Published in final edited form as:
J Vet Med Educ. 2009 ; 36(1): 70–75. doi:10.3138/jvme.36.1.70.

The Need for Veterinarians in Biomedical Research

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Abstract

The number of veterinarians in the United States is inadequate to meet societal needs in biomedical research and public health. Areas of greatest need include translational medical research, veterinary pathology, laboratory-animal medicine, emerging infectious diseases, public health, academic medicine, and production-animal medicine. Veterinarians have unique skill sets that enable them to serve as leaders or members of interdisciplinary research teams involved in basic science and biomedical research with applications to animal or human health. There are too few graduate veterinarians to serve broad national needs in private practice; academia; local, state, and federal government agencies; and private industry. There are no easy solutions to the problem of increasing the number of veterinarians in biomedical research. Progress will require creativity, modification of priorities, broad-based communication, support from faculty and professional organizations, effective mentoring, education in research and alternative careers as part of the veterinary professional curriculum, and recognition of the value of research experience among professional schools' admissions committees. New resources should be identified to improve communication and education, professional and graduate student programs in biomedical research, and support to junior

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faculty. These actions are necessary for the profession to sustain its viability as an integral part of biomedical research.

Keywords

biomedical research; veterinarian; laboratory animal; pathology; public health

INTRODUCTION

It is well documented that the number of veterinarians in the United States is inadequate to meet societal needs in biomedical research and other fields important to public health.[1-4] The areas of greatest need include translational medical research, veterinary pathology, laboratory-animal medicine, emerging and infectious diseases, public health, academic medicine, production animal medicine, and many of the veterinary clinical specialties. Some geographic regions are also underserved by companion animal and equine veterinary practitioners. Graduate veterinarians have a wide choice of career opportunities in private veterinary practices, large corporate practices, academia, local, state, and federal governmental agencies, and private industry. Therefore, these groups all compete for the same narrow pools of veterinary graduates and all encourage veterinary students to follow paths leading to careers in their respective areas. There are only approximately 2,500 veterinary graduates in the United States per year, which is why the pipeline for the workforce is so constricted.[5]

This review focuses predominantly on the current need for veterinarians in biomedical research. Two studies commissioned by the National Research Council (NRC) have provided important data for this paper.[6,7] First, the Committee on Increasing Veterinary Involvement in Biomedical Research was commissioned by the Institute for Laboratory Animal Research of the NRC to determine the national need and priorities for veterinarians in biomedical research.[6] Second, the Committee on the National Needs for Research in Veterinary Science reported on and emphasized the need for veterinary research in public health and food safety, animal health and welfare, comparative medicine, and emerging diseases (including zoonotic diseases). In addition this report identified the current resources for veterinary research and projected future workforce and infrastructure needs. More recently, the NRC has convened a committee to study the issues related to the veterinary workforce in the United States in a project entitled “Assessing the Current and Future Workforce Needs in Veterinary Medicine.” This report will be available in mid-2009. Collectively, these reports stress the important role of veterinarians in public health and biomedical research, and the real or projected shortages of veterinarians trained to perform research.

THE ROLE AND CENTRALITY OF THE VETERINARIAN IN RESEARCH

Veterinarians in academia, industry, or the government are often leaders or key team members involved in a broad array of research including basic science research, biomedical research with applications to animal or human health, laboratory-animal medicine, public health, and medical product development. With their background and training, veterinarians have unique skill sets that enable them to serve as important members of interdisciplinary research teams. The professional veterinary curriculum uniquely includes education in systems biology and pathobiology, clinical and comparative medicine of a wide range of small and large animal species (often in context to human disease), surgery, epidemiology, and public health.

A subset of veterinarians receive advanced research training, often leading to MS or PhD degrees. These highly trained individuals will typically serve as principal investigators or members of collaborative research teams in academia, industry, or government. An increasing

number of veterinarians opt for advanced clinical training in one of the many specialties (analogous to human medicine) recognized by the American Veterinary Medical Association (AVMA) (http://www.avma.org/education/abvs/specialty_orgs). Many of these individuals will work in private specialty practices, but some will become academic faculty or work in industry. A smaller number of veterinarians combine advanced education in research with post-professional specialty training. This direction is common in veterinary pathology, but also includes individuals who work in clinical specialties, public health, and laboratory-animal medicine. In reviewing the role of veterinarians in academia, it is important to consider that veterinary colleges have increasingly hired faculty who are not veterinarians to augment the research mission. These faculty serve vital roles in the research and educational missions of nearly all veterinary colleges worldwide.

