The Effect of Market Forces on Bovine Respiratory Disease

Derrell S. Peel, PhD

KEYWORDS

• Bovine respiratory disease • Respiratory disease • Economics • Market failure

KEY POINTS

- The inability to enhance BRD control is caused partly by market failure.
- The complex economic structure of the cattle industry results in misalignment of costs and benefits across production sectors and suboptimal investment in BRD control.
- Better BRD control requires an industry-wide effort to focus on lifetime animal health.

INTRODUCTION

Bovine respiratory disease (BRD) is the costliest disease affecting the cattle industry, persisting despite efforts to reduce the disease and resulting economic losses. The continued and, arguably, growing impacts of BRD have frustrated animal health professionals and members of the cattle industry, who have been unable to improve BRD control and reduce its economic impact. This article discusses the economic impacts of BRD, some economic considerations for BRD control, and reasons for slow progress in improving BRD control.

WHAT IS BOVINE RESPIRATORY DISEASE?

BRD is caused by a complex of viral and bacterial infection, linked to stressors related to management and environmental conditions. Weaning, crowding, sorting, commingling, processing, and shipping often trigger BRD. For this reason, BRD is commonly referred to as "shipping fever" because many of these stressors are associated with movement between production sectors. Environmental conditions, such as temperature (high or low), wet conditions, exhaust fumes, and dust, also contribute. The interaction and timing between these factors is complex and adds significantly to the challenge in understanding BRD. Although the end-result is typically the same, the sequence and timing of events that lead to BRD varies by case.

Oklahoma State University, 519 Ag Hall, Stillwater, OK 74078, USA
E-mail address: derrell.peel@okstate.edu

Vet Clin Food Anim 36 (2020) 497–508
https://doi.org/10.1016/j.cvfa.2020.03.008 **vetfood.theclinics.com**

BOVINE RESPIRATORY DISEASE AND THE BEEF CATTLE INDUSTRY

The US cattle industry is complex and this adds to the challenge of understanding and controlling BRD. The industry consists of multiple production sectors that are separated by space and time. The biology of cattle production is slow, and this subjects cattle to prolonged opportunity for exposure to pathogens and conditions that contribute to BRD. Depending on the specific production system, cattle production typically covers 24 to 28 months including 9 months of gestation, 7 to 8 months of suckling before weaning, 4 to 6 months in stocker/backgrounding, and 5 to 8 months for finishing.

Cow-calf production is the most widespread sector of the beef cattle industry, occurring over most of the country in climates ranging from subtropical to subalpine. There are 13 states with more than 900,000 head of beef cows, spread from Florida and Kentucky in the east and from Texas to Montana and North Dakota in the west. These 13 states account for 67.1% of the total beef cowherd with another seven states each having more than 500,000 beef cows.[1] The 2017 Census of Agriculture shows that beef cow-calf production occurs on 729,046 farms with an average herd size of 44 head (**Table 1**). Beef cowherds are widely distributed in size with 27.2% of cows in herds of less than 50 cows, 55.6% in herds from 50 to 500 cows, and 17.2% in herds greater than 500 head.[2]

Most beef and dairy steers and feeder and cull heifers are finished in feedlots. Feedlot production is highly concentrated in size and location. The 2017 Census of Agriculture shows that 700 feeding operations of 2500 head or greater account for 70.7% of cattle in feedlots with an average inventory of 15,181 head.[2] These 700 feedlots represent just 2.7% of all feedlots. On January 1, 2020, the top five cattle feeding states of Nebraska, Texas, Kansas, Iowa, and Colorado accounted for 72.1% of total

Table 1
Beef cow, dairy cow, and feedlot inventory by herd size, December 31, 2017

	Beef Cows	Milk Cows	Feedlots
Inventory, head	31,722,039	9,539,631	15,025,052
Farms, n	729,046	54,599	25,776
Average herd size, head	44	175	582
	Cows by herd size, %		By herd size, %
1–9	3.52	0.41	
10–19	6.30	0.36	0.34[a]
20–49	17.34	3.27	1.33
50–99	16.94	8.65	2.34
100–199	17.82	9.35	3.48
200–499	20.84	12.00	6.86
500–999	9.26	10.73	8.44
1000–2499	5.18	20.32	6.48
2500–4999	1.50	18.53	70.72[b]
5000 or more	1.30	16.39	

[a] 1–19 head.
[b] 2500 or more head.
Data from USDA-NASS. 2017 Census of Agriculture United States Summary and State Data, Volume 1, Geographic Area Series, Part 51. AC-17-A-51, National Agricultural Statistics Service, April 2019.

feedlot inventories.[1] The movement of cattle from small herds of geographically widespread cow-calf production to large, geographically concentrated feedlots implies much assembly, sorting, commingling, and shipping of cattle. Thus, the stressors associated with BRD are an integral and inevitable component of beef cattle production.

