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Economic optimization of selective dry cow treatment

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ABSTRACT

The objective of this study was to develop a mathematical model to identify a scenario with the lowest costs for mastitis associated with the dry period while restricting the percentage of cows to be dried off with dry cow antimicrobials. Costs of clinical and subclinical mastitis as well as antimicrobial use were quantified. Based on data from a large field trial, a linear programming model was built with the goal to minimize the costs associated with antimicrobial use at drying off. To enable calculations on minimizing costs of dry cow treatment on herd-level by drying-off decisions in an "average" herd, we created an example herd. Cows were projected on 3 different types of herds, based on bulk tank somatic cell count, and were categorized in groups based on parity and somatic cell count from the last test recording before drying-off. Economically optimal use of antimicrobials was determined while restricting the maximum percentage of cows dried off with antimicrobials from 100 to 0%. This restriction reveals the relationship between the maximum percentage of cows dried off with antibiotics and the economic consequences. A sensitivity analysis was performed to evaluate the effect of variation in the most important input variables, with the effect of dry cow antimicrobials resulting in a lower or higher percentage of clinical and subclinical mastitis depending on being dried off with or without dry cow antimicrobials, respectively, and the milk price. From an economic perspective, blanket dry cow treatment seems not to be the optimal approach of dry cow therapy, although differences between approaches were small. With lower bulk tank somatic cell counts, more dry cow antimicrobials can be omitted without economic consequences. The economic impact of reducing the percentage of clinical mastitis was found to be much larger than reducing the bulk tank somatic cell count. The optimal percentage of cows to be dried off with antimicrobials depends on the udder health situation, expressed as the bulk tank somatic cell count and the incidence of clinical mastitis. For all evaluated types of herds, selective dry cow treatment was economically more beneficial than blanket dry cow treatment. Economic profits of selective dry cow treatment are greater if bulk tank somatic cell count and clinical mastitis incidence are lower. Economics is not an argument against reduction of dry cow antimicrobials by applying selective dry cow treatment.
Key words: linear programming, mastitis, antimicrobial reduction, dry cow treatment, economics

INTRODUCTION

Control of mastitis is of major importance for the dairy sector. Apart from other consequences, mastitis leads to high monetary costs because of treatment, discarded milk, and major production losses (Hogeveen et al., 2011). In the dairy industry, antimicrobials are mainly used for treatment of clinical mastitis (**CM**) and dry cow treatment (**DCT**). For many years, approximately 60% of the antimicrobial use (**AMU**) in dairy cows in the Netherlands was related to mastitis, of which roughly two-thirds related to DCT (Kuipers et al., 2016).

One of the points recommended since the 1970s in the 5 Points Mastitis Control Plan (Neave et al., 1969) was blanket dry cow treatment (**BDCT**) to control the risk of new IMI during the dry period (Dodd et al., 1969). The main goal of DCT was to reduce the prevalence of IMI, both by eliminating IMI present at drying off and preventing new IMI from occurring during the dry period (Bradley and Green, 2001). In many countries, more than 90% of all dairy cows were treated with antibiotics during the dry period [e.g., 94% in the Netherlands (Lam et al., 2013) and 99% in the United Kingdom (Berry and Hillerton, 2002)].

Due to public health concerns and risk for antimicrobial resistance (**AMR**), prudent and restricted use of antimicrobials is promoted and preventive use of antimicrobials for all food animals has been prohibited since 2012 in the Netherlands (Santman-Berends et al., 2016). Selective dry cow treatment (**SDCT**), not using

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DCT in cows that had a low SCC at the last milk recording before drying off, significantly increased the incidence rate of CM as well as SCC postpartum in a study in the Netherlands (Scherpenzeel et al., 2014).

A meta-analysis done by Halasa et al. (2009a) showed that BDCT seemed to protect better against new IMI than SDCT, which seemed to protect better than no DCT at all. It was also shown that the decrease in AMU due to SDCT was substantial and by no means compensated by an increase in AMU due to an increased incidence rate of CM (Scherpenzeel et al., 2016).

