Enhancing Clinical Decision Making

First steps to efficient use of the scientific literature in veterinary practice

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Scientific literature can be used in veterinary practice to make better clinical decisions for the benefit of patients, clients, and society as a whole. Developments in the 20th and 21st centuries have provided tools that allow and compel veterinarians to move beyond simple clinical observations and experience when making judgments regarding health and disease of animals. Methods have been devised to control bias (systematic distortion of results away from the truth) and confounding (distortion of the apparent relationship between 2 variables by a third factor) in multiple types of research study designs, and these methods allow researchers to be more confident that study findings truly address their research questions. Advances in computing speed, creation of literature databases, and widespread availability of connectivity to the Internet have led to unprecedented access to information for veterinarians and their clients. All of these changes have made it essential that veterinarians develop skills to efficiently acquire, evaluate, and interpret a continuously growing body of scientific literature to support their clinical decisions.

Formulating a Clear and Precise Clinical Question

The first step to successful incorporation of scientific information into decision making is formulating a clear and precise clinical question. Clinical questions can be related to diagnosis, prognosis, prevention, treatment, causation, or other concerns. The volume of available literature and range of potentially relevant topics to address each question can be overwhelming; therefore, it can be helpful to express a question in several ways or to create subquestions until the precise wording is identified that will yield a specific answer.

One memory aid to guide formatting of clinical questions is the mnemonic PICO (patient or problem, intervention, comparison, and outcome), which can be used to structure a question into 4 important components.[1] The letter P reminds clinicians to clearly identify specific characteristics of the patient or group of patients (eg, herds, flocks, or shelter animals) and the problem that prompted the question (**Table 1**). Such characteristics might include age, sex, reproductive status, or breed and a specific health or production concern. The letter I represents the intervention being considered to address the health or production concern. This intervention can be an exposure (eg, disease risk factor), diagnostic test, or treatment. The letter C represents the particular comparison being made. This comparison could be whether an exposure, diagnostic test, or treatment is better than, equivalent to, or comparable with another exposure, diagnostic test, or treatment. For treatments, it is useful to consider whether the comparison treatment is no treatment (negative control), an existing treatment (positive control), or both. Finally, the letter O represents the primary outcome of interest, such as risk of disease onset, risk of death, interval to full recovery, or likelihood of pregnancy.

Several methods are available to search databases of scientific literature for specific information, and the method of question formulation can influence the value or applicability of literature search results. The PICO approach facilitates identification of potential keywords for a focused and directed search to identify all articles pertinent to the clinical question while limiting the number of less relevant articles identified by the search engine (**Table 1**).

Searching Literature Databases

Until recently, the process of searching through the scientific literature to identify articles relevant to a particular clinical question was challenging, particularly for veterinarians without convienient access to a veterinary medical library.[2] Just 15 years ago, clinicians were not using the Internet as a major source of current information when making decisions.[3] However, that paradigm changed with the development of searchable databases that are continually updated and available via the Internet, making access to and identification of scientific articles considerably easier than in the past. The US National Institutes of Health was among the first organizations to provide searchable, online collections of scientific literature information that had relevance to veterinarians. This information is made available through Medline and the PubMed literature retrieval system. PubMed[a] and PubMed Central[b] were created by the National Center for Biotechnology Information of

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This is the second installment of a series of articles intended to help practitioners enhance their ability to convert research information into clinical application. Please watch for additional articles in the series in future issues of the *JAVMA*.

Table 1—Comparison of general clinical questions and PICO (a mnemonic for patient or problem, intervention, comparison, and outcome) questions to demonstrate how the PICO approach yields keywords to facilitate focused and directed literature searches.

