Use of decision analysis to evaluate the delivery method of veterinary health care on dairy farms as measured by correction of left displaced abomasum

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Objective—To use decision and sensitivity analysis to examine the delivery of health care on US dairy farms as measured by correction of left displaced abomasum (LDA).

Sample Population—5 journal articles evaluating outcomes from veterinarian- or herd personnel–delivered correction of LDA via laparotomy or a roll-and-toggle procedure.

Design—Economic analysis.

Procedures—A decision tree was constructed on the basis of published outcome data for correction of LDAs performed by veterinarians and herd personnel. Sensitivity of the model to changing input assumptions was evaluated via an indifference curve and tornado graph.

Results—Decision tree analysis revealed that correction of an LDA provided by herd personnel had an expected economic advantage of $76, compared with correction provided by a veterinarian. Sensitivity of this analysis to variations in inputs indicated that changes of 2 input levels would shift the advantage to veterinarian-provided correction: a reduction (from 0.74 to 0.62) in the probability of success for correction provided by herd personnel or an increase (from 0.78 to 0.87) in the probability of success for correction provided by a veterinarian.

Conclusions and Clinical Relevance—In this model, LDA correction by herd personnel had a significant economic advantage, compared with veterinarian-provided correction. Continued absorption of traditional veterinary tasks by unlicensed herd personnel may threaten the veterinarian-client-patient relationship (VCPR), which could have profound economic and regulatory impacts. Food animal veterinarians need to evaluate their business model to ensure they continue to provide relevant, sustainable services to their clients within the context of a valid VCPR. (*J Am Vet Med Assoc* 2011;238:60–65)

One of the challenges for veterinarians serving the food animal industries is to enhance value for producers whose profit margins have been under considerable economic pressure for the past half century. Decreasing profit margins and relative animal value have limited the scope of cost-effective interventions veterinarians can provide for producers that are also profitable for the veterinarians. In response to these economic forces, larger farms employ unlicensed, full-time health-care providers to deliver many services previously provided by licensed veterinarians. The common endemic nature of diseases on dairy farms likely contributes to this trend because common conditions are amenable to prescriptive diagnosis and treatments. Although the incidence of disease conditions is similar on farms of various sizes,[1] larger farms manage more cows. Therefore, a similar disease incidence provides dairy producers on larger farms more exposure to an absolute number of routine disease conditions. Conversely, smaller farms lack the number of affected cattle to successfully train and employ a dedicated health-care

Abbreviations

ACVS	American College of Veterinary Surgeons
CostHP	Cost of herd personnel–provided intervention
CostV	Cost of veterinarian-provided intervention
CVT	Credentialed veterinary technician
LDA	Left displaced abomasum
ProbHP	Probability of a successful outcome with herd personnel–provided service
ProbV	Probability of a successful outcome with veterinarian-provided service
R&T	Roll-and-toggle
VCPR	Veterinarian-client-patient relationship
Vf	Value of a dairy cow after a favorable outcome
Vu	Value of a dairy cow after an unfavorable outcome

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provider for their herds. This places smaller farms at an economic disadvantage and may be one of the factors that favor the consolidation of food animal production into larger production units.

Correction of an LDA is the most common surgical procedure in dairy cattle.[2] Numerous techniques have been described for the correction of this condition, including medical management, abomasopexy or omentopexy via laparotomy or laparoscopy, and percutaneous abomasopexy (such as the R&T procedure).[2] Originally used as a salvage procedure, the R&T technique for correction of LDAs has been found to have outcomes similar to those for laparotomy or laparoscopy.[3,4] The simplicity of the R&T procedure has enabled correction by on-farm health-care providers in place of surgical correction by licensed veterinarians in an attempt to reduce cost of correction.

Survival outcomes after LDA correction provided by veterinarians and LDA correction provided by herd personnel have been compared.[4] In that study,[4] veterinarians used the R&T method or laparotomy. The 60-day postintervention survival rate was 79% and 73% for veterinarian-provided R&T and laparotomy interventions, respectively. All LDA corrections performed by herd personnel were via the R&T method, with a 60-day postintervention survival rate of 71%, which was similar to the rate for veterinarian-provided corrections via the R&T procedure. A similar survival rate (76.6%) at 70 days of lactation was reported for herd personnel performing the R&T procedure.[5] In other studies,[6–8] survival data for LDA corrections performed by veterinarians via the R&T procedure ranged from 52% to 92%. Given the variation possible in outcome reported for correction via the R&T procedure, producers need to make informed decisions on whether to have herd personnel perform the procedure on the farm or to have a veterinarian perform this procedure. Veterinarians need to determine whether they should offer this procedure to producers or, instead, should train and oversee herd personnel to perform this procedure.

