ONE HEALTH CONCEPT AND KNOWLEDGE

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ONE HEALTH CONCEPT AND KNOWLEDGE

Module Overview

This module fosters an understanding of the One Health approach, including its history, players and application.

Module Competencies

Competencies#1	Learning Objectives to Develop Competencies
Ability to communicate and discuss OH concept to colleagues, students, as well as general population.	a) Define One Health b) List organizations and groups currently involved in One Health c) Compare and contrast One Health with ecosystem health and global health
Competencies#2	**Learning Objectives to Develop Competencies**
Ability to identify experts/ expertise required in a One Health approach.	a) Define One Health b) List organizations and groups currently involved in One Health c) Compare and contrast One Health with ecosystem health and global health
Competencies#3	**Learning Objectives to Develop Competencies**
Ability to identify and appreciate competencies required by One Health future workforce	a) Describe the OHCC domains including their purpose and how they can be used
Competencies#4	**Learning Objectives to Develop Competencies**
Be able to describe the application of the One Health approach in addressing a (/an example of) pandemic threat	1. Explaining how One Health is an approach 2. Describing how One Health is transdisciplinary 3. Explain how One Health successfully brings together stakeholders to address complex emerging and re-emerging pandemic threats

A. ONE HEALTH, GLOBAL HEALTH, ECOSYSTEM HEALTH, AND ENVIRONMENTAL

As the world and its economies become increasingly **globalized**, including extensive international **travel and commerce**, it is necessary to think about health in a global context. Rarely a week goes by without a headline about the **emergence or re-emergence of infectious disease(s)** or other health threat somewhere in the world.

> *"Threats to health know no borders. In an age of widespread global **trade and travel**, new and existing diseases **can cross national borders** and threaten our collective security,"*
> – Dr. Margareth Chan, WHO-Director General.

A.1. One Health

In order to better understand One Health, we need to step back and take a global look at the world. The world population is the total number of living humans on Earth. As of today, it is estimated to number 7.135 billion by the United States Census Bureau (USCB). The USCB estimates that the world population exceeded 7 billion on March 12, 2012. Current UN projections show a continued increase in population in the near future (but a steady decline in the population growth rate), with the global population expected to reach between 8.3 and 10.9 billion by 2050. Today, it is estimated that 60% of existing human infectious disease are zoonotic and at least 75% of emerging infectious disease of humans have an animal origin (www.oie.int). That phenomenon means that we are facing complex problem that needs to apply a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originated at the animal-human-ecosystems interface (www.onehealthglobal.net).

One Health recognized 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 environment (www.cdc.gov). The One Health concept was introduced at the beginning of the 2000s and implemented by the World Organization of Animal Health (OIE) as a collaborative global approach to understanding risks for human, animal, and ecosystem as a whole (www.oie.int).

American Veterinary Medical Association defined One Health is the collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals and our environment. While One Health Commission defines One Health as advocacy to unite human and veterinary medicine with ecosystem health. Recognizing that human health, animal health, and ecosystem health are inextricably linked, One Health seeks to promote, improve, and defend the health and well-being of all species by enhancing cooperation and collaboration between physicians, veterinarians, other scientific health and environmental professionals and by promoting strengths in leadership and management to achieve these goals.

A.2. Ecological Health

The EcoHealth approach focuses above all on the place of human beings within their environment. It recognizes that there are inextricable links between humans and their biophysical, social, and economic environments, and that these links are reflected in a population's state of health. (International Development Research Centre). The International Association for Ecology & Health (abbreviated as EcoHealth) is a professional organization that promotes research, education and practice (including policy development) on the linkage between human health, conservation medicine and ecosystem sustainability. The specific objectives of EcoHealth are to: serve a diverse international community including scientists, educators, policy makers, practitioners and the general public; provide mechanisms and forums to facilitate international and interdisciplinary discourse (e.g., through publication of the journal *EcoHealth* and by holding biennial conferences); encourage development of trans-disciplinary teaching, research and problem-solving that cut across many fields of scholarship and draws upon multiple types of knowledge.

The mission of EcoHealth is to strive for sustainable health of people, wildlife and ecosystems by promoting discovery, understanding and trans-disciplinarily. EcoHealth Alliance works at the intersection of ecosystem, animal and human health through local conservation programs and develops global health solutions to emerging diseases. It is an international organization of scientists dedicated to the conservation of biodiversity. EcoHealth Alliance focuses efforts on innovative research, education and training, and accessibility to international conservation partners. EcoHealth Alliance specializes in saving biodiversity in human-dominated bioscapes where ecological health is most at risk because of habitat loss, species imbalance, pollution and other environmental issues caused by human-induced change. Work includes research into the discovery and causes of disease emergence such as SARS, AIDS, Lyme disease, West Nile virus, avian influenza and the deadly Nipah virus.

EcoHealth Alliance researches ways for people and wildlife to share bioscapes for their mutual survival with an overall mission to empower local conservation scientists worldwide to protect nature and safeguard ecosystem and human health. Behavior is the result of the interaction between what we believe and how we feel. If we want to change behavior it is necessary to change the underlying beliefs and feelings related to that behavior. We are all creatures of habit and purposeful behavior changes is both difficult to achieve and even more difficult to maintain. There are many factors that influence whether we achieve behavior change in a health context, of which the level of intrinsic motivation or intention to change that behavior is but one. Other significant factors that influence behavior change include the beliefs underlying the behavior, the value of it, the perceived costs and benefits of changing, the barriers to changing, beliefs about our ability to perform the behavior change, and not least the support and reinforcement of others.

A.3. Environmental Health

Environmental health is a branch of public health that is concerned with all aspects of the natural and built environment that may affect human health. Other phrases that concern or refer to the discipline of environmental health include environmental public health and environmental protection. The field of environmental health is closely related to environmental science, and public health, as is environmental health, is concerned with environmental factors affecting human health. Environmental health addresses all the physical, chemical and biological factors external to a person and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments. This definition excludes behavior not related to the environment, as well as behavior related to the social and cultural environment, as well as to genetics.

Environmental health is defined by the WHO as those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health. Environmental health, as used by the WHO Regional Office for Europe, includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and wellbeing of the broad physical, psychological, social and cultural environment, which includes housing, urban development, land use and transport.

A.4. Global Health

Global health is the health of populations in a global context and transcends the perspectives and concerns of individual nations. In global health, problems that transcend national borders or have a global political and economic impact are often emphasized. It has been defined as "the area of study, research and practice that places a priority on improving health and achieving equity in health for all people worldwide." Thus, global health is about worldwide improvement of health, reduction of disparities, and protection against global threats that disregard national borders. The major international agency for health is the World Health Organization (WHO). Other important agencies with impact on global health activities include UNICEF, World Food Programme (WFP), and the World Bank. A major initiative for improved global health is the United Nations Millennium Declaration and the globally endorsed Millennium Development Goals.

EXERCISE#1

Discussion

✓ Define environmental health, ecological health, global health, and one health in your own perspective.

Notes:

B. ONE HEALTH AS AN APPROACH

Around the world, there have been many discussions as to whether One Health is or is not a discipline. As noted previously, there are many descriptions or definitions of One Health, most of which generally refer to the health of humans, animals and the environment. In academia, subjects or topics tend to get separated or grouped into departments, schools, faculties, majors, degrees, etc., with a group of lecturers or professors dedicated to teaching that subject or topic. Therefore, the question has arisen, is One Health a discipline (subject or topic) that can result, for example, in a degree, or is it something else, such as an approach to solving complex issues?

