Incidence of lameness and association of cause and severity of lameness on the outcome for cattle on six commercial beef feedlots

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OBJECTIVE
To describe the incidence of specific causes of lameness and the associations of cause and severity of lameness on the outcome for cattle on commercial feedlots.

DESIGN
Dynamic population longitudinal study.

ANIMALS
Cattle on 6 commercial feedlots in Kansas and Nebraska during a 12-month period (mean daily population, 243,602 cattle; range, 223,544 to 252,825 cattle).

PROCEDURES
Feedlot personnel were trained to use a standardized diagnostic algorithm and locomotion score (LMS) system to identify and classify cattle by cause and severity of lameness. Information regarding lameness cause, severity, and treatments was recorded for individual cattle. Cattle were monitored until they left the feedlot (ie, outcome; shipped with pen mates [shipped], culled prematurely because of lameness [realized], or euthanized or died [died]). Incidence rates for various causes of lameness, LMSs, and outcomes were calculated. The respective associations of cause of lameness and LMS with outcome were evaluated.

RESULTS
Lameness was identified in 2,532 cattle, resulting in an overall lameness incidence rate of 1.04 cases/100 animal-years. Realized and mortality rates were 0.096 cattle/100 animal-years and 0.397 deaths/100 animal-years, respectively. Injury to the proximal portion of a limb was the most frequently identified cause of lameness followed by undefined lameness, septic joint or deep digital sepsis, and interdigital phlegmon (foot rot). As the LMS (lameness severity) at lameness detection increased, the percentage of cattle that died but not the percentage of cattle that were realized increased.

CONCLUSIONS AND CLINICAL RELEVANCE

Lameness accounts for 16% of all morbidity in beef feedlots and up to 70% of lost revenue associated with premature (salvage) slaughter of cattle because of chronic injury. Costs associated with lameness in feedlot cattle include treatment costs, death loss, and revenue loss associated with the sale of cattle that failed to respond to treatment (ie, chronic [chronics] or realized [realizer] cattle). Cattle that develop interdigital phlegmon (foot rot) at any time during the feeding period have a decrease in ADG of 0.02 kg/d (0.044 lb/d) and require 5 additional days to achieve a finished slaughter weight, compared with cattle that do not develop foot rot. However, cattle that develop foot rot during the last 120 days of the feeding period have a decrease in ADG of 0.05 kg/d (0.110 lb/d) and require 14 additional days to achieve a finished slaughter weight, compared with cattle that do not develop foot rot. Thus, it appears that the negative consequences of foot rot on production increase as the DOF at which the condition is diagnosed increases.

In a survey of 147 feedlot consulting nutritionists, veterinarians, and managers, 85 (58%) respondents considered lameness in the feedlot to be a welfare concern, and 29 (20%) respondents considered lameness in feedlot cattle to be a growing concern. The potential negative effect of lameness on the overall welfare, comfort, health, and performance of cattle makes identifying and understanding the risk factors and pathogenesis of lameness imperative for the feedlot industry.

Only a limited number of studies have been conducted to investigate lameness in feedlot cattle, espe-
cially in regard to the incidence, severity, and specific causes of lameness. At 1 feedlot during an 8-year period, the incidence rate of foot rot was 6.5% throughout the mean duration (262 days) of the feeding period. On the basis of a survey of feedlot veterinarians, the estimated annual prevalence of digital dermatitis in feedlot cattle is 0.01%. The purpose of the study reported here was to describe the incidence of specific causes of lameness in feedlot cattle and assess the respective associations between cause and severity of lameness on the outcome for cattle at 6 large commercial feedlot operations in Kansas and Nebraska.

Materials and Methods

Animals

Individual cattle health records from 6 large commercial beef feedlot operations (operation capacity, >20,000 cattle) in Kansas and Nebraska were analyzed for a period of 12 months. The feedlots were purposely selected on the basis of geographic proximity to the investigators so they could regularly visit the feedlots to train new personnel and ensure quality data collection. All cattle at the participating feedlots were enrolled in the study at the beginning of the observation period. Cattle were observed and health data were recorded on a daily basis throughout the duration of the observation period. All cattle were cared for in accordance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching.

Study design

The study was designed as a dynamic population longitudinal study. The observation period began on August 1, 2012, and ended on July 31, 2013. At the beginning of the observation period, the 6 participating feedlots had 245,494 cattle. Throughout the 12-month observation period, 524,780 and 527,220 cattle arrived and left the feedlots, respectively.

