Beyond One Health
Beyond One Health

From Recognition to Results

Edited by John A. Herrmann and Yvette J. Johnson-Walker

University of Illinois, IL, USA

WILEY Blackwell
For Wanda, who always knew the way; and for Anne and Kate, who are my guideposts.

J.A. Herrmann

For Mom, Lauren, and Lamar – my shelter from the storm; and for Ikenna, Ndidi, and Amaya – my windows of hope.

Y.J. Johnson-Walker
Contents

List of Contributors xiii
Foreword xvii
Foreword xix
Preface xxi

Section 1  The Science of One Health  1

1  Epidemiology: Science as a Tool to Inform One Health Policy  3
Yvette J. Johnson-Walker and John B. Kaneene
1.1  Introduction  3
1.2  Enhancing Our Understanding of Health and Disease  5
1.2.1  Causes of Disease  5
1.2.1.1  Deterministic Models of Disease  6
1.2.1.2  Hill's Causal Criteria  7
1.2.1.3  Multifactorial Models of Disease Causation  8
1.2.1.4  Breaking the Chain of Transmission  8
1.2.2  Assessing the Impact of Disease  10
1.2.3  Natural Course of Disease  13
1.2.3.1  Reservoirs of Disease  13
1.2.3.2  Humans as a Reservoir  14
1.2.3.3  Domestic Animal Reservoirs  14
1.2.3.4  Wildlife Reservoirs  17
1.2.3.5  Environmental Reservoirs  17
1.3  From Understanding Epidemiology to Public Policy  19
1.3.1  Assessments of Diagnostic Test Reliability  20
1.3.2  Determination of Safety and Effectiveness of New Treatments and Vaccines  20
1.3.3  Assessing Health at the Level of the Individual, Community, or Ecosystem and Establishing Standards of Care for Prevention and Treatment Protocols/Programs  21
1.3.4  Establishing Disease Response Regulations and Control Standards  22
1.4  Examples of the Benefits of Using a One Health Approach  23
1.4.1  Overall Summary of Practical Experiences Applying a One Health Approach  25
References  28

2  Health Impacts in a Changing Climate  31
Donald J. Wuebbles
2.1  Introduction  31
2.2  Our Changing Climate  32
2.2.1 Climate Change Effects on Temperature 33
2.2.2 Climate Change Effects on Precipitation 34
2.2.3 Climate Change Effects on Severe Weather 37
2.3 The Basis for a Human Cause for Climate Change 41
2.4 Twenty-first Century Projections of Climate Change 43
2.5 Climate and Health 49
2.5.1 Temperature-Related Death and Illness 49
2.5.2 Air Quality Impacts 50
2.5.3 Vector-Borne Diseases 50
2.5.4 Water-Related Illnesses 52
2.5.5 Food Safety, Nutrition, and Distribution 52
2.5.6 Extreme Weather-Related Impacts 54
2.5.7 Mental Health and Well-being 54
2.5.8 Climate–Health Risk Factors and Populations of Concern 55
2.6 Summary and a Look Forward 55
References 56

3 Food Safety and Security 61
Megin Nichols, Lauren Stevenson, Casey Barton Behravesh, and Robert V. Tauxe
3.1 Evolution of Food Production 61
3.2 Foodborne Illness 63
3.3 A One Health Approach to Foodborne Illness Detection and Response 70
3.4 Antibiotic Resistance and Food Safety 78
3.5 Zoonotic Disease and Foodborne Pathogens 82
3.6 Outbreak Response Communication 83
References 86

4 Water Security in a Changing World 91
Jeffrey M. Levengood, Ari Hörman, Marja-Liisa Hänninen, and Kevin O’Brien
4.1 Introduction 91
4.2 Waterborne Pathogens and Contaminants: Technologies for Drinking Water Treatment and Management of Water Safety 92
4.2.1 Waterborne Pathogens 92
4.2.2 Antibiotic-Resistant Bacteria in Source and Drinking Water 93
4.2.3 Chemical Hazards in the Drinking Water 95
4.2.4 Pharmaceuticals in Wastewater and Raw Water Sources 95
4.2.5 Water Treatment Methods 95
4.2.5.1 Thermal Treatment 96
4.2.5.2 Chemical Disinfection 96
4.2.5.3 Filtration 97
4.2.5.4 Other Treatment Methods 98
4.2.6 Surveillance for Waterborne Diseases 98
4.2.7 Requirements for Drinking Water Quality 98
4.2.8 Water Safety Plans (WSPs) 99
4.3 The Water/Energy/Food Nexus: Mitigating Global Risks 101
4.3.1 Water/Energy Nexus 101
4.3.1.1 Nuclear 104
4.3.1.2 Coal 105
4.3.1.3 Natural Gas 105
4.3.1.4 Renewables 105
5 One Toxicology, One Health, One Planet 117
Daniel Hryhorczuk, Val R. Beasley, Robert H. Poppenga, and Timur Durrani

