**Critical Evaluation of Veterinary Literature**

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**Introduction**

 When first formally learning about veterinary medicine and science, technicians typically start in a classroom filled with didactics and textbooks. Textbooks provide a wealth of knowledge, summarizing scientific literature and processes on topics within the scope of the text’s subject matter, making it easier for students to learn. As veterinary professionals, veterinary technicians are expected to continue to learn and stay up to date with advances in veterinary medicine. To do so, they are unlikely to dust off those old textbooks (besides, they already learned from them in school). The Veterinary Technician Specialist (VTS) is expected to write case reports as part of their application process and cite and justify their knowledge base; the “whys” behind their “hows” of the case. Further, as veterinary technician leaders emerge, they themselves provide didactics, lectures, presentations, writings and other publications to educate others in our field. The information that veterinary technician leaders pass on is unlikely to come from the days in vet tech school, but rather experiences, objective observations, and continued education in veterinary technology and medicine. Whether a technician is interested in a VTS, writing, or speaking, they, like all other professionals, will have to substantiate their claims and knowledge with references. Afterall, thanks to the Enlightenment era, we no longer rely on the “word of mouth” of experts, we expect evidence, and this evidence may be challenged.

 The use of scientific literature is one means of supporting opinions, claims and what is viewed as facts. Not all scientific literature is the same, as published articles will revolve around different research methods. With different research methods, comes different strengths and weaknesses and different applications of the knowledge.

**Types of Scientific Literature Found in Veterinary Medicine**

 Primary research articles are those that are authored by the researchers that conducted the study being published. In this kind of literature, the authors want to inform the reader about their study that they conducted. These kinds of articles are in-depth reviews of their study and can at times be hard to read with detailed analyses of their methods, results, and statistical analyses. Primary research articles can be found in journals (preferably peer-reviewed) and other scientific publications. They can be identified by their title if they include the type of research design, a methods section outlining how they conducted their study and a results section, and providing an in-depth analysis of what they found.

 Secondary research articles reference other studies in order to provide a lot of information on one specific topic from several sources. Rather than being written by the researchers themselves, the authors of secondary research want to inform readers on a particular topic. Commonly, veterinary technicians will encounter secondary research articles in the form of literature reviews. Literature reviews are typically easy to identify as the word “Review” is often present within the title or first few paragraphs of an article. Unlike primary research, these types of reviews do not contain a “methods” or “results” section. The exception to this are “systematic reviews.” In this kind of article, the authors take a systematic approach to the literature that they are including in their review and will provide a summary of what studies were included, exclusion criteria and the methods by which they chose the studies to include in their review.

 Tertiary scientific literature contains a summary of scientific information on a given topic. Unlike primary and secondary articles, tertiary literature tends to target more lay audiences and can be a fast and simple way to look up facts regarding a specific topic or provide a general overview. Examples include the type of patient handouts you may encounter at one’s own doctor’s office, regarding a specific disease or syndrome. In veterinary medicine, this kind of literature can be encountered in the form of client handouts on diseases and medications, or textbooks and magazines.

**Research Designs: How is the Research Conducted?**

 Research designs are an important consideration when interpreting results and applying those results to one’s library of knowledge and their didactics and writings. The technician will primarily encounter different research designs when reading primary research articles, but this information is also frequently included in secondary research articles and some tertiary literature. Listing all types of research designs goes well beyond the scope of these proceedings, however the following reviews some of the common research categories and designs found in veterinary scientific literature.

 First consideration is whether the research is prospective or retrospective. Prospective studies, from the start of the study, look forward and track the data as it occurs throughout the study. Retrospective studies are the opposite of prospective, in that the study involves looking at information in the past to gather the data and information. When determining causation, retrospective studies can rarely be utilized because there is limited ability to control or manipulate variables. However, either kind of study could be utilized for inferring correlation or covariation with enough data and ethical design. The next consideration is whether a study is an observational study, or an experimental study, where a prospective or retrospective approach could be applied to either.

 Observational studies, a researcher is simply observing what is going on in the natural setting around them and measuring the variables without any manipulation. These studies are good for describing what is going on around in the world around us, such as how common a certain procedure or illness is. Experimental designs also measure variables but manipulate one or more of these variables to be able to determine the effect, if any, on a dependent variable. Experimental studies are most commonly the kinds of studies used to infer causation; however, no single study alone should be trusted to infer such information. Although experimental designs are best for inferring a direct relationship, they are typically more expensive to run than observational designs and may not be possible or ethical to run based on what variables would be needed to manipulate and the scientific question the researcher is trying to answer.