Feedlot personnel responsible for identifying and treating cattle within pens and in designated hospital areas were trained to use a 4-point LMS system developed by the Kansas State University Beef Cattle Institute for assessing the severity of lameness in individual cattle (Appendix). That scoring system was based on assessment of an individual animal’s stride length, head movement, and willingness to move and bear weight on the affected limb or limbs. Stride length was evaluated by comparing the symmetry of the distance in placement of the front and hind feet of the left side with that of the right side. Head movement was evaluated on the basis of the presence or absence of a head bob, which was defined as an abnormal lifting or dropping of the head from its normal plane when the animal was walking. Briefly, cattle that were not lame were assigned an LMS of 0, and cattle that were severely lame were assigned an LMS of 3.

Additionally, feedlot personnel responsible for treating cattle were trained to assign a cause of lameness to each lame animal on the basis of a diagnostic algorithm (Figure 1). The causes of lameness included in the algorithm were foot rot, digital dermatitis (hairy heel wart), laceration of the foot or hoof wall, laminitis, septic joint or deep digital sepsis, sole ulcer or abscess, toe ulcer or abscess, lameness associated with an injury to the proximal portion of a limb (upper limb lameness), and undefined.

All training and training materials were provided to feedlot personnel in both English and Spanish. Training for new feedlot personnel was performed by a study investigator (SPT) as needed on each feedlot throughout the observation period. Following training, feedlot personnel were assessed for consistency in terms of LMS assignment. Investigators made additional training visits to each participating feedlot at least monthly to ensure that all feedlot personnel were adequately trained.

Individual cattle were observed for lameness on a daily basis by feedlot personnel (pen riders), whose responsibility was to identify sick and injured cattle. Once an animal was identified as lame, the pen rider recorded the animal's identification and LMS on a diagnosis card, and that animal was moved from its home pen to the feedlot hospital. If the pen rider failed to record the LMS on the diagnosis card for a particular animal, hospital personnel assigned that animal an LMS prior to restraining it in a chute for further evaluation. Once the animal was in the chute, hospital personnel examined the animal and used the diagnostic algorithm (Figure 1) to identify and record the cause of lameness. Each animal was treated in accordance with the standard protocol established by the consulting veterinarian for each feedlot operation and tracked until it left the feedlot. Decisions to euthanize specific animals were made following consultation with the attending feedlot veterinarian, and euthanasia of those animals was performed in accordance with standard euthanasia protocols established by the consulting veterinarian for each feedlot.

Data collection

For each lame animal, information recorded included individual identification, lot identification (ie, the cohort of cattle with which the lame animal arrived to the feedlot), mean body weight at feedlot arrival for lot, LMS, cause of lameness, initial and all subsequent treatments administered, season (spring [March, April, and May], summer [June, July, and August], fall [September, October, and November], and winter [December, January, and February]) at initial treatment for lameness, DOF at initial treatment and outcome, revenue lost, and outcome (shipped, realized, or died). Cattle that were shipped were defined as those that recovered sufficiently to be returned to their home pen and transported for slaughter with their pen mates. Cattle that were realized were defined as those that did not recover from lameness and were transported for slaughter prior to their pen mates. Data regarding subsequent treatments and outcome for individual animals were collected after the end of the observation period until all cattle ini-
Ruminants

Potentially identified as lame during the observation period died or were realized or shipped. Cattle euthanized for reasons associated with lameness were included in mortality rate calculations.

Statistical analysis

Descriptive data were generated for each variable assessed. The percentage of cattle within each respective category for the outcome, LMS, and cause of lameness variables was also calculated. The mean daily population of cattle for all 6 participating feedlots was calculated and used to determine the mean cattle population at risk of developing lameness for each month (reported as animal-months) and year (reported as animal-years). Incidence and mortality rates were calculated as the number of incidences (cases) or deaths divided by the number of animal-years at risk and reported as the number of cases or deaths/100 animal-years. A baseline-category multinomial logit model was used to assess the respective associations of sex, cause of lameness, LMS at initial treatment for lameness, season at initial treatment for lameness, and number of times treated (ie, number of pulls) with outcome (shipped, realized, or died). Model results were reported as the least squares mean, SEM, exponentiated least squares mean, and associated 95% confidence intervals. All analyses were performed with statistical software, and values of \( P < 0.05 \) were considered significant.