SEAOHUN has taken the position that One Health is an approach. This is because One Health requires people from various sectors and disciplines to work together on grand challenges. Each person is expected to be an "expert" in his/her respective discipline. Therefore, One Health is the approach used by a group of people to work together. It is not a discipline as no one person can be an expert in all areas needed to solve grand challenges.

The One Health approach:

- Recognizes the interdependence of, and seeks to improve human, animal and environmental health.
- Recognizes that communication, collaboration and trust between human and animal health practitioners is at the heart of the One Health concept.
- Has a broad vision and includes other disciplines such as economics and social behavior that are essential to success.
- Needs to promote the 'doable,' such as improving surveillance and response for emerging infectious diseases whilst developing the broader approach.
- Emphasizes community participation and development of community capacity, and especially, an open transparent dialogue.
- Requires both 'ground up' and 'top down' action.
- Recognizes that understanding ecosystems, including molecular ecobiology, are an essential part of One Health.
- Recognizes that One Health is a major component of food security and safety.

EXERCISE#2

Discussion

✓ What are the main characteristics of the One Health approach

Notes:

C. HISTORY OF ONE HEALTH

Although the term “One Health” is fairly new, the concept has long been recognized both nationally and globally. Since the 1800s, scientists have noted the similarity in disease processes among animals and humans, but human and animal medicine were practiced separately until the 20th century. In recent years, through the support of key individuals and vital events, the One Health concept has gained more recognition in the public health and animal health communities.

Click on the events below to learn more about the important people and events in the history of One Health.

Timeline: People and Events in One Health

1821-1902: Virchow recognizes the link between human and animal health

Rudolf Virchow, MD, was one of the most prominent physicians of the 19th century. Dr. Virchow was a German pathologist who became interested in the linkages between human and veterinary medicine while studying a roundworm, *Trichinella spiralis*, in swine. He coined the term “zoonosis” to indicate an infectious disease that is passed between humans and animals.

In addition to his medical career, Dr. Virchow served in several parliamentary posts and advocated for the importance of improved veterinary education. He emphasized, “Between animal and human medicine there are no dividing lines—nor should there be. The object is different but the experience obtained constitutes the basis of all medicine.”

1849-1919: William Osler, father of veterinary pathology

William Osler, MD, was a Canadian physician who is considered the father of veterinary pathology in North America. Dr. Osler had a deep interest in the linkages between human and veterinary medicine. He trained with many well-known physicians and veterinarians, including Dr. Virchow. One of his first publications was titled “The Relation of Animals to Man”. While serving on the medical faculty of McGill University, Dr. Osler lectured to medical students and veterinary students from nearby Montreal Veterinary College.

Following his time at McGill, Dr. Osler became the Chair of Clinical Medicine at the University of Pennsylvania in Philadelphia. In 1889, he became the first Physician-in-Chief of Johns Hopkins Hospital and played an instrumental role in establishing the Johns Hopkins University School of Medicine.

1947: The Veterinary Public Health Division is established at CDC

In 1947, James H. Steele, DVM, MPH, founded the Veterinary Public Health Division at CDC. Dr. Steele understood the important role of animals in the epidemiology of zoonotic diseases (the study of how these diseases are spread and how they can be controlled), and he recognized that good animal health is important for good public health. The Division played an important role in the public health response to diseases such as rabies, brucellosis, salmonellosis, Q fever, bovine tuberculosis, and leptospirosis. With this Division at CDC, the principles of veterinary public health were introduced to the United States and other countries around the world.

1927-2006: Calvin Schwabe coins the term "One Medicine" and calls for a unified approach against zoonoses that uses both human and veterinary medicine

Calvin Schwabe, DVM, ScD, MPH, made many important contributions to veterinary epidemiology over his career. He began his career studying zoonotic parasitic diseases and directed the World Health Organization programs on hydatid disease and other parasitic diseases. In 1966, Dr. Schwabe became the founding chair of the Department of Epidemiology and Preventive Medicine at the Veterinary School at the University of California Davis. It was the first department of its kind at a veterinary school.

Dr. Schwabe's support for One Health was evident in his writings. In the 1964 edition of his monograph, he proposed that veterinary and human health professionals collaborate to combat zoonotic diseases. In his textbook, *Veterinary Medicine and Human Health*, Dr. Schwabe coined the term "One Medicine." The term emphasizes the similarities between human and veterinary medicine and the need for collaboration to effectively cure, prevent, and control illnesses that affect both humans and animals.

2004: The Wildlife Conservation Society publishes the 12 Manhattan Principles expanded

On September 29, 2004, the Wildlife Conservation Society brought together a group of human and animal health experts for a symposium at Rockefeller University in New York City. Attendees of this symposium, titled "Building Interdisciplinary Bridges to Health in a 'Globalized World'," discussed the movement of diseases among humans, domestic animals, and wildlife. The symposium set 12 priorities to combat health threats to human and animal health. These priorities, known as the "Manhattan Principles," called for an international, interdisciplinary approach to prevent disease and formed the basis of the "One World, One Health™" concept.

2007: The American Medical Association passes the One Health resolution promoting partnership between human and veterinary medicine

In June 2007, Ronald Davis, MD, President of the American Medical Association (AMA), collaborated with Roger Mahr, DVM, President of the American Veterinary Medical Association (AVMA), to establish a bond between the two organizations. On July 3, 2007, the House of Delegates of the AMA unanimously approved a resolution calling for increased collaboration between the human and veterinary medical communities.

2007: The One Health approach is recommended for pandemic preparedness

December 4–6, 2007, representatives of 111 countries and 29 international organizations met in New Delhi, India, for the International Ministerial Conference on Avian and Pandemic Influenza. During this meeting, governments were encouraged to further develop the One Health concept by building linkages between human and animal health systems for pandemic preparedness and human security.

2008: FAO, OIE and WHO collaborate with UNICEF, UNSIC and the World Bank to develop a joint strategic framework in response to the evolving risk of emerging and re-emerging infectious diseases

In response to the recommendations of the previous International Ministerial Conference on Avian and Pandemic Influenza in New Delhi, FAO, WHO, OIE, UNICEF, the World Bank and UNSIC came together to develop a document titled "Contributing to One World, One Health™-A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystems Interface." It built on the lessons learned from the highly pathogenic H5N1 avian influenza response during the early 2000s and presented a strategy for applying the One Health concept to emerging infectious diseases at the animal-human-ecosystem interface.

2008: One Health becomes a recommended approach and a political reality

October 25–26, 2008, representatives from more than 120 countries and 26 international and regional organizations attended the International Ministerial Conference on Avian and Pandemic Influenza in Sharm el-Sheikh, Egypt. During this meeting, the joint strategic framework was officially released. Based on the framework, participants endorsed a new strategy for fighting avian influenza and other infectious diseases, one that focuses infectious disease control in areas where animals, humans and ecosystems meet.

2009: The One Health Office is established at CDC

In 2009, Lonnie King, then director of CDC's National Center for Zoonotic, Vectorborne and Enteric Diseases, proposed the One Health Office. The office was created as a point of contact for external animal health organizations and to maximize external funding opportunities. Since that time, the role of the One Health Office has expanded to include supporting public health research that furthers the One Health concept, facilitating the exchange of data and information among researchers across disciplines and sectors.

2009: USAID establishes the Emerging Pandemic Threats program

In 2009, the USAID launched the Emerging Pandemic Threats (EPT) program. The program's purpose is to ensure a coordinated, comprehensive international effort to prevent the emergence of diseases of animal origin that could threaten human health. The EPT program draws on expertise from across the animal and human health sectors to build regional, national and local One Health capacities for early disease detection, laboratory-based disease diagnosis, rapid disease response and containment, and risk reduction.

