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A Comparison of Two Multivalent Viral Vaccine Programs in Feedlot Calves at High Risk of Developing Undifferentiated Fever/Bovine Respiratory Disease

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Abstract

A field study was conducted to compare the relative effects of two multivalent viral vaccine programs on animal health, feedlot performance, and carcass characteristics of feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease (UF/BRD). Upon arrival at the feedlot, 3,264 animals were randomly allocated to one of two experimental groups: PYR5 (Pyramid® 5, Fort Dodge Animal Health, Division of Wyeth, Overland Park, Kansas) or EXP5 (Express® 5, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri). All animals were re-vaccinated with their respective vaccines at 139 days-on-feed. The initial undifferentiated fever (UF) treatment rate was significantly ($P<0.05$) lower in the PYR5 group than in the EXP5 group (RR=0.70, 95% CI=0.53-0.93). On a live-weight basis, the dry matter-to-gain ratio (DM:G) was significantly ($P<0.05$) improved in the PYR5 group compared to the EXP5 group. Yield grades were improved in the PYR5 group, with a significantly ($P<0.05$) lower proportion of YG USDA 3 carcasses in the PYR5 group compared to the EXP5 group. No significant differences were detected in any other animal health, feedlot performance, or carcass characteristic variables between the experimental groups at the $P<0.05$ level. The economic analysis showed an advantage of $1.36 US per animal in the PYR5 group due to the lower initial UF treatment rate and proportion of YG USDA 3 carcasses.

Keywords: bovine, BRD, feedlot, vaccine

Résumé

Une étude sur le terrain a été menée afin de comparer les effets relatifs de deux programmes de vaccination avec vaccins viraux multivalents sur la santé animale, la performance à l'engraissement et les caractéristiques de carcasse des veaux d'engraissement à haut risque de développer une fièvre non différenciée, aussi connue sous le nom de maladie respiratoire bovine (BRD). À leur arrivé au parc d'engraissement, un total de 3264 animaux ont été alloués aléatoirement parmi deux groupes expérimentaux : PYR (Pyramid® 5, Fort Dodge Animal Health, Division of Wyeth, Overland Park, Kansas) ou EXP (Express® 5, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri). Tous les animaux ont été vaccinés à nouveau avec leur vaccin respectif 139 jours suivant le début de l'engraissement. Le taux initial de traitement des animaux était significativement (P<0.05) moins élevé dans le groupe PYR que dans le groupe EXP (RR=0.70, I.C. 95%=0.53-0.93). En termes de poids vif, le rapport de matières sèches sur le gain était significativement (P<0.05) plus élevé dans le groupe PYR que dans le groupe EXP. La catégorie de rendement s'améliorait dans le groupe PYR avec une proportion significativement (P<0.05) moins élevée de la catégorie de rendement USDA 3 dans le groupe PYR que dans le groupe EXP. Il n'y avait pas de différence significative au niveau des autres variables de santé animale, de performance à l'engraissement et de caractéristiques de carcasse entre les deux groupes expérimentaux au seuil statistique de 0.05. L'analyse

économique démontrait un avantage de 1.36$ US par animal dans le groupe PYR en raison du plus faible taux de traitement des animaux fiévreux et de la plus faible proportion de carcasses avec la catégorie de rendement USDA 3.

Introduction

Undifferentiated fever/bovine respiratory disease (UF/BRD) complex or shipping fever, is an important animal health concern in commercial feedlot production. Because of the substantial mortality and production losses due to UF/BRD in feedlot cattle, continued development of control and management strategies by researchers and clinicians are ongoing.[1,3,4,6,9,10,13,14]

The etiology of UF/BRD is multifactorial, often including both viral and bacterial infectious agents. Viruses that may be associated with UF/BRD include infectious bovine rhinotracheitis (IBR) virus, bovine viral diarrhea (BVD) virus, bovine respiratory syncytial (BRS) virus, and parainfluenza-3 (PI_3) virus, while bacterial agents such as *Histophilus somni*, *Mannheimia haemolytica*, and *Pasteurella multocida* may also be involved.