Between the cow-calf and feedlot sectors, many cattle pass through stocker or backgrounding operations. These are often grazing-based postweaning growing programs, although they may be confined or semiconfined growing/backgrounding operations.[3] These operations add an additional layer of assembly, handling, commingling, sorting, and shipping that increase exposure to pathogens and stresses that increase BRD risk.

Compared with other sectors, there is little published information describing the size and location of stocker/backgrounding production. Cattle inventory estimates on January 1st allow the calculation of estimated feeder supplies outside of feedlots. This is the best estimate of stocker inventories on that date, but it also includes unweaned calves. Winter stockers are heavily concentrated on cool-season cereal forages and each year 25% to 30% of feeder cattle are located in the states of Kansas, Oklahoma, and Texas, based on the January 1st cattle inventory. Summer stockers are even less well documented but large concentrations are found regionally, including the Flint Hills and Osage regions of Kansas and Oklahoma.

In summary, the geographic concentration of cattle begins as calves move from dispersed cow-calf production to stocker/backgrounding production and is complete as animals are placed in feedlots for finishing. Cattle move through a complex marketing and transportation system that often involves movement through multiple auctions or other sale facilities. Moreover, many calves begin this process leaving primary cow-calf production unweaned and with naive and immature immune systems.

BOVINE RESPIRATORY DISEASE AND THE DAIRY INDUSTRY

The dairy industry is focused on milk production and much of the emphasis on BRD has been in replacement heifers.[4,5] Dairy calves are typically removed from cows shortly after birth and reared separately. Neonatal dairy calves are raised in separate hutches before commingling to grow in calf farms. Dairy steers often move into feeding facilities as lightweight calves and may finish on feed for a year before harvest. Dairy heifers are grown in heifer development facilities. More recently, the use of sexed semen and the production of more valuable beef-dairy crossbreed steer calves, increase the motivation to manage these calves for increased survivability.

IMPACTS OF BOVINE RESPIRATORY DISEASE

BRD affects all sectors of the cattle industry and all classes of animal to varying degrees. Some impacts are general across all classes and some are specific to certain animals/production sectors. The general list of BRD impacts includes

Feedlot/stocker (backgrounding):
- Mortality (value of death loss)
- Reduced weight gain
- Reduced feed efficiency
- Reduced salvage value of chronic animals
- Treatment costs
- Vaccination costs
- Metaphylaxis costs

Cow-calf (beef and dairy):
- Mortality (value of death loss, cows and preweaning calves)
- Reduced weaning weights
- Treatment costs (cows and calves)
- Reduced productivity (eg, milk production)
- Reduced pregnancy percentage (failure to breed or early embryonic death caused by bovine viral diarrhea virus [BVDV])
- Reduced calving percentage (abortion, stillborn, or perinatal mortality caused by BVDV)
- Vaccination costs

BOVINE RESPIRATORY DISEASE MORTALITY

Total nonpredator death loss in all cattle was reported by US Department of Agriculture (USDA) in 2017 at 3.21%.[6] This includes 2.17% death loss among cattle (>500 pounds) and 5.55% among calves. Death loss in cattle caused by respiratory disease accounted for 23.9% of nonpredator death loss or 0.52% of total nonpredator cattle death loss. Among calves, respiratory disease accounts for 26.9% of nonpredator death loss, which is 1.5% of total nonpredator calf death loss. The total value of nonpredator death loss in cattle and calves was reported at $3.69 billion, with $907.8 million, or 24.6%, because of respiratory disease.

Among beef cow operations, respiratory disease accounts for 15.9% of cattle death and 23.0% of calf death with a total value of $370.8 million.[6] Among feedlot and stocker/backgrounding operations, respiratory disease accounts for 55.0% of nonpredator death loss in cattle and 36.3% among calves with a total value of $274.84 million. (The USDA reports cattle operations as beef cattle, dairy cattle, mixed [beef and dairy] and other. Data reported here are for "other," which includes primarily stocker and feedlot operations[6]). In dairy operations, respiratory disease accounts for 16.0% of nonpredator cattle death loss and 32.7% of calf losses with a total value of $197.89 million.

