Trends in mortality ratios among cattle in US feedlots

Guy H. Loneragan, BVSc, MS; David A. Dargatz, DVM, PhD; Paul S. Morley, DVM, PhD; Marty A. Smith, DVM, MS

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Objective—To evaluate trends in feedlot cattle mortality ratios over time, by primary body system affected, and by type of animal.

Design—Retrospective cohort study.

Animals—Approximately 21.8 million cattle entering 121 feedlots in the United States during 1994 through 1999.

Procedures—Yearly and monthly mortality ratios were calculated. Numbers of deaths were modeled by use of Poisson regression methods for repeated measures. Relative risks of death over time and by animal type were estimated.

Results—Averaged over time, the mortality ratio was 12.6 deaths/1,000 cattle entering the feedlots. The mortality ratio increased from 10.3 deaths/1,000 cattle in 1994 to 14.2 deaths/1,000 cattle in 1999, but this difference was not statistically significant ($P = 0.09$). Cattle entering the feedlots during 1999 had a significantly increased risk (relative risk, 1.46) of dying of respiratory tract disorders, compared with cattle that entered during 1994, and respiratory tract disorders accounted for 57.1% of all deaths. Dairy cattle had a significantly increased risk of death of any cause, compared with beef steers. Beef heifers had a significantly increased risk of dying of respiratory tract disorders, compared with beef steers.

Conclusions and Clinical Relevance—Results suggested that although overall yearly mortality ratio did not significantly increase during the study, the risk of death attributable to respiratory tract disorders was increased during most years, compared with risk of death during 1994. The increased rates of fatal respiratory tract disorders may also reflect increased rates of non-fatal respiratory tract disorders, which would be expected to have adverse production effects in surviving animals. (*J Am Vet Med Assoc* 2001;219:1122–1127)

Cattle deaths result in substantial losses for US feedlots.[1] Economic losses include, but are not limited to, the purchase price of the animal, the cost of feed consumed from the time of arrival at the feedlot to the time of death, processing and medical costs incurred, disposal costs, costs for any labor associated with animal disposal, and interest on invested money.

Most feedlot-associated deaths result from **bovine respiratory disease (BRD)** complex, and postmortem lesions often include fibrinous bronchopneumonia.[2] Bovine respiratory disease complex is a consequence of interactions among stressors, host immunity, pathogenicity of agents, and environmental factors that alter the probability of pathogen exposure. Factors that may influence the overall health of feedlot cattle include arrival weight (which provides a crude estimate of an animal's age and maturity), distance transported to the feedlot, water and feed restriction during transportation, commingling, and experience of the feedlot personnel.[3-5] These factors can directly and indirectly affect the proportion of feedlot cattle that do not survive to harvest.

Careful monitoring of causes of death may be useful in elucidating broad trends in animal health within and among feedlots. These trends may include increases or decreases in mortality rates and changes in proportional mortality ratios. The sentinel feedlot monitoring program was developed under the umbrella of the United States Department of Agriculture's **National Animal Health Monitoring System (NAHMS)** to monitor cattle in feedlots and serves as a benchmarking tool for participating feedlot managers and veterinary consultants. This program has been collecting data on feedlot cattle since March 1993. Feedlots supply data to NAHMS voluntarily and confidentially through their veterinary consultants. This information is, therefore, an ideal source of data to monitor trends in mortality rates and ratios of feedlot cattle. The purpose of the study reported here was to evaluate trends in feedlot cattle mortality ratios over time, monthly proportional mortality ratios of cattle by primary body system affected, and risk of death by type of animal among feedlots participating in the sentinel feedlot monitoring program.

Materials and Methods

Study participants—Data on feedlot cattle submitted to the NAHMS sentinel feedlot monitoring program through feedlot veterinary consultants were used in the study. The confidentiality of the participating feedlots was maintained by the veterinary consultants; consultants were located in Texas (n = 5), Nebraska (2), Kansas (2), and Idaho (1). All submitted data were considered for inclusion in the study; data were included in the study if they referred to the time period of January 1994 through December 1999 and if complete placement and mortality data had been provided by the consultant.

Data acquisition—Participating veterinary consultants assigned numeric codes for each of their participating feed-

From the Integrated Livestock Management Program, Department of Clinical Science, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Ft. Collins, CO 80523 (Loneragan, Morley); and the United States Department of Agriculture: Animal Plant Health Inspection Service: Veterinary Services: Centers for Epidemiology and Animal Health, Ft. Collins, CO 80521 (Dargatz, Smith).