5.1 Introduction 117
5.1.1 History 117
5.1.2 Toxic Chemicals in Our Environment 119
5.1.3 One Toxicology 120
5.2 Key Concepts 122
5.2.1 Dose-Response Relationships 122
5.2.2 Differences in Susceptibility 122
5.2.3 Periods of Increased Susceptibility 124
5.2.4 Receptors 124
5.2.5 Toxicokinetics and Toxicodynamics 125
5.3 Ecotoxicology and Human Exposures 126
5.3.1 Everyday Toxicology and Ecotoxicology: Contrasts, Complexities, and Challenges 126
5.3.2 Toxicant Fate in the Environment 127
5.3.3 Contrasts in Feasibility: Examinations and Interventions 131
5.3.4 Indirect Effects of Chemicals 134
5.3.5 Direct Immunotoxicity and Indirectly Mediated Immunosuppression 139
5.3.6 Neurotoxicity 140
5.3.7 Endocrine Disruption 140
5.3.8 Reproductive and Developmental Toxicity 142
5.4 Toxicological Risk Assessment and One Health 143
5.4.1 Risk Assessment 143
5.4.2 Regulatory Toxicology 143
5.4.3 One Health and One Toxicology on One Earth 144
5.5 Conclusions 145
References 146

6 Biodiversity and Health 155
Dominic A. Travis, Jonathan D. Alpern, Matteo Convertino, Meggan Craft, Thomas R. Gillespie, Shaun Kennedy, Cheryl Robertson, Christopher A. Shaffer, and William Stauffer

6.1 Introduction 155
6.2 Connectivity 157
6.2.1 Biodiversity as an Indicator of Health 157
6.2.2 Social Factors 160
6.3 Grand Challenges, Development Goals, Global Health Security, and Ecosystem Health 161
6.3.1 The Case of Agriculture, Food Security, and Biodiversity 163
6.3.2 The Case of Wildlife Trade, Bushmeat, and Biodiversity 164
6.3.3 The Case of Infectious Diseases and Biodiversity 167
6.3.4 The Case of Climate Change, Conflict, and Human and Animal Migration 168
6.4 Conclusions and a Way Forward 170
6.4.1 The Application of Complexity Science and Technology Tools to Optimize Health and Environmental Outcomes 170
References 172

7 Emerging Infectious Diseases: Old Nemesis, New Challenges 179
Ronald C. Hershow and Kenneth E. Nusbaum
7.1 Introduction 179
7.2 Rabies 182
7.2.1 Natural History 182
7.2.2 The Epizootology of Rabies Virus 183
7.2.3 Global Burden 183
7.3 Avian Influenza 184
7.3.1 Natural History 184
7.3.2 Recent Outbreaks 185
7.4 Zika Virus 188
7.5 Ebola Virus Disease (EVD) 190
7.6 Summary 191
Acknowledgments 192
References 192

8 Reigning Cats and Dogs: Perks and Perils of Our Courtship with Companion Animals 197
Sandra L. Lefebvre and Robert V. Ellis
8.1 Introduction 197
8.2 Benefits and Hazards of Human-Pet Relationships 199
8.2.1 Physical and Mental Health 199
8.2.1.1 Impacts on Humans 199
8.2.1.2 Impacts on Pets 202
8.2.2 Overweight and Obesity 204
8.2.3 Feeding Practices and Illness 205
8.2.3.1 Human Illness Related to Pet Feeding Practices 205
8.2.3.2 Pet Illness Related to Feeding Practices 207
8.2.4 Infectious Disease Transmission 208
8.2.4.1 Companion Animal-to-Human Transmission 208
8.2.4.2 Human-to-Companion Animal Transmission 218
8.2.5 Pets, People, and Antimicrobial Resistance 218
8.2.6 Social and Community Health 223
8.2.7 Domestic Health and Violence 225
8.3 Interactions Among Humans, Pets, and the Environment 225
8.3.1 Working Dogs 225
8.3.2 Environmental Toxicants 226
8.3.3 Pets and the External Environment 227
8.3.4 Disaster Preparedness 229
8.3.5 Climate Change 230
8.3.6 Zoonotic Disease Surveillance for Both People and Pets 230
8.4 Conclusion 231
Disclaimer 232
References 232
9  **Zoological Institutions and One Health**  
*Thomas P. Meehan and Yvonne Nadler*

9.1  Introduction  245

9.2  **Zoos, Aquariums, and Field Conservation**  245

9.3  **Zoos, Aquariums, and the Care of Animals**  246

9.4  **Social Aspects of Zoos and Aquariums**  247

9.5  **Zoonotic Disease Challenges: Protecting Visitors, Staff, and Animals**  248

9.6  **Case Studies in One Health from Zoological Institutions**  251

9.6.1  **West Nile Virus: A Case Study for the One Health Paradigm**  251

9.6.1.1  **Emergence of West Nile Virus in North America**  251

9.6.1.2  **Centers for Disease Control: ArboNET**  252

9.6.1.3  **A Failure of Early Coordination**  253

9.6.1.4  **Lessons Learned from the West Nile Virus Outbreak, 1999**  254

9.6.1.5  **Zoological Institutions as Forerunners to the ‘One Health’ Paradigm**  255

