Evaluation of economic effects and the health and performance of the general cattle population after exposure to cattle persistently infected with bovine viral diarrhea virus in a starter feedlot

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Objective—To evaluate economic effects and health and performance of the general cattle population after exposure to cattle persistently infected (PI) with bovine viral diarrhea virus (BVDV) in a feedlot.

Animals—21,743 high-risk calves from the southeastern United States.

Procedures—PI status was determined by use of an antigen-capture ELISA (ACE) and confirmed by use of a second ACE, reverse transcriptase–PCR assay of sera, immunohistochemical analysis, and virus isolation from sera. Groups with various amounts of exposure to BVDV PI cattle were used. After being placed in the feedlot, identified PI cattle were removed from 1 section, but PI cattle remained in another section of the feedlot. Exposure groups for cattle lots arriving without PI animals were determined by spatial association to cattle lots, with PI animals remaining or removed from the lot.

Results—15,348 cattle maintained their exposure group. Performance outcomes improved slightly among the 5 exposure groups as the risk for exposure to BVDV PI cattle decreased. Health outcomes had an association with exposure risk that depended on the exposure group. Comparing cattle lots with direct exposure with those without direct exposure revealed significant improvements in all performance outcomes and in first relapse percentage and mortality percentage in the health outcomes. Economic analysis revealed that fatalities accounted for losses of $5.26/animal and performance losses were $88.26/animal.

Conclusions and Clinical Relevance—This study provided evidence that exposure of the general population of feedlot cattle to BVDV PI animals resulted in substantial costs attributable to negative effects on performance and increased fatalities. (*Am J Vet Res* 2009;70:73–85)

Bovine viral diarrhea is reported to be one of the most economically important diseases in cattle throughout the world.[1–3] Through immunosuppression, BVDV can potentiate the effects of the BRD pathogens *Mannheimia haemolytica*, bovine herpesvirus-1, and bovine respiratory syncytial virus.[4–7] Bovine respiratory disease may cause the greatest economic impact in the cattle feeding industry as a result of increased health-related costs from morbidity and fatalities as well as decreased performance.[8,9] The relationship between BVDV and BRD has been extensively reported.[4,5,10–15] In 1 study,[16] investigators reported that BVDV is the virus most frequently isolated from pneumonic lungs of cattle with BRD (ie, shipping fever), with BVDV isolated from 21% of affected cattle.

Bovine viral diarrhea virus is shed in most excretions and secretions from transiently infected and PI cattle. It is generally accepted that transiently infected cattle shed considerably lower amounts of virus and for an abbreviated time of only 1 to 7 days.[17,18] However, investigators in 1 study[17] determined that acute infection with a virulent strain resulted in severe clinical disease and viral shedding that lasted for more than 7 days.

Abbreviations

ACE	Antigen-capture ELISA
ADG	Average daily gain
BRD	Bovine respiratory disease
BVDV	Bovine viral diarrhea virus
COG	Cost of gain
F:G ratio	Feed-to-gain ratio
NEg	Net energy for weight gain
NEm	Net energy for maintenance
PI	Persistently infected

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Persistently infected cattle are considered to be the principal reservoir of BVDV infections. Persistently infected calves develop in utero when the dam becomes viremic with BVDV between approximately 42 and 125 days of gestation.[19] Infected fetuses that survive until birth are born immunotolerant to the specific exposing viral strain and are lifelong shedders of the virus.[1] Although cattle transiently infected with BVDV temporarily shed low amounts of the virus and can pose exposure risks to herd mates, PI cattle are considered to be the primary source of virus transmission.[1] It has been reported[20,21] that PI cattle are more efficient transmitters of the virus than transiently infected cattle.

Interestingly, BVD is not a commonly reported clinical illness in the cattle feeding industry. Inapparent BVDV infections are common, and the prevalence has been estimated to be as high as 70% to 90%.[22] In another study,[23] investigators reported that 95% of BVDV infections were subclinical. In a Canadian study,[24] unvaccinated control cattle seroconverted to BVDV in a feedlot without having evidence of undifferentiated fever. Clinical signs associated with virulent strains can be quite severe, as was evident with the outbreak attributable to BVDV type 2 in North America in 1993. Conversely, mild or moderate strains typically are subclinical in nature and generally cause only a mild increase in body temperature for 1 or 2 days.[21,25–29] Acute infections with low-virulence strains can cause multifocal infections of the intestinal mucosa, but these infections are cleared in a short period. More aggressive strains typically spread to more tissues and can cause necrosis of gastrointestinal epithelium, which leads to ulcerative lesions in the digestive tract.[30]

In a study[31] of auction-derived cattle from multiple sources, investigators detected a 43% increase in the risk of morbidity from BRD in feedlot cattle that had direct contact with PI animals. In that study, investigators also reported that the direct exposure to PI animals was responsible for 15.9% of the BRD episodes. However, there was no increased risk of morbidity in primarily single-source cattle in direct contact with PI animals in a feedlot of another study.[32] The economic impact provided by exposure to PI animals was not evaluated in either of these studies. Although economic costs associated with BVDV infections have been reported for the dairy industry,[3,33–36] economic studies are generally lacking for the beef industry, especially for feedlot cattle.

The purpose of the study reported here was to evaluate health or performance effects of PI BVDV cattle on the general cattle population in a commercial feedlot during the early period after cattle arrival in a starter feedlot. The study was designed to examine the effects for different amounts of exposure to BVDV PI cattle, with both direct and indirect contact, and to identify economic, health, and performance effects that were a result of that exposure. In this study, we also evaluated the percentage of fatalities and cattle with chronic illness in the PI cattle population.

Materials and Methods

Animals—Cattle were acquired by a starter feedlot in southwestern Kansas, and the study was conducted in conjunction with the typical practices of the feedlot. There were 21,743 cattle included in the study from July 1, 2004, to December 21, 2004. Cattle originated from auction market facilities from multiple states in the southern and southeastern United States. Mean ± SEM body weight at time of arrival at the feedlot was 233.182 ± 1.70 kg. Mean weight for cattle lots ranged from 175 to 289 kg/animal.

Study approval was not sought because this study was conducted in a commercial feeding facility in accordance with the feedlot's standard operating procedures. No additional invasive or harmful procedures were conducted outside of the feedlot's normal management. The feedlot's ownership and management approved the study prior to initiation.

Processing and sample collection—On arrival, cattle were allowed to rest for 12 to 24 hours. Each animal was then processed in accordance with the feedlot's standard procedures for incoming cattle. This included administration of a combination vaccine[a] that contained modified-live virus bovine herpesvirus-1, parainfluenza type 3 virus, and bovine respiratory syncytial virus and killed BVDV type 1a and 2a strains. Clostridial[b] and *M haemolytica–Pasteurella multocida*[c] bacterins as well as an anthelmintic, metaphylatic antimicrobial injections, and individual animal identification were also provided during initial processing procedures. Cattle received a second modified-live virus vaccine[d] 10 days after initial processing; that vaccine contained bovine herpesvirus-1, parainfluenza type 3 virus, bovine respiratory syncytial virus, and BVDV type 1a and 2a strains. Growth-promoting implants were not administered to any cattle during the study.

Cattle were tested for BVDV in accordance with a protocol described elsewhere.[37] During initial processing procedures, ear notch samples were collected and placed in PBS solution for testing to detect BVDV antigen by use of an ACE.[e] The initial testing by use of the ACE was performed by personnel at the Haskell County Animal Hospital. Typically, results for the first ACE were completed within 24 hours after sample collection. Cattle with positive results for the ACE subsequently underwent additional testing. A second set of samples was obtained for immunohistochemical analysis (ear notch fixed in formalin), testing by use of the ACE (fresh ear notch sample), and virus isolation and reverse transcription–PCR assay (serum samples). The second set of samples was obtained within 48 hours after the results of the initial ACE. All follow-up testing was performed by personnel at the Oklahoma State University Center for Veterinary Health Services.

Feeding—Rations were formulated to meet or exceed nutrient requirements of beef cattle.[38] Ingredients used were chopped oat hay, corn silage, alfalfa haylage, flaked corn, high-moisture corn, dried distillers grains, and a liquid additive that contained urea, macrominerals, and microminerals.

