Laura L. Pavlech. A Bibliometric Analysis of Articles Published in the *Journal of Veterinary Internal Medicine* from 1998 to 2013. A Master's Paper for the M.S. in L.S degree. March, 2014. 113 pages. Advisor: Bradley Hemminger

Several bibliometric studies of the human health sciences literature have been published, but there have been few attempts to quantify the research published in the veterinary medical literature. The purpose of this bibliometric analysis was to detect patterns in articles published in the *Journal of Veterinary Internal Medicine* over a 15-year period, and thereby provide an assessment of the research available to clinicians in the specialty of veterinary internal medicine. Articles from four select years over the period of study were classified according to authorship, species investigated, purpose of study and study design. The results of this study provide a base for future bibliometric analysis of the veterinary literature and an appraisal of the articles published in the *Journal of Veterinary Internal Medicine* for the editors of that journal and those with an interest in veterinary internal medicine.

Headings:

Bibliometrics

Evidence-based medicine

Periodical publishing

Research

Study design

Veterinary medical literature

A BIBLIOMETRIC ANALYSIS OF ARTICLES PUBLISHED IN THE *JOURNAL OF VETERINARY INTERNAL MEDICINE* FROM 1998 TO 2013

by
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A Master's paper submitted to the faculty
of the School of Information and Library Science
of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements
for the degree of Master of Science in
Library Science.

Chapel Hill, North Carolina

March 2014

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Introduction

Over 30 years ago, a research group at McMaster University established the principles of evidence-based medicine (EBM). A 1992 article in the *Journal of the American Medical Association* was the first instance of the term 'evidence-based medicine' in the human medical literature (Vandeweerd, Kirschvink, et al., 2012). Since that time, EBM has permeated almost all fields of human medicine, at least in theory, and extended beyond medicine into other disciplines, such as nursing, dentistry, pharmacy and even librarianship. Veterinary medicine frequently adopts methods of practice that are standard in human medicine. Since the first mention of EBM in the veterinary literature in 1998, evidence-based veterinary medicine (EBVM) has been discussed in veterinary journal articles, reviews, editorials, commentaries and the occasional conference, but there is no indication that EBVM has entered the daily routine of veterinary practitioners ("Identifying a future for evidence-based veterinary medicine," 2012; McKenzie, 2011). One perceived barrier to the practice of EBVM is the lack of sufficient high quality evidence in the field of veterinary medicine (Cockcroft & Holmes, 2003; Vandeweerd, Gustin, & Buczinski, 2012; Viner, 2010). While veterinarians lament the paucity of high quality evidence in their field, few studies have evaluated the quality of the veterinary literature. The focus of the studies that have evaluated the veterinary literature has been narrow with either a single year (Giuffrida & Brown, 2012), specialty (Arlt, Dicty, & Heuwieser, 2010; Sahora & Khanna, 2010; Simoneit, Heuwieser, & Arlt, 2011) or topic (Chen, Dou, & Cai, 2012; Jansson & Harris, 2013) examined. No attempt has been made to quantify the evolution and current state of research published in a single English-language veterinary journal over a period of time.

The purpose of this bibliometric analysis was to detect publication trends in the *Journal of Veterinary Internal Medicine* (*JVIM*) over the past 15 years. The primary aim of this study was to describe patterns in the articles published in *JVIM* in terms of: number of authors per article, author affiliation, species, purpose of study and study design. The secondary aim of this study was to provide an assessment of the research available to clinicians in the specialty of veterinary internal medicine.

Literature Review

Origin and Application of Bibliometrics

Bibliometrics is the area of study that analyzes the information in research publications to construct a representation of an author, journal or discipline's scientific output (Verbeek, Debackere, Luwel, & Zimmermann, 2002). In a 1969 note in the *Journal of Documentation*, Pritchard proposed 'bibliometrics' as an alternative name for the subject previously described as statistical bibliography and reported that "an intensive search of the literature has failed to reveal any previous use of the term" (p. 349). Pritchard defined his new term as "the application of mathematics and statistical methods to books and other media of communication" (1969, p. 349). Godin argued that the seeds that led to the development of bibliometrics were sown much earlier in the twentieth century by psychologists who wanted to measure the quantity and quality of science (Godin, 2006). Regardless of the true origins of bibliometrics, authors in various disciplines have worked to refine the practice of bibliometrics and apply it to the literature in a meaningful way. The availability of information in electronic form, and tools to harvest and analyze that information, has facilitated the practice of bibliometrics.

The application of bibliometrics to a single journal allows for the assessment of the content and publication trends within that journal over time (Coronado, Wurtzel, Simon, Riddle, & George, 2011). The results of such a study quantitatively measure the research published within a journal and are of interest to the editors and organizations responsible for that journal. If the journal is a prominent publication within its field, then a bibliometric study can be an indirect indication of the evolution and current state of the peer-reviewed research within that field (Anyi, Zainab, & Anuar, 2009; Coronado, Riddle, Wurtzel, & George, 2011). In an introduction to a bibliometric study of the *Journal of the American Society for Information Science*, the authors argued that "Journal articles offer many explicit and several implicit variables that point to the evolution of the *Journal* as well as the discipline it represents" (Koehler et al., 2000, p. 2). The state of peer-reviewed research within a field is relevant to researchers, practitioners and educators within the field. Peer-reviewed research affects current and future work and may prompt changes in clinical practice, study design and education. In recent years, the widespread acceptance of EBM in the human health sciences has resulted in intense scrutiny of peer-reviewed research. Practitioners of EBM are encouraged to utilize an evidence pyramid to select the highest level of research appropriate to their clinical question. Several bibliometric studies of the human health sciences literature have been conducted in an attempt to quantify the type and quality of research published within a particular journal or specialty.

Bibliometric Analysis of the Human Health Sciences Literature

Bibliometric analysis has been used to investigate publication patterns and assess the overall status of research in many areas of the human health sciences including, but are not limited to: medicine (Merenstein, Rao, & D'Amico, 2003; Thomas, Fahey, & Somerset, 1998); obstetrics and gynecology (Dauphinee, Peipert, Phipps, & Weitzen, 2005); surgery (Gnanalingham, Robinson, Hawley, & Gnanalingham, 2006; Hanzlik, Mahabir, Baynosa, & Khiabani, 2009); pediatrics (Hayden & Saulsbury, 1982); dentistry

(Gibson & Harrison, 2011); nursing (Jacobsen & Meininger, 1985); allied health (Coronado, Riddle, et al., 2011) and public health (Freimuth, Massett, & Meltzer, 2006). The authors of these studies utilized various analytic methods. The first methodological decision in a bibliometric analysis of the peer-reviewed literature is how to obtain a representative sample of articles. Several authors have examined articles from a single journal over a period of multiple years, including in their analysis either articles from all years during the designated time period (Becker et al., 2008; Becker, Blumle, & Momeni, 2013; Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011) or articles from select years evenly spaced over the given time period (Hanzlik et al., 2009; Hayden & Saulsbury, 1982; Loiselle, Mahabir, & Harrop, 2008). One study utilized a variation of the latter methodology, evaluating the first 75 articles that met the inclusion and exclusion criteria for three select years over a 10-year period (Dauphinee et al., 2005). Other bibliometric studies of the human health sciences literature have focused on a particular specialty, as opposed to a single journal, and thus, evaluated articles from multiple journals. Authors of these studies either searched electronic databases for articles related to their specialty (Chou, 2009; Glanville, Kendrick, McNally, Campbell, & Hobbs, 2011) or selected a set of journals that were considered representative of the specialty (Gnanalingham et al., 2006; Merenstein et al., 2003). The studies that utilized a select set of journals reviewed articles for inclusion from: all years within a multiyear period (Chang, Pannucci, & Wilkins, 2009; Gibson & Harrison, 2011; Mogil, Simmonds, & Simmonds, 2009; Rosales, Reboso-Morales, Martin-Hidalgo, & Diez de la Lastra-Bosch, 2012); select years within a multiyear period (Fletcher & Fletcher, 1979; Gnanalingham et al., 2006; Jacobsen & Meininger, 1985; McDermott et al., 1995; Xu, Cote, Chowdhury, Morrissey, & Ansari, 2011; Zaidi et al., 2012) or a single year (Lai et al., 2006; Ruiz, Alvarez-Dardet, Vela, & Pascual, 1991). The myriad methods utilized to attain a representative sample of articles for the purposes of bibliometric analysis reflect the different aims, and resources, of the authors of these studies. The generalizability of the results of a bibliometric analysis of a single journal to an entire specialty depend on: the importance of the journal selected for study, the number of other peer-reviewed journals within the specialty, the size of the specialty itself, and the number of articles selected for analysis. Studies that evaluate a large number of articles, either from one journal over an extended period of time or from multiple journals, require multiple investigators. However, the results of these studies may provide a valid indicator of the state of research within the chosen specialty.

Bibliometric studies of the human health sciences literature have assessed a variety of variables. Variables that were consistently evaluated in bibliometric studies of the human health sciences literature include: number of authors (Fletcher & Fletcher, 1979; Hayden & Saulsbury, 1982; McDermott et al., 1995; Mogil et al., 2009; Xu et al., 2011); author affiliation, specifically country of origin and/or type of practice (Hayden & Saulsbury, 1982; McDermott et al., 1995; Ruiz et al., 1991; Thomas et al., 1998); purpose of study, for example therapy, prognosis or diagnosis (Barske & Baumhauer, 2012; Bentsianov, Boruk, & Rosenfeld, 2002; Xu et al., 2011; Zaidi et al., 2012); and study design, for example RCT, cohort or case study (Bentsianov et al., 2002; Chang et al., 2009; Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011; Fletcher & Fletcher, 1979; Gnanalingham et al., 2006). Other variables considered indicative of the quality and utility of peer-reviewed research, but not consistently evaluated in bibliometric studies of the human health sciences literature include: level of evidence (Barske & Baumhauer, 2012; Bentsianov et al., 2002; Chang et al., 2009; Dauphinee et al., 2005; Hanzlik et al., 2009; Obremskey, Pappas, Attallah-Wasif, Tornetta, & Bhandari, 2005; Paci, Cigna, Baccini, & Rinaldi, 2009); clinical condition (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011; Hayden & Saulsbury, 1982); study population, for example size and/or age (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011; Fletcher & Fletcher, 1979); and clinical relevance or outcome (Lauritsen & Moller, 2004; Merenstein et al., 2003).

Bibliometric studies of the literature of a single specialty have utilized different variables in their analyses. In 2008, Loiselle et al. assigned a level of evidence to articles published in the journal *Plastic and Reconstructive Surgery* over a 20-year time period. Chang et al. (2009), in an assessment of the quality of clinical studies in aesthetic surgery, including articles published in *Plastic and Reconstructive Surgery*, classified the study design and level of evidence of each included article. A later bibliometric study (Xu et al., 2011) of facial plastic surgery literature, which also included articles published in *Plastic and Reconstructive Surgery,* evaluated purpose of the study and level of evidence for each article, but did not consider study design. Although the authors of these three studies examined articles from the same journal, they did not include the same variables in their analyses.

Even when bibliometric studies have evaluated the same variables, differences in the conceptualization and operationalization of those variables make it difficult to compare the results of these studies. For example, Frey and Frey (1981), in an early bibliometric study of the family medicine and general practice literature, placed articles into one of eight study design categories: review article, case report, cross-sectional analysis/questionnaire, longitudinal retrospective, longitudinal cohort/prospective, clinical trial, descriptive study or opinion paper. The authors provided definitions for most of these categories. In a later study of the primary care literature, Thomas et al. (1998) categorized the study design of the articles as: qualitative, survey, cohort/longitudinal, RCT, or other quantitative design. No definitions were provided for these categories. In another study of the family medicine literature, Merenstein et al. (2003) utilized eight categories for study design: survey/cross section, cohort, randomized trial, qualitative, case-control, systematic review, case series and decision analysis. These categories were similar to, but distinct from, those of Frey and Frey, and no definitions for the categories were offered in the article. Thus, three studies of a single specialty used different categories to classify study design and did not consistently provide definitions for the categories.

The lack of consistency in the methodology of bibliometric studies makes it difficult to compare the results of these studies. Moreover, each of the specialties evaluated in these studies has unique logistical, ethical and financial barriers to conducting research with human subjects. Nevertheless, a few patterns have emerged in bibliometric studies of the human health sciences literature. First, the number of authors per article has increased over time. This pattern was observed in early and current bibliometric studies. In a study of articles published in the *Journal of the American Medical Association, The Lancet* and the *New England Journal of Medicine* from 1946 to 1976 (Fletcher & Fletcher, 1979), the authors found that the number of authors per article increased over the 30-year period from a mean of 2.0 in 1946 to 4.9 in 1976. Another study of articles published in *The Journal of Pediatrics* over a 50-year time period (Hayden & Saulsbury, 1982) showed that the mean number of authors per article increased from 1.5 in 1932 to 4.0 in 1981. In 1995, McDermott et al. repeated the Fletcher and Fletcher study, this time evaluating articles published between 1971 and 1991. The authors discovered that the average number of authors per article increased from 3.5 in 1971 to 7.3 in 1991. When multicenter studies were excluded from this analysis, the average number of authors per article was 3.4 in 1971 and 5.6 in 1991. Recent studies in the pain (Mogil et al., 2009) and plastic surgery literature (Xu et al., 2011) have substantiated this finding of an increase in the number of authors per article over time. The trend toward more authors per article may reflect an increased ability or need to collaborate. Technology has facilitated multicenter research by allowing researchers around the country, or the world, to communicate easily with one another. Increased specialization among researchers (McDermott et al., 1995) and a recent emphasis on interdisciplinary research has also encouraged collaboration. A more cynical interpretation of the trend towards multi-authorship is that it is “a manifestation of academic gamesmanship in a ‘publish or perish’ environment” (Hayden & Saulsbury, 1982, p. 9).

The second pattern that has emerged in bibliometric studies of the human health sciences literature is that treatment/therapy studies are the most common purpose of study, regardless of specialty. In a study of the orthopedic literature, therapeutic studies were the most common study purpose, representing 70.7% of the 383 articles that the authors evaluated (Obremskey et al., 2005). Therapy/prevention/cause/harm studies were the most common study purpose (87.6%) in an analysis of 975 plastic surgery articles

(Xu et al., 2011). Two separate studies showed that therapy articles were the most common study purpose in the foot and ankle literature (Barske & Baumhauer, 2012; Zaidi et al., 2012). One notable exception to the high frequency of therapy studies was the physical therapy literature, where anatomy and physiology studies were the most common purpose of study (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011). Anatomy and physiology are integral to the daily practice of physical therapy. Anatomy and physiology studies were often excluded from the analysis in other bibliometric studies, so it is difficult to determine the frequency of this study purpose in other specialties.

Although there was considerable variation among bibliometric studies of the human health sciences literature in the categories and definitions used for study design, case series and case reports have emerged as a frequent study design. In a study of the rheumatology literature (Ruiz et al., 1991), 30.62% of the 1,107 articles evaluated were case reports and an additional 10.39% were case series. Chang et al. (2009) grouped case series, expert opinion and nonsystematic review articles into one category and reported that 86.3% of 1,419 plastic surgery articles fit into this category. A bibliometric analysis of the foot and ankle surgery literature (Barske & Baumhauer, 2012) found that 30% of the 245 articles included in the analysis were case series and 26% were case reports. In studies of the family medicine and physiotherapy literature, cross-sectional/survey and observational/descriptive were the most frequent study designs, respectively (Merenstein et al., 2003; Paci et al., 2009).

The RCT study design is of particular interest in the human health sciences literature because this design is considered the gold standard of clinical research and placed near the top of the evidence pyramid used in EBM. Sackett, Rosenberg, Gray, Haynes and Richardson (1996), in an oft- quoted editorial, explained that “The practice of evidence based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research” (p. 71). The hierarchy of evidence of pyramid is used to help clinicians choose the best available research to answer their clinical questions. Meta-analyses and systematic reviews are placed at the pinnacle of the evidence pyramid with RCTs one level below. RCTs control for known and unknown confounding variables and reduce the potential for bias in an experiment (Gnanalingham et al., 2006). RCTs are therefore regarded as the most scientifically rigorous study design for evaluating the effect of an intervention (Sprague, McKay, & Thoma, 2008). In bibliometric studies of the health sciences literature, the frequency of RCTs ranged from 3.2% (Chang et al., 2009) to 15.62% (Ruiz et al., 1991) of articles that met the inclusion criteria. The specialty in which the research is conducted affects study design. Gnanalingham et al. (2006), in a bibliometric analysis of 25 journals from five specialties, found a significant difference in study design between the five specialties. Anesthesia journals had the highest proportion of RCTs (18%) followed by psychiatry (9.6%), medicine (8.1%), pediatrics (6.4%) and surgery (5.3%). Other bibliometric studies of various specialties seem to confirm these findings. In a bibliometric analysis of five high impact anesthesia journals, RCTs were second only to animal and laboratory research as the most frequent study design, representing 20.4% of the 5,468 pages evaluated in the study (Lauritsen & Moller, 2004). Bibliometric studies of the family medicine (Merenstein et al., 2003) and rheumatology literature (Ruiz et al., 1991) found that 11.8% and 15.62% of the included articles, respectively, were RCTs. An analysis of the journal *Aesthetic Plastic Surgery* showed that only 1% of the 1,048 original articles published from 1990 to 2005 were RCTs (Becker et al., 2008). An analysis of the journal *Plastic and Reconstructive Surgery* found that 2.23% of the 7,121 original articles published from 1990 to 2010 were RCTs (Becker et al., 2013). One possible explanation for the higher frequency of RCTs in the anesthesia literature is the ease of data collection from anesthetized patients (Gnanalingham et al., 2006). However, this alone cannot account for the discrepancy between specialties. Gnanalingham et al. (2006) suggested that the difference in the frequency of RCTs between specialties may be due to prevailing views within each specialty on the utility of this study design, and willingness to question and change clinical practice. Regardless of the cultures within the specialties, questions that involve a surgical intervention are difficult to resolve with a RCT. Solomon and McLeod (1995) conducted a study to determine what percentage of surgical intervention questions could be answered with a RCT. The authors obtained a representative sample of articles from the gastrointestinal surgery literature and concluded that only 38.8% of clinical treatment questions in gastrointestinal surgery could be answered with a RCT. Problems precluding the use of a RCT included: uncommon condition; lack of community equipoise; methodological issues; patient preference or surgeon preference. In addition to these problems, Becker et al. (2008) observed that it is difficult to standardize surgical treatments because the skill and experience of the surgeon has a significant effect on the outcome of the procedure.

Bibliometric studies of the health sciences literature suggest that researchers have found a way to perform more RCTs. These studies have shown either an increase or no change in the frequency of the RCT study design over time. In an analysis of articles published in the *Journal of the American Medical Association*, *The Lancet* and the *New England Journal of Medicine*, McDermott et al. (1995) found that the prevalence of clinical trials doubled from 17% in 1971 to 35% in 1991. The proportion of clinical trials that were RCTs increased from 31% to 76%. Gnanalingham et al. (2006) reported a significant increase in the proportion of RCTs published in 25 journals, from 5.9% in 1983 to 9.6% in 2003. The percentage of RCTs in three plastic surgery journals quadrupled from 1.2% in one five-year time period (1998-2002) to 4.8% in the next (2003-2007) (Chang et al., 2009). Gibson and Harrison (2011) evaluated the orthodontic literature and reported an increase in RCTs from 8.5% in one five-year interval (1999-2003) to 12.5% in the next (2004-2008), although the difference was not statistically significant. In two separate studies of the physical therapy literature (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011), the authors found no significant change in the percentage of RCTs in studies published in the journals *Physical Therapy* and the *Journal of Orthopedic and Sports Physical Therapy* from 1980 to 2009.