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lots. Completed data entry forms were identified with the feedlot code and submitted monthly by veterinary consultants to ensure confidentiality of participating feedlots. Month-end data submitted for each feedlot included total number of cattle that entered the feedlot, cattle inventory, and the number of deaths attributable to respiratory tract, digestive tract, and other disorders for the preceding month. Feedlot personnel, in conjunction with the veterinary consultant (with or without ancillary diagnostic tests), attributed the cause of each animal's death to respiratory tract disease, digestive tract disease, or any other cause. Some feedlots in this study also reported the number of cattle that entered the feedlot and the number of deaths according to cattle type (ie, beef steer, beef heifer, and dairy animal). Submitted data were entered into an electronic database,[a] and monthly summary reports were generated and returned to the veterinary consultants for distribution to participating feedlot managers.

Data analysis—Feedlots that supplied at least 10 months of data for each year from 1994 through 1999 were classified as regular contributors; all other feedlots (ie, feedlots that irregularly contributed data, feedlots that entered the program after January 1994, and feedlots that left the program) were classified as other. Yearly estimates of mortality risk for regular contributors and other feedlots were calculated. Overall and body system-specific death counts were compared between regular contributors and other feedlots by use of Cochran-Mantel-Haenszel statistics.[6] The **relative risk (RR)** of death for cattle in feedlots classified as regular contributors and its 95% **confidence limits (CL)** were calculated relative to cattle in other feedlots while controlling for year of the study.[7]

Data from all participating feedlots were analyzed initially. Subsequently, data from feedlots that provided information according to cattle type (beef steers, beef heifers, and dairy animals) were analyzed separately. Feedlots that provided information according to cattle classification represented a subset of all feedlots included in the study. Yearly numbers of cattle entering the feedlot and deaths for each feedlot were summed for all feedlots and, when possible, for cattle classification and attributed cause of death.

Yearly numbers of cattle entering the feedlots and deaths for all participating feedlots were aggregated across months within each year. Month-specific counts were also aggregated across years. Ratios of the number of body system-specific deaths to the number of cattle entering the feedlot (mortality ratios) were then calculated for each year averaged over months and for each month averaged over the study years. Animals that died during a certain month may or may not have entered the feedlot during that month, but these monthly mortality ratios provided the best estimates of risk that were available from the data. It was more likely that animals dying during a given year entered the feedlot during that year; therefore, yearly mortality ratios were likely less biased estimates of risk.

Relative risks of body system-specific deaths for each year, compared with 1994, were estimated, using Poisson regression techniques.[a] Frequency counts of total deaths and deaths attributed to each cause were the dependent variables, and year was the independent variable. Cattle that entered each feedlot during a given year were considered a cohort of cattle. Within each feedlot, first-order autoregressive matrices were used to model the covariance structure of cohorts within feedlots over time.[7] The offset used in the marginal models was the logarithm of number of cattle for each cohort. Parameter estimates were generated with generalized estimator equations.[7] There was evidence that dependence in the outcome variables within feedlots (overdispersion) was present in the data. To adjust for this overdispersion, the exponential dispersion parameter was scaled to the Pearson χ^2 statistic divided by the model degrees of freedom, thereby adjusting standard errors of the estimates.[7]

Yearly mortality risks for each cause of death were calculated by animal type and examined graphically. The association between mortality risk and animal type was evaluated by use of Poisson regression. Frequency counts for body system-specific deaths were the dependent variables of interest, and animal type was included in the model as the independent variable. On the basis of a preliminary graphic evaluation of the risk of death attributable to respiratory tract disease for animal types, the risk of death attributable to respiratory tract disease for beef heifers relative to beef steers was further analyzed for 2 time periods: 1994 through 1996 and 1997 through 1999.

Results

One hundred thirty-eight feedlots supplied at least 1 month's data to the study; feedlots participating in the study contributed a total of 5,139 monthly data records. Of these 5,139 monthly data records, 792 were not included in the study because of incomplete information on number of cattle that entered the feedlot or number of deaths. Therefore, 4,347 monthly data records submitted for 121 feedlots were included in the study. These records provided information on 21,753,082 cattle. Numbers of participating feedlots and total number of cattle monitored through the sentinel feedlot monitoring program increased during the study period (**Table 1**).