For the first 4 days after arrival at the feedlot, cattle were provided long-stem hay in the feed bunk in addition to a receiving ration. Cattle were fed the receiving ration (0.39 Mcal/kg of diet for NEm and 0.26 Mcal/kg of diet for NEg) for 12 days, followed by an intermedi-

ate diet (0.41 Mcal/kg of diet for NEm and 0.28 Mcal/kg of diet for NEg), and then a growing diet (0.43 Mcal/kg of diet for NEm and 0.30 Mcal/kg of diet for NEg) for the remainder of the study. Fresh feed was offered to the cattle twice daily.

Cattle were fed as much as they could eat of the receiving and intermediate diets but were limit fed the growing diet to achieve a calculated ADG (excluding cattle that died) of 0.91 kg; the amount fed was determined on the basis of net energy equations.[38] Limit fed refers to offering a specified amount of feed daily that has been calculated to provide the necessary calories for NEm and NEg to achieve a predetermined daily weight gain. Amounts of the growing diet were increased at 2-week intervals to ensure energy intake was adequate to achieve the desired weight gain as body weight increased with the number of days in the feedlot.

Feedlot design—The feedlot used for the study was newly built and had not previously contained cattle. This starter feedlot was built for the sole purpose of conditioning high-risk cattle prior to transferring them into a finishing feedlot; it was intended to adapt high-risk cattle to the feedlot environment. This includes feed transitions and growth of the cattle as well as alleviating health issues associated with high-risk cattle prior to entering a finishing feedlot. Duration in a starter feedlot depends on acclimation to the feed, animal growth, and resolution of health issues.

The feedlot consisted of pens, feed delivery alleys, and cattle alleys. A cattle alley was used for movement of cattle to a designated pen at arrival, to transport when leaving the feedlot, and for movement to and from the hospital facility for the respective feeding alleys. There were 3 feeding alleys in this starter feedlot, with 4 feed delivery alleys (**Figure 1**). Each feeding alley contained its own hospital facility. The pens available in the feedlot had a mean capacity of 80 or 100 cattle/pen and provided a mean of 30 cm of linear space at the feed bunk and 16 m^2 of pen space/animal. The starter feedlot also contained 2 quarantine pens for PI cattle; these pens were located adjacent to each other. Cattle in the quarantine pens were separated from direct contact with other cattle by a cattle alley in the back and a 1.8-m double-barrier fence between the adjacent feeding pens.

Classifications of cattle—A pen was the physical location where a group of cattle was fed. A lot was the identification of a group of cattle being fed and generally represented ownership. A lot could comprise > 1 pen. For ownership purposes, data were recorded for the lot whether cattle were fed in a single pen or multiple pens. The unit of measure in this study was the lot.

Five exposure groups were used in the study. Exposure groups were based on different amounts of exposure in each lot to BVDV PI cattle. One group (group PI) comprised a lot in which there were PI cattle in the lot at arrival, the PI cattle were allowed to remain in that lot throughout the study, and adjacent pens contained a mixture of PI cattle and non-PI cattle. The second group (PI cattle removed [group PIR]) comprised a lot in which there were PI cattle in the lot at arrival, the PI cattle were removed from the lot within 72 hours after arrival, and adjacent pens contained a mixture of cattle from lots with no PI cattle at arrival or from which the PI cattle were removed within 72 hours after arrival. The third group (non-PI exposed cattle [group NPIE]) comprised a lot in which there were no PI cattle in the lot at arrival but cattle were exposed because an adjacent pen or pens contained ≥ 1 PI animal. The fourth group (non-PI exposed cattle adjacent to a pen from which PI cattle were removed [group NPIER]) comprised a lot in which there were no PI cattle in the lot at arrival but cattle were exposed because an adjacent pen or pens contained cattle from which the PI cattle were removed within 72 hours after arrival. The fifth group (non-PI unexposed cattle [group NPIU]) comprised a lot in which there were no PI cattle in the lot at arrival and adjacent pens contained cattle from lots in which there were no PI cattle at arrival.

The unit determining exposure in this study was the pen, with the exposure resulting from cattle within the pen (PI or PIR pens) or from cattle not exposed at arrival (ie, no PI cattle in the lot) but exposed by the animals contained in adjacent pens (NPIE, NPIER, or NPIU pens). There were more pens than lots for the PI, PIR, and NPIU exposure groups because some lots were of sufficient size to require > 1 pen at the starter feedlot. All lots consisting of multiple pens that main-

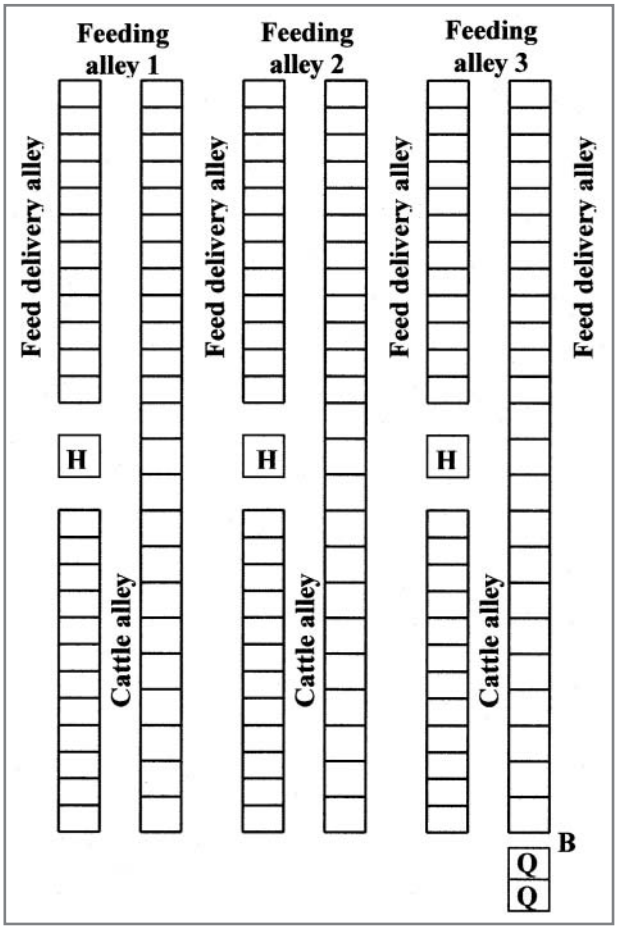

Figure 1—Schematic diagram of the starter feedlot. The diagram is not to scale; therefore, the actual distance between the various structures, pen size, and number of pens per alley are not accurately represented. H = Hospital facility. Q = Quarantine pen for BVDV PI cattle. B = Barrier fence.

tained exposure throughout the study were eligible for data analysis. A lot consisting of multiple pens that did not have identical exposure for all pens throughout the study was withdrawn from the study.

Lots were placed arbitrarily (ie, a randomization schedule was not used) in pens on the basis of number of cattle in the lot and pen capacity available in the 3 feeding alleys. In this commercial feedlot setting, as soon as the initial processing procedures for incoming cattle were completed, cattle were placed in a pen (or pens) that accommodated the number of cattle in that lot. Randomization for pens, feed alleys, sex of cattle, and other factors for each exposure group was unachievable because of the fact that the status of the pen (PI cattle or non-PI cattle) was not known until after a lot was placed in the feeding pens. Classification into exposure groups was not possible until results of the ACE were known (results were not known until approx 24 hours after initial processing and placement in feeding pens).

Feeding alley 1 was designated as the section of the feedlot in which PI cattle were allowed to remain in the pens after being identified by use of the ACE (PI pens). Feeding alleys 2 and 3 were designated as the section of the feedlot in which PI cattle were removed from a pen after being identified by use of the ACE (PIR pens); PI cattle were removed from these pens and placed in the quarantine facility. Pens that did not contain a PI animal at arrival at the feedlot were classified as NPIE, NPIER, or NPIU pens on the basis of their spatial association to a pen containing PI or PIR groups in their respective section.

