ONE HEALTH
& STAKEHOLDER ENGAGEMENT

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Lecture Overview

• Motivation
• One Health foundations
• Stakeholder approaches
• Case studies
• Health Security
• Preparedness
• Disaster & Outbreak Response

“Poppy”
Why learn about One Health?

- One Health is a required CEPH competency
- One Health approaches aid in systems thinking
- One Health requires multidisciplinary teams
- One Health knowledge is foundational to outbreak response

Swine flu outbreak among attendees exposed to pigs at a Michigan fair.
Cat owners: 12.1%
2018 cohort: 10.5%
U.S. Average: 30-35%

Dog owners: 14.8%
2018 cohort: 11.6%
U.S. Average: 35-45%

Other pets: 3.3%
2018 cohort: 2.7%
The Opioid Epidemic: What Veterinarians Need to Know

The epidemic of opioid abuse is affecting medical and health professionals such as physicians and pharmacists, but also veterinarians.
California Police Rush to Save Animals From Fires: ‘Get In, Get In. That’s a Good Dog.’

Police officers in Vacaville, Calif., rescued animals from an S.P.C.A. on Aug. 11 as a wildfire was approaching. The fire was contained the following day and all the animals were saved and placed in foster homes, the police said. Aug. 14, 2018

Source: NY Times
Minamata (水俣病) Disease, 1950s

Chisso Corporation in Minamata, Japan
- Production of fertilizers and acetaldehyde
- Methylmercury was a byproduct of catalytic reaction used to produce acetaldehyde
- Discharged into Minamata Bay

“Dancing cat disease”
- Cats that ate fish from Minamata Bay showed neurologic signs

Epidemic of neurologic signs in people in the community who ate fish

Image source: BBC
Human-Animal Interface

Human Health  Animal Health

One Medicine
The roots of One Health in One Medicine

“...[I]mproved human health is the sole among veterinary medicine’s several benefits to society that arises from virtually all of veterinarians’ diverse activities...Therefore, if the considerable public and professional advantages of visualizing a major social focus for veterinary medicine en toto are to be realized, these underlying human health implications of its practice must become much better understood. To do this, people need to perceive that there is now and always has been only one medicine.”

- Calvin Schwabe

Veterinary Medicine and Human Health, 1984

Image source: UC Davis
A field guide to animal professionals in public health

• Private practice veterinarians & associated professionals
  – Control of zoonoses at the household and in the hospital
  – Control of food-borne diseases at the farm level
  – Protection of health of human companions (mental health)

A field guide to animal professionals in public health

• Private practice veterinarians & associated professionals
  – Control of zoonoses at the household level (e.g. roundworms)
  – Control of food-borne diseases at the farm level
  – Protection of health of human companions (mental health)

• Public health veterinarians (e.g. state public health vet)
  – Rabies control programs (state, federal, international)
  – Animal surveillance programs (e.g. ProMED)
  – Food and drug safety (e.g. FDA Center for Veterinary Medicine)
  – Bioterrorism & disaster preparedness (incl. military)
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• Animal control
  – Rabies control programs (local, regional)
  – Animal population control (local, regional)
A field guide to animal professionals in public health II

• Department of Agriculture
  – Interstate and International movement of animals
  – Federal control programs for zoonotic diseases, *e.g.* bTB
  – Control of drug residues (food producing animals)
  – **Bioterrorism & disaster preparedness**

*Under suspicion.* The U.K.’s Institute for Animal Health is a possible source of the virus that caused foot-and-mouth disease among cattle on two nearby farms.

A field guide to animal professionals in public health II

• Department of Agriculture
  – Interstate and International movement of animals
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• Veterinary researchers & laboratory staff (*e.g.* CDC, academia)
  – Foreign animal disease research (threats to food supply)
  – Research in zoonotic & vector-borne diseases
  – Research in antimicrobial resistance
  – Research and outbreak investigation for foodborne diseases
  – Animal models for human disease (*e.g.* FIV & SIV to HIV)
  – Application of veterinary knowledge to human disease

One Health domains (or sectors)

(A) Studies or programs relating factors between animal and human health

(B) Studies or programs relating factors between environmental and human health

(C) Studies or programs relating factors between animal and environmental health

One Health is an exploding field of study

2016: 435
2017: 570
2018: 685
2019…
Already at 452

What is One Health?