Decision analysis is a common technique used in business and medical practice to examine a range of outcomes that have associated probabilities of occurrence. The construction and use of a decision tree in veterinary medicine have been described elsewhere.[9–11] Decision analysis has been used in food supply veterinary medicine to determine whether treatment or salvage has greater economic value[10] as well as to identify the treatment with the best economic outcome.[11,12]

Briefly, a decision tree is constructed of decision nodes (represented as squares) and chance nodes (represented as circles) that follow mutually exclusive decision choice paths and associated probability attributes. The decision nodes represent points at which a veterinarian or producer makes a decision about who will be involved in the treatment of the animal. The chance nodes represent the probability of each outcome along with its associated cost. The expected value of each decision is calculated by weighting the value of each outcome by its expected probability and summing the branches within the same chance node. The resulting values are compared for each alternative, and choosing the branch with the highest value will maximize economic return over a series of choices. In the study reported here, we used decision analysis to evaluate the economic outcomes for health-care services provided by a licensed veterinarian or herd personnel as measured by comparison of outcomes for correction of an LDA.

Materials and Methods

Sample population—Data on outcomes after correction of an LDA were obtained from 5 journal articles evaluating outcomes from veterinarian- or herd personnel–delivered correction of LDA via laparotomy or an R&T procedure.[4–8]

Decision tree—A decision tree was constructed for correction of an LDA provided by a licensed veterinarian or by on-farm herd personnel. The economic decision tree was constructed by use of the mean survival data (78% and 74% for veterinarians and herd personnel, respectively) for published studies.[4–8]

Several assumptions were used in constructing the decision tree:

- Two mutually exclusive interventions were possible, each with associated costs (one for veterinarian-provided correction [CostV] and one for herd personnel–provided correction [CostHP]).
- Each LDA had 2 exhaustive and mutually exclusive outcomes (favorable [Vf] and unfavorable [Vu]). The Vf outcome was assigned the value of a typical healthy dairy cow. The Vu outcome was assigned the expected value of a dairy cow culled from the herd.
- Each intervention had a probability of a favorable outcome (one for veterinarian-provided correction [ProbV] and one for herd personnel–provided correction [ProbHP]). The likelihood of an unfavorable outcome for veterinarian-provided correction and herd personnel–provided correction was 1 – ProbV and 1 – ProbHP, respectively.

The CostV for veterinary intervention for an LDA corrected via the R&T procedure was assigned a value of $137 on the basis of a survey of veterinarians conducted through the American Association of Bovine Practitioners listserv (n = 13 respondents) by one of the authors (DWR). The CostHP for correction of an LDA by herd personnel was assigned a value of $25 on the basis of hourly wages of herd managers obtained from the 2000 Dairy Wage Survey[13] (adjusted to 2009 dollars to account for inflation) and associated supply costs. The assigned value for Vf was $1,500, whereas the assigned value for Vu was $600. The assigned value for ProbV (0.78) was determined from values reported in other studies,[4,6–8] and the assigned value for ProbHP (0.74) was determined from values reported in 2 studies.[4,5]

Sensitivity analysis—Sensitivity analysis was performed to examine the effects of changes in cost, probability, and cow value on outcome. A graphic method that enables researchers or clinicians to quickly choose between 2 alternatives is to use the inputs from a decision tree to define an indifference curve. We used the fundamental structure described in another study.[11] The curve was defined as all of the combinations of (Vf – Vu) and (ProbV – ProbHP) at a cost of (CostV – CostHP). By use of this curve, various scenarios of differences in expected value (Vf – Vu) and probability of success (ProbV – ProbHP) were plotted. When the point is located above and to the right of the indifference curve, the more expensive intervention is more appropriate. When the point is located below and to the left of the indifference curve, the less expensive intervention is the more profitable option. When the point is located directly on the curve, the economic value is equivocal and factors other than economics can be used to determine the intervention.