Management of this disease complex includes vaccination of cattle upon arrival at the feedlot with modified-live viral vaccines and bacterin-toxoids containing antigens from UF/BRD pathogens. Clinical and field studies in commercial production settings are valuable resources in the evaluation of the efficacy and cost-effectiveness of different vaccine programs, including the actual vaccines used in each program. Recently, several studies in commercial feedlot settings have demonstrated that multivalent viral vaccines (e.g., IBR, PI_3, BVD type I, and BRS viruses) are more cost-effective than univalent viral vaccines (e.g., IBR virus only) or bivalent viral vaccines (e.g., IBR and PI_3 viruses only) for the prevention and control of UF/BRD in feedlot calves.[1,13] In these studies, the benefits observed from multivalent vaccine programs were due to significant ($P<0.05$) reductions in UF/BRD morbidity, overall chronicity, overall wastage, overall mortality rates, and/or improvements in average daily gain (ADG) compared to univalent or bivalent viral vaccine selections. These benefits were detected even after accounting for the incremental costs of the multivalent viral vaccines. In addition, further improvements in morbidity, mortality, and ADG were achieved by including type I and type II BVD viruses in the vaccine program to prevent and control UF/BRD.[17] Moreover, a recent study comparing three multivalent vaccines found an economic advantage and improved morbidity rates, relapse rates, and feed conversion ($P\leq0.10$) in cattle vaccinated with Pyramid 5[a] compared to the other two vaccines evaluated in the study.[4]

Pyramid 5 (PYR5) and Express 5[b] (EXP5) are both approved for vaccination of healthy cattle as an aid in the prevention of disease caused by IBR, BVD types I and II, PI_3, and BRS viruses. However, limited field trial data are available for these two vaccines in terms of comparative efficacy for prevention and control of UF/BRD in commercial feedlot production.

The purpose of this field study was to compare the relative effects of two multivalent viral vaccine programs (PYR5 and EXP5) on the animal health, feedlot performance, and carcass characteristics of feedlot calves at high risk of developing UF/BRD.

Materials and Methods

General overview

Upon arrival at the feedlot, commercial feedlot calves at high risk of developing UF/BRD were randomly allocated to one of two experimental groups included in the study. Pen was the experimental unit, and five pens were allocated to each experimental group. Cattle enrolled in the trial were followed from allocation to harvest with the purpose of comparing animal health, feedlot performance, and carcass characteristics between the two experimental groups. Statistical comparisons were used to determine the probabilities that differences between groups were due to experimental group (vaccine) effects or random chance. Economic models were constructed to evaluate the relative economic impact of each experimental group, and only differences in outcome variables that were unlikely to be the result of random chance ($P<0.05$) were incorporated into the economic model.

Study facilities

The study was conducted near Broken Bow, Nebraska at a commercial feedlot with a one-time capacity of approximately 85,000 animals. The basic design of this feedlot is representative of the standard design used in Nebraska. Open-air, dirt-floor pens are arranged side by side with central feed alleys. There are 176 large pens in the feedlot with capacities ranging from 200 to 600 animals/pen. The remaining 102 pens are smaller and have animal capacities ranging from 60 to 200 animals/pen.

This feedlot is equipped with three hospital facilities (two mobile, one permanent) and one enclosed processing facility. Each facility includes a hydraulic chute equipped with an individual animal scale and a chute-side computer for collection of individual animal data. Separation alleys are available to facilitate the return of animals to designated pens, and the feedlot has seven recovery and "chronic" pens, 17 receiving pens, and several shipping pens.

Study animals

Animals enrolled in the study were exotic crossbred steer and bull calves purchased from auction markets

throughout the western and central United States. After assembly at auction markets, cattle were transported to the feedlot by truck. At allocation, the average weights of cattle in pens ranged from 506 to 533 lb (230 to 242 kg). Animals used in this study were designated as high risk for developing UF/BRD based on purchase weight, auction market origin, anticipated degree of post-arrival purchase group commingling in feedlot pens, and detailed historical records on similar cattle purchased in previous years at the same feedlot.