2009: Key recommendations for One World, One Health™ are developed

March 16–19, 2009, the Public Health Agency of Canada's Centre for Food-borne, Environmental and Zoonotic Infectious Diseases hosted the One World, One Health™ Expert Consultation in Winnipeg, Manitoba. Experts attended from 23 countries. This technical meeting was held to further discuss the One World, One Health™ strategy and the objectives in the Strategic Framework, which was first released at the International Ministerial Conference on Avian and Pandemic Influenza in Sharm elSheikh. During the meeting, key recommendations emerged for actions that countries could take to advance the concepts of One Health.

2010: The Hanoi Declaration, which recommends broad implementation of One Health, is adopted unanimously

April 19–21, 2010, a total of 71 countries and regional bodies, along with representatives from international organizations, development banks and other stakeholders, attended the International Ministerial Conference on Avian and Pandemic Influenza in Hanoi, Vietnam. With the experience of the H1N1 pandemic and highly pathogenic H5N1 avian influenza, participants confirmed the need to bring greater attention to the links between human and animal health to address threats that happen when animals, humans and the ecosystem interface. At the conclusion of the meeting, participants unanimously adopted the Hanoi Declaration, which called for focused action at the animal-human-ecosystem interface and recommended broad implementation of One Health.

2010: Experts identify clear and concrete actions to move the concept of One Health from vision to implementation

May 4–6, 2010, CDC, in collaboration with OIE, FAO and WHO, hosted a meeting in Stone Mountain, Georgia, titled "Operationalizing 'One Health': A Policy Perspective—Taking Stock and Shaping an Implementation Roadmap." The meeting, which came to be known as the "Stone Mountain Meeting," was designed to define specific action steps to move the concept of One Health forward. Participants identified seven key activities to advance the One Health agenda. These activities formed the basis of six workgroups which focused on:

- Cataloguing and developing One Health trainings and curricula.
- Establishing a global network.
- Developing a country-level needs assessment.
- Building capacity at the country level.
- Developing a business case to promote donor support.
- Gathering evidence for proof of concept through literature reviews and prospective studies.

2010: The United Nations and the World Bank recommend adoption of One Health approaches

In July 2010, the World Bank and the United Nations released the "Fifth Global Progress Report on Animal and Pandemic Influenza." The report reiterated the findings of the delegates at the International Ministerial Conference on Avian and Pandemic Influenza in Hanoi. It also emphasized the importance of adopting a One Health approach to sustain momentum in pandemic preparedness. Rather than focusing on controlling avian influenza through emergency initiatives, countries and regional bodies should build One Health capacity to respond to a broad range of emerging and existing disease threats, the report advised.

2010: The European Union reaffirms its commitment to operate under a One Health umbrella

In August 2010, the European Union published the "Outcome and Impact Assessment of the Global Response to the Avian Influenza Crisis" report. This report states, "The European Union has already taken new initiatives under the One Health umbrella and will continue to do so in the coming years." The report emphasizes the need to translate the One Health concept into practical policies and strategies that promote interagency and cross-sectoral collaboration.

2011: The 1st International One Health Congress is held in Melbourne, Australia

February 14–16, 2011, the 1st International One Health Congress was held in Melbourne, Australia. More than 650 people from 60 countries and a range of disciplines came together to discuss the benefits of working together to promote a One Health approach. In addition to understanding the interdependence of human, animal and environmental health, attendees agreed that it is important to include other disciplines such as economics, social behavior, and food security and safety.

2011: The 1st One Health Conference in Africa is held

July 14–15, 2011, the Southern African Centre for Infectious Disease Surveillance organized the 1st One Health Conference in Africa at the National Institute for Communicable Diseases in Johannesburg, South Africa. The conference brought together scientists from Africa, Asia, Europe, Russia, Australia and the United States.

2011: The High Level Technical Meeting to Address Health Risks at the Human-Animal-Ecosystem Interface builds political will for the One Health movement

Building on the agreements in the Tripartite Concept Note, the Tripartite organized a High Level Technical Meeting in Mexico City November 15–17, 2011. The focus of this meeting was to address health risks that occur in different geographic regions by highlighting three priority One Health topics—rabies, influenza and antimicrobial resistance. These topics served as a basis to discuss what needs to be done to build political will and more actively engage ministers of health in the One Health movement.

2012: The Global Risk Forum sponsors the first One Health Summit

February 19–22, 2012, the Global Risk Forum One Health Summit was held in Davos, Switzerland. The Summit presented the One Health concept as a way to manage health threats, focusing on food safety and security. The conference ended by approving the "Davos One Health Action Plan," which pinpointed ways to improve public health through multi-sectoral and multi-stakeholder cooperation.

2013: The 2nd International One Health Congress is held in conjunction with the Prince Mahidol Award Conference

From January 29 through February 2, 2013, the 2nd International One Health Congress was held in conjunction with the Prince Mahidol Award Conference. With more than 1,000 attendees from over 70 countries, it was the largest One Health conference to date. The conference encouraged collaboration across disciplines to promote effective policy development related to human, animal and environmental health.

The Historical Timeline of One Health	
460–370 BCE (see PowerPoint)	Hippocrates publishes "On Airs, Waters and Place," promoting the concept that public health depends on a clean environment.
1749–1823 (see PowerPoint)	Edward Jenner produces the first successful vaccine to prevent small pox.
1821–1902 (see PowerPoint)	Virchow recognizes the link between human and animal health.
1822–1895 (see PowerPoint)	Louis Pasteur links human medicine and veterinary medicine.
1843–1910 (see PowerPoint)	Robert Koch establishes the field of bacteria.
1849–1919 (see PowerPoint)	William Osler establishes the field of veterinary pathology.
1859–1934 (see PowerPoint)	Theobald Smith and F.L. Kibourne discover that parasites can transmit diseases to cattle.
1927–2006 (see PowerPoint)	Calvin Schwabe coins the term "One Medicine" and calls for a unified approach against zoonoses that uses both human and veterinary medicine.
2004	The Wildlife Conservation Society publishes the 12 Manhattan Principles.
2007	The American Medical Association passes the One Health resolution promoting a partnership between human and veterinary medicine.
2007	The One Health approach is recommended for pandemic preparedness.
2008	FAO, OIE and WHO collaborate with UNICEF, UNSIC and the World Bank to develop a joint strategic framework in response to the evolving risk of emerging and reemerging infectious diseases.
2008	One Health becomes a recommended approach and a political reality.

The Historical Timeline of One Health	
2009	Key recommendations for One World, One Health are developed.
2010	The Hanoi Declaration, which recommends broad implementation of One Health, is adopted unanimously.
2010	FAO publishes the Tripartitie Concept Note.
2010	CDC, OIE, FAO and WHO identify clear and concrete actions to move the concept of One Health from vision to implementation.
2010	The United Nations and the World Bank recommend adoption of One Health approaches.
2010	The European Union reaffirms its commitment to operate under a One Health umbrella.
2011	The 1st International One Health Congress is held in Melbourne, Australia.
2011	The 1st One Health Conference in Africa is held.
2011	The High Level Technical Meeting to Address Health Risks at the Human-Animal-Ecosystem Interface builds political will for the One Health movement.
2012	The Global Risk Forum sponsors the first One Health Summit.
2013	The 2nd International One Health Congress is held in conjunction with the Prince Mahidol Award Conference.