To estimate revenue loss associated with cattle that died or were realized for lameness-associated causes, the mortality or realized rate was multiplied by the estimated revenue lost for each dead or realized animal, respectively. The estimated revenue lost for a dead animal was the calculated market value of a nonlame animal, whereas that for a realized animal was the difference between the market value of a nonlame animal and the expected salvage value of the realized animal, which was assumed to be 54% of the market value for a nonlame animal. The estimated market value for a nonlame animal was calculated as follows: (mean body weight of individual cattle at

Figure 1—Diagnostic algorithm used by trained feedlot personnel to identify the cause of lameness in individual beef cattle on 6 large commercial feedlot operations (operation capacity, > 20,000 cattle) in Kansas and Nebraska between August 1, 2012, and July 31, 2013. The final diagnoses are outlined in red.
feedlot arrival for all lots within the study population + [mean DOF at removal from feedlot \( \times \) ADG] \( \times \) market price as determined by the mean price paid for cattle of similar weight sold at Oklahoma sale barns in April 2015. The ADG used for the calculation was 1.25 kg/d (2.75 lb/d), which is a conservative benchmark for the feedlot industry.

**Results**

**Cattle**

The mean daily population for all 6 participating feedlots was 243,602 cattle (range, 223,544 to 252,825 cattle). Mean body weight at feedlot arrival for all lots of cattle received by the participating feedlots during the observation period was 334 kg (735 lb; median, 335 kg [737 lb]).

**Lameness incidence and mortality rates**

Lameness was identified in 2,532 cattle during the observation period, resulting in an overall incidence rate of 1.04 cases/100 animal-years. For all lame cattle, the mean DOF at lameness detection was 57 days. The most frequently identified cause of lameness was upper limb lameness (901 [36%]) followed by undefined lameness (685 [27%]; Table 1).

Five hundred sixty-seven cattle that were treated for lameness subsequently died or were euthanized, and an additional 401 cattle that were not treated for lameness died or were euthanized for lameness-associated reasons. Thus, 968 of 2,532 (38%) cattle died or were euthanized for reasons associated with lameness, resulting in an overall lameness mortality rate of 0.397 deaths/100 animal-years. The mortality rate was greatest for cattle with undefined lameness (0.161 deaths/100 animal-years) followed by upper limb lameness (0.119 deaths/100 animal-years; Table 1).

For the 968 cattle that died or were euthanized for reasons associated with lameness, the mean DOF at lameness identification was 58 days (range, 14 to 104 days), mean DOF at death was 74 days (range, 44 to 139 days), and mean interval between lameness identification and death was 16 days (range, 10 to 31 days; Table 2). Cattle with a toe ulcer or abscess had the lowest mean DOF at lameness identification (14 days) and the longest mean interval between lameness identification and death (31 days), whereas cattle with digital dermatitis had the highest mean DOF at lameness identification (104 days), and cattle with upper limb lameness had the shortest interval between lameness identification and death (10 days).

**Table 1**—Descriptive statistics for various causes of lameness in beef cattle on 6 large commercial feedlot operations (operation capacity, > 20,000 cattle) in Kansas and Nebraska between August 1, 2012, and July 31, 2013.

<table>
<thead>
<tr>
<th>Cause of lameness</th>
<th>No. of cattle</th>
<th>Mean (SD) DOF at diagnosis (d)</th>
<th>Outcome</th>
<th>Mortality rate (No. of deaths/100 cattle-years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital dermatitis (hairy heel wart)</td>
<td>21</td>
<td>137 (49)</td>
<td>11</td>
<td>0.002</td>
</tr>
<tr>
<td>Interdigital phlegmon (foot rot)</td>
<td>222</td>
<td>40 (44)</td>
<td>184</td>
<td>0.012</td>
</tr>
<tr>
<td>Laceration of the foot or hoof wall</td>
<td>81</td>
<td>42 (45)</td>
<td>58</td>
<td>0.008</td>
</tr>
<tr>
<td>Laminitis</td>
<td>99</td>
<td>79 (56)</td>
<td>73</td>
<td>0.010</td>
</tr>
<tr>
<td>Septic joint or deep digital sepsis</td>
<td>257</td>
<td>44 (41)</td>
<td>156</td>
<td>0.035</td>
</tr>
<tr>
<td>Sole ulcer or abscess</td>
<td>138</td>
<td>29 (41)</td>
<td>88</td>
<td>0.019</td>
</tr>
<tr>
<td>Toe ulcer of abscess</td>
<td>128</td>
<td>25 (41)</td>
<td>100</td>
<td>0.007</td>
</tr>
<tr>
<td>Undefined</td>
<td>685</td>
<td>68 (30)</td>
<td>446</td>
<td>0.064</td>
</tr>
<tr>
<td>Upper limb lameness‡</td>
<td>901</td>
<td>70 (56)</td>
<td>619</td>
<td>0.076</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,532</td>
<td>57 (48)</td>
<td>1,735</td>
<td>0.233</td>
</tr>
</tbody>
</table>