This feedlot was typical in that cattle lots arrived and left independent of each other (ie, it was a continuous flow procedure, rather than an all-in, all-out procedure). Therefore, exposure group classification of the pens without PI cattle had the potential to change, depending on the cattle placed in adjacent pens during the study. All changes in exposure group classifications were tracked by the date of change and number of days after arrival at the feedlot when the classification changed. The PI and PIR pens did not change exposure classification because their classification was based on the presence of a PI animal at arrival and not because of exposure resulting from the spatial relationship to adjacent pens.

A second evaluation of exposure groups was made to evaluate economic effects from exposure to BVDV PI cattle. This evaluation compared results for lots with direct exposure (PI and NPIE groups) with results for lots that remained unexposed (NPIU group).

Standard feedlot procedures—Management of the cattle during the study was typical for this feedlot's standard operating procedures. Clinical illness (morbidity) was determined by observation of clinically affected cattle by a crew of pen riders, in accordance with standard operating procedures. When an animal was deemed ill on the basis of clinical signs of depression, lethargy, ocular or nasal discharge, increased respiratory rate, coughing, or inappetence, it was removed from the pen, transferred to the hospital facility, and treated in accordance with standard treatment regimens. Treatment relapse was defined as any additional BRD treatment required on the basis of recurrence of clinical illness throughout the study. Cattle (including PI cattle allowed to remain in the original pen [feed alley 1]) considered to be chronically ill were sold for salvage slaughter. After the study period, PI cattle were fed to slaughter weight in a quarantine pen and sent to slaughter with the other cattle in their lot or, when deemed to have chronic illness, were sold for salvage slaughter.

Initial results of the ACE were reported to the investigators, feedlot manager, and cattle foreman at the feedlot. Pen riders were not aware of the status of the pens in alley 1, which contained the PI cattle. The cattle foreman obtained the second group of samples. Pen riders were aware of pens containing PIR cattle because they had to remove the PI cattle and place them in the quarantine pens as instructed by the cattle foreman.

Postmortem examinations were performed on all cattle that died. Attending veterinarians performed most of these examinations. There were a few times when the attending veterinarians were unavailable, and in these instances, trained feedlot personnel performed the postmortem examination. Respiratory, digestive, urinary, reproductive, cardiovascular, muscular, and skeletal systems were examined for gross abnormalities during postmortem examinations. Fatality diagnosis was determined by observation of gross pathologic abnormalities.

Data—Data were collected from the feedlot's computerized health and accounting records after completion of the study for all cattle arriving at the feedlot (21,743 cattle in 236 lots in 248 pens) during the study. Performance variables evaluated were weight gain, feed conversion (ie, F:G ratio), ADG, and COG. Performance data typically were reported with the number of cattle that died included or excluded. Health variables were morbidity percentage, first relapse percentage, chronic illness percentage, fatality percentage, treatment cost per animal, and mean number of treatments per illness.

Any lots that had fatalities prior to processing and from which samples were not obtained from the cattle that died were withdrawn from the analysis. Lots with the non-PI classification at arrival had the potential that exposure group classification could change, depending on the movement of cattle into adjacent pens. The data for this study were based only on those lots that maintained the same exposure group classification throughout the study.

Because data were calculated by lot and not by pen, any lot that was allocated to multiple pens was not used unless each pen of that lot maintained the same exposure group classification. Thus, 3 lots of cattle representing 7 pens that had only 1 PI animal were removed from the analysis for this reason. In addition, 1 lot that arrived in 2 loads (1 load with a PI animal and 1 without any PI animals) on different dates was removed from the analysis because the loads arrived with different exposure groups. There were 4 lots (each of which contained multiple PI cattle) with a sufficiently large number of cattle that required allocation to 2 pens/lot. Each pen of those lots contained at least 1 PI animal and therefore those lots were able to be used in the data

analysis. For these reasons there were 70 lots containing 1 or more PI cattle, and these 70 lots were in 74 pens. This consideration was also true of any non-PI lot in which cattle were in multiple pens. When the pens constituting a non-PI lot did not maintain the identical exposure group classification throughout the study, that lot was withdrawn from analysis. The non-PI lots were also at risk of changing exposure group classification because of changes in status for adjacent pens. Any non-PI lot that changed exposure classification because of change in the status of an adjacent pen was withdrawn from analysis.

One of the objectives of the study was to evaluate fatalities and cause of death in the population of PI cattle. Fatality data for the population of PI cattle were collected from the feedlot's computerized records. Chronic illness percentage was only evaluated on the population of PI cattle that were allowed to remain in their original lots (ie, PI lots). The PI cattle removed and placed in the quarantine pens were not eligible for chronic illness analysis because of potential bias.

Statistical analysis—Differences among outcomes for the exposure groups with regard to treatment cost per animal, mean number of treatments per illness, weight gain, F:G ratio, ADG, and COG were compared by ANOVA procedures by use of commercially available computer software.[f] Differences among outcomes for the exposure groups for morbidity percentage, first relapse percentage, chronic illness percentage, and fatality percentage were compared after transformation with the arcsine square-root transformation. Lot was considered to be the experimental unit for all analyses. A completely randomized design model was used in all ANOVA calculations, and when the overall test of exposure groups was judged to be significant at $P \leq 0.05$, pairwise *t* tests were used to determine significant differences among exposure groups. Two variables (COG and F:G ratio) had heterogeneity of variance and were transformed (arcsine square-root transformation) prior to analysis. Differences in variable outcomes were considered significant at values of $P \leq 0.05$. Differences between lots with direct exposure (PI and NPIE) and nonexposed lots (NPIU) were analyzed by use of preplanned contrasts of the group means, with all percentage outcomes compared after transformation with the arcsine square-root transformation.

Economic analysis—To evaluate economic effects of exposure to BVDV PI cattle, a second evaluation was performed of results for lots with direct exposure (PI and NPIE), compared with results for lots with no direct exposure (NPIU). The same variables evaluated among the 5 exposure groups were evaluated in this comparison. In the economic analysis, 3 variables were used (COG, weight gain, and fatality percentage). Cost of gain represented all expenditures associated with the weight gain of the cattle in the lots. Differences in COG multiplied by weight gain of the improved group will reveal economic differences in performance among groups. The initial purchase cost of any animal that died was not included in the COG calculation; therefore, the purchase cost of any difference in fatality percentage was also used to evaluate any economic difference. These variables were only used when the differences were significant ($P \leq 0.05$). A reduction in the COG or in the fatality percentage would represent an economic advantage for that exposure group.

Data were evaluated to detect outliers (± 3 SDs from the mean) on the basis of the COG outcome. This was used to identify any excessive influence outliers may have had on the economic analysis, which could have distorted the results.

Results

Animals—The prevalence of PI cattle in the study population was 0.4% (86/21,743). Of the lots eligible for health, performance, and economic analysis, the prevalence was 0.5% (82/15,348).

Because of the need to withdraw several lots, the data set for analysis comprised 15,348 cattle in 167 lots occupying 172 pens. These 167 lots represented only those lots that did not have a change in exposure group classification, were not single lots of cattle fed in multiple pens with different exposure groups, and were not lots that arrived in multiple loads on different dates with mixed exposure groups.

Health and performance outcomes—Fatality percentage among all PI cattle during the study period (mean ± SEM, 66 ± 0.88 days) was 25.6% (22/86), compared with 2.4% (365/15,266) for the non-PI cattle population used for analysis. On the basis of postmortem lesions for the 22 PI cattle that died, 14 (63.6%) were attributable to mucosal disease, 6 (27.3%) were attributable to BRD, 1 (4.5%) was attributable to bloat, and the cause of 1 (4.5%) was not conclusively determined. The mean number of days in the feedlot for the 14 PI cattle that died as a result of mucosal disease was 23, whereas the mean number of days in the feedlot for the 6 PI cattle that died as a result of BRD was 38. The PI cattle allowed to remain in their original pens were used to evaluate the chronic illness percentage of PI cattle. In this study, 4 of 37 (10.8%) PI cattle were deemed to be chronically ill and sold for salvage slaughter, compared with 544 of 15,266 (3.6%) of the non-PI cattle population.