A tornado graph is a multidimensional sensitivity analysis that graphically illustrates the changes in output value relative to independent changes in inputs. The vertical axis lists model inputs, and the horizontal axis depicts changes in the difference between economic outcomes of the 2 choices. For the study reported here, the difference between economic outcomes of the 2 interventions was calculated as the expected value for herd personnel–corrected LDA minus the expected value for veterinarian-corrected LDA. Thus, as the value for each input moved farther to the right, the expected economic value for herd personnel–provided correction of an LDA via the R&T procedure increased relative to the expected economic value for the veterinarian-provided correction. Similarly, as the value for each input moved toward the left, the expected economic value for herd personnel–provided correction of an LDA via the R&T procedure decreased relative to the expected economic value for the veterinarian-provided correction.

Upper and lower limits for all input values were determined. Minimum and maximum values for CostV ($35 and $171, respectively) were obtained from the survey of veterinarians conducted through the American Association of Bovine Practitioners listserv (n = 13 respondents) by one of the authors (DWR). Similarly, inflation-adjusted wages based on data obtained from the USA Dairy Wage Survey[13] were used to establish the minimum and maximum values for CostHP ($15 and $60, respectively). The lower and upper limits for Vf were $900 and $3,000, respectively, on the basis of the value for which a lactating commercial dairy cow would be sold. Value of cull cows described the range for Vu; death of a cow was assigned the minimum cull value ($0), and sale of a cow for beef purposes was assigned the maximum cull value ($900).

Minimum and maximum values for ProbV (0.61 and 0.87, respectively) and ProbHP (0.62 and 0.88, respectively) were determined from results of another study.[4]

Results

On the basis of the initial mean inputs and assumptions, correction of an LDA by herd personnel had an economic advantage of $76, compared with correction by a veterinarian **(Figure 1)**. When the difference in cost (CostV – CostHP) remained the same ($112) but the expected ProbHP decreased to 0.66, the value for correction of an LDA by herd personnel shifted to a point above and to the right of the original indifference curve, which indicated an expected economic advantage for veterinarian-provided correction of an LDA.

Assumptions regarding the indifference curve could also be changed. An increase to $60 for CostHP (ie, CostV – CostHP = $135 – $60 = $75) shifted the curve down and to the left, which increased the area for which veterinarian-provided correction was expected to be most valuable **(Figure 2)**. The highest expected economic return at this cost difference (ie, $75) remained herd personnel–provided correction of an LDA. However, when a veterinarian could provide service at

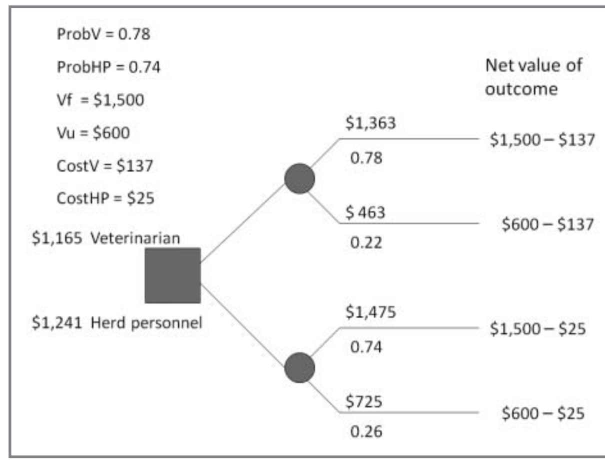

Figure 1—A decision tree for determining the most economical intervention for correction of an LDA in a US dairy cow. For these assumptions, CostV – CostHP = $112, which results in an expected advantage of $76 for correction of an LDA performed by herd personnel via an R&T procedure, compared with correction of an LDA performed by a veterinarian.