*Recovered sufficiently to be transported for slaughter with unaffected pen mates. †Transported for slaughter prior to unaffected pen mates (i.e., salvaged). ‡Lameness associated with an injury to the proximal portion of a limb.

**Table 2**—Descriptive data for the cattle of Table 1 that died or were euthanized for reasons associated with lameness.

<table>
<thead>
<tr>
<th>Cause of lameness</th>
<th>No. of cattle</th>
<th>Mean (SD) DOF at diagnosis (d)</th>
<th>Mean (SD) DOF at death (d)</th>
<th>Mean (SD) interval between diagnosis and death (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital dermatitis (hairy heel wart)</td>
<td>5</td>
<td>104 (45)</td>
<td>139 (47)</td>
<td>26 (43)</td>
</tr>
<tr>
<td>Interdigital phlegmon (foot rot)</td>
<td>29</td>
<td>24 (36)</td>
<td>53 (49)</td>
<td>29 (35)</td>
</tr>
<tr>
<td>Laceration of the foot or hoof wall</td>
<td>19</td>
<td>21 (25)</td>
<td>50 (37)</td>
<td>29 (29)</td>
</tr>
<tr>
<td>Laminitis</td>
<td>24</td>
<td>63 (46)</td>
<td>80 (47)</td>
<td>18 (14)</td>
</tr>
<tr>
<td>Septic joint or deep digital sepsis</td>
<td>86</td>
<td>45 (46)</td>
<td>65 (44)</td>
<td>21 (22)</td>
</tr>
<tr>
<td>Sole ulcer or abscess</td>
<td>46</td>
<td>31 (30)</td>
<td>48 (34)</td>
<td>17 (13)</td>
</tr>
<tr>
<td>Toe ulcer of abscess</td>
<td>17</td>
<td>14 (33)</td>
<td>44 (42)</td>
<td>31 (31)</td>
</tr>
<tr>
<td>Undefined</td>
<td>157</td>
<td>66 (51)</td>
<td>79 (51)</td>
<td>14 (23)</td>
</tr>
<tr>
<td>Upper limb lameness</td>
<td>184</td>
<td>75 (60)</td>
<td>85 (58)</td>
<td>10 (16)</td>
</tr>
</tbody>
</table>

See Table 1 for key.
Table 3—Descriptive data for the cattle from Table 1 that were realized or died at the time various causes of lameness were identified.

<table>
<thead>
<tr>
<th>Cause of lameness</th>
<th>No. of cattle</th>
<th>Realized (%)</th>
<th>95% Confidence interval for percentage</th>
<th>Died (%)</th>
<th>95% Confidence interval for percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital dermatitis (hairy heel wart)</td>
<td>5</td>
<td>14.6 (7.0) a,b</td>
<td>0.9–28.2</td>
<td>5</td>
<td>21.2 (9.0) a,b,c</td>
</tr>
<tr>
<td>Intersdigital phlegmon (foot rot)</td>
<td>9</td>
<td>3.1 (1.1) a</td>
<td>0.9–5.3</td>
<td>29</td>
<td>12.4 (2.3) b</td>
</tr>
<tr>
<td>Laceration of the foot or hoof wall</td>
<td>4</td>
<td>4.4 (2.2) a,b</td>
<td>0.0–8.7</td>
<td>19</td>
<td>23.8 (5.1) a,b,c</td>
</tr>
<tr>
<td>Laminitis</td>
<td>2</td>
<td>1.8 (1.3) a</td>
<td>0.0–4.2</td>
<td>24</td>
<td>19.1 (3.9) a,b,c</td>
</tr>
<tr>
<td>Septic joint or deep digital sepsis</td>
<td>15</td>
<td>4.5 (1.3) a</td>
<td>2.0–7.1</td>
<td>86</td>
<td>32.9 (3.4) a</td>
</tr>
<tr>
<td>Sole ulcer or abscess</td>
<td>4</td>
<td>2.3 (1.2) a</td>
<td>0.0–4.7</td>
<td>46</td>
<td>28.8 (4.2) a</td>
</tr>
<tr>
<td>Toe ulcer of abscess</td>
<td>11</td>
<td>6.6 (2.2) a,b</td>
<td>2.4–10.9</td>
<td>17</td>
<td>14.9 (3.5) a,c</td>
</tr>
<tr>
<td>Undefined</td>
<td>82</td>
<td>8.5 (1.4) a</td>
<td>5.8–11.3</td>
<td>157</td>
<td>24.2 (2.1) a</td>
</tr>
<tr>
<td>Upper limb lameness:‡</td>
<td>98</td>
<td>8.1 (1.3) a</td>
<td>5.5–11.1</td>
<td>184</td>
<td>21.6 (1.9) a</td>
</tr>
</tbody>
</table>