The effect of SDCT compared with BDCT on udder health, AMU, and economics is influenced by the criteria used to select cows for DCT (Cameron et al., 2014; Scherpenzeel et al., 2016). The chosen criteria have an effect on quantifiable parameters, such as CM incidence, AMU, and economics, but also nonquantifiable parameters, such as welfare and practical feasibility. These effects can be contradictory; SDCT as compared with BDCT leads to more CM cases and a higher SCC, whereas it decreases AMU substantially (Scherpenzeel et al., 2014). Udder health, welfare, production losses, AMU, and economic consequences are all parameters that are influenced by decisions on DCT, but that potentially move in different directions. Additionally, although the relationship between AMU and development of AMR in mastitis pathogens is complex and unclear (Oliver et al., 2011), there is a potential effect of AMU on the development of AMR (Chantziaras et al., 2014). In decision making of farmers, this can, however, be considered as an externality because these consequences are experienced by the environment or society while they are not necessarily directly experienced by the farmer. A common way to quantify different parameters, with the exception of animal welfare and public health, is in economic units. As such, economic consequences along with animal welfare, legislation, and public health concerns, may be helpful in making decisions on animal health strategies.

A few studies describe the economic consequences of DCT. Most economic analyses have concluded that BDCT is financially beneficial, because of increased milk yield, lower SCC, or reduced CM cases, when compared with SDCT or no DCT (McNab and Meek, 1991; Berry et al., 1997; Yalcin and Stott, 2000). Most of these calculations were, however, based on uncertain assumptions and the results had much variation. In a study done by Huijps and Hogeveen (2007), SDCT was economically most attractive. In that study, however, differences between BDCT and SDCT were small and with regard to selection of the appropriate animals, the assumptions for DCT were rough. None of the above studies described the level of reduction of AMU while practicing SDCT.

The economic impact of SDCT likely varies for different types of herds and for different levels of DCT use. Studies describing and evaluating economic consequences of SDCT on the herd level can be used by dairy farmers and their advisors to help them to optimize decisions on DCT, thereby minimizing costs. Thus, the economic consequences of decisions on DCT need further attention. Therefore the objective of this study was to develop a mathematical model to minimize economic costs while restricting the percentage of cows to be dried off with DCT, accounting for effects of CM, subclinical mastitis (**SCM**), and AMU.

MATERIALS AND METHODS

A randomized controlled field trial was carried out between June 2011 and March 2012 in the Netherlands in which the effect of DCT on CM, bacteriological status, SCC, and AMU was evaluated (Scherpenzeel et al., 2014). Based on these data, data from literature for high-SCC cows dried off with antimicrobials (Barkema et al., 1998) and smoothed data based on regression analysis for high-SCC cows dried off without antimicrobials (data not shown) a linear programming (**LP**) model was built with the goal to minimize the costs associated with AMU at drying off. In this model different approaches of selecting cows for DCT were compared based on the SCC at the last milk recording before drying off (Scherpenzeel et al., 2016). A timeframe of 1 yr was used to take seasonal differences into account and to represent the financial planning horizon of dairy farmers. The general purpose of an LP approach is to maximize or minimize a goal variable (e.g., maximize profit or minimize costs) by finding the optimal combination of different parameters with respect to a set of fixed constraints. Microsoft Excel (Microsoft Corp., Redmond, WA) was used to develop and run the LP model, using the Simplex Algorithm for optimization.

Definition of the Herd

To enable calculations on minimizing costs of DCT on herd-level by drying-off decisions in an "average" herd, we created an example herd. Cows that were dried off at the end of their first lactation were referred to as first dry period (**FDP**) cows at drying off, during the dry period and the first 100 DIM of the subsequent lactation. Cows that were dried off for the second or later time were referred to as multiple dry period (**MDP**) cows at drying off, during their dry period and the first 100 DIM of the subsequent lactation.

Nine cow groups (i = 1–9) were considered, consisting of 4 classes of FDP cows (0–50,000 cells/mL; 51,000–100,000 cells/mL; 101,000–150,000 cells/mL;