Exposure of cattle in a pen to at least 1 PI animal resulting from the placement of PI cattle in adjacent pens at the time of arrival, assuming the PI cattle were not removed (PIR pens), would have resulted in cattle in 107 of 172 (62.2%) pens having direct exposure to a BVDV PI animal within the pen or a BVDV PI animal in an adjacent pen or pens.

Performance and health outcomes for those lots that remained in the same exposure group throughout the study were determined. There were no significant differences in mean body weight at time of arrival or mean number of days in the feedlot among exposure groups.

For performance outcomes, both the NPIU and NPIER groups had a significantly higher weight gain, compared with weight gain for the PI and PIR groups (**Table 1**). The F:G ratio and ADG were significantly improved for the NPIE, NPIER, and NPIU groups, compared with results for the PI group. The ADG was also significantly higher for the NPIER and NPIU groups,

compared with the ADG for the PIR group. Pattern for the COG was comparable to that for the F:G ratio, with the value for the PI group being similar to that for the PIR group but significantly greater than values for the NPIE, NPIER, and NPIU groups.

For health outcomes, morbidity percentage for the NPIER group was significantly less than the morbidity percentage for the PI and PIR groups (**Table 2**). Morbidity percentage for the NPIU group was significantly less than the morbidity percentage for the PIR group, but not different from that for the PI group. The first relapse percentage for the NPIER group was significantly lower, compared with the percentages for the PI, PIR, and NPIE groups, and the first relapse percentage for the NPIU group was significantly lower than the percentages for the PI and PIR groups. There was no significant difference for chronic illness percentage among the PI, PIR, and NPIE groups, although the chronic illness percentage of the NPIU group was significantly lower, compared with the percentages for the PI and PIR groups. Fatality percentage was not significantly different among the PI, PIR, and NPIE groups. Both the NPIER and NPIU groups had a significantly lower fatality percentage, compared with results for the PI and PIR groups. No significant differences were detected in treatment cost per animal among groups, but the mean number of treatments per illness was significantly lower for the NPIER group, compared with the numbers for the PI, PIR, and NPIU groups.

Table 1—Mean ± SEM values for performance outcomes of 5 exposure groups of feedlot cattle for which their exposure status did not change throughout the study.

Group*	No. of lots	No. of cattle	No. of pens	Weight gain (kg)	F:G ratio†,‡	ADG (kg)	COG ($/kg)†
PI	33	2,987	35	34 ± 2.73[a]	18.88 ± 8.15[a]	0.55 ± 0.04[a]	6.31 ± 2.81[a]
PIR	37	3,454	39	38 ± 2.60[a]	9.47 ± 1.03[a,b]	0.59 ± 0.04[a,b]	3.09 ± 0.37[a,b]
NPIE	17	1,573	17	42 ± 2.80[a,b]	7.27 ± 0.45[b]	0.68 ± 0.03[b,c]	2.25 ± 0.18[b]
NPIER	16	1,525	16	48 ± 4.20[b]	6.57 ± 0.23[b]	0.73 ± 0.03[c]	2.01 ± 0.09[b]
NPIU	64	5,809	65	50 ± 1.60[b]	6.78 ± 0.38[b]	0.74 ± 0.02[c]	2.09 ± 0.15[b]

Results represent analysis with data included for cattle lots that were outliers or cattle that died.
*Group PI comprised a lot in which there were PI cattle in the lot at arrival, the PI cattle were allowed to remain in that lot throughout the study, and adjacent pens contained a mixture of PI cattle and non-PI cattle; group PIR comprised a lot in which there were PI cattle in the lot at arrival, the PI cattle were removed from the lot within 72 hour after arrival, and adjacent pens contained a mixture of cattle from lots with no PI cattle at arrival or from which the PI cattle were removed within 72 hours after arrival; group NPIE comprised a lot of non-PI exposed cattle in which there were no PI cattle in the lot at arrival but cattle were exposed because an adjacent pen or pens contained ≥ 1 PI animal; group NPIER comprised a lot of non-PI exposed cattle in which there were no PI cattle in the lot at arrival but cattle were exposed because an adjacent pen or pens contained cattle from which the PI cattle were removed within 72 hours after arrival; and group NPIU comprised a group of non-PI unexposed cattle in which there were no PI cattle in the lot at arrival and adjacent pens contained cattle from lots in which there were no PI cattle at arrival. †Analysis performed on transformed data; results reported represent raw mean ± SEM. ‡Dry-matter basis.
[a–c]Within a column, values with different superscript letters differ significantly ($P \leq 0.05$).

Table 2—Mean ± SEM values for health outcomes of 5 exposure groups of feedlot cattle for which their exposure status did not change throughout the study.

Group*	No. of lots	No. of cattle	No. of pens	Morbidity (%)	First relapse (%)	Chronic illness (%)	Fatalities (%)	Treatment cost ($/animal)	Mean No. of treatments per illness
PI	33	2,987	35	34.0 ± 2.33[a,b]	46 ± 0.02[a]	4.6 ± 0.62[a,b]	3.6 ± 0.50[a]	17.04 ± 0.76	1.79 ± 0.04[a]
PIR	37	3,454	39	37.0 ± 2.17[a]	46 ± 0.03[a]	5.0 ± 0.66[a]	3.5 ± 0.62[a]	15.69 ± 0.75	1.77 ± 0.06[a,b]
NPIE	17	1,573	17	29.2 ± 4.03[b,c]	45 ± 0.03[a,b]	3.6 ± 1.13[a,b,c]	2.4 ± 0.54[a,b]	16.45 ± 1.66	1.72 ± 0.06[a,b,c]
NPIER	16	1,525	16	24.8 ± 1.73[c]	35 ± 0.03[c]	2.7 ± 0.54[b,c]	1.3 ± 0.32[b]	14.30 ± 0.44	1.58 ± 0.06[c]
NPIU	64	5,809	65	29.0 ± 1.55[b,c]	40 ± 0.02[b,c]	2.8 ± 0.36[c]	1.7 ± 0.25[b]	15.65 ± 0.61	1.66 ± 0.04[b]

Results represent analysis with data included for cattle lots that were outliers or cattle that died.
See Table 1 for remainder of key.

Table 3—Mean ± SEM values for performance outcomes of cattle lots with direct exposure (PI and NPIE groups)* and with no exposure (NPIU group)* to BVDV PI animals for those feedlot cattle in which their exposure status did not change throughout the study.

Group	No. of lots	Weight gain (kg)	F:G ratio†,‡	ADG (kg)	COG† ($/kg)
Direct exposed	50	37 ± 2.09[a]	14.93 ± 5.41[c]	0.59 ± 0.03[a]	4.94 ± 1.87[c]
Unexposed	64	50 ± 1.60[b]	6.78 ± 0.38[d]	0.74 ± 0.02[b]	2.09 ± 0.15[d]

Results represent analysis with data included for cattle lots that were outliers or cattle that died.
[a–d]Within a column, values with different superscript letters differ significantly ([a,b]$P <$ 0.001 and [c,d]$P = 0.03$).
See Table 1 for remainder of key.

Table 4—Mean ± SEM values for health outcomes of cattle lots with direct exposure (PI and NPIE groups)* and with no exposure (NPIU group)* to BVDV PI animals for those feedlot cattle in which their exposure status did not change throughout the study.

Group	No. of lots	Morbidity (%)	First relapse (%)	Chronic illness (%)	Fatalities (%)	Treatment cost ($/animal)	Mean No. of treatments per illness
Direct exposed	50	32 ± 2.06	46 ± 0.02	4.2 ± 0.56	3.17 ± 0.38	16.84 ± 0.75	1.76 ± 0.03
Unexposed	64	29 ± 1.55	40 ± 0.02	2.8 ± 0.36	1.70 ± 0.25	15.65 ± 0.61	1.66 ± 0.04
P value†	—	0.32	0.02	0.07	0.001	0.24	0.09

Results represent analysis with data included for cattle lots that were outliers or cattle that died.
†Values were considered to differ significantly at $P \leq 0.05$.
— = Not applicable.
See Table 1 for remainder of key.