General clinical question	PICO question
What is the best method to manage diarrhea in calves?	In young (< 2-month-old) calves in beef cow-calf herds, does environmental management reduce the number of calves developing diarrhea more than does vaccination? Keywords: bovine, calf, vaccine, diarrhea, environment
Should I use antimicrobial X to treat respiratory disease in cattle?	In lightweight (200–250 kg [440–550 lb]) cattle newly arrived at a feedyard, does antimicrobial X increase success of first treatment or decrease risk of death, compared with outcomes for antimicrobial Y? Keywords: bovine, feedyard or feedlot, antimicrobial X, antimicrobial Y
Which medication should I use to prevent postoperative pain in cats?	In apparently healthy cats undergoing elective ovariohysterectomy, does medication X reduce measurable signs of postoperative pain more completely or longer than medication Y? Keywords: feline, ovariohysterectomy, postoperative pain, medication X, medication Y

Key words are descriptors and, with their variations, can serve as a starting point for a structured literature search.

the National Library of Medicine in 1996 and are excellent, free sources of journal article citations, abstracts, and some full-length articles.[4] The database is updated daily to provide timely information on and access to published literature from around the world. More than 80% of articles cited in PubMed are English-language publications, and English translations of abstracts for articles published in other languages are also provided. Full-length articles from > 7,000 journals can be accessed electronically through PubMed or PubMed Central, some of which can be accessed for free, whereas others require payment for access. In addition, the LoansomeDoc feature of PubMed allows users to request articles from libraries (which would be provided for a fee), and many libraries associated with colleges of veterinary medicine will allow access to identified articles on a cost-recovery basis.[5]

The Veterinary Medical Library Section of the Medical Library Association has created a veterinary-focused adaptation of a PubMed brochure (produced by the National Library of Medicine) that provides instruction on the use of PubMed.[6] In addition, PubMed provides online tutorials and other resources to help users gain familiarity and expertise when using focused clinical questions to identify relevant search terms.

Another resource provided free of charge by the US government is AGRICOLA,[c] the catalog of the National Agricultural Library, which includes access to veterinary and animal science literature as a service of the USDA. The database includes citations for and links to abstracts, some full-text journal articles, book chapters, and short reports. An electronic resource provided on a paid-subscription basis is CABI,[d] which includes a catalog of articles from all of the veterinary journals indexed in PubMed as well as those from several other journals, conference proceedings, and university or extension publications more specific to agriculture, animal nutrition, and veterinary medicine. The CABI veterinary science database contains > 650,000 abstracts and citations, with 15,000 records added annually.[7]

Google Scholar[e] is a search engine that differs from Google and other search engines in that a search is limited to scholarly literature from peer-reviewed journals. Google Scholar is simple to use and provides a familiar interface for current users of Google. In general, searches made by use of Google Scholar will identify many, but not all, articles identified by the PubMed search engine and may identify articles from some journals not indexed in PubMed.

Many of the articles identified in a literature search are not available free of charge, but reading the abstracts of those articles can help clinicians determine whether an article is likely to yield information worth paying for. Although not free, this option allows users to pay for only the articles they need, rather than to pay for an annual journal subscription. Clinicians are also encouraged to contact their local public library, which may provide free access to scientific literature (including literature available through other sources on a fee-for-use basis) through interlibrary loans or other services.

Evaluating the Clinical Relevance of Articles

The usefulness of any article for clinical decision making is largely influenced by the ability of the reported study to control for sources of bias and confounding through its design and the manner in which it is conducted (ie, internal validity). Identification of serious design or analysis flaws should prompt clinicians to discontinue reading and consider an article no further. During assessment of studies for internal validity, a clinician must consider whether the study question or hypothesis and the target population (ie, group to which the results are intended to be extrapolated) are similar to the question and animals that prompted the clinical question (ie, the clinical scenario). For some common clinical questions, several relevant studies may have been conducted and may provide answers suitable to the specific clinical scenario. In other situations, a few related studies may have been conducted, but the study population, hypothesis, or outcome measured in those studies may not specifically address the clinical question. When that happens, the PICO elements of the clinical question can be compared with similar elements of the hypothesis tested in each study. Compari-

son of the similarities and differences between a clinical question and the question addressed by a study will help a clinician to determine whether the results are generalizable to the clinical scenario and can be helpful for identifying articles that can be quickly eliminated from consideration without the need to finish reading them. It is important to recognize that practicing veterinarians may put different limitations on their interpretation of the published results of a study than the investigators placed on their own interpretation of the results.