Upon arrival at the feedlot, animals were moved through a hydraulic chute for a group of procedures collectively known as processing. At processing, each animal received a unique identification tag, a trenbolone acetate and estradiol benzoate growth implant,[c] and a multivalent clostridial/*Histophilus somni* bacterin-toxoid.[d] In addition, each animal received subcutaneous tilmicosin[e] at a dose of 4.55 mg/lb, (10 mg/kg) body weight (BW), a *Mannheimia haemolytica/Pasteurella multocida* bacterin-toxoid,[f] and topical ivermectin[g] (0.5%) at a dose of 1 mL/22 lb (10 kg) BW. All bull calves were castrated at this time. At approximately 139 days-on-feed (DOF) for each pen, all animals were re-implanted with a trenbolone acetate and estradiol benzoate growth implant.[c]

Experimental design

Upon arrival at the feedlot (February 6-20, 2004), 3,264 animals were randomly allocated using a computer-generated randomization table to one of two experimental groups (PYR5 or EXP5), and each animal received the appropriate viral vaccine via subcutaneous injection at enrollment. Experimental groups were housed in separate pens, with up to 398 animals per pen. Replicates (one pen from each experimental group) were filled consecutively until there were five replicates with a total of 10 pens. It took two to four days to fill each replicate. Outcome variables were measured on a pen basis. All animals were re-vaccinated with their respective vaccines at approximately 139 DOF, and pens from both experimental groups within a replicate were handled, revaccinated, and reimplanted on the same day.

Feeding program

Standard mixed complete feedlot diets, formulated to meet or exceed the nutritional requirements of feedlot cattle,[h] and water were offered *ad libitum*. Feedlot diets were blended by combining dry-rolled corn, high-moisture corn, corn silage, alfalfa hay, corn distiller's grains solubles, soybean meal, and supplement in a modern, batch-milling facility equipped with overhead bins. The supplement was manufactured in a granular form by a commercial feed mill.[i] Diets were delivered to pens once or twice daily using truck-mounted mixers on load cells. Daily feed allowances to each pen were recorded. Animals were adapted to a finisher diet over 34 to 37 days by increasing the dry-rolled and high-moisture corn proportion and decreasing the corn silage and alfalfa hay proportion at approximately eight-day intervals.

From arrival to approximately 56 DOF, a medicated premix[j] containing chlortetracycline and sulfamethazine[j] was added to the mixed, complete, feedlot diets to provide 350 mg per animal per day of each antimicrobial.

Animal health

Experienced animal health personnel observed the study animals on a daily basis during the course of the trial. Animals deemed "sick" by animal health personnel, based on subjective criteria such as attitude, appearance, and willingness to move about, were moved to a hospital facility, diagnosed, and treated as per written treatment protocols provided by the consulting veterinarians. The treatment protocols used in the study were the same for both experimental groups.

A diagnosis of UF was made when an animal showed evidence of depression, as characterized by lack of response to stimulation, reluctance to move, and/or abnormal posture/carriage of the head; a lack of abnormal clinical signs referable to body systems other than the respiratory system; a rectal temperature >104.5°F (40.3°C); and no previous treatment history for UF/BRD. A diagnosis of no fever (NF) was made when an animal showed evidence of depression, as characterized by lack of response to stimulation, reluctance to move, and/or abnormal posture/carriage of the head; a lack of abnormal clinical signs referable to body systems other than the respiratory system; a rectal temperature ≤104.4°F (40.2°C); and no previous treatment history for UF/BRD.

Relapses of UF or NF were defined as animals returned to their original feedlot pen following initial UF or NF therapy and subsequently determined to be "sick" by animal health personnel. A diagnosis of UF or NF relapse was made if there was a previous treatment history for UF or NF and absence of clinical signs referable to organ systems other than the respiratory tract. All animals that relapsed subsequent to initial UF therapy were defined as UF relapses (i.e., first UF relapse, second UF relapse, or third UF relapse). All animals that relapsed subsequent to initial NF therapy were defined as NF relapses (i.e., first NF relapse, second NF relapse, or third NF relapse). The maximum number of UF or NF treatment regimes permitted for all animals in the study was four. Once an animal was treated as a third UF or NF relapse, no further therapy for UF or NF occurred.