D. WHO SHOULD BE INVOLVED IN ONE HEALTH TEAM

One health is a collective effort science professions, biologists, virologists, geologists, environmentalists, to name only a small fraction of participants. One Health approach facilitates experts from different disciplines and sectors to communicate and discuss problem from all angles that will provide not only more solutions, but more robust solutions (www.crdfglobal.org). One Health Approach has a broad vision. It doesn't only need to promote the doable such as improving surveillance and response for EID, but also include other disciplines such as economics and social behavior that are essential to success. World Health Organization (WHO), Food and Agriculture Organization (FAO), and World Organization for Animal Health (OIE) are the examples of international organization involved in One Health approach.

Organizations Operating in the One Health Sphere

- World Health Organization (WHO)
- Food and Agriculture Organization (FAO)
- World Organization for Animal Health (OIE)
- One Health Initiative
- United States Centers for Disease Control (CDC)
- Eco Health Alliance
- United States Agency for International Development (USAID)
- Southeast Asia One Health University Network (SEAOHUN)
  - Indonesia One Health University Network (INDOHUN)
  - Malaysia One Health University Network (MYOHUN)
  - Thailand One Health University Network (THOHUN)

  Vietnam One Health University Network (VOHUN)
- Universities - Departments, Centers, etc.
- Ministries of Health, Agriculture, Environmental Resources, etc.
- Medical or Health Professional Associations.

Possible Members of a One Health Team

Team Member	Examples of skills or roles that they might bring or play in a One Health team
Veterinarian	For animal health and food safety issues, epidemiology of animal diseases
Physician	For human health issues, epidemiology of human diseases
Nurse	For human/community health issues
Public Health Worker	For community health issues, disease prevention strategies, epidemiology, communicable disease knowledge
Epidemiologist	Epidemiology, disease control, surveillance, questionnaire design
Wildlife Scientist	Wildlife ecology, zoology
Traditional Healer	Community health issues, understanding of local healing methods
Local Leader/ Politician	Important for support and any action in the local community
Environmental Health Worker	Assess environmental contamination, source of disease, alteration of environmental factors
Ecologist	Connection between organisms and the relevant components of the environment
Economist	Assessing financial impact of the disease and the cost of the recommendations for control or eradication; often money and numbers are important to politicians
Communications Specialist	Risk communication, interaction with media, engaging with communities
Emergency Responder	For acute outbreaks or disasters
Laboratory Technician	For confirmation of organism causing the disease
Pharmacist	For treatment of disease
Logistician	Outbreak response logistics
Public Affairs/Marketing	For interactions with the media and the public
Information Technology Specialist	For information technology, data analysis, data storage and data sharing
Social Scientist	For culture and group dynamics affecting risk, transmission or prevention

E. ONE HEALTH CORE COMPETENCY

Since One Health Approach is needed to fix the complex problem that can't be remedied by viewing from one professional perspective, defining One Health Core Competency is important in order to identify what organization needs to be involved. Competency and domain are interconnected and can't be separated. Core Competency is a measurable knowledge, skill, or behavior that every member of a One Health team must have. It is used in a specific course to derive learning objectives and methods to achieve. While domain is a grouping of competencies based on the common type of knowledge involved. It is used in program, curriculum, and course planning, design and development to identify areas of focus.

Tuft University, along with USAID/RESPOND partners at the University of Minnesota Colleges of Veterinary Medicine, Public Health, Nursing, and Medicine, are using their framework with institutional partners across Southeast Asia and Africa, as follows:

1. Management
   The ability to plan, implements, monitors, and evaluates One Health programs in order to maximize effectiveness of One Health action and desired health outcomes.
2. Culture and Beliefs
   The ability to understand, analyze, and appreciate social, religious, and historical diversity across different cultures within individuals and societies.
3. Leadership
   The ability to initiate a shared trans-disciplinary vision and to motivate and inspire teams across sectors to organize, manage, and foster OH action.
4. Values and ethics
   The ability to identify and respond to OH issues at multiple levels with integrity, honesty, trust, fairness, accountability, adaptability in diverse contexts.
5. Collaboration and Partnership
   The ability to foster and sustain effective collaboration across disciplines within OH teams, individuals, stakeholders, communities in the advancement of OH actions.
6. Communication and Informatics
   The ability to effectively acquire, process, synthesize, share, and exchange information across sectors and disciplines in order to establish, enhance, and promote One Health actions.
7. Systems Thinking
   The ability to analyze how various elements influence and interact with one another within a global perspective that results from the dynamic interdependencies among human, animal, environmental, and ecological systems.

ONE HEALTH COMPETENCY FRAMEWORK					
Global Domains	SEAOHUN Regional	Malaysia	Indonesia	Thailand	Vietnam
February 2013	Domains				
Management	Management	Management	Management	Planning and Management	Planning and Management
Communication	Communications and Informatics	Communication	Communication	Communications and Informatics	Communications and Informatics
Culture and Beliefs	Culture and Beliefs	Culture and Belief	Culture and Belief	Culture and Ethics	Culture and Beliefs
Leadership	Leadership	Leadership and Professionalism	Leadership and Professionalism	Leadership	Leadership
Collaboration and Partnership	Collaboration and Partnership	Collaboration and Partnership	Collaboration	Collaboration and Partnership`	Collaboration and Partnership
Values and Ethics	Values and Ethics	Ethics	Values and Ethics		Values and Ethics
Systems Thinking	Systems Thinking	Systems Thinking	Systems Thinking	Systems Thinking	Systems Thinking
				One Health Knowledge	Policy, Regulation and Advocacy

Deforestation and malaria: Revisiting the human ecology perspective

Subhrendu K. Pattanayak and Junko Yasuoka[1]

In CJP Colfer (ed.), People, Health, and Forests: A Global Interdisciplinary Overview.

Earthscan.

1. Introduction

The ecological basis for disease dates at least as far back as 400 B.C. to Hippocrates's writing of On Airs, Waters, and Place. As Wilson (1995) clarifies, our understanding and therefore control of diseases would be inadequate without an "ecological" perspective on the life cycles of parasitic microorganisms and the associated infectious diseases. As Smith et al. (1999; p 583) contend, "many of the critical health problems in the world today cannot be solved without major improvement in environmental quality." In this chapter we focus on malaria because its transmission (and control) has clear links to ecosystem changes that result from natural resource policies such as land tenure, road building, and agricultural subsidies. The resulting ecosystem change has a tremendous influence on the pattern of diseases such as malaria (Martens 1998; Molyneux 1998; Grillet 2000). This is partly because, of all the forest species that transmit diseases to human beings, mosquitoes are among the most sensitive to ecosystem change: their survival, density, and distribution have been altered by environmental changes caused by different land transformations. While we agree that 'ecological lenses' can help improve our understanding of disease prevention, we use this chapter to articulate a particular ecological perspective – a human ecology viewpoint that puts human behavior change front and center.

In the last decade, we have seen a series of widely cited papers drawing out the connections between ecosystem change and diseases, many of which are synthesized in the 2005 Millennium Ecosystem Assessment (Corvalan et al., 2005a; Corvalan et al. 2005b; Campbell-Lendrum, 2005; Patz et al., 2005; McMichael et al., 1998). This renewed interest in the more distal causes of disease reflects in part the emergence of new fields such as 'sustainability science' (Kates et al., 2001) and 'biocomplexity' (Wilcox and Colwell, 2003) that argue for "a more realistic view [requiring] a holistic perspective that incorporates social as well as physical, chemical, and biological dimensions of our planet's systems." The resurgence also reflects the growing importance of fields of social epidemiology (e.g., Berkman and Kawachi, 2000; Oakes and Kaufman, 2006) that draw on Rose's (1985) call to examine the *cause of cause* and resolve the *prevention paradox* in developing a population strategy for health.

