Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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COMMENTARY

Highlighting the role of veterinary pharmacists in zoonotic diseases including COVID-19

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ABSTRACT

Veterinary pharmacy is an often unknown and therefore, underrepresented career path for pharmacists. Uniquely, pharmacists—even untrained in veterinary medicine—are the only health professionals legally allowed to provide care for human and nonhuman patients. The 2019 coronavirus disease (COVID-19) pandemic is a peculiar situation that, not only highlights veterinary pharmacy as a career path, but stresses the role veterinary pharmacists, trained in both human and veterinary medicine, can play in zoonotic diseases. Specialized training in veterinary medicine allows the pharmacist to serve as a resource for both physicians as well as veterinarians during zoonotic events by helping to ascertain feasibility of therapeutic options given the species. In addition, veterinary pharmacists involved in translational research would be vital for the drug development process as they would be aware of biologic nuances between the species and how they may affect the ultimate therapeutic outcome.

Veterinary pharmacy training

Despite the lack of widespread veterinary pharmacotherapy at pharmacy schools, pharmacists are the only health care provider expected by society to provide care for all species.[1] Appreciating this expectation, a 2014 resolution from the National Association of Boards of Pharmacy encourages "…the development and availability of veterinary pharmacology education at colleges and schools of pharmacy in collaboration with schools of veterinary medicine" so that pharmacists "dispensing medications for veterinary patients possess the competence and have access to resources necessary to appropriately dispense and provide care."[2] Echoing the need for veterinary pharmacology training, a 2013 study of over 700 veterinarians across the United States found that, of all professional interactions, they most frequently interact with pharmacists.[3] As all pharmacists in the United States are, veterinary pharmacists are trained at schools accredited by the Accreditation Counsel for Pharmacy Education but choose to further their education by pursuing opportunities both as a student pharmacist as well as post-doctoral experiences or positions in veterinary medicine in an effort to expand their pharmaceutical knowledge by including nonhuman species.[4] Veterinary pharmacy electives, although growing in number, are not readily available at most schools of pharmacy. A 2015 survey found that, whereas 22% of responding pharmacy schools offered a veterinary pharmacy elective, a mere 4% of the graduates from those schools completed the elective.[5] This educational deficit is further depicted by a survey of more than 13,000 licensed pharmacists in North Carolina that showed 77% of the respondents routinely fill veterinary prescriptions yet 61% felt less than confident in their ability to verify the appropriateness of veterinary prescriptions.[4] This survey highlights the need for veterinary pharmacotherapy in the pharmacy curriculum to ensure that pharmacists are knowledgeable in caring for all species as a majority will ultimately fill prescriptions for nonhuman species. For practicing pharmacists looking to obtain crucial information for filling veterinary prescriptions, several continuing pharmacy education (CPE) courses in veterinary pharmacy can be found online however, the presenter's credentials should be considered when deciding which course would be most beneficial. Namely, there is a CPE course offered by a fellow of the Society of Veterinary Hospital Pharmacists (SVHP) in conjunction with the University of Florida as well as a PowerPak CPE, with modules written by a board-certified veterinary pharmacist with more than 30 years of experience.[6,7]

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Although clinical veterinary residency positions are available, they are much fewer than traditional residencies and are not accredited by the American Society of Helth System Pharmacists (ASHP). Currently, there are 5 post-graduate year 1 (PGY-1) clinical veterinary pharmacy residency sites whereas, according to a search of the ASHP Residency Directory on June 16, 2020, there are 1456 residency sites for traditional PGY-1 pharmacy residencies. Clinical veterinary pharmacy residencies are presently offered at the following colleges of veterinary medicine: North Carolina State University, Purdue University, University of Wisconsin, Texas A&M University, and University of California at Davis.[4] Although all residency sites aim to prepare the resident for competency in treating all veterinary species, the residency position at University of California at Davis is co-funded by the Food Animal Residue Avoidance Databank and focuses on training the pharmacist to be competent in food animal pharmacotherapy and pertinent litigious considerations.