‡Within a column, values with different superscripts differ significantly (P < 0.05). See Table 1 for remainder of key.

The mean percentage of cattle with a septic joint or deep digital sepsis that were dead or euthanized at the time lameness was identified (32.9%) was significantly (P < 0.001) greater than that of cattle with foot rot (12.4%) or a toe ulcer or abscess (14.9%; Table 3).

Similarly, the mean percentage of cattle with a sole ulcer or abscess (28.8%), undefined condition (24.2%), or upper limb lameness (21.6%) that were dead or euthanized at the time lameness was identified was significantly (P < 0.05) greater than that for cattle with foot rot.

Realizer rates

Two hundred thirty of the 2,532 cattle identified with lameness were realized, or sold for slaughter prior to their pen mates for salvage purposes, resulting in an overall realizer rate of 0.096 cattle/100 animal-years. The condition with the highest proportion of cattle realized was digital dermatitis (5/21 [24%]), followed by undefined lameness (82/685 [12%]) and upper limb lameness (98/901 [11%]; Table 1). The mean percentage of cattle with undefined lameness (8.5%) and upper limb lameness (21.6%) that were dead or euthanized at the time lameness was identified was significantly (P < 0.001) greater than that for cattle with foot rot (3.1%), laminitis (1.8%), and sole ulcer or abscess (2.3%; Table 3).

Retreatment rate

Of the 2,532 lame cattle identified, 2,304 (91.0%) were treated once, 116 (4.6%) were treated twice, and 112 (4.4%) were treated 3 or more times. The mean number of treatments administered did not differ among the causes of lameness.

Association of LMS with outcome

At the time lameness was detected, 561 of 2,532 (22.2%) cattle were assigned an LMS of 1, 795 (31.4%) were assigned an LMS of 2, and 576 (22.7%) were assigned an LMS of 3. The remaining 600 (23.7%) cattle were not assigned an LMS at the time of lameness detection (Table 4). The mean percentage of cattle with an LMS of 3 (33.3%) that were dead or euthanized at the time of lameness detection was significantly greater than that for cattle with an LMS of 2 (19.1%) or 1 (10.0%) but did not differ significantly from that for cattle that were not assigned an LMS at lameness detection (31.3%; Table 5). Likewise, the mean percentage of cattle with an LMS of 2 that were dead or euthanized at the time of lameness detection was significantly greater than that for cattle with an LMS of 1. The mean percentage of cattle with an LMS of 1 (6.4%) that were realized at the time of lameness detection did not differ significantly from that of cattle with an LMS of 3 (6.67%), but was significantly greater than that for cattle with an LMS of 2 (3.67%) and cattle that were not assigned an LMS (3.65%).

Association of season with outcome

The mean percentage of cattle that were identified as lame in the winter (29.7%) that were dead or euthanized at the time of detection was significantly greater than that for cattle that were initially identified as lame in the spring (19.4%) and summer (18.3%), but did not differ significantly from that for cattle that were initially identified as lame in the fall (20.1%; Table 6). Likewise, the mean percentage of
cattle that were initially identified as lame in the fall that were dead or euthanized at the time of detection did not differ from that for cattle that were initially identified as lame in the spring and summer.