In joining this growing chorus, we focus on an older human ecology tradition (Wessen, 1972; McCormack, 1984), which posits that (a) we humans modify our natural environment, sometimes increasing disease risks, and (b) we ultimately adapt to the new disease risk environment. Two stylized, yet complicating, facts emerge from this viewpoint (Pattanayak et al., 2006a). First, disease prevention behaviors (including ecosystem changes that modify disease risks) respond to disease levels, suggesting a dynamic feedback exposure and control.

Second, individuals and households typically will not consider how their private actions affect public health outcomes and therefore will make socially inappropriate and sub-optimal choices, unless convinced otherwise. Typically, some combination of government laws (e.g., regulation), community norms (information), and markets prices (compensation) help narrow this wedge between private and 'optimal' social behaviors. This modification of domain to now more systematically human behavior is consistent with complaints that the ecology-and- health approach takes a predominantly biophysical approach that can easily overlook the social, cultural, and economic driving forces that are crucial to understanding anthropogenic ecosystem disruptions and their human health impacts (McMichael, 2001; Parkes et al. 2003). In this chapter, we focus on malaria and deforestation, rather than a sweeping review of broad links between infectious diseases and ecosystem change to keep things manageable and present somewhat in- depth arguments. We restrict ourselves to malaria not only because its transmission is clearly linked to ecological changes, but because it is a major (if not the major) health concern in the tropics (Hay et al., 2004). We focus on deforestation because it is a major development policy concern and often heralds many other 'malaria-causing' land use changes (Pattanayak et al., 2006c).

The remainder of the chapter is organized as follows. In Section II, we briefly review the literature on ecology of infectious diseases. In Section III, we re-introduce the human ecology perspective for better understanding the role of humans in land use change as well as in a variety of behaviors to prevent (e.g., sleep under nets, take prophylaxis) and treat (e.g., seek medical care, follow the drug regimen) malaria. In Section IV, we draw out the empirical implications of such a strategy, using our own fieldwork and secondary data sets. Finally, we conclude with a call for systematic environmental and health impact assessments that rely on inter-disciplinary longitudinal studies.

2. A brief synthesis of mosquito ecology and malaria epidemiology

While the impacts of ecosystem change on health are diverse and longstanding, its rate and geographical range have increased markedly over the last few decades. Different kinds of environmental changes have resulted from a wide variety of human activities, including deforestation, agricultural activities, plantations, logging, fuel wood collection, road construction, mining, hydropower development and urbanization (Walsh et al. 1993, Patz et al. 2000, Patz et al. 2004). It is the process of clearing forests and subsequent land transformation that alters every element of local ecosystems, including microclimate, soil and aquatic conditions, and most significantly, the ecology of local fauna and flora. These in turn have profound impact on the survival, density and distribution of human disease vectors and parasites (Martens 1998, Grillet 2000), including influences on breeding places, daily survival probability, density, human- biting rates, and incubation period. Thus, the altered vector/parasite ecology modifies the transmission of vector-borne diseases such as malaria, Japanese encephalitis and filariasis (Sharma and Kondrashin 1991, Walsh et al. 1993).

Numerous country and area studies have described how the density and distribution of local vector species have been altered due to ecosystem change, and some longitudinal studies have shown that the change in vector ecology has altered local disease incidence and prevalence (Sharma and Kondrashin 1991, Patz 2000). However, the mechanism linking ecosystem change, vector ecology and vector-borne diseases is still unclear. We draw on a paper by Yasuoka and Levins (forthcoming) that examines the mechanisms linking deforestation, anopheline ecology, and malaria epidemiology by drawing together 60 examples of changes in anopheline ecology as a consequence of deforestation and agricultural development in Latin America, Africa, and South and Southeast Asia.

Massive clearing of forests has enormous impacts on local ecosystems and human disease pattern. It alters microclimates by reducing shade, altering rainfall patterns, augmenting air movement, and changing the humidity regime (Reiter 2001). It also reduces biodiversity and increases surface water availability through the loss of topsoil and vegetation root systems that absorb rain water (Chivian ed. 2002). For anopheline species that breed in shaded water bodies, deforestation can reduce their breeding habitats, thus affecting their propagation. On the other hand, some environmental and climatic changes due to deforestation can facilitate the survival of other anopheline species, resulting in prolonged seasonal malaria transmission (Kondrashin et al. 1991).

As shown in Table 1 (drawn from Yasuoka and Levins), different land transformations have different impacts on local ecosystem and disease pattern. For example, rubber plantation increased local major malaria vectors in all four cases in Malaysia and Thailand. In Malaysian hilly areas, forest clearance for rubber plantation, which started early in the 1900s, exposed the land and streams to the sun and created breeding places for *An. maculatus*, which led to an increase in this species and a marked rise in the incidence and severity of malaria (Cheong 1983). Cyclic malaria epidemics in Malaysia over 50 years are correlated with rubber replanting in response to market fluctuations (Singh and Tham 1990). Another example is in Chantaburi, Thailand, where the land was transformed to rubber plantation and other fruit tree cultivations, such as rambutan, durian and mangosteen spurred by high markets between 1974 and 1984. The consequent ecological changes favored *An. dirus*, which demonstrated its greatest capability for adaptation in circumstances of rubber and fruit tree cultivations. As a result, local malaria reemerged and malaria transmission was established at high levels (Rosenberg et al. 1990).

All papers on the development of irrigation systems reported an increase in the density of major vectors and following increase in malaria incidence. For example, irrigation schemes developed by the Mahi- Kadan Project across the River Mahi in India in 1960 had typical management problems, including over- irrigation, lack of proper drainage, weedy channels, leaking sluice gates, and water-logged fallow fields. These created extended breeding habitats for *An. culicifacies*, which resulted in an increase of the vector and malaria transmission.

In some cases, different anopheline species responded differently to the same land transformation. For example, due to deforestation for rice cultivation and irrigation development in Sri Lanka, *An. annularis*, *An. barbirostris*, *An. culicifacies*, and *An. varuna* decreased, while *An. jamesii* and *An. subpictus* increased, and *An. nigerrimus* and *An. vagus* did not change substantially (Amerasinghe et al. 1991; Konradsen et al. 2000). Not only species abundance, but also species involvement in malaria transmission changed markedly during the land transformation. *Anopheles annularis*, *An. culicifacies* and *An. vagus* were the main vectors during the construction phase and the first irrigation year. *Anopheles subpictus* was playing a major role in the second and third years, when rice fields were fully irrigated.

Throughout the process, *An. culicifacies* demonstrated continuous involvement in malaria transmission.

Other cases demonstrated species replacement. Land use such as cassava and sugarcane cultivations, which need little water and provide little shade, often create unfavorable environment for anophelines, especially those which require shade. In Thailand, the transformation from forest to cassava or sugarcane cultivations eliminated shady breeding habitats for the primary vector species, *An. dirus*, but created widespread breeding grounds for *An. minimus*, which have greater sun preference and was the predominant species throughout the year. Consequently, malaria transmission among resettled cultivators became high (Prothero 1999).

We also see that same kind of land transformation could result in totally different malaria situations, depending on locality and ecological characteristics of local vector species. For example, deforestation followed by development of coffee plantations in southeast Thailand favored the breeding of *An. minimus* and made the previously malaria-free region to hyperendemic (Suvannadabba 1991). On the contrary, in Karnataka, India, large-scale deforestation for coffee plantations reduced seepages, which were the principal breeding sites for An. fliviatilis, a vector responsible for hyper-endemic malaria in the region.