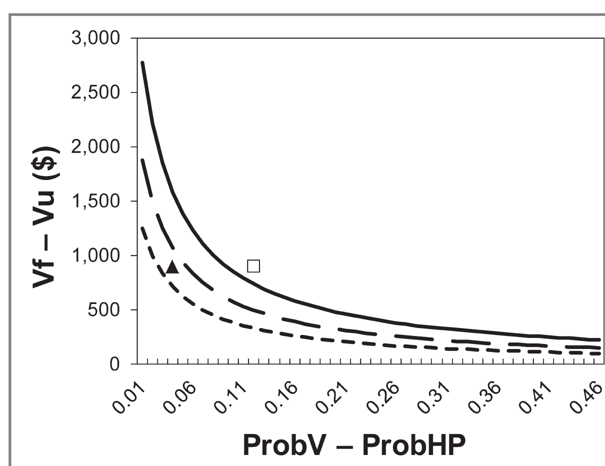

Figure 2—Graph depicting changes in various inputs regarding outcome for correction of an LDA in a US dairy cow. The value calculated by use of the assumptions from the decision tree in Figure 1 (black triangle) is located below the indifference curve calculated by use of assumptions in Figure 1 (ie, CostV – CostHP = $112 [solid line]), which indicates the inexpensive option (herd personnel–provided correction of an LDA) is preferred. Use of the same cost assumptions but a change in ProbV – ProbHP to 0.12 results in a value that is located to the right of the indifference curve (white square), which indicates that veterinarian-provided correction of an LDA is preferred. Two additional indifference curves represent changes in CostV – CostHP = $75 (long-dashed line) and CostV – CostHP = $50 (short-dashed line). Notice that for the indifference curve of CostV – CostHP = $50, the decision based on expected economic value always favors veterinarian-provided correction of an LDA.

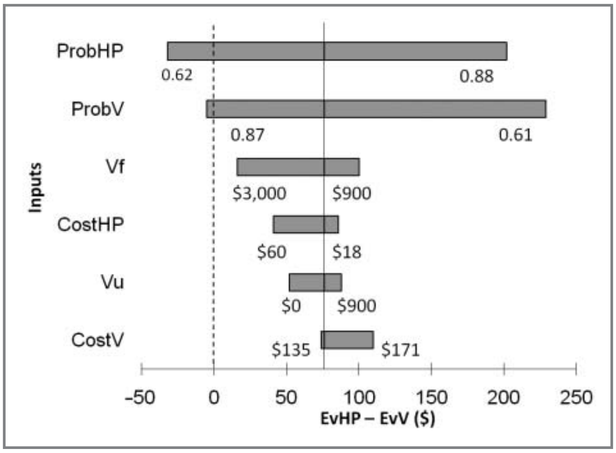

Figure 3—Tornado graph of the sensitivity analysis of alternative delivery methods for correction of an LDA via an R&T procedure in US dairy cattle. The bars represent the range of values for the inputs. The expected economic advantage for herd personnel–provided correction of an LDA, compared with veterinarian-provided correction of an LDA, was $76 (solid vertical line). Notice the point (vertical dashed line) and values at which the expected economic outcome is advantageous ($35 and $5 for ProbHP and ProbV, respectively) for veterinarian-provided correction of an LDA. EvHP = Expected value for herd personnel–provided correction of an LDA. EvV = Expected value for veterinarian-provided correction of an LDA.

a cost of $75 (CostV – CostHP = $75 – $25 = $50), the curve shifted down and to the left, and the value for correction of an LDA was located to the right of the curve, which indicated the best economic return was via veterinarian-provided correction.

Evaluation of the tornado graph indicated that on the basis of the range for inputs in this model, herd personnel–provided correction of an LDA via an R&T procedure continued to dominate veterinarian-provided LDA correction on an expected economic value basis (**Figure 3**). Only changes in 2 inputs (ProbHP and ProbV) shifted the outcome to a negative number that indicated an expected economic advantage for veterinarian-provided correction. Most influential was the probability of success for herd personnel–provided correction. When ProbHP decreased to 0.62, veterinarian-provided correction of an LDA via an R&T procedure had an expected value of –$32. Similarly, when ProbV increased to 0.87, the expected economic value for veterinarian-provided correction of an LDA via an R&T procedure was –$5. The range of the other inputs did not cross zero and therefore did not change the economic outcome.