9.6.1.6  **Zoological Parks as Sentinels for Human Disease**  255

9.6.1.7  **A Model for Sentinel Surveillance: The Zoological WNV Surveillance Project**  256

9.6.1.8  **Lessons Learned from the Zoological WNV Surveillance Project**  256

9.6.1.9  **The Role of Zoological Institutions in Preparing for Pandemics**  257

9.6.2  **The Emergence of Highly Pathogenic Avian Influenza Virus, 1999**  257

9.6.2.1  **Consequences of HPAI Detection in a Zoological Institution**  258

9.6.2.2  **The Association of Zoos and Aquariums Prepares for HPAI**  259

9.6.2.3  **Lessons Learned from HPAI Surveillance System**  260

9.7  **Conclusion**  261

References  262

---

Section 2  **Four Perspectives on One Health Policy**  267

10  **One Health Leadership and Policy**  269
*William D. Hueston, Ed G.M. van Klink, and Innocent B. Rwego*

10.1  Introduction and Definitions  269

10.2  **Grand Challenges in Health (aka “Wicked Problems”)**  269

10.3  **Implications of Grand Challenges for One Health Leadership**  270

10.4  **Critical Competencies for One Health Leadership**  270

10.5  **Policy-Making with One Health in Mind**  271

10.6  **Integrating One Health Leadership Approaches in Hierarchical Organizations**  272

10.7  **Demonstrating One Health Leadership and Policy in Action**  273

10.8  **Case Study 1: National One Health Policy Development in Cameroon and Rwanda**  274

10.8.1  Cameroon  274

10.8.2  Rwanda  275

10.9  **Case Study 2: The Campaign for Global Elimination of Dog-Mediated Human Rabies**  275

10.10  **Case Study 3: Antimicrobial Resistance – USA**  276

References  278

11  **Implementing One Health**  279
*Laura H. Kahn*

11.1  Financing One Health Initiatives  279

11.2  **Conclusion**  281

References  281
12  The Social Cost of Carbon  283  
   William J. Craven  
12.1  Introduction  283  
12.2  Some Context on Cost-Benefit Analyses  284  
12.3  The Social Cost of Carbon (SCC)  284  
12.3.1  Looking at Costs  285  
12.3.2  Getting the SCC as Good as it Can Get  287  
12.4  Current Challenges to Reducing and Mitigating the Effects of Climate Change  289  
References  290  

13  Complex Problems, Progressive Policy Solutions, and One Health  293  
   John A. Herrmann  
13.1  One Health as Prevention  293  
13.1.1  Successes  293  
13.1.2  Failures  294  
13.2  Translating Science: Risk Communication and Science Literacy  295  
13.2.1  Communication of Science  296  
13.2.2  Liberal Education and the Sciences  297  
13.2.3  Community Empowerment and Participatory Democracy  301  
13.3  The Economics of One Health  302  
13.4  From Here to There  304  
References  304  

Section 3  Conclusion  307  

14  The Long and Winding Road  309  
   John A. Herrmann and Yvette J. Johnson-Walker  
14.1  One Health: Many Facets, All Interrelated  309  
14.2  One Health Policy Development  312  
14.2.1  Policy Basics and Challenges to Enacting One Health-based Policies  312  
14.2.2  Microeconomic One Health Dilemmas  313  
14.2.3  One Health Research in Emerging Infectious Diseases: Macroeconomic Dilemmas  314  
14.2.4  The Long and Winding Road Forward  315  
References  323  

Index  325
List of Contributors

Jonathan D. Alpern, MD
Infectious Disease Fellow
Department of Medicine, Division of Infectious Diseases & International Medicine
School of Medicine
University of Minnesota
Minneapolis, Minnesota, USA

Casey Barton Behravesh, MS, DVM, DrPH, DACVPM
Captain, US Public Health Service
Director, One Health Office
National Center for Emerging and Zoonotic Infectious Diseases
Centers for Disease Control and Prevention
Atlanta, Georgia, USA

Val R. Beasley, DVM, PhD, Diplomate ABVT
Professor of Veterinary, Wildlife, and Ecological Toxicology
Department of Veterinary and Biomedical Sciences
College of Agricultural Sciences
The Pennsylvania State University
University Park, Pennsylvania, USA

Matteo Convertino, PhD, PE
Assistant Professor
Division of Environmental Health Sciences & PH Informatics
School of Public Health
University of Minnesota
Minneapolis, Minnesota, USA

Meggan Craft, PhD
Assistant Professor of Disease Ecology
Department of Veterinary Population Medicine
College of Veterinary Medicine
University of Minnesota
Minneapolis, Minnesota, USA

William J. Craven, JD
Chief Consultant
California State Senate
Sacramento, California, USA

Timur Durrani, MD, MPH, MBA
Co-Director of the Western States Pediatric Environmental Health Specialty Unit
Assistant Clinical Professor
University of California at San Francisco
School of Medicine
San Francisco, California, USA