There are a number of areas in basic and applied research in which veterinarians play leading roles. These areas include, but are not limited to, the human–animal bond, food safety, emerging diseases and zoonoses, bioterrorism or agro-terrorism with select agents (often representing zoonoses), animal and human health and safety, and ecosystem and wildlife health. The public and federal sponsors of biomedical research have placed increased importance on the translation of basic research to improve human health. “Translational research” has become an important term used in the scientific literature and lay press. It is often poorly defined, but typically includes the application of bench or basic research to the human patient. Animal research is often a necessary link to connect basic research with human clinical research. Likewise, animal research that lays the foundation for improved human health also has a positive impact on advancing animal health. In some instances, through clinical trials, veterinary patients with serious illnesses (such as cancer) can have access to leadingedge therapies even before they are available for human patients.

Animal models of human disease are often an integral part of translational research. The National Center for Research Resources (NCRR) in the National Institutes of Health (NIH) promotes and funds research, education, and centers dedicated to animal models of disease. Unfortunately, there are often too few veterinary scientists to support translational research in academic and research centers. This problem has become especially acute in veterinary pathology and laboratory-animal medicine. Multiple studies report a deficiency of veterinary pathologists in multiple job settings.[8,9] This is particularly severe in colleges of veterinary medicine and other academic settings. Pathologists with research training are critical in the “translational” setting in which discovery is integral to treatments of human or animal patients.[10]

The laboratory mouse has become the preferred animal model for many diseases due to the availability of reagents and ease of manipulation of its genome. Mouse pathologists and laboratory animal veterinarians dramatically improve the ability of research teams to use mouse models of human disease to translate bench research to human medicine. There are too few of these individuals to serve the biomedical community. Academic medical centers with a nearby veterinary college have the advantage of being in close proximity to these experts.

VETERINARY PROFESSION

The veterinary profession has continually adapted to the changing needs of society.[11] In the nineteenth century, horses and their health were the primary focus of veterinary medicine because of the important role horses played in the lives and livelihood of people, including farming and transportation. In the early twentieth century, animal agriculture rose in prominence. In the late twentieth century, veterinary medicine gave much greater attention to the health of companion animals. The human–companion animal relationship and bond continues to evolve. Pets often play a key role in the family structure, and the importance of

the human–animal bond is well recognized to have positive effects on human well-being, health, stress, healing, and the immune system.[12-14]

In 2007, approximately 80% of veterinarians were in private clinical practice, and 77% of those served companion animals exclusively or predominantly.[15] The number of veterinary clinical specialties (that require additional post-graduate education) continues to rise. In 1973, there were 10 recognized specialties: public health, pathology, laboratory-animal medicine, radiology, surgery, toxicology, ophthalmology, theriogenology, microbiology, and internal medicine. By 2007, the number of recognized veterinary specialties had doubled to 20, with most of the growth in the clinical specialties and sub-specialties. However, the increase in the number of veterinary schools and class sizes has not kept in pace with population growth and the public demand for services. This lack of growth has resulted in a shortage of new gradates for most types of practice and service to society, including research and public health. In 2002, it was estimated that 500 of the 2,500 total new graduates would be needed in the population health and public practice arena just to satisfy current needs.[16]

"ONE HEALTH, ONE MEDICINE"

One Health is the concept that the health of the earth's ecosystems, flora, fauna, and people is connected in interdependent and integral ways.17,18 This perspective has been recognized to different degrees over the ages of humankind.[11] In ancient times, healers cared for both people and animals. In medieval times, there was a cultural splitting of human and veterinary medicine. Medieval universities focused on the healing arts for humans. In contrast, equerries were individuals who practiced veterinary medicine predominantly for the well-being of horses. In the eighteenth and nineteenth centuries there was a reconnection of human and veterinary medicine. The first veterinary school was founded in Lyon, France in 1762, where Bourgelat proposed that veterinarians should also receive human clinical training (and was criticized by some). In the nineteenth century, Rudolf Virchow and others proposed the idea of comparative medicine that connected human and veterinary medicine. This was based on pathological concepts and the microbiology of disease. In the twentieth century, increased specialization in both the veterinary and medical fields tended to separate the two professions. Now, in the twenty-first century, there has been a rediscovery of the common connections between human, animal, and ecosystem health.[19] This One Health, One Medicine perspective will be especially important in the prevention and treatment of new emerging infectious diseases, which are often zoonotic.20

