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The contribution of previous lameness events and body condition score to the occurrence of lameness in dairy herds: A study of 2 herds

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ABSTRACT

It has been demonstrated that low body condition and previous occurrence of lameness increase the risk of future lameness in dairy cows. To date the population attributable fraction (PAF), which provides an estimate of the contribution that a risk factor makes toward the total number of disease events in a population, has not been explored for lameness using longitudinal data with repeated measures. Estimation of PAF helps to identify control measures that could lead to the largest improvements on-farm. The aim of this study was to use longitudinal data to evaluate the proportion of lameness that could be avoided in 2 separate herds (2 populations) through (1) reduced recurrence of previous lameness events, (2) and moving body condition score (BCS) into more optimal ranges. Data were obtained from 2 UK dairy herds: herd A, a 200-cow herd with 8 yr of data from a total of 724 cows where lameness events were based on weekly locomotion scores (LS; 1 to 5 scale), and herd B, a 600-cow herd with data recorded over 44 mo from a total of 1,040 cows where treatment of clinical cases was used to identify lameness events. The PAF for categories of BCS were estimated using a closed equation appropriate for multiple exposure categories. Simulation models were used to explore theoretical scenarios to reflect changes in BCS and recurrence of previous lameness events in each herd. For herd A, 21.5% of the total risk periods (cow-weeks) contained a lameness event (LS 3, 4, or 5), 96% of which were repeat events and 19% were recorded with BCS <2 (3 wk previously; 0 to 5 scale). When lameness events were based on 2 consecutive weeks of LS 4 or 5, 4% of risk periods were recorded as lame, of which 89.5% were repeat events. For herd B, 16.3% of the total risk periods (consecutive 30 d) contained a lameness event (72.6% were repeat events) and 20% were recorded with BCS ≤2 (0 to 120 d previously). The median PAF for all previous lameness was between 79 and 83% in the 2 herds. Between 9 and 21% of lameness events could be attributed to previous lameness occurring >16 wk before a risk period. The median PAF estimated for changes in BCS were in the region of 4 to 11%, depending on severity of lameness. Repeated bouts of lameness made a very large contribution to the total number of lameness events. This could either be because certain cows are initially susceptible and remain susceptible, due to the increased risk associated with previous lameness events, or due to interactions with environmental factors. This area requires further research.

Key words: lameness, dairy cattle, population attributable fraction, body condition score, previous lameness events

INTRODUCTION

Numerous risk factors for lameness in dairy cattle have been reported in the literature, including risk factors related to the external environment such as flooring surfaces and time spent standing (Galindo and Broom, 2000; Bergsten et al., 2015) as well as animal-based factors that might affect structure and function of the claw such as milk yield, BCS, and previous lameness events (Green et al., 2014; Randall et al., 2015). Low BCS and previous lameness are both risk factors for lameness that occur repeatedly over time and have been highlighted as important for lameness control (Hirst et al., 2002; Bicalho et al., 2009; Green et al., 2014; Randall et al., 2015, 2016). Randall et al. (2015) showed that relatively low body condition precedes and is associated with an increased risk of a first lameness event in a cow's life. Consequently, management strategies to maintain appropriate BCS may provide an opportunity for the dairy industry to reduce lameness in herds. Hirst et al. (2002) demonstrated that dairy heifers with lameness-causing claw horn lesions were at greater risk of lameness in subsequent lactations. A recent study suggested that this relationship might be

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explained by development of new bone (exostosis) on the distal phalanx (Newsome et al., 2016). If this is an irreparable anatomical change to the foot, it would contribute toward an increased risk of a cow becoming lame again. Odds ratios (**OR**) reported for these 2 risk factors indicate that they are highly associated with lameness; for example, the OR associated with moving from a nonlame to a lame state for cows with BCS 1.00 to 1.75 at calving versus 2.50 to 2.75 was 7.73 (2.37–17.71) and the OR associated with clinical lameness for cows having been identified lame 31 to 60 d previously versus no previous lameness was 13.80 (10.58–17.78; Green et al., 2014; Lim et al., 2015).