Robert V. Ellis, MD, FAAFP
Associate Professor
University of Cincinnati College of Medicine
Cincinnati, Ohio, USA

Thomas R. Gillespie, PhD
Associate Professor
Departments of Environmental Sciences & Environmental Health
Emory University & Rollins School of Public Health
Math and Science Center
Georgia, USA
Marja-Liisa Hänninen, DVM
Professor Emeritus
Department of Food Hygiene and Environmental Health
University of Helsinki
Helsinki, Finland

John A. Herrmann, DVM, MPH, DACT
Clinical Associate Professor
Director, DVM/MPH Joint Degree Program
Center for One Health Illinois
College of Veterinary Medicine
University of Illinois at Urbana-Champaign
Urbana, Illinois, USA;
Division Affiliate
Epidemiology and Biostatistics
School of Public Health
University of Illinois at Chicago
Chicago, Illinois, USA

Ronald C. Hershow, MD
Director, Division of Epidemiology and Biostatistics
School of Public Health
University of Illinois at Chicago
Chicago, Illinois, USA

Ari Hörman, DVM, PhD, MPH
Department of Food Hygiene and Environmental Health
University of Helsinki
Helsinki, Finland

Daniel Hryhorczuk, MD, MPH, FACMT
Clinical Professor of Medical Toxicology
Director, Environmental Health, Center for Global Health
College of Medicine
University of Illinois at Chicago
Chicago, Illinois, USA;
Professor Emeritus
Environmental and Occupational Health Sciences and Epidemiology
School of Public Health
University of Illinois at Chicago
Chicago, Illinois, USA

William D. Hueston, DVM, PhD, Diplomate ACVPM, Epidemiology Specialty
Professor Emeritus
College of Veterinary Medicine and School of Public Health
Global Leadership Programs
Center for Animal Health and Food Safety
University of Minnesota
Minneapolis, Minnesota, USA

Yvette J. Johnson-Walker DVM, MS, PhD
Clinical Epidemiologist
Center for One Health Illinois
University of Illinois Urbana-Champaign
College of Veterinary Medicine
Urbana, Illinois, USA

Laura H. Kahn, MD, MPH, MPP
Research Scholar
Program on Science and Global Security
Woodrow Wilson School of Public and International Affairs Princeton University
Princeton, New Jersey, USA;
Co-Founder, One Health Initiative

John B. Kaneene DVM, MPH, PhD, FAES, FAVES
University Distinguished Professor of Epidemiology and Public Health
Director, Center for Comparative Epidemiology
Michigan State University
East Lansing, Michigan, USA

Shaun Kennedy, PhD
President and CEO
Food Systems Institute
St Paul, Minnesota;
Adjunct Associate Professor
College of Veterinary Medicine, University of Minnesota
Minneapolis, Minnesota, USA

Sandra L. Lefebvre, BA, BSc (Hons Neuroscience), DVM, PhD
Assistant Editor, JAVMA and AJVR
American Veterinary Medical Association
Schaumburg, Illinois, USA

Jeffrey M. Levengood, PhD
Illinois Natural History Survey, Prairie Research Institute
University of Illinois at Urbana-Champaign
Urbana, Illinois, USA
Thomas P. Meehan, DVM  
Vice-President of Veterinary Services  
Chicago Zoological Society  
Adjunct Clinical Assistant Professor  
Veterinary Clinical Medicine  
College of Veterinary Medicine  
Brookfield Zoo  
University of Illinois at Urbana-Champaign  
Brookfield, Illinois, USA

Yvonne Nadler, DVM, MPH  
Program Manager  
Zoo and Aquarium All Hazards Preparedness, Response, and Recovery  
Fusion Center  
Silver Spring, Maryland, USA

Megin Nichols, DVM, MPH, DACVPM  
Lead, Enteric Zoonoses Activity  
Division of Foodborne, Waterborne, and Environmental Diseases  
National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)  
Centers for Disease Control and Prevention  
Atlanta, Georgia, USA

Kenneth E. Nusbaum, DVM, PhD  
Professor Emeritus  
College of Veterinary Medicine  
Auburn University  
Auburn, Alabama, USA

Kevin O’Brien, PhD  
Director  
Illinois Sustainable Technology Center  
Prairie Research Institute  
University of Illinois at Urbana-Champaign  
Urbana, Illinois, USA

Robert H. Poppenga, DVM, PhD, DABVT  
Professor  
CAHFS Toxicology Laboratory  
School of Veterinary Medicine  
University of California  
West Health Sciences Drive  
Davis, California, USA

Cheryl Robertson, PhD, MPH, RN, FAAN  
Associate Professor  
Chair, Population Health and Systems Cooperative Unit  
School of Nursing  
University of Minnesota  
Minneapolis, Minnesota, USA

Innocent B. Rwego, BVM, MSc, PhD  
Assistant Professor  
Department of Veterinary Population Medicine  
College of Veterinary Medicine  
University of Minnesota  
Minneapolis, Minnesota, USA;  
Senior Technical Lead for Africa  
USAID One Health Workforce Project  
University of Minnesota-Makerere  
University Uganda Hub  
Kampala, Uganda