BOVINE RESPIRATORY DISEASE MORBIDITY AND TREATMENT

Respiratory disease is reported to affect 16.2% of all feedlot cattle with 96.9% of feedlots reporting incidence of respiratory disease (100% of large feedlots).[7] All feedlots (100%) reported treating cattle affected with respiratory disease with 87.5% of affected cattle receiving treatment. Most common treatments for respiratory disease include injectable antibiotic (100% of cattle treatments) and respiratory vaccination (48.5%), with other treatments given less frequently. Over all feedlot cattle, 13.4% receive an injectable antibiotic, and 6.5% receive a respiratory vaccine. Average BRD treatment cost was reported at $23.60/head for treated cattle, indicating that feedlots were spending in excess of $75 million annually on BRD treatments at the time of this study. The cost of respiratory treatment has nearly doubled between 1999 and 2011 (from $12.59 to $23.60 per case) suggesting that the direct cost is higher today.[7]

Among feedlot cattle treated for respiratory disease, 81.7% of those placed weighing less than 700 pounds responded, with 14.9% retreated, 4.0% mortality, and 2.3% marketed as chronics.[7] Of those cattle placed weighing less than 700 pounds and treated a second time, 63.1% responded, with 12.0% treated a third time, 13.3% mortality, and 6.1% marketed as chronics. For cattle placed weighing more than 700 pounds, 86.5% responded, 12.4% were retreated, 3.6% mortality, and 1.9% marketed as chronics. Among cattle placed weighing more than 700 pounds and treated

a second time, 69.5% responded, with 17.1% treated a third time, 13.2% mortality, and 8.2% marketed as chronics.

The stocker/backgrounding sector likely experiences BRD impact similar to feedlots, although little data are available. In fact, it is possible that stocker morbidity caused by BRD is higher than for feedlots because weaning and other processes associated with movement into stocker or feedlot production lead to substantial stress.

There is little information on BRD in cow-calf production. The 2007 to 2008 NAHMS beef cow-calf report indicates that of 1.5% of breeding animal death loss, just 3.4% of breeding cattle mortality, or 0.05% of total death loss, was attributable to BRD, indicating that respiratory morbidity is low among mature animals.[8] However, the same report indicated of the 3.6% of preweaning calf mortality, 31.4% of mortality among calves older than 3 weeks of age was caused by respiratory disease.

Respiratory disease was reported by 60.5% of dairy operations, affecting 2.8% of dairy cows.[9] Of cows affected by BRD, 62.0% remained in the herd, whereas 27.5% were permanently removed and another 10.5% died. Most of these cows likely received some treatment. Dairy cows are permanently removed from the herd generally as a result of a serious health issue and/or low production. Respiratory disease accounts for 24.0% of mortality in preweaned dairy heifers and 58.9% of weaned dairy heifer mortality.

LOST PRODUCTIVITY CAUSED BY BOVINE RESPIRATORY DISEASE

The costs of BRD include a wide variety of negative impacts on productivity. Animals lose productivity during active BRD infections and, in many cases, those that survive have compromised productivity for the remainder of their lives.

Feedlot and stocker cattle that have BRD experience reduced gains, reduced feed efficiency, and degraded carcass quality. The impacts of BRD on productivity are not well measured because BRD animals are averaged into pen level data at feedlots. An extreme example from a commercial feedlot illustrates the likely impacts of BRD on feedlot production. Production parameters from a “wreck” pen are compared with average metrics for similar cattle.[10] The wreck pen had 37.04% death loss (2.05% average), 7.66% sick head days (0.7% average), 0.66 pounds/day average daily gain (3.78 average daily gain average), 221 days on feed (166 days average), and a feed/gain ratio of 27.48 (5.88 average). It is likely, although unconfirmed, that the example wreck pen was primarily impacted by respiratory disease. Chronic animals represent about 2.1% of feedlot animals treated for respiratory disease that never recover to perform well. These animals are marketed for minimal salvage value.

BRD has a variety of impacts on beef cow-calf productivity. In addition to mortality, calves that survive summer pneumonia typically have reduced weaning weights. BVDV, one component of the BRD complex, results in unique impacts on cow-calf production and in all other cattle production sectors.