Other study design trends that emerged from bibliometric studies of the human health sciences literature include: an increase in the frequency of systematic reviews, and corresponding decrease in topical reviews (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011); an increase in cross-sectional studies and decrease in longitudinal studies (Fletcher & Fletcher, 1979); and an increase in meta-analyses (Gnanalingham et al., 2006). The increase in systematic reviews and meta-analyses over time has occurred in conjunction with the acceptance of EBM. These two study designs are provide the highest level of evidence because they utilize systematic and explicit methods to integrate the results of multiple studies ("Glossary of Terms in the Cochrane Collaboration ", 2005). The rise in RCTs provided the evidence base that authors prefer to use for systematic reviews and meta-analyses, and access to electronic databases and articles have made it easier for authors to locate and access articles to include in their studies. Study design determines what level of evidence an article provides to the reader. There are several levels of evidence systems in use in the human health sciences literature. A few of the more prominent systems include those from the Oxford Centre for Evidence Based Medicine (OCEBM), the U.S. Preventive Services Task Force and *The Journal of Bone and Joint Surgery* (Hanzlik et al., 2009; Petrisor, Keating, & Schemitsch, 2006). Although these systems vary in their organization and classification of study designs, systematic reviews and RCTs are usually placed in the highest level of evidence (level 1[1]) while case series and expert opinion are placed in the lower levels of evidence (level 4 or 5) (Phillips et al., 2009; Wright, Swiontkowski, & Heckman, 2003). In bibliometric studies of the human health sciences literature, the percentage of articles classified as level 1 was low, corresponding to the low number of systematic reviews and RCTs, while the percentage of studies classified as level 4 was high, corresponding to a greater number of case studies. In a 2002 study of the otolaryngology literature, 80% of the articles included in the analysis were considered a level 4 using the OCEBM system and only 7% of the articles were classified as level 1 (Bentsianov et al., 2002). Studies that would have been classified as level 5 were not included in this analysis. A study of the orthopedic surgery literature found that 58.1% of the articles were level IV using *The*

[1] Different levels of evidence systems use different numerical systems. For example, the Oxford Centre for Evidence Based Medicine system utilizes Arabic numerals (1, 2, 3,…) while *The Journal of Bone and Joint Surgery* system utilizes Roman numerals (I, II, III,…). In this paper, Arabic numerals will be used to refer to individual levels of evidence, except when discussing a study that employed a system with Roman numerals.

Journal of Bone and Joint Surgery levels of evidence system; 11.3% of the articles were level I (Obremskey et al., 2005). This study excluded review articles, basic-science articles, case reports and expert opinion. Paci et al. (2009) also utilized *The Journal of Bone and Joint Surgery* levels of evidence system for their analysis of the physiotherapy literature. In this analysis, 23.67% of the 1,864 articles included in the study were placed in the level III category, and 12.61% of the articles were placed in the level I category. *The Journal of Bone and Joint Surgery* levels of evidence system was again used in a 2012 bibliometric analysis of the foot and ankle surgery literature (Zaidi et al.). In this study, 37% of the 720 included articles were classified as level IV, an additional 27% were classified as level V and 2.4% were level I. A study of the plastic surgery literature, which used the OCEBM levels of evidence system, found that 53.2% of the 975 included articles were level 4 and only 0.7% of the articles were level 1 (Xu et al., 2011).

The levels of evidence of articles published in the human health sciences literature have improved over time. Dauphinee et al. (2005) examined articles published in the journal *Obstetrics and Gynecology* over a 10-year time period. The authors reported a significant increase in the percentage of level II studies from 71% in 1991 to 88% in 2001, and a significant decrease in the percentage of level III studies from 19% in 1991 to 1% in 2001. A study of articles published in the journal *Plastic and Reconstructive Surgery* over a 20-year period also discovered a trend toward higher levels of evidence with the combined percentage of levels 1, 2 and 3 studies increasing from 7.2% in 1983 to 13.7% in 2003 (Loiselle et al., 2008). Nevertheless, in all three decades, the majority of articles published were either level 4 or level 5 studies: 92.8% in 1983, 87.6% in 1993 and 86.9% in 2003. Hanzlik et al. (2009) detected a significant trend toward higher levels of evidence in an analysis of articles published in *The Journal of Bone and Joint Surgery* over a 30-year period. The combined percentage of levels I, II and III studies increased from 17% in 1975 to 52% in 2005; the percentage of level I studies alone rose from 4% in 1975 to 21% in 2005. Over the period of study, the average article level of evidence decreased (improved) from 3.72 to 2.9. A study of the facial plastic surgery literature over a 10-year period showed that the absolute number and proportion of levels 2 and 3 studies trended upward from 1999 to 2008 while the absolute number and proportion of levels 4 and 5 studies decreased significantly over the same time period (Xu et al., 2011). Finally, Zaidi et al. (2012) found that the percentage of high levels of evidence studies (levels I and II) increased from 2000 to 2010 and the percentage of low levels of evidence studies (levels III, IV and V) decreased over this 10-year time period. Overall, the results of bibliometric studies that included levels of evidence in their analyses indicated a trend towards the publication of higher level of evidence studies.

Bibliometric Analysis of the Veterinary Literature

EBM has not been as thoroughly integrated into veterinary practice, veterinary school curricula, graduate veterinary education and continuing education as it has in human medicine. One barrier that restricts the practice of EBVM is lack of sufficient high quality evidence in the field of veterinary medicine. Schulz et al. suggested that "the majority of clinically applicable studies in veterinary surgery fail to meet…even lower levels of clinical evidence" (2006, p. 697). In the *Handbook of Evidence-Based Veterinary Medicine*, Cockcroft and Holmes claimed that "The main differences between the practice of EBM in veterinary medicine and human medicine lie in the emphasis we necessarily place in evaluating poorer sources of evidence" (2003, p. 15). While there is a perceived paucity of high quality evidence in veterinary medicine, few studies have quantitatively characterized the type of studies that are published in the veterinary literature.

The bibliometric studies of the veterinary literature that have been published evaluated different aspects of the literature including: a single journal (Arya, 2012; Carreño, Poutou-Piñales, Mattar, & González T, 2009; Crawley-Low, 2006; Rojas-Moreno, Cásares, Viloria, & Chaparro-Martínez, 2013a, 2013b); a particular specialty or topic (Arlt et al., 2010; Chen et al., 2012; Jansson & Harris, 2013; Sahora & Khanna, 2010; Sanz-Casado, Pau, Suárez-Balseiro, Iribarren-Maestro, & Pedro-Cuesta, 2006; Simoneit et al., 2011) or a specific type of literature (Pelzer & Wiese, 2003). Like bibliometric studies of the human health sciences literature, studies of the veterinary literature utilized different methodologies to acquire a representative sample of articles and evaluate the characteristics of those articles.

Several studies have examined authorship trends in veterinary medicine. Elsinghorst (2005) recorded the country of the first author for the 96 most frequently cited articles published in veterinary journals from 2002 to 2003. Twenty-four countries were represented, with the first author of 35.4% of the articles from the United States and the first author of another 15.6% of the articles from England. The other most frequently represented countries in this study were Canada (6.2%), Denmark (4.2%) and Spain (4.2%). In 2006, Hruska evaluated articles published by persons associated with the Veterinary Research Institute in Brno, Czech Republic and noted that 31 countries were represented among the 277 papers published between 2001 and 2005 with Germany, the

United States and Hungary the countries with which the authors collaborated most frequently. Jansson and Harris (2013) reviewed the literature on nutrition of the exercising horse from 1970 to 2010 and reported that seven of the top eleven authors, with respect to number of publications, were from the United States and one was from the United Kingdom. Five of the top ten affiliations, with respect to number of publications, were located in the United States and two were in the United Kingdom. A more recent study (Christopher & Marusic, 2013), which focused on geographic trends in research output and citations in veterinary medicine, discovered that the United States accounted for the highest percentage (17.7%) of articles published in veterinary journals indexed in the Scopus database in 2010, followed by the United Kingdom, India, Germany, Brazil, Canada, France, Turkey and Japan. China had the highest relative increase in articles published from 21 in 1996 to 602 in 2010, a 2,767% increase in article output over the 15-year period of study. Both Hruska (2006) and Christopher and Marusic (2013) utilized a single citation and abstract database, Web of Science and Scopus, respectively, to obtain articles that met their inclusion criteria. In 2012, Arya and Sharma (2012) utilized another citation and abstract database, CAB Abstracts, which is recognized as providing the best overall coverage of the veterinary literature (Grindlay, Brennan, & Dean, 2012; Murphy, 2007), to acquire articles published by veterinarians from 2006 to 2010. This study evaluated authorship trends in the veterinary literature and found that 83.55% of the 97,740 articles included in the analysis had multiple (more than one) authors, with almost a quarter (24.4%) of articles having six or more authors. The average degree of collaboration over the 5-year period was 0.84. Arya (2012) obtained similar results from an analysis of articles published in the *Indian Journal of Veterinary*

Medicine from 1999 to 2007. In this study, 95.5% of the included articles had more than one author, and 38.26% of the articles had three or more authors. The degree of collaboration over the 9-year period was 0.96. The average number of authors per article increased from 3.02 in 1999 to 3.27 in 2007 (Arya, 2012). A bibliometric analysis of articles published in *Revista de la Facultad de Ciencias Veterinarias de la Universidad Central de Venezuela* between 2002 and 2011 reported an average of 4.06 signatories per article (Rojas-Moreno et al., 2013a).

Sahora and Khanna (2010) evaluated author affiliation, but not number of authors per article, in their study of veterinary oncology articles published in *JVIM* and seven other human medical journals from 1999 to 2007. An overwhelming majority of the articles (82%) published in *JVIM* were from authors with academic affiliations while only 43% of the articles published in the human medical journals were from academic institutions. Twelve percent of the articles published in *JVIM* were the result of collaboration between academic and private practice groups while 43% of the articles published in the human medical journals were the result of such collaborations. A content analysis of articles published in the *Journal of Veterinary Medical Education* from 1974 to 2004 revealed a similarly high percentage of articles with authors who were associated with academic institutions (94% of the 168 articles included in the analysis) (Olson, 2011). The *Journal of Veterinary Medical Education* is the official publication of the Association of American Veterinary Medical Colleges and aims to encourage the improvement of veterinary medical education (Olson, 2011). Thus, it is not unexpected that the majority of articles published in this journal were authored by persons with an academic affiliation. The content analysis of this journal also showed a significant increase in the median number of authors per article over time. A recent study of 209 companion animal (dog and cat) articles published in five veterinary journals found that the number of authors per article ranged from 1 to 13, with a median of 4 authors per article (Giuffrida & Brown, 2012). The majority of the 209 articles included in the analysis (80.9%) were conducted exclusively at academic institutions. Bibliometric studies suggest that multi-authorship and affiliation with an academic institution in the United States are common characteristics of articles published in the veterinary literature.

Species of interest, an article variable unique to the veterinary literature, has been evaluated in two bibliometric studies of this literature. In their 2010 analysis of the veterinary oncology literature, Sahora and Khanna reported that 74% of the articles from *JVIM* investigated canine cancer, 16% investigated feline cancer and 6% investigated equine cancer. The search for veterinary oncology articles in seven human medical journals was limited to canine or feline patients; the majority of articles (84%) from these journals addressed cancer in the canine patient, with only 11% of the articles discussing feline cancer. Giuffrida and Brown (2012) limited their bibliometric analysis to articles "in which client-owned companion animals were the primary study subject" (p. 253). The majority (74.6%) of the 209 articles included in the study had canine subjects, with only 19% of the articles having feline subjects and 6.2% have both canine and feline subjects. Christopher and Marusic (2013) did not evaluate individual articles, but they did determine the percentage of articles published in species-specific journals for each country and world region over a 15-year period. Worldwide, 31.1% of veterinary articles were published in species-specific journals. More than half (50.4%) of these articles were published in food animal journals, 30.9% were in small animal journals and 22.5%

were in equine journals. Western Europe and North America combined to publish 64% of the articles in food animal journals, 80.1% of the articles in small animal journals and 77.3% of the articles in equine journals. Africa had the highest proportion of articles in food animal journals as a percentage of regional output.

The Sahora and Khanna (2010) study was the only bibliometric analysis of the veterinary literature to evaluate clinical condition. The analysis found that the top seven diseases in the veterinary oncology literature in *JVIM* from 1999 to 2007 were: lymphoma (25%), hemangiosarcoma (6%), osteosarcoma (6%), mast cell tumors (5%), mammary tumors (5%), melanoma (4%) and brain tumors (4%). Multiple cancer types (19%), lymphoma (11%) and osteosarcoma (11%) were the most frequently addressed types of cancer in veterinary oncology articles published in seven human medical journals. The authors noted that this pattern was not unexpected because lymphoma, hemangiosarcoma, osteosarcoma, mast cell tumors, mammary cancer, brain tumors and melanomas are among the most prevalent types of cancer in veterinary patients, in particular the dog. The bibliometric study of the companion animal literature published in five veterinary journals (Giuffrida & Brown, 2012) did not examine specific clinical conditions, but the authors did place each article into a subspecialty category. The eight categories with ten or more articles each were: internal medicine (44 articles), oncology (32), general surgery (25), cardiology 922), infectious disease (21), orthopedics (16), neurology (14) and dermatology (12).

Only one bibliometric analysis of the veterinary literature evaluated purpose of study. In their bibliometric study of the companion animal literature, Giuffrida and Brown (2012) discovered that therapeutic studies were the most common type of study, representing 41.1% of the 209 articles included in the analysis. This finding is similar to bibliometric studies of the human health sciences literature. Description of disease studies, which were defined as “reports of disease or health states that do not seek to test a specific hypothesis” (Giuffrida & Brown, 2012, p. 254), were also common at 30.1% of the included articles.

A few studies of the veterinary literature have included study design and/or timing in their analyses. In one study (Sahora & Khanna, 2010), the most common study design for oncology articles published in *JVIM* over a 9-year period from 1999 to 2007 was the case series (40%), followed by pathobiologic studies (27%) and case reports (13%). The percentage of review articles published in *JVIM* decreased from 10% in 1999 to 0% in 2007; there were no other notable changes in study design over the period of study. The majority of articles published in *JVIM* (58%) were retrospective studies. When evaluated in 3-year time periods, the percentage of prospective studies increased from 29% of articles from 1999 to 2001 to 44% of articles from 2005 to 2007, with a slight decrease in the intervening three-year time period (25% from 2002 to 2004). Case series and pathobiologic studies were the most common study designs for veterinary oncology articles published in seven human medical journals at 38% and 41%, respectively. The percentage of RCTs was higher for articles published in the human medical journals (14%) than for those published in *JVIM* (1%). All articles published in the human medical journals were prospective in design. Giuffrida and Brown (2012) evaluated study timing and found that 45.5% of the articles included in their analysis were retrospective in nature.

Two studies that considered study design utilized a 40-item, Likert-based questionnaire to evaluate article quality in five categories: materials and methodology, study design, statistics, presentation and information content, and applicability and conclusions (Arlt et al., 2010; Simoneit et al., 2011). In the earlier study (Arlt et al., 2010), the authors searched PubMed and the Veterinary Science database to find articles published between 1996 and 2006 on canine reproduction. The majority of the 287 articles included in the analysis were case reports (67.9%), with RCTs comprising only 7.3% of the articles. This study was later replicated to include articles on bovine, equine and canine reproduction published from 1999 to 2008 (Simoneit et al., 2011). The predominant study design overall was the ‘not experimental descriptive trial’, in other words case series or observational studies, at 43.3% of the 268 articles included in the study. Twenty-one percent of the included articles were RCTs. The number of case or personal reports on dogs was significantly higher (19 articles) than it was for either cattle (0) or horses (11).

Levels of evidence systems have not been as widely accepted in the veterinary literature as they have been in the human health sciences literature. Thus, few bibliometric studies of the veterinary literature have included this variable in their analyses. The Sahora and Khanna (2010) study utilized a modified OCEBM levels of evidence system to classify each article included in their study. Pathobiologic studies were classified as either pathobiology study type III or pathobiology study type IV, and these two categories were considered separate from the other categories. Like studies in the human medical literature, level IV was the predominant level of evidence with 41% of the articles published in *JVIM* falling into this category. The other two most frequently occurring levels were level V and pathobiology level IV at 20% and 19% of the articles, respectively. The percentage of level V articles declined from 31% from 2002-2004 to 13% from 2005 to 2007. No level I studies were present among the articles included in the analysis. The authors did not report levels of evidence for articles published in the human medical journals because the majority of these studies focused on cancer biology. Giuffrida and Brown (2012) also assigned a level of evidence to articles included in their study of the companion animal literature. These authors adapted the system from the American Academy of Orthopedic Surgeons, which was itself revised from *The Journal of Bone and Joint Surgery* system. The majority of studies were classified as level 4 (70.8%), with 4.3% of studies classified as level 1. Trend analysis could not be performed for the data gathered in this bibliometric analysis because articles were only obtained for a single year of publication (2004).

Methods

The purpose of this bibliometric analysis was to evaluate publication trends in *JVIM* over a 15-year time period, and thereby provide an assessment of how the evidence base and authorship has changed in this journal since the first mention of EBM in the veterinary literature in 1998. This journal was selected for its importance within the specialty of veterinary internal medicine and beyond, to the general practice of veterinary medicine. *JVIM* is the official publication of the American College of Veterinary Internal Medicine (ACVIM), the European College of Veterinary Internal Medicine-Companion Animals (ECVIM-CA), the European College of Veterinary Neurology (ECVN) and the European College of Equine Internal Medicine (ECEIM) ("Journal of Veterinary Internal Medicine," 2014). The ACVIM is the national certifying organization for veterinarians who have completed graduate medical education, and passed examinations, in one of the following specialties: cardiology, large animal internal medicine, neurology, oncology, or small animal internal medicine. The ACVIM is the veterinary specialty organization with the largest number of active board-certified diplomates ("Market research statistics - Veterinary specialists - 2013," 2013). A group of medical librarians ranked *JVIM* third on the most recent edition of the 'Basic List of Veterinary Medicine Serials', a core list of veterinary publications that ranks journals according to five criteria: indexing coverage; scholarly ranking from two sources, Journal Citation Reports and SCImago Journal Rank; inclusion on a recommended reading list from a veterinary specialty board and librarian ranking (Ugaz, Boyd, Croft, Carrigan, & Anderson, 2010). In the 2012 Journal Citation Reports (2013), *JVIM* had an impact factor of 2.064, which placed the journal 13th when the 143 journals in the 'Veterinary Sciences' subject category were ranked according to impact factor.

The year 1998 was selected as a starting point because this was the year that the term EBM first appeared in the veterinary literature, in a series of letters published in *The Veterinary Record* (Schmidt, 2007). Examining articles from this year established the state of research in veterinary internal medicine prior to the recognition of EBM. One of the first mentions of the phrase 'evidence-based veterinary medicine' in the veterinary literature occurred in an editorial in *JVIM* in 2000 (Keene). Major changes transpired at *JVIM* in 2008 when the journal transferred all publishing responsibilities to Wiley-Blackwell. At that time, the co-editors-in-chief of the journal reminded readers that a primary objective of the ACVIM was: "encouraging research and other contributions to knowledge relating to diagnosis, therapy, prevention and control of animal diseases, and promoting communication and dissemination of this knowledge" (Hinchcliff & DiBartola, 2008, p. 1). In a new set of editorial policies, introduced in 2010 , the co-editors-in-chief of *JVIM* wrote "there will be a higher bar for quality of studies acceptable for publication in the journal based on an assessment of their utility in forming evidence-based medicine decisions..." (Hinchcliff & DiBartola, p. 8).