Christopher A. Shaffer, PhD  
Assistant Professor  
Department of Anthropology  
Grand Valley State University  
Allendale, Michigan, USA

William Stauffer, MD, MSPH, FASTMH  
Professor  
Department of Medicine, Division of Infectious Diseases & International Medicine  
Department of Pediatrics, Infectious Diseases  
School of Medicine and Public Health  
University of Minnesota  
Minneapolis, Minnesota, USA

Lauren Stevenson, MHS  
Assessment Epidemiologist  
Division of Foodborne, Waterborne, and Environmental Diseases  
National Center for Emerging and Zoonotic Infectious Diseases  
Centers for Disease Control and Prevention, Atlanta, Georgia, USA

Robert V. Tauxe, MD, MPH  
Director  
Division of Foodborne, Waterborne, and Environmental Diseases  
National Center for Emerging and Zoonotic Infectious Diseases  
Centers for Disease Control and Prevention  
Atlanta, Georgia, USA
Dominic A. Travis, DVM, MS
Associate Professor
Division of Ecosystem Health
Department of Veterinary Population Medicine
College of Veterinary Medicine
University of Minnesota
Minneapolis, Minnesota, USA

Ed G.M. van Klink, DVM, PhD, Dipl. ECVPH, MRCVS
Senior Lecturer in Veterinary Public Health
School of Veterinary Science

University of Bristol
Lower Langford
Bristol, United Kingdom;
Wageningen Bioveterinary Research
Lelystad, The Netherlands

Donald J. Wuebbles, PhD
Harry E. Preble Endowed Professor of Atmospheric Sciences
Department of Atmospheric Sciences
University of Illinois
Urbana, Illinois, USA
Foreword

We encourage you to set aside time to read *Beyond One Health: From Recognition to Results*. We hope that you will be as inspired by its contents as we are.

One Health is one of the great innovations of our time. It is an idea, a concept, a way of thinking and working, and a means to organize action. One Health starts from a recognition that 75% of the new infections affecting humans come from animals. The risks of animal diseases can be decreased through proper attention to livestock health in livestock production: the One Health approach guides efforts to intensify production. It recognizes the benefits of food systems that are sensitive to nutrition and the threats posed by infections that are resistant to antimicrobial therapies.

The One Health idea came to life in 2004 as scientists considered how best to tackle diseases that move between human, domestic animal, and wildlife populations. It reflected experiences with the Ebola virus disease, avian influenza, and chronic wasting disease. It is set out as the Manhattan principles (https://www.cdc.gov/onehealth/pdfs/manhattan/twelve_manhattan_principles.pdf) for *One World, One Health*.1 It is an international, interdisciplinary approach for tackling threats to the health of life on Earth. It has practical application for reducing risks of unsafe foods and diseases that move from animals to humans.

One Health connects science and systems to the needs of society. It has matured into a new way of thinking and working and contributes to the health of both humans and animals. It links several disciplines that focus on health. It helps professionals to see their work differently and to do it with new purpose. It stimulates integration when remaining separate is less effective. One Health frames how we speak and act: it encourages us to focus on the interfaces between human, animal, and environmental systems. It helps us make sense of multiple interacting determinants of illness. It helps us to better reduce risk and prepare for threats.

Many of us with coordination responsibilities have found that One Health makes our joint working more effective and efficient. It makes sense on the farm, in the factory, and at home, encouraging us to prevent costly outbreaks.

More recently, One Health has helped with restructuring institutions and transforming education. It helped drive collaboration between the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the Food and Agriculture Organization of the United Nations (FAO). It stimulated new academic departments and degree programmes. It provided a basis for local and national governments to combine animal, human, and environmental health programs, and to reap economic benefits.

*Beyond One Health: from Recognition to Results* offers us an update on One Health topics from the perspectives of different professional and academic disciplines. It includes

---

1 Organized by the Wildlife Conservation Society and hosted by The Rockefeller University (http://www.oneworldonehealth.org).
an analysis of different threats to people and planet (including zoonoses and climate change), the epidemiology that underlies One Health, as well as the evidence base for different One Health policies and their benefits. It shows how One Health is best approached from a systems perspective and explains the importance of good leadership in making One Health a reality.

If we want to learn how One Health can best be applied in practice, we should study its use in different situations. In this book, we can see how One Health approaches help when analyzing risk and devising prevention, preparedness, and response strategies; when monitoring the evolution of threats and establishing early warning systems; or when prioritizing actions and coordinating actors during implementation. We can understand how One Health has been used in responses to avian influenza, yellow fever, Zika, Middle East respiratory syndrome (MERS), and Ebola.

When combining animal and environmental health practice, we must be sensitive to variations in motivations, responsibilities, and accountability of practitioners in these disciplines. In our experience, the One Health approach is especially useful when coalitions of actors are being established and a consensus is being built. It should be applied in ways that are sensitive to context, adapted to capabilities of systems (for public, veterinary, and environmental health), and adjusted to ecosystem, economic, and societal realities of interfaces between humans, animals, and nature.