As a result, this vector population completely collapsed, and malaria disappeared from the area (Karla 1991).

Deforestation for mine development is one of the examples that not only create breeding sites, but also significantly increase human contacts with vectors. Where settlement and mining activities took place in the Amazon, *An. darlingi* increased because of the increase in breeding sites, including borrow pits after road or settlement constructions, drains, and opencast mine workings. As a result, malaria, which was present in the Amazon's indigenous population, was spread to immigrants and miners (Conn et al. 2002).

In summary, the changes in anopheline density and malaria incidence are both varied and complex, depending on the kind of land transformation, ecological characteristics of local mosquitoes, and altered human behavior (to be discussed further). Some key findings include:

- Some anopheline species were directly affected by deforestation and/or subsequent land use, some favored or could adapt to the different environmental conditions that were created, and some invaded and/or replaced other species in the process of development and cultivation.
- Malaria incidence fluctuated according to different stages of development, changes in vector density, and altered human contact patterns with vectors.
- More mosquitoes (vector density or variety) were neither a necessary nor a sufficient condition for increases in malaria incidence. In fact, inverse relationships between the vector abundance and disease incidence have been reported from different regions (Ijumba and Lindsay 2001, Amerasinghe 2003), presumably because of human adaptations (see next).
- In general, a complex set of macroeconomic (changes in terms of trade), demographic (*e.g.*, migration), policy (e.g., colonization of forest frontiers) and behavioral (e.g., 'malaria literacy and knowledge') factors underlie the ecosystem changes and land transformations that influence mosquito ecology and malaria epidemiology (Sharma and Kondrashin 1991; Molyneux 1998). We turn to these considerations in some detail next.

3. Revisiting the human ecology perspective

If ecosystem changes impact mosquito density and activity, and possibly malaria incidence, then environmental management (e.g., vegetation management, modification of river boundaries, drainage of swamps, reduction of standing water, oil application etc.) could reverse these trends. Even though insecticide-treated bed nets and indoor residual spraying of insecticides are the predominant vector control tools, there is growing support for the management of vegetation and water bodies in light of increasing resistance to insecticides and antimalarials (Lindsay and Birley, 2004). Keiser et al.'s (2005) review of 24 environmental management studies suggests that environmental management can reduce malaria risk ratio by 88% (compared to 79.5% for human habitation modifications, for example).

Furthermore, if these are indeed modifiable behavioral causes, it should be possible to induce these behaviors. Yasuoka et al. (2006a) conducted a 20-week pilot education program to improve community knowledge and mosquito control with participatory and non-chemical approaches in Sri Lanka. They evaluated their program effectiveness using pre-educational and posteducational surveys in two intervention and two comparison villages. Their controlled intervention shows that participatory education program led to improved knowledge of mosquito ecology and disease epidemiology, changes in agricultural practices, and an increase in environmentally sound measures for mosquito control and disease prevention. The success of the intervention was attributed to four 'human ecology' characteristics: a community-based education that enhanced residents' understanding of the mosquito-borne disease problems in their own community, a participatory approach that allowed participants to gain hands-on experiences with actions to be taken, using non-chemical measures that decreased environmental and health risks in residential areas and paddy fields, and an approach that required no cost or extensive instruments. Furthermore, this community-based approach suppressed the density of adult Anopheles in the southwest monsoon season, though little impact was detected on Culex and Aedes densities (Yasuoka et al., 2006b).

Vegetation and water management, however, are just one class of human behaviors that impact the transmission and control of malaria. The links between ecosystem change, vector ecology and disease epidemiology all depend critically on human density, gender ratio, immigration of non-immune people, and knowledge, attitudes and practices primarily because they alter the pattern and frequency of human contacts with vectors. Furthermore, a recent special colloquium of the International Society of Ecosystem Health (Patz et al., 2004) suggests that malaria can be exacerbated by a broad array of land use drivers and underlying human behavioral factors beyond changes to the biophysical environment. These include movement of populations, pathogens, and trade; agriculture; and urbanization. Deforestation features prominently in this review and is closely linked to many of these mechanisms.

Pattanayak et al. (2006b) underscore this behavioral aspect of malaria control and present four reasons why it is important to understand the role of deforestation from a policy and planning perspective. These include:

1. Deforestation is not merely the exogenous (remote control) removal of forest cover. It is the beginning of an entire chain of activities, including forest clearing, farming, irrigation, livestock, and non-timber forest product collection, that have ecological (vector habitat) as well as behavioral (exposure and transmission) consequences for malaria.

2. Deforestation is an integral part of life and the landscape in many parts of the world with high malaria rates (Donohue, 2003; Wilson, 2001). Consequently, sustainable forest management has become an important policy goal, as donor agencies and local policy makers take a more integrated view of people in the natural landscape. The resulting changes in land cover, as well as changes in how people interact with the forest, have implications for malaria. Thus, conservation policies aimed at slowing deforestation will impact malaria (Taylor, 1997; and Walsh et al., 1993).

3. Millions of rural households depend directly on a wide variety of forest products and services (Byron and Arnold, 1999). By lowering local people's natural wealth, deforestation can reduce household capacity to invest in health care and pay for malaria prevention and treatment. At the same time, deforestation may increase the wealth of other households, who will then be better able to avoid and cure malaria.

4. Deforestation and malaria are central elements of the vicious cycle of poverty in rural areas of developing countries. In simplistic terms, malaria could be considered to "cause" deforestation, because malaria can make people poorer and poverty has been found to "cause" deforestation under some conditions. In reality, the linkages are more complex and site-specific.

These ideas lead us to a human ecology framework for understanding the links between deforestation and malaria. Human ecology involves the study of human–environment interactions and extends notions of ecology and health by explicitly traversing boundaries between "nature and culture" and "environment and society" (Parkes et al., 2003). Others have labeled these the 'environmental health' or the 'ecology and health' (Aron and Patz,

2001) perspectives. As Parkes et al. (2003) clarify; ultimately all these fields converge on three themes:

(a) integrated approaches to research and policy,
(b) methodological acknowledgment of the synergies between the social and biophysical environments,
(c) incorporation of core ecosystem principles into research and practice

Specific to malaria, we need a shift in the view of humans as passive or constant factors in malaria epidemiology to a view in which people are very active factors (actors) in causing significant changes in epidemiological patterns (Wessen, 1972; MacCormack, 1987). The centrality of human behavior is confirmed by the number of instances in which human behaviors show up in Figure 1 in this chapter and in the Patz et al. (2004) review.

4. Empirics of human ecology: Approach and evidence

In this section we present an initial attempt to examine the importance of human behaviors in malaria transmission and control, and recognize the "active" (dynamic) aspects of human behavioral response. Omitting behavioral responses from any analysis of malaria and ecosystem change would result in a classic case of confounding. Human behavior in this case has all attributes of a confounding factor because it is (a) correlated with the outcome and the risk factor, (b) not necessarily in the causal chain, and (c) very likely to be unbalanced across the different levels of risks. As such behavioral confounders can mimic the risk factor and mask the ecological relationship we are attempting to discover.

What does this mean in practical terms? If we are, for example, using cross-sectional or time series variation in data on deforestation and malaria only, we will face what is labeled an "omitted variable" problem in statistics/econometrics. This problem leads to biased inferences and inconsistent estimates of policy parameters because the real cause is an omitted variable, e.g., the

in-migration of susceptible sub- populations. A second related and possibly more pernicious issue is that of endogeneity or reverse causality (or simultaneity). Consider an example from Sawyer (1993) to better understand this 'endogeneity' bias. High rates of malaria can encourage forms of land use in which men work as day laborers (in logging or ranching), allowing their wives and children to live in towns with relatively lower threat of malaria, rather than establishing family farms. It in such a situation is often difficult to disentangle the causal role of deforestation in malaria transmission.