Once the clinical relevance of an article has been established, the next thing to consider is the design of the reported study. Not all reported scientific studies are regarded as being of equal evidentiary value. Various types of study designs inherently differ in the degree to which the investigation controls for bias and confounding, which contributes to internal validity. In general, study designs can be ranked in descending order of evidentiary value as follows: systematic reviews and meta-analyses, randomized controlled trials, cohort studies, case-control studies, cross-sectional studies, case series, and case reports.[8–10] Although a simple ranking of research study types is helpful to describe evidentiary value, such a classification system incorrectly depicts the heirarchy of evidence as 1-dimensional and simplistic. For example, a clinician may be forced to consider whether a randomized controlled trial involving a related species has better evidentiary value than does a case-control study involving the species in the clinical scenario or whether a randomized controlled trial of animals of the same species but different age, breed, or housing conditions has better value than does a case-control study of the same species with similar signalment and housing conditions to those in the clinical scenario. For research regarding dogs, studies commonly involve Beagle colonies that typically differ from client-owned pets in breed, housing conditions, or routine care. Similarly, studies of the effectiveness of a vaccine to protect against bovine respiratory disease may involve 2-month-old dairy calves housed in hutches, but the clinical scenario may involve 7-month-old beef calves housed in open-air drylot pens. In these situations, clinical expertise and judgment can help veterinarians rank evidentiary value by considering whether the differences between species, breeds, or housing conditions would be likely to affect the outcome for the clinical question.

Thinking Critically

No single study can fully address most clinical questions, and every study, no matter how well designed, has limitations. As a result, clinical decision making typically requires consideration of various, often diverse, sources of information, and clinicians may not reach a clear-cut decision. Thomas Bayes, an 18th-century minister and mathematician, described a step-by-step process by which new information is used to build on past beliefs held with some subjective degree of certainty, resulting in a change (reduce, maintain, or increase) in that degree of certainty about the past belief.[11,12] In other words, prior belief that a particular intervention is unlikely to yield a positive outcome would influence interpretation of the results of a single study in which a positive outcome was identified.

In studies in which effects of interventions or other factors are evaluated, statistical analysis can be used to reveal the probability that, by random chance, a study would identify a difference between treatment and control groups of at least the same magnitude as that found in the study if, in fact, the groups were not different. However, by definition, traditional statistical tests do not take into account previous knowledge of the true likelihood that a difference exists among particular groups. The true likelihood of that difference will impact the frequency with which statistical analyses accurately convey the probability of actual differences between treatment and control groups. Thus, prior knowledge about a topic should influence interpretation of results from a single study. For example, numerous studies have shown that hormonal implants have growth-promoting effects in cattle, and findings for those numerous studies can lead a clinician to believe with fairly high certainty that these effects are legitimate. On the other hand, results of a single study that failed to show the same beneficial effects would be unlikely to influence a clinician's belief that implants promote growth.

The situation is different when nothing is known about the effects of an intervention or factor and when a single study is conducted, providing the only information available on that intervention or factor. In that circumstance, veterinary clinicians would need to decide whether the intervention or factor would be likely to work or behave in the hypothesized manner and to interpret study findings in light of that expectation. For example, when a particular treatment is not expected to have a given effect, but findings from a single study indicate it does have that effect, a clinician may still doubt that the association between treatment and effect is truly causal, but with less certainty than before the new information was available. When the particular treatment is expected to have a given effect and a single study reveals that it does have that effect, a clinician can still believe the treatment works, but with more certainty than before the study was conducted.

Incorporation of prior beliefs into a clinician's interpretation of study results is a valid approach provided that both the past belief and new information have been rigorously tested and are unbiased.[13] Prior beliefs regarding the expected outcome should be weighted (typically subjectively) on the basis of the manner in which the beliefs were acquired. For example, when information from several scientifically valid studies is available, clinicians can draw conclusions with a fairly high degree of confidence, meaning a large amount of new data would be required to change those conclusions. Caution should be applied when little scientific data exist on a subject and conclusions are drawn on the basis of clinical observations because this process can allow inadvertent introduction of bias.

The scientific method in the biological and health sciences is not purely data-driven or mathematical; in-

deed, the powers and limitations of human thought and decision making are important components in the interpretation of data and collation of results from multiple studies. Statistical correlation does not replace human thought. When the results of many well-controlled studies of various types with similar hypotheses are combined, and the direction and magnitude of effect identified in those studies are consistent, a clinician can begin to believe strongly that an accurate understanding of the effect has been achieved. However, in many situations, veterinary clinicians have few studies on which they can draw to answer a clinical question, and results of those studies may be inconsistent or may be contradictory. In situations of limited data, intelligent and well-informed people can reasonably be expected to disagree until the results of more well-controlled studies become available to add certainty to some interpretations and diminish certainty for other interpretations.

