One Health Une santé

The origins and lineage of One Health, Part I

Justin Ancheta, Raad Fadaak, R. Michele Anholt, Danielle Julien, Herman W. Barkema, Myles Leslie

Zoonotic diseases have become a major worldwide challenge; with COVID-19 being the latest and most dramatic example of an animal-derived virus affecting humans. With COVID-19 and previous zoonotic disease epidemics, the concept of One Health has gained prominence (1). Based upon several hundred years of thinking and social development, One Health has developed a holistic, systems approach to address complex problems at the intersection of humans, animals, and the environment. This paper summarizes evolving and competing ideas underlying contemporary One Health concepts and practices.

In the 17th and 18th centuries, important figures in veterinary medicine aligned aspects of human and animal medicine, thereby initiating comparative medicine (2). In 1761, Claude Bourgelat founded the first veterinary college in Lyon, France. This college, focused entirely on horses, made veterinary medicine a distinct discipline. Paradoxically, separation of veterinary medicine from human medicine benefitted One Health, as it initiated an advantageous and reciprocal flow of ideas and perspectives between human and animal medicine. As veterinary researchers moved away from framing disease in exclusively human terms, a new view of health emerged, leading to investigations of herd animal health, with findings informing human health. In addition, Bourgelat introduced comparative pathology (3).

One Health at UCalgary, University of Calgary, 3280 Hospital Drive NW, Calgary, Alberta T2N 4Z6 (Ancheta, Fadaak, Anholt, Julien, Barkema, Leslie); School of Public Policy, University of Calgary (Fadaak, Leslie); Department of Production Animal Health, Faculty of Veterinary Medicine (Barkema); Department of Community Health Science, Cummings School of Medicine (Barkema, Leslie); Antimicrobial Resistance — One Health Consortium, University of Calgary, 3330 Hospital Drive NW, T2N 4N1 (Julien, Barkema, Leslie).

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Félix Vicq D'Azyr, the chair of comparative medicine at Lyon, expanded on Bourgelat's work with his research, including dissecting animals to learn more about human anatomy (3,4). Anatomical similarities between humans and animals were the impetus to use animals to study human diseases. In 1790, Vicq D'Azyr also recommended that educational institutions work towards collaboration between human and animal health in the curriculum(4). His goal to merge medicine, pharmacy, veterinary, and surgery schools into a single institution (4) was interrupted by the French Revolution, an early example of social developments affecting One Health ideas.

Edward Jenner introduced animal models for disease when he vaccinated dogs against rabies. His success demonstrated the importance of comparative medicine and its value in evaluating medical interventions (3). Jenner later became famous for protecting humans against smallpox using cowpox inoculations, highlighting the equivalence between humans and animals regarding immunity and leading to the first vaccination campaign in France (3). Jenner's use of comparative medicine linked human and animal medicine to address a human health issue at the population level; an early precursor of two of One Health's constituent components being integrated as early as the 18th century.

Collaborations between scientists in human and animal health continued into the 19th century (2). At that time, germ theory regarded disease as a product of germs and was heavily influenced by outbreaks in livestock, e.g., the 1867 cattle plague in Britain and early work on vaccines (2). Robert Koch was an early germ theorist, a physician and microbiologist who discovered *Mycobacterium tuberculosis, Vibrio cholerae,* and *Bacillus anthracis* (3), contributing to his theory of *contagium vivum,* the transfer of disease through a living organism (3). Using germ theory, Koch first combined human, animal, and environmental components of One Health, noting that livestock disease outbreaks could be related to environmental conditions. However, those treating patients based on Koch's discoveries usually regarded disease as the environment influencing human health, or as a direct invasion of human bodies (2).

In the 19th century, there was public concern regarding epidemics and increasing demand to investigate them. Research on epidemics shifted from examining causes of individual cases to examining disease as a product of factors within a population and the broader environment. John Snow, a London physician, combined environmental and population health perspectives to examine disease outbreaks. He is widely regarded as the father of epidemiology for his use of interviews, case-finding, and statistical mapping to understand disease transmission in an

1854 cholera outbreak (5). Early application of epidemiological (i.e., "population") methods to understand disease were a key contributor to One Health (6).

Veterinary Public Health (VPH) was established in the 19th century to address zoonotic diseases (2). Veterinary Public Health used epidemiological approaches and methods to address population-level health issues. Rudolph Virchow integrated germ theory and the interface of human-animal populations to investigate zoonotic disease transmission in the meat industry (2). He established new links in disease transmission between humans and animals and the understanding that health of animals, especially those consumed by humans, affected human health (2). Although veterinary medicine had previously contributed to public health with Edward Jenner's use of cowpox to protect against smallpox (3), VPH truly integrated public health and veterinary medicine.

Demand for expansion of public health began in 1878 with a yellow fever epidemic in the southern US (7). Consequently, the National Board of Health (NBH) was created on March 3rd, 1879 (7), the first attempt at nationalizing public health in the US. The NBH president, James L. Cabell, was a physician with a strong interest in environmental sanitation who subsequently achieved prominence in public health (8). Under his influence, the NBH attributed yellow fever to an interaction of population and environmental elements. The NBH sought to promote population-level sanitation at a national level, advocating for a national quarantine to control the rapid spread of yellow fever, especially in seaport towns (7). This attempt to combine population and environmental elements of One Health was contested by southern state representatives, who successfully argued that nationalization would be ineffective and unconstitutional (7). The NBH, which lacked funding or quarantine powers and could only allocate resources to state and municipal boards, was forced to abandon its original goals of promoting sanitation by improving air and water quality, sewage, and drainage (7). The NBH, constantly in conflict with state and local health systems, ultimately failed. Social developments thus prevented not just a national epidemic response, but also segregated key elements of what would eventually constitute One Health.