Animals identified as "sick" subsequent to third UF or NF relapse therapy were deemed to be "chronics", as were animals that were unsuitable to be returned to their designated feedlot pens based on subjective appraisal of the attitude and appearance of each animal. Chronics

that did not die during the study were defined as wastage. Finally, all other diseases were treated as per standard feedlot protocols provided by the consulting veterinarians. All animal health events, including treatment date, presumptive diagnosis, and drug usage and dosage, were recorded on the chute-side computer system.

Trained feedlot personnel prosected the carcasses of all animals that died during the study using standardized procedures to capture appropriate digital images as outlined in the written necropsy protocol provided by the study investigators. These images were electronically transferred to the study investigators so cause of death could be determined by a veterinarian for each animal based on the findings of the gross postmortem examination.[16] Feedlot personnel and veterinarians were masked (blinded) to the experimental status of each animal.

Marketing

Cattle were sold under normal marketing procedures. The feedlot manager, based on visual appraisal and/or weight data, determined when a replicate (or portion of a replicate) was ready for sale. Animals were scheduled for harvest and trucked to the packing plant.[k] Within each replicate, approximately equal numbers of animals from each experimental group were shipped to the packing plant on the same day.

Data collection and management

Initial weight (lb) and hip height (inches) were measured for each animal at processing. These data were imported into a spreadsheet program,[l] where the average initial weight and hip height were calculated for each pen. These baseline variables were used to assess the homogeneity of the animals in each experimental group at the start of the study. The ancillary production variables, harvest weight, weight gain, carcass weight, dressing percentage, DOF, and daily dry matter intake (DDMI), were calculated for each pen (Table 1).

The computerized animal health data were verified and summarized. From these data, risk rates for initial UF treatment, first UF relapse, initial NF treatment, first NF relapse, overall chronicity, overall wastage, overall mortality, BRD mortality, histophilosis mortality, arthritis mortality, metabolic mortality, and miscellaneous mortality were calculated for each pen (Table 1).

The feedlot performance variables, ADG and dry matter intake to gain ratio (DM:G), were calculated for each pen. The feedlot performance variables were calculated by two methods: the live-weight basis method utilized the live weights obtained at the time of sale and the carcass-weight basis method utilized the hot carcass weights obtained from the packing plant (Table 1).

Quality grade (QG) and yield grade (YG) data were collected for each carcass at harvest. The proportions of carcasses with USDA Prime, USDA Choice, USDA Select, No Roll, and USDA Standard quality grades and the proportions of carcasses with USDA 1, USDA 2, USDA 3, USDA 4, and USDA 5 yield grades were calculated for each pen.

Statistical analysis

Data were analyzed using SAS®, a commercial analytical software program.[m] Animal health variables were compared between the experimental groups using Poisson regression in a log linear model for replicate and experimental group effects and generalized estimating equations to control for intra-pen clustering of disease[7,8] (Proc Genmod).

Baseline, ancillary production, feedlot performance, and carcass grading variables were compared between the experimental groups using least squares analysis of variance for replicate and experimental group effects (Proc GLM).[12] Baseline variables were tested as covariates of feedlot performance variables and included in the final model comparing experimental groups when significant ($P<0.05$) effects were detected.[15]

Economic analysis

A computer spreadsheet program[l] that simulates all economic aspects of feedlot production was used to estimate the relative cost-effectiveness of the experimental groups.[6,11,13,14] In the economic model, initial and final weights, feeder and harvest prices, processing and ration costs, and yardage and interest rates were fixed for both experimental groups. The costs of the multivalent viral vaccines were assumed to be equal. Animal health, feedlot performance (ADG carcass-weight basis and DM:G carcass-weight basis), and carcass characteristic (YG and QG) outcome variables were incorporated into the economic model when significant ($P<0.05$) differences existed between the experimental groups. When there were no significant ($P\geq0.05$) differences between the experimental groups, the animal health, feedlot performance, and carcass characteristics of the EXP5 group were used for both experimental groups in a comparison. All other factors were fixed in the economic simulations. The cost of each initial UF treatment regime was $13.83 US per animal, and the discount for YG USDA 3 was $-3.00 US per 100 lb (45.5 kg) carcass weight. The interest rate used in the analysis was 4.0% per annum. Sensitivity analyses were performed for outcome variables that were significantly ($P<0.05$) different between the experimental groups to evaluate the effects of changes in input values on the economic analysis (Table 2).