Averaged over time, the overall mortality ratio was 12.6 animals/1,000 cattle entering the feedlot. Deaths attributed to respiratory tract, digestive tract, and other disorders accounted for 7.2, 2.9, and 2.5 animals/1,000 cattle entering the feedlot, respectively. Respiratory tract disorders were the most common cause of death and accounted for 57.1% of total deaths.

Of the 121 enrolled feedlots, 24 were classified as regular contributors as they supplied at least 10 months of data each year from 1994 through 1999. Statistical analyses indicated that the RR of death was significantly ($P < 0.01$) associated with regularity of data submission (regular contributors vs other feedlots). However, the effect, albeit statistically significant, was deemed biologically negligible, as the RR of death for cattle in feedlots classified as regular contributors was only 4% less than the risk for cattle in other feedlots (RR, 0.959; 95% CL, 0.955 and 0.962). Because this effect was deemed biologically unimportant, no

Table 1—No. of veterinary consultants, eligible feedlots, enrolled feedlots, and animals that entered enrolled feedlots involved in the National Animal Health Monitoring Service sentinel feedlot monitoring program

	No. of participants and animals			
Year	**Veterinarians**	**Eligible feedlots**	**Enrolled feedlots***	**Animals**
1994	6	56	56	2,889,150
1995	9	78	71	3,636,107
1996	9	78	69	3,583,161
1997	9	77	64	3,486,750
1998	9	97	81	3,815,659
1999	10	108	94	4,342,255
Total	**10**	**138**	**121**	**21,753,082**

*Monthly data records for 17 feedlots were excluded because of incomplete or missing information.

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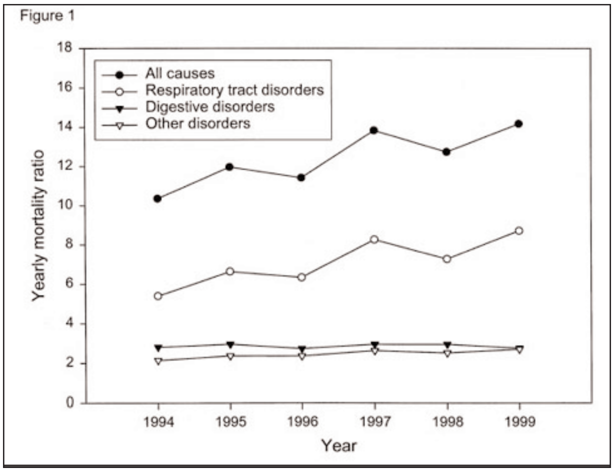

Figure 1—Yearly mortality ratios (No. of deaths/1,000 animals entering the feedlot) for 21,753,082 cattle in 121 feedlots in the United States. Ratios were calculated for deaths attributable to any cause, to respiratory tract disorders, to digestive tract disorders, and to other disorders.

Table 2—Relative risk of death attributable to respiratory tract, digestive tract, and other disorders among cattle in feedlots in the United States

	Relative risk of death		
Year	Respiratory tract disorders	Digestive tract disorders	Other disorders
1995	1.16* (1.01, 1.33)	0.91 (0.72, 1.16)	1.03 (0.89, 1.19)
1996	0.87 (0.54, 1.41)	0.69 (0.40, 1.17)	0.83 (0.54, 1.25)
1997	1.35* (1.02, 1.79)	0.92 (0.69, 1.23)	0.95 (0.70, 1.29)
1998	0.92 (0.48, 1.77)	0.65 (0.30, 1.39)	0.81 (0.50, 1.31)
1999	1.46* (1.13, 1.88)	0.75 (0.49, 1.14)	1.02 (0.76, 1.37)
Overall *P* value	< 0.01	0.11	0.52

*Relative risk is significantly ($P < 0.05$) different from 1.

Relative risks were calculated relative to data for 1994; values in parentheses represent 95% confidence limits.

further analyses were performed stratifying data by regularity of data submission.

Results of analyses for all feedlots—The yearly mortality ratio increased 38% between 1994 and 1999, from 10.3 deaths/1,000 cattle entering the feedlot in 1994 to 14.2 deaths/1,000 cattle entering the feedlot in 1999 **(Fig 1)**. This increase was not statistically significant ($P = 0.09$).