In 2007, the AVMA charged the One Health Initiative Task Force with studying the feasibility of an initiative that would facilitate collaboration among the health professions, academe, government, and industry to promote One Health and to identify workforce and infrastructure needs. The final report validated the concept of One Health and identified the need for convergence, collaboration, and the formation of a national coalition or commission to continue with the work.[21]

The public has high expectations for continued and rapid progress in protecting human and animal health and solving challenging current health issues such as emerging diseases, obesity, diabetes mellitus, cancer, and nervous system disorders. This expectation has increased the importance of and need for integrative and translational veterinary medical scientists. Areas of need include virology, microbiology, cellular and molecular physiology, immunology, public health, pathology, surgery, translational clinical trials in animals and humans, and cutting-edge research in gene therapy, stem cells, and genetically modified animals.[22] In addition, there is increasing interest in using natural or genetically modified environmental microbes to help solve the challenges of renewable energy sources, human and animal waste management, and pollution control.

The veterinary profession has a long history of accomplishment in biomedical research and comparative medicine with important contributions to human health.[23] Examples of historical accomplishments in research include demonstration that insects can transmit disease with Texas cattle fever by Smith and Kilbourne in 1893, identification of the first animal virus (foot-and-mouth disease) by Loeffler and Frosch in 1898, discovery of the first leukemia caused by a virus by Ellerman and Bang in 1908, and identification of prions in slow viral disease of scrapie and kuru by Eklund and Hadlow in 1973. In addition, the veterinary profession has demonstrated long-standing leadership in research and discovery in fields such as retrovirology (e.g., HIV research), bacteriology, and hematogenous parasites.

VETERINARIANS AS CRITICAL TEAM MEMBERS IN BIOMEDICAL RESEARCH

In addition to performing research themselves, veterinarians play crucial roles in the support of biomedical research. Laboratory animal veterinarians support the medical care and health of laboratory animals, promote animal well-being and humane care of laboratory animals, maintain barrier conditions against diseases to improve laboratory research, conduct collaborative research, provide technical instruction to scientists, monitor compliance with state and federal regulations, and serve on institutional animal research review panels. Veterinary and medical pathologists (that specialize in laboratory animal pathology) are central to the diagnosis of spontaneous diseases, understanding the mechanisms of disease induced by experimental procedures, and analyzing the phenotype of spontaneous or induced genetic modifications in animals. When there is a lack of expert pathology support on a research project important information may be misinterpreted or go undiscovered, which reduces the impact of animal-based research.[24]

In addition, the public health profession has become increasingly aware of the role of veterinary medicine in the prevention of human illness. This awareness has been demonstrated in joint programs conducted by the American Association of Veterinary Medical Colleges and the Association of Schools of Public Health.[25] Many veterinary colleges offer advanced education in veterinary public health in partnership with schools and colleges of public health. Veterinary medicine has played a longstanding role in food inspection and safety in both society and the military. The armed forces employ and provide post-graduate educational opportunities for veterinarians in public health, pathology, and biomedical research.

Genomics has irreversibly changed biomedical research. The pace of genomic sequencing is continually and exponentially increasing with improvements in technology and data processing. When information and ethical medical systems are developed to effectively utilize the data, the genetic sequencing and analysis of individuals will lead to a revolution in personalized health care. Genomics contributes to the translation of basic and animal research to human medicine by using comparative genetics. For example, it has been recognized that the approximately 120 dog breeds represent valuable narrow lineages that can be used to mine the dog genome for disease-specific genes and polymorphisms with applications to cancer, metabolic diseases, behavior, personality studies, and heritable mutations.[26-28] Genetically modified mice have become central to comparative genetics. It has been estimated that over 60 million mice/year will be used to study the genome. It has become more important to share genetically modified mice between laboratories around the world. The international movement of laboratory animals has increased the need for veterinarians to control and monitor for disease to keep animal collections free from pests and contagious diseases.