THE UNIQUE ROLE OF BOVINE VIRAL DIARRHEA VIRUS

BVDV is an immunosuppressive agent that significantly increases the likelihood of concurrent or subsequent viral and bacterial infections. BVDV has two other unique characteristics: it causes reproductive disease in cows, and it results in persistently infected (PI) animals. Cows can acquire BVDV infections that lead to inapparent or mild signs. However, these infections can cause various reproductive problems that result in lower calving rates. Calves may be born with congenital deformities, or weak, leading to neonatal or preweaning mortality. Cows infected with BVDV during

the first trimester of gestation may produce calves that are PI. These calves may seem normal or may be weak or deformed. Many die before weaning but some survive, and may be marketed as feeder or breeding cattle, or be retained in the herd for breeding. Although these PI animals may never develop signs of disease, they constantly shed BVDV and expose all other animals as long as they remain in the herd. PI cows always give birth to PI calves. PI calves that enter the feeder cattle supply expose all cattle with direct or fence line contact. These PI animals are a reservoir of BVDV that spreads across the entire cattle industry through marketing facilities, transportation systems, and in stocker and feedlot operations.

BRD would still occur in the absence of BVDV. It is not known how much controlling or eliminating BVDV would reduce BRD impacts in the cattle industry. However, BVDV is deserving of particular attention because PI cattle clearly represent a known reservoir of a pathogen that impacts the industry, and the source of PI calves is at the cow-calf level. Better control or elimination of BVDV must necessarily be directed at the cow-calf sector.

BOVINE RESPIRATORY DISEASE PREVENTION

Vaccines are available to help prepare cattle for the challenge of BRD. However, among beef cattle operations, 60.6% do not vaccinate calves for respiratory disease. Small herds (<50 cows) were least likely to vaccinate for BRD with 73.7% of operations not vaccinating.[8] Among herds of 200 or more cows, only 18.0% gave no BRD vaccinations. Overall, 69.1% of calves are vaccinated for BRD, which means that 30.9% are not vaccinated. Among small herds, 63.9% of calves received no BRD vaccinations, in contrast to herds with more than 200 cows, in which just 11.9% received no BRD vaccination. Roughly 25% of beef cow operations vaccinate cows for each of the common BRD viruses (infectious bovine rhinotracheitis virus [IBRV], 24.6%; BVDV, 28.1%; parainfluenza type-3 virus [PI3V], 22.6%; bovine respiratory syncytial virus [BRSV], 21.1%). However only 7.9% of operations vaccinate for *Histophilus somni* and 4.5% vaccinate for *Pasteurella/Mannheimia*.

More than 85% of all feedlot operations vaccinate for the major viral respiratory viruses (IBRV, BVDV, PI3V, and BRSV), with more than 90% vaccinating for IBRV and BVDV.[7] Thus, more than 90% of feedlot cattle receive some respiratory vaccinations. However, fewer cattle receive other respiratory vaccinations: only 61.4% of cattle receive BRSV vaccination, and only 55.1% receive PI3V vaccination. Some 60% to 70% of all feedlot operations vaccinate for some bacterial pathogens.

Feedlots can also use metaphylaxis to prevent respiratory disease. Metaphylaxis, or mass medication of incoming feedlot cattle, is a costly practice and is only applied under certain conditions and with specific managerial consideration. Overall, 59.3% of feedlot operations use metaphylaxis on any cattle; with 59.3% of operations using metaphylaxis on 39.2% of cattle weighing less than 700 pounds on arrival and 29.6% of operations using metaphylaxis on 5.2% of all cattle weighing more than 700 pounds on arrival.[7]

In dairy operations, more operations vaccinate cows than pregnant heifers or preweaned heifers for respiratory disease. Some 55% to nearly 70% of dairy operations vaccinated cows for various viral pathogens, with the highest at 68% of operations vaccinating for BVDV.[9] The percent of operations vaccinating is lower for IBRV (60.2%), PI3V (55.8%), and BRSV (54.8%). Less than 10% of dairy operations vaccinate for bacterial pathogens, such as *Histophilus* and *Mannheimia*. The levels of vaccination is lower for pregnant heifers, with roughly 45% to 50% of operations using viral vaccines, and lower still for preweaned heifers, with about 20% to 35% of operations using viral vaccines.