Discussion

The transfer of veterinary technical duties to farm-based personnel may be a result of increasing exposure of herd personnel to affected animals because of the growing scale of US dairy farms. Although disease rates are similar among farms of various sizes,[1] herd personnel on large farms have a case-exposure level that enables them to quickly become competent in the delivery of treatment. For example, disease conditions (such as metritis, hypocalcemia, and mastitis) for which treatment requires less technically demanding skills have been quickly absorbed into herd personnel duties. On some larger farms, herd personnel are also providing correction of LDAs, most commonly via the R&T technique. Farm size is likely a determinant because of the number of cases needed to achieve competence.

Competence is achieved through a combination of supervision and repetition. In its 2009–2010 Residency Program Guidelines,[14] the ACVS required residents in training programs to perform a minimum of 52 abdominal surgeries, including 26 supervised surgeries. On a 1,000-cow US dairy farm with an industry-average incidence rate for LDA of 6%,[2] an interested herd manager could perform correction of 60 LDAs via the R&T procedures annually. The authors do not propose that herd personnel have the veterinary knowledge, surgical training, or experience that approaches that of a diplomate of the ACVS; however, the ACVS requires that 50 abdominal surgeries be performed during a 3-year training program to attain a minimum level of competence, and herd managers have the opportunity to perform the same number of specialized LDA correction procedures annually. Although the supervision of herd personnel during the training period is unlikely to be as extensive as that for veterinarians in a surgical residency training program, data from studies[4–8] included in our analysis support the ability of herd personnel to achieve a similar level of competence for use of the R&T procedure as can be attained by licensed veterinarians.

An alternative approach for use of CVTs as part of a veterinary health-care delivery team has been suggested.[15] Incorporation of CVTs into a veterinary health-care delivery team could allow veterinarians to provide service at competitive prices needed to shift the economic decision (ie, CostV – CostHP = $75; Figure 2). In some states, CVTs are used as part of veterinary health-care delivery teams to administer injections, collect feed samples, assess body condition score, and monitor outcomes for herd health programs. Additionally, CVTs could perform disbudding-dehorning services, dystocia assistance, venipuncture for metabolic or pregnancy testing, hoof trimming, necropsy services, employee training, and data collection, input, and processing. Specifically, veterinary teams could also collaborate on sick animals, with CVTs collecting the initial medical history and physical examination findings and providing treatment after a veterinarian has made a diagnosis. Furthermore, CVTs could record ultrasonographic images during reproductive examinations, and veterinarians could subsequently review those images and provide a diagnosis, similar to the model used in radiology services of the human medical profession. In some states, the veterinary practice act may classify the R&T technique as surgery, thereby precluding CVTs as an alternative for service delivery. The logic of legally allowing farm personnel without formal training or veterinary supervision to perform surgery while excluding licensed, regulated, and supervised members of the veterinary profession appears inconsistent.

Under similar economic pressures, the human medical profession has adopted the use of health-care delivery systems that use paraprofessionals, such as registered nurses, certified nurse practitioners, and physician assistants. A registered nurse holds a position similar to that of a CVT with a similar amount of education, and registered nurses currently perform invasive procedures (such as diagnostic cardiac angiography[16] and renal angiography[17]) on human patients. Certified nurse practitioners are required to obtain additional education and training, after which they assume more complex roles in health-care delivery; there is no equivalent position in veterinary medicine. The demand for certified nurse practitioners has been to meet areas unfilled by physicians because of budgetary or geographic shortages. Their roles are also more complex, including providing primary responsibility for patient care in a neonatal intensive care unit[18] or serving as part of a surgical team focused on patient care and cost-effective services.[19]

Similarly, a veterinary team approach that uses CVTs working under indirect supervision of a licensed veterinarian could ensure satisfactory health and economic outcomes for producers limited by economic or geographic factors. The consolidation of the dairy industry into fewer but larger farms will likely continue a trend of on-farm health-care delivery. For the veterinary medical profession, this trend may have profound impacts on the business and regulatory structure of the profession. The information reported here is one example of the ways in which economic forces are shaping the delivery of on-farm veterinary services. From a regulatory standpoint, a continued shift from services provided by the veterinary profession to services provided by herd personnel requires that the definition of a valid VCPR be reinterpreted. According to the AVMA,[20] a valid VCPR exists when the following 3 conditions are met:

- The veterinarian has assumed responsibility for making clinical judgments regarding the health of the animal(s) and the need for medical treatment, and the client has agreed to follow the veterinarian's instructions.
- The veterinarian has sufficient knowledge of the animal(s) to initiate at least a general or preliminary diagnosis of the medical condition of the animal. This means that the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of an examination of the animal(s), or by medically appropriate and timely visits to the premises where the animal(s) are kept.
- The veterinarian is readily available, or has arranged for emergency coverage, for follow-up evaluation in the event of adverse reactions or the failure of the treatment regimen.