All articles published in *JVIM* in the years 1998, 2003, 2008 and 2013 were considered for inclusion in the study. All issues from the selected years, except a single supplemental issue from 2013, were reviewed online through the Wiley Online Library, which was accessed through the University of North Carolina at Chapel Hill University

Libraries' electronic resources and provided full access to all issues of the journal from 1987 to the present. Articles found under the headings of review, original or standard articles, and case reports were included in the study. Articles found under the headings of consensus statement, clinical vignettes, brief communications, conference abstracts, editorials, letters to the editor or other correspondence, erratum, news of the College and books review were excluded from the study. For each issue, the total number of articles and number of included articles were recorded. The title, author(s), author affiliation, abstract and when necessary, full text, of the articles selected for inclusion were examined and the following information extracted and recorded in a Microsoft Excel® spreadsheet: number of authors, author affiliation, species investigated, purpose of study, study design, and clinical condition.

The affiliation of each article was recorded as country and type of institution, where type of institution was classified as private practice, academia, or mixed (Sahora & Khanna, 2010). The country category was open-ended; each country reported in the author affiliation details of an article was recorded once. A country was entered into the spreadsheet only one time for each article, even if multiple authors came from different institutions within the same country. Some investigators have chosen to only record the country of origin of the first author, which does not accurately capture the geographic diversity and collaboration between authors who publish in a particular journal or specialty (Elsinghorst, 2005; Hayden & Saulsbury, 1982). Other investigators have recorded the country of origin for all authors on an article, which provides a full description of authorship in a journal or specialty, but is time-consuming data to collect. The method selected for this study was a compromise between completely capturing author affiliation and expedient recording of data. For the purposes of this study, academia was defined as any postsecondary institution included in the Database of Accredited Postsecondary Institutions and Programs from the U.S. Department of Education (2013). Academic affiliations outside of the United States were evaluated on an individual basis according to the standards of the country in which the institution was located. Private practice was any veterinary hospital or research facility that was not associated with an academic institution. The private practice category was a heterogeneous one that included institutions owned or operated by the state or federal government, a for-profit corporation, or individuals. Mixed affiliation was at least one coauthor from an academic institution and another from private practice. The sites where the studies were performed were not recorded. The number of multicenter studies could be inferred from the number of studies with authors from more than one country and the number of studies designated ‘mixed’. However, such an inference would not provide an accurate description of the number of multicenter studies because a study may be conducted at multiple academic institutions located in one country, or an author may contribute to a study, but not be involved in data collection as his or her own institution. Therefore, the number of multicenter studies was not evaluated in this study.

The species investigated was categorized according to data collected from, or referring to, one of the following categories: canine, feline, equine, bovine, ovine, caprine, porcine, camelid, multispecies or nonspecific (see Appendix A for definitions). This category permitted only one selection per article. Exotic species were not considered in the coding scheme because it was highly unlikely that an article in *JVIM* would address these species as it is outside the editorial purview to do so.

The purpose of study was the primary intent of the research. Each article was placed into one of the following categories for purpose of study: anatomy/physiology, etiology, prognosis, diagnosis, treatment, prevention, description of disease, or metric. Purpose of study was determined according to the definitions provided by Coronado et al. (2011) (see Appendix B for complete definitions). Clinical condition was the primary diagnosis or pathology of the subjects investigated in the article. This category was open-ended (Coronado, Wurtzel, et al., 2011). An effort was made to choose a single term that best described the clinical condition of all patients included in the study. The term 'nonspecific' was used for articles in which the study population was sick animals with no further description of disease. The term 'not applicable' was used to describe articles in which the study population consisted solely of healthy animals or for review articles that did not describe a specific disease. Upon completion of data collection, the entries in this category were reviewed and similar terms for a single condition were merged to reduce redundancy and provide a concise list of the most common conditions over the period of study.

The study design of each article was recorded as one of the following: meta-analysis, systematic review, nonsystematic review, RCT, other clinical trial, cohort, case-control, cross-sectional, case series, case report or nonclinical experiment (see Table C1). Articles were placed in a study design category based upon definitions compiled from several sources (Bentsianov et al., 2002; Dekkers, Egger, Altman, & Vandenbroucke, 2012; "Glossary of Terms in the Cochrane Collaboration ", 2005; "Guidelines for preparation of manuscripts submitted to the *Journal of Veterinary Internal Medicine*," 2013; Law & Howick, 2013; Mann, 2003; McDermott et al., 1995; Merenstein et al., 2003; Rigatto & Barrett, 2009; Sahora & Khanna, 2010) and a modified study design decision tree ("Centre for Evidence Based Medicine," 2013; Coronado, Riddle, et al., 2011; Grimes & Schulz, 2002; Kleinbaum, Sullivan, & Barker, 2007) (see Figure C1). While the authors' description of their study design was used to guide classification, articles were classified according to the aforementioned standards and not the authors' designation because authors may have misidentified their own study design (Grimes, 2009; Koletsi, Pandis, Polychronopoulou, & Eliades, 2012a, 2012b), or utilized different definitions for study design than those used for the purposes of this study.

Statistical analysis for descriptive information was conducted using JMP® 10.0.1 for Windows (SAS Institute Inc., Cary, NC) and Microsoft Excel® 2010 (Redmond, WA). Nominal data was reported as counts and frequencies for each year and overall. The number of authors per article was reported as mean values for each year and overall. Author country was reported as counts and frequencies for each country, calculated out of the total number of included articles. The number and frequencies of articles with at least one author from the United States and no authors from the United States were reported for each year and overall. The number and frequencies of articles with authors from more than one country (international collaboration) were recorded for each year and overall.

Results

A total of 598 articles were reviewed for inclusion in the study. Five hundred and six articles met the inclusion criteria; three articles, two in vitro studies and a review of the quality of reporting in the small animal literature, were later excluded for a total of 503 articles included in the study. The mean number of authors per article increased over the period of study from 4.29 in 1998 to 5.97 in 2013, as shown in Table 1.

Table 1

Number of Articles Published and Mean Number of Authors per Article in the Journal of Veterinary Medicine *in Four Select Years over a 15-Year Period*

	1998	2003	2008	2013	Total
Total no. of articles published	74	138	169	217	598
Total no. of articles included	61	115	149	178	503
Mean no. of authors per article	4.29	4.95	5.68	5.97	

The authors of the articles included in this study represented 30 countries (see Table 2 and Figure 1). Seventy percent of the articles had at least one author who was associated with an institution or practice in the United States. Other countries with which authors were frequently associated included the United Kingdom (10.7%), Canada (5.4%), Germany (5.4%) and the Netherlands (4.2%). The percentage of articles with at least one author based in the United States decreased over the period of study from 86.9% in 1998 to 65.2% in 2013. The percentage of articles with authors from more than one country increased over the period of study from 6.6% in 1998 to 24.2% in 2013.

Table 2

Author Affiliation by Country for 503 Articles Published in the Journal of Veterinary Internal Medicine *in Four Select Years over a 15-Year Period*

Country	*N*	*%*
Australia	13	(2.6)
Austria	1	(0.2)
Belgium	12	(2.4)
Brazil	2	(0.4)
Canada	27	(5.4)
China	1	(0.2)
Columbia	1	(0.2)
Croatia	1	(0.2)
Denmark	12	(2.4)
Finland	3	(0.6)
France	14	(2.8)
Germany	27	(5.4)
Greece	1	(0.2)
Iran	2	(0.4)
Israel	2	(0.4)
Italy	13	(2.6)
Japan	13	(2.6)
Netherlands	21	(4.2)
New Zealand	2	(0.6)
Norway	7	(1.4)
Portugal	1	(0.2)
Slovenia	3	(0.6)
South Africa	4	(0.8)
South Korea	6	(1.2)
Spain	8	(1.6)
Sweden	16	(3.2)
Switzerland	17	(3.4)
Turkey	2	(0.4)
United Kingdom	54	(10.7)
United States	352	(70.0)

In each of the four years examined, authors were most commonly associated with an academic institution, followed by a mixed association and private practice (see Table 3 and Figure 2). The percentage of papers with a mixed author affiliation increased over the 15-year time period, with a corresponding decrease in both academic and private affiliations.

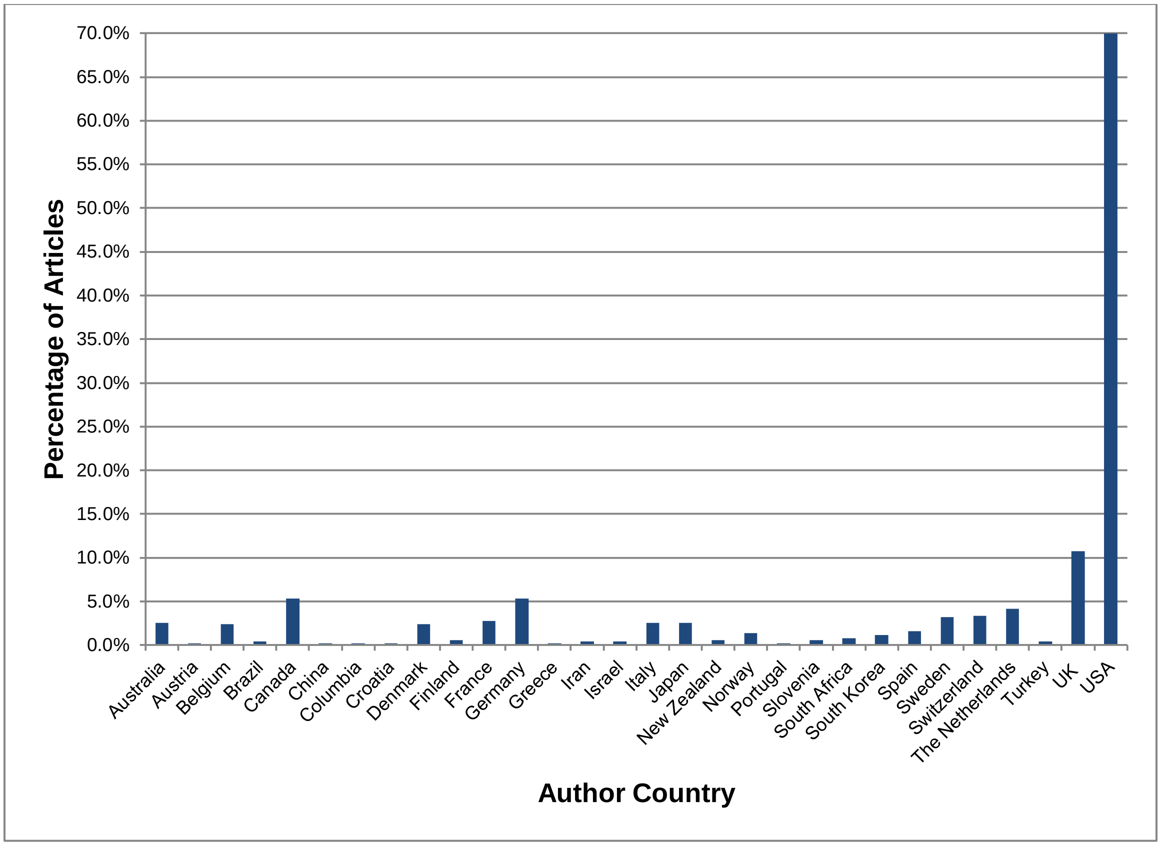

Figure 1. Graph depicting author country as a percentage of total articles (*N* = 503). Percentages total more than 100% because more than one entry per article was permitted for this category. Each country that appeared in the author affiliation details was recorded once, even if multiple authors came from the same country.

Table 3

Author Affiliation by Type of Institution for 503 Articles Published in the Journal of Veterinary Internal Medicine *in Four Select Years over a 15-Year Period*

	1998		2003		2008		2013		Total	
Affiliation	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Academic	45	(73.8)	90	(78.3)	104	(69.8)	116	(65.2)	355	(70.6)
Private	4	(6.6)	4	(3.5)	4	(2.7)	1	(0.6)	13	(2.6)
Mixed	12	(19.7)	21	(18.3)	41	(27.5)	59	(33.1)	133	(26.4)

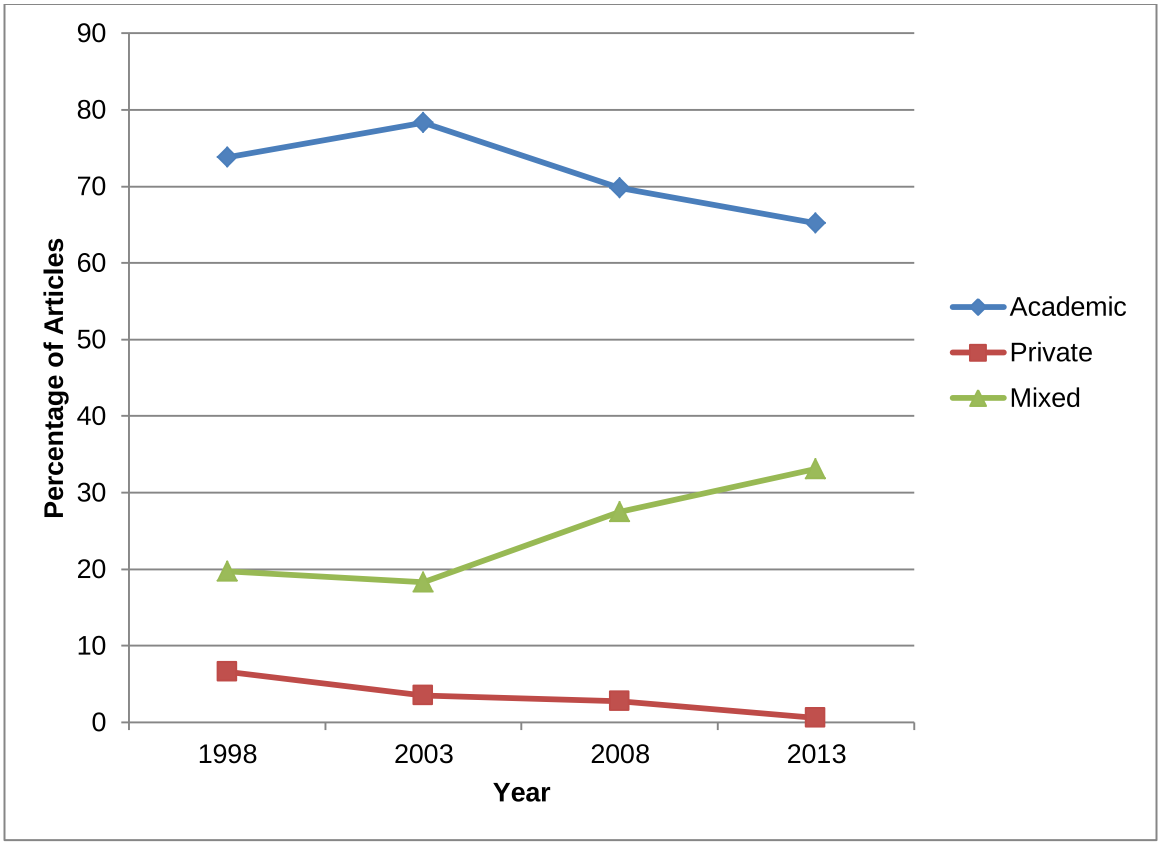

Figure 2. Graph depicting author affiliation by type of institution as a percentage of yearly article totals.

Dogs were the most frequently investigated species each year and in total, followed by horses and cats, as shown in Table 4. Overall, 53.5% of the articles included in the study investigated dogs, 20.7% investigated horses and 13.9% investigated cats, with each of the remaining categories in this domain comprising a small percentage of the total. No studies investigated goats. Figure 3 and Figure 4 show that the frequencies for species investigated did not change over the four years selected for this study.

Table 4

Species Investigated for 503 Articles Published in the Journal of Veterinary Medicine *in Four Select Years over a 15-Year Period*

	1998		2003		2008		2013		Total	
Species	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Canine	32	(52.5)	62	(53.9)	82	(55.0)	92	(51.7)	269	(53.5)
Feline	8	(13.1)	14	(12.2)	22	(14.8)	26	(14.6)	70	(13.9)
Equine	11	(18.0)	27	(23.5)	31	(20.8)	35	(19.7)	104	(20.7)
Bovine	4	(6.6)	2	(1.7)	7	(4.7)	9	(5.1)	22	(4.4)
Ovine	0	(0.0)	2	(1.7)	1	(0.7)	2	(1.1)	5	(1.0)
Caprine	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Porcine	1	(1.6)	0	(0.0)	0	(0.0)	0	(0.0)	1	(0.2)
Camelid	0	(0.0)	2	(1.7)	0	(0.0)	4	(2.2)	6	(1.2)
Multispecies	4	(6.6)	3	(2.6)	6	(4.0)	4	(2.2)	17	(3.4)
Nonspecific	1	(1.6)	3	(2.6)	0	(0.0)	5	(2.8)	9	(1.8)

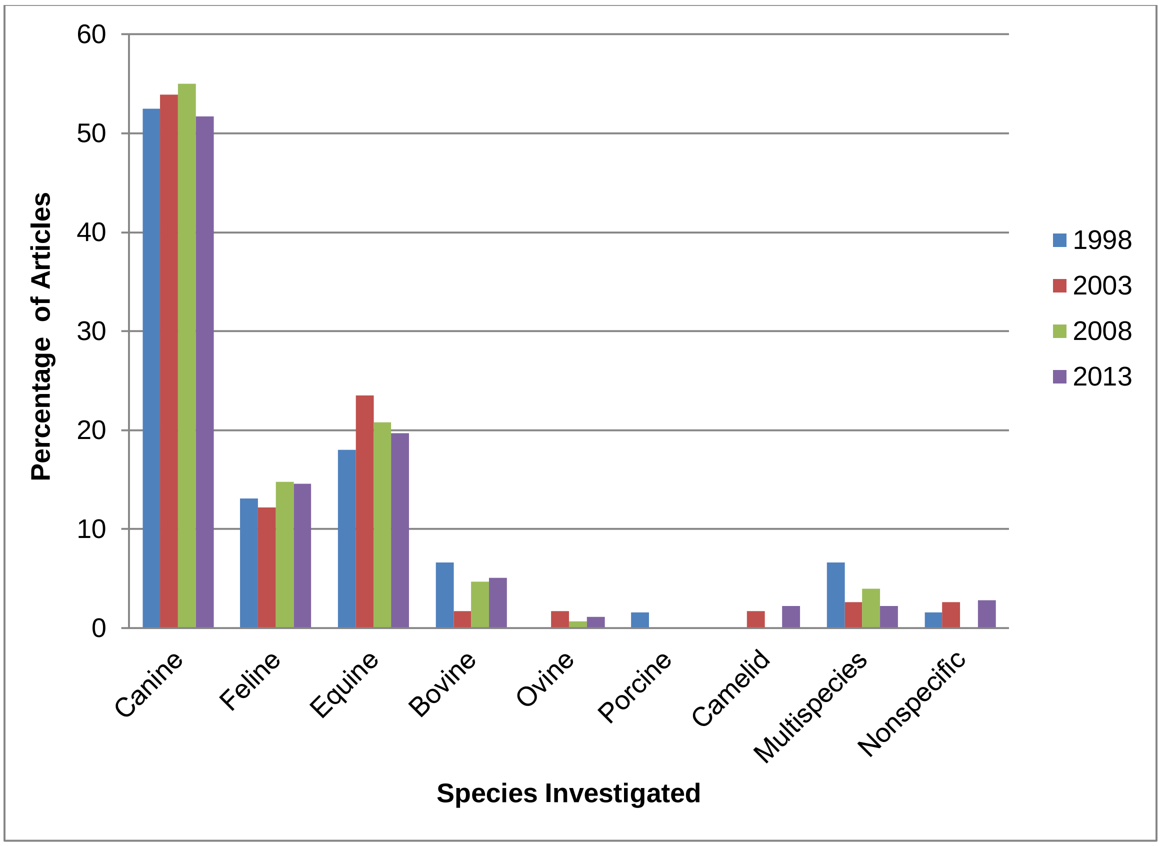

Figure 3. Graph depicting species investigated as a percentage of yearly article totals. Caprine omitted from graph because none of the included articles investigated this species.