Following residency training, the most common practice site for veterinary pharmacists is at a veterinary teaching hospital followed by academia, hospital pharmacy, compounding, and community pharmacies (Figure 1). Although most of the residency trained veterinary pharmacists practice in veterinary teaching hospitals, those practicing in other areas remain involved with veterinary pharmacy through research endeavors, teaching veterinary electives, and serving as a resource for veterinary drug-information questions.

Veterinary pharmacy organizations and membership

The Society of Veterinary Hospital Pharmacists (SVHP), which is the organization responsible for credentialing veterinary pharmacists, has 153 members compared to a reported 64,000 members of the American Pharmacists Association. Of SVHP members, 55% are employed at veterinary teaching hospitals.[4] The American College of Veterinary Pharmacists (ACVP), another veterinary pharmacy organization, has a total of 182 pharmacist members with an additional (and encouraging) 468 student members. ACVP members primarily focus on compounding and therefore, provide a combination of human and veterinary pharmacy services.[4] Of all veterinary pharmacists both in the United States and internationally, there are currently only 32 board-certified veterinary pharmacists, signified as Diplomate of the International College of Veterinary Pharmacy (DICVP), that have met credentialing requirements and passed a 5-part examination to demonstrate competency in veterinary pharmacotherapy. Although veterinary pharmacists provide care to a number of species, including companion animals, equine, exotic animals, and food animal species, there are currently no board-certifications for specific species thus, DICVP candidates are expected to be knowledgeable in treating all veterinary patients.

Veterinary pharmacists' impact on the One Health Initiative and COVID-19

The importance of the relationship between humans, animals, and the environment is highlighted by the Centers for Disease Control and Prevention (CDC) One Health initiative, which has a "goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment."[8] An unfortunate but epitomic example of the importance of One Health is depicted by the novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which has led to a global pandemic. First described in Wuhan, China in late 2019, SARS-CoV-2 has spilled over from an animal species, likely bats, and is now able to infect humans as well as spread via human-to-human transmission.[9-11] Reports have also surfaced regarding human-to-animal transmission when a tiger at the Bronx Zoo was found to be positive for coronavirus disease (COVID-19) after being cared for by an infected zookeeper. Since then, an additional 4 tigers and 3 lions' fecal samples have also tested positive for COVID-19.[12,13] A health professional trained to provide care for both human and nonhuman species is an incredible asset as the world attempts to navigate cross species transmission concerns, identification of infections, and recommendations for interactions with personal pets. This niche is highlighted by a study that found veterinarians desired more interprofessional interaction to help understand zoonotic diseases and most commonly interacted with pharmacists.[3]

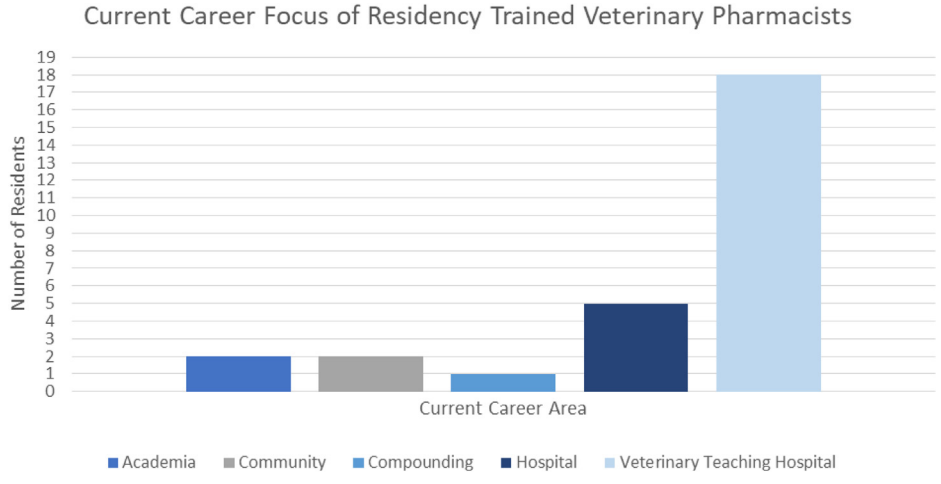

Figure 1. Ultimate career areas for clinical veterinary pharmacy residents from 2003 through 2020 residency class (n = 30; 1 unemployed, 1 deceased).