We are starting to see One Health approaches being used to frame analyses of costs, benefits, acceptability, and scalability of different interventions. Academic groups are often asked to provide the evidence base for One Health policies and interventions. Their inputs are most helpful when interdisciplinary research methods are used. This is especially necessary when exploring links among environmental dynamics, disease vectors, pathogens, and human susceptibility.

Enlightened approaches like One Health – which focus on prevention and response from the perspectives of multiple disciplines – are vital to success in achieving the 2030 Agenda for Sustainable Development and in building a common future for all. This book will help you move along that path.

Chadia Wannous
David Nabarro

Chadia Wannous, PhD, is a Public Health professional and expert in prevention, emergency preparedness, and risk reduction for health threats. She previously served in several senior policy advisory positions with the UN.

David Nabarro, MD, is a medical doctor and Adviser on Sustainable Development. He previously served as Special Adviser to the United Nations Secretary-General.
The naturalist and conservationist, John Muir, once stated, “When one tugs at a single thing in nature, he finds that it is attached to the rest of the world.” The interconnectedness that Muir described in the early twentieth century is much more profound today, and much more consequential, regarding our health. The globalization of trade, travel, information, and investments, integrated and consolidated global food systems, urbanization, and a group of anthropogenic drivers that negatively impact our ecosystems, have created a new dynamic and an unprecedented interdependence among the health and well-being of people, animals, and our environment. The complex construct that describes these three domains of health is termed “One Health” and, indeed, tugging on any one of these domains demonstrates their significant attachments to one another. As a corollary to this axiom, we can no longer focus on health through a single lens or discipline.

Our new twenty-first century interdependence, including social, economic, political, and biological factors, has created new threats and risks to our health and has produced ecological changes that have fractured our planet. Several decades ago, the concept of One Health re-emerged from past medical thinking and gained important traction and acceptance. Recently, there have been many articles and books published focusing on One Health but, fortunately and very timely, this book has added special insights and brought together diverse disciplines and thinking to give us a better understanding of One Health in our contemporary lives, with an important and unique emphasis on operationalizing the concept. The book’s authors have substantially improved our understanding of the key themes of One Health, added to our knowledge base, and stressed that new skills and competencies need to be acquired to successfully address the threats to human, animal, and ecosystem health.

The factors and drivers of our interdependent world, and increasingly risky lives, show no signs of abating; rather, they are accelerating. These drivers are leading to the intensification of the human-animal-ecosystem interface and causing further ecological damage. One consequence of this reality has been the dramatic increase in zoonotic diseases worldwide over the last few decades, which is thoroughly detailed in several chapters. This book also discusses the serious consequences of the degradation of our water resources and ecosystems, as well as threats to biodiversity and food security, all underpinned by climate change. The authors present evidence that our complex and interconnected world has generated a group of “wicked problems” that demand our attention and resources to resolve. A key feature of “wicked problems” is the recognition that past solutions and practices are not likely to be relevant or effective when applied to today’s unparalleled challenges. A One Health mindset and an ability to work holistically across disciplines need to become the new norm to address complex problems and to take appropriate actions. In addition, we must champion new partnerships and innovations, and learn to effectively lead and manage change.
However, our medical fields continue to become progressively more specialized and, at the same time, progressively more isolated and siloed. While we appreciate the impressive advances in medicine, our health systems are increasingly disease-oriented and reactive. One Health, on the other hand, stresses disease prevention, shifting interventions closer to the origins of the problem, often in our animals and environment. *Beyond One Health: From Recognition to Results* argues that improving animal and environmental health can be a very effective and cost-beneficial public health strategy. As this text points out so well, maintaining and improving health must go beyond a strictly disease-oriented approach to consider the impact of the environment, social-economic status, genetics and human behavior, and other social determinants of health, which is truly a One Health perspective. This timely book makes the case that we need to normalize good health through this larger and more comprehensive context.

In differentiating *Beyond One Health: From Recognition to Results* from past One Health books, this book emphasizes the need to translate new knowledge into practice. We know that this transformation is a difficult and dynamic process that involves synthesis, dissemination, exchange, and finally application of One Health knowledge to the maintenance and improvement of health in all of its domains and dimensions. The book’s authors acknowledge and present compelling evidence that critical gaps exist today between the promise of good health and actual results. The book reiterates that developing and implementing new strategies and polices represent the tactics necessary to support a One Health framework and plan of action. In addition, the authors argue in favor of the growing evidence that One Health thinking can offer a favorable value proposition, demonstrating that maintaining the status quo for our current healthcare delivery and disease response system is no longer acceptable, cost-effective, or scientifically valid.