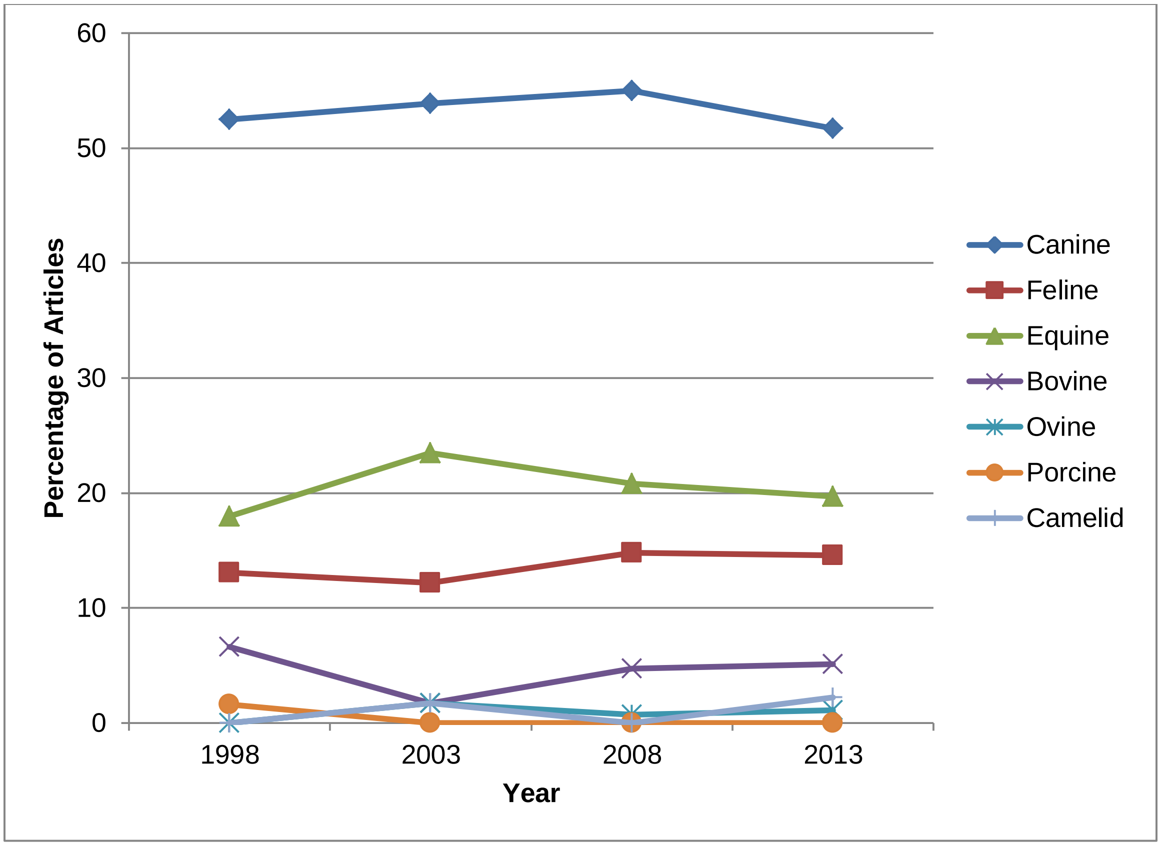

Figure 4. Graph depicting species investigated as a percentage of yearly article totals. Caprine omitted from graph because none of the included articles investigated this species. Multispecies and nonspecific omitted from graph to preserve readability.

The most frequent purpose of study overall was description of disease at 21.7% of the 503 articles included in the study (see Table 5, Figure 5 and Figure 6). Description of disease was the predominant purpose of study in 1998 (34.4%) and 2003 (27.8%), but declined in 2008 and 2013, with treatment becoming the most frequent purpose of study in 2008 (23.5%) and anatomy/physiology the most frequent purpose of study in 2013 (18.0%). The least frequent purpose of study each year and overall was prevention at 1.6% of the total articles.

Table 5

Purpose of Study for 503 Articles Published in the Journal of Veterinary Medicine *in Four Select Years over a 15-Year Period*

	1998		2003		2008		2013		Total	
Purpose	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Anatomy[a]	6	(9.8)	14	(12.2)	20	(13.4)	32	(18.0)	72	(14.3)
Etiology	5	(8.2)	16	(13.9)	21	(14.1)	19	(10.7)	61	(12.1)
Prognosis	7	(11.5)	10	(8.7)	15	(10.1)	11	(6.2)	43	(8.5)
Diagnosis	5	(8.2)	13	(11.3)	24	(16.1)	27	(15.2)	69	(13.7)
Treatment	9	(14.7)	16	(13.9)	35	(23.5)	30	(16.8)	90	(17.9)
Prevention	0	(0.0)	3	(2.6)	0	(0.0)	5	(2.8)	8	(1.6)
Description[b]	21	(34.4)	32	(27.8)	25	(16.8)	31	(17.4)	109	(21.7)
Metric	8	(13.1)	11	(9.6)	9	(6.0)	23	(12.9)	51	(10.1)

[a]Anatomy/physiology. See Table B1 for complete definitions.
[b]Description of disease. See Table B1 for complete definitions.

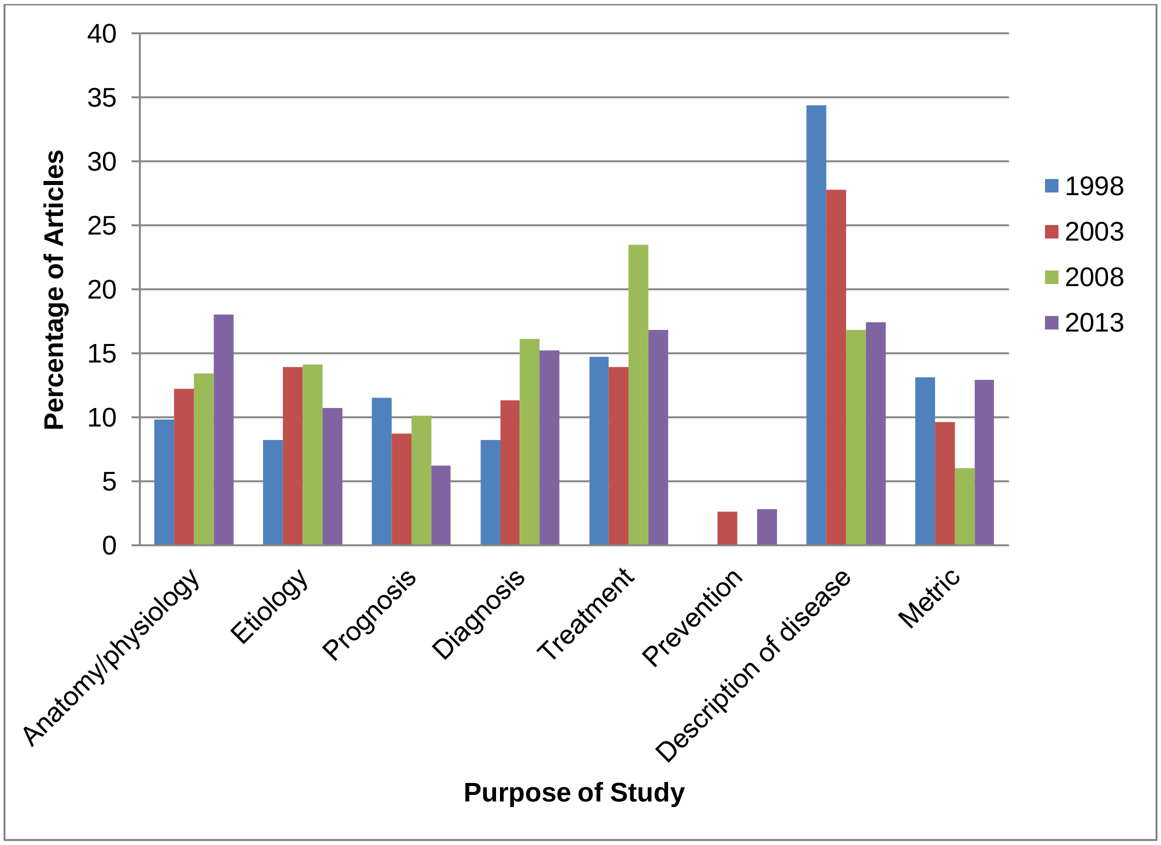

Figure 5. Graph depicting purpose of study as a percentage of yearly article totals.

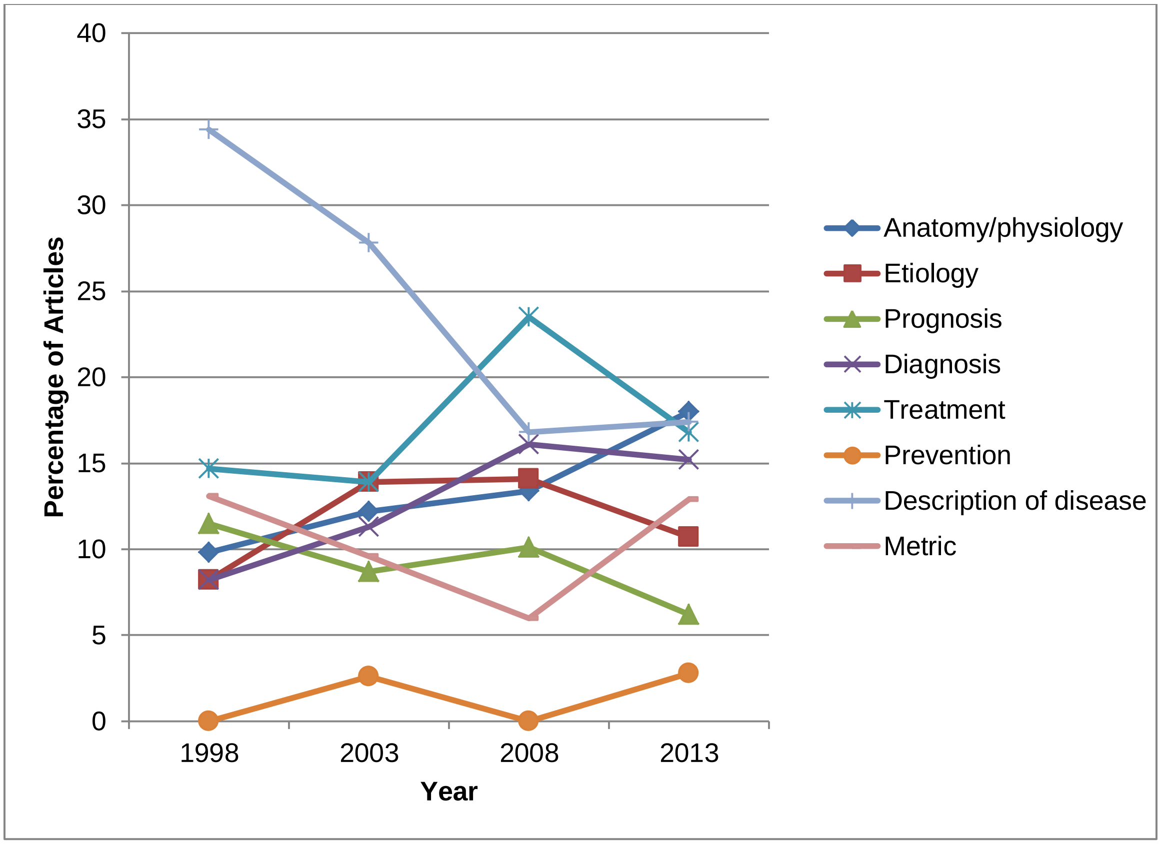

Figure 6. Graph depicting purpose of study as a percentage of yearly article totals.

The study designs for articles published in 1998, 2003, 2008 and 2013 are shown in Table 6, Figure 7 and Figure 8. In 1998, the most frequent study designs were the case series (22.9%) and the case report (18.0%). By 2013, the percentage of case series and case reports had declined to 10.1% and 6.2%, respectively. In this year, cohort and case-control were the most frequent study designs at 18.5% and 16.8% of the articles published, respectively. RCTs represented 8.1% of the articles published in 1998 and 9.5% of the articles published in 2013, with a decline in the percentage of RCTs in the intervening years. No meta-analyses or systematic reviews were published in 1998, 2003 and 2008 and only two articles of each study design were published in 2013. The percentage of nonclinical experiments did not change over the 15-year study period and overall, represented 12.5% of the 503 articles included in the study.

Table 6

Study Designs for 503 Articles Published in the Journal of Veterinary Medicine *in Four Select Years over a 15-Year Period*

	1998		2003		2008		2013		Total	
Study Design	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Meta-analysis	0	(0.0)	0	(0.0)	0	(0.0)	2	(1.1)	2	(0.4)
Systematic review	0	(0.0)	0	(0.0)	0	(0.0)	2	(1.1)	2	(0.4)
Nonsystematic review	6	(9.8)	9	(7.8)	3	(2.0)	9	(5.1)	27	(5.4)
Randomized controlled trial	5	(8.1)	4	(3.5)	5	(3.4)	17	(9.5)	31	(6.2)
Other clinical trial	0	(0.0)	0	(0.0)	7	(4.7)	6	(3.4)	13	(2.3)
Cohort	8	(13.1)	22	(19.1)	37	(24.8)	33	(18.5)	100	(19.9)
Case-control	7	(11.5)	15	(13.0)	30	(20.1)	30	(16.8)	82	(16.3)
Cross-sectional	3	(4.9)	12	(10.4)	14	(9.4)	21	(11.8)	50	(9.9)
Case series	14	(22.9)	18	(15.6)	19	(12.7)	18	(10.1)	69	(13.7)
Case report	11	(18.0)	21	(18.3)	15	(10.1)	11	(6.2)	58	(11.5)
Nonclinical experiment	7	(11.5)	14	(12.2)	20	(13.4)	22	(12.4)	63	(12.5)

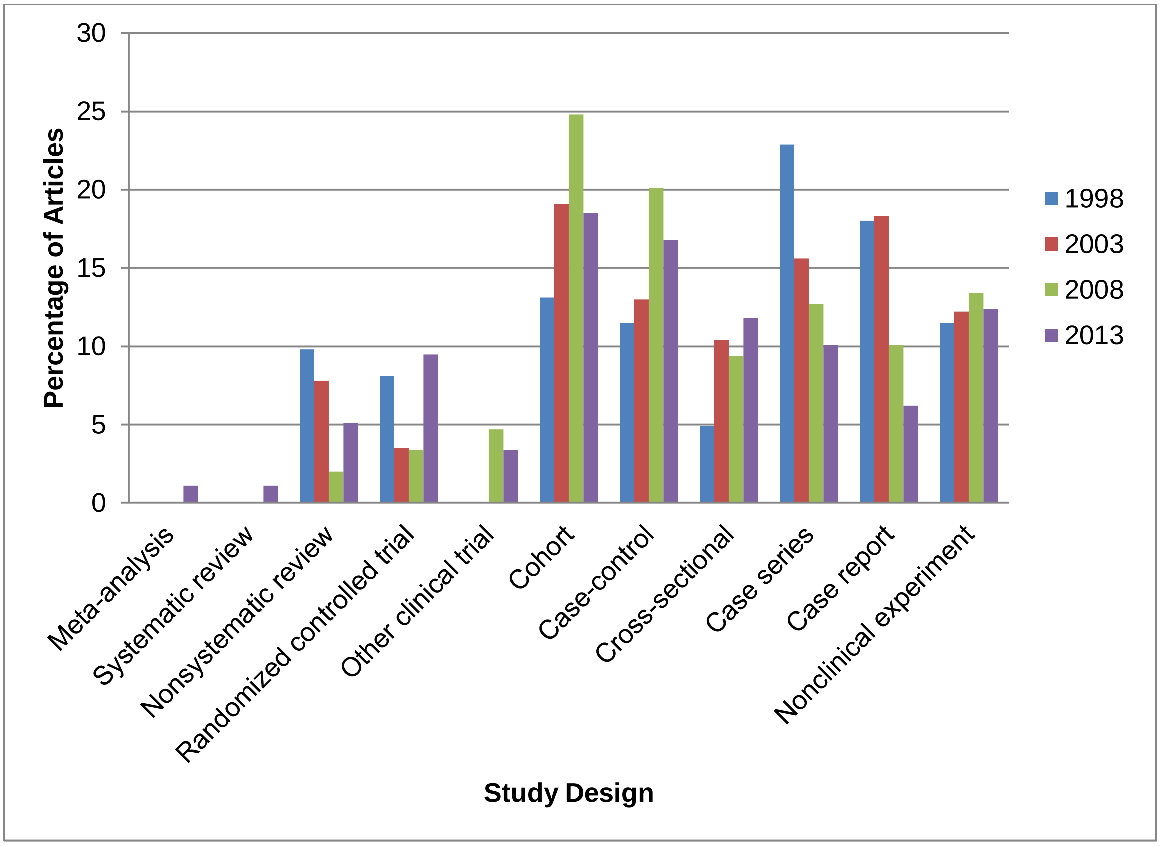

Figure 7. Graph depicting study design as a percentage of yearly article totals. Study designs displayed in order of decreasing level of evidence from left to right.

