with prevalence p, the probability of clearance for herds with prevalence p ($c(p)$), the probability for herds in group x of purchasing at least 1 infected animal ($\alpha_x(p)$), according to the animal-level prevalence at a given time.

The calculated parameters depend on the test characteristics (Se=0.33; Sp=1), the herd characteristics (purchasing rate, culling rate, herd size and within-herd prevalence p), and the proportion of closed herds.

RESULTS

Dynamics of herds health status

The number of certified truly MAP-free herds (S_1) increases over time (Fig.1). Undetected but infected herds (U_1, U_2) are either cleared and certified, or detected (Fig.1).

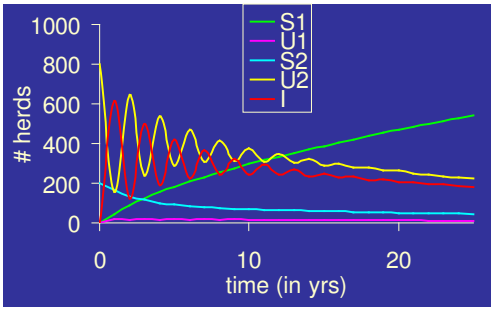


Fig. 1: evolution over time of the # of herds per status

Decrease in global animal-level prevalence

Purchases are assumed to arise in herds of the same or higher level of certification, i.e. U_2 herds are allowed to purchase animals in groups 1 and 2.

The animal-level prevalence in the population of undetected but infected herds (U_1 and U_2) decreases over time. A higher decrease in the animal-level prevalence is obtained if all the purchases are restricted to animals from herds in group 1 (Fig.2).

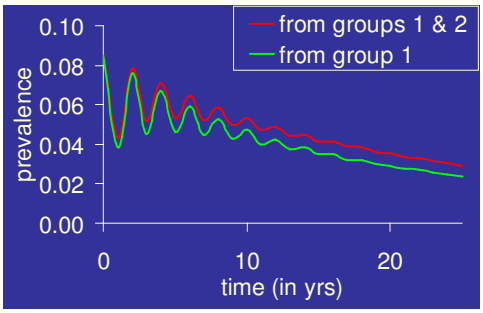


Fig. 2: evolution over time of the global animal-level prevalence with (green) or without (red) restriction of purchases

Sensitivity analysis

The number of S1 herds after 25 years highly increases after a decrease in the mode or the 95th percentile of the distribution of the within-herd prevalence in group 2 (Fig. 3).

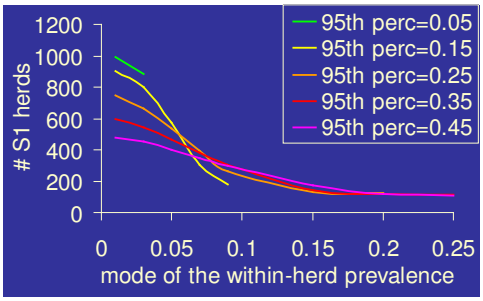


Fig. 3: sensitivity of the # of S_1 herds after 25 years to change in the distribution of the within-herd prevalence in group U_2

CONCLUSIONS

With a 100% specific test, a certification-and-monitoring programme will lead to an increase in the number of certified and truly MAP-free herds and to a decrease in the animal-level prevalence.

To further increase the number of certified and truly MAP-free herds, the animal-level prevalence should be reduced, especially the within-herd prevalence in herds in the lowest level of the certification process (U_2).