The RR that animals would die of respiratory tract disorders was significantly increased during 1995, 1997, and 1999, compared with data for 1994 **(Table 2)**. On the other hand, the RR that animals would die of digestive tract disorders ($P = 0.11$) or of other disorders ($P = 0.52$), compared with data for 1994, did not vary statistically during 1995 through 1999.

When data were aggregated across years by month, there appeared to be 2 distinct peaks in number of cattle entering the feedlots. The first occurred during spring, and the second, and larger, peak occurred during the late summer and fall **(Fig 2)**. Overall, 40.1% of the cattle entered participating feedlots between August and November. October represented a disproportionately high percentage (12.3%) of cattle entering participating feedlots, and December represented a disproportionately low percentage (5.5%).

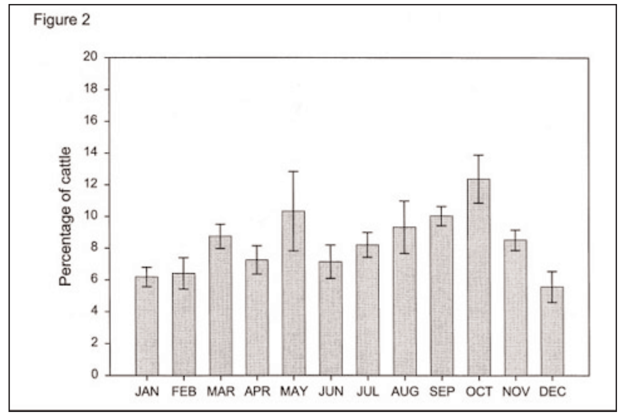

Figure 2—Percentages of cattle entering 121 feedlots in the United States during 1994 through 1999, expressed on a monthly basis. Error bars represent the minimum and maximum percentages for the 6 years.

The monthly mortality ratio for animals that died of respiratory tract disorders was highest during November through January **(Fig 3)**. During December, 17.3 animals died of respiratory tract disorders/1,000 cattle entering the feedlot, compared with only 3.5 animals that died of respiratory tract disorders/1,000 cattle entering the feedlot during May. Distinct patterns in mortality ratios for animals that died of digestive tract disorders and for animals that died of other disorders were not seen.

Results of analyses based on animal type—Eighty-three feedlots provided at least 1 month's data categorized by type of animal (beef steers, beef heifers, and dairy animals). These data represented 5,057,441 beef steers, 2,649,219 beef heifers, and 101,471 dairy cattle. In contrast to data from all feedlots, differences in yearly mortality ratios for animals that died of respiratory tract disease were not detected ($P > 0.20$). Dairy animals had increased RR of death attributable to respiratory tract disorders (RR, 1.99; 95% CL, 1.23 and 3.21), digestive tract disorders (RR, 4.18; 95% CL, 2.30 and 7.58), and other disorders (RR, 2.52; 95% CL, 1.92 and 3.30), compared with beef steers. Beef heifers did not have a statistically increased risk of death attributable to respiratory tract disorders (RR, 1.28; 95% CL, 0.96 and 1.71; $P = 0.09$), compared with beef steers, but did have a decreased RR of death attributable to digestive tract disorders (RR, 0.77; 95% CL, 0.66 and 0.91) and an increased RR of death attributable to other disorders (RR, 1.35; 95% CL, 1.14 and 1.60). Graphically, there appeared to be little difference between the yearly mortality ratios of beef heifers and beef steers that died of respiratory tract disorders between 1994 through 1996 **(Fig 4)**. However, the mortality ratio of beef heifers that died of respiratory tract disorders increased after 1996. When analyzed in 2 time-periods, there was no evidence ($P = 0.94$) that beef heifers were at increased risk of dying of respiratory tract disorders during 1994 through 1996, compared with beef steers (RR, 0.98; 95% CL, 0.64 and 1.51). However, the risk that beef heifers would die of respiratory tract disorders was higher than the risk for beef steers from 1997 through 1999 (RR, 1.63; 95% CL, 1.36 and 1.96; $P < 0.01$).