• *Conceptually?*

“[T]he collaborative effort of multiple disciplines — working locally, nationally, and globally — to attain optimal health for people, animals and our environment” – AVMA One Health Initiative Task Force
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• *Methodologically?*
  An approach to the conduct of multidisciplinary scientific research, government programs, or policy initiatives
    - Engagement of stakeholders
What are stakeholders?

“Stakeholders are people or organizations invested in the program, interested in the results of the evaluation, and/or with a stake in what will be done with the results of the evaluation.” – CDC

Typical stakeholders:

- People involved in research or program operations
- People affected by the research or program
- Decision-makers and funding sources

Adapted from CDC’s Program Performance and Evaluation Office
Why is engagement of stakeholders important?

“[E]volving concepts about health and its dependence on environmental resilience necessitate the inclusion of ministries, organisations [sic] and disciplines that may not have been traditionally considered to be related to health.”

— Jonna Mazet et al. 2014
(A few) Stakeholders in One Health

- Health departments / Ministries of health
  - U.S. example: CDC, state depts of health, local depts of health

- Departments of Agriculture
  - U.S. example: USDA, state depts of agriculture, academic extension services
  - Farmers & operators
  - Transportation (animal movement; import/export of animals & food)
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• Drug development and safety (private and governmental)
  – U.S. example: FDA, private pharmaceutical companies, academia
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• Research
  – U.S. example: veterinary, medical and other institutions; government agencies (intramural research)
  – Granting organizations: NIH, USDA, NGOs (extramural research)
One Health recognizes that the health of people is connected to the health of animals and the environment. The goal of One Health is to encourage the collaborative efforts of multiple disciplines-working locally, nationally, and globally-to achieve the best health for people, animals, and our environment.

A One Health approach is important because 6 out of every 10 infectious diseases in humans are spread from animals.
Prioritizing Zoonoses: A Proposed One Health Tool for Collaborative Decision-Making

Cassidy Logan Rist, Carmen Sofia Arriola, Carol Rubin

Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America

An Assessment of Epidemiology Capacity in a One Health Team at the Provincial Level in Thailand

Soawapak Hinjoy, Arthicha Wongkumma, Somkid Kongyu, Punnarai Smithsuwan, Paphanij Suangtho, Thitipong Yingyong, Sunicha Chanvatik and Soledad Colombe
Global applications

Piloting the One Health Systems Mapping and Analysis Resource Toolkit in Indonesia

Kaylee Myhre Errecaborde,¹ Katharine M. Pelican,¹ Heidi Kassenborg,¹ Ong-Orn Prasarnphanich,¹ Linda Valeri,¹ Erinaldi Yuuzar,² Rama Prima Syahti Fauzi,³ Nyoman Sri Budayanti,⁴ Agus Suwandono,⁵ Wayan T. Artama,⁶ Wiku Adisasmito,⁷ and Tracey Dutcher⁸

REVIEW ARTICLE
One Health capacity building in sub-Saharan Africa

Innocent B. Rwego, BVM, MSc, PhD¹,⁷*, Olutayo Olajide Babalobi, DVM, MPVM, PhD², Protus Musotsi, BSc³, Serge Nzietchueng, DVM, MSc¹,⁴, Christian Keambo Tiambo, BSc, PhD⁵,⁶, John David Kabasa, BVM, MSc, PhD⁷, Irene Naigaga, BVM, MSc, PhD⁸, Gladys Kalema-Zikusoka, BVetMed, MRCVS⁹ and Katherine Pelican, DVM, PhD¹
Human-Animal Interface

Human Health  Animal Health

Zoonosis

75% of all emerging infectious diseases are zoonotic
Human-Animal Interface

Human Health

Animal Health

Anthroponosis
Human-Animal Interface

Human Health

Animal Health

Reality?
What is infectious disease?

“An illness due to a specific infectious [communicable] agent or its toxic products that arises through transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector, or the inanimate environment.”