As on-farm health care is more frequently provided by herd personnel on large farms and technologies (such as testing for pregnancy-specific protein B and ultrasonography) replace routine reproductive herd examinations on farms, veterinarians providing only technical services are unlikely to be familiar with the animals through regular and timely visits. Without a valid VCPR, the fundamental basis for providing prescription medications or treatment protocols to farm clients is void. As a consequence, veterinarians offering services to clients without a VCPR face a difficult situation. To overcome this problem, veterinarians will need to change the dimensions in which they offer services to a herd health or production medicine level that can support their educational debt while ensuring services are of value to their clients. Technical responsibilities not provided by farm personnel could be delivered through CVTs working under indirect supervision to ensure that veterinarians remain involved in routine health-care delivery. Delivery of LDA correction services by CVTs is a farm-scale neutral strategy that could increase the expected economic value of R&T procedures for correction of an LDA to dairy producers on farms of all sizes while maintaining outcome probabilities similar to those of a veterinarian-provided R&T procedure. Furthermore, CVTs could expand the profitable geographic service area of a practice, thus reaching previously underserved producers who do not have an alternative delivery method available.[a] This health-care delivery system has been suggested,[15] but to the authors' knowledge has been poorly adopted. However, the market forces shaping the need for change in the business model for food animal veterinarians continue unabated.

Economic decision tree analysis is a useful tool for evaluating mutually exclusive treatment options in veterinary health care. The inputs and assumptions used in these models are continuously shaped by market forces. In veterinary medicine, the educational cost of becoming a licensed veterinarian has steadily increased, forcing salaries (and costs to clients) to respond in a similar manner. For producers, continued trends of lower animal value decrease the difference in value between favorable and unfavorable outcomes (Vf – Vu) and limit the income for herd owners and their employees. As animal value decreases, producers must increase their efforts to become more efficient, including utilizing advantages associated with economies of scale. Increased farm size offers numerous advantages, one of which may be the ability of herd personnel to adequately identify and treat routine disease conditions at a level that approaches the success of a licensed veterinarian (ie, ProbV – ProbHP is approx 0). As economic trends continue to define an environment in which the cost of veterinary service increases at a rate disproportionate to the cost of service delivered by herd personnel, and the value of animals and difference in expected probability outcomes decrease, the range of services for which herd personnel have an expected economic advantage will likely expand.

Conclusion

Results for the study reported here, which was conducted by use of published data,[4–8] revealed that correction of an LDA via an R&T technique may be more profitable when performed by herd personnel than when performed by a licensed veterinarian. This may explain the growth in adoption of herd personnel–provided correction of LDAs among large farms. By absorbing traditional veterinary tasks, unlicensed herd personnel may threaten veterinarian income streams derived from technical expertise and the VCPR required for selling prescription drugs. In response, the authors believe the veterinary medical profession needs to expand its business model to maintain its current framework of providing relevant, economical service to their food animal–producing clients within the context of a valid VCPR. One approach that could meet economic and regulatory concerns, modeled on the widespread adoption of paraprofessionals in the human medical profession, is the utilization of CVTs as part of veterinary health-care teams.

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Correction: Comparison of complications and long-term survival rates following hand-sewn versus stapled side-to-side jejunocecostomy in horses with colic

In the article "Comparison of complications and long-term survival rates following hand-sewn versus stapled side-to-side jejunocecostomy in horses with colic" (*J Am Vet Med Assoc* 2010;237:1060–1067), in Table 2, as a point of clarification, the variable "Postoperative colic and reflux" should instead be "Postoperative colic, reflux, or both." In the study, no horse in the hand-sewn group had both complications together, but 2 had colic only and another 2 had reflux only. In the stapled group, 3 horses had both postoperative colic and reflux, and the remainder had 1 of these complications only.