Results

The pen-based summary statistics for the baseline variables are presented in Table 3. The experimental groups were considered homogenous ($P\geq0.05$) with re-

Table 1. Ancillary production, animal health, and feedlot variable calculation formulas used in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

Variable		Definition	
		Ancillary Production	
Harvest Weight	=	(total harvest weight divided by the number of animals harvested)	
Weight Gain	=	(average harvest weight minus average initial weight)	
Carcass Weight	=	(total carcass weight divided by the number of carcasses)	
Dressing Percentage	=	(total carcass weight divided by total harvest weight x 100%)	
Days-on-Feed (DOF)	=	(average harvest date minus average allocation date)	
Daily Dry Matter Intake (DDMI)	=	(total dry matter fed (100% dry matter basis) divided by the number of animal days)	
		Animal Health	
Initial UF[1] Treatment Rate	=	(number of animals initially treated for UF divided by the number of animals allocated)	x 100%
First UF Relapse Rate	=	(number of first UF relapses divided by the number of animals initially treated for UF)	x 100%
Initial NF[1] Treatment Rate	=	(number of animals initially treated for NF divided by the number of animals allocated)	x 100%
First NF Relapse Rate	=	(number of first NF relapses divided by the number of animals initially treated for NF)	x 100%
Overall Chronicity Rate	=	(number of animals designated as chronic divided by the number of animals allocated)	x 100%
Overall Wastage Rate	=	(number of animals designated as chronic that did not die divided by the number of animals allocated)	x 100%
Overall Mortality Rate	=	(number of mortalities due to all causes divided by the number of animals allocated)	x 100%
BRD[2] Mortality Rate	=	(number of mortalities due to BRD divided by the number of animals allocated)	x 100%
Histophilosis[3] Mortality Rate	=	(number of mortalities due to histophilosis divided by the number of animals allocated)	x 100%
Arthritis Mortality Rate	=	(number of mortalities due to arthritis divided by the number of animals allocated)	x 100%
Metabolic Mortality Rate	=	(number of mortalities due to metabolic disease divided by the number of animals allocated)	x 100%
Miscellaneous Mortality Rate	=	(number of mortalities due to causes other than BRD, histophilosis, arthritis, or metabolic disease divided by the number of animals allocated)	x 100%
		Feedlot Performance	
Average Daily Gain (ADG) Live-weight Basis	=	((total net harvest weight plus total weight of animals shipped for salvage harvest plus total weight of animals that died minus total initial weight) divided by the number of animal days)	
ADG Carcass-weight Basis	=	(((total carcass weight divided by a fixed dressing percentage of 63%) plus total weight of animals shipped for salvage harvest plus total weight of animals that died minus total initial weight) divided by the number of animal days))	
Dry Matter Intake to Gain Ratio (DM:G) Live-weight Basis	=	(DDMI divided by ADG Live-weight Basis)	
DM:G Carcass-weight Basis	=	(DDMI divided by ADG Carcass-weight Basis)	

[1]UF is undifferentiated fever and NF is no fever.
[2]BRD is bovine respiratory disease.
[3]Histophilosis is based on post mortem findings consistent with *Histophilus somni* infection.

Table 2. Economic model input values and sensitivity analysis from a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

Description	Unit	Input value	Change evaluated in sensitivity analysis	Economic impact in PYR5[1] vs EXP5[2]
Initial UF[3] treatment cost[4]	$/animal	$13.83	$1.00	$0.02
Yield Grade USDA 3 discount[4]	$/100 lb carcass weight	-$3.00	$1.00	$0.30

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]UF is undifferentiated fever.
[4]All economic impact values are expressed in $US/animal and should be interpreted as the effect on the economic analysis that is associated with the input value changes evaluated in the sensitivity analysis.