- Last, Dictionary of Epidemiology, 2001

**Vector:** organism (usually a biting insect) that transmits infectious agents from one host to another
The confusion over vectors

- Vector (organism)

Vector-Borne Diseases (VBD)
Malaria, Dengue, Chagas, etc.
The confusion over vectors

• Vector (organism)
• Vector (fomite)

Vehicle or mechanical vector

Wikimedia
The confusion over vectors

- Vector (organism)
- Vector (fomite)
- Vector (math)
The confusion over vectors

- Vector (organism)
- Vector (fomite)
- Vector (math)
- Vector (Hollywood)

Commuting crimes with both direction and magnitude
Environmental Reservoirs

• An environmental reservoir is part of the abiotic (or inanimate) landscape that potentiates pathogen survival and transmission

• A “good” environmental reservoir
  – Pathogen “habitat” – pathogen can reproduce
  – Ecosystem
    • Pathogens & non-pathogens live together (microbiome)
    • Pathogen may acquire genes for fitness (e.g. antibiotic resistance: resistome)
Animal Reservoirs

• An **animal reservoir** is an animal (or insect) population that specifically maintains and perpetuates a disease
  – Pathogen “habitat” – pathogen can reproduce
  – e.g. birds and avian influenza

• Animals also may serve as transient or non-reservoir hosts (dead-end hosts)
  – May still help maintain disease
  – e.g. horses and West Nile virus
A “good” reservoir

• Reservoir host highly infected
  – Viremia/bacteremia/parasite load high
  – High level of pathogen shedding (discharge)

• Infectious disease does not cause morbidity (symptoms) or mortality (death) in reservoir host

• Reservoir host has a large, dense population

Adapted from *Dictionary of Veterinary Epidemiology*, 1999
Examples of animal reservoirs

- Rodents (rats and mice)
- Birds
- Bats
- Primates

Image source: CDC
Emerging Infections & Ecology

Fig. 1. The host-parasite ecological continuum (here parasites include viruses and parasitic prokaryotes). Most emerging diseases exist within a host and parasite continuum between wildlife, domestic animal, and human populations. Few diseases affect exclusively any one group, and the complex relations between host populations set the scene for disease emergence. Examples of EIDs that overlap these categories are canine distemper (domestic animals to wildlife), Lyme disease (wildlife to humans), cat scratch fever (domestic animals to humans) and rabies (all three categories). Arrows denote some of the key factors driving disease emergence.

Source: Daszak et al. Science
Example: Lyme Disease

- **Borrelia burgdorferi**
  - Spirochete bacteria
- **Vector: Ixodes scapularis** (deer tick)
- **Reservoir host: rodents**
  - *Peromyscus leucopus* (white-footed mice)
- **Amplifying host: deer**
- **Complex ecology!**

Image source: CDC
AMR AS A ONE HEALTH CASE STUDY
What are antimicrobials?

- **Chemicals** that kill or inhibit the growth of certain microbes (bacteria)
  - *Bacteriocidal*: antibiotics that work through killing bacteria
  - *Bacteriostatic*: antibiotics that work by hindering the reproduction (growth) of bacteria
What are antimicrobials?

- Chemicals that kill or inhibit the growth of certain microbes (bacteria)
- Antimicrobials can be found in nature
  - Often produced by fungi or other bacteria
  - May be important in inter-species competition or for communication among microbes
How do bacteria become resistant?

• **Mutation**
  - Mistake in replication or damage and repair of DNA produces genetic change
  - Change in genetic code produces resistance or proto-resistance gene

• **Horizontal Gene Transfer (HGT)**
  - Bacterium acquires resistance genes from donor

It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.
What is selective pressure?

Antibiotics in hosts and the environment expose bacterial populations, selecting for bacteria with resistance genes.
How does use of antimicrobials lead to resistance?

• *Resistome*: all the genetic determinants of resistance present in a community of organisms
  – Resistance may arise by mutation or by conjugation
  – Selective pressure expands the resistome

• Pathogenic and non-pathogenic bacteria
  – Even “good” bacteria can share genes for resistance
  – Bacterial communities important (microbiomes)

• Animal, human and environmental reservoirs
What is the resistome?

Why is antibiotic resistance a problem?

