

## ORIGINAL ARTICLE

# Advancing One Health Policy and Implementation Through the Concept of One Medicine One Science

推进一项医疗政策和通过“一种疾病一门科学”的理念来实行政策

Fomento de la política sanitaria y su implantación a través del concepto de Una Medicina Una Ciencia

## Author Affiliations

Department of Veterinary and Biomedical Sciences, College of Veterinary Medicine, University of Minnesota, Minneapolis (Drs Cardona and Murtaugh); Department of Veterinary Population Medicine, College of Veterinary Medicine, University of Minnesota (Dr Travis and Mr Kennedy); Gryphon Scientific, LLC, Takoma Park, Maryland (Dr Berger); CRDF Global, Arlington, Virginia (Ms Coat); The Food System Institute, LLC, St Paul, Minnesota (Dr Kennedy); Departments of Medicine and Genetics, Cell Biology and Development, University of Minnesota Medical School (Dr Steer); College of Veterinary Medicine, University of Minnesota, St Paul (Dr Sriramarao).

## Correspondence

P. Sriramarao  
psrao@umn.edu

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Carol Cardona, DVM, PhD, *United States*; Dominic A. Travis, DVM, MS, *United States*; Kavita Berger, PhD, *United States*; Gwenaële Coat, MA, MSc, *United States*; Shaun Kennedy, BS, ChE, *United States*; Clifford J. Steer, MD, *United States*; Michael P. Murtaugh, PhD, *United States*; P. Sriramarao, PhD, *United States*

## ABSTRACT

Numerous interspecies disease transmission events, Ebola virus being a recent and cogent example, highlight the complex interactions between human, animal, and environmental health and the importance of addressing medicine and health in a comprehensive scientific manner. The diversity of information gained from the natural, social, behavioral, and systems sciences is critical to developing and sustainably promoting integrated health approaches that can be implemented at the local, national, and international levels to meet grand challenges. The Concept of One Medicine One Science (COMOS) as outlined herein describes the interplay between scientific knowledge that underpins health and medicine and efforts toward stabilizing local systems using 2 linked case studies: the food system and emerging infectious disease. Forums such as the International Conference of One Medicine One Science (iCOMOS), where science and policy can be debated together, missing pieces identified, and science-based collaborations formed among industry, governmental, and non-governmental policy makers and funders, is an essential step in addressing global health. The expertise of multiple disciplines and research foci to support policy development is critical to the implementation of one health and the successful achievement of global health security goals.

## 摘要

大量跨物种疾病传播事件强调了人、动物和环境之间的复杂相互作用，以及用综合性科学方式解决医疗和健康问题的重要性，埃博拉病毒的大量跨物种疾病传播事件就是近期一种有说服力的示例。从自然、社会、行为学和系统科学获得的各种信息对于开发和可持续地促进实施能够迎接本地、国内和国际水平挑战的综合医疗方法至关重要。此处概述的“一种疾病一门科学 (COMOS)”理念描述了支撑健康与医学的科学知识的相互影响，以及使用两项关联的病例研究（食物系统和新发传染病）为稳定本地医疗系统所做的努力。论坛（如一种疾病一门科学国际会议 (iCOMOS) 中），参与者可以一起讨论相关科学和政策，鉴别缺失的信息，并在行业、政府和非政府政策制定者和投资者间形成以科学为基础的合作，因而借由论坛平台是解决全球医疗问题必不可少的步骤。支持政策制定的多学科专门知识和研究焦点对于实施一体化健康和成功实现全球医疗安全目标至关重要。

## SINOPSIS

Los numerosos acontecimientos de transmisión de enfermedades entre especies, de los cuales el virus del Ébola es un ejemplo claro y reciente, ponen de manifiesto las complejas interacciones que existen entre la salud humana, animal y medioambiental, así como la importancia de abordar la medicina y la salud de una manera científica e integral. La diversidad de la

información obtenida de las ciencias naturales, sociales, conductuales y de los sistemas es fundamental para el desarrollo y fomento sostenibles de enfoques integrados de salud que puedan implementarse a nivel local, nacional e internacional para atender los grandes retos. El concepto de Una medicina una ciencia (Concept of One Medicine One Science, COMOS) esbozado aquí describe la interrelación entre el conocimiento científico que sustenta la salud y la medicina, y los esfuerzos hacia la estabilización de los sistemas locales por medio de dos estudios de casos relacionados: el sistema alimentario y las enfermedades infecciosas emergentes. Los foros como la Conferencia internacional de una medicina una ciencia (International Conference of One Medicine One Science, iCOMOS), donde se hace posible el debate conjunto de la ciencia y la política, la identificación de eslabones perdidos, y la formación de colaboraciones basadas en la ciencia entre los formuladores y fundadores de políticas industriales, gubernamentales y no gubernamentales, representan un paso decisivo para abordar el tema de la salud mundial. La experiencia de múltiples disciplinas y enfoques de investigación para apoyar el desarrollo de políticas es fundamental para la implementación de una salud y el logro de los objetivos relativos a la seguridad de la salud mundial.