The mean percentage of cattle that were initially identified as lame in the spring (9.76%) that were realized at the time of detection was significantly greater than that for cattle initially identified as lame in the fall (3.45%) and winter (3.25%), but did not differ significantly from that for cattle initially identified as lame in the summer (6.13%; Table 6). Likewise, the proportion of cattle that were initially identified as lame in the summer and realized at the time of detection did not differ significantly from that for cattle initially identified as lame in the fall and winter.

**Estimated revenue lost because of lameness**

The mean body weight at feedlot arrival for the study population was 334 kg, and the mean DOF at the time of death for the lame cattle that died was 77 days. Therefore, the mean expected body weight of a nonlame animal at 77 DOF was calculated as follows: (334 kg + [77 days X 1.25 kg/d]) = 430 kg. The market price paid for feedlot cattle of that size was $3.85/kg; thus, the market value for a nonlame animal at 71 DOF was $1,725 (ie, 448 kg X $3.85/kg), and the estimated salvage value for an animal realized at 91 DOF was $932 (ie, $1,725 X 0.54). The estimated revenue lost per realized animal was calculated as $1,725 – $932 = $793. Given that the realizer rate for lame cattle was 0.008 cattle/100 animal-months, or 0.096 cattle/100 animal-years, the estimated revenue lost for cattle realized because of lameness was $0.06/animal-month, or $0.76/animal-year. Thus, the estimated loss of revenue associated with lameness because of death or premature (realized) slaughter was $7.36/animal-year.

**Discussion**

Lameness in feedlot cattle has been evaluated by review of large data sets from multiple feedlots and from a single feedlot over multiple years. To our knowledge, the present study was the first to prospectively evaluate lameness on multiple large commercial feedlot operations that used a standardized diagnostic algorithm and LMS scale to identify the
specific cause and severity of lameness in individual cattle and assess how those variables affected the outcome for lame cattle.

Review\(^1\) of health records for > 1.8 million cattle from 5 commercial feedlots in the early 1990s revealed that 13.1% of feedlot cattle develop a health problem during the feeding period, and 16% of those health problems are associated with lameness, resulting in a lameness incidence rate of 2.09% for the duration of the mean feeding period for the feedlots evaluated. In the present study, the lameness incidence rate was 1.04 cases/100 animal-years (ie, 1.04%), approximately half that of the previous study.\(^1\) However, the previous study\(^4\) was a retrospective review of data sets obtained from feedlots where the personnel had not been formally trained to identify, assess, treat, and monitor lame cattle, whereas the present study was prospective in nature and feedlot personnel received standardized training on how to identify and assess the severity of lameness in individual cattle. The incidence rate of a disease is affected by the sensitivity of the method used to detect it. In the present study, the lameness incidence rate was dependent on the ability of feedlot personnel to identify, remove, and treat lame cattle and should be evaluated in conjunction with the realized and mortality rates.

Review\(^2\) of data from a single large feedlot in Nebraska over an 8-year period revealed that the incidence rate of foot rot in steers over the mean duration of the feeding period (262 days) was 6.5%. In the present study, the incidence of foot rot was 0.09%. Several factors likely contributed to the disparity in the foot rot incidence rates between the 2 studies. The previous study\(^2\) involved a retrospective review of data from only 1 feedlot, whereas in the present study, data were prospectively collected from 6 feedlots. Multiple feedlot-specific factors can affect the incidence rate of foot rot such as pen conditions (eg, muddy or dry), type of cattle, and ration fed.\(^3\) Additionally, use of a standardized diagnostic algorithm to identify cattle with foot rot by all 6 feedlots that participated in the present study may have improved the specificity for identification of cattle with foot rot, compared with the previous study.\(^2\)