Table 3. Baseline data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group		
Baseline variable	PYR5[1,5]	EXP5[2,5]	*P*-value
Initial weight (lb)[3]	519.8 ± 1.8	517.8 ± 1.8	0.474
Hip height (inches)[4]	44.43 ± 0.06	44.47 ± 0.06	0.714

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Initial weight for each pen was calculated as the summation of the individual animal initial weights corrected for the shrink from purchase to arrival at the feedlot.
[4]Hip height is the average hip height within each pen.
[5]Least square means ± standard errors.

spect to average initial weight and average hip height. An average of 7% of study animals were castrated in both groups at allocation. The ancillary production data summary is presented in Table 4. There were no significant ($P \geq 0.05$) differences in harvest weight, weight gain, carcass weight, dressing percentage, DOF, or DDMI between experimental groups.

The morbidity and mortality data summaries are presented in Tables 5 and 6, respectively. The initial UF treatment rate was significantly ($P<0.05$) lower in the PYR5 group than in the EXP5 group (RR=0.70, 95% CI=0.53-0.93). However, there were no statistically significant differences detected in first UF relapse, initial NF treatment, first NF relapse, overall chronicity, overall wastage, overall mortality, BRD mortality, histophilosis mortality, arthritis mortality, metabolic mortality, or miscellaneous mortality rates between the experimental groups at the $P<0.05$ level.

The feedlot performance variables are summarized in Table 7. On a live-weight basis, DM:G was significantly ($P<0.05$) improved in the PYR5 group compared to the EXP5 group. There were no significant differences detected in ADG between the experimental groups on either a live-weight or a carcass-weight basis at the $P<0.05$ level.

The carcass characteristic data summary is presented in Table 8. Yield grades were improved in the PYR5 group, with a significantly ($P<0.05$) lower proportion of YG USDA 3 carcasses in the PYR5 group compared to the EXP5 group. There were no significant differences detected in the other carcass characteristic variables evaluated in the study between the experimental groups at the $P<0.05$ level.

In the economic analysis, there was an advantage of $1.36 US per animal in the PYR5 group compared to the EXP5 group, due to a lower initial UF treatment

rate and a lower proportion of YG USDA 3 carcasses in the PYR5 group.

Discussion

In this study, vaccinating cattle at high risk of developing UF/BRD with PYR5 at feedlot arrival improved animal health, feedlot performance, and carcass characteristic outcomes as compared to vaccination with EXP5. This was manifested by different findings throughout the study. Initial UF treatment rates were reduced in cattle administered PYR5 compared to cattle administered EXP5 (P=0.016), translating into both economic benefit and improved animal health (Table 5). In addition, there were improved yield grades in the PYR5 group (Table 8), with a significant reduction in the number of YG USDA 3

Table 4. Ancillary production data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group		
Ancillary production variable[3]	PYR5[1,4]	EXP5[2,4]	P-value
Harvest weight (lb)	1,306.4 ± 8.8	1,308.8 ± 8.8	0.856
Weight gain (lb)	786.6 ± 9.3	790.9 ± 9.3	0.755
Carcass weight (lb)	835.3 ± 3.7	835.0 ± 3.7	0.958
Dressing percentage	63.94 ± 0.20	63.80 ± 0.20	0.653
Days-on-feed (DOF)	251.0 ± 0.0	251.0 ± 0.0	1.000
Daily dry matter intake (DDMI) (lb/day)	19.28 ± 0.09	19.45 ± 0.09	0.247

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Refer to Table 1 for the formulas used to calculate each variable.
[4]Least square means ± standard errors.

Table 5. Morbidity data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group				
Morbidity variable[6]	PYR5[1,5]	EXP5[2,5]	Relative risk[3]	95% CI[4]	P-value
Initial UF[7] treatment	89 (5.45)	127 (7.78)	0.70	0.53 - 0.93	0.016
First UF relapse	43 (48.31)	60 (47.24)	1.05	0.71 - 1.57	0.803
Initial NF[7] treatment	106 (6.50)	128 (7.84)	0.83	0.64 - 1.07	0.151
First NF relapse	38 (35.85)	61 (47.65)	0.76	0.50 - 1.14	0.180
Overall chronicity	81 (4.96)	87 (5.33)	0.93	0.69 - 1.25	0.643
Overall wastage	60 (3.68)	69 (4.23)	0.87	0.63 - 1.21	0.402