## INTRODUCTION

Human, animal, and environmental health are inextricably linked in our modern, highly globalized society. We expect better health, secure food, clean water, and more comfort from limited natural resources. Balancing competing demands of human health, animal health, and sustainable environmental health is a grand challenge of our time. As the distance between human, domestic animal, and wild-life populations narrows and global trade and travel amplify our connectivity, pathogens shared by humans and animals have concurrently emerged.<sup>1</sup> Since 1999, among many examples, humans experienced outbreaks of West Nile virus in the United States and Europe, severe acute respiratory syndrome (SARS) virus in China, Middle East respiratory syndrome coronavirus (MERS-CoV) in the Middle East, and the emergence of the Ebola virus in West Africa. Shared pathogen exchange is perhaps best illustrated in the case of influenza, where humans serve as the source of influenza A virus (IAV) infection of pigs, and, after further evolution of the virus, it returns from pigs to humans, causing new outbreaks. The 2009 influenza outbreak was the most recent example of this cycle of human and animal infection. The failure to address interspecies transmission and ensuing pandemics as a one health issue has created the opportunity for continued emergence of novel IAV like H<sub>3</sub>N<sub>2</sub>v that emerged as a human pathogen during the agricultural fair season.<sup>2</sup>

These events highlight the complex interactions between human, animal, and environmental health and the importance of addressing medicine and health in a scientific manner that considers all contributing factors. Advancement of health at this level of complexity requires integration of medical disciplines spanning individual care to public health, with basic and applied sciences from atomic structure to sociology providing the knowledge base as shown in the Figure. The concept of One Medicine One Science (COMOS) builds on the idea that the basic biological processes underlying health and disease share common features such that medical knowledge and expertise in one species is relevant and applicable to other species. The scientific approach that expands our understanding of biological processes and the rational basis for medical practice is the same for all species. Thus, COMOS provides common ground to assist the organization of interdisciplinary groups to seek solutions to health challenges at local and global scales. Another aspect of COMOS is development of forums that, in addition to medical and scientific participants, includes industry, governmental and nongovernmental policy makers, and funders to assist in communicating the interconnectedness of human, animal and environmental health to a broad audience so that development of public policies that guide health priorities and investments at the national and international level are informed by the best scientific knowledge.

## ONE HEALTH

The concept of one health emphasizes the interconnectedness of animal, environmental and human health, and has become a part of the health security and international development lexicon.<sup>3</sup> The 2005 revised International Health Regulations and 2014 Global Health Security Agenda (GHSA) are 2 of many instruments that cement this connection/relationship/interdependence. At the international launch of the GHSA, the United States and 30 other countries, the World Health Organization (WHO), Food and Agriculture Organization (FAO), and World Organisation for Animal Health (OIE) agreed to work to prevent, detect, and respond to global infectious disease threats from the perspective of one health. Years before the release of the GHSA, the US Agency for International Development established the Emerging Pandemic Threats Program to “prevent, detect, and control” animal and human pathogens. These activities, which promote one health approaches in the United States and globally, are an important beginning but fall short of providing the robust scientific and culturally informed approach that is needed to address real world challenges.

Much dialogue on one health has focused on emerging disease surveillance, public health preparedness, and policy issues without connecting these issues to the scientific foundations that underlie pathogen emergence, global health threats, food security, environmental health, social organization, communication, and implementation of health, security, and safety measures. This limitation has resulted in a perceived and apparent separation of science and policy, sometimes diluting the utility of the one health movement. This article builds on the discussions and dialogue about the science of one health and its connection to policy that were held at the International Conference on One Medicine One Science (iCOMOS; [www.icomos.umn.edu](http://www.icomos.umn.edu)) in 2014 and to be held again in 2016.<sup>4</sup> In particular, it was concluded that the key roles of food and medicine in addressing health needs of a changing world require the support of rigorous science that empowers informed decision-making and development of useful policies. The goal of iCOMOS is to examine the connections between science and one health policy implementation by (1) focusing on case studies and research that demonstrate the successful integration of human, animal, plant, and environmental health and social and behavioral sciences; (2) examining the science-policy connection by convening panels that include scientists, policy makers, and representatives from private industry; and (3) conducting forward-looking workshops in areas of research, collaboration, and policy formulation. iCOMOS-2014 was focused on 2 of the most important grand challenges of our time—food safety/security and emerging infectious diseases.<sup>4,5</sup>