To further investigate the empirical implications of these 'behavioral' or 'human ecology' models, we offer two simple tests that are conducted at three different scales. First, we compare a simple regression model of malaria and deforestation ('naïve model') to model including linear behavioral controls ('linear controls model'). Second, we compare the same naïve model to one where the behavioral factors are used as determinants of deforestation or the 'endogenous' risk exposure. Behavior in this case is an instrument for the deforestation risk (the instrumental variable [IV] model). Economic theory provides one basis for identifying variables that can explain deforestation and thus serve as instruments (Sills and Pattanayak, 2006).

Arguably the naïve model is a bit of straw man, but it allows us to investigate the importance of a human ecology strategy. We conduct these evaluations at three scales: a micro analysis of child malaria and community deforestation (case from Indonesia), a meso analysis of regional malaria and regional deforestation (case from Brazil), and a macro analysis of national malaria and deforestation. Data limitations preclude the use of accurate behavioral indicators and force us to use proxy variables.[2] Thus, our analysis should be considered as preliminary, and therefore illustrative of the overarching human ecology approach proposed here.

4a. Macro analysis using global data from 120 countries

In this case study, we examine the macro level correlation of malaria and forest using a global data set. Pattanayak et al. (2006) describe the combination of data from 5 sources to produce a global malaria dataset and use it to examine how disease prevention behaviors respond to disease levels. The World Health Organization's Global Health Atlas provides data on a range of malaria variables, including the number of cases, for up to 195 countries from 1990 to 2004. The World Development Reports provide data on forest cover in 1990 and the annual rate of increase from 1990 to 2000. We obtain behavioral proxies from three other sources.

First, data from the 2001 Human Development Report (HDR) provides measures of economic conditions (per capita GDP) and social conditions (adult literacy rates, educational enrollment rates, and life expectancy). Second, Kaufmann et al. (2003) provide data on political stability, voice and accountability, and control of corruption. Additionally, we also include a malaria ecology index to capture vector ecology and climatic factors (Kiszewski et al., 2004). This index combines climatic factors (*e.g.*, rainfall and precipitation), the presence of different mosquito vectors, and the human biting rates of these vectors to proxy for mosquito transmission. This index captures the ecological conditions with the strongest influence on the intensity of malaria prevalence and can therefore predict the actual and potential stability of transmission. Descriptive statistics and other details of the data compilation and synthesis are included in Pattanayak et al. (2006).

Our key variable is the number of malaria cases in a country in the 1996-2000 periods. Various variables (malaria cases, malaria ecology index, and GDP index) are converted into natural logarithms to reduce scale differences, improve linearity and pull in outliers. Median regression methods are used. Results of the three models – naïve, linear controls, and IV are presented in columns 2, 3 and 4 of Table 2 (Panel 1). We report the coefficient on the deforestation variable, the probability value (p.value) associated with this coefficient and the overall significance of the model. The regression coefficient reflects the size and sign of the correlation with malaria incidence. The p.value reflects the statistical significance of the correlation (i.e., less than 0.1 is suggestive of a relationship).

The naïve model is statistically significant and explains about 41% of the variation. We also find confirmation of our key hypothesis: annual rate of forest cover increase (during the 1990 to 2000 period) is negatively correlated with malaria incidence in the 1996-2000 period: more deforestation is positively correlated with higher levels of malaria.

The linear-controls model (where we account for potential confounding due to GDP, school enrollment, voice and accountability, and stability of the governmental institutions) is also statistically significant and explains about 52% of the variation in the malaria cases. We also find that deforestation is positively correlated with malaria, except now the size of this correlation is twice as big.

Finally, the IV model is also significant and explains about 54% of the variation. In this model, first behavioral variables are used to predict deforestation, and then the predicted deforestation is used to explain malaria. Again we see that the deforestation variable is positive correlated with malaria, but now the size of this coefficient is almost 4 times as big as the naïve model – providing a statistically significant evidence of a much stronger correlation between the disease and exposure change due to deforestation.

4b. Meso (regional) analysis using the case of 480 Brazilian micro-regions

In this case study, we examine the hypothesis regarding the regional level correlation of malaria and forest cover. We use a cross-sectional data set of approximately 490 Brazilian micro regions, which in the Brazilian context is anything between one to twelve counties. The malaria data comes from DATASUS (website). It is reported in terms of 1000 inhabitants, and represents hospital morbidity over the 1992- 2000 period. Climate is represented by long run temperature and rainfall (averaged over several years) in the 490 micro-regions, based on weather stations that are located approximately one per micro-region.

Census data (website address) on housing, population, education levels, income, medical care (proxied by number of doctors and hospital beds) and infrastructure (percent of the households connected to water, sanitation, and all-weather roads) is for 1991. Forest cover and vegetation data of the same vintage are from IPEA and protected area data is from INPE, both Brazilian data agencies. Pattanayak et al. (2006b) present additional detail on the compilation and use of this data in analysis.

Instead of dwelling on the details on the analysis, we focus on the key results using the structure from the previous case study. The naïve model (including some ecological controls for weather) is statistically significant and explains 46% of the variation. First, we see that micro-regions with higher forest cover have lower rates of malaria, all things considered. Second we find that micro regions with higher deforestation (in the 1985 to 1995 time period) have greater rates of malaria.

The linear controls model (where we account for potential confounding due to demographics, income, infrastructure, and institutions such as protected areas) is statistically significant and explains 56% of the variation. First, we find that micro-regions with higher deforestation have greater rates of malaria – with the correlation that is significantly larger than the naïve model coefficients (almost twice as large).

Second, micro-regions in the Amazon with conservation units have lower malaria rates for a given level of deforestation.

Finally, the IV model uses a variety of regional factors – presence of protected area, distance to highway and to state capital, population, size and location of the micro-region – as instruments for deforestation in the micro-regions. The overall model is significant. Now the size of the deforestation coefficient is almost 3 times as big as the linear-controls model. The results are consistent across the three models (i.e., deforestation is correlated with more malaria), but the sizes of the estimated coefficient are much larger (3-6 fold) in the models that include proxies for human behavior.

4c. Micro analysis using data on 340 children from Flores, Indonesia

Malaria is highly contextual, with incidence and transmission depending on local conditions, perturbations, and catastrophes. Thus, household or community-level multi-factor research is perhaps best suited to incorporate the diversity and heterogeneity of the ecological, epidemiological, and economic phenomena surrounding malaria. This case study examines the evidence on whether deforestation causes child malaria in the setting of Ruteng Park on Flores Islands in eastern Indonesia.

The data for this analysis are drawn from a household survey in the Manggarai district of Flores, Indonesia in 1996 around a protected area (Ruteng Park), established to conserve biodiversity. The survey and accompanying secondary data collection generated household data on wealth, housing quality, and number of adults, as well as individual data on age, gender, occupation, education and disease history during the twelve months prior to the survey. GIS is used to combine environmental statistics, including the amount and extent of primary and secondary forest cover at the village level, with the survey data and secondary data on public infrastructure such as sub-regional health care facilities. The sample includes approximately 340 kids under the age of 5. Given the binary nature of the data on malaria in kids under the age of 5, we estimate and report probit models of child malaria. Pattanayak et al. (2005) include details.