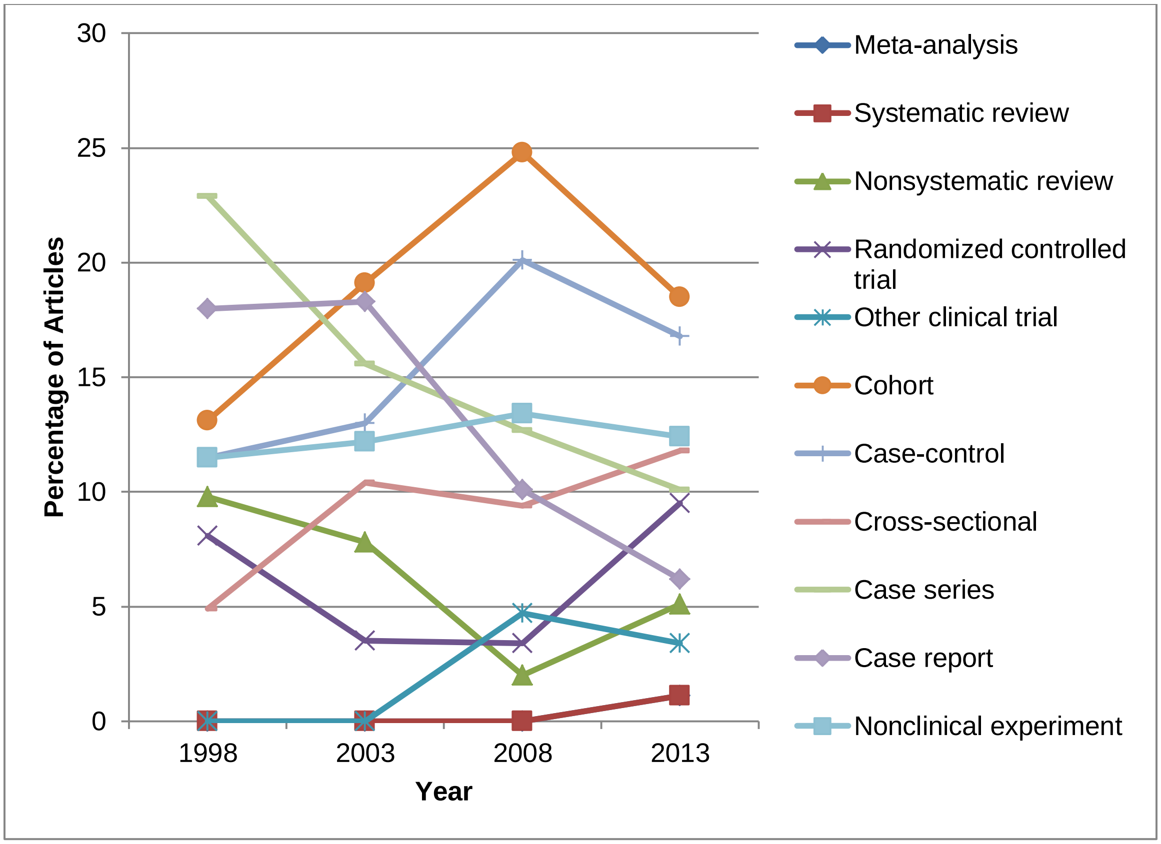

Figure 8. Graph depicting study design as a percentage of yearly article totals.

Discussion

Quantity of Articles

Five hundred and three articles published in *JVIM* over a 15-year period were analyzed for this study. The number of articles published per year increased over the period of study. This pattern has been shown in studies of the human and veterinary medical literature. In a 2009 study of articles in 91 gastroenterology journals, the number of articles published per year increased from 9,447 in 2001 to 13,340 in 2007 (Chou, 2009). A bibliometric analysis of veterinary literature indexed in the Scopus database showed an increase in the number of articles published per year from 8,815 in 1996 to 19,077 in 2010 for a net increase of 66.6% (Christopher & Marusic, 2013). In this study, the total number of articles published per year increased from 74 in 1998 to 217 in 2013 for a 65.9% increase over the 15-year study period. This increase in the number of articles published reflects a maturation of *JVIM* and the specialty of veterinary internal medicine itself. American veterinary specialty organizations have developed relatively recently. The first veterinary specialty organizations, the American College of Veterinary Pathologists and the American Board of Veterinary Public Health, were officially recognized in 1951 ("American Veterinary Medical Association," 2014). The ACVIM achieved full recognition from the American Veterinary Medical Association in 1980 and the first issue of *JVIM* was published in 1987 ("American College of Veterinary Internal Medicine," 2013). The ECVIM-CA, established in 1994 and formally recognized by the

European Board of Veterinary Specialists in 2002, is an even younger organization ("European College of Veterinary Internal Medicine - Companion Animals," 2014). Over the past several years, these organizations have gone through a period of rapid growth marked by an increase in the number of approved residency training programs and ultimately, board-certified diplomates. As of December 2013, the ACVIM had 2,490 active board-certified diplomates, the largest number of all the veterinary specialty organizations in the United States ("Market research statistics - Veterinary specialists - 2013," 2013). This increase in the number of residents and diplomates available, and in the case of residents required, to conduct and publish research is one explanation for the increase in the number of articles published in *JVIM* over the past 15 years.

Another explanation for the increase in the number of articles published over the period of study is heightened awareness of clinical research in the age of EBM. While EBM has not infiltrated the teaching and practice of veterinary medicine as thoroughly as it has in human medicine, the veterinary community, and others with a stake in human and animal health, has recognized the need for veterinary clinical researchers and the evidence that their work generates. In 2004 – 2005, a committee of stakeholders and experts in veterinary research met to discuss their vision for the future of veterinary research (Committee on the National Needs for Research in Veterinary Science, 2005). This committee issued a report that offered several recommendations to address the deficiency of clinical researchers in veterinary medicine. ACVIM diplomates have also recognized the need for clinical researchers. An editorial published in *JVIM* proclaimed that “It was the vision and intent of the ACVIM that every ACVIM diplomate would function to some degree as a veterinary clinical scientist” (Toll & Breitschwerdt, 2007, p.

364). In 2008, on the occasion of the first issue of the journal to be published by Wiley-Blackwell, the co-editors-in-chief of *JVIM* expressed their commitment to "publishing high quality, clinically relevant information pertinent to the practice of veterinary internal medicine" (Hinchcliff & DiBartola, p. 1). In a later editorial, Hinchcliff and DiBartola introduced a new set of editorial policies designed to improve the quality of the research and reporting in *JVIM* (Hinchcliff & DiBartola, 2010). In this editorial, the co-editors-in-chief explicitly stated that "there will be a higher bar for quality of studies acceptable for publication in the journal…" (Hinchcliff & DiBartola, 2010). Thus, the increase in the number of articles published per year is likely a result of the overall increase in the number of diplomates coupled with an editorial and individual commitment to clinical research in veterinary internal medicine.

Authorship

Number of authors per article. As expected, the mean number of authors per article increased over the 15-year period of study. This pattern of increasing number of authors over time has been observed in bibliometric studies of the human and veterinary medical literature (Arya, 2012; Fletcher & Fletcher, 1979; Hayden & Saulsbury, 1982; McDermott et al., 1995; Mogil et al., 2009; Olson, 2011; Rojas-Moreno et al., 2013a; Xu et al., 2011). This trend towards multi-authorship is likely the result of one or more of the following factors: availability and access to technology; the necessity of collaboration as researchers become increasingly specialized; and the ambiguous ethics of authorship.

Technology has made it possible for researchers to easily communicate and share data with one another, breaking down many of the barriers that once made multicenter studies unfeasible. Technology has also played a role in the trend toward specialization that has been seen in both human and veterinary medicine. The practice and research of internal medicine has become increasingly complex and it is no longer possible for a lone investigator to conduct a rigorous clinical study. Indeed, a clinical study often requires the unique contributions of multiple clinicians and consultation with a statistician, epidemiologist and other specialists (McDermott et al., 1995). Researchers that do choose solo authorship must accept full responsibility for their work, which can be a daunting proposition, especially when the researcher is a resident or even an intern (Frey & Frey, 1981). The final factor that has contributed to the rise in the number of authors per article over time is the ethics of authorship itself. Authors and editors have blamed the publish-or-perish environment of academia, where residents and faculty are encouraged to publish to meet the requirements for board certification and promotion, for the rise in number of authors per article (Frey & Frey, 1981; Hayden & Saulsbury, 1982; Lee, 2009). The rules governing attribution of work with an authorship credit are ill-defined and often determined by the scholarly community in the discipline in which a researcher works. Trainees may feel pressured to include senior clinicians as authors on their work as either a ‘gift’ to those clinicians or to add prestige to their work (Broad, 1981; Lee, 2009). Likewise, it may be convention within a laboratory or a department for researchers to grant their colleagues authorship credit. In 1982, Hayden and Saulsbury hypothesized that the trend toward multi-authorship, which they discovered in their bibliometric analysis of articles published in *The Journal of Pediatrics*, was a “manifestation of academic gamesmanship in a ‘publish or perish’ environment” (p. 9). These authors observed that for case reports from the most recent year included in their study (1981), there was twice the number of authors per report (4.0) as there were cases per report (2.1). The "Guidelines for Preparation of Manuscripts Submitted to the *Journal of Veterinary Internal Medicine*" (2013) indicates that for questions of authorship the journal adheres to the "Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals" from the International Committee of Medical Journal Editors. The *JVIM* guidelines require that persons included as authors on a manuscript meet the following four conditions: contributions to: the conception or design of the work, or the acquisition, analysis or interpretation of data; drafting or revising the manuscript; final approval of the peer-reviewed manuscript and acceptance of accountability for the work. These requirements, coupled with the instructions to consult the "Recommendations for the Conduct, Reporting, Editing and Publishing of Scholarly Work in Medical Journals" if authorship conflicts arise, seemingly eliminate the ambiguity and gratuitous attribution surrounding authorship, provided that authors submitting manuscripts to *JVIM* adhere to them. The increase in number of authors per article observed in this analysis of articles published in *JVIM* over a 15-year period is attributable to a combination of the proffered explanations: ease of communication and sharing of data in the digital age; the necessity of collaboration as clinical researchers become increasingly specialized; and pressures of the publish-or perish-environment. Finally, the overall increase in the number of internal medicine residents and diplomates, as discussed in the previous paragraph, likely contributed to the increase in the number of authors per article over time.

Country of origin. The authors of the articles included in this study represented 30 countries. The countries with which authors were most frequently associated were: the United States, the United Kingdom, Canada, Germany and the Netherlands. Previous analyses of the veterinary literature have shown either a predominance of American researchers, universities and institutes (Elsinghorst, 2005; Hruska, 2006; Jansson & Harris, 2013), or a predominance of countries in which the disease of interest is prevalent. For example, an analysis of articles on the small ruminant disease, Peste Des Petits Ruminant, found that India contributed the highest number of articles at 124 (36.2%), followed by England and France with 47 articles each (13.7%), Pakistan with 29 articles (8.5%), Austria with 16 articles (4.7%) and the United States with 15 articles (4.4%) (Chen et al., 2012). The authors attributed the discrepancy between the number of articles from India and the number of articles from other countries to the high number of Peste Des Petits Ruminant outbreaks in developing countries. Christopher and Marusic (2013), in their analysis of article data retrieved from the Scopus database, discovered that 193 countries in eight regions were represented among the 163,250 articles published between 1996 and 2010. North America (2 countries) and Western Europe (25 countries) accounted for 60.9% of the articles published during the period of study. It is not surprising that the authors of articles published in *JVIM*, a journal for and about the specialty of internal medicine, are based in more affluent nations where an infrastructure for training veterinary specialists and conducting research exists, and the populace can afford to visit veterinary specialists. Christopher and Marusic (2013) detected a strong correlation between Gross Domestic Product, number of articles and number of veterinary faculties.

The predominance of American authors among articles published in *JVIM* was an expected result of this analysis because the ACVIM is far older than the European Board for Veterinary Specialisation, which recognizes specialty colleges in Europe. As such, *JVIM* was originally an exclusively American journal. The journal maintains an editorial board that is based primarily in the United States, with one of two co-editor-in-chiefs and 11 of 16 associate editors located at universities in the this country. The ECVIM-CA and ECVN were officially recognized by the European Board of Veterinary Specialisation in 2002 ("European College of Veterinary Internal Medicine - Companion Animals," 2014; "European Society of Veterinary Neurology - European College of Veterinary Neurology," 2012) while the ECEIM did not achieve full recognition until 2010 ("European College of Equine Internal Medicine," 2013). *JVIM* became the official journal of the EVCN in 2001. Since the ACVIM has been certifying veterinary specialists for over 20-years longer than the European specialty colleges and the population of the United States is larger than any individual European country, the number of ACVIM diplomates is larger than the number of diplomates in the European specialty colleges. As of December 2013, the ACVIM was the largest specialty college in the United States with 2,490 active board-certified specialists ("Market research statistics - Veterinary specialists - 2013," 2013). Within the ACVIM, there are 234 cardiologists, 531 large animal internists, 248 neurologists, 332 oncologists and 1,219 small animal internists. In comparison, the European Board of Veterinary Specialisation reported that it had 283 practicing diplomates in internal medicine (companion animal), 125 in neurology and 116 in equine internal medicine for a total of 524 active diplomates certified by the European internal medicine colleges ("How many are we?," 2013). Given the significantly higher number of ACVIM diplomates, compared to the number of specialists certified by the European specialty colleges, the predominance of American authors in *JVIM* are expected.

The percentage of articles with at least one author based in the United States decreased from 1998 to 2013. This finding reflects the results of the Christopher and Marusic (2013) study which found a dramatic increase in the output of articles from Asia (net increase of 21% from 1996 to 2010), Western Europe (17.2%) and Latin America (17%) from 1996 to 2010. China had the highest relative increase in article output from 21 articles in 1996 to 602 articles in 2010 (2,767% increase), followed by South Korea with 18 articles to 354 articles (1,867% increase), Iran with 28 articles to 365 (1,207% increase) and Brazil with 162 articles to 1,458 articles (800% increase). During this same time period the article output from the United States increased 36% from 2,337 articles in 1996 to 3,179 articles in 2010. China appeared only once among the articles included in the present study while South Korea appeared six times, and Iran and Brazil each appeared twice. The infrastructure for veterinary specialty training, practice and research is not as robust in these countries as it is in the United States and Western Europe.

The percentage of articles with authors from more than one country increased over the period of study. Overall, 18.3% of the 503 articles analyzed were the product of an international collaboration. This finding is consistent with the work of Christopher and Marusic (2013) who noted that, on average, 23.0% of the articles from North America were the result of an international collaboration while other regions of the world demonstrated a higher average percentage of articles with international collaboration, including Africa (52.9%), Pacific (39.0%), Latin America (32.2%) and Western Europe (31.2%). The increasing availability of technological tools that allow researchers to communicate and share their data in a variety of ways is one explanation for the observed increase in international collaboration among authors publishing in *JVIM* over the past 15 years. Another explanation is the mobility of veterinary specialists. Veterinarians from around the world have the opportunity complete internships and ACVIM approved residencies in the United States, Western Europe and Australia. The relationships that veterinarians establish with their colleagues during specialty training endure throughout their careers. Veterinary specialists may also meet potential collaborators at conferences. Despite the predominance of authors from the United States in this analysis of articles published in *JVIM*, the decline in the percentage of articles with at least one author from the United States and the increase in the percentage of articles with authors from more than one country suggest a trend towards increasing geographic diversity in the authorship of articles published in *JVIM*. The co-editors-in-chief of *JVIM* have identified increasing geographic diversity of submissions as a measure of the journal's success (Hinchcliff & DiBartola, 2008).

Type of institution. The results of this study showed that authors of articles published in *JVIM* were most frequently associated with an academic institution, although the frequency of this affiliation declined over the period of study from 73.8% in 1998 to 65.2% in 2013. Over this period of time, there was a corresponding increase in the number of articles categorized as mixed from 19.7% in 1998 to 33.1% in 2013. Few bibliometric studies of the human health sciences literature have investigated author affiliation. An analysis of articles published in the *Journal of the Royal College of General Practitioners* and the *Journal of Family Practice* from 1977 to 1979 categorized the location of the first author as university, community hospital, practice or other (Frey & Frey, 1981). The results revealed a distinct national pattern in which authors from the United States were more likely to be located at a university (84.5%) than their British counterparts (47%). The authors of this analysis suggested that this pattern was the result of a difference in training practices and organizational culture between the two countries. The American Academy of Family Physicians offered political and organizational support to its members while the Royal College of General Practitioners provided political, organizational and research support to general practitioners. This argument does not explain the difference between academic and private affiliation observed in this study because the ACVIM, the ECVIM-CA, the ECEIM and the European Society for Veterinary Neurology, which is intertwined with the ECVN, encourage and support research in veterinary internal medicine. Indeed, the mission of the ACVIM is “to enhance animal and human health by advancing veterinary internal medicine through training, education, and discovery” ("American College of Veterinary Internal Medicine," 2013) and “the primary objectives of the ECVIM-CA are to advance companion animal internal medicine and increase the competence of those who practice it” ("European College of Veterinary Internal Medicine - Companion Animals," 2014). The ECEIM also has a commitment to “encourage research and other contributions to knowledge…and promoting communication and dissemination of this knowledge” ("European College of Equine Internal Medicine," 2013).

Giuffrida and Brown (2012), in their analysis of the companion animal literature, reported that 80.9% of the articles included in their study were conducted exclusively at academic institutions. A study of oncology manuscripts published in *JVIM* between 1999 and 2007 found that 82% of the included articles were from academic institutions, 6% were from private practices and 12% were the product of a mixed affiliation (Sahora & Khanna, 2010). This study also found that 14% and 43% of veterinary oncology articles published in other health sciences journals were from private practices and a mixed affiliation, respectively. These authors were surprised by these findings, given the increase in the number of veterinary oncologists employed in private practices. They concluded that the persistently high number of publications from academic institutions was due to the publish-or-perish environment where residents need to publish in order to achieve board certification and faculty are compelled to publish for promotion and tenure. There are additional differences between academic and private settings that could explain the scarcity of articles authored by internists in private practice. Veterinary specialists in private practice face significant barriers to conducting research, including lack of dedicated research time, insufficient human and equipment resources, and difficulty securing funding. Moreover, veterinary specialists in private practice may feel that they do not possess the knowledge and skills necessary to conduct clinical research. Veterinarians, unlike physicians, do not receive significant exposure to clinical research in either school or graduate medical education. In veterinary school, students typically have two and a half years of classroom instruction and one and a half years of clinical rotations. In contrast, some medical students have only one year of classroom instruction and spend the remainder of their time in scholarly research and clinical rotations. Prolonged classroom instruction is necessary in veterinary school because students are required to learn the fundamentals of care for all animal species, regardless of their desired career path. The North American Veterinary Licensing Examination (NAVLE), which students must pass if they wish to practice veterinary medicine, covers “all animal species commonly seen by entry level practicing veterinarians” ("National Board of Veterinary Medical Examiners," 2013). Given the amount of material that students need to learn in order to become practicing veterinarians, it would be difficult to incorporate clinical research into the veterinary school curriculum. Thus, most veterinarians are not directly involved with clinical research during veterinary school.

Veterinary clinical internships do not typically have a research component, and while completion and publication of at least one original research study is a requirement of board-certification for the majority of the veterinary internal medicine colleges ("American College of Veterinary Internal Medicine (ACVIM) General Information Guide (GIG)," 2013; "ECEIM Training Brochure," 2013; "The European College of Veterinary Internal Medicine - Companion Animals (ECVIM-CA) Information Brochure for Diplomates and Residents," 2013; "Guidelines for Admission to the Certification Examination of the European College of Veterinary Neurology," 2009), the length of veterinary residencies do not allow for either comprehensive training in clinical research or the completion of lengthy investigations. This problem has also been identified for residents in human medicine, where one group of authors observed that “Trainees lack the time and funding to conduct high-level-of-evidence studies” (Offer and Perks, as quoted in Loiselle et al., 2008, p. 210e). Few ACVIM approved residency training programs offer the option of attaining a doctorate in combination with clinical training (see Table 7).

Table 7

Number and Percentage of American College of Veterinary Internal Medicine Approved Residency Training Programs for 2013 to 2014 that Offer PhDs

	PhD Offered[a]		PhD Not Offered[b]	
Specialty	*N*	%	*N*	%
Cardiology	2	(5.1)	37	(94.9)
Large animal internal medicine	25	(53.2)	22	(46.8)
Neurology	12	(26.7)	33	(73.3)
Oncology	13	(30.2)	30	(69.8)
Small animal internal medicine	14	(21.5)	51	(78.5)
Total	66	(27.6)	173	(72.4)

Note. Source '2013-2014 Residency Training Programs', 2013, retrieved March 2, 2014 from http://www.acvim.org/.
[a]Program requires or offers option of obtaining a PhD in addition to residency training.
[b]Program does not offer option of obtaining a PhD in addition to residency training.