In general, vaccines for viral respiratory pathogens are more widely used than those for bacterial pathogens. Efficacy of vaccines for bacterial respiratory pathogens (*Pasteurella*, *Mannheimia*, *Histophilus*, and *Mycoplasma*) is lower and this is likely the reason that these vaccines are less widely used in beef cow-calf, feedlot, and dairy operations.[11]

THE ECONOMICS OF BOVINE RESPIRATORY DISEASE CONTROL

BRD is clearly a huge challenge in the beef and dairy industries with large economic impact on all sectors. The cost of BRD has led to significant research by public and private sectors and vast private sector development and marketing of technologies for detection, prevention, and treatment of BRD. Despite continued improvement and effectiveness of vaccines and other technologies, BRD persists as the most economically significant disease affecting the cattle industry. In fact, BRD may be getting worse instead of better. **Fig. 1** shows feedlot death loss (12-month moving average) as reported from monthly surveys of Kansas feedlots. Death loss has generally trended up over the data period from 1994 to present. Although the specific contribution of BRD to this trend is uncertain, it is believed to be a significant component.

Industry participants and animal health professionals are increasingly frustrated by the inability to make significant progress in reducing the impact of BRD. This situation raises the question of whether limitations or factors that extend beyond animal health, narrowly focused, contribute to the failure to make progress in controlling BRD. The following sections discuss several considerations that may be important to enhanced control of BRD.

IMPROVED BOVINE RESPIRATORY DISEASE AWARENESS

As noted previously, 60.9% of all cow-calf operations gave zero vaccinations for respiratory disease, including 73.7% of small operations. Failure to be aware of the disease or failure to understand the impact of BRD is surely part of the problem. For cow-calf producers, the direct impacts may be unrecognized or underrecognized.

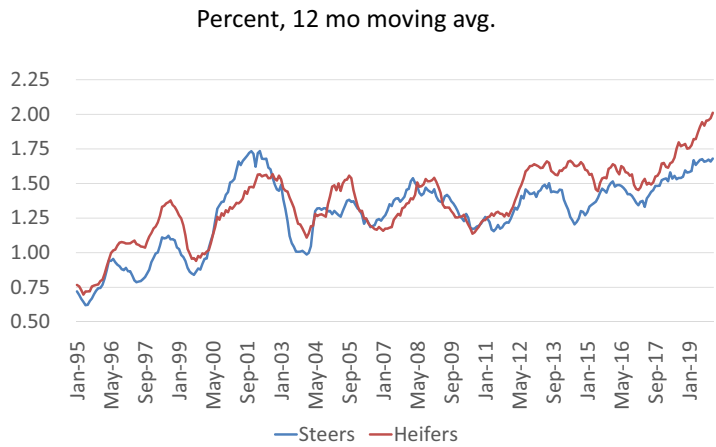

Fig. 1. Feedlot death loss. (*Data from* Focus on Feedlots Monthly Reports. Kansas State University Animal Sciences and Industry Website. https://www.asi.k-state.edu/about/newsletters/focus-on-feedlots/monthly-reports.html. Updated March 5, 2020. Accessed March 16, 2020.)

Producers who experience an outbreak of summer pneumonia perhaps become more aware, but operations that experience, for example, low levels of BVDV infections may fail to notice the reductions in reproductive productivity that occur. USDA surveys showed that although 64% of cow-calf producers were fairly knowledgeable or knew some basics about BVDV, 36% either had not heard of it or had heard the name but knew nothing about the disease.[12]

Stocker and feedlot operations are keenly aware of the impacts of BRD. Frustration is high and mounting because, despite better (and more expensive) pharmaceuticals, cattle morbidity and mortality continues. Although the problems are well recognized among stocker and feedlot producers, it is possible that there is only now a growing recognition that the problems are coming to them from the cow-calf level. It has long been recognized that the stressors involved in weaning and shipping cattle trigger respiratory disease (ie, shipping fever), but there is growing recognition that the calf health situation before weaning determines much of the impact later.

The evolution of preconditioning programs illustrates this changing sentiment. Originally, many preconditioning programs started as VAC-30 or VAC-35 programs, which meant that the preconditioning protocol included weaning calves a minimum of 30 or 35 days. Within a few years most programs changed to VAC-45 protocols, requiring a minimum of 45 days of weaning along with vaccinations and other management. Although most programs still require the 45-day weaning protocol, feeder cattle buyers are increasingly emphasizing longer weaning periods and buyers are paying additional premiums for 60 to 90 days of weaning.