Essentially, good clinical decisions require good critical thinking skills as well as access to clinically relevant information from well-designed studies. However, access to that information alone does not guarantee that good decisions will be made. A person with excellent critical thinking skills may be severely limited in decision making when a lack of validated data is available, and a person with poor critical thinking skills may be similarly limited even when abundant data from well-controlled studies are available. Although many definitions of critical thinking exist, for veterinary clinicians, we describe it as being able to gather information on a given topic; evaluate that information and rank its evidentiary strength; reflect on all available information to identify what is known about the topic, what is unknown, and the effect of personal biases and perspective on the decision-making process; and come to a clinical decision, with the recognition that any conclusion is subject to reassessment and change as new information becomes available (**Figure 1**).

Critical thinking is a principle and process and as such is never completed. In clinical decision making, critical thinking involves repeating the steps of gathering information, evaluating that information, reflecting on the information, and coming to tentative conclusions. Each repetition or iteration should result in increased understanding of the problem, its solution, and the current limitations to understanding and solving the problem and should converge on the best available answer.

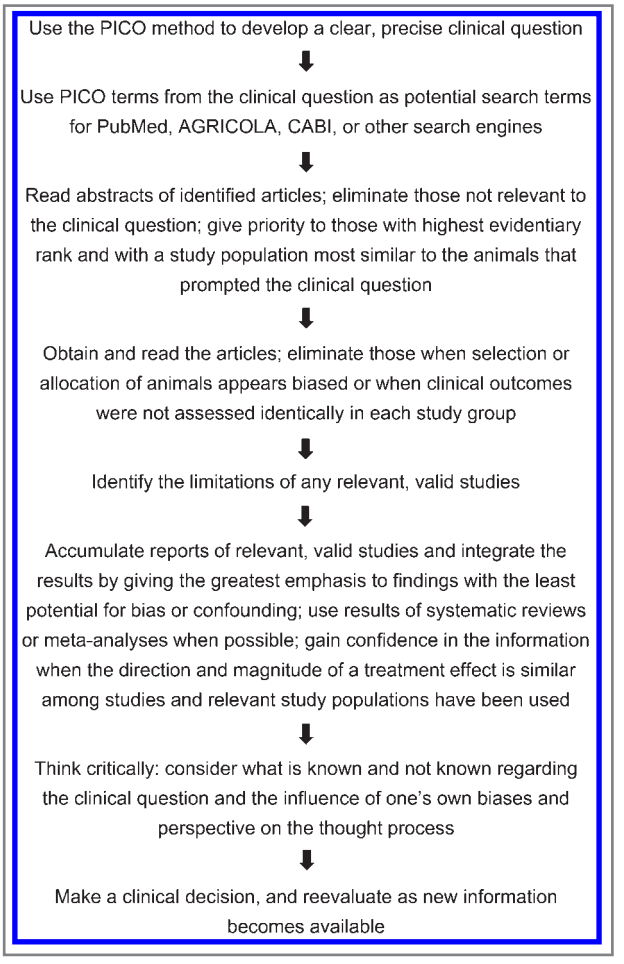

Figure 1—Steps involved in the use of scientific information in clinical decision making. The mnemonic PICO (patient or problem, intervention, comparison, and outcome) is a memory aid to guide clinicians during formatting of clinical questions.

Clinical Summary

The practice of high-quality medicine involves incorporation of information from scientific literature into veterinary decisions. The approach is a problem-solving process, with recognition of the limitations that bias, confounding, and the complex interactions among homeostatic and repair mechanisms and disease processes place on clinicians' knowledge about biology and health. The process also involves recognition of the value that well-designed studies provide to reduce bias and explore some aspects of complex interactions. Even well-designed studies have some degree of bias and are limited in the exploration of complex interactions. The extreme limitations associated with poorly designed studies can magnify the effect of bias. For these reasons, keeping appraised of accurate and timely information is a slow, iterative process with no shortcuts for the complex problems commonly encountered by veterinary clinicians; however, such constant effort to make the best possible clinical decisions can be personally rewarding, with benefits to patients, clients, and society as a whole.

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