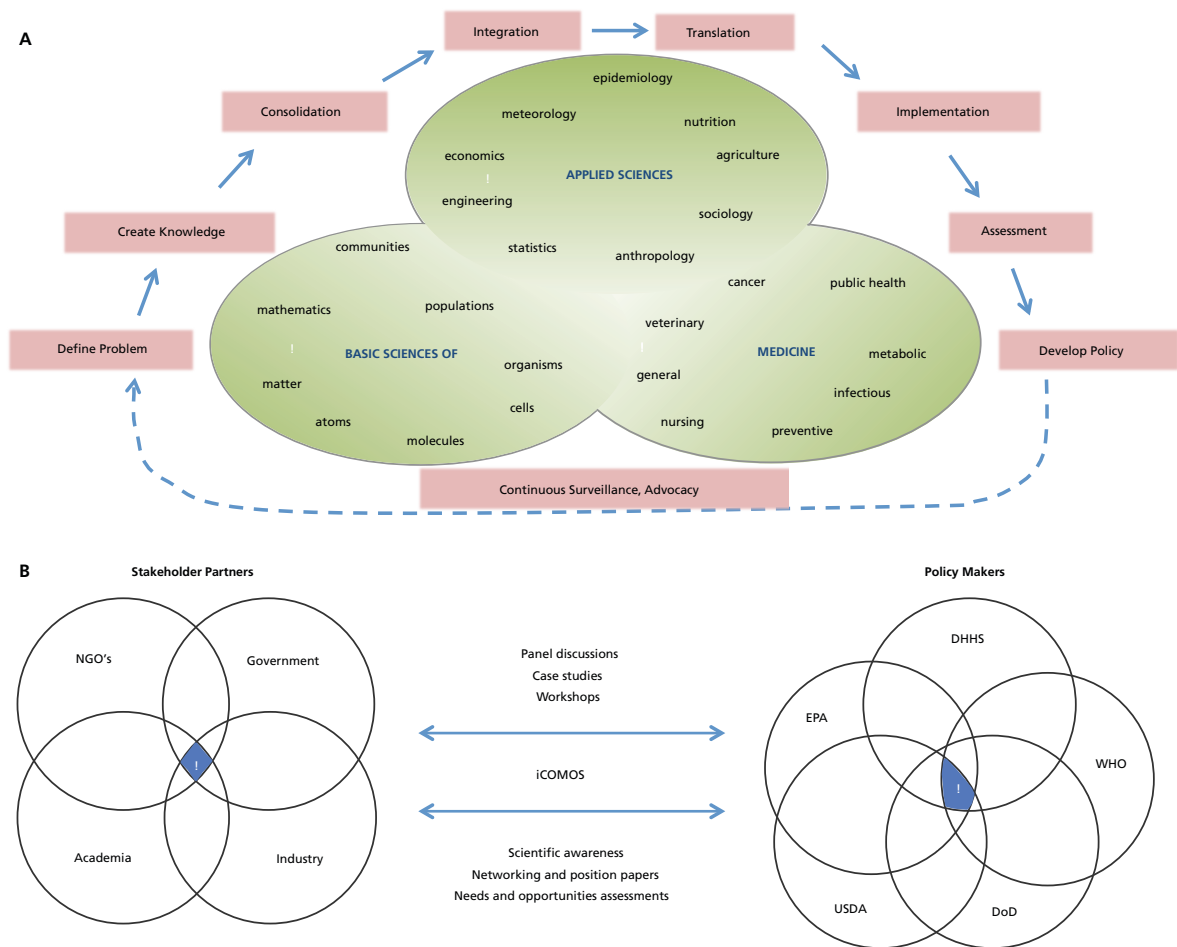
## FOOD SECURITY: FEEDING THE WORLD NOW AND IN THE FUTURE

Good policy must be based on objective scientific studies that integrate epidemiology, ecology, microbi-