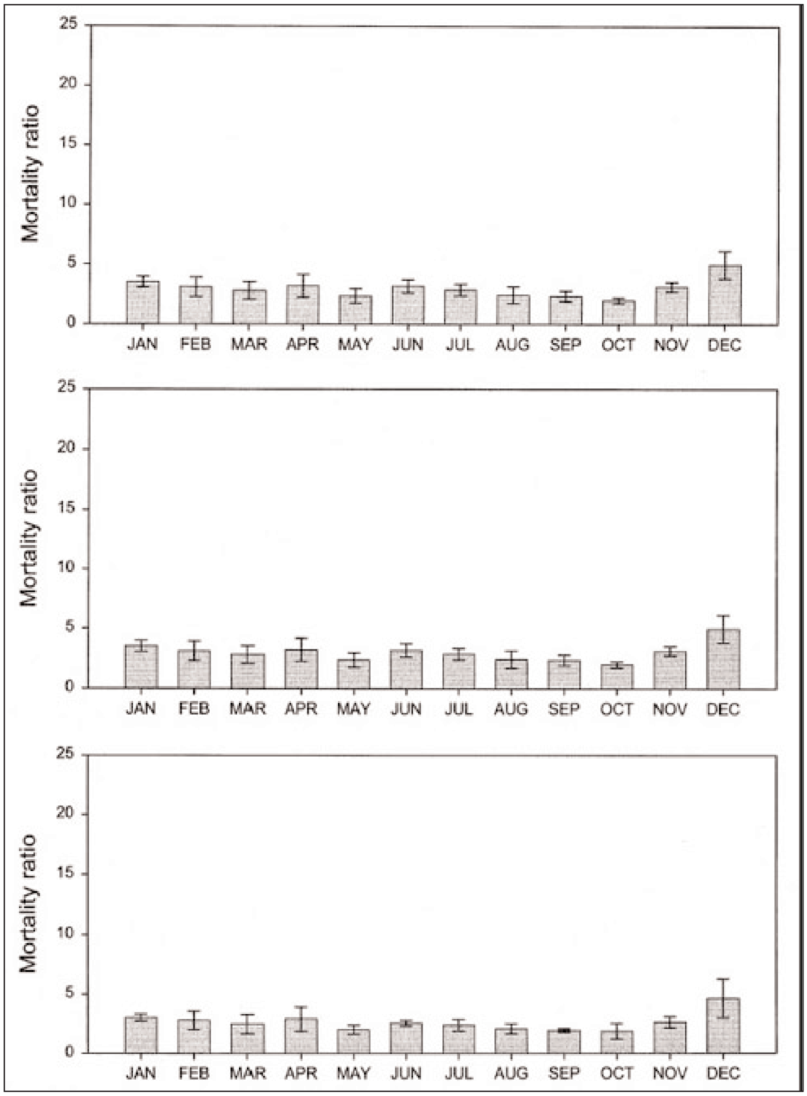

Figure 3—Monthly mortality ratios (No. of deaths/1,000 cattle entering the feedlot) for cattle in 121 feedlots in the United States during 1994 through 1999. Mortality ratios were calculated for cattle dying of respiratory tract disorders (top), digestive tract disorders (middle), and other disorders (bottom).

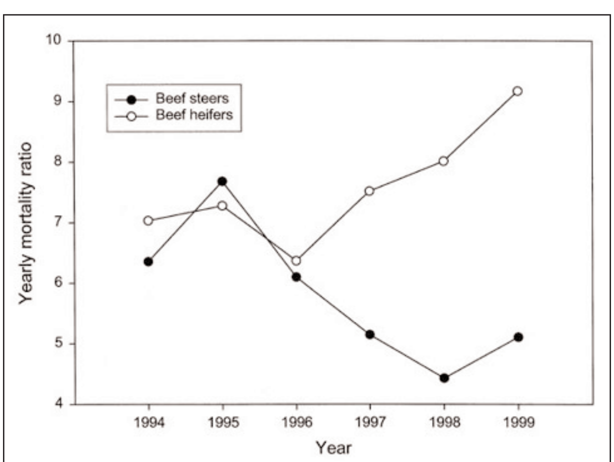

Figure 4—Yearly respiratory tract disorder mortality ratios for 5,057,441 beef steers and 2,649,219 beef heifers in 83 feedlots in the United States during 1994 through 1999.

Discussion

Although not statistically significant ($P = 0.09$), there was evidence of a biologically important increase in yearly mortality ratios from 1994 through 1999 in the present study. The RR of death attributable to respiratory tract disorders was increased during most years of the study, compared with risk of death during 1994. Although the RR of death attributable to digestive tract disorders did not differ statistically over time ($P = 0.11$), there was some evidence of a decrease in the mortality ratio for deaths attributable to digestive tract disorders, in that all RR estimates were < 1.