Veterinary pharmacists are also called on to answer numerous drug-information questions especially regarding personal pets in light of some companion animals testing positive for COVID-19.[13] Their unique training allows them to understand that members of the *Felidae* family, before the pandemic, were known reservoirs of coronaviruses, and their susceptibility to COVID-19 was not surprising. However, dogs are not known to have a high susceptibility to coronaviruses as they do not replicate efficiently but after some dogs have tested positive for antibodies, more research is needed to ascertain the risk.[13] Veterinary pharmacists, especially those working in community pharmacy, are able to converse with patients and explain how COVID-19 may affect their pet as well as their own interaction with their pet.

Although the animals mentioned above recovered without medical treatment, it leaves veterinarians wondering—much like their physician counterparts have been for months—what treatments may be effective if the disease is not self-limiting in the next patient. To answer this question, researchers and health care workers are working diligently to develop vaccines and drugs to prevent and treat patients, respectively, with COVID-19.

Benefits of veterinary pharmacist involvement in drug development

According to the International Conference on Harmonisation (ICH), drug development in the United States typically necessitates that the experimental compound is tested first in rodent and nonrodent animals, usually healthy mice and beagle dogs, for chronic toxicology data.[14] However, during COVID-19, effective therapeutic options were necessary and available information was conflicting, so animal studies to evaluate efficacy became vitally important.[15] Coronaviruses are known to affect a wide range of animals including domestic and exotic felines as well as ferrets, which have been suggested as a naturally occurring animal model for COVID-19 after it was found that the virus replicates in the nasal turbinate, soft palate, and tonsils of ferrets.[12,16] Naturally occurring animal models have tremendous value in helping to ascertain clinical applicability of novel therapeutics as efficacy can be evaluated in tandem, which can be critical during a pandemic when little otherwise information is known.[17] As, pursuant to ICH guidance, drugs seeking Food and Drug Administration (FDA) approval undergo pharmacokinetic analysis in animal models, data may be available from pharmaceutical companies that could help aid veterinarians in treating their patients. To fulfill this need, a collaborative between the University of Missouri-Kansas City and Kansas State University called 1Data, which serves as a repository for both human and animal health data, was started in 2018. This consortium seeks to acquire human and animal data from a variety of sources so that it can be used to accelerate the development of human and animal drugs and help to answer vital questions that arise during zoonotic outbreaks such as the COVID-19 pandemic by leveraging data from numerous species.[18] A veterinary pharmacist would understand where to find available animal pharmacokinetic data and the impact it could have on veterinarians attempting to treat animals, such as those at the Bronx Zoo, as well as the larger impact on public health.

As the world scrambles to learn more about SARS-CoV-2 and how best to treat COVID-19, emergency use authorization (EUA) of certain drugs, such as remdesivir, have been approved by FDA.[19] Before being granted the EUA, remdesivir was being evaluated for treatment of the Ebola virus but has shown promise in treating coronaviruses such as severe acute respiratory syndrome and Middle Eastern Respiratory Syndrome in animal models.[15,20] Following the EUA, clinicians were now able to treat human patients with a drug that had minimal exposure in human patients and only limited information obtained from animal studies. Veterinary pharmacists act as a unique resource with the ability to analyze animal data and reasonably extrapolate into clinical information for human use. For example, an experimental drug requiring acetylation during phase II metabolism would be expected to show severe toxicity in research dogs because of a complete deficiency in N-acetyl transferase in canid species.[21] A veterinary pharmacists on the drug development team would be able to elucidate that the toxicity has occurred owing to the differences in metabolism and not because of drug failure, a contribution that could be invaluable to the pharmaceutical company developing the drug.

Conclusion

Looking forward, an increased number of trained veterinary pharmacists could result in a workforce ready to respond during zoonotic pandemics. In addition, veterinary pharmacists remain an underutilized resource and future endeavors should include partnership with industrial and academic organizations to help develop treatment options and answers questions related to zoonotic diseases. To meet this need, an increased availability of veterinary pharmacy residencies is warranted. Veterinary pharmacists can play a pivotal role in helping to answer the myriad of questions surrounding zoonotic disease, such as COVID-19, by understanding species differences, evaluating the feasibility of repurposing current drugs, and actively participating in drug development.

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