The identification of specific causes of lameness and the factors that contribute to the development of those causes is important for disease management. Historically, foot rot, injury, and toe ulcers or abscesses have been considered the most common causes of lameness in feedlot cattle.\(^5,6\) In a more recent survey\(^4\) of 147 feedlot veterinarians, nutritionists, and managers, 62 (42.2%), 52 (35.4%), and 14 (9.5%) perceived that foot rot, injury, and toe ulcer or abscess, respectively, was the most common cause of lameness in feedlot cattle. Interestingly, in the present study, the most frequently identified causes of lameness were upper limb lameness (incidence rate, 0.37%), undefined lameness (0.28%), and septic joint or deep digital sepsis (0.11%), whereas foot rot (0.09%) and toe ulcers or abscess (0.05%) were the fourth and sixth most frequently identified causes of lameness, respectively. It is possible that, in practice, a large number of cattle with secondary infections resulting from digital dermatitis, toe ulcers or abscesses, sole ulcers or abscesses, and septic joints or deep digital sepsis are misclassified as having foot rot. In this study, undefined lameness was the second most commonly identified condition, which indicated that, for many cattle, the cause of lameness could not be determined on the basis of the diagnostic algorithm used. That algorithm was developed with the primary intention of maximizing the diagnostic specificity for the defined causes of lameness, which resulted in some sacrifices in the diagnostic sensitivity for those same causes and many cattle being classified with undefined lameness. Thus, the estimated incidence rates for all causes other than undefined lameness are likely conservative. Furthermore, the results of the present study and the 2 other studies\(^8,9^1\) in which the incidence rates of lameness in feedlot cattle were calculated represent snapshots of the condition during a specific period of time on specific feedlots. The perceptions of the feedlot veterinarians, nutritionists, and managers who responded to the aforementioned survey\(^3\) are likely more reflective of continuous long-term surveillance on a much broader population of feedlots.

Results of another study\(^7\) indicate that, on 1 large commercial feedlot, the prevalence of lameness for steers before processing (ie, routine vaccination, treatment for internal and external parasites, application of ear tags, and other procedures such as dehorning and castration; 52/3,243 [1.6%]) at feedlot arrival was significantly \((P = 0.02)\) less than that immediately after processing (81/3,243 [2.5%]). Of those 3,243 steers, 120 (3.7%) were treated for lameness during the first 100 DOF, with 5 (0.15%) classified with foot rot, 63 (1.94%) classified as bullers (ie, steers that are ridden by other steers in a pen), 45 (1.39%) classified with a musculoskeletal disorder, and 7 (0.22%) classified with arthritis.\(^7\) When the steers classified as bullers were removed from calculation, the incidence rate of lameness during the first 100 DOF was 1.76% (57/3,243).\(^7\) Although the cause of lameness was categorized in that study,\(^7\) the steers were not followed until slaughter; therefore, the incidence rate of lameness for those steers over the entire duration of feeding period was likely > 1.76%, which was greater than that for the present study (1.04%). However, compared with the present study, that study\(^7\) involved data obtained from a much smaller number of cattle from only 1 feedlot over a much shorter observation period (100 days vs 12 months).

Information regarding the effect of lameness on realizer and mortality rates for feedlot cattle is sparse. In a retrospective review\(^1\) of health records for > 1.8 million cattle on 5 commercial feedlots, lameness was attributed to 70% of cattle that were realized and 5% of cattle that died; however, the actual realizer and mortality rates were not reported. The financial cost of lameness for feedlot operations is not unsubstantial. In the present study, the estimated loss of revenue associated with lameness because of death
or premature (realized) slaughter was $7.36/animal-year. To help clarify this further, the mean daily population for all 6 feedlots of the present study was 243,602 cattle, which is equivalent to the mean animal-years for the study population. Thus, the estimated revenue lost because of the premature slaughter or death of lame cattle from the 6 feedlots of this study during the 12-month observation period alone was almost $1.8 million (243,602 animal-years $7.36/animal-year). Moreover, that estimate is simply lost revenue; it does not account for drug and labor costs associated with the treatment of lame cattle.

Locomotion scoring is frequently used in the dairy industry but is not commonly used in the beef industry. One of the first LMS systems developed for cattle was a 9-point scale with scores that ranged from 1 to 5 in 0.5-point increments. A simplified 5-point system was developed that focused on gait and the extent of arch in the back. Investigators of another study developed a 4-point system with scores that ranged from 0 to 3 and included evaluation of head movement (ie, the presence or absence of a head bob while walking). The LMS system used in the present study was developed from components of the previously described 4- and 5-point scoring systems developed for dairy cattle and was described in practical and commonly used beef production terminology, with the expectation that it could be used by feedlot personnel with diverse experience, educational, and cultural backgrounds.