The NAHMS sentinel feedlot monitoring program is a voluntary program. This provided some strengths and potential weaknesses in the present study. In particular, data were not necessarily derived from a representative sample of all US feedlots. In addition, the estimate of risk of death derived from these data was the ratio of deaths to cattle entering the feedlot. However,

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animals did not necessarily enter the feedlot during the same month or even the same year that they died, and it is likely that some animals that died did so in a month subsequent to the month that they entered the feedlot. Hence, month-specific mortality ratios may not be accurate estimates of risk. However, it is likely that most animals that died did so during the year that they entered the feedlot. Therefore, yearly mortality ratios are likely to be more accurate estimates of risk.

Because many disease conditions result in similar clinical abnormalities, categorizing cause of death on the basis of antemortem clinical abnormalities alone can lead to misclassification,[8] and a thorough postmortem examination is more likely to correctly identify the affected body system.[9] In the present study, animals classified as having died of respiratory tract disorders had a variety of abnormalities, including bronchopneumonia, acute interstitial pneumonia, respiratory tract infection with *Haemophilus* spp, and other disease conditions. Animals classified as having died of digestive tract disorders had ruminal tympany (typically frothy bloat), rumen lactic acidosis, or enterotoxemia. Animals classified as having died of other disorders had diseases of the CNS, musculoskeletal system, or urogenital system, other miscellaneous diseases, or diseases of undetermined cause.

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Nation-wide surveys[10,11] of the feedlot industry indicate that the percentage of dead animals that underwent postmortem examination increased slightly from 45.9% (SE, 2.5%) in 1994 to 53.9% (SE, 2.3%) in 1999. As such, a further weakness of the present study was that it is unlikely that postmortem examinations were performed on all animals that died at the participating feedlots. Thus, the potential for misclassification of diseases existed and would have been greatest among animals that did not undergo a postmortem examination.

Newly arrived animals are at greatest risk of developing BRD, and most animals that die in feedlots of respiratory tract disorders do so soon after arrival.[2] Conversely, most animals that die of digestive tract disorders do so during the later stages of the feeding period. For instance, Jensen et al[12] reported that 72% of cattle that died of shipping fever did so during the first 45 days after arrival at the feedlot, whereas Pierson et al[13] found that 87.5% of cattle that died of bloat did so > 45 days after arrival at the feedlot. Vogel and Parrott[14] reported that mean times from arrival at the feedlot to death attributable to respiratory and digestive tract disorders were 48.6 and 93.2 days, respectively. This difference may have affected the accuracy of monthly mortality ratios in the present study. If an increased proportion of animals in the present study died early in the feeding period of respiratory tract disease, then a smaller proportion of animals survived to the time when deaths attributable to digestive tract disease are more likely to occur. Data in the present study suggested that the risk of dying of respiratory tract disease increased over time, and although time from feedlot arrival to death was not reported in the present study, we expect that most animals that died of respiratory tract disease did so early in the feeding period.

All factors being equal, one would expect that as the proportion of animals dying of respiratory tract disease increased, proportionally fewer animals would have had an opportunity to die of digestive tract disease. Analysis of data in the present study, however, did not support this expectation, in that the increase in the RR of dying of respiratory tract disease was not accompanied by a decrease in the RR of dying of digestive tract disease.

The reason for the increase over time in the risk of dying of respiratory tract disease in the present study was unclear. Many factors could have contributed to this increase, such as a change in the source of cattle (eg, cattle purchased from a sale barn compared with cattle purchased directly from a ranch), a change in pre-arrival animal health management, an increase in transportation stress, commingling of animals, a change in environmental conditions, and a change in dietary management of new arrivals (such as micronutrient supplementation or a change in the concentration of nonstructural carbohydrates in the diets). These factors, alone or in combination, are generally expected to compromise immune function, although the effect of transportation distance on occurrence of fatal fibrinous pneumonia has been questioned.[15] Other factors that may have contributed to the increase in risk of death attributable to respiratory tract disease include purchase of a greater proportion of lightweight animals (body weight may serve as a crude proxy for an animal's age and maturity), changes in treatment protocols, decreases in the ratio of animal health employees to feedlot inventory, and changes in skill levels and experience of feedlot personnel.