While we remember John Muir as an outstanding ecological thinker, we also recognize that he was a very effective political spokesperson who understood the importance of translating science and knowledge into policies in support of conservation. Likewise, we need to move One Health from an abstract concept to a catalyst for new policies and interventions that can change the existing dynamic and improve health outcomes across all the domains of health. We understand that there are three stages of translating knowledge into practice, and this book discusses all three throughout its chapters. Awareness, acceptance, and adoption comprise the sectors of translation and all are integrated throughout the text. The authors also stress an important lesson: as we develop and adopt new strategies and policies, we also must design and carry out processes for outcome measurement and evaluation and continuous improvement for them to remain relevant and effective.

We are indebted to the editors and authors who have successfully built momentum toward a more universal acceptance of One Health and, perhaps even more importantly, have been especially instructive in helping us appreciate the need to enact new policies and shift One Health from theory to effective field implementation. They have reminded us, throughout this text, that One Health is likely just to be relegated to an academic exercise if it is not accompanied by a new value proposition, new policies, and more efficient interventions in the rapidly changing human, animal, and environmental health dynamic. Finally, we are grateful for both the intellectual and practical contributions of the book’s editors and authors and are well advised to use their ideas and examples to better address the threats to our health, in all its dimensions.

Lonnie King, DVM, MS, MPA, DACVPM
Professor and Dean Emeritus
College of Veterinary Medicine
Ohio State University
“One Health” has caught on, some 140 years after Virchow coined the term “zoonoses” and said, “between animal and human medicine there are no dividing lines – nor should there be” (Schultz, 2008). The principles of One Health are often assigned singular ownership of that conceptual triad. However, other models, such as the Ecological Model in public health, eco-social theory, EcoHealth, conservation medicine, ecological medicine, and others, also take the holistic view that individual or population health outcomes are the result of many interrelated exposures, determinants, and contributing factors, and that an understanding of them, and their relatedness to each other, is required to formulate effective public policy designed to improve health.

Much has been written about One Health, its history and importance, especially in the context of emerging infectious diseases. One cannot minimize previous essays and textbooks focused on the need for viewing modern challenges to population health through a One Health lens, or the many peer reviewed journal articles that framed their research findings as examples of the demand for One Health thinking and the challenges associated with it. It was only after we discussed our interest in public policy, and our experiences in the policy formation process, that we came up with the idea to edit a One Health book that is directed at policy solutions. The title of this textbook should be instructive. Our book is intended to serve as a reference for students and professionals in many disciplines, from architecture through urban planning, and not just for those working in traditional healthcare and health-related fields. The concept of One Health, that human, animal, and ecosystem health are inextricably linked, is an idea that is, at its core, about prevention. One Health may be easy to describe but it is a challenge to operationalize as policy. One Health thinking recognizes the interrelatedness of determinants of health and uses the scientific method to discover how strongly exposures are related to outcomes. Data are tested until they are accepted as fact; those facts must be based on scientific consensus drawn from independent, well-constructed, repeatable research that is published for all to read and analyzed in well-respected, peer reviewed journals. We need to get beyond the abstract and actually do. Centuries ago, the German writer and statesman, Johann Wolfgang von Goethe, counseled that knowing and willing to do something is all well and good but eventually we must actually do it.

When we received a request from our publisher to edit a textbook about One Health, we initially declined. There were already four or five excellent books that describe One Health thinking and the challenges associated with it. It was only after we discussed our interest in public policy, and our experiences in the policy formation process, that we came up with the idea to edit a One Health book that is directed at policy solutions. The title of this textbook should be instructive. Our book is intended to serve as a reference for students and professionals in many disciplines, from architecture through urban planning, and not just for those working in traditional healthcare and health-related fields. The concept of One Health, that human, animal, and ecosystem health are inextricably linked, is an idea that is, at its core, about prevention. One Health may be easy to describe but it is a challenge to operationalize as policy. One Health thinking recognizes the interrelatedness of determinants of health and uses the scientific method to discover how strongly exposures are related to outcomes. Data are tested until they are accepted as fact; those facts
can, gradually, after the iterative process of the scientific method, be translated into policy that should be designed to prevent the adverse effects of natural and human-derived phenomena on an ecosystem and to improve health.

Population growth, climate change, environmental degradation, inconsistent food production and distribution, water resource management, nonparticipatory governance, lack of civil society – all of the many determinants of global health – indicate that we are at a critical point in world history. To make significant improvements in global health, to improve the lives of global societies, we must engage thinkers from virtually all academic and professional fields and develop solutions, in public policy and in individual behaviors, that are effective, efficient, and sustainable. This is true One Health.

So, it is in this context that we offer this collection of critical population health topics, written by an international group of experts, that addresses not only the technical aspects of their topics but also offers potential policy solutions to help mitigate current threats and to prevent additional threats from occurring. Too often, public policy is based on the short-term benefit for the few at the long-term cost to the many. Too often, short-sighted policies defer current costs to future generations.

Reference


*John A. Herrmann*

*Yvette J. Johnson-Walker*
Section 1

The Science of One Health
1

1.1 Introduction

Epidemiology is the study of disease dynamics in populations. It seeks to understand patterns of disease as a means of identifying potential prevention and control measures. It has been described as “an interesting and unique example of cross-fertilization between social and natural sciences” (Vineis, 2003). The basic principle of epidemiology is that disease is not a random event. Each individual in a population has a unique set of characteristics and exposures (risk factors) that determine his or her probability of disease. Clinical medicine is focused on the health of the individual while epidemiology and public health seek to apply assessment of risk factors at the community level. Understanding how those risk factors impact a community provides public health officials with the tools to develop policies and interventions for disease control and prevention in the community as a whole.