- ~2 million bacterial infections annually
- 90,000 deaths from these infections annually
- 70% are drug-resistant infections
- Drug-resistant infections cost more to treat and lead to longer hospital stays

* IDSA data

[Image: MRSA skin infection]
What does agriculture have to do with AMR?
Reminder: Anatomy of an Industrial Hog Operation (ILO)

Image source: animalschange.org
Reminder: Worker and animal exposures

How much of U.S. antimicrobial use is in food animals?

• Food animal sales / distribution
  – 13.5 million kg *
  – 80% of all antimicrobial use (by weight)
  – 74% of this is non-therapeutic use

• Human use
  – 3.3 million kg *
  – 20% of all antimicrobial use (by weight)

* FDA data (2011)
FDA Summary of Antimicrobials Sold or Distributed for Use in Food-Producing Animals

Production for Domestic Distribution (kg)

- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

- NIR
- Tetracyclines
- Sulfas
- Penicillins
- Macrolides
- Lincosamides
- Ionophores
- Fluoroquinolones
- Cephalosporins
- Amphenicols
- Aminoglycosides
How are antimicrobials used in food-producing animals?

• Therapeutic use for treatment of sick animals
  – Veterinary-Client-Patient Relationship (VCPR)
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• Preventative uses in animals that are not sick but have been or may have been exposed to an infectious agent
How are antimicrobials used in food-producing animals?

• Therapeutic use for treatment of sick animals
  – Veterinary-Client-Patient Relationship (VCPR)

• Preventative uses in animals that are not sick but have been or may have been exposed to an infectious agent

• Uses for growth promotion or feed efficiency ("economic" or "production" uses)
  – "Growth promotion" (GPA) or "production use"
  – Est. 35-85% of U.S. antibiotic production (historically)
  – May include purchase and use outside of VCPR
Snapshot of a feed store

Over-the-Counter (OTC) drug availability may vary by country
CDC Data, 2013

Use of molecular techniques in environmental & ID epi

• Tracking strains important for outbreak and other epi investigation
  – DNA “fingerprints”
Use of molecular techniques in environmental & ID epi

• Tracking strains important for outbreak and other epi investigation
  – DNA “fingerprints”

• Techniques have evolved over time
  – CDC’s PulseNet (Pulsed-field gel electrophoresis)
  – Serotyping (*E. coli*, *Salmonella*) via agglutination methods
  – Genotyping (many microbes) by DNA/RNA methods
PFGE method

The Pulsed-field Gel Electrophoresis Process

1. The scientist takes bacterial cells from an agar plate.
2. The scientist mixes bacterial cells with melted agarose and pours into a plug mold.
3. The bacterial cells are broken open with biochemicals, or lysed, so that the DNA is free in the agarose plugs.
4. The scientist loads the DNA gelatin plug into a gel, and places it in an electric field that separates DNA fragments according to their size.
5. The gel is stained so that DNA can be seen under ultraviolet (UV) light. A digital camera takes a photograph of the gel and stores the picture in the computer.

Image source: CDC
Use of molecular techniques in environmental & ID epi

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• Why so many techniques?
  – Whole Genome Sequencing (WGS) – gold standard
  – Less expensive methods for surveillance, research
Whole Genome Sequencing

The Whole Genome Sequencing (WGS) Process

1. DNA Extraction
   Scientists take bacterial cells from an agar plate and treat them with chemicals that break them open, releasing the DNA. The DNA is then purified.

2. DNA Shearing
   DNA is cut into short fragments of known length, either by using enzymes “molecular scissors” or mechanical disruption.

3. DNA Library Preparation
   Scientists make many copies of each DNA fragment using a process called polymerase chain reaction (PCR). The pool of fragments generated in a PCR machine is called a “DNA library.”

4. DNA Library Sequencing
   The DNA library is loaded onto a sequencer. The combination of nucleotides (A, T, C, and G) making up each individual fragment of DNA is determined, and each result is called a “DNA read.”

5. DNA Sequence Analysis
   The sequencer produces millions of DNA reads and specialized computer programs are used to put them together in the correct order like pieces of a jigsaw puzzle. When completed, the genome sequence containing millions of nucleotides (in one or a few large pieces) is ready for further analysis.