Residents in a private practice setting receive even less exposure to clinical research than those in an academic environment for the same reasons that board-certified specialists in private practice produce less research: lack of dedicated time and resources. Table 8 displays the number of ACVIM approved residency training programs in academia and private practice by subspecialty.

Table 8

Distribution of Primary Sites for American College of Veterinary Internal Medicine Approved Residency Training Programs for 2013 - 2014

	Academic		Private		
Specialty	*N*	%	*N*	%	Total
Cardiology	27	(69.2)	12	(30.8)	39
Large animal internal medicine	47	(100.0)	0	(0.0)	47
Neurology	26	(57.8)	19	(42.2)	45
Oncology	28	(65.1)	15	(34.9)	43
Small animal internal medicine	42	(64.6)	23	(35.4)	65
Total	170	(71.1)	69	(28.9)	239

Note. Source '2013-2014 Residency Training Programs', 2013, retrieved March 2, 2014 from http://www.acvim.org/.

Unfortunately, the increasing popularity of nonacademic residencies and careers threaten the existence of the clinical researcher because private practices do not have the infrastructure to support research (Toll & Breitschwerdt, 2007).

Several authors have extolled the benefits of involving private practitioners, both generalists and specialists, in veterinary clinical research (Faunt, Lund, & Novak, 2007; Lanyon, 2012; Ness, 2009; Vandeweerd, Gustin, et al., 2012). Academics tend to investigate the problems that are of interest to them, which are not necessarily the same as the problems that confront veterinarians in practice (Holmes, 2009). Private practitioners "own a large part of the clinical truth" and efforts should be made to capture the data that is generated in course of their daily practice (Vandeweerd, Gustin, et al., 2012). Furthermore, pet owners may be more likely to enroll their pets in clinical studies if the request to do so comes from a veterinarian with whom they have an established relationship. Lanyon proclaimed:

> …the main responsibility for the conduct of the veterinary profession is where the majority of veterinary work is done – by veterinarians, veterinary nurses and practice managers in commercial practices, in contact with the predominant caseload and the public that owns it. (2012, p. 129)

According to market research statistics from the American Veterinary Medical Association, approximately 61.3% of veterinary positions in the United States are in private practice ("Market research statistics - US veterinarians - 2013," 2014) and with only 28 veterinary schools in the United States, it is reasonable to assume that private practitioners see the majority of veterinary patients. Unfortunately, private practitioners may not have either the skills or the data-collecting systems necessary to conduct clinical research. In an attempt to address the lack of research experience amongst private practitioners, the Cambridge Infectious Disease Consortium in England established an outreach program, which allows private practitioners to work with veterinarians in academia and research on clinical research projects (Faunt et al., 2007). In 2009, the *Journal of Small Animal Practice*, the official journal of the World Small Animal Veterinary Association and British Small Animal Veterinary Association, established a group of research mentors who could work with private practitioners to design, execute and publish clinical studies (Ness, 2009). These efforts are encouraging and offer a way for private practitioners, who care for the majority of animals, to get involved in generating the evidence to support EBVM.

Species Investigated

Dogs were the most frequently investigated species for each year included in the study and overall, followed by horses and cats with no change over the 15-year study period. These findings are consistent with previous studies of the veterinary literature (Giuffrida & Brown, 2012; Sahora & Khanna, 2010). According to the American Pet Products Association, the number of pet cats in the United States in 2012 was higher than the number of pet dogs (86.4 million and 78.2 million, respectively) (2013). A survey conducted by the American Veterinary Medical Association in 2011 showed a similar discrepancy with a reported 74.1 million pet cats and 69.9 million pet dogs (2012). This survey also showed that the percentage of households owning a dog (36.5%) was higher than the percentage of households owning a cat (30.4%), indicating that the mean number of dogs per household (1.6) was lower than the mean number of cats per household (2.1). Unlike the American Pet Products Association survey, the American Veterinary Medical Association surveyed horse owners, soliciting responses only from owners who considered their horses to be pets. The results showed that there were an estimated 4.9

million pet horses in the United States with 1.5% of households owning a horse and an average of 2.7 horses per household. These numbers suggest that cats should be the most frequently investigated species in the veterinary medical literature. However, the American Veterinary Medical Association survey showed that the average number of visits with a veterinarian per year is lower for both cats and horses (0.7 visits per pet) than it is for dogs (1.6 visits per pet) (2012). When results from the 2011 American Veterinary Medical Association survey were compared with those from the 2006 survey, the following changes emerged: a 9.2% increase in veterinary visits for dogs with an increase of 6.7% in the average number of visits per pet; a 4.4% decrease in veterinary visits for cats with no change in the average number of visits per pet; and a 12% decrease in veterinary visits for horses, with a 40.0% increase in the average number of visits per pet. The American Pet Products Association survey also found that cats had fewer visits to the veterinarian over a 12-month period (2.0) than dogs (2.8) (2013). Cat owners also spend less money on their pets than either dog or horse owners. The American Pet Products Association survey found that dog owners spent more per year than cat owners on routine, sick and surgical veterinary care. Dog owners spent an average of 231 dollars per year for routine veterinary care, 364 dollars per year for sick veterinary care, and 621 dollars per year for surgical veterinary care while cat owners spent an average of 193 dollars, 248 dollars and 382 dollars, for routine, sick and surgical veterinary care, respectively. The only category in which cat owners spent more per year than dog owners was emergency veterinary care. Results of the American Veterinary Medical Association survey were similar with mean veterinary expenditures 378 dollars per household per year for dogs, 191 dollars for cats and 373 dollars for horses, which equaled a mean expenditure of 227 dollars per dog, 90 dollars per cat and 133 dollars per horse (2012). Thus, although there are more pet cats in the United States than pet dogs and horses, the latter two species have more visits with a veterinarian each year. Moreover, dog owners spend more money per animal on veterinary care than either cat or horse owners. These surveys provide an explanation for the higher frequency of articles investigating dogs than those investigating either horses or cats.

Unfortunately, there have been no published surveys of the number of dogs, cats and horses seen by veterinary internists each year, and the amount of money invested in the care associated with those visits. However, the number of diplomates in each subspecialty does offer a justification for the lower percentage of studies investigating large animals (horses, cows, sheep, goats, pigs and camelids) than those investigating small animals (dogs and cats). As of December 2013, 49.0% of the 2,490 active ACVIM diplomates were board-certified in small animal internal medicine, while only 21.3% were board certified in large animal internal medicine ("Market research statistics - Veterinary specialists - 2013," 2013). If one considers that board-certified cardiologists, neurologists and oncologists typically treat small animal patients, then 81.6% of active ACVIM diplomates specialize in the care of dogs and cats (the sum of the numbers provided for individual subspecialties did not equal the total number of active ACVIM diplomates, therefore the percentages do not total to 100%). Thus, the finding that the majority of articles published in *JVIM* investigated either cats or dogs is a reflection of the interests of the readers and authors of this journal.

Owners of large animals have less access to veterinary specialists because there are fewer board-certified large animal internists. Large animal veterinary specialists do not typically practice ambulatory care and the scarcity of board-certified large animal internists may require owners transport their large animals long distances, which can be a tedious process. Moreover, the costs associated with specialty care of a large animal are considerable. Production animals, animals raised for the products that they generate such as meat, milk and wool, are not usually worth the expense of specialty care. Thus, limited access to large animal internists and the economic realities of treating these animals may explain why *JVIM* published fewer articles investigating large animal species. Moreover, veterinarians who care for large animals may choose to publish in veterinary journals that have an audience more closely aligned with their research. In an analysis of data retrieved from Scopus, 31.1% of the 163, 250 articles published during the period of study were published in species-specific journals, as designated by the Scopus subject category (Christopher & Marusic, 2013). Approximately 50% of these articles were published in food animal journals, 30.9% in small animal journals and 22.5% in equine journals. Western Europe and North America together accounted for 63.7% of articles published in food animal journals, 80.2% of articles published in small animal journals and 77.4% of articles published in equine journals. As a percentage of regional output, Africa has the highest proportion of articles published in food animal journals while North America had the highest proportion of articles published in small animal and equine journals. In their discussion, the authors of this study observed that "the true magnitude and geographic distribution of species-specialized research remains uncertain" (Christopher & Marusic, 2013) because the majority of journals in the veterinary subject area in the Scopus database were designated 'miscellaneous'. These miscellaneous journals, as well as other medical, animal science and bioscience journals also publish species-specific research. Sahora and Khanna (2010), in their analysis of veterinary oncology articles, included articles published in human medical and basic sciences journals, thereby acknowledging that veterinary specialists publish in a wide variety of journals. Ugaz et al. (2010) considered 238 journals for inclusion in the third edition of the "Basic List of Veterinary Medical Serials"; human medical and sciences journals were not considered for inclusion and the number of foreign language journals considered was limited. The work of Christopher and Marusic (2013), Sahora and Khanna (2010) and Ugaz et al. (2010) suggests that there are numerous options available to authors who wish to publish in the veterinary literature. It is likely that veterinarians who treat and research large animals, in particular production animals, have decided that journals other than *JVIM* will best disseminate their research to their desired audience.

Purpose of Study

Description of disease was the most frequent purpose of study in 1998 (34.4%), 2003 (27.8%) and overall (21.7%). The high percentage of description of disease studies can be attributed to the high percentage of case series and case reports, with a decline in these two study designs over the period of study reflected in a decline in description of disease as purpose of study. Case series and case reports are by their very definition descriptive studies. In this study, case series and case reports were coded as purposes other than description of disease when appropriate, but as the results showed, many of these studies were descriptions of disease. In the one bibliometric study of the veterinary literature that that evaluated purpose of study, approximately 41% and 30% of the 209 articles were treatment and description of disease studies, respectively (Giuffrida & Brown, 2012). Study design was not explicitly reported in this article; however, articles were assigned a level of evidence according to an adaptation of the American Academy of Orthopedic Surgeons level of evidence guidelines. In this system, case series were assigned to level 4, the lowest level of evidence. The majority of the description of disease studies (62 of 63 articles, or 98.4%) were classified as level 4. Thus, the high percentage of description of disease studies in the current analysis, and that of Giuffrida and Brown (2012), was due to a high percentage of case series and case reports.

With the exception of description of disease in 1998 and 2003, there was not one predominant purpose of study in this analysis. This result was somewhat unexpected as bibliometric studies of the human health sciences literature consistently found that treatment/therapy/prevention studies were the most frequent study purpose (Barske & Baumhauer, 2012; Obremskey et al., 2005; Xu et al., 2011; Zaidi et al., 2012). Overall, treatment studies represented 17.9% of the 503 articles included in this analysis; when combined with prevention articles, these two categories represented 19.5% of the total number of articles. There are three possible explanations for the discrepancy in the percentage of treatment studies in the current analysis and the percentage in investigations of the human health sciences literature. First, all of the aforementioned studies examined articles published in surgical literature. The authors of these studies acknowledged the high frequency of treatment studies and lamented the lack of economic studies (a category not included in the present study), but provided no explanation for the predominance of treatment studies in the surgical literature. The obvious explanation for the high percentage of treatment articles in the surgical literature is that the very nature of this specialty is to perform surgery, and therefore treat, patients. In contrast, specialists in internal medicine are usually concerned with the full spectrum of disease, including prevention, diagnosis, treatment and prognosis. Unfortunately, bibliometric studies of the human medical literature (Chou, 2009; Fletcher & Fletcher, 1979; Frey & Frey, 1981; Glanville et al., 2011; Gnanalingham et al., 2006; McDermott et al., 1995; Merenstein et al., 2003) have not included purpose of study in their analyses so it is difficult to make a comparison between either the human medicine and surgery literature or the human and veterinary medicine literature. The second possible explanation for the difference in the percentage of treatment studies in the present study and the percentage observed in analyses of the human health sciences literature is a difference in article inclusion criteria. Obremskey et al. (2005) excluded the following studies from their analysis: animal and cadaver studies; basic science, review and expert opinion articles; and case reports. Zaidi et al. (2012) also excluded animal, cadaver and basic science articles from their study but chose to include case reports and expert opinions. Barkse and Baumhauer (2012) excluded animal, cadaver, basic science and review articles from their analysis. The exclusion of certain articles, in particular cadaver studies and case reports, from the bibliometric analysis may have affected the purpose of study results. However, the one study of the human surgical literature that did include animal studies, basic science studies, case reports and reviews still had a high percentage (87.6%) of treatment studies (Xu et al., 2011). This suggests that exclusion criteria did not affect the purpose of study results. The final possible explanation for the observed difference between purpose of study results in the present study and those in studies of the human health sciences literature is the number of categories included in this domain for the present study. Three of the aforementioned studies of the human surgical literature had four categories in the purpose of study domain (therapeutic, prognostic, diagnostic and economic) and one had five categories (therapy/prevention/cause/harm, prognosis, diagnosis, differential diagnosis, and economic and decision analysis). The present study, in which the purpose of study categories were modeled after those in two studies of the physical therapy literature (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011), had eight categories for the purpose of study domain. This provided a more thorough description of the types of articles published in *JVIM* but makes it difficult to compare the results of the present study to previous bibliometric analyses. In summary, explanations for the difference in frequency of treatment studies between the current analysis and analyses of the human health sciences literature include: the surgical nature of the specialties investigated in the studies of the human literature; the exclusion criteria for the studies of the human literature; and the higher number of purpose of study categories in this study.

In the present study, the percentage of anatomy/physiology studies increased from 9.8% in 1998 to 18.0% in 2013. This category included studies that examined interventions in asymptomatic animals in nonclinical or laboratory settings. The veterinary literature may be expected to have more studies with this purpose than the human health sciences literature because veterinary researchers have the opportunity to perform challenge studies in experimental subjects by exposing them to pathogens, risk factors, or interventions, a practice which would be unethical in human medicine, for obvious reasons (Holmes, 2009). The anatomy/physiology category also included studies that evaluated pharmacoresponse in asymptomatic animals. Similar studies in humans would be considered phase I clinical trials and therefore, classified as treatment studies. The increase in the number and percentage of anatomy/physiology studies noted in the present study suggest that much is still unknown about the pathophysiology of disease and pharmacoresponse to drugs in animals. The increase may also indicate discovery of new drugs and new uses for old drugs.

Few studies of the human health sciences literature have included the anatomy/physiology category in the purpose of study domains. In two separate analyses of the physical therapy literature, anatomy/physiology was the most frequent purpose of study category, at nearly 35% (Coronado, Riddle, et al., 2011) and 50% (Coronado, Wurtzel, et al., 2011) of articles published in *Physical Therapy* and the *Journal of Orthopaedic & Sports Physical Therapy*, respectively. These analyses detected a significant decrease in the frequency of anatomy/physiology studies and a significant increase in the frequency of diagnostic and prognostic studies over the 30-year study periods. The authors hypothesized that more diagnostic and prognostic studies were needed to support evidence-based clinical decision making (Coronado, Riddle, et al., 2011, p. 651).

Study Design

Few meta-analyses and systematic reviews were published during the period study with each of these study designs comprising only 0.4% of the total number of articles included in the study. These results are consistent with other bibliometric studies of the human health sciences literature where the frequency of meta-analyses and systematic reviews ranged from 0.4% (Lauritsen & Moller, 2004) to 1.29% (Paci et al., 2009) and 1% to 7% (Merenstein et al., 2003), respectively. Previous bibliometric studies of the veterinary literature have also shown a low percentage of meta-analyses. The two studies that included meta-analysis in study design evaluation reported a percentage of 0% (Arlt et al., 2010) and 0.4% (Simoneit et al., 2011) for this study design. No bibliometric studies of the veterinary literature have evaluated the frequency of systematic reviews. There are several possible reasons for the low number of meta-analyses and systematic reviews published in *JVIM* over the period of study. First, veterinarians may not be familiar with the methodology of these two study designs. Second, veterinarians may not have either the human resources or time necessary to complete a meta-analysis or systematic reviews. These types of studies require at least two authors, usually more, and the services of a statistician and ideally, a librarian. These requirements necessarily restrict the pool of researchers who can conduct a meta-analysis or systematic review to those who work in an academic institution. The amount of time required to conduct a meta-analysis or systematic review may further restrict the author pool by eliminating residents; the typical residency is three years with a small percentage of that time dedicated to research. The third possible reason for the low number of meta-analyses and systematic reviews detected in this study is the lack of clinical studies in the veterinary literature and the difficulty of finding those studies that do exist. Meta-analyses and systematic reviews are generally considered to provide the highest level of evidence because they utilize rigorous methods to find, select, and analyze the results of, multiple studies. Thus, the validity of meta-analyses and systematic reviews depends, to some extent, on the quality of the articles available for the analyses (Lauritsen & Moller, 2004; Sprague et al., 2008). Bibliometric studies of the human health sciences literature have detected an increase in the percentage of meta-analyses (Gnanalingham et al., 2006) and systematic reviews (Coronado, Riddle, et al., 2011) over time. An increase in the percentage of meta-analyses and systematic reviews was also noted in this study. No conclusions about trends in the publication of meta-analyses and systematic reviews in

JVIM can be drawn from the results of this study because these two study designs only emerged in the final year of the analysis (2013) and the overall number of these types of studies was low.

The percentage of nonsystematic reviews published in *JVIM* was low, 5.4% of the total number of included articles, and declined over the 15-year study period. Sahora and Khanna (2010), in their analysis of oncology manuscripts published in *JVIM* from 1999 to 2007, reported that overall, 5% of 172 articles were classified as reviews, with a decline from 10% in 1999 to 0% in 2007. The authors of this study defined a review as "An overview about a disease, therapy, or diagnostic used over a period of time based on the prior published literature" (Sahora & Khanna, 2010, p. 52). Studies of the human health sciences literature have also shown a decline in the percentage of nonsystematic reviews over time (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011). These types of articles are considered to provide a lower level of evidence because they do not typically include a thorough explanation of either the search strategy utilized to locate articles or article selection criteria. Moreover, nonsystematic reviews often include author opinion. The decline in the percentage of nonsystematic review articles published in *JVIM* over the 15-year period of study may reflect a change in editorial policy at the journal. A 2008 *JVIM* editorial (Hinchcliff & DiBartola) introducing a new publisher for the journal emphasized that the change in publisher would extend beyond the cosmetic and into the content of the journal. The editors indicated that "our overarching goal is that the *Journal of Veterinary Internal Medicine* be recognized as the pre-eminent journal dedicated to publishing high quality, clinically relevant information…" (Hinchcliff & DiBartola, 2008, p. 1). This commitment to publishing high quality articles is reflected in the current 'Guidelines for preparation of manuscripts submitted to the *Journal of Veterinary Internal Medicine*' (2013) which indicate that certain manuscript types and study designs are "prioritized for publication" (p. 1), namely: meta-analyses, randomized clinical trials, prospective case series that include a control population, and epidemiological studies. Nevertheless, *JVIM* has continued to publish a few nonsystematic review articles each year. These types of articles are of interest to readers because they provide a thorough description of expert opinion on current clinical topics and may offer a provocative perspective that stimulates further research (Coronado, Wurtzel, et al., 2011).