 The kinds of observational study designs that are commonly encountered are cross-sectional designs, case-control studies, and cohort studies. Cross-sectional designs are simple, easy and cheap for the researcher to perform and can be a good way to describe something going on in a population of interest. It involves measuring a group of variables of interest, at one time point, with no intervention or manipulation and recording the information. Case-control studies are best for studying risk factors for rare diseases and involves comparing two groups of interest (say dogs with DCM, and dogs without DCM) and compare the differences between them. The purpose of this study isn’t to prove one factor or the other is the cause or risk factor, but rather gather information as to why it may occur more commonly in one group versus another. Cohort studies are those that follow participants over time. As a longitudinal study, the participants in the study have the variables of interest checked at multiple time points. It can be a good way to track changes over time and studying risk factors for disease. The downside to this research is that it is extremely expensive, time consuming (studies can be decades long in people) and as we see with many observational studies, there is a concern for confounding variables.

 Case reports and case series may be of particular interest to the veterinary technician. These are the types of studies that are expected as part of the VTS application. In scientific literature, they are slightly different than the VTS application. Like the VTS case report, these studies follow a single case of a disease (or multiple cases in a case series) and are a detailed account of the patient’s history, treatments, and outcome. Unlike the VTS case report, they are typically involving a rare disease or syndrome, and are a starting place in the formulation of a hypothesis that a researcher would want to answer as opposed to trying to answer a scientific question.

 Experimental designs are extremely important in veterinary medicine, and all scientific disciplines. As stated previously, because of the manipulation of variables is required in an experiment, they aren’t always possible to perform when trying to answer a scientific question. The gold standard study design to provide evidence-based medical decisions is the randomized controlled trial (RCT). In these studies, samples are randomly selected and randomly assigned to treatment or control groups. Variables are controlled and manipulated per the research question’s need, and confounding variables can be identified and controlled for. Clinical trials are a kind of RCT that is used to determine the efficacy and safety of medications and other therapies for patients.

**When to Use What Source & When**

 When trying to determine what kind of resource one should use depends on the context of the project ahead and the intent of points the author is trying to make. Primary and secondary studies lend themselves better for making an argument for or against topics or going in-depth on a topic. Tertiary resources may be more helpful when trying to give general information to the target audience.

 If using primary or secondary articles and publications, the technician should choose the most reliable scientific literature based on the research designs. The lowest level of reliability when it comes to providing evidence for claims in veterinary medicine (and human medicine for that matter) would be in vitro studies and controlled animal experiments, especially if the animals represented in the study are not the same animals of the target population. These two are at the bottom of the reliability scale because despite having excellent internal validity, they typically have poor external reliability and generalizability. These kinds of studies are great places to start “proof of concept” but are not a good final landing place for evidence.

 Next are editorials and expert opinions. Individual experts, and those writing editorials are likely highly educated and knowledgeable, but without evidence to back their claims, it’s hard to stand up to objective science. Individuals, like all people, can be biases even subconsciously, and writings and opinions can reflect that.

 Case studies and series are next highest on the reliability of evidence scale. The sample sizes are too small to provide any generalizable evidence and are retrospective in nature describing patient with a certain disease. They are good for generating hypotheses or provide a specific point in a paper. Climbing the reliability scale, are case-control and cohort studies. Both are observational in nature and because the researchers cannot control for variables, it brings into question confounding variable influences and covariation and causation can be difficult to prove.

 Randomized controlled trials are the most reliable of primary research. When performed ethically, they provide the best evidence for covariation and potentially causation. One drawback to these experiments is that they can contain little external validity and generalizability to the population at large. This isn’t a flaw in design, but rather a reflection of the real world. Both humans and veterinary patients alike don’t live in a sterile, controlled environment.

 No one study or research design is 100% fool-proof, but systematic reviews and meta-analyses are some of the best resources. They include results and analyses based on several studies in a systematic and methodical fashion. This allows the technician reader to effectively read dozens or hundreds of results from vetted primary research articles and designs, in one article. Because these reviews are systematic (as opposed to narrative) authors include inclusion and exclusion criteria for transparency in their findings and conclusions.

**Continuing Scientific Skepticism:** **Confounders, Random Chance and Biases.**

 Confounding variables are always possible, with a greater chance of their influence in observational studies than experimental. These variables may be hidden in the background but will affect the results of a study. One of the most famous examples is the positive association between ice cream sales and drowning deaths. Clearly buying ice cream doesn’t cause a person to drown, so what is the confounding variable behind this association? Skeptical readers should always remember that correlation doesn’t equal causation.