Interestingly, the disproportionate increase in risk of death attributed to respiratory tract disease among beef heifers, compared with beef steers, from 1997 through 1999 coincided with a reduction in the US cattle herd inventory.[16,17] It is likely that during this time, a greater number of heifers were culled from herds at a younger age, compared with periods of herd expansion when more heifers would be kept for breeding purposes. It is possible that herd contraction contributed to the increase in heifers that developed fatal respiratory tract disease by supplying a greater number of lightweight heifers to the feedlot industry. This explanation is supported by information regarding numbers of animals entering feedlots; heifers as a proportion of the total number of beef animals entering feedlots increased from 34.1% (SE, 0.9) in 1994 to 41.4% (SE, 1.0) in 1999.[10,11] However, during the same period, the proportion of all animals entering feedlots that weighed < 600 lb at the time of arrival only changed from 27.0 to 28.2%.[16,18] Unfortunately, animal type distributions within arrival weight categories are not available.

Morbidity data for participating feedlots were not collected as part of the sentinel feedlot monitoring program. However, respiratory tract disease morbidity and mortality are associated.[19] Because the proportion of animals dying of respiratory tract disease increased, it is likely that the proportion of animals surviving to harvest that had 1 or more episodes of nonfatal respiratory tract disease also increased (assuming that the case-fatality rate for respiratory tract disease did not change significantly during the study period). Others have demonstrated that detection of pulmonary lesions at harvest was associated with significant decreases in feedlot gains of 0.07 to 0.20 kg/animal-day and with decreased carcass quality.[20,21] Ultimately, the trend for an increased risk of death attributable to respiratory tract disease in the present study may, therefore, indicate decreased rates of gain and feed efficiency among cattle at participating feedlots. Therefore, the economic losses of fatal respiratory tract disease likely extend beyond those losses directly attributable to animals that fail to survive to harvest.

Because dairy cattle generally enter feedlots at lighter weights and have lower average daily gains than do beef animals, they typically stay at the feedlot longer than do beef animals. The higher risk of death in dairy cattle, compared with beef steers, in the present study may in part be attributable to this increased time at the feedlot. Unfortunately, it was not possible to control for time at risk in the analyses as information on time in the feedlot was not collected as part of the sentinel feedlot monitoring program. It was also not possible to evaluate differences in mortality risks among breeds of cattle for animals classified as beef cattle.

Results of the present report also suggest that for beef cattle, the risk of death was associated with sex. Except for differences such as type of implant and inclusion of melengestrol acetate in the ration, there is little variation in the day-to-day management of beef heifers and beef steers in feedlots. However, heifers generally have lower dry matter intakes and average daily gains than do steers. Thus, they may be less likely to develop fatal rumen lactic acidosis or frothy bloat than steers. The reason for the apparent increased risk of death attributable to respiratory tract disease in beef heifers is unclear. Other causes of death included diseases that are sex specific or display a predilection for 1 sex or the other, such as dystocia, metritis, urolithiasis, and the buller steer syndrome.[22] Therefore, comparison of differences in RR of other causes of death between beef heifers and steers is of limited value.

Benchmarking is an important practice that feedlot managers and veterinary consultants can use to compare characteristics of their feedlots with characteristics of a large population of other feedlots. The sentinel feedlot monitoring program provides timely reports to veterinary consultants to aid in identification of strengths and weaknesses in animal health programs and changes in mortality patterns. Although random sampling was not used to select the participating feedlots, results of the present study may serve as benchmarks for use by nutritionists, veterinarians, researchers, and managers working in the wider feedlot industry.

The following veterinary consultants provided data to the National Animal Health Monitoring System sentinel feedlot monitoring program that were included in the study: Drs. David T. Bechtol, Palo Duro Consulting, Canyon, Tex; Charles E. Deyhle Jr, Deyhle Veterinary Services, Canyon, Tex; Phillip L. Kesterson, Western Livestock Consulting, Bridgeport, Neb; Steve Lewis, Hereford Veterinary Clinic, Umbarger, Tex; Scott MacGregor, Livestock Consulting Services, Jerome, Idaho; John Mayer, Midlands Consulting, Omaha, Neb; Leon J. Mills, Herington, Kan; Rodney Oliphant, Oliphant Veterinary Clinic, Offerle, Kan; Robert A. Smith, Palo Duro Consulting, Canyon, Tex; and Galen Weaver, Sheldon Associates, Amarillo, Tex.

[a]SAS, release 8.0, SAS Institute Inc, Cary, NC.