Over the past two decades, there has been an increase in the number of research grants for studies using animals. Approximately 32% of NIH-funded research projects use animals.[29] This growth has also increased the demand for veterinarians to function as integrative and

clinician scientists, laboratory animal veterinarians, investigative or diagnostic pathologists, and members of research oversight committees. Over 85% of laboratory animals are rats and mice. In 1998, 23 million rats and mice were used in research. While accurate numbers are not available, it is estimated that mouse use will continue to increase 10–20% per year and that by 2010, 200 million or more rats and mice may be used each year in research.[29] The increased use of rats and mice for research has occurred on many academic campuses, which has required greater institutional investment in facilities and infrastructure. When this steady increase will plateau is not known.

The growth in animal research has resulted in an increased need for and subsequent shortage of laboratory animal veterinarians. Numbers of laboratory animal veterinarians (certified by the American College of Laboratory Animal Medicine, ACLAM) increased 15% from 1997 to 2002. In 2002, there were 1,608 US Department of Agriculture–registered research institutions and 666 employed laboratory animal veterinarians. Over the same time period, 25% fewer veterinarian trainees entered post-graduate programs in laboratory-animal medicine. Nine of the programs had no students complete training during those five years.[29] The University of Massachusetts Donahue Institute completed a Laboratory Animal Care Workforce Study for the Massachusetts Society for Medical Research in February 2008.30 Although the study assessed the need for biomedical research in the state of Massachusetts, the findings are in agreement with the NRC report6 and suggest a national trend. The report confirmed the lack of laboratory animal veterinarians and animal caretakers and the difficulties with recruiting and hiring professional and lay personnel. The lack of adequate numbers of laboratory animal veterinarians was concluded to have a potential detrimental effect on biomedical research funding and progress.

Animal models of human disease have become increasingly important in fostering translational research. Research using spontaneous or experimental animal models of disease can have benefits for both veterinary and human medicine. Clinical trials and evidence-based medicine for spontaneous diseases in companion animals can have direct relevance to similar human conditions. In some cases, clinical trials with spontaneously occurring diseases in dogs, cats, horses, and other companion animals may better predict pathogenesis and treatment outcomes in humans than experimental rodent studies.

Animal models take advantage of a wide range of species, including zebra fish, rodents, ungulates, dogs, and primates. Each species has its advantages and disadvantages. Zebra fish offer rapid, high throughput screening for genetic mutations and targets of biochemical pathways. Mouse models of disease can be developed by chemical mutagenesis or by directly modifying the genome using transgenic, knock-out, and knock-in technologies. Transgenic rats, pigs, and ruminants have been successfully produced. For example, transgenic proteins have been made by the mammary glands of small ruminants or cattle. Primate models of disease are used only when other species of animals are unable to effectively model human disease pathogenesis or treatment. Although most institutes of the NIH fund biomedical research using animals, the NCRR at the NIH has two divisions that promote animal-based research (http://www.ncrr.nih.gov/). The Division of Comparative Medicine funds specialized facilities for animal models, supports the development of animal models from invertebrates to lower vertebrates, supports the eight National Primate Research Centers, and funds the training and career development of veterinarians, repositories for genetically modified animals, and breeding of scarce research animals. The Division of Research Infrastructure at the NCRR provides matching funds to improve biomedical research facilities that often involve animal facilities.

GOALS AND BARRIERS

An important goal is to increase the workforce of integrative or systems-based scientists, veterinary scientists (basic and applied research), veterinary pathologists, laboratory animal veterinarians, and public health veterinarians.

Barriers exist to accomplishing this goal. These include financial burdens and high (and continually increasing) student debt, the time necessary for completion of advanced education and training, competition from the private sector, and a lack of relevant educational programs at colleges of veterinary medicine (or medical centers). For additional reading, see the companion articles in this journal on "Veterinarians in Biomedical Research: Building National Capacity" (Buss et al.) and "Factors that Attract Veterinarians to or Discourage Them from Research Careers: A Program Director's Perspective" (Atchison).