ology, social science, and economics to balance the expectation of safe and nutritious food with the need for efficient and profitable production, and sustained environmental health. Given that an estimated 870 million people are currently suffering from malnutrition and that the combination of human population growth and consumer preference shifts associated with a rising global middle class are expected to exacerbate this problem, global production and delivery of food for protein, energy, and micronutrients must not just be maintained, it must be increased.<sup>6</sup> In addition, existing land and water resources are already strained and their availability for agriculture will likely decrease, especially as the impacts of climate change shift traditional production regions. The obvious solution is to produce more efficiently, yet the very strategies that promote efficient production of food, such as concentrated farming systems, monoculture cropping, and chemical inputs of fertilizer, pesticides, and herbicides, have unintended consequences that threaten human, ani-

mal, and environmental health.<sup>7</sup> We are faced with a paradox in which the demand for increased food production to improve human health today sows the seeds of resource depletion that limit health advances tomorrow. Thus, new research on the direct and indirect impacts of food production on human, animal, and environmental health as well as social, organizational, and behavioral sustainability should be a priority.

Ensuring that sufficient food is not only safely and efficiently delivered to consumers but that it is produced in ways according to local preferences presents another paradox. Consumer demand for local and organic production systems actually increases the greenhouse gas footprint of most developed and many developing country food systems, depending on the crop or animal product<sup>8-10</sup> and also can increase food safety risks relative to today's widely used production systems.<sup>11</sup> Those producers that remain local are often small in size, thus limiting benefits of scale, and many use organic methods, which can limit their ability to



**Figure iCOMOS:** a knowledge forum using science and medicine to find common ground and solutions to complex problems of animal, human, and environmental health. (A) Process of policy development and implementation based on scientific and medical knowledge. (B) Role of iCOMOS in information sharing and networking among local and international stakeholders, partners, and policy makers. Blue area at center of Venn diagrams represents the common health agenda. Balancing competing priorities is a major public policy challenge as societies seek to maximize human health, animal health and welfare, and environmental integrity.

Abbreviations: DHHS, United States Department of Health and Human Services; DoD, United States Department of Defense; EPA, United States Environmental Protection Agency; NGO, nongovernmental organization; USDA, United States Department of Agriculture; WHO, World Health Organization.

prevent disease through approaches such as constructing barriers and facilities for containment. The result is increased contact with wildlife, which increases opportunities for the transmission of infectious diseases to crops, livestock, and humans. For instance, interaction between domestic poultry and wild waterfowl reservoirs has resulted in the introduction of new IAV,<sup>12</sup> and the movement of H5 HPAI from domestic poultry to free-flying bird populations demonstrates that the exchange can be bidirectional,<sup>13</sup> which changes paradigms of transboundary disease spread.

The interface between wildlife and agriculture will only increase as more land is converted for agricultural use to meet consumer demands, thus forcing wildlife into shrinking habitats or to adapt to increased contact with humans and livestock. Housing food animals inside helps to protect animal health, prevent cross-species disease transmission, and improve production efficiency, but it does not always meet consumer preference for local needs and resources. Non-therapeutic (nonclinical) antibiotic use in food animals is a tool that promotes production efficiency, but it has been associated with a rise in antibiotic resistance of human pathogens. However, epidemiological and ecological studies fail to support a causal link; instead, these studies indicate the spread of antibiotic resistance from humans to pigs and chickens.<sup>14</sup> In the future, the World Food Summit global food strategy of “providing access for all people at all times to sufficient, safe, and nutritious food to maintain a healthy and active life” must be expanded to include considerations for environmental sustainability, animal welfare and non-nutritional aspects of public health.<sup>15</sup> Progress toward these goals requires strong linkage of scientific knowledge and discovery that helps both to advance medical practice and health improvement as well as inform health policy development.

### EMERGING INFECTIOUS DISEASES: EVOLVING PATHOGEN RISK IN A CHANGING WORLD

Human population expansion and exploration has increased as never before, and thus attention to the risk of disease emergence at the interface between humans, domesticated animals, and wildlife is increasingly important. While many human pathogens have wildlife reservoirs,<sup>1</sup> the converse is also an issue. Humans and their companion animals have triggered epidemic plagues of canine distemper in Serengeti lions<sup>16</sup> and morbillivirus in Pacific seals<sup>17</sup> while spreading influenza A to food animal species.<sup>18</sup> Other dramatic changes include the explosive growth in global travel and trade patterns and legal and illegal trade in live animals, animal products, and wildlife as well as effects of climate change on all of the above. Retrospective and emerging analyses may provide insights into these systems. However, focusing on the processes and mechanisms that facilitate pathogen evolution and emergence will help us prepare for unpredictable new outbreaks, thus raising awareness

of prevention and control policies that could reduce both the likelihood and magnitude of disease emergence and its resulting effects on animals and humans.