Starting with the naïve model, we find that the overall model is significant and, this being micro data, explains only about 6% of the variation. We find that the extent of protected (primary) forest cover is not statistically related to malaria, whereas the extent of disturbed (secondary) forest is positively correlated with malaria rates.

The linear-controls model accounts for potential confounding due to various individual, household and village characteristics. The overall model is significant, now explaining about 15% of the variability in the malaria data. As in the naïve model, the extent of disturbed forests is positively correlated with malaria (although now the coefficient is twice as big as before). Most interesting, we now confirm our key hypothesis that the extent of protected forests is indeed negatively correlated with malaria incidence.

Finally, the IV model uses a variety of community level factors – distance to highway, population, village size, elevation, and rainfall – as instruments for protected and disturbed forest cover around the villages. The overall model is highly significant. Most crucially, now the sizes of the coefficients are almost 3 times as big as the linear-controls model. Malaria in little children is highly positively correlated with the extent of disturbed forests and negatively correlated with the extent of protected forests.

5. Concluding though

Vector-borne diseases such a malaria wreak havoc on the lives of many millions of people in poor, tropical countries, partly because these regions are exposed to environmental conditions such deforestation, livestock rearing, irrigated farming, road construction, and dam-building that encourage vector abundance and disease transmission. We argue that it is critical to focus on the deforestation linkage because it is the beginning of an entire chain of activities that affect malaria risks; can trigger behavioral changes due to accompanying increases or decreases in wealth; can lock communities into a vicious cycle of poverty, illness and environmental degradation; and is an integral part of the landscape and therefore of donor agencies and policy maker focus. Recognizing that deforestation often precedes many other relevant land use changes (particularly conversion to agriculture), taking deforestation as a starting point allows us to look at the impact of other elements in the “matrix of transformations.” As such it serves as a broad indicator of change in the ecology of infectious disease paradigm. This lead us to recommend a human ecology that focuses on the role of humans in land use change as well as in a variety of behaviors to prevent (e.g., sleep under nets, take prophylaxis) and treat (e.g., seek medical care, follow the drug regimen) malaria. We then review the implications of this framework change for empirical research and application – both in data collection and analysis and inference.

he empirical case studies draw attention to the role of socio-economic determinants of malaria and importance of including behavioral variables in empirical models of malaria incidence and prevalence. They illustrate how omitting behavioral factors from the analysis can lead to erroneous and biased interpretations regarding the nature of ecosystem changes and disease transmission – the size, sign, and statistical significance of regression coefficients can be wrong. In general, they are intended to highlight different elements of human-induced ecosystem change, disease outcomes, and economic causes and consequences.

What we have not discussed is the inherent dynamics of coupled natural and social systems. In a recent paper, for example, Pattanayak et al. (2006a) analyze global and micro data to show that malaria prevention behaviors depend on malaria prevalence. They find that households and countries engage in greater degree of prevention if they face high rates of malaria and fewer prevention behaviors if they confront low rates of malaria. That is, the causal arrow can also flow in the other direction (such an arrow is shown as a dotted arrow in Figure 1, typically missing from most assessments). This logical feedback and dynamic between prevention and prevalence suggests that it is insufficient and inappropriate to model and consider socioeconomic behaviors as something outside the malaria infection and transmission process. Behavior and its determinants are part and parcel of the ecology and epidemiology and must be built into the analysis and planning.

In fact, it is safe to say that many of these findings hold for a general class of vector-borne infectious diseases such as dengue, leishmaniasis, hantavirus pulmonary syndrome, schistosomiasis, filariasis, lyme disease, onchocerciasis and loiasis. Space limitations preclude a comprehensive discussion of these diseases (for additional details, see Wilson [2001] and tables 4 and 5 in Colfer et al. [2006], for example). As suggested in Figure 1, ecosystem changes influence the emergence and proliferation of these diseases by altering the ecological balance and context within which disease hosts or vectors and parasites breed, develop and transmit diseases (Patz et al 2000). For example, deforestation is often followed by water resources development and livestock management, which open up numerous possibilities for disease risks.

Moreover, the simultaneity between prevalence and prevention discussed previously Pattanayak et al. (2006a) only points to the proverbial tip of the dynamic that is inherent in coupled natural and social systems. As Hammer (1993) suggests, in the case of malaria, very little is known about the inter-related dynamics of ecosystem changes, vector density and infectivity, development of immunity and resistance (to pesticides and drugs) and human response. Wiemer's (1987) case of schistosomiasis in China and Gersovitz and Hammer's (2005) model of malaria prevention and treatment are early attempts to examine these dynamics through mathematical simulations. Much more conceptual work is needed before ecosystem change dynamics can be incorporated into such models. Empirical research must test hypotheses about the nature and magnitude of these relationships and generate statistical parameters that can then be used for policy scenario analysis.

In the interim, however, the human ecology approach to public health can take root and thrive through the conduct of systematic economic and health impact assessments of forest policies. Such evaluations need to be inter-disciplinary longitudinal studies, with at least the following features:

1. It is impossible to design and implement a rigorous study and make credible inferences without a c l e a r understanding of the policy scenario. Specificity of the policy scenario – be it a project at a site, a program that includes a collection of projects, or a nation/region wide policy – allows the analyst to understand the mechanism of disease transmission and economic impacts in terms of 'modifiable causes'.

2. With a clear scenario, it is then possible to design rigorous evaluations to infer 'causal policy impacts'. These are typically through randomized assignment of the program or a quasi-experimental design that includes data collection in program and control (non-program) sites during various stages of program implementation, including baseline (preprogram) and end line (post-program) data.

3. The credibility of the resulting evaluation will ultimately ride on the quality of the data and the rigor and care in data analysis. For a study of this type, outcomes variables include indicators of health, wealth, and the environment. Extent of forest cover and forest condition are among the key explanatory variables. Other explanatory variables include socio-economic, demographic, environmental, health, and public health policy indicators. The challenge in empirical work is to identify robust measures of these variables and separate independent and dependent variables. The multiple channels for feedback between malaria, deforestation and poverty suggest that these variables would be dependent variables in some specifications, and independent variables in other specifications and data sets.

4. Although researchers can employ an array of sophisticated techniques to remedy defects in available data, clearly "prevention" in the form of careful data collection is superior to "cure" in the form of ad hoc statistical fixes. Longitudinal data sets – and particularly panel data sets – are keys to addressing at least three critical issues in the types of research proposed here: heterogeneity, endogeneity, and dynamics or mobility (Ezzati et al., 2005). Ideally, data should be collected at several scales, ranging from individual level health and demographic data, to household level economic information, to community and regional level environmental statistics and policy factors.

The human ecology approach proposed in this chapter that is built on these conceptual and empirical roots can be used for at least two practical purposes (Pattanayak et al. 2006c). First, it can help organize the conceptual links between coupled natural and socio-economic systems and serve as a platform for generating testable hypothesis and policy parameters. Such efforts are critical for understanding the ecological, entomological, epidemiological and economic aspects of deforestation, malaria, and their behavioral underpinnings. Second, it will be vital for building decision analysis and scenario simulation tools (Kramer et al., 2006), which rely on estimated parameters, for formulating integrated strategies that cut across health, environment and economic sectors to address the broad idea of ecosystem change and disease control. Scenario simulation can for example inform the design of surveillance and monitoring framework necessary to detect changes in the environment, vector density, human migration and behavior, and incidence of diseases in order to both contain vector-borne diseases and prevent epidemics.

EXERCISE#3

Discussion

- ✓ Who (i.e, what occupations/professions/positions) should be involved to Large Group address the issue of deforestation and the outbreak of malaria?
- ✓ Why would each role be important and what would be their primary roles

Notes: