

INNOVATION

One health, one literature: Weaving together veterinary and medical research

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Translating veterinary research to humans will require a “one literature” approach to break through species barriers in how we organize, retrieve, cite, and publish in biomedicine.

Translational research has begun to blur interdisciplinary boundaries, but a few, including those separating veterinary and medical research, persist. Veterinary medicine offers clinically relevant large animal models for a wide range of diseases and treatments in humans, from diabetes in cats to stem cell therapy in horses (1). Even as spontaneous animal models of human diseases merge into the mainstream of translational medicine, traditional boundaries in the biomedical literature—peer-reviewed journals and their knowledge domains—continue to reinforce separation between animal and human health by demarcating species-specific contexts for organizing, retrieving, citing, and publishing. To facilitate communication among scientists, physicians, and veterinarians, a paradigm of “one literature” can raise cross-species awareness and bring together new research communities and collaborations that advance translational medicine.

STUBBORN SILOS: “VETERINARY” VERSUS “MEDICAL” LITERATURE

What is the difference between medical literature and veterinary literature? The boundaries of individual “literatures” or discipline-specific journals are clearly defined in a bibliometric study or meta-analysis but are less clear in the context of a research or clinical study. Categorical silos—whether imposed by our own frame of reference or by an indexer—can impede the healthy and creative cross-exchange of knowledge, and at times such categories can seem arbitrary. Veterinarians might be surprised to learn, for example, that veterinary journals in Scopus include *Vaccine*, whose June 2015 issue contained research articles on human poliovirus, influenza, race/ethnicity, perinatal hepatitis, smallpox, childhood vaccination, and maternal im-

munity, with a single article on animals (Tasmanian devils). Physicians, in turn, might be surprised to learn that medical (but not veterinary) journals include *Comparative Clinical Pathology*, whose September 2014 issue included articles on dogs, rats, chickens, buffalo, sheep, goats, cattle, cockatoos, sturgeon, rabbits, and eastern hellbenders (giant salamanders), as well as the occasional human. Categorization of the veterinary and medical literature, therefore, imposes borders that do not always coincide with an intended focus.

“It is one thing to talk about the literature of a field. It is quite another to discuss



One Health. Human and veterinary biomedical research must forge a single path forward.

the literature used by researchers in that field” (2). Translational scientists seek relationships and pathways leading from basic and preclinical research—including research in animals—toward clinical applications. Publishing silos present a barrier to

this process and to new ways of thinking. Veterinarians often consult, cite, and publish in medical journals, in part because of their comparative training but also because medical research underpins many of the advances made in veterinary medicine (3). Physicians and medical researchers may be less familiar with veterinary journals and thus may not be aware, for example, that cats, like people, get chronic kidney disease and interstitial cystitis or that regeneration of mandibular bone in dogs using recombinant human bone morphogenetic protein 2 (rhBMP-2) was a stepping-stone in developing effective methods for reconstructing the human jaw.

Barbara Natterson-Horowitz, author of *Zoobiquity*, describes: “I, like most physicians, only interacted with veterinarians when my own animals got sick.... listening to the veterinarians [at the Los Angeles Zoo] on their rounds, [I began to see] that they were dealing with heart failure, and cancer, and behavioral disturbances, and infectious diseases, and really essentially the same diseases that I was taking care of in human patients” (4). Today’s veterinary literature is replete with studies that inform our knowledge of human disease, and with fewer regulatory constraints, medical and surgical advances in animal patients can sometimes precede those in humans.

Failure to consider the broad literature can result in narrow context, omissions, and errors. An editorial about reporting guidelines in *Veterinary Record* cited *Journal of the American Medical Association (JAMA)* and *British Medical Journal (BMJ)* references to CONSORT but failed to cite REFLECT, reporting guidelines essential to the design of clinical trials in food animals (5). Cardiff *et al.* (6) described the failure of researchers to cite consensus reports, diagnostic criteria, and terminology published in part by veterinary pathologists for precancerous and cancerous lesions in mice. They documented numerous studies in which normal glands in mice were misdiagnosed as skin tumors, papillomas were misdiagnosed as normal epithelium, and runting was attributed to aberrant genes without excluding the much more likely (to a veterinarian) possibility of dental malocclusion. These misinterpretations have serious implications for the integrity of the multi-million dollar Knockout Mouse Phenotyping Program (<http://commonfund.nih.gov/KOMP2>), an NIH Common Fund project and part of the International Mouse Pheno-

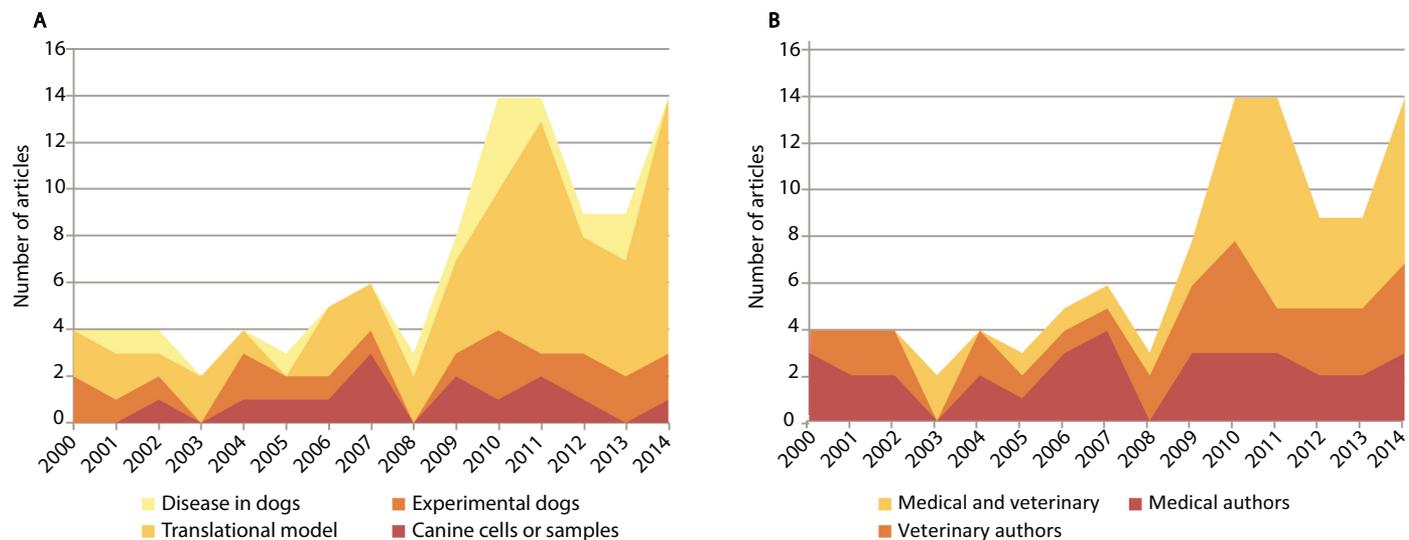


Fig. 1. A meeting of minds. Physicians and veterinarians were collaborating and publishing together more than a decade ago. There has been sharp growth in translational articles and medical-veterinary collaborations involving canine lymphoma. Articles ($n = 103$) were retrieved on August 24, 2015, by a PubMed search on “canine lymphoma” ($n = 930$ from 2000 to 2014) filtered by “Human” species ($n = 146$) and excluding irrelevant articles (e.g., in which “canine” modified other terms). Each data point is the number of articles in 1 calendar year. **(A)** Articles relating to human lymphoma. Studies characterizing lymphoma in dogs compared the results to human disease, while studies of canine lymphoma as a translational model emphasized the application of the findings to human disease. **(B)** Articles sorted by author affiliations. Medical affiliations include basic science departments. Veterinary affiliations include both veterinary schools and private veterinary practices. Affiliation may not always match with professional degrees (e.g., veterinarians sometimes work in medical schools).

typing Consortium (www.mousephenotype.org). Journals contribute to such errors by drawing on narrow pools of peer reviewers whose expertise does not extend beyond the medical or molecular context to veterinary pathologists. But responsibility lies with potential reviewers as well; veterinarians may be reluctant to review manuscripts involving human disease, and both communities may be reticent to cross the imaginary line between animal and human work.

Failure to consult or cite literature across the medical-veterinary divide works in both directions. I have heard of veterinary clinical researchers, for example, balking at citing relevant experimental animal work from the “medical literature.” John Young, veterinarian and director of comparative medicine at Cedars-Sinai Medical Center, has been a strong advocate of the interconnectedness of medical research and veterinary practice, in part through public outreach for the nonprofit group Americans for Medical Progress. Translational efforts at his institution have contributed to the ability of veterinarians to use novel immunotherapies for treating glioblastoma in dogs, a model for human brain cancer, and brought together the expertise of a prominent neurosurgeon with that of a local veterinary internist, to use a high-definition

video-telescope for the surgical removal of pituitary tumors in dogs.

MEETING POINT: WHERE THE LITERATURE CONNECTS

Progress has been made in recognizing and strengthening connections between veterinary and medical literature. The World Association of Medical Editors (WAME) formally welcomed veterinary medical editors into the organization, thanks to the editor-in-chief of *Plastic and Reconstructive Surgery* and then-secretary of WAME. The decision recognized the parallel spheres of veterinary and medical editing, practice, and policy, including peer review, manuscript types, conflicts of interest, and reporting guidelines. Veterinary editors participated in roundtable discussions on biosecurity and dual-use research organized by the U.S. National Institutes of Health (NIH) Office of Biotechnology Activities. And since 2006, the Literature Selection and Review Committee of the National Library of Medicine has included a veterinarian on its team of physicians, nurses, dentists, basic scientists, and library and information specialists. Another important milestone was the decision by the British Veterinary Association to join with BMJ Group to publish its national journals

Veterinary Record and *In Practice*, based in part on synergies between physicians and veterinarians and following a successful joint issue on the links between human and animal health.

Importantly, physicians and veterinarians are collaborating on and publishing in translational research more than ever. Non-Hodgkin’s lymphoma, for example, is one of the most common cancers affecting people and dogs; its diagnosis, molecular characterization, and treatment have been greatly enriched and advanced by comparative translational research. Based on a PubMed search of “canine lymphoma,” filtered for “Species: Human,” research articles involving spontaneous canine lymphoma as a translational model for human lymphoma have tripled since 2000 (Fig. 1A). Further, the number of papers authored jointly by medical and veterinary researchers grew from 0 to 1 per year in 2000 to as many as 9 in 2011 (Fig. 1B). Nearly one-half of the articles on canine lymphoma as a translational model were published in medical or basic sciences journals, but nearly one-quarter were published in veterinary journals.

These collaborations have also changed how the two communities communicate and unify biomedical languages. For instance, the term non-Hodgkin’s lymphoma

is not widely used in veterinary medicine (because Hodgkin's lymphoma is rare in animals, there is no need to make the distinction); but, as research on canine lymphoma as a translational model has increased, so too has use of the term non-Hodgkin's lymphoma (i.e., in the titles of articles in Fig. 1), from 3% in 2000–2008 to 12% in 2009–2014. It is clear there is strong impetus within the translational research community to “reach across the aisle” that separates veterinary and human medicine.

Translational research collaborations may explain the upward trend in cocitations between veterinary and medical journals in the Scopus database, which since 2005 have exceeded those between veterinary and agricultural journals for authors in the U.S. (7). This shift in alignment for veterinary medicine, from an agricultural to a medical focus, reflects the robust growth of companion animal specialties and evidence-based medicine and their accelerating translational applications to human health.

TOWARD A “ONE LITERATURE” PARADIGM

The One Health Initiative, endorsed by the American Medical Association and the American Veterinary Medical Association, embraces the concept that animal, human, and environmental health are inseparable and that the expertise of all health care professionals is essential for solving problems and advancing research (8). This premise lies at the core of translational medicine, where animal models of neoplasia, infection, and degenerative diseases inform medical research and where animals' relationships with humans extend to their role in mental health, cancer detection, war, sustainable agriculture, elder care, and domestic abuse. Translational scientists have begun to rediscover the value

of the uniquely comparative approach veterinarians bring to the biomedical table. The concept of “One Literature” extends the One Health approach to how we retrieve, cite, and publish biomedical research, removing contextual boundaries between veterinary and medical literature and facilitating knowledge exchange and collaborative approaches that benefit translational research.

To achieve this, One Literature challenges indexers to cross-list veterinary specialty journals under relevant medical specialties, focusing on similarities rather than differences. One Literature challenges editors to draw on both veterinary and medical experts in their reviewer pools to bring appropriate scientific expertise to the critical evaluation of manuscripts. One Literature also challenges publishers to develop collaborative veterinary-medicine ventures, such as joint publications, that facilitate connections between the professions.

Online innovations in scientific publishing, open access, and social networking already have opened new and exciting ways to transcend traditional disciplinary and journal boundaries and establish new relationships among articles (9). Open access enhances article visibility and retrieval and facilitates text mining, natural language processing, and semantic analysis, which add new value and functionality to traditional search algorithms, without regard to disciplinary silos. Just as social media have led to “context collapse”—bringing together individuals of different geographic, educational, and cultural backgrounds—so, too, digital publishing innovations are effectively deconstructing or “unbinding” the highly contextualized world of traditional biomedical journals and bringing together new research communities of scientists, authors, readers, and reviewers (10).

A future in which One Literature has displaced rigid notions of veterinary and medical research is a future in which translational medicine has fully capitalized on the essential connection between animal and human health.

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