The population attributable fraction (**PAF**) provides an estimate of the contribution that a risk factor makes to the total disease burden in a population. Knowledge of the PAF of risk factors can facilitate decision making for farmers and policy makers to maximize disease reduction with existing resources when the knowhow exists, or it can influence funders of research (Steenland and Armstrong, 2006) when knowledge to reduce the effect of risk factors is not known.

A range of formulas is used to calculate PAF and these have different limitations, such as biases arising when adjusted estimates of relative risk (**RR**) are used or when the exposure is across different levels (Rockhill et al., 1998; Benichou, 2001; Steenland and Armstrong, 2006). Where risk factors vary over time, the method used to estimate PAF must account for repeated risk events. In addition, a risk factor can be complex; for example, cows in a herd have a range of body conditions rather than a uniform BCS of, for example, 3, so assessing a change in BCS to reduce the PAF needs to use a continuous scale for BCS. Simulation can be used to estimate PAF to allow for sources of uncertainty, such as uncontrolled confounding, to be incorporated into estimates (Steenland and Armstrong, 2006) as well as allowing for more complex scenarios to be investigated (Hudson et al., 2014).

The aim of this study was to investigate the contribution of previous lameness and BCS to the occurrence of total lameness events in 2 UK dairy herds. A novel simulation-based approach to estimating PAF for lameness risk factors was used.

MATERIALS AND METHODS

Study Herds

Data were obtained from 2 UK dairy herds, where detailed and accurate herd records were available. Study herds and data sets have been described in detail by Green et al. (2014) and Randall et al. (2015). They are summarized here briefly.

Herd A. A total of 724 Holstein Friesian dairy cows managed on the Langhill herd held at the Scotland's Rural College's Crichton Royal research farm, Dumfries, Scotland, with data recorded over an 8-yr period from 2003 to 2011 (Randall et al., 2015). Cows were managed on a long-term 2 × 2 factorial genetic and feeding system study; select and control genetic lines (Pryce et al., 1999) were divided equally into low-forage (**LF**) and high-forage (**HF**) groups and managed as 1 herd of approximately 200 cows, as described in detail by Chagunda et al. (2009). The LF cows were continuously housed whereas HF cows were grazed during the summer grazing period (typically March to November). Cows were milked 3 times daily and the herd was all-year-round calving. Target yields were 13,000 and 7,500 kg per cow per year for LF and HF cows, respectively. Housing was the same for LF and HF cows: cubicles with mattresses and automatically scraped grooved concrete passageways. Regular footbathing was carried out and a professional foot trimmer attended the whole herd twice a year. Locomotion scores (**LS**) were recorded weekly by trained assessors on a 1 to 5 scale (Manson and Leaver, 1988). Lame cows (LS 4 or 5 on a single occasion or 2 successive scores of LS 3) were treated by a veterinarian on a weekly basis before 2006 and every 2 wk after this time. Severely lame cows were treated within 24 h by trained farm staff. The BCS was measured weekly using a 0 to 5 scale with increments of 0.25 (Mulvany, 1977). All health, production, and management data were recorded in a database.

Herd B. A total of 1,040 Holstein dairy cows on 1 dairy farm in Somerset, England, with data recorded over 44 mo between 2008 and 2011 (Green et al., 2014). Cows were milked twice daily in a 60-point rotary parlor and continuously housed all year, apart from summer when grazed during the last 2 mo of lactation. Rations were formulated with the aim of maximizing yield while minimizing feed costs and fed to milking cow groups (early, mid, and late lactation) accordingly. Biotin was added at 20 mg/cow per day. Housing was modern free-stall accommodation with water mattresses in cubicles and solid concrete passageways with automatic scrapers. Mean yearly yield was approximately 10,000 kg per cow per annum. A professional foot trimmer attended the herd each month; typically cows at the end of lactation and with misshapen feet were trimmed, with a minimum routine foot trim once per year. Daily observations of the herd by senior herdsmen identified lame cows, which were treated under veterinary direction using standard protocols, generally within 2 to 3 d. Body condition score was recorded at 60-d intervals throughout the study period by the head herdsman with appropriate training to prevent drift in scoring, on a scale of 0 to 5 in 0.5 increments [based on examina-