POPULATION MEDICINE NEWS

Epidemiology, Preventive Medicine, Public Health
Production Medicine, Computer Applications in Vet Med

September 14, 1992 5(19)

Quandary

Health interventions in livestock operations must be considered, first and foremost, as investments. In this light, comparing alternatives sometimes makes us uncomfortable with a number of blue-sky assumptions. When this happens we must seek some robust principle to make life easier.

In the last issue, we debated whether to recommend whole-herd culture in a dairy herd in which clinical mycoplasma mastitis had been identified. Although individual milk cultures on all cows in the herd was recommended to us by several mastitis experts, we had difficulty with the following points:

1. Since milk culture for mycoplasma is not 100% sensitive, a single whole-herd culture will probably not eliminate all mycoplasma-infected cows.

2. About 1 week is required from collection of samples to availability of results; mycoplasma infection would potentially continue to spread during this interval.

3. The practical effect of items 1 and 2 is that eradication by culture and removal of all infected cows would require several whole-herd cultures, and, even then, long term monitoring would be necessary.

4. The cost for each whole-herd culture would be > $3,000 for the herd in question (about 300 cows).

5. Most mycoplasma infected cows become clinical mastitis cases and would therefore be detected through culturing of all future clinical cases.

6. Bulk tank culture for mycoplasma is a good--though not perfect--screening tool to determine if undetected carriers remain in the clean herd.

7. Detection of mycoplasma in a bulk tank milk sample opens several options other than whole-herd culture to identify subclinical carriers. Given the very strong tendency of mycoplasma infections to be associated with high SCC, one could begin with the cows on the most recent "hot sheet." After removal of any additional infections, the bulk tank culture could be repeated and the search extended, if necessary.

8. Because of items 1 and 2, the infection will likely continue to spread, even if whole-herd culture is performed, unless steps are taken to improve milking time hygiene.

Our Big Quandary, which ties together all 8 of the aforementioned points, was the following:

If improvements in milking time hygiene are necessary to reduce transmission rate in the parlor <u>even if whole-herd culture is used</u>, wouldn't the same changes make control and eventual elimination possible through a more conservative approach of monitoring for mycoplasma infections using cultures from bulk tank milk and clinical mastitis cases?

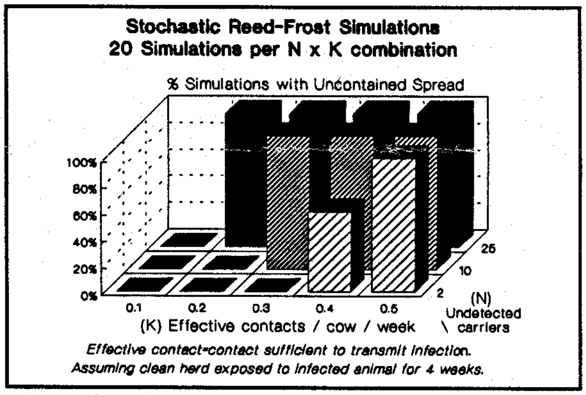

Figure 1.* *Stochastic Reed-Frost modelling of intramammary mycomplasma infections.

We described the results of an economic analysis in the last issue which attempted to address the quandary. It was, somehow, not very satisfying because of the numerous blue-sky assumptions we were forced to make. The analysis none-the-less suggested the possibility that whole herd culture would be cost-beneficial only if there were numerous subclinical mycoplasma carriers (eg., >6% of the herd). And, we noted, the probability of obtaining a negative bulk tank culture if 6% of the herd were mycoplasma-infected was quite small. Over and above the assumptions of our economic analysis, two important reservations could be raised:

Reservation 1. Cost efficiency analysis can be misleading when we are evaluating a procedure designed to avoid a catastrophic outcome. Telling a producer that, on average, he's better off with choice X, since 9 times out of 10 it has a better payoff than choice Y, will not necessarily comfort him if he would be driven to financial ruination 1 out of 10 times by choosing X.

Reservation 2. Intuitively, the transmission rate of mycoplasma through the milking herd would be a function of number of infected individuals. What sort of logic suggests that an infection might be contained as well with 6% of the population infected as with < 1%?

Reservation 1 is a valid point; the client's risk aversion must be taken into account with any investment decision whether it relates to health management or junk bonds. Yet, we must also confront the grim reality that there is a chance (not small, as we shall see) of a catastrophic outcome under either the whole-herd culture option or conservative monitoring. In either case, catastrophe would come in the form of the uncontained spread of mycoplasma infection to involve a large fraction of the herd.

Paying a big price to make modest reductions in risk can itself be a source of financial ruination. How many investment advisors today would recommend 3% yielding CD's so that their clients might avoid the risks of equities? Only those who are training to become convenience store clerks. On reflection, we must admit that our profession's native "it can't hurt" attitude toward health management interventions--tacitly taught as doctrine in non-analytic veterinary courses--has sometimes contributed to the financial downfall of our clients and even more frequently to investment opportunities lost. Dairy producers keep cows to make money; that's the one assumption with which we won't have to struggle in analyzing this problem.

Reservation 2 is centrally important and answering it will bring us to a much more comfortable conclusion. Like economic analyses, modelling infection dynamics requires assumptions; but what we are after here is a robust principle rather than an answer to one specific question.