Single approaches to comprehend and anticipate disease emergence, especially using simplified disease models, are unlikely to produce informative insights involving environmental factors, multiple reservoirs, and complex human-animal-environment interactions.<sup>19</sup> Concepts of wildlife reservoirs and spill-over/cross-species transmission into food animal and human populations followed by expansion and outbreak potential have been developed into mathematical models. Although not a predictor in itself, models of zoonotic transmission dynamics have made valuable contributions to inform public health recommendations for control of novel H1N1 influenza and SARS and are crucial for understanding pathogen transmission patterns and changes in disease epidemiology.<sup>20</sup>

Human orthopoxvirus infection is a highly relevant example in which modeling based on rigorously collected data provides prevention strategies for a highly plausible emergent disease. The global human population is increasingly susceptible to smallpox due to the cessation of vaccination programs following eradication. Loss of crossreactive immunity has opened an ecological niche that can and has been replaced by related orthopoxviruses, including monkeypox in the Congo and novel orthopoxvirus in the country of Georgia.<sup>21</sup> Emergence of new orthopoxvirus outbreaks with pandemic potential is possible as human-infectious poxviruses circulate in natural reservoirs. The recent discovery of viable smallpox in a US Food and Drug Administration refrigerator on the National Institutes of Health (NIH) campus recently reinvigorated the discussion of both susceptibility and/or risks from infections to smallpox.<sup>22</sup> The specter of a new pandemic, fueled by relatively recent experience with the emergence of AIDS and new influenza viruses, has driven the US Centers for Disease Control and Prevention, the NIH-National Institute of Allergy and Infectious Diseases, the US Department of Agriculture, the US Agency for International Development, and others to develop programs focused on predictive modeling of and early detection and response to novel pathogens that have evolved under a complex set of pressures such as environmental pollution, land use changes, new trade patterns, climatic change, and other anthropogenic factors. The role of medicine in addressing individual and public health needs to be supported by rigorous science that empowers informed decision-making and development of useful policies in the face of unexpected disease threats.

The rapid growth and persistence of the ongoing outbreak of Ebola virus in West Africa presents an unfortunate but perfect opportunity for implementing science-based policy at the crossroads of emerging infectious disease ecology and sustainable food security. Experts hypothesize that Ebola virus entered the West African population through consumption of

infected fruit bats, a plausible scenario given local food needs and practices.<sup>23,24</sup> The ongoing outbreak has stressed social organization and an already thin public health infrastructure to the breaking point in the affected countries. It threatens to exacerbate baseline food insecurity as disease control measures and fear shut down food and agriculture systems, further stressing local food security.<sup>25</sup> This situation makes for the “perfect storm” of grand challenges in the one health arena. Frighteningly, while more than 27 000 cases and 11 200 deaths have been recorded as of July 14, 2015, a new ecological niche risk model predicts that 22 million people in 22 Central and West African countries are at potential risk for Ebola.<sup>26,27</sup> While the world seems to be stepping up with much-needed scientific, medical, and infrastructure support to this tragedy, broader policies and preparedness are needed for prevention, containment, and response if we are to avoid more extreme human suffering from the virus itself as well as malnutrition, community instability, and other social consequences.

### THE WAY FORWARD

Addressing the grand challenges of our time—such as novel disease emergence and food security—is difficult from any perspective. But the universal scientific discovery and exploration approaches that have been applied so effectively to resolve focused problems offer promise in addressing the complex health issues of modern life. A linear refocusing of health research away from disease surveillance and investigation resulting primarily in treatment toward environmental surveillance resulting in prediction and prevention is not enough to inform societal debates on these complex health issues. Reducing challenges to simple scenarios allows us to find solutions that do not address the complex problems we face but instead bring on a myriad of unintended and undesirable consequences. Grand challenges do not have simple solutions. Rather, they represent “wicked problems” that are complex and difficult-to-balance dilemmas with fluid dynamics whose competing components change over time.<sup>28</sup> The creation of forums for convergence on grand challenges where science and policy can be debated together, missing pieces identified, and science-based collaborations stimulated in the presence of industry, governmental and nongovernmental policy makers, and funders is an essential step. The underpinnings of COMOS—ie, promoting team science that builds on the expertise of different disciplines, stakeholders, and research foci to support policy development—is all the more relevant to the implementation of one health and the successful achievement of global health security goals (Figure). Universal scientific discovery and exploration approaches that have been applied so effectively to advance human society will need to be applied to complex health issues of modern life so that the resulting knowledge can inform public policy and decision-making at every level.

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