The dairy sector is more aware of BRD because the focus of the industry is the growth of heifers into milk-producing cows. However, smaller percentages of dairy operations vaccinate pregnant heifers for respiratory disease and fewer still vaccinate preweaned heifers. Only 20% to 35% of preweaned heifers are vaccinated for viral respiratory pathogen and less than 5% of operations vaccinate for *Histophilus* and *Mannheimia*.[9]

Continued and enhanced education is clearly a vital component of any strategy to better control BRD. Until producers at all levels recognize and understand the impacts of BRD, make better use of the pharmaceutical technology, and make some changes in management, progress in controlling BRD will be slow. Among beef cow-calf producers and dairies, in particular, smaller operations tend to be less aware of BRD and its impacts, and generally vaccinate less. Lack of awareness is less the case for feedlots where the differences in vaccine use between small and large operations is less pronounced. However, smaller feedlots are less likely to use metaphylaxis than larger feedlots.[7]

Producers at all levels of the industry use animal health inputs (eg, vaccines, treatments, testing), like any other input into production, so long as expected returns exceed the cost of the input. However, the complex production structure of the industry increases the difficulty of recognizing and understanding the impacts of BRD as animals move through multiple production stages with different ownership. Additionally, the complexity of the disease makes it extremely challenging to evaluate the costs and benefits of BRD control on an individual level. Moreover, awareness and understanding of the disease and the impacts on an individual level may not be enough.

A COMPREHENSIVE APPROACH IS NEEDED

Historically, most BRD control has been focused on individual production sectors. In particular, stocker and feedlot operations, which face the most BRD impacts and costs, have attempted to deal with BRD as best they can with the animals that

come to them. There is little communication across sectors, and even fewer attempts to coordinate animal health management comprehensively in the industry. Feedlots routinely maintain records of sources of cattle and, in many cases, are aware of the health history of those sources. That information is often reflected in prices paid, which does send information back to the producer, but the information is more likely used to plan treatment and management of the cattle. Initiatives, such as certified preconditioning programs, have had a positive impact but have limited adoption across the industry.[13] The growing emphasis on long-weaned calves noted previously provides incentives for cow-calf producers, but is not widely recognized or adopted at this time. In general, the cattle industry has focused more on treatment instead of immunity and prevention of BRD. An industry-wide shift to focus more on immunity and prevention implies education; improved communication; more coordination; and, critically, improved economic signals across industry sectors to improve incentives for changing health and management practices.

Quantifying the costs of BRD and the benefits of enhanced control is a challenge. The figure of $800 to $900 million annually caused by feedlot mortality, reduced feed efficiency, and treatment cost from Chirase and Greene[14] has been widely quoted. A wide range of estimates have been offered for various aspects of BRD including mortality, treatment cost, reduced productivity, and reduced value of chronics. Most of the estimates have focused on feedlot production. Brooks and colleagues[15] also looked at the impact of BRD on backgrounding heifers. Little information is available on the cost of BRD at the cow-calf level, although Hurt[16] did provide estimates of the value of BVDV control for cow-calf producers. The impact of BRD in the dairy industry is similarly difficult to estimate and is likely underestimated.

THE ECONOMICS OF DISEASE CONTROL

Despite the difficulties in comprehensively quantifying the costs of BRD, the value to the industry of improving BRD control probably exceeds the cost of improved control. This situation leads to the question of why the industry is underinvesting in BRD control. The answer is most likely because of economics rather than animal health limitations. Markets are efficient when individual participants make decisions for their own interest that ultimately results in a socially optimal allocation of resources. If all producers in cattle and dairy industries had the correct incentives to control BRD at an optimal level, the entire industry would be better off. The use of the word “optimal” highlights that striving for 100% control or eradication is probably not economic even if it were achievable.

There are several reasons why markets may not be efficient. One has already been discussed: when producers do not fully understand BRD and its impacts, and thus do not use optimal levels of disease detection, prevention and/or treatment. In this situation, producers can make themselves better off by reducing the direct impacts of the disease with additional investment in health technology and/or management. Enhanced education to improve BRD awareness and adoption of detection, prevention, and treatment technology may be beneficial.

The more challenging economic problem is market failure. Market failure occurs when the full costs and/or benefits are not recognized by the decision-maker and the resulting decision is not socially optimal. Although markets are generally efficient, market failure can occur in several ways. For example, the broader public value of education likely exceeds the value that individuals realize from better education, and thus results in a suboptimal level of investment in education. This example is the argument for public support of education. In another example, a manufacturing firm that is able

to dump wastes into air or water will not take the negative social costs of pollution into account and would thus produce more of a product than is socially optimal. With market failure, individual firms make entirely economical decisions based on the costs and benefits they realize, and yet the overall outcome to society is suboptimal, and results in an incorrect allocation of resources.