The Reed-Frost model is one of the oldest of the infection modelling tools, but it still serves very well to illustrate the interaction of hygiene and number of infected individuals in affecting transmission rate. Another advantage is that it is easy to compute and graph with a spreadsheet program. Reed-Frost is a chain model in that computations are made for discrete time intervals--we chose weeks--that occupy the rows of the spreadsheet. The number of new infections occurring each week is a function of the number of existing infections (those passed down from the previous week) and the effective contacts. In our model, we assumed that the average infected cow would stay with the clean herd for 4 weeks. Though it could be argued that there would be long term undetected carriers, we felt that most cows would be detected prior to 4 weeks either by bulk tank monitoring or culture of clinical mastitis cases and cows with high SCC. If an average transmission period for infected animals greater than 4 weeks is chosen, uncontained transmission occurred in all simulations regardless of the intervention choice made.

The effect of hygiene is measured using the intuitive parameter of ***effective contacts***. Simply put, "K" is the number of contacts any one individual makes during a time interval that is sufficient to transmit infection to a susceptible individual. This is partly a function of the agent: the quantity in which it is shed relative to the number of organisms in an infective dose. However, agent characteristics are beyond our control and we can only influence the other component of effective contacts: hygiene. For a contagious mastitis agent, this is exercised in the milking parlor by procedures such as backflushing.

Classical Reed-Frost models are deterministic: given the parameters of population size, effective contacts and number of existing infections, the outcome is always the same. However, in nature we understand that the number of effective contacts made over a time interval is a random variable. Some infected individuals shed more organisms, some contacts are more susceptible. Chance occurrences in the milking process would also play a role in variation of effective contacts. Thus, we chose to use a stochastic Reed-Frost model in which the effective contacts are allowed to vary around a set average in a log-normal distribution. The infected individuals might have a much different number of effective contacts but the average would remain at the level chosen. The effect of introducing a stochastic parameter is that every simulation does not come out the same. This more accurately reflects reality in that we don't always expect things to work exactly the same even when we carry out the same intervention. We are searching for the parameter combinations that give stable results even when the number of effective contacts is a random variable.

Figure 1 shows the results of 20 simulations at each of 15 combinations of effective contacts by number of initial infectives. "Uncontained" transmission was assumed to occur when the infection was transmitted over the subsequent 3 months to > 10% of the uninfected cows. If this occurred, the long term goal of eliminating mycoplasma from the herd would become difficult. "Contained" transmission was that which was limited to < 10% of the uninfected cows (usually much less) and which, by 12 weeks post-initiation, ceased without further intervention beyond the conservative monitoring program, which would be a necessary fixture under either intervention.

An important finding from our Reed-Frost simulations was that uncontained transmission was inevitable regardless of starting number of infectives if effective contacts was 0.5/cow/week or greater. To put this number in perspective, 0.5 effective contacts/cow/week would require about 150 major milking-time hygiene lapses per week out of 4,200 milking events. Thus, if milkers performed milking time hygiene tasks (backflushing, etc.) correctly only 96.5% of the time, catastrophe seemed inevitable. If whole-herd culturing reduced the number of initial infectives to only 2 cows, transmission could be reliably contained if effective contacts were reduced to 0.3/cow/week by ensuring correct milking time hygiene practices during about 98% of milking events. If correct hygiene practices were performed during 98.5% of milking events (0.2 effective contacts/cow/week), transmission would be reliably contained even with 10 starting infectives. Even at 25 starting infectives, transmission would be reliably contained if correct practices were performed in 99.3% of milkings.

But, one asks, what are the effects of the assumptions made? Changing the average exposure period for infectives from 4 weeks only serves to shift the bars on the X-axis; the relationships remain the same. We have, therefore, found our desired robust principle: reducing the number of initial infectives slightly reduces the required percentage of milking events where correct hygiene is practiced. Since the bulk tank culture of the herd under consideration was negative after removing the clinical cows, it seemed probable that, at most, 10 undetected infectives remained; more likely the figure was 5 or less. Thus for a >$3,000 expenditure for whole-herd culture, the milkers would earn the right to make somewhere between 10 and 50 extra mistakes per week--that's $5 to $25 per mistake over the 3 month containment period. If transmission was uncontained after 3 months (ie, if the effective contacts were higher than the critical level), the 3 scenarios in Fig 1 (2, 10, 25 initial infectives) would eventually become indistinguishable and the investment in whole-herd culture would be (completely) squandered. Thus, our recommendation was to save the money for whole-herd culture and concentrate on milking-time hygiene and monitoring of bulk milk and clinical mastitis cases.

We understand that these conclusions are controversial and invite commentaries which we will print in future issues of this Newsletter. To paraphrase the letter policy of the Colorado State University campus newspaper, unnecessary obscenities should be avoided.

POPULATION MEDICINE NEWS is produced by the Washington State University Field Disease Investigation Unit, Pullman, WA 99164-6610 (509-335-0711) and is supported in part by the WSU Cooperative Extension Service. Viewpoints expressed are not necessarily those of the University or its Administration. This newsletter may be copied by anyone. Editors: Dale Hancock and Susan Holler.