Table 5—Mean ± SEM values determined by use of an economic analysis of variables associated with cattle lots with direct exposure (PI and NPIE groups)* and with no exposure (NPIU group)* to BVDV PI animals for those feedlot cattle in which their exposure status did not change throughout the study.

Group	COG ($/kg)	Weight gain (kg)	Fatalities (%)
Direct exposed	4.94 ± 1.87	36.82 ± 2.09	3.17 ± 0.38
Unexposed	2.09 ± 0.15	49.79 ± 1.60	1.70 ± 0.25
Difference	2.85 ± 1.88	ND	1.47 ± 0.45

Values were calculated assuming a mean purchase price of $2.464/kg and mean purchase weight of 233.182 kg, which yielded a mean purchase cost of $574.56. Mean ± SEM value of the difference in fatality percentage was calculated as 0.0147 × $574.56 = $8.45 ± 2.46. Mean ± SEM value of the difference in COG was calculated as $2.85/kg × 49.79 kg = $141.90 ± 58.30. Thus, total costs of direct exposure to PI were $8.45 + $141.90 = $150.35.

The percentage of the population with exposure costs was 62.2% (9,539 exposed cattle/15,348 cattle in the feedlot). Thus, cost of exposure to PI cattle for the total population was 0.622 × $150.35 = $93.52.

ND = Not determined.
See Table 1 for remainder of key.

Economic analysis outcomes—Comparisons were made to evaluate the effect that direct exposure to BVDV PI cattle had during the study. In this comparison, lots defined as having direct exposure to BVDV PI animals were exposure groups PI (at least 1 PI animal within the pen) and NPIE (no PI animals in the pen but at least 1 PI animal in an adjacent pen or pens). Comparisons were made with those lots that were unexposed or had no direct exposure to a BVDV PI animal (ie, NPIU group).

For this comparison (PI and NPIE groups vs NPIU group), there were no significant differences in the arrival weight or number of days in the feedlot. All performance outcomes for the NPIU group were significantly better, compared with results for PI and NPIE groups (ie, the lots that had direct exposure to BVDV PI cattle; **Table 3**). Of the health outcomes, only first relapse percentage and fatality percentage were significantly lower for the NPIU group, compared with results for the PI and NPIE groups (**Table 4**).

An economic analysis was performed to compare results for lots containing cattle with direct exposure to PI animals (PI and NPIE groups) with lots containing cattle without exposure to PI animals (NPIU group). The economic analysis was based on significant differences in COG outcome reported with cattle that died included and significant differences in fatality percentage. The analysis revealed that an increase in fatality percentage accounted for a mean ± SEM of $8.45 ± 2.46/animal in the cattle with direct exposure (**Table 5**). Differences in COG accounted for another $141.90 ± 58.30/animal in the exposed cattle for a total cost in exposed cattle of $150.35. Of the 167 lots that met the criteria and were used to evaluate total feedlot exposure rate, 103 would have had direct exposure (ie, PI, PIR, NPIE, and NPIER lots) had some of the PI cattle not been removed and placed in the quarantine pens. This yielded a lot exposure rate of 61.7% (103/167 lots). The population exposure rate (had some of the PI cattle not been removed and placed in the quarantine pens) was 62.2% (9,539/15,348 cattle). Total cost per animal on the basis of population exposure to BVDV PI cattle was $93.52.

Graphs were made to compare the F:G ratio between lots with direct exposure (PI and NPIE groups) and lots without exposure (NPIU group). Lots with direct exposure had significantly ($P = 0.03$) lower mean ± SEM values for the F:G ratio (14.93 ± 5.41), compared with results for lots with no exposure (6.78 ± 0.38; **Figure 2**). The F:G ratio ranged from 5.11 to 270.21 in lots with direct exposure and from 4.76 to 28.66 in lots with no exposure.

Comparisons of COG differences were made between lots with direct exposure to PI cattle and lots with no exposure to PI cattle (**Figure 3**). Lots with direct exposure had a mean ± SEM COG of $4.94 ± 1.87/kg) and ranged from $1.43/kg to $93.32/kg. Mean COG for the unexposed group was $2.09 ± 0.15/kg and ranged from $1.41/kg to $11.16/kg. This was a significant ($P = 0.03$) difference in mean values (Table 3). Variability was much greater in lots with direct exposure to a BVDV PI animal. It should be mentioned that 20 of 50 (40%) lots of the direct exposure group had values equal to or less than the mean for the unexposed group. Conversely, only 1 of 64 (1.6%) lots of the unexposed group had a higher COG than the mean of the direct exposure group. Direct exposure lots 1 through 37 had a steeper linear increase in the COG, compared with the slope for the unexposed lots, but direct exposure lots 38 through 50 had a marked increase in COG, compared with the slope for the unexposed lots as well as the slope for direct exposure lots 1 through 37. It is quite possible that lots 38 through 50 had more of the factors involved in determining the outcome from BVDV PI exposure than did the other lots.

Fatality percentage for the directly exposed and unexposed groups was graphed (**Figure 4**). Mean ± SEM fatality percentage for the directly exposed group was 3.17 ± 0.38%, which differed significantly ($P = 0.001$) when compared with 1.70 ± 0.25% for the unexposed group; this resulted in a 46% reduction in fatalities in

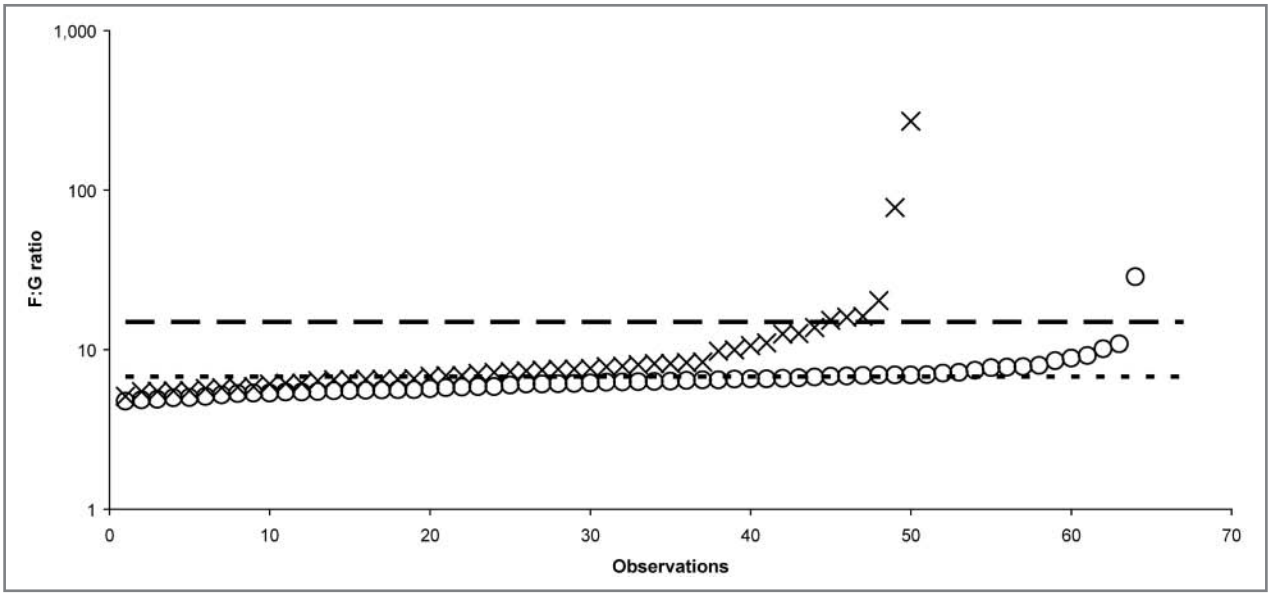

Figure 2—Semilogarithmic graph of the comparison of F:G ratio for cattle lots with direct exposure (crosses) and with no exposure (circles) to BVDV PI cattle in a starter feedlot. The mean F:G ratio for cattle with direct exposure (dashed line) and with no exposure (dotted line) to BVDV PI animals is indicated. Lots with direct exposure were group PI (which comprised a lot in which there were PI cattle in the lot at arrival, the PI cattle were allowed to remain in that lot throughout the study, and adjacent pens contained a mixture of PI cattle and non-PI cattle) and group NPIE (which comprised non-PI exposed cattle in which there were no PI cattle in the lot at arrival but cattle were exposed because an adjacent pen or pens contained ≥ 1 PI animal), whereas the lot with no exposure was group NPIU (which comprised non-PI unexposed cattle in which there were no PI cattle in the lot at arrival and adjacent pens contained cattle from lots in which there were no PI cattle at arrival). Each observation is the variable outcome value for each cattle lot in the exposure groups. Results were calculated on a dry-matter basis, and data for cattle lots that were outliers or cattle that died were included in the analysis.