Image source: CDC
Example: WGS to inspect household MRSA transmission

Measure genetic “distance” using single-nucleotide polymorphisms (SNPs)

Index patient cluster

Dog cluster

Household member outlier

Davis MF; Masic AM; Morris DO; Moss JT; Tolomeo P; Beiting D; Nachamkin I; and Lautenbach E; Rankin SC. Genome sequencing reveals strain dynamics of methicillin-resistant *Staphylococcus aureus* in the same household in the context of clinical disease in a person and a dog. *Veterinary Microbiology* 2015, 180(3-4):304-7.
Pathways for Resistant Bacteria

Case: Klebsiella from urinary infections and from meat

Source:
clinical – dark gray
meat source – light gray

Multidrug resistant isolates among predominantly meat-source isolates

Case: Klebsiella from urinary infections and from meat

The same strain (ST) types are found in both meat source isolates and isolates from human urinary tract infections.
What solutions exist to address this challenge?
What strategies are available to combat antimicrobial resistance?

• Farmer education
  – Decrease use of OTC antimicrobials / medicated feed

• Consumer-driven change – *e.g.* organic
What strategies are available to combat antimicrobial resistance?

- Farmer education
  - Decrease use of OTC antimicrobials / medicated feed
- Consumer-driven change – *e.g.* organic
- Voluntary withdrawal or restriction
  - Ceftiofur in Canada
  - Roxarsone in the U.S. (arsenic)
  - Guidance #213: voluntary phase-out of production uses by 2017
What strategies are available to combat antimicrobial resistance?

• Farmer education
  – Decrease use of OTC antimicrobials / medicated feed

• Consumer-driven change – e.g. organic

• Voluntary withdrawal or restriction
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  – Guidance #213: voluntary phase-out of production uses by 2017

• Legal action
  – NRDC lawsuit

• Federal, state, or local regulation
  – Withdrawal of fluoroquinolone use in poultry
  – California SB27
Medically important antimicrobial drugs approved for use in food-producing animals
Actively marketed 2009-2017
Domestic sales and distribution data
Reported by dispensing status (combined annual totals)
Key Points – One Health

• One Health is the interface of human, animal, and environmental health
• One Health methods can be applied to scientific research, government programs, and policy initiatives
• Stakeholders are people or organizations invested in the research or program
• Stakeholder engagement is important for One Health approaches
More summer reading options...

- *The Fatal Menace of MRSA Superbug* by Maryn McKenna
- *Beating Back the Devil* by Maryn McKenna
- *The Coming Plague* by Laurie Garrett
- *Rabid* by Bill Wasik and Monica Murphy
185.600.81 One Health Tools to Promote and Evaluate Healthy and Sustainable Communities

**Department:** Environmental Health and Engineering  
**Term:** 4th term  
**Credits:** 3 credits  
**Academic Year:** 2017 - 2018  
**Location:** Internet  

**Auditors Allowed:** Yes, with instructor consent  
**Grading Restriction:** Letter Grade or Pass/Fail  
**Contact:** Meghan Davis  
**Course Instructor:**  
  - Meghan Davis  
**Resources:**  
  - CoursePlus

**Prerequisite:** 340.722.81 EPIDEMIOLOGIC INFECTION IN PUBLIC HEALTH or any equivalent or more advanced course in epidemiology Introduction to Online Learning

**Description:** Students will learn and apply tools and principles of One Health, which is the interface of human health, animal health and environmental health, to promote and evaluate healthy and sustainable communities. Classes will cover methods central to the conduct of One Health research or programs, which includes study design, stakeholder participation, community engagement and program evaluation, and will cover topics of high relevance to One Health in a way that uses systems approaches and synthesis to join perspectives from the multiple disciplines. These topics include drivers—such as the food system and antimicrobial resistance—that can contribute to or detract from the health and sustainability of communities. Methods will be presented in the context of applications such as policy, regulation, and economics and will connect One Health techniques for knowledge integration and other approaches to the design of healthy communities.
One Health Capstone Opportunities

- Animal Assistance Therapy
- Animal shelters and housing loss
- Unintended consequences (financial, animal welfare) from public health laws
- Sustainability in military farmer’s markets
- Pet ownership and health
- Many more...

- Data analysis (epidemiology)
- Qualitative data analysis
- Literature review
One Health Day 2016 (JHSPH One Health group)