 Random chance can always affect the outcome of a research study. This is typically mitigated by researchers determining a p-value, which is the chance that they would get the results they did simply by random chance. Generally, a p-value less than 0.05 is considered statistically significant and means that there is a 5% chance (or less) that their results were a result of random chance, as opposed to a genuine relationship. This is why the ability to repeat a research study is so important, and why systematic review and analysis is more reliable than a single study. The more information and studies on a topic reiterating the same information, the more likely it can be trusted.

 Biases on the authors’ and researchers’ part is always possible. Even in the most well-intentioned researchers. Bias can come in the form of how population samples are determined and collected all the way through to whether or not the study gets published. Publication biases may lead some research to never get published if the results of the study weren’t of any perceived clinical importance and can affect the results of systematic reviews and meta-analyses.

 The C.R.A.A.P. test is tool that technicians can use to help them evaluate the literature they are intending to use for their publications, presentations, and other writings. It refers to the evaluation of the Currency (how timely is the research/article?), Relevance (how does this information pertain to the needs at hand?), Authority (how reliable is the source of the information?), Accuracy (how truthful is the information?) and Purpose (what was the intent of the publication?). Technicians should be able to understand the kind of study performed, by whom, why and how relevant this research design and information is for their purposes.

**Glossary / Important Terms:**

Association: Whether or not two variables are related.

Bias: Any factor that can lead to a difference in the true value of a parameter in a population and the resultant statistics elucidated from a research design. They can occur in the sampling process, research design, selection of inclusion and exclusion criteria, publication, and more.

Causation: Whether or not the outcome of one variable is the result of another variable’s influence.

Confounding Variable: Any factor or variable that can influence the outcome of a study that distorts the true relationship between variables.

Correlation: The strength and direction of the relationship between variables.

Covariation: How and in what direction variables in a research design change or vary with each other.

Deductive Reasoning: The process of deriving specific implications and outcomes from general theories.

Empiricism: The philosophy that beliefs, concepts and facts can be regarded as justifiably true if there are objective observations to back them up.

Epistemology: The study of knowledge.

External Validity: Whether or not the results of the study would translate truthfully in the real world.

Generalizability: How accurately the information in the study can be applied to the population of interest at large.

Hermeneutics: The process of putting the context of evidence with how the researcher or authors were thinking.

Inductive Reasoning: The process of deriving general hypotheses or theories from specific examples.

Internal Validity: Whether or not the results of a study, and any relationship of variables therein, are strongly supported within the study in question.

Journal: A type of magazine that focuses on one specific subject. Peer-reviewed journals provide articles that have been reviewed by subject matter experts within the field for accuracy and ethics prior to publication.

Population: All the patients (human or veterinary) in the real world that the researchers/authors wish to know more about.

Radical Skepticism: The concept that one can only accept things that can be justified to their own satisfaction.

Sample: A group of patients or participants that are selected for a study that is designed to be representative of the population at large about which the researchers/authors wish to know more about.

Science Council: a professional organization providing registration of scientists and set standards for the professional standards of registered scientists.

Sensitivity: How well a test will identify a disease or condition in patients that truly have the disease. (True positives)

Solipsist: One who is never sure of anything outside of their own mind as being true.

Specificity: How well a test identifies non-disease (negative result) in patients that truly do not have the disease (True negatives).

Statistical Significance (p-value): an estimate of the risk that the observed outcome of a study was due to random chance.

Type 1 error: reporting a result as significant when in fact it resulted from chance. Otherwise known as a “false positive.”

Type 2 error: Reporting a result as *not* significant, when in fact it was. Otherwise known as a “false negative.”

Variable: Any person, place, thing, or phenomenon that a researcher is trying to measure in some way.

**References:**

*Our definition of science*. (n.d.) Science Council. Retrieved February 15, 2022 from <https://sciencecouncil.org/about-science/our-definition-of-science/>

Süt, N. (2014). Study designs in medicine. *Balkan Medical Journal*. 31, 273-277.

Dingman, M. (October, 2020). [Lecture notes on principles of epidemiology]. Department of Biobehavioral Health, The Pennsylvania State University. https://hhd.psu.edu/bbh

Edwards, B. (January-March, 2020). [Lecture notes on research and applications in biobehavioral health]. Department of Biobehavioral Health, The Pennsylvania State University. https://hhd.psu.edu/bbh

Gyekis, J. (September, 2018). [Lecture notes on research strategies for studying biobehavioral health]. Department of Biobehavioral Health, The Pennsylvania State University. https://hhd.psu.edu/bbh