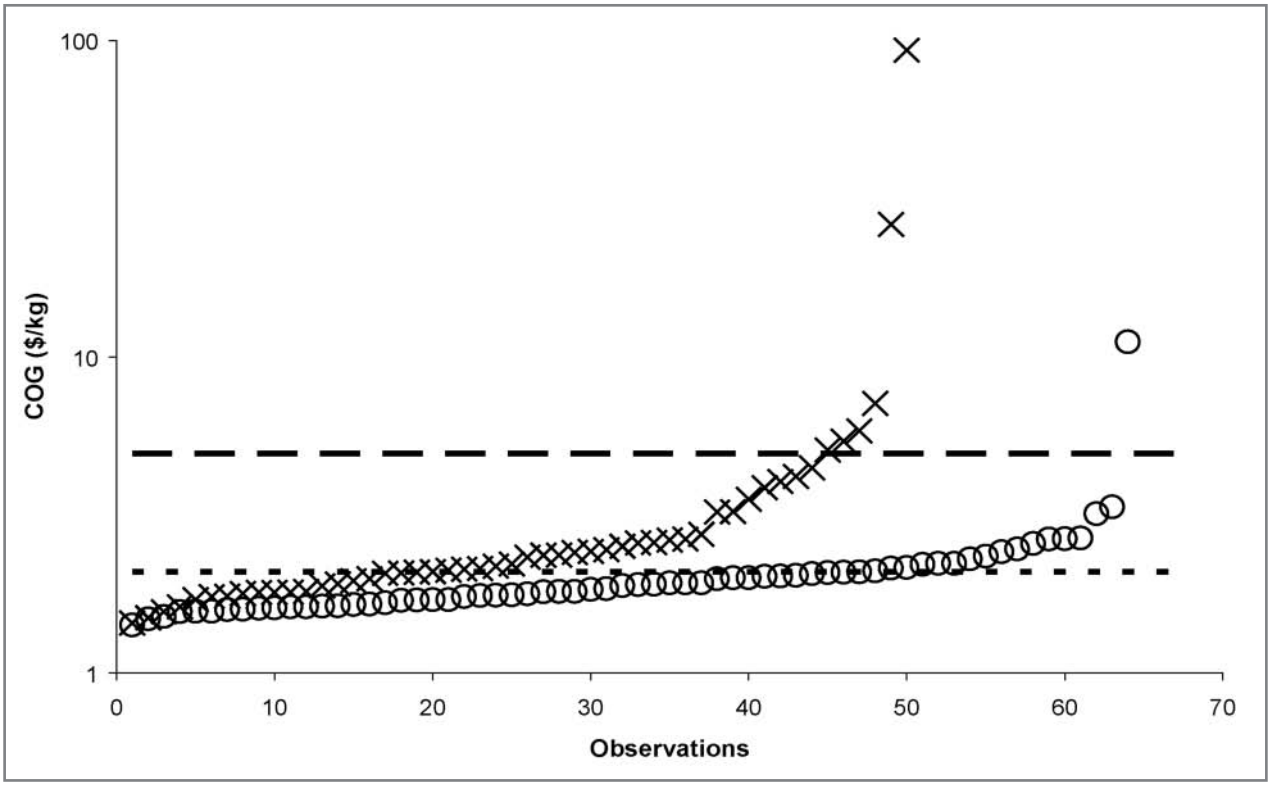

Figure 3—Semilogarithmic graph of the comparison of COG for cattle lots with direct exposure (crosses) and with no exposure (circles) to BVDV PI cattle in a starter feedlot. Data for cattle lots that were outliers or cattle that died were included in the analysis. *See* Figure 2 for remainder of key.

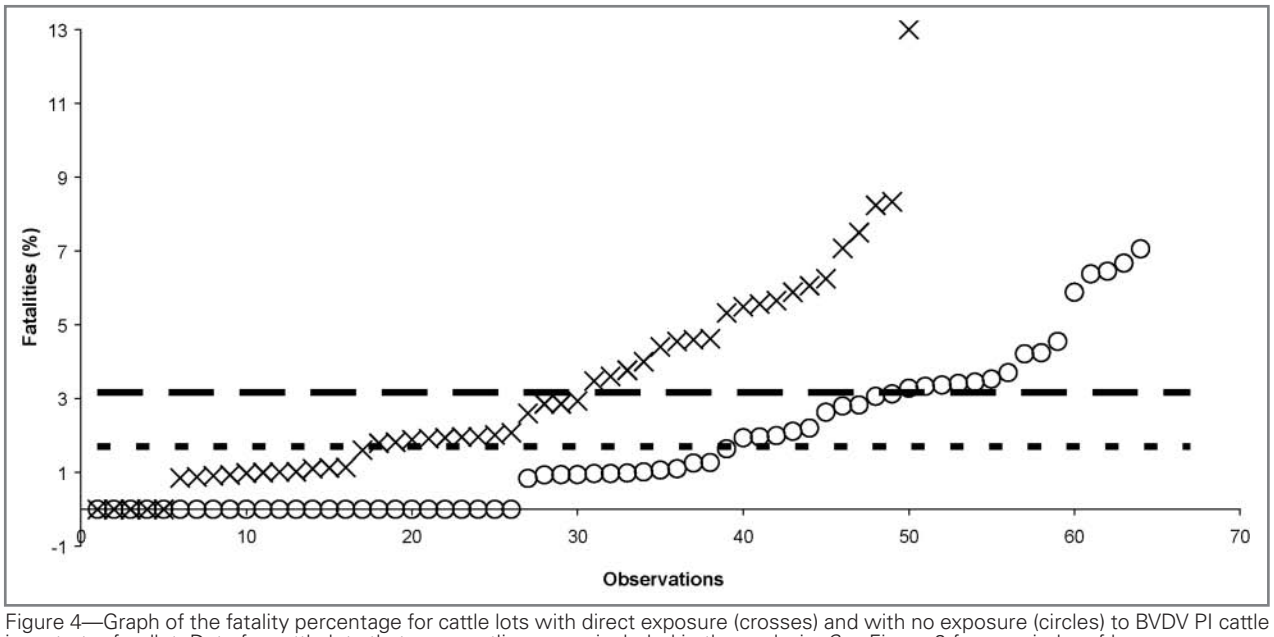

Figure 4—Graph of the fatality percentage for cattle lots with direct exposure (crosses) and with no exposure (circles) to BVDV PI cattle in a starter feedlot. Data for cattle lots that were outliers were included in the analysis. *See* Figure 2 for remainder of key.

the unexposed group. Fatality percentage varied from 0% to 13.0% in groups with direct exposure and from 0% to 7.1% in unexposed groups. In lots with direct exposure, only 5 of 50 (10.0%) had a fatality percentage of 0%, but in the unexposed group, 26 of 64 (40.6%) had a fatality percentage of 0%. This indicated exposure to a PI animal increased the chances of having at least 1 fatality in a lot by a factor of 4.