The One Health concept is coherent with the principles of epidemiology because risk factors for many diseases occur at the interface between humans, animals, and the environment. Failure to consider the interactions between them may result in public health policies that fail to effectively control disease and protect the environment. The One Health triad (Figure 1.1) of humans, animals, and the environment is analogous with the other triads that epidemiologists use to describe disease dynamics within a population:

- The host, agent, environment triad (Figure 1.2) is used to describe the interplay between these three key components of infectious disease transmission. Changes in any of these components alters the probability of disease.
- The three states of infectious disease status are illustrated by the susceptible, infected, removed (SIR) triad (Figure 1.3).
- Outbreaks of disease are characterized in terms of person or animal, place, and time as the first step of identifying the population at risk.
- Risk factors for disease causation are categorized as: necessary, sufficient, and component causes (Figure 1.4).

The goal of public health policy is to prevent transmission of disease agents to the susceptible segment of the population by controlling and treating disease among the infected and increasing the segment of the population that is removed (recovered or resistant). Identification and isolation of cases, quarantine of the exposed, and vaccination of the
susceptible are the primary tools employed by public health practitioners for infectious disease control. Development of effective programs to accomplish these goals requires an understanding of the:

1) Causes of disease (etiologic agent, pathophysiology, and risk factors).
2) Impact of the disease on the population (number of cases, ease of transmission, economic and social impact).
3) Natural course of the disease (reservoirs for the agents of disease, means of introduction of the agent into the population, period of infectivity, severity of disability, length of immunity, and potential for long-term sequelae) (Figure 1.5).

Figure 1.1 The One Health triad. Source: Thompson, 2013. Reproduced with permission of Elsevier.

Figure 1.2 The "epidemiologic triad" of infectious disease summarizes the factors that influence an infection, and the measures you might take to combat the infection. Source: Used with permission from Ian McDowell (http://www.med.uottawa.ca/SIM/data/Pub_Infectious_e.htm#epi_triad).
The goals of this chapter are to elucidate how epidemiology can 1) provide a tool for understanding the causes, impacts, and course of disease in human and animal populations within various ecosystems, and 2) form the basis for evidence-based health and environmental policy development.

1.2 Enhancing Our Understanding of Health and Disease

1.2.1 Causes of Disease

Epidemiology is unique among biomedical investigative approaches because of the observational nature of many of the study designs. Unlike laboratory studies, the epidemiologist often studies a naturally

---

**Figure 1.3** Infection modeling: the SIR model. **Susceptible** nodes – have not been infected yet and are therefore available for infection. They do not infect other nodes. **Infectious** nodes – have been infected and infect other nodes with a certain probability. **Removed** (recovered) nodes – have gone through an infectious period and cannot take part in further infection (neither actively nor passively). **Source:** Used with permission from Michael Jaros (http://mj1.at/articles/infection-modelling-the-sir-model/).

**Figure 1.4** Necessary, sufficient, and component causes. The individual factors are called component causes. The complete pie (or causal pathway) is called a sufficient cause. A disease may have more than one sufficient cause. A component that appears in every pie or pathway is called a necessary cause, because without it, disease does not occur. **Source:** Rothman, 1976. Reproduced with permission of Oxford University Press.

**Figure 1.5** Natural history of disease timeline. **Source:** CDC, 1992.
Epidemiology: Science as a Tool to Inform One Health Policy

occurring disease within a free-living population in which study subjects are not assigned to intervention groups (except in the case of clinical trials). Individuals may have a variety of independent exposures during the study period. Whether studying human or animal populations, the epidemiologist seeks to identify exposures that are associated with the probability of disease using statistical analysis of data from carefully documented exposures and outcomes. However, even if a statistically significant association between an exposure and disease outcome has been identified, that does not necessarily mean that a cause and effect relationship has been established. Much more rigorous standards have been set for establishing a causal relationship between a risk factor and the probability of disease.

1.2.1.1 Deterministic Models of Disease

Criteria for establishing causation for infectious disease have been described since the nineteenth century. Research by Robert Koch, Friedrich Loeffler, and Jakob Henle resulted in the Koch–Henle postulates published in 1882 (Sakula, 1983; Gradmann, 2014) (Figure 1.6). While this approach is useful when seeking to identify the etiologic agent responsible for an infectious disease, it has many limitations. The simplistic approach of a deterministic model for establishing disease causation is insufficient for identifying risk factors for chronic noninfectious diseases (such as type II diabetes) or even infectious diseases with a multifactorial etiology (such as new variant Creutzfeldt–Jakob disease, or CJD). In more recent years more complex

Figure 1.6 The steps for confirming that a pathogen is the cause of a particular disease using Koch’s postulates.