In the case of BRD, the stocker and feedlot sectors experience most of the treatment costs, lost productivity, and death loss from the disease and would benefit the most from enhanced BRD control. However, evidence is growing that the health of stocker and feedlot cattle is largely determined at the cow-calf level, who currently receive little economic incentive to manage cattle for better lifetime health and immunity. This market failure results in less than optimal efforts and investment in BRD control in the cattle industry. Riley and colleagues[17] discuss market failure in the context of BVDV control. Johnson and Pendell[18] note that improved BRD control would have short-run market impacts because of changing the supply of cattle and beef with reduced BRD morbidity and mortality.

Research on fetal (developmental) programming suggests that nutrition and management of the cow in gestation is a principal determinant of lifetime productivity and health of the calf, whether for feedlot finishing or replacement heifers.[19] At birth, the health of the calf is greatly influenced by the availability of colostrum and the passive immunity it provides. The incidence of BVDV in the herd may determine whether the calf is PI or exposed, which increase the probability of disease. Appropriate vaccinations at the proper time, good calf management, and low-stress weaning all impact health in the stocker and feedlot phases. One example is castration of bulls. Despite that bull calves are discounted, many bull calves are still marketed. These feeder bulls will suffer productivity losses because of later castration and are three times more likely to get BRD in the feedlot.[20]

The beef industry will benefit from more emphasis on immunity and keeping cattle healthy than from better treatment technology for management of sick cattle. The cow-calf sector is key to this, but currently have no incentive to enhance efforts to ensure healthy, immune calves leaving the ranch. It will require some way to realign the benefits and costs of enhanced BRD control to see significant progress. The complex, multisector structure of the cattle industry means that stresses that contribute to BRD cannot be eliminated but they can be managed and minimized. Weather and other environmental factors cannot be controlled, they can only be managed for or around to a limited degree.

However, one of the biggest factors impacting BRD is simply that too little is known about calves that arrive at auction or the feedlot. Visual appraisal and the limited information that passes from sellers to buyers is insufficient to reveal the true health status (and therefore the value) of calves when ownership is transferred from cow-calf to stocker or feedlot. The buyer would have to know the answer to a long list of questions to properly value calves and provide better incentives to the cow-calf producers. The list of questions includes

- Did the dam receive adequate and proper nutrition during gestation?
- Was the dam properly vaccinated and not exposed to disease during gestation?
- Did the calf receive ample, high-quality colostrum after birth?
- Is the calf persistently infected with BVDV?
- Was the calf exposed to BVDV after birth?
- Did the calf have BRD (summer pneumonia) before weaning?
- Was the calf properly managed before weaning (eg, castration, dehorning, worming)?

- Did the calf receive appropriate vaccinations in the correct amount and at the proper time?
- Was the calf weaned (low stress) for at least 45 days before marketing?

At the current time, cow-calf producers likely do not know the answer to some of these questions, in part because they do not currently have any incentive to know those answers.

The challenge of increasing cattle health and immunity to prevent BRD rather than focusing on treatment likely requires an increased emphasis on health management at the cow-calf level. This in turn implies that the industry must consider economic mechanisms to realign costs and benefits to provide additional incentives for cow-calf producers to provide healthier calves for the rest of the industry. This might involve industry-designed and managed programs to provide incentives in the form of premiums for adoption of desired health practices, or indemnity to test for and eliminate PI BVDV animals and so forth. It could also be accomplished as a government-administered program of testing, vaccination, and eradication similar to brucellosis or tuberculosis programs.

SUMMARY

BRD continues to be a persistent negative economic impact on the beef and dairy industries, and the inability to show any progress in controlling BRD is a source of increasing frustration among animal health professionals and producers. Although there is a continuing need for more and better animal health testing, prevention, and treatment technology, the challenges of enhancing BRD control likely extend beyond veterinary science. The complex economic structure of the cattle industry leads to market failures in which producers, particularly at the cow-calf level, do not have sufficient economic incentive to invest in better BRD control, which leads to higher costs for stocker and feedlot sectors. An industry-wide comprehensive effort is needed to coordinate and motivate enhanced BRD control focusing on producing calves with better immunity and less morbidity rather than treatment.

DISCLOSURE

No disclosure or conflict of interest.