When analyzing the 5 exposure groups for outliers on the basis of the COG (data for cattle that died were included), 4 observations were found that were more than 3 SDs from the mean value. In the PI group, 1 observation was 5.76 SDs from the mean. In the PIR group, 2 observations had outlier status with an SD 4.47 and 4.77 from the mean, respectively. In the NPIU group, 1 observation was 9.2 SDs from the mean. These outliers may have had excessive influence on the economic analysis and distorted the results. When these outliers were removed from the data analysis, significant differences were still detected for the outcomes for fatality percentage and COG; thus, we were able to calculate the economic variables with these outliers removed. When the economic variables were evaluated with the outliers removed, cost attributable to fatalities in the exposed group was $8.66/animal. Cost attributable to COG differences in the exposed group was $58.83/animal. Therefore, total cost disadvantage was $67.49/animal in cattle with direct exposure to a PI animal. Because 9,343 of 15,058 (62.0%) cattle of the population (outliers removed) of the feedlot had exposure to a PI animal, the cost of this exposure would have been $41.84/animal entering the study. Depending on the data evaluation, the cost of exposure to PI cattle in this study ranged from $41.84/animal (outliers removed) to $93.52/animal (outliers remained in) for cattle entering the feedlot.

Discussion

The prevalence of BVDV PI cattle of 0.4% for all cattle tested in the study reported here is slightly higher than the prevalence in other studies[31,32] in which investigators evaluated prevalence of PI cattle at feedlot arrival, but it is consistent considering the population in our study weighed considerably less at arrival, compared with body weight of cattle in those other studies. This may appear to be a low prevalence, but it resulted in 74 of 172 (43%) pens having at least 1 PI animal.

The PI status of each pen was not known until approximately 48 hours after cattle arrived at the feedlot and after lots were placed in feeding pens because results of the ACE were not available until that time. Therefore, randomization was not achievable for the lots for exposure classification. This study tracked effects of different amounts of PI exposure (by removing some of the PI cattle in designated sections) in this feedlot, which managed the cattle in accordance with the feedlot's standard operating procedures. The larger population diminished the chances that a BVD strain of high (or low) virulence would have a profound effect, which could be the case in studies with smaller populations.

The NPIER lots had the lowest morbidity percentage, whereas PIR lots had the highest morbidity percentage. It is interesting that the NPIU lots did not have the lowest morbidity percentage, first relapse percentage, fatality percentage, treatment costs, or mean number of treatments per illness. This is possibly explained by the fact that some of the NPIU lots were fed in feeding alley 1 but were not adjacent to any lots containing PI cattle. However, when the NPIU cattle in pens in feeding alley 1 were moved to the hospital facility for treatment, they would have been likely to come into contact with cattle from a PI pen and quite possibly a PI animal. This may indicate that the exposure through the hospital was an important factor. This potential effect in the study requires further evaluation. Also of interest is the fact that the PIR lots had a numerically higher morbidity percentage than did the PI lots, although the values did not differ significantly. Pen riders were not aware of which

pens had PI cattle in them that were not removed, but they were aware of which pens had PI cattle in them that were removed. This knowledge may have resulted in the pen riders being more aggressive in identifying cattle that required treatment in the pens with known PI cattle, thus falsely increasing the morbidity percentage in the PIR group.

Investigators in 2 other studies[31,32] that considered the influence of BVDV PI cattle in feedyards used a much smaller population of cattle (2,000 and 5,041 cattle, respectively) that weighed much more (318 and 352 kg, respectively) at time of arrival than did cattle in the study reported here. In addition, those investigators evaluated only morbidity and fatalities. Influence of disease status of cattle in an adjacent pen was not evaluated in one of those studies, and influences on performance were not evaluated in either study. The fact that cattle in the study reported here weighed less likely provided more susceptibility to the effects of the PI cattle. In another study[39] of auction market–derived calves (7,132 cattle in 25 pens), health and performance were evaluated and only the BVDV-enteritis mortality rate was significantly higher in PI pens, compared with results for non-PI pens. In that study, type-specific differences were detected when evaluating BVDV infections in cattle at time of arrival (viremia in PI cattle and cattle with acute infections), with BVDV type 1 causing significantly higher overall mortality rates and infectious disease mortality rates and BVDV type 2 causing significantly lower overall mortality rates, compared with results for BVDV-negative pens.

Fatalities attributable to BRD in the PI cattle in the study reported here may have been an overrepresentation. The PI cattle in the quarantine pens that developed BRD were not eligible for treatment in the hospital facilities. Quarantined cattle were administered treatment in the quarantine pens and were not administered booster vaccinations because the investigators did not want to risk BVDV exposure via the hospital and processing system.

Many factors may be involved in determining the outcome of exposure to a PI animal in a feedlot setting. These include virulence of the BVDV PI strain, amount of shedding by the PI animal, susceptibility of the recipient cattle, population density, exposure rates, and stressors typically found in the beef feeding industry. Because no virulence factors have been identified as yet, it is quite possible that a range of virulence among the PI strains was represented by the BVDV in this study.

An issue that cannot be resolved by this study is the metabolic cost of continual exposure to BVDV as a result of PI cattle in the feedlot. Constant immune stimulation as a result of exposure to BVDV PI cattle or acute exposure, along with the other associated pathogens that can take advantage of immune suppression, undoubtedly has an associated cost in the feedlot industry. Another issue of importance is whether cellular changes of the gastrointestinal tract mucosa as a result of constant exposure to PI cattle in the feedlot hinder performance outcomes, such as feed conversion. One possible explanation for the differences in feed conversion (ie, F:G ratio) in our study is differences in fatality percentage. Fatality percentage in the cattle exposed to BVDV was significantly higher (3.17 ± 0.38%), compared with the percentage for unexposed cattle (1.7 ± 0.25%). However, when the F:G ratio was evaluated after data for cattle that died were excluded (ie, fatalities not influencing feed conversion), the value was significantly higher for cattle with direct exposure (6.66 ± 0.23), compared with the value for unexposed cattle (5.94 ± 0.10). This indicated that the differences in feed conversion were attributable to other metabolic factors and not to the fatalities. There were no significant differences in morbidity percentage between these groups, which indicated that the difference in F:G ratio may have been attributable to a metabolic cost of constant exposure (maintenance energy requirements), subclinical disease, or changes at the cellular level as a result of BVDV PI exposure.

Viral concentration in nasal secretions may be greater than the concentration in serum; concentrations in nasal secretions range from $10^{3.9}$ to $10^{7.9}$ organisms/mL in PI calves.[37,g,h] Although virus is isolated from acutely infected calves, researchers in 1 study[g] detected virus titers ($< 10^{2.9}$) in nasal swab specimens obtained during acute infection that were not comparable to the high titers detected in nasal swab specimens obtained from PI calves. Virus concentrations in nasal secretions from PI cattle are substantially higher than are the concentrations in nasal secretions from cattle with acute infections, and within the PI population, there is a tremendous range in the number of virus organisms being shed. Because a large number of PI cattle were included in the study reported here, it is less likely that a PI animal with high or low amounts of virus (ie, high or low amounts of viral shedding) had an undue influence on the outcomes than had a smaller population of PI cattle been used. Because direct contact is considered to be one of the most important modes of transmission of BVDV, the population density of the feedlot along with the amount of viral shedding provided by PI cattle allows for efficient but variable transmission of BVDV.

Susceptibility of the recipient cattle also plays an important role in the outcome after BVDV exposure from PI cattle. Multiple studies[12,14,40,41] have provided evidence of an increased risk of BRD in calves that seroconvert to BVDV in the feedlot. These results are consistent with results of a study[42] of samples obtained from dairy cattle that revealed BVDV type 1b in dairy calves with BRD. In another study,[43] in which calves were vaccinated at the ranch and again at arrival at a feedyard, cattle with low BVDV titers on entry into the feedyard had significantly increased treatment costs and number of treatments per sick animal and decreased profitability when compared with results for calves with higher titers at arrival. It was also identified that the 3 groups with the lowest morbidity percentage in that study had significantly higher titers against BVDV type 1 at arrival, compared with titers for the 3 groups with the highest morbidity percentage.

Other investigators have conducted studies to evaluate seroconversion rates between vaccinates and nonvaccinates exposed to PI cattle in a feedlot. In 1 study,[44] auction-source calves were evaluated. Half of the calves were vaccinated 3 days prior to arrival at the feedlot. At day 35 of the study, there was no significant difference

in seroconversion between vaccinates and nonvaccinates (88% and 91.5%, respectively). The authors reported that vaccination with a modified-live virus vaccine containing BVDV type 1a and BVDV type 2 three days prior to exposure to PI calves with BVDV type 1b did not prevent infection in vaccinated calves exposed to the PI calves.[44] In another study,[45] calves were administered vaccines 30 and 17 days prior to exposure to BVDV PI calves, and 83% of these vaccinates seroconverted, compared with 97.9% of the nonvaccinates that seroconverted after exposure to the PI calves.

