



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.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Teaching “One Medicine, One Health”

The concept that animal health and the environment influence human health has been around since ancient times. Indeed, the initial mission of veterinary medicine was to benefit human health by improving the food supply. In the late 19th and early 20th centuries, leaders in medicine such as Drs. Rudolf Virchow and William Osler embraced the concept that human health and animal health were inextricably linked.¹ As the 20th century progressed, collaboration between medicine and veterinary medicine waned. In the 21st century, the emergence of deadly zoonotic diseases, such as human immunodeficiency virus/acquired immune deficiency syndrome, severe acute respiratory syndrome, and West Nile virus, present the urgent need that these professions renew and increase collaborative efforts.

A BRIEF HISTORICAL PERSPECTIVE

In the 18th century, Pope Clement XI instructed a physician, Dr. Giovanni Maria Lancisi, to devise disease control measures to combat rinderpest, a highly lethal viral disease of cattle that was devastating the human food supply. Lancisi recommended that ill and suspect animals be destroyed. In order to put Lancisi's principles into effect, the first veterinary medical school in the world was established in Lyon, France.²

Virchow and Osler continued these cross-disciplinary efforts. Early in his academic medical career, Virchow conducted animal experiments such as the study of the life cycle of *Trichinella spiralis* in porcine muscular tissue and cysticercosis and tuberculosis in cattle; he coined the term “zoonosis.”³ His efforts helped lead to regular meat inspections by veterinarians in Europe and eventually in the United States. In 1873, Osler, who had recently received his medical degree from McGill University, left Canada to study with Virchow in Berlin. Virchow impressed upon the young Osler the importance of the autopsy and of scientific inquiry in the practice of medicine. Osler returned to Canada in 1874, where he established veterinary pathology as an academic discipline in a North American school of veterinary medicine.⁴

EMERGING ZOOONOTIC DISEASES

In the 1960s, Dr. Calvin W. Schwabe, the late veterinary epidemiologist and parasitologist at the University of California, Davis, coined the term “One Medicine,” which promoted a unified medical and veterinary medical approach

against zoonotic diseases. This strategy is important because there have been recent emerging zoonotic disease outbreaks, including the Nipah virus, severe acute respiratory syndrome, and avian influenza (A) H5N1, that are spreading across Asia, Africa, and Europe. Reasons for the emergence of these zoonotic diseases include: intensive agricultural practices, global trade in exotic animals, consumption of “bush meat,” and human population pressures. We must anticipate many more zoonotic disease outbreaks “emerging” in the future.

COLLABORATION IN EDUCATION

Unlike the late 19th century, in which there was considerable collaboration, particularly in medical and veterinary medical education and research, there are limited collaborative efforts today. Part of the problem might stem from the fact that medical schools typically do not emphasize the ecology of zoonotic pathogens, as is done in schools of veterinary medicine.

This lack of emphasis on the ecology of zoonotic pathogens in medical schools might explain the findings by Grant and Olsen, who studied the roles of physicians and veterinarians in preventing zoonotic disease risks in immunocompromised patients. They found that physicians were generally not comfortable discussing these issues with their patients, yet the patients did not view veterinarians as a source of information for human health.⁵ In the end, these issues typically do not get addressed.

The risks of owning or working with animals are considerably greater for chronically immunosuppressed individuals than for those who are immunocompetent. Significant improvement for all could be achieved if both physicians and veterinarians educated their patients/clients about zoonotic risks of their pets. Schools of medicine and veterinary medicine should provide their students the opportunities to learn about how animal and human health can impact on each other.

COLLABORATION IN COMPARATIVE MEDICINE RESEARCH

Collaborative research efforts between schools of medicine and veterinary medicine could be done under the auspices of comparative medicine. Comparative medicine, a field of study that exemplifies the “One Medicine” concept, involves the study of host-pathologic agent interactions in

infectious diseases and their pathogenesis, which is critical to our understanding of zoonotic agents.

In 1893, a physician and veterinarian research team, Drs. Theobald Smith and F. L. Kilbourne, respectively, discovered that the cause of cattle fever, *Babesia bigemina*, was transmitted by an arthropod vector (ticks). Their work helped set the stage for the discovery by Walter Reed and his colleagues of the transmission of yellow fever.⁶

Drs. Rolf Zinkernagel and Peter C. Doherty, a physician and veterinarian, respectively, discovered how the immune system distinguishes normal cells from virus-infected cells. They received the 1996 Nobel Prize in physiology or medicine.⁷ Together, medicine and veterinary medicine can generate new scientific insights across species, which is exactly what is needed to meet today's challenges.

CONCLUSION

To confront the 21st century threats of emerging zoonotic diseases, we should learn from our predecessors in the 18th and 19th centuries. Visionary leaders and educators of medicine embraced the fact that zoonotic pathogens infect both humans and animals and, as a result, they encouraged their physician colleagues to work closely with their veterinary medical colleagues. On June 25th, 2007, the American Medical Association House of Delegates approved a "One Health" resolution, which promotes the partnership between human and veterinary medicine. The American Veterinary Medical Association set up a task force of prominent veterinarians, physicians, and allied health scientists in July 2007. It was charged with developing strategies to implement the "One Health" concept. These are important steps toward our understanding of how to control, and ultimately, prevent zoonotic disease transmission, which would improve the health and lives of both animals and humans. Schools of medicine, veterinary medicine, and public health

should embrace the "One Health" concept and prepare their students to meet the challenges of the future.

Laura H. Kahn, MD, MPH, MPP, FACP

Program on Science and Global Security

Woodrow Wilson School of Public and International Affairs

Princeton University

Princeton, NJ

Bruce Kaplan, DVM

Sarasota, Fla

Thomas P. Monath, MD

Kleiner Perkins Caufield & Byers

Pandemic & Biodefense Fund

Harvard, Mass

James H. Steele, DVM, MPH

University of Texas School of Public Health

Houston, Tex

References

1. Kahn LH, Kaplan B, Steele JH. Confronting zoonoses through closer collaboration between medicine and veterinary medicine (as 'one medicine'). *Vet Ital.* 2007;43(1):5-19.
2. Palmarini M. A veterinary twist on pathogen biology. *PLoS Pathog.* 2007;3(2):e12. Available at: <http://dx.doi.org/10.1371/journal.ppat.0030012>.
3. Saunders LZ. Virchow's contributions to veterinary medicine: celebrated then, forgotten now. *Vet Pathol.* 2000;37:199-207. Available at: <http://www.vetpathology.org/cgi/content/short/37/3/199>.
4. Saunders LZ. From Osler to Olafson. The evolution of veterinary pathology in North America. *Can J Vet Res.* 1987;51:1-26.
5. Grant S, Olsen CW. Preventing zoonotic diseases in immunocompromised persons: the role of physicians and veterinarians. *Emerg Infect Dis.* 1999; 5:159-63. Available at: <http://www.cdc.gov/ncidod/EID/vol5no1/grant.htm>.
6. Wilkinson L. *Animals and disease. An introduction to the history of comparative medicine.* Cambridge, UK: Cambridge University Press; 1992.
7. Zinkernagel RM, Doherty PC. Immunological surveillance against altered self components by sensitized T lymphocytes in lymphocytic choriomeningitis. *Nature.* 1974;251:547-548.