REFERENCES

1. USDA-NASS. Cattle. National Agricultural Statistics Service; 2020. Available at: https://downloads.usda.library.cornell.edu/usda-esmis/files/h702q636h/rb68xv24k/76537h73d/catl0120.pdf.
2. USDA-NASS. 2017 Census of agriculture United States summary and state data, Vol. 1, Geographic area series, Part 51. AC-17-A-51. National Agricultural Statistics Service; 2019. Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1.pdf.
3. Peel DS. Beef cattle growing and backgrounding programs. Vet Clin North Am Food Anim Pract 2003;19:365–85.
4. Jenny BF, Gramling GE, Glaze TM. Management factors associated with calf mortality in South Carolina dairy herds. J Dairy Sci 1981;64:2284–9.
5. Wells SJ, Dargatz DA, Ott SL. Factors associated with mortality to 21 days of life in dairy heifers in the United States. Prev Vet Med 1996;29:9–19.
6. USDA. Death loss in U.S. cattle and calves due to predator and nonpredator causes, 2015. USDA-APHIS-VS-CEAH-NAHMS; 2017. Available at:

https://www.aphis.usda.gov/animal_health/nahms/general/downloads/cattle_calves_deathloss_2015.pdf.
7. USDA. Feedlot 2011 Part IV: health and health management on U.S. feedlots with a capacity of 1,000 or more head. USDA-APHIS-VS-CEAH-NAHMS; 2013. Available at: https://www.aphis.usda.gov/animal_health/nahms/feedlot/downloads/feedlot2011/Feed11_dr_PartIV_1.pdf.
8. USDA. Beef 2007-08 Part IV: reference of beef cow-calf management practices in the United States, 2007-08. USDA-APHIS-VS-CEAH-NAHMS; 2010. Available at: https://www.aphis.usda.gov/animal_health/nahms/beefcowcalf/downloads/beef0708/Beef0708_dr_PartIV_1.pdf.
9. USDA. Dairy 2014 health and management practices on U.S. dairy operations, 2014. USDA-APHIS-VS-CEAH-NAHMS; 2018. Report 3. Available at: https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy14/Dairy14_dr_PartIII.pdf.
10. Stehle A, Peel DS, Riley JM. A profile of cattle feeding: beyond the averages. West Econ Forum 2018;16-2:62–77.
11. Larsen RL, Step DL. Step. Evidence-based effectiveness of vaccination against *Mannheimia haemolitica*, *Pasteurella multocida* and *Histophilis somni* in feedlot cattle for mitigating the incidence and effect of bovine respiratory disease complex. Vet Clin North Am Food Anim Pract 2012;28:97–106.
12. USDA. Beef 2007-08 Part II: reference of beef cow-calf management practices in the United States, 2007-08. USDA-APHIS-VS-CEAH-NAHMS; 2009. Available at: https://www.aphis.usda.gov/animal_health/nahms/beefcowcalf/downloads/beef0708/Beef0708_dr_PartII_1.pdf.
13. Williams GS, Raper KC, DeVuyst EA, et al. Determinants of price differentials in Oklahoma value-added feeder cattle auctions. J Ag & Res Econ 2012;37-1:115–28.
14. Chirase, NK, LW Greene. Dietary zinc and manganese administered from the fetal stage onward affect immune response of transit stressed and virus infected offspring steer calves. Anim Sci Feed Tech 2001;93:217.
15. Brooks KR, Raper KC, Ward CE, et al. Economic effects of bovine respiratory disease on feedlot cattle during backgrounding and finishing phases. The Professional Animal Scientist 2011;27(27):195–203.
16. Hurt C. Market failure in disease control: bovine viral diarrhea virus (BVDV) and the economic feasibility of enhanced control in the beef cattle industry. Unpublished M.S. Thesis, Dept of Ag Econ, Oklahoma State Univ; 2018. Available at: https://shareok.org/bitstream/handle/11244/317801/Hurt_okstate_0664M_15723.pdf?sequence=1&isAllowed=y.
17. Riley JM, Peel DS, Raper KC, et al. Economic consequences of cow-calf disease mismanagement: bovine viral diarrhea virus. Appl Anim Sci 2019;35(6). https://doi.org/10.15232/aas.2019-01861.
18. Johnson KK, Pendell DL. Market impacts of reducing the prevalence of bovine respiratory disease in United States beef cattle feedlots. Front Vet Sci 2017;4:189.
19. Summers AF, Funston RN. Fetal programming: implications for beef cattle production. Range Beef Cow Symposium. 2013. Available at: http://digitalcommons.unl.edu/rangebeefcowsymp/319. Accessed April 16, 2020.
20. Richeson JT, Pinedo PJ, Kegley EB, et al. Association of hematologic variables and castration status at the time of arrival at a research facility with the risk of bovine respiratory disease in beef calves. J Am Vet Med Assoc 2013;243(7):1035–41.