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Relative risk is the ratio of the rate of disease in the PYR5 group divided by the rate of the disease in the EXP5 group.
[4]95% CI is the 95% confidence interval calculated for each relative risk, and corrected for pen and replicate effects using generalized linear modeling techniques. The partially maximized likelihood function was used to calculate the confidence intervals.
[5]Number of events with percentages in parentheses.
[6]Refer to Table 1 for the formulas used to calculate each variable.
[7]UF is undifferentiated fever and NF is no fever.

carcasses (P=0.020). The lower initial UF treatment rate and lower proportion of YG USDA 3 carcasses resulted in a net economic advantage of $1.36 US per animal in the PYR5 group when the cost of the vaccine programs was assumed to be equal.

The exact reasons for differences observed in this study between the PYR5 and EXP5 vaccination programs are not known. Both the PYR5 and EXP5 vaccines were manufactured to prevent infection of the same five viruses (IBR, BVD type I and II, BRS and PI_3). However, the results of this study are similar to a previous study comparing PYR5 to another multivalent 5-way vaccine, in which cattle administered PYR5 also had improved UF/BRD morbidity indices (P<0.10).[4]

Table 6. Mortality data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group				
Mortality variable[6]	PYR5[1,5]	EXP5[2,5]	Relative risk[3]	95% CI[4]	*P*-value
Overall mortality	57 (3.49)	57 (3.49)	1.00	0.68 - 1.46	1.000
BRD[7] mortality	23 (1.41)	29 (1.78)	0.79	0.46 - 1.38	0.411
Histophilosis[8] mortality	4 (0.25)	2 (0.12)	2.00	0.37 - 10.91	0.424
Arthritis mortality	0 (0.00)	1 (0.06)	N/A	N/A	0.999
Metabolic mortality	14 (0.86)	13 (0.80)	1.08	0.51 - 2.29	0.848
Miscellaneous mortality	16 (0.98)	12 (0.74)	1.33	0.54 - 3.32	0.536

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Relative risk is the ratio of the rate of disease in the PYR5 group divided by the rate of the disease in the EXP5 group.
[4]95% CI is the 95% confidence interval calculated for each relative risk, and corrected for pen and replicate effects using generalized linear modeling techniques. The partially maximized likelihood function was used to calculate the confidence intervals.
[5]Number of events with percentages in parentheses.
[6]Refer to Table 1 for the formulas used to calculate each variable.
[7]BRD is bovine respiratory disease.
[8]Histophilosis is based on post mortem findings consistent with *Histophilus somni* infection.

Table 7. Performance data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group		
Performance variable[3]	PYR5[1,4]	EXP5[2,4]	*P*-value
ADG[5]			
Live-weight basis	3.25 ± 0.01	3.26 ± 0.01	0.817
Carcass-weight basis	3.32 ± 0.01	3.31 ± 0.01	0.645
DM:G[5]			
Live-weight basis	5.93 ± 0.01	5.97 ± 0.01	0.046
Carcass-weight basis	5.81 ± 0.03	5.87 ± 0.03	0.189

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Refer to Table 1 for the formulas used to calculate each variable.
[4]Least square means ± standard errors.
[5]The effect of animals that died has been removed from the ADG and DM:G values.

Table 8. Carcass characteristic data summary in a study to compare two multivalent viral vaccine programs in feedlot calves at high risk of developing undifferentiated fever/bovine respiratory disease.