Analysis of the results of these studies indicates that for exposure to BVDV PI cattle in a feedlot, susceptibility is likely a function of resistance of the non-PI population and also a function of challenge exposure from PI cattle. Challenge exposure from a PI animal would include virulence of the BVDV strain, amount of BVDV shedding, and the frequency and duration of contact between susceptible animals and the virus. In 1 study,[45] the degree of challenge exposure posed by PI cattle did not prevent infection in cattle with titers against BVDV as high as 512 because they seroconverted after exposure to the PI cattle.

Population density in a feedlot environment also plays a major role in exposure outcomes. In the study reported here, cattle were allowed 16 m^2 of pen space/animal and 30 cm of linear feed bunk space/animal. As the density of the population increases, exposure to PI cattle will increase as a result of an increase in frequency of contacts and, possibly, the duration of those contacts. This will increase the rate of exposure as well as the magnitude of the exposure.

Exposure occurs within a pen of cattle containing a PI animal as well as in any pen with direct contact with a PI animal, such as adjacent pens.[31] In the entire population, the exposure rate is dictated by feedlot design, prevalence of PI cattle, and pen capacity. Differences in feedlot design, such as alleys for pen riders, feed delivery alleys, and roads, that result in separation of pens may reduce (or increase) direct exposure. Pen population (the number of cattle per pen) can have a dramatic effect on exposure from PI cattle. In the data analyzed in the study reported here, we detected a prevalence of 0.5%. As pen population increases, exposure rates will also increase. In this study, pen population was 80 to 100 cattle/pen; with the design of this feedlot, cattle in 107 of 172 (62.2%) pens would have been exposed to PI cattle had the PI cattle not been removed from specified pens.

Many stressors contribute to BRD in cattle in the cattle feeding industry, and these stressors increase susceptibility to disease. Each load of cattle that arrives at a feedlot has its own unique amount of these stressors prior to arrival, and management of new arrivals contributes to additional stress. Stressors that are typical in the beef feeding industry likely contribute to the outcomes from exposure to BVDV PI cattle at feedlots. Different populations will have different amounts of stressors involved. The population in our study likely dealt with a greater amount of stressors than did cattle in other studies[31,32] simply because they weighed less. In 1 study,[39] investigators used auction-derived calves but did not indicate body weight of the cattle.

The magnitude of the aforementioned factors for cattle lots in a feedlot will determine the outcomes. The more factors that are involved, the more detrimental the outcomes are likely to be. Total risk is an issue of the probability of having any or all of these factors within a particular exposure group.

Deaths attributable to mucosal disease may have been overrepresented in the study reported here as a result of the fact that most of the PI cattle were placed together in the quarantine pens. Mucosal disease develops when a PI animal infected with a noncytopathic strain becomes superinfected with a homologous cytopathic strain.[46,47] Because most PI cattle were housed together in a quarantine pen, any animal with a mutation or recombination event that resulted in a cytopathic biotype would develop mucosal disease, and in addition, any PI animal with a homologous noncytopathic strain would be at a greater risk of dying as a result of mucosal disease. We identified 86 PI cattle in the study. Of 49 PI cattle in the quarantine pens, 10 (20.4%) died as a result of mucosal disease, whereas only 4 of 37 (10.8%) PI cattle that were allowed to remain in their original pens died as a result of mucosal disease.

In this study, comparison of the performance and health outcomes for cattle lots with direct exposure to at least 1 PI animal (PI and NPIE groups) with those for cattle lots without exposure to PI animals (NPIU group) revealed significant differences for all outcomes, except for morbidity percentage, chronic illness percentage, treatment cost per animal, and mean number of treatments per illness (Tables 3 and 4). The outcome for morbidity percentage is in contrast to results of another study[31] in which investigators detected a significant difference in morbidity percentage.

We considered the calves used in our study to be at substantial risk for the effects of BVDV via exposure to PI cattle. Possibly the only group of calves with greater risk for the effects of exposure to PI cattle would be lighter-weight calves typically procured by the stocker industry through the auction market system. Maternal antibody protection is waning in calves procured for the stocker industry, and active protection is often lacking, which provides a substantial window of opportunity for any infectious disease to have a tremendous influence on health and performance. Calves enrolled in the study reported here weighed considerably less at arrival, compared with the weight of calves in other studies[31,32] conducted to evaluate health consequences. Cattle used in our study were all of commingled, auction-derived sources, which inherently increases susceptibility to infectious diseases, compared with another study[32] conducted to evaluate health effects from exposure to BVDV PI cattle in a feedlot (the population in that study was primarily single-source cattle).

This extensive field study of the first 66 days of the feeding period revealed several important findings. Most importantly, this study revealed that there is a detrimental impact from exposure to BVDV PI cattle in a feedlot. Economically, this amounted to $93.52/animal ($41.84/animal when the outliers were removed) in this study population at this feedlot. The largest segment of this loss was the result of performance losses of $88.26/animal ($36.48/animal when outliers were removed),

and the balance of $5.26/animal ($5.36/animal when outliers were removed) resulted from an increase in the fatality percentage. Feed efficiency or feed conversion may have provided the greatest impact to the economic outcomes because unexposed cattle had converted feed into body weight 55% more efficiently than did cattle with direct exposure. It is important to mention that the cattle were limit fed a moderate NEg ration and that the calves were not implanted with growth-promoting products.

The effect on feed conversion likely represented the maximum difference because this study represented only the first 66 days of the feeding period, and there would likely be some compensatory gains in the remainder of the feeding period. On the other hand, there is no compensation for fatalities, and differences in fatality percentages among the exposure groups may have increased throughout the entire feeding period.

We did not detect a significant difference in morbidity percentage as a result of direct exposure to BVDV PI cattle. This is in contrast to results of 1 study[31] but is consistent with results of another study.[32]

The prevalence of BVDV PI cattle among all animals tested in this study was 0.4%, which is slightly higher but still consistent with other reports[31,32,39] of populations entering a feedlot and was based on possibly the largest population used to date. The prevalence of PI cattle in our study is also consistent with the prevalence of PI cattle reported for the general population.[48]

Survival rate of PI cattle during the study time frame ranges from 0% to 100%.[31,32,49,50] In our study of cattle during the starter phase of feedlots, 25.6% of the PI cattle died and 10.8% were sold for salvage slaughter because of chronic disease. Results of our study are consistent with those in another study[31] in which investigators reported that PI cattle are at a greater risk of death or chronic illness, compared with the risk for non-PI cattle.

The study reported here also revealed that at the pen level, a PI animal does not always equate to poorer outcomes. Many lots of exposed cattle in this study had acceptable performance and health outcomes. Many risk variables likely determine the degree of impact a PI animal will have on the population. When considering the entire feedlot population, this study revealed obvious negative effects and indicated that BVDV PI cattle pose an economic threat to the beef feeding industry. This is only a partial evaluation of the effects of PI cattle on the feeding industry, and additional studies are required to evaluate the total potential effects throughout the entire feeding period.

a. Prism 4, Fort Dodge Animal Health, Fort Dodge, Iowa.
b. Caliber 7, Boehringer Ingelheim Vet Medica Inc, St Joseph, Mo.
c. Pulmoguard PhM-1, Boehringer Ingelheim Vet Medica Inc, St Joseph, Mo.
d. Express 5, Boehringer Ingelheim Vet Medica Inc, St Joseph, Mo.
e. HerdCheck BVDV antigen ELISA, IDEXX Laboratories, Westbrook, Me.
f. PC SAS, version 8,2, SAS Institute Inc, Cary, NC.
g. Fulton RW, Elam N, Hessman BE, et al. Bovine viral diarrhea virus persistently infected and acutely infected calves: assays for viral infectivity, polymerase chain reaction analysis, and antigen detection (abstr), in *Proceedings*. 49th Annu Meet Am Assoc Vet Lab Diagn 2006;212.
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