Approximately 6% of the articles included in this study were RCTs, with no change over the period of study. The percentage of RCTs reported in bibliometric studies of the human internal medicine, general practice and family medicine literature has been variable. In an analysis of articles published in three prominent medical journals from 1946 to 1976, the authors found that 5% of all the articles reviewed were RCTs (Fletcher & Fletcher, 1979). A later study evaluated articles published in the same three journals from 1971 to 1991 (McDermott et al., 1995). In this study, the percentage of clinical trials doubled from 17% in 1971 to 35% in 1991, and the percentage of those clinical trials that were randomized increased from 31% in 1971 to 76% in 1991. Ruiz et al. (1991) reported that 15.6% of the articles published in seven rheumatology journals over one year were RCTs. Thomas et al. (1998) found that 6% of the articles in three primary care journals over a 5-year period from 1991 to 1996 were RCTs. In a bibliometric study of articles published in 25 clinical journals from five different specialties (medicine, surgery, pediatrics, anesthesia, and psychiatry) over a 30-year period, the authors found that 8.1% of the articles published in the five medicine journals were RCTs (Gnanalingham et al., 2006). In a study of the gastroenterology literature, 4.6% of the 81,561 articles included in the study were classified at RCTs (Chou, 2009). A few studies have taken a different approach to the question of RCTs in the health science literature, evaluating the percentage of interventions that are supported by published RCTs. Ellis, Mulligan, Rowe and Sackett (1995) found that 53% of 109 primary treatments administered to general medicine patients were supported with evidence from published RCTs. A later study reported published RCTs existed to support 52% of 312 drug interventions prescribed for patients in an acute general medicine ward (Hui et al., 2000). Some bibliometric studies of the human health sciences literature detected a change in the percentage of RCTs over time (Chang et al., 2009; Gnanalingham et al., 2006; McDermott et al., 1995) while others did not (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011; Thomas et al., 1998).

The percentage of RCTs in bibliometric studies of the veterinary literature has been inconsistent. Arlt et al. (2010) noted that 7.3% of 287 canine reproduction articles were RCTs. In a later study of the veterinary theriogenology literature, 21.3% of the 268 studies included in the analysis were considered RCTs, with 3% of the RCTs investigating dogs, 7.5% investigating horses, and 10.8% investigating cows (Simoneit et al., 2011). The authors suggested that the difference in the percentage of RCTs in bovine reproduction compared to either equine or canine reproduction was due to the considerable economic value and public health interest in bovine reproduction. Sahora and Khanna (2010) reported that 1% and 2% of the oncology articles published in *JVIM* were RCTs and randomized placebo blinded clinical trials, respectively.

RCTs provide the highest level of evidence for studies that seek to evaluate the effect of an intervention on a patient. Unfortunately, there are several barriers that may prevent veterinary clinical researchers from conducting RCTs. Like meta-analyses and systematic reviews, planning and conducting RCTs requires considerable human resources and time. Gibson and Harrison (2011), in their bibliometric analysis of the orthodontic literature, observed that the 3-year time period allotted to orthodontic residents for completion of their clinical and research training makes completion of a RCT during a residency a “difficult proposition” (p. e481). As previously mentioned, the majority ACVIM approved residency training programs are also three years. Residents who choose to obtain an additional doctoral degree as part of their residency training programs devote two to three years to education and research, which, when combined with the three years of clinical training, would allow time for completion of an RCT. However, residency training programs that offer a doctoral degree are the exception to the standard ACVIM residency (see Table 7).

Another barrier to conducting RCTs is attaining sufficient funds. Lack of adequate funding is a problem that plagues all areas of research, but it is particularly problematic for veterinary medicine. Simoneit et al. (2011) suggested that pharmaceutical companies, a major funding source for clinical trials in human medicine, are reluctant to conduct veterinary clinical trials because such an investment is unlikely to yield significant returns . Nevertheless, some authors have proposed that the veterinary community cultivate partnerships with pharmaceutical and pet food companies as well as implant and equipment manufacturers to relieve the financial burden that veterinary clinical scientists confront when they wish to perform a rigorous investigation (Schulz et al., 2006). It cannot hurt to seek financial support from companies and manufacturers, but veterinarians must aggressively pursue partnerships with other organizations as well, including government agencies, professional associations and universities (Toews, 2011). A novel solution to the financial problems that veterinary clinical researchers face is to create a program in which a portion of the cost of a particular procedure or treatment is donated to a fund that supports research in that area (Schulz et al., 2006).

Veterinary clinical researchers who have the time, expertise and funds to conduct RCTs still face the difficult task of recruiting patients for their studies. Veterinary researchers have trouble enrolling high numbers of patients in studies for the following reasons: clinical researchers do not collaborate with colleagues at other institutions or in private practice; small number of institutions that actively conduct veterinary clinical research; clinicians investigating uncommon disease; and owners who are reluctant to allow their pet, or herd of animals, to participate in a research study (Lanyon, 2012; Spoor, Priestnall, Claridge, Dustan, & Reed, 2009).

The recognition of the barriers that researchers face in conducting meta-analyses, systematic reviews and RCTs, the study designs considered to provide the highest levels of evidence, has prompted some to question whether increasing the number or percentage of these types of studies is ideal or realistic (Coronado, Wurtzel, et al., 2011). While a thorough discussion of study design in clinical research is beyond the scope of this paper, a few observations on this topic will be made. First, RCTs may not be appropriate or necessary for the evaluation of all types of interventions. This is particularly true for surgical interventions; one study found that only 38.8% of gastrointestinal surgical treatment questions could be answered with a RCT (Solomon & McLeod, 1995).

Second, the belief that only RCTs produce valuable results is untrue. A study that compared meta-analyses of RCTs with meta-analyses of observational studies (either cohort or case-control design) that evaluated the same clinical topic discovered that the average results of the observational studies were “remarkably similar” (Concato, Shah, & Horwitz, 2000, p. 1887) to those of RCTs. The authors of this study noted that observational studies can be designed with rigorous methods that approximate those of clinical trials, and the results of such studies do not necessarily overestimate the efficacy of interventions. Finally, RCTs may produce conflicting results, which perhaps is an argument for more meta-analyses and systematic reviews. Meta-analyses, systematic reviews and RCTs are important tools in clinical research but researchers should carefully consider all their options and the resources available to them when selecting a study design.

Case series and case reports were the highest number and percentage of study designs for articles from the first year of this study (1998). Over the 15-year period of study, the percentage of case series and case reports declined. These types of studies provide a low level of evidence (Phillips et al., 2009) and their use is not generally recommended for making clinical decisions. Nevertheless, these types of studies do have their place in clinical research. Thornton (2010), referencing the work of Richard Smith, noted that case reports can contribute to improvements in patient care, but they can also be lethal if they ultimately prove to be invalid. Case series and case reports provide an account of novelty witnessed in the course of clinical practice and as such, serve to stimulate further research (Shale & Weber, 2012). These types of studies are particularly important for documenting the occurrence of adverse drug reactions. A systematic review of the literature supporting the removal of drugs from the Spanish market between January 1990 and December 1999 found that in 18 of 22 cases (82%) the evidence for withdrawal came from case reports, case series, or a combination of RCTs and case reports (Arnaiz et al., 2001).

The decline in the percentage of case series and case reports published in *JVIM* over the period of study reflects a change in editorial policy. As mentioned in the discussion of nonsystematic reviews, the editors of the journal expressed a renewed commitment to publishing high quality, clinically relevant information in 2008 (Hinchcliff & DiBartola). The current author guidelines for *JVIM* state that single case reports and retrospective case series are unlikely to be accepted unless there are “exceptional reasons”, the details of which are provided in the guidelines ("Guidelines for preparation of manuscripts submitted to the *Journal of Veterinary Internal Medicine*," 2013).

Nonclinical experiments represented 12.5% of the total number of articles included in this study, with no change in the percentage of nonclinical experiments over the 15-year study period. Nonclinical experiments were fourth highest percentage of study designs overall, despite the author guidelines for *JVIM*, which indicate that studies involving only healthy animals are unlikely to be accepted for publication and studies of animals models of animal disease will be considered, but not prioritized ("Guidelines for preparation of manuscripts submitted to the *Journal of Veterinary Internal Medicine*," 2013). This unique category was included to distinguish between experiments conducted in patients with naturally occurring disease and those conducted in healthy animals, animals with induced disease, or tissues or body fluids not associated with individual patient histories. As previously mentioned, veterinary researchers can perform experiments in animals that would not be permitted in humans for ethical reasons. However, the results of these studies, which are conducted in controlled settings or involve induced disease, may not be transferable to clinical practice. Nonclinical experiments do provide valuable information, but it is important that their potential limitations be recognized.

Overall, the results of the study design analysis show a promising trend towards the publication of fewer types of studies that are considered low levels of evidence: nonsystematic reviews, case series and case reports. Unfortunately, there was not a corresponding increase in RCTs, which provide a higher level of evidence. It is too early to define the trend for meta-analyses and systematic reviews because the only four articles with these two study designs were published in 2013, the last year analyzed for this study. Researchers need to carefully consider what study designs are appropriate for their question, and the personal limitations that may prevent them from using a particular study design, for example funding, experience or time. When considering study design, researchers should not view study design as a "rigid hierarchy" (Concato et al., 2000, p. 1891), rather should pursue a study design that provides the highest level of evidence that they can reasonably conduct given their limitations. There are several study design factors that can improve the quality of research. In a discussion of the level of evidence of articles published in orthopedic journals, Obremskey et al. (2005) encouraged authors to add a control group to their studies, a change that could increase the level of evidence and "improve the confidence with which one can apply the information to a clinical setting" (p. 2635). Other authors have also advocated for the inclusion of a comparison group in studies (Barske & Baumhauer, 2012; Hanzlik et al., 2009; Loiselle et al., 2008). Another factor that can improve study design is prospective collection of data (Barske & Baumhauer, 2012). Careful planning and application of study design can improve the quality of evidence available in veterinary medicine.

Limitations

There were several limitations to this study. Many of these limitations were the result of a single person conducting the study. The first limitation of having one person responsible for data collection was, in the interest of time and fatigue, the necessity of restricting the size of the data set (Mogil et al., 2009). Ideally, all articles from all years of the selected time period would have been evaluated in order to reduce the potential for sampling error. Several bibliometric studies of the human health sciences literature have used a similar sampling method as that which was used in this study (Fletcher & Fletcher, 1979; Gnanalingham et al., 2006; Hanzlik et al., 2009; Hayden & Saulsbury, 1982; Loiselle et al., 2008; Xu et al., 2011). In an analysis of the nursing literature, Jacobsen and Meininger (1985) reviewed articles from seven years over a 32-year time period, with no more than five years between each selected year. These authors suggested that the limitation of this method was not necessarily an inability to detect trends over time, but an inability to determine whether changes occurred rapidly or gradually. The purpose of the current study was to detect the presence or absence of change in articles published over a 15-year time period, not to calculate the rate at which those changes occurred.

Another limitation of one person doing all data collection and analysis was the potential for coding errors. Coding errors, due to either questionable judgment during article review or mistakes entering data, are inherent to any bibliometric analysis (Mogil et al., 2009). Such errors affect the reliability of the results and may be more common when a single person does the coding, with no one to cross check coding decisions and data entry. However, a single reviewer for some or all of the articles included in a bibliometric analysis is not uncommon, even for studies with multiple authors (Frey & Frey, 1981; Gibson & Harrison, 2011; Giuffrida & Brown, 2012). Arlt et al. wondered whether two or more reviewers improved "objectivity to an extent that justifies additional time and manpower" (2010, p. 1056). One way to mitigate coding errors due to erroneous categorization would have been reevaluate a portion of the articles a few weeks after the initial evaluation to establish intraobserver reliability. The coding scheme presented in this study, in particular the study design definitions and decision tree, was the final iteration of earlier schemes, which were modified after being tested with a subset of articles. An effort was made to utilize explicit, exclusive definitions, but some subjectivity in the definitions for purpose of study and study design was inevitable (Mogil et al., 2009). Only one category, author country, allowed more than one entry per article. Thus, this reviewer was forced to select the most appropriate code for species, purpose of study and study design, even if the article potentially fit more than one code. This quandary was also noted in a bibliometric study of the physical therapy literature (Coronado, Riddle, et al., 2011).

A third limitation to a single reviewer was that it was not feasible to blind to the articles' authors and affiliations, which introduced the potential for detection bias. However, bibliometric studies, regardless of the number of authors often do not blind the reviewers (Al-Harbi, Farrokhyar, Mulla, & Fitzgerald, 2009; Zaidi et al., 2012). Even when blinding is attempted, it may be difficult to completely disguise an article due to recognizable font and style changes over time (Dauphinee et al., 2005).

This study did not evaluate levels of evidence, a variable that several bibliometric studies of the human health sciences literature have included in their analyses (Barske & Baumhauer, 2012; Dauphinee et al., 2005; Hanzlik et al., 2009; Loiselle et al., 2008; Obremskey et al., 2005; Xu et al., 2011; Zaidi et al., 2012). Levels of evidence are hierarchical rating systems of study quality, which are designed to help clinicians rapidly choose the best evidence to answer their clinical questions (Howick, Chalmers, Glasziou, Greenhalgh, Heneghan, Liberati, Moschetti, Phillips, & Thornton, 2011; Wright et al., 2003). Some journals have adopted a levels of evidence system and provide a level of evidence for each article published within their pages (Wright et al., 2003). A levels of evidence system was developed for this study, but was abandoned after preliminary testing with a small number of articles. There were several reasons that levels of evidence were ultimately not included in this bibliometric study. First, assessment of levels of evidence is problematic because there are several systems by which articles can be evaluated, some of which are more complicated than others, and there is no clear consensus on the use of a particular system in either human or veterinary medicine (Innes, 2007). The OCEBM, the U.S. Preventive Services Task Force, and *The Journal of Bone and Joint Surgery* are a few examples of institutions and journals that have developed their own levels of evidence systems (Hanzlik et al., 2009; Petrisor et al., 2006). The levels of evidence systems applied to human studies are typically the result of expert opinion and have not been validated (Petrisor et al., 2006). Depending on the system employed studies may be placed in different levels of evidence categories.

Moreover, levels of evidence systems only provide an approximate guide of study quality and therefore, do not replace critical appraisal of an article (Al-Harbi et al., 2009). Another problem with levels of evidence systems is that they are designed to evaluate clinical research and are therefore biased against basic science research (Loiselle et al., 2008). Patient-centered clinical research is considered more relevant and valid for clinical practice, although basic science research may contribute to clinical decision-making (Sackett et al., 1996, p. 72). Basic science studies were not explicitly included in the March 2009 OCEBM levels of evidence system (Phillips et al.), the U.S. Preventative Services Task Force system (*U.S. preventative task force procedure manual*, 2008) or *The Journal of Bone and Joint Surgery* system (Wright et al., 2003). In the more recent iteration of the OCEBM system (Howick, Chalmers, Glasziou, Greenhalgh, Heneghan, Liberati, Moschetti, Phillips, Thornton, et al., 2011), 'mechanism-based reasoning' was placed in level 5, the lowest level of evidence.

An additional reason that levels of evidence were not evaluated for this study is that the systems used for the human literature may not be appropriate for the veterinary literature. There has been one attempt to modify a levels of evidence system for use in veterinary orthopedics (Aragon & Budsberg, 2005). An analysis of oncology manuscripts in *JVIM* utilized a simplified version of the OCEBM levels of evidence system (Sahora & Khanna, 2010), and a recent analysis of the companion animal literature adapted The American Academy of Orthopedic Surgeons levels of evidence system for use in the study (Giuffrida & Brown, 2012). Veterinary medical research is at a different stage of development than human health sciences research. The inherent differences between clinical research with animals and clinical research with humans suggest that veterinary medical research may follow a different trajectory than human health sciences research. Therefore, rather than adapting a levels of evidence system from the human literature, a new levels of evidence system needs to be developed for veterinary medicine.

Another potential problem with the evaluation of levels of evidence is the experience of the evaluator. Bhandari et al. (2004) investigated interobserver agreement, among surgeons trained in epidemiology and those who were not, in determination of study type and application of levels of evidence to scientific articles. Surgeons trained in epidemiology demonstrated greater agreement across all aspects of classification than those who were not trained in epidemiology. The intraclass correlation coefficient for overall levels of evidence among surgeons who were trained in epidemiology was 0.99, compared to 0.60 for surgeons who were not trained in epidemiology. Experience, or lack thereof, would have been particularly concerning for this study because there was only one person evaluating the articles. The absence of an accepted system to assess levels of evidence in veterinary medicine and the relative inexperience of this researcher would have reduced the validity and reliability of this variable. Therefore, levels of evidence were not included in the present study.

This study made no attempt to assess the quality of the reporting in the articles. Quality of reporting is an area of concern in both the human and veterinary medical literature because inadequate reporting makes it difficult to truly appraise the validity and relevance of the evidence provided in an article. Over the past 15 years, inadequate reporting of research results has been addressed in human health sciences through the development of standards that guide authors as they prepare their research for publication

(Toews, 2011). In 2010, Sargeant et al. used one of the accepted reporting standards in human medicine, the Consolidated Standards of Reporting Trials (CONSORT), to evaluate the methodological quality and completeness of reporting of 100 randomly selected dog and cat clinical trials. The authors concluded that "published clinical trials involving dogs and cats often have substantive deficiencies in reporting of features related to methodological quality and the detail needed to evaluate external validity" (p. 49). Arlt et al. (2010) developed a 40-item questionnaire that was used to evaluate five aspects of research articles on canine reproduction: materials and methodology; study design; statistics; presentation and information content; and applicability and conclusions. The authors either strongly agreed or agreed that 37.6% of the 287 included articles provided adequate information about treatment or interventions and that 63.8% of the articles presented results completely. However, the authors concluded that data was inadequate to draw valid conclusions for 67.9% of the included articles. A second study (Simoneit et al., 2011) that used the 40-item questionnaire found that only 33%, 11% and 7% of the articles in bovine, equine and canine reproduction, respectively, provided enough detail for a reader to draw meaningful conclusions from the article.

Recently, efforts have been made to improve the quality of reporting of clinical studies in veterinary medicine. A group of biostatisticians, epidemiologists, food safety researchers, livestock production specialists and journal editors adapted the CONSORT statement for the reporting of RCTs in livestock and food safety (O'Connor et al., 2010). The publication of this modified CONSORT statement in *JVIM* was accompanied by an editorial calling for authors to use reporting guidelines from both human and veterinary medicine when preparing their research for publication (Hinchcliff & DiBartola, 2010).

Authors were informed that the journal had revised its editorial policies to reflect the need for high quality studies in veterinary medicine. Unfortunately, this author had neither the expertise nor the time required to perform a thorough analysis of reporting quality in the articles selected for this study. However, this author did perceive a lack of high quality reporting in the articles included in this study, which often made it difficult to determine the appropriate study design category. Given the importance of accurate reporting of research results and the changes in editorial policy at *JVIM*, such an analysis should be pursued in future studies.

This study did not evaluate the clinical relevance of the articles included in the analysis. In 2008, the co-editors-in-chief of *JVIM* declared that the journal was devoted to publishing "clinically relevant information pertinent to the practice of veterinary internal medicine" (Hinchcliff & DiBartola, 2008, p. 1). Unfortunately, clinical relevance is difficult to define, and therefore difficult to measure, because it is unique to each clinician. The authors of a brief report in a human medical journal offered that publishers define clinical relevance as "the importance of information to clinicians: anyone involved in patient care" (Ballard, Graf, & Young, 2011, p. B11). These authors suggested that three types of research are considered in a discussion of clinical relevance: research that changes practice; research that confirms existing practice; and research that has no immediate impact on practice but is of interest to the clinician. Measures of journal and article impact, including Impact Factor, Eigenfactor and number of citations per article, capture the importance or prestige of a journal or article within the scholarly community, but they do not capture the relevance of the article to practicing clinicians who do not publish. Nevertheless, bibliometric studies of the human and veterinary literature have included citation metrics in their analyses as measures of journal, article and author influence (Coronado, Riddle, et al., 2011; Coronado, Wurtzel, et al., 2011; Crawley-Low, 2006; Giuffrida & Brown, 2012; Mogil et al., 2009). Other studies have utilized different methods to measure clinical relevance. An analysis of articles published in four family medicine journals had two reviewers independently evaluate each article according to three relevance criteria: did the authors study an outcome patients would care about; does the article address a specific clinical question that you encounter frequently in your practice; and will this information, if true, require you to change your current practice (Merenstein et al., 2003). Such an analysis was not feasible in the present study because a single person who did not have the expertise to make relevance judgments was conducting the study. An investigation of articles published in five human anesthesia journals defined clinical relevance as an article that utilized a statistically valid study design and clinically relevant end-point (Lauritsen & Moller, 2004). Ballard et al. (2011) proposed the use of a composite measure of clinical relevance where articles would be receive a score of 1-10 in four categories: accessibility and suitability; meaning and utility; internal validity and generalizability; and innovation and creativity, for a maximum possible score of 40. The authors recognized that this measure would be open to interpretation, but suggested that this was appropriate for a quality as subjective as clinical relevance. Given the limitations of this author and the difficulty of measuring clinical relevance, this variable was not included in the present study.