	Experimental group		
Carcass characteristic variable	PYR5[1,3]	EXP5[2,3]	*P*-value
Yield Grade[4]			
1	12.56 ± 2.07	8.77 ± 2.07	0.265
2	43.45 ± 2.11	41.92 ± 2.11	0.634
3	35.27 ± 0.67	38.87 ± 0.67	0.020
4	8.28 ± 2.07	9.86 ± 2.07	0.619
5	0.44 ± 0.17	0.59 ± 0.17	0.566
Quality Grade[4]			
Prime	4.94 ± 1.32	5.34 ± 1.32	0.842
Choice	78.51 ± 1.02	78.66 ± 1.02	0.919
Select	14.68 ± 1.84	13.98 ± 1.84	0.800
No Roll	1.87 ± 0.36	1.63 ± 0.36	0.665
Standard	0.00 ± 0.11	0.39 ± 0.11	0.076

[1]Animals in the PYR5 group received Pyramid® 5 (Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS). There were five pens and 1,632 animals in the PYR5 group.
[2]Animals in the EXP5 group received Express® 5 (Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). There were five pens and 1,632 animals in the EXP5 group.
[3]Least square means (percentages) ± standard errors.
[4]Each yield grade (YG) and quality grade (QG) variable reflects the proportion of carcasses (pen level) that received that YG or QG.

One difference between the PYR5 and EXP5 vaccines is the adjuvant used in each vaccine. The PYR5 vaccine contains the MetaStim adjuvant (MetaStim®, Fort Dodge Animal Health)[5] while the EXP5 vaccine does not. In a previous study comparing bacterin-toxoids for the prevention of UF/BRD, improved animal health outcomes were identified in the group immunized with the product containing Metastim.[11] However, purposefully designed studies would be required to appropriately address whether or not the adjuvant was responsible for differences in the animal health, production, and carcass characteristic outcomes identified in this study.

The type 2 BVD strain in each vaccine is another difference identified between the two vaccines compared in this study. The PYR5 vaccine contains BVD type 2 strain 5912,[5] while the EXP5 vaccine contains BVD type 2 strain Bolin 296,[2] and it is possible that the different type 2 BVD strains may have had an effect on outcomes in this study.

This study was based on only five replicates (pens) per experimental group. As a result, the allocation of additional replicates may have increased the power of the study to find small but biologically and economically important differences between experimental groups. However, based on the results of these five replicates, differences in economically important variables (overall mortality, ADG and DM:G) between experimental groups were so small that additional replicates would likely not change the interpretation of study findings.

The economic model used in this study was designed to include animal health, feedlot performance, and carcass characteristic variables if differences between groups were detected at the $P<0.05$ level, keeping all other factors fixed. This methodology did not incorporate ranges of input values and did not evaluate economic effects for variables where differences could be due to chance alone ($P\geq0.05$). As a result, this economic model is a relatively conservative assessment of economic impacts, and was chosen for its straightforward approach, for its ability to ascribe economic effects to specific biologic outcomes, and for its ease of interpretation by producers.

Conclusions

Based on the results of this study, it is more cost effective to use PYR5 than EXP5 vaccine in feedlot calves at high risk of developing UF/BRD. This was evidenced by the reduced initial UF treatment rate and lower proportion of YG USDA 3 carcasses. In the economic analysis, there was an advantage of $1.36 US per animal in the PYR5 group compared to the EXP5 group. The underlying reasons for the observed differences in outcome variables between the two vaccine groups in this study remain unknown.

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Endnotes

[a]Pyramid® 5, Fort Dodge Animal Health, Division of Wyeth, Overland Park, KS
[b]Express® 5, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO
[c]Synovex® Choice, Fort Dodge Animal Health, Division of Wyeth, Fort Dodge, IA
[d]Bar-Vac® 7/Somnus, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO
[e]Micotil® 300 Injection, Elanco Animal Health, Division of Eli Lilly & Co., Greenfield, IN
[f]Pulmo-guard™ PHM-1, Boehringer Ingelheim Vetmedica, Inc., St Joseph, MO
[g]Ivermectin Pour-On, Durvet Inc., Blue Springs, MO
[h]Nutritional Requirements for Beef Cattle, National Research Council, 1996
[i]Farr Better Feeds, Animal Nutrition Division, Cargill Inc., Duncan, NE
[j]Aureo S 700® Granular 35G, Animal Health Division, Alpharma Inc., Fort Lee, NJ
[k]Tyson Fresh Meats, Inc., A Division of Tyson Foods, Inc., Lexington, NE
[l]Microsoft® Excel 2003, Microsoft Corporation, Redmond, WA
[m]The SAS™ System for Windows, Release 9.1, SAS Institute Inc., Cary, NC

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