In the present study, the mean percentage of cattle that died increased significantly as the LMS assigned at the time of lameness detection increased. However, a similar trend was not observed for the mean percentage of cattle that were realized (Table 5). In fact, the mean percentage of cattle realized that were assigned an LMS of 1 (6.40%) was significantly greater than that for cattle that were assigned an LMS of 2 (3.67%), but did not differ significantly from that for cattle that were assigned an LMS of 3 (6.67%). This finding warrants further investigation. It is possible cattle with mild lameness that did not require treatment, particularly those that were near finished slaughter weight, were realized before the disease progressed in an attempt to salvage as much revenue as possible. Nevertheless, when the mean percentages of cattle that were realized and died were combined, the summary percentage for cattle assigned an LMS of 1 was less than that for cattle assigned an LMS of 2, which indicated that a greater proportion of cattle assigned an LMS of 1 were sent to slaughter as scheduled with their respected lots (ie, shipped), compared with cattle that were assigned an LMS of 2. Thus, there appeared to be an inverse relationship between LMS at lameness detection and the probability of a favorable outcome (shipped vs realized or died). Feedlot personnel should be trained to use an LMS system similar to that developed for this study so that lame cattle can be identified and treated before the disease progresses and substantially affects animal welfare and production. The LMS can also be used as a prognostic indicator in deciding whether individual animals should be treated, realized, or euthanized.

Further research and validation of the LMS system developed for the present study are necessary before it can be used as a tool to better understand both the subclinical and clinical effects of lameness in feedlot cattle. Without some kind of objective measure, it is likely that lameness in feedlot cattle is underestimated much like it was in dairy cattle prior to the use of an LMS system. For example, in a survey of 53 dairy operations in the United Kingdom, the mean prevalence of lameness was 5.73% when subjectively estimated by producers, compared with 22.11% when cattle were objectively assessed as lame or severely lame by use of an LMS system. Information regarding lameness in feedlot cattle is currently limited because, although the number of cattle removed (pulled) from a pen for treatment is frequently reported, the reason individual animals are pulled is generally not recorded; therefore, it is difficult to estimate the prevalence of lameness within a specific pen or feedlot, let alone the entire feedlot industry. The wide-scale adoption of a standardized system to assess lameness in feedlot cattle within individual pens is necessary to better estimate the costs and losses associated with both clinical and subclinical lameness in the feedlot industry.

The LMS system developed for this study could also be useful in other areas of the beef industry. In another study, 1,404 of 9,299 (15.1%) beef cows and 168 of 1,091 (15.4%) beef bulls marketed in the western United States in 2008 were noticeably lame. Further research is necessary to elucidate the association between LMS and outcome for beef cows and bulls and provide insight into culling decisions.

Results of the present study provided data regarding the incidence, realizer, and mortality rates for various causes of lameness in feedlot cattle on 6 large commercial feedlot operations in Kansas and Nebraska during a 12-month period. This study was unique in that a standardized diagnostic algorithm and LMS system were used to differentiate the cause and severity of lameness in individual cattle, respectively. Those data were then used to calculate incidence rates and assess the respective associations between outcome and lameness cause and severity at detection. These results may provide clinically useful prognostic guidelines for the management of lame cattle on feedlot operations.

**Acknowledgments**

Supported in part by Zinpro Corp. This manuscript represents a portion of a dissertation submitted by Dr. Terrell to the Kansas State University Department of Clinical Sciences as partial fulfillment of the requirements for a Doctor of Philosophy degree.

**Footnotes**


b. SAS, version 9.4, SAS Institute Inc, Cary, NC.

444

**Ruminants**
**References**


**Appendix**

Description of LMS system used to assess lameness in beef feedlot cattle on 6 large commercial beef feedlot operations (operation capacity, > 20,000 cattle) in Kansas and Nebraska between August 1, 2012, and July 31, 2013.

**LMS Clinical description**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal; animal walks normally with no apparent lameness or change in gait.</td>
</tr>
<tr>
<td>1</td>
<td>Mild lameness; animal walks with a shortened stride and may move head slightly from side to side but does not have a head bob.</td>
</tr>
<tr>
<td>2</td>
<td>Moderate lameness; animal walks with an obvious limp with or without a head bob, and the affected limb or limbs can be readily identified.</td>
</tr>
<tr>
<td>3</td>
<td>Severe lameness; animal applies little or no weight to the affected limb while standing or walking and is reluctant to move. When walking, the head is dropped and the back is arched, and the animal has an obvious limp and head bob.</td>
</tr>
</tbody>
</table>

All cattle were assessed at a walk.