RESEARCH BRIEF: Evaluating the uptake of a new diagnostic test for sheep scab by livestock farmers using stochastic game theory

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1. KEY MESSAGE

Farmers adopting the new diagnostic ELISA test for subclinical sheep scab will reduce prevalence of sheep scab and improve welfare in a cost-neutral way.

2. MAJOR FINDINGS

1. Our model results show that farmers' test adoption decisions are strongly dependent on whether they consider themselves at high risk- , medium risk-, or low risk of infestation with sheep scab (see section 5 for a definition of the risk states). The more at risk of infestation a farmer considers his flock, the more likely he is to adopt the new test.
2. For biologically realistic parameters and an expected test cost of around 50% more than the current clinical diagnosis via skin scraping, our model predicts that farmers at high risk of infestation will always adopt the new ELISA blood test. By contrast, the model predicts no uptake of the test for farmers believing their flock is at low risk of infestation. If a farmer considers his flock at medium risk, whether they adopt the test or not is decided by their preference for short-term over long-term benefits. These results are shown in Figure 1 (blue triangles).
3. The uptake of the test should reduce the proportion of infected farms by 50% or more but the financial benefits for the farmers are not substantial.
4. Farmers make decisions about adopting the test not only on the cost of the new diagnostic test but also by their preference between short term vs long term benefits. Key to the decision is to weigh up:
   (1) immediate costs and benefits of adopting the test (may not pay off in the current year if test costs are high)
   (2) long-term benefits of moving to a lower risk state, should neighbouring farmers adopt the test.

For example, if a farmer at medium risk values immediate returns only, he will not adopt the test this season, particularly if the test becomes very expensive or unlikely to be subsidised by the Government. However, a farmer in the medium risk state who does consider long term benefits will adopt the test.

5. Test adoption decisions when farmers acted in their own self-interest only (see Fig. 1 blue triangles) resulted most of the time in the best outcome for both farmers in terms of their combined profits (red triangles in Fig. 1).
6. Test adoption decisions are relatively robust to the cost of the test, with substantial increases or decreases in test cost required to change the overall pattern of test adoption. The test costs would need to more than double before test adoption is not always observed in the high-risk state, and would need to become very low before test adoption can be seen in the low-risk state.

3. OBJECTIVES

New diagnostic tests and control measures are typically developed without an assessment of whether they are likely to be taken up by the farming community. An example of current importance is the recently developed sheep scab ELISA blood test. This test is able to detect the disease within 2 weeks of infestation and critically, prior to the appearance of clinical signs, thus providing a new tool for the effective and sustainable control of sheep scab. We used stochastic game theory to evaluate whether farmers will use the newly available diagnostic test and treat early or whether they will wait and treat on clinical diagnosis only.

4. POLICY IMPLICATIONS

Our results could inform new or existing policy on sheep scab eradication and control. The outcomes suggest that the primary goal should be to facilitate test adoption amongst farms at high-risk of infestation, as this would provide most of the epidemiological benefits. Identifying regional hotspots with high sheep scab prevalence, which represent suitable targets for such a programme, may be an effective approach. Further, cooperative behaviour among the farming community could provide additional benefits, first by encouraging the farmer to take a decision that benefits all (the *social optimum*) rather than acting out of self-interest only, and secondly, by reducing the external risk of infestation and therefore the expected prevalence of infestation following widespread test adoption. Subsidising the overall cost of the test would be likely to incentivise farmers towards such cooperative schemes.

5. IMPORTANT ASSUMPTIONS AND LIMITATIONS

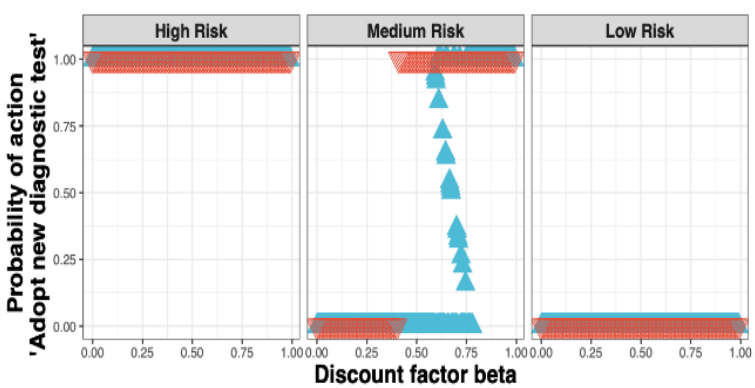
The model is a two-farm transmission model where infestation occurs either through bought-in sheep or through transmission from neighbour's sheep. We assume that a farmer believes his flock to be (i) at high risk of infestation in the current year, if either he or his neighbour suffered clinical sheep scab in the previous year, (ii) at low risk of infestation if both farms were free of infestation last year, (iii) and at a medium risk of infestation if sheep scab was diagnosed using the new test and then treated at the subclinical stage. Hence, depending on infestation status and test adoption decisions in the previous year, a farm may be at high, medium or low risk of infestation this year – a status which then influences the decision the farmer makes and the farmer payoffs. Limitations: (1) The framework does not account for the fact that the external risk to farms should decline as the expected prevalence of infestation in the farms adopting the test declines. Whilst capturing this would be desirable, it is not something that can readily be done within the stochastic game framework. Hence, our results are a conservative assessment of the benefits of adopting the test, since widespread adoption would reduce the external risk to farms. (2) The model considers a two-farm system only and widespread adoption should ideally be assessed by extending the analysis to include multiple farms as well as multiple farmer strategies. (3) The costs used in these analyses were based on the ADAS report (2008) and some changes may have occurred. Nevertheless, the robustness of the results to test cost would suggest that we would expect a similar picture with current figures.

6. FIGURE

Fig. 1. : The probability of adopting the new ELISA test in each of the three states (*high, medium* and *low risk*) when the cost is 1.5x the *status quo* clinical diagnosis cost, plotted against the discount factor (if the discount factor is 0, a farmer only values short term payoffs; if it is 1 he values only long-term benefits). The left panel (blue triangles) shows that farmers will also adopt in the high risk state; the middle panel shows that the probability of adoption depends on whether farms take a short term view (low values of beta) or a long term view (high values of beta); the right panel shows that farmers will not adopt the test in the low risk state.

▲ Farmers acting out of self-interest only

▽ Farmers acting socially optimal, i.e. a decision that benefits all farmers



7. LINKS TO EXISTING PUBLICATIONS OR REPORTS: https://doi.org/10.3389/fvets.2020.00036