The introduction and expansion of VPH modified the role of veterinarians to include public health. Towards the late 19th century, there were advocates for the expansion of veterinarians into public health, including Frank S. Billings. He applied the emerging science of bacteriology to identify the causes of milk-borne illness with epidemiological approaches to determine that milk from diseased cows was dangerous (9). Billings' research combined key elements of One Health. With his approach, health research expanded beyond the individual level to include potential environmental sources of disease at the population level. Consequently, Billings' work was the impetus to integrate human and animal medicine with ecology; combining environmental and population level components of One Health, and setting the stage for Dr. Daniel Salmon.

Dr. Salmon oversaw multiple public health initiatives in the US, including the Bureau of Animal Industry, a national veterinary service organization launched in 1884 that focused on controlling livestock disease outbreaks and associated public health issues (10). Under Salmon's direction, the Bureau, created a foundation for VPH (10). In addition to bringing a public health population focus, VPH as imagined by Salmon, offered a unique view of health that differed from reductionism. Establishing a Division of Pathology within the Bureau, Salmon's aim was to use pathology to support epidemiology. Rather than using pathology for highlighting individual abnormalities, he envisioned it holistically supporting systemic investigations. Although the Bureau controlled livestock outbreaks, it lacked funding and training to discover the underlying epidemiology of disease outbreaks and was not able to garner support for One Health. However, this was not Salmon's last attempt.

In 1890, Salmon founded a meat inspection service based on similar principles, but the service unfortunately floundered as Salmon lacked support of health systems and authorities (9). Salmon's vision of a national meat inspection service was "de-prioritized" by other nationwide public health initiatives, e.g., school vaccination laws (9,11). His 1890 *Meat Inspection Act* was contested by states arguing their rights were being infringed upon and that national level action was unconstitutional (6,9). Although passed into law, the *Act* only allowed inspection if it was requested by the buyer, seller, or exporter (12). A more effective public health intervention and efforts at combining One Health's elements was not introduced until 1906 when social developments favored national meat inspection (12). The impetus was public outrage at unsanitary conditions in Chicago abattoirs, as described in a novel by the popular writer Upton Sinclair (12). Billings' and Salmon's efforts to combine human-animal, environmental, and population level elements were not entirely successful, but influenced veterinary medicine to view disease as a multi-factorial phenomenon. Veterinarians in the VPH tradition, influenced by Billings and Salmon, encouraged researchers to understand disease within animal herds as well as within ecosystems, and to adopt research methodology that emphasized statistics alongside an improved understanding of diagnostic testing accuracy measures; disease approaches similar to current One Health principles (13). From the early 1940s to the late 1950s, disease became defined as an interaction among humans, the environment, and disease management (13). This mid-century approach integrated the 3 key elements in current One Health, albeit with different terms and emphasis. What would become One Health's examination of interacting human-animal-environment systems was then expressed as the study of the importance of the environment, including animals, on human health. Epidemiology (i.e., the population element of contemporary One Health), increased in importance, but was thought of and described as disease management. Our examination of the evolution of One Health as it is understood today, and of the actors and social developments that led to its core concepts being combined or divided, will continue in our next column.

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Answers to Quiz Corner
Les réponses du test éclair

1. **D)** Renal epithelial casts are present with acute tubular necrosis.
D) Les cylindres épithéliaux rénaux sont présents lors de nécrose tubulaire aiguë.

2. **C)** Gout is caused by diets high in protein.
C) La goutte est causée par des diètes riches en protéines.

3. **D)** In an effort to prevent large, pulsatile release of massive amounts of insulin which can aggravate the disease, the feeding of small, frequent meals is preferred. The rest of the steps are appropriate measures to institute to prevent neuroglycopenic episodes.
D) Dans un effort pour prévenir de grandes libérations pulsatives de quantités massives d'insuline qui peuvent aggraver la maladie, l'alimentation en petits repas fréquents est préférable. Les autres options sont des mesures appropriées à instaurer pour prévenir des épisodes de neuroglycopénie.

4. **C)** Small ruminants affected by Johne's disease do not typically have diarrhea as is seen in cattle. More common clinical signs are depression, chronic wasting, and low serum protein concentrations.
C) Les petits ruminants souffrant de paratuberculose n'ont pas de façon caractéristique de diarrhée comme on observe chez les bovins. Les signes cliniques les plus communs sont l'abattement, le dépérissement chronique et des concentrations basses de protéines sériques.

5. **D)** Melanoma lesions typically occur in gray adult horses and are nonpainful, spherical, smooth, alopecic, raised, or ulcerative masses and may be amelanotic or black to brown in color. The most common sites are the underside of the root of the tail and the perianal/perineal region.
D) Les lésions de mélanome se produisent de façon caractéristique chez les chevaux adultes gris et sont des masses non douloureuses, sphériques, lisses, alopéciques, élevées ou ulcératives, qui peuvent être amélanotiques ou de couleur noire à brune. Les sites les plus communs sont le dessous de la base de la queue et la région périanale/périnéale.