RECOMMENDATIONS[6]

Acquaint Students with Opportunities in Comparative and Translational Medicine throughout Veterinary School

Veterinary colleges, faculty, and professional societies must make this a strategic priority. Research clubs, summer research experiences, and research externships are effective tools to foster student interest in research. Although most participants will not pursue research careers, knowledge of the scientific method, basic research, and evidence-based medicine will lead to better clinicians who are more supportive of the need for research at many levels. Veterinary practitioners and clinicians are clinical scientists who are constantly investigating the cause (diagnosis) of disease and are on the front line for recognizing and diagnosing emerging diseases or disease outbreaks. Therefore, providing meaningful and useful research training and experiences during the veterinary school curriculum will better prepare them for their front-line role in promoting animal health.

Increase Veterinary School Recruitment of Applicants with an Interest or Experience in Comparative and Translational Medicine

The admissions process for professional students at veterinary colleges could and would need to be modified to support this recommendation.

Change Veterinary School Curricula: Provide More Electives or Required Courses in Biomedical Research and Laboratory-Animal Medicine

Course offerings and elective opportunities in research and laboratory-animal medicine are needed. Faculty mentoring of veterinary professional and graduate students will help students to appreciate the wide array of career opportunities. All faculty should foster and support students who are interested in alternative career paths.

Address Financial Barriers to Post-graduate Education in Comparative and Translational Medicine

There are relatively few sources of federal funding for post-professional education. The NIH funds competitive five-year institutional (T32) and up to three-year individual (F32) national research service awards to support research fellowships and doctoral studies. In addition, five-year research career awards (K awards) are available to fund the transition period of trainees to junior faculty. Although there are few of these awards, the stipend levels are competitive compared with starting salaries for veterinarians in private practice, but are not competitive compared with starting salaries for veterinary specialists. Educational institutions will need to develop creative opportunities for post-professional education for veterinarians, including optimizing the time required for completion of both specialty and research training and

enhancing the financial benefits of participation. Broad faculty and peer support are especially important.

Increase the Number of Veterinarians in Roles Supporting Biomedical Research and as Role Models for Future Veterinarians in Research

It will be important to increase the number of residency positions at academic institutions, particularly in laboratory animal medicine, public health, and other key disciplines that are facing shortages. While it is critical to improve the pipeline of veterinarians with opportunities for training in biomedical research, it is equally important to promote outstanding role models for veterinary students who are interested in a career in biomedical research. The celebration of the veterinarian as a key contributor to biomedical research must be incorporated into the culture of colleges of veterinary medicine to stimulate veterinary students to explore career paths in biomedical research.

Increase the Number of Veterinarians Serving as Principal Investigators

Few veterinarians are funded as principal investigators through traditional NIH research grants (such as R01s). However, NIH-funded principal investigators serve as important mentors for other faculty and students. Success depends on many factors, including personal ambition and drive, excellent training and mentoring, and a supportive environment. Institutions need to provide substantial time commitments (often greater than 50% of working time), effective mentoring, start-up funding, and the necessary infrastructure to enable veterinary scientists to be competitive for federal research funding. Collaborative teams that nurture individuals are critical. Cluster hiring can be an effective tool to build research teams more quickly. Cluster hiring may be implemented in one department, but in times of limited resources it may be more feasible and even beneficial if the faculty are in different departments or colleges. Interdisciplinary research with strong team members focused on important societal needs is the future of biomedical research.

Promote Diversity to Expand the Pool of Veterinarians in Biomedical Research

A principal goal of veterinary medicine is to increase the diversity of the profession. A culturally diverse pool of veterinarians will strengthen the role of veterinarians in society. It is important to note that, based on the authors' experience with our training programs, underrepresented populations often view biomedical research as a viable and laudable career goal. Veterinary medical colleges and other training institutions that aggressively promote the veterinarian as a biomedical researcher will benefit both the profession and society.

SUMMARY

There are no easy solutions for increasing the number of veterinarians in biomedical research. However, some progress can be made with current resources. Success in this effort will require creativity and flexibility, modification of priorities, broad-based communication, support from faculty peers and professional organizations, effective mentoring programs, education in research and alternate careers as part of the veterinary professional curriculum, and recognition of the value of research experience among professional school admission committees. New resources from local, private, and federal sources should be identified to improve local communication and constituent education, provide professional student programs in research, provide post-professional graduate programs in biomedical research, veterinary pathology, laboratory animal medicine, and public health, and support junior faculty with adequate research time, mentoring, and state-of-the-art facilities. These actions are necessary for the profession to sustain its viability as an integral part of biomedical research.

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