References

1. Smith RA. Impact of disease on feedlot performance: a review. *J Anim Sci* 1998;76:272–274.
2. Ribble CS, Meek AH, Jim GK, et al. The pattern of fatal fibrinous pneumonia (shipping fever) affecting calves in a large feedlot in Alberta (1985–1988). *Can Vet J* 1995;36:753–757.
3. Ribble CS, Meek AH, Janzen ED, et al. Effect of time of year, weather, and the pattern of auction market sales on fatal fibrinous pneumonia (shipping fever) in calves in a large feedlot in Alberta (1985–1988). *Can J Vet Res* 1995;59:167–172.
4. Lechtenberg KF, Smith RA, Stokka GL. Feedlot health and management. *Vet Clin North Am Food Anim Pract* 1998;14:177–197.
5. Galyean ML, Gunter SA, Malcolm-Callis KJ. Effects of arrival medication with tilmicosin phosphate on health and performance of newly received beef cattle. *J Anim Sci* 1995; 73:1219–1226.
6. *SAS/STAT user's guide: version 6.* Vol 1. 4th ed. Cary, NC: SAS Institute Inc, 1989.
7. *SAS/STAT software: changes and enhancements through release 6.12*. 6.12 ed. Cary, NC: SAS Institute Inc, 1997.
8. Salman MD, Frank GR, MacVean DW, et al. Validation of disease diagnoses reported to the National Animal Health Monitoring System from a large Colorado beef feedlot. *J Am Vet Med Assoc* 1988;192:1069–1073.
9. Miles DG, Hoffman BW, Rogers KC, et al. Diagnosis of digestive deaths. *J Anim Sci* 1998;76:320–322.
10. National Animal Health Monitoring System. *Part I: feedlot management practices*. Ft Collins, Colo: USDA:APHIS:VS:CEAH, National Animal Health Monitoring System, 1995.
11. National Animal Health Monitoring System. *Part I: baseline references of feedlot management practices, 1999*. Ft Collins, Colo: USDA:APHIS:VS:CEAH, National Animal Health Monitoring System, 2000.
12. Jensen R, Pierson RE, Braddy PM, et al. Shipping fever pneumonia in yearling feedlot cattle. *J Am Vet Med Assoc* 1976;169:500–506.
13. Pierson RE, Jensen R, Lauerman LH, et al. Sudden deaths in yearling feedlot cattle. *J Am Vet Med Assoc* 1976;169:527–529.
14. Vogel GL, Parrott C. Mortality survey in feedlot: the incidence of digestive, respiratory and other death losses. In: *Scientific update on Rumensin/Tylan for the professional veterinary consultant*. Amarillo, Tex: Elanco Animal Health, 1993.
15. Ribble CS, Meek AH, Shewen PE, et al. Effect of transportation on fatal fibrinous pneumonia and shrinkage in calves arriving at a large feedlot. *J Am Vet Med Assoc* 1995;207:612–615.
16. National Agricultural Statistics Service. Cattle: final estimates, 1994–1998. Available at: http://usda.mannlib.cornell.edu/reports/general/sb/b9530199.txt. Accessed Jul 24, 2000.
17. National Agricultural Statistics Service. Cattle. Available at: http://usda.mannlib.cornell.edu/reports/nassr/livestock/pct-bb/CATL0199.TXT. Accessed Sep 7, 2000.
18. National Agricultural Statistics Service. Cattle on feed. Available at: http://usda.mannlib.cornell.edu/reports/nassr/livestock/pct-bbc/. Accessed Aug 31, 2000.
19. Martin SW, Meek AH, Davis DG, et al. Factors associated with morbidity and mortality in feedlot calves: the Bruce County beef project, year two. *Can J Comp Med* 1981;45:103–112.
20. Wittum TE, Woollen NE, Perino LJ, et al. Relationships among treatment for respiratory tract disease, pulmonary lesions evident at slaughter, and rate of weight gain in feedlot cattle. *J Am Vet Med Assoc* 1996;209:814–818.
21. Gardner BA, Dolezal HG, Bryant LK, et al. Health of finishing steers: effects on performance, carcass traits, and meat tenderness. *J Anim Sci* 1999;77:3168–3175.
22. Taylor LF, Booker CW, Jim GK, et al. Epidemiological investigation of the buller steer syndrome (riding behaviour) in a western Canadian feedlot. *Aust Vet J* 1997;75:45–51.