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A multivariable assessment quantifying effects of cohort-level factors associated with combined mortality and culling risk in cohorts of U.S. commercial feedlot cattle

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ABSTRACT

Economic losses due to cattle mortality and culling have a substantial impact on the feedlot industry. Since criteria for culling may vary and may affect measures of cumulative mortality within cattle cohorts, it is important to assess both mortality and culling when evaluating cattle losses over time and among feedlots. To date, there are no published multivariable assessments of factors associated with combined mortality and culling risk. Our objective was to evaluate combined mortality and culling losses in feedlot cattle cohorts and quantify effects of commonly measured cohort-level risk factors (weight at feedlot arrival, gender, and month of feedlot arrival) using data routinely collected by commercial feedlots. We used retrospective data representing 8,904,965 animals in 54,416 cohorts from 16 U.S. feedlots from 2000 to 2007. The sum of mortality and culling counts for each cohort (given the number of cattle at risk) was used to generate the outcome of interest, the cumulative incidence of combined mortality and culling. Associations between this outcome variable and cohort-level risk factors were evaluated using a mixed effects multivariable negative binomial regression model with random effects for feedlot, year, month and week of arrival. Mean arrival weight of the cohort, gender, and arrival month and a three-way interaction (and corresponding two-way interactions) among arrival weight, gender and month were significantly ($P < 0.05$) associated with the outcome. Results showed that as the mean arrival weight of the cohort increased, mortality and culling risk decreased, but effects of arrival weight were modified both by the gender of the cohort and the month of feedlot arrival. There was a seasonal pattern in combined mortality and culling risk for light and middle-weight male and female cohorts, with a significantly ($P < 0.05$) higher risk for cattle arriving at the feedlot in spring and summer (March–September) than in cattle arriving during fall, and winter months (November–February). Our results quantified effects of covariate patterns that have been heretofore difficult to fully evaluate in smaller scale studies; in addition, they illustrated the importance of utilizing multivariable approaches when quantifying risk factors in heterogeneous feedlot populations. Estimated effects from our model could be useful for managing financial risks associated with adverse health events based on data that are routinely available.

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1. Introduction

Losses due to cattle mortality and culling have tremendous economic impacts on North American feedlot production systems (Smith et al., 2001). These economic impacts reflect costs associated with feed consumption, personnel labor, pharmaceutical products, carcass disposal, price paid for the animal, and loss of interest on invested money. Despite continued advances in health management programs and pharmaceutical products, recent research indicates that U.S. feedlot mortality risk has increased over time (Loneragan et al., 2001; Loneragan, 2004; Babcock et al., 2006). However, the apparent increased risk over time may be due to true increases in mortality across feedlot populations, changes in cattle demographics and corresponding risk factors, or an increasing reluctance of feedlots to cull cattle. Culling is defined as removal of animals from their cohort prior to harvest. Feedlots may have different criteria on culling chronically ill or poor performing animals prior to harvest, and may cull animals in an attempt to decrease overall mortality. If feedlot personnel cull animals quickly and aggressively, the mortality risk for the population may appear low relative to similar populations of cattle in feedlots with more conservative culling practices. Some researchers have suggested that a more comprehensive approach to assessing cattle losses across multiple feedlots and years would require that data on mortality and culling are combined and assessed simultaneously using multivariable models accounting for differences in cattle populations (Loneragan, 2004).

Multivariable approaches assessing risk factors for mortality and culling are important because cattle demographics changing over time, within and across feedlots, can confound the observed relationship between seasonal patterns and health risks (Ribble et al., 1995). Literature quantifying effects of risk factors of feedlot mortality are limited, and there are no published data on factors affecting culling of feedlot cattle. Animal weight at feedlot arrival, gender, arrival month, weather, and commingling of cattle have been found to be associated with feedlot mortality risk (Martin et al., 1982; MacVean et al., 1986; Ribble et al., 1998; Loneragan, 2004). However, most studies of mortality risks have used data from only a limited number of feedlots, or used data aggregated by month at the feedlot level; when cohort should be the unit of interest as feedlots tend to purchase, manage and market cattle as cohorts (often called "lots" of cattle). There are no published data demonstrating the effects of multiple risk factors and their interactions on combined mortality and culling risk in cohorts of commercial feedlot cattle. Quantifying the effects of potential risk factors will allow managers of feedlot finances and cattle health to make more informed production decisions about cattle cohorts they typically purchase, and also provide data on atypical cohorts where the effects of risk factors are often difficult to quantify due to a lack of data. The objective of our study was to quantify the effects of commonly measured cohort-level risk factors on combined cumulative mortality and culling risk within cattle cohorts using operational data routinely collected by commercial feedlots.

2. Materials and methods

2.1. Data

We collected cohort-level data from commercial feedlots in four U.S. states (Colorado, Kansas, Nebraska, and Texas). Cohorts were considered as "lots" of animals that may or may not have been housed in the same physical location (pen) for the duration of the feeding period; however, all animals in a lot were purchased, managed and marketed similarly. Cohort-level variables regularly collected across feedlots were: mean weight on arrival at the feedlot (recorded on an interval scale), days on feed (recorded on a continuous scale), gender and arrival date (recorded on a nominal scale). Cattle were designated as male or female in our analysis, rather than steer or heifer, as data on the castration or pregnancy status on arrival to the feedlot were not consistently available. Data on several other potential risk factors were either not existent or were not collected consistently across feedlots; therefore, additional variables (e.g., shipping distance, source location, and preconditioning) were not incorporated in the analysis. Study inclusion criteria included: feedlots that reported cohort-level data on both mortality and culling, cohorts classified as male or female (not mixed) that arrived to the feedlot between 2000 and 2007, and cohorts containing between 40 and 340 animals upon arrival with a mean arrival weight between 91 and 470 kg. The sum of mortality and culling counts for each cohort (given the number of cattle at risk) was used to generate the outcome of interest, hereafter referred as the combined mortality and culling risk, representing the cumulative incidence over each cohort's feeding period.

2.2. Regression model

Associations between cohort-level demographic factors with the incidence risk of the combined mortality and culling were modeled using a generalized linear mixed model (Proc GLIMMIX) built in SAS 9.2 (SAS Institute Inc., Cary, NC, USA), with a negative binomial distribution, log link function, and maximum likelihood estimation based on Laplace approximation of the marginal log likelihood. The count of combined mortality and culling within each cohort was the outcome of interest and the natural logarithm of the total number of cattle within each cohort upon feedlot arrival (considered our population at risk) was specified as the offset variable of the model. To account for the hierarchical structure of the data, a cross-classification of feedlot-years (11 feedlots in 2000, 13 in 2001–2002, 14 in 2003, and 16 in 2004–2007) was included as a random intercept to model the overdispersion arising from the lack of independence of cohorts nested within feedlots, and of feedlots nested within arrival years. In addition, arrival month ($n = 12$) was modeled as a random intercept using a first-order autoregressive covariance structure to account for the repeated measures of cohorts, within feedlot-years, over months with decay in correlation with increasing distance between observations (Dohoo et al., 2009). Lastly,