The timing of the study, where timing addresses the question of when the health outcome occurred relative to the initiation of the study and is designated either prospective or retrospective, was not determined in this study. Prospective studies are those in which the health outcome occurred after the study began and retrospective studies are those in which outcomes occurred prior to the beginning of the study ("Glossary of Terms in the Cochrane Collaboration ", 2005; Kleinbaum et al., 2007). Prospective and retrospective are also often used to refer to timing of data collection where prospective studies utilize data that has not yet been collected (future data) and retrospective studies utilize data that has already been collected (past data) (Bhopal, 2008). Prospective and retrospective have also been used erroneously as synonyms for cohort and case-control studies, respectively (Bhopal, 2008). The timing classification has largely been abandoned except when used to describe cohort studies (Bhopal, 2008). Few bibliometric studies of the human health sciences literature evaluated study timing and only one study of the veterinary literature included this variable in the analysis (Sahora & Khanna, 2010). Timing of study was not included in the present analysis because there is confusion surrounding the use of the terms prospective and retrospective and this variable has not typically been examined in bibliometric studies of the human health sciences literature. Nevertheless, timing of study/data collection is an important methodological consideration when designing or evaluating a research study.

Clinical condition, the primary diagnosis or pathology of the subjects investigated in the article, was not included in the analysis. This data was collected for each article with the intention of determining the top five most frequent clinical conditions for cats, dogs and horses during analysis. Upon completion of data collection, the entries in this category were considered too heterogeneous to provide meaningful information, even when similar terms for a single condition were merged to reduce redundancy. The top 25 most frequent clinical conditions were reported in bibliometric studies of 1,689 articles published in *Physical Therapy* (Coronado, Riddle, et al., 2011) and 1,732 articles published in the *Journal of Orthopaedic and Sports Physical Therapy* (Coronado, Wurtzel, et al., 2011). The present study included 503 articles and far fewer when categorized according to species investigated: 269 canine articles, 70 feline articles, and 104 articles equine articles. Moreover, the scope of the two physical therapy journals was narrower than *JVIM*, which covers cardiology, large animal internal medicine, neurology, oncology and small animal internal. In a study of the companion animal literature published in five peer-reviewed veterinary clinical journals, a senior academic veterinary specialist with considerable experience assigned each article to one of the following subspecialties: anesthesia, behavior, cardiology, critical care, dermatology, dentistry, infectious disease, internal medicine, neurology, nutrition, oncology, ophthalmology, orthopedics, general surgery or theriogenology (Giuffrida & Brown, 2012). This classification method was considered for the present study but ultimately rejected due to the potential for lack of exclusivity between categories, reduction in the granularity of clinical condition, and reviewer misclassification.

The final limitation of this study was the method itself. Bibliometric analysis is only a proxy for knowledge production and should be interpreted in conjunction with other measures of research (Verbeek et al., 2002). This study analyzed only one major journal in veterinary internal medicine over a 15-year time period; therefore, the results may not be representative of this specialty and observed trends may simply be a reflection of changes in editorial policy over the years of study (Mogil et al., 2009). Moreover, the results of this analysis are not generalizable to the entirety of veterinary research. According to one study on the coverage of veterinary journals by bibliographic databases (Grindlay et al., 2012), there are more than 1,100 journals that are either specific, or publish content relevant, to veterinary medicine and science. Therefore, it would be impossible to characterize the published research for veterinary medicine.

There is no established standard for what constitutes an ideal proportion of study designs in a journal (Coronado, Riddle, et al., 2011) or discipline. Multiple studies have evaluated trends in study design in individual journals and specialties in the human health sciences. Views expressed in these bibliometric studies represent author opinion and may not be applicable beyond the journal or specialty investigated in the study. Given the paucity of bibliometric studies that have evaluated the veterinary literature, the results of this study are important to the veterinary internal medicine community regardless of the findings and provide a base for future work in this area.

Conclusion

The mission of *JVIM* is to “advance veterinary medical knowledge and improve the lives of animals by publication of authoritative scientific articles of animal diseases” ("American College of Veterinary Internal Medicine," 2013). On the occasion of a new publisher in 2008, the co-editors-in-chief of the journal expressed a desire for continued growth of the journal over the decade and indicated that success of the journal would be judged by, among other elements: impact factor, the quality and breadth of the articles published, and the geographic diversity of submissions (Hinchcliff & DiBartola, 2008). The aim of the present study was to quantify authorship, species investigated, purpose of study and study design for articles published in *JVIM* over the past 15 years, and thereby provide an assessment of how the journal was fulfilling its mission and goals. The results showed that the article output of the journal increased over the period of study, which was an expected finding for a maturing journal and an indicator of persistent growth. The mean number of authors per article increased the study period, which could be a sign of gratuitous attribution or collaboration. The journal has taken the proper steps to eliminate inappropriate attribution by providing explicit authorship guidelines, in accordance with the International Committee of Medical Journal Editors. The increase in the percentage of articles with a mixed affiliation and the increase in the percentage of articles with authors from more than one country are evidence of greater collaboration among authors conducting research in veterinary internal medicine. The percentage of articles with a private affiliation decreased over the 15-year study period. As veterinary specialists continue to seek positions in private practice, the Colleges need to explore ways to engage these practitioners in clinical research. The increase in international collaboration, coupled with the finding of a decline in the percentage of articles with at least one author from the United States, suggests that the journal has successfully achieved its goal of increasing the geographic diversity of submissions.

Species investigated did not show an appreciable change over the period of study, with dogs, horses and cats the most frequently investigated species all four years. A change in species investigated was not expected. The finding that cats are consistently underrepresented in *JVIM* is inconsistent with the large number of pet cats in the United States but consistent with surveys that have shown cats visit a veterinarian less frequently than either dogs or horses, and cat owners spend less money on their cats than either dog or horse owners. The results of this study may reflect the typical patient population for the internal medicine specialties. Nevertheless, the journal may wish to encourage submission of articles that investigate cats. In addition, an attempt should be made to accurately estimate the patient population of veterinary specialists in academic and private practice.

Unlike previous bibliometric studies of the human health sciences and veterinary literature, there was no one predominant study purpose for the articles included in this analysis. This finding is a reflection of the breadth of *JVIM* and the specialty of veterinary internal medicine. The percentage of articles that addressed prevention was consistently low across all four years. Issues of prevention tend to fall within the purview of general practitioners rather than specialists. However, prevention and control of animal diseases is one of the primary objectives of the ACVIM and should be a consideration for all clinical researchers. *JVIM* and the Colleges should consider making prevention of disease a priority for manuscript submissions and clinical researchers.

The results of the study design analysis showed a decline in articles considered low quality, specifically nonsystematic reviews, case series and case reports. The percentage of cohort, case-control and cross-sectional studies increased over the period of study while the pattern for RCTs and other clinical trials was inconsistent. Meta-analyses and systematic reviews emerged in the final year of the study (2013), so it is too early to detect a pattern for these study designs.

Overall, observational studies were the predominant type of study, representing 71.4% of the articles included in the study with experimental studies representing only 8.7% of the include articles. The decline in low quality studies is encouraging and suggests that the change in the editorial policies of *JVIM* during the period of study have successfully enhanced the quality of the research published in the journal. In order for this pattern to continue, the journal needs to continue to accept high quality, clinically-relevant articles that accurately report study methodology and results. A survey of internal medicine diplomates, both in the United States and abroad, may reveal the barriers to conducting high quality clinical research, and how the journal and Colleges can work with clinicians to overcome those barriers.

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Appendix A: Definitions for Species Investigated

Category	Species Investigated
Canine	Dog
Feline	Cat
Equine	Horse, pony, donkey, mule
Bovine	Dairy or beef cow
Ovine	Sheep
Caprine	Goat
Porcine	Pig
Camelid	Llama, alpaca, camel
Multispecies	More than one species
Nonspecific	None specifically mentioned

Appendix B: Definitions for Purpose of Study

Purpose of Article	Definition
Anatomy/physiology	Articles informing or examining new or existing information on foundational and theoretical information, such as: basic anatomy; pathoanatomy; physical, physiological, or pathophysiological processes and responses; or pharmacokinetics and pharmacodynamics. Includes studies examining aspects of interventions utilizing asymptomatic participants in nonclinical or laboratory settings.
Etiology	Articles informing or examining the incidence, prevalence, risk factors, and impact of a particular disease or disorder. Determining an association between an exposure and a disease or condition.
Prognosis	Articles informing or examining factors related to the prediction of the clinical course or natural history of a disease or condition. Prognosis studies must use or discuss a valid outcome measure at a follow-up session.
Diagnosis	Articles informing or examining data on the diagnostic process or specific aspects of diagnosis, including screening for disease, characterization of the disease or condition, specific features or symptoms, and classification. Diagnosis studies must use or discuss a reference standard for diagnosis.
Treatment	Articles informing or examining the potential mechanisms, utilization, or effects of an intervention. Treatment studies must discuss both a clinical population and active treatment.
Prevention	Articles informing or examining potential mechanisms, utilization, or effects of preventative measures.
Description of Disease	Reports of disease or health states that do not seek to test a specific hypothesis.
Metric	Articles informing or examining the development, utilization, reliability, validity, or responsiveness of a measurement, tool, scale, questionnaire, or technique.

Note. Adapted from "Bibliometric Analysis of Articles Published from 1980 to 2009 in *Physical Therapy*, Journal of the American Physical Therapy Association," by R. A. Coronado, D. L. Riddle, W.A. Wurtzel, S. Z. George, 2011, *Physical Therapy*, *91*, p.3 [eAppendix].

Appendix C: Study Design

Table 1

Definitions for Study Design

Study Design	Definition
Meta-analysis	The use of statistical techniques in a systematic review to integrate the results of included studies.
Systematic review	A review of a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review.
Nonsystematic review	A review article that provides an overview of a disease, therapy or diagnostic and summarizes a number of different studies; may draw conclusions about a particular intervention. Methods utilized to identify, select and appraise the relevant research may not be included in the article. Data analysis of the chosen studies may not be performed. May reflect the opinion of the author(s).
Randomized controlled trial	An experiment in which a therapeutic or preventative intervention is part of the study protocol and specified in advance by the investigator. Patients are randomly allocated into groups, typically called study and control groups, to receive or not receive the intervention. In most trials, one intervention is assigned to each individual but sometimes assignment is to defined groups of individuals, for example animals in a herd or a barn, or interventions are assigned within individuals, in different orders.
Other clinical trials	An experiment in which a therapeutic or preventative intervention is part of the study protocol and specified in advance by the investigator. Studies did not include a control group (uncontrolled clinical trial) or utilized nonrandom methods to allocate patients to groups. Intervention assigned between or within individuals or groups of individuals. Includes phase I and II clinical trials.
Cohort	An observational study in which patients are sampled on the basis of exposure, where exposure can be a risk factor, disease or intervention. Patients are followed over time and evaluated for the incidence of specific outcomes. Patients may be divided into two or more groups based on risk factor, disease or intervention; however, a comparison group is not a defining feature of this study design. When the exposure-outcome association is evaluated, the comparison group can be either internal or external.

Table 1

Definitions for Study Design (continued)

Study Design	Definition
Case-control	An observational study that compares patients with a specific disease or outcome of interest (cases) to patients from the same population without that disease or outcome (controls), and which seeks to find associations between the outcome and prior exposure to particular risk factors or treatment, or the prevalence of a variable in each of the study groups.
Cross-sectional	An observational study measuring the distribution of some characteristic in a population at one particular point in time.
Case series	A study reporting observations on a series of patients with a specific disease, disease-related outcome or characteristics, with no control group. Sampling is based on either: a specific outcome and the presence of a specific exposure; or only a specific outcome.
Case report	A study reporting observations on a single patient with a specific disease or characteristic.
Nonclinical experiment	An experiment that utilized one or more of the following: solely healthy animals; animal models of animal disease in which disease induced in either target or non-target species; or body fluids or tissues not associated with individual patient histories and a target disease state.

Note. Adapted from: “Evidence-Based Medicine in Otolaryngology Journals,” by B .L. Dekkers, M. Boruk and R. M. Rosenfeld, 2002, *Otolaryngology and Head and Neck Surgery*, *126*(4), p. 372; “Distinguishing Case Series from Cohort Studies,” by O. M. Dekkers, M. Egger, D. G. Altman and J. P. Vandenbroucke, 2008, *Annals of Internal Medicine*, *156*(1_Part 1*)*, pp. 37-40; “Glossary of Terms in the Cochrane Library,” Version 4.2.5, 2005, from http://www.cochrane.org/glossary; “Guidelines for preparation of manuscripts submitted to the *Journal of Veterinary Internal Medicine*”, 2013, retrieved January 21, 2014 from http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1939-1676/homepage/AuthorGuidelines_10-8-13.pdf ; “OCEBM Table of Evidence Glossary” by K. Law and J. Howick, 2013, retrieved January 20, 2014 from http://www.cebm.net/?o=1116; “Observational Research Methods. Research Design II: Cohort, Cross Sectional and Case-Control Studies,” by C. J. Mann, 2003, *Emergency Medicine Journal*, *20*(1), pp. 54-60; “Changes in Study Design, Gender Issues, and Other Characteristics of Clinical Research Published in Three Medical Journals from 1971 to 1991,” by M. M. McDermott, F. Lefevre, J. Feinglass, D. Reifler, N. Dolan, S. Potts and K. Senger, 1995, *Journal of General Internal Medicine*, *10*(1), p. 14; “Clinical Research in Family Medicine: Quantity and Quality of Published Articles,” by J. Merenstein, G. Rao and F. D’Amico, 2003, *Family Medicine*, *35*(4), p. 285; and “A Survey of Evidence in the Journal of Veterinary Internal Medicine Oncology Manuscripts from 1999 to 2007 by A. Sahora and C. Khanna, 2010, *Journal of Veterinary Internal Medicine*, *24*(1), p. 52.

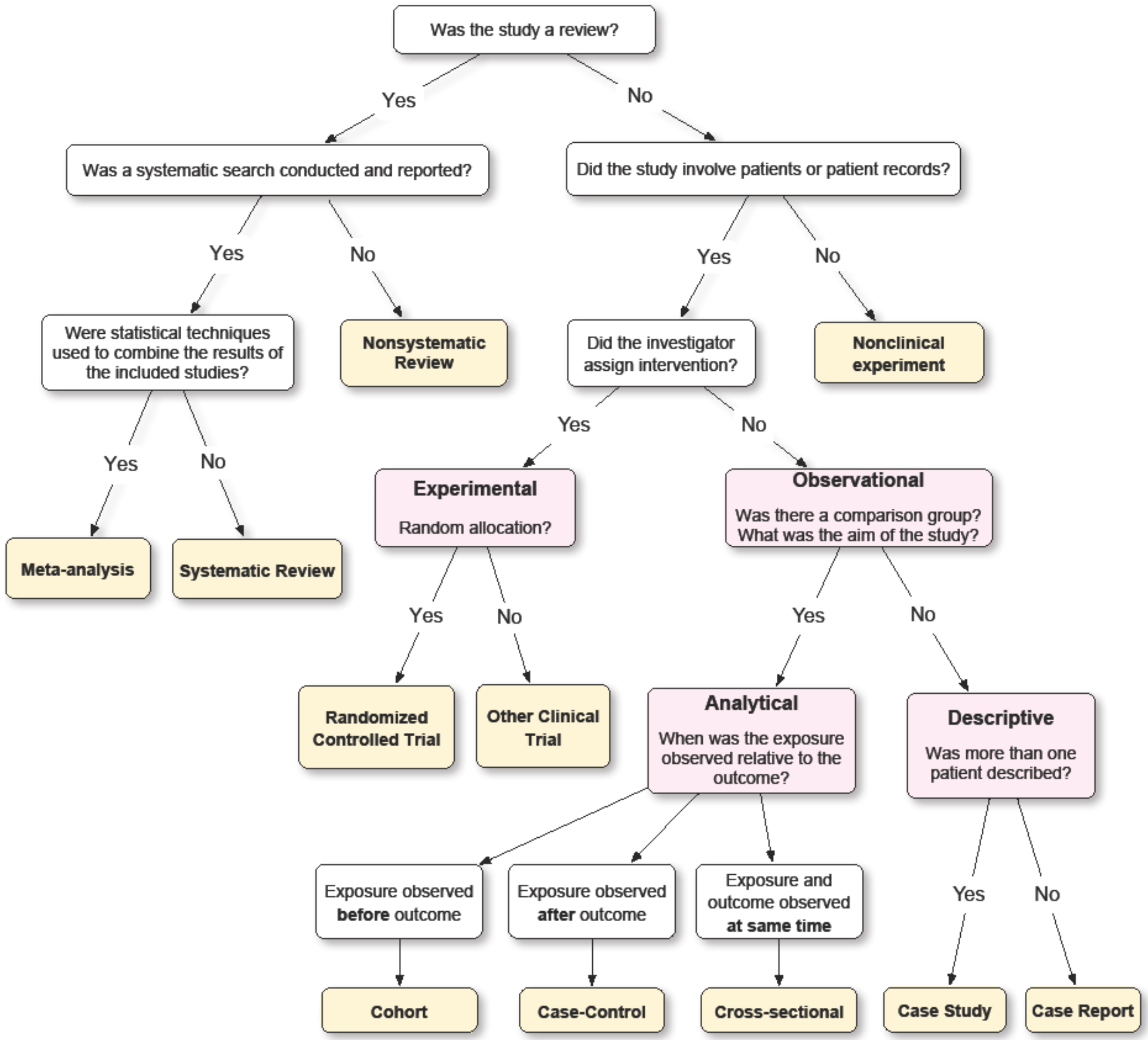

Figure B1. Study design decision tree. Image designed by Robert Ladd for this study. Adapted from: "Centre for Evidence Based Medicine", 2013, retrieved November 19, 2013 from http://www.cebm.net/index.aspx?o=1001; "Bibliometric Analysis of Articles Published from 1980 to 2009 in *Physical Therapy*, Journal of the American Physical Therapy Association," by R. A. Coronado, D. L. Riddle, W.A. Wurtzel, S. Z. George, 2011, *Physical Therapy*, *91*, p.2 [eAppendix]; "An Overview of Clinical Research: The Lay of the Land," by D. A. Grimes and K. F. Schulz, 2002, *Lancet*, *359*, p. 58; and "How to Set Things Up? Study Designs," by D. G. Kleinbaum, K. M. Sullivan and N. D. Barker, 2007, A Pocket Guide to Epidemiology, New York: Springer, p. 25.