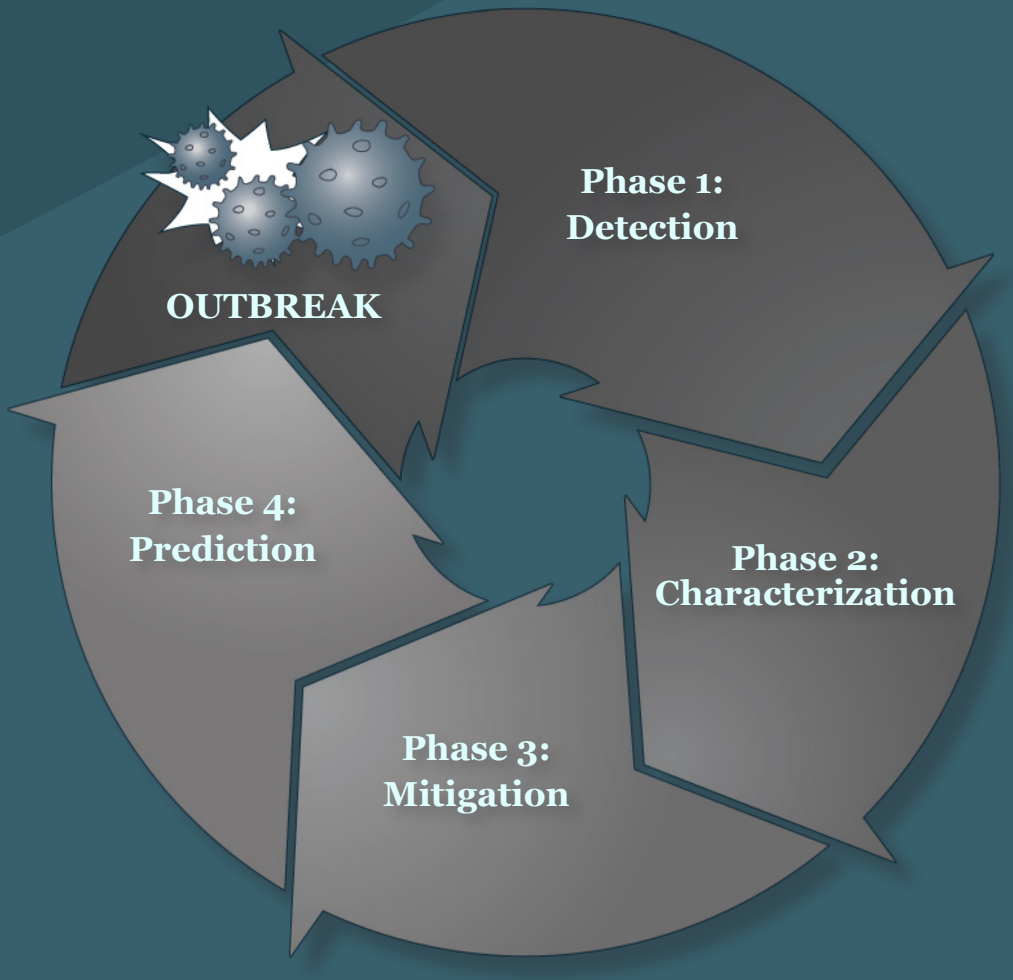
Scientific Collections International Report (1) March 2015

Scientific Collections and Emerging Infectious Diseases:

Report of an Interdisciplinary Workshop



Scientific Collections International

Scientific Collections International (SciColl) is a global consortium devoted to promoting the use and impact of object-based scientific collections across disciplines. SciColl's member countries and institutions own and manage collections of objects used for research in archaeology, biology, biomedicine, earth and space sciences, technology, and other fields.

SciColl's mission is to increase the return on investment that countries and institutions make in their scientific collections by catalyzing international and interdisciplinary collaboration. Emerging Infectious Diseases, Food Security, Environmental Change, and Human Migration are the four research initiatives identified by SciColl for demonstrating the interdisciplinary value and impact of collections. SciColl is also developing an online Global Registry of Scientific Collections to increase access to information across disciplinary boundaries.

This document presents a report of SciColl's first activity in the area of Emerging Infectious Diseases.

The workshop was designed by the Steering Committee:

Diane diEuliis, Richard Jaffe, Manuela da Silva, Richard P. Lane, Tim Littlewood, Eileen Graham, and David E. Schindel, assisted by Adele Crane and Franco Ciammachilli.

This report is a written record of the workshop presentations and discussions as compiled by the Steering Committee with input from the entire field of participants. A full list of workshop participants and their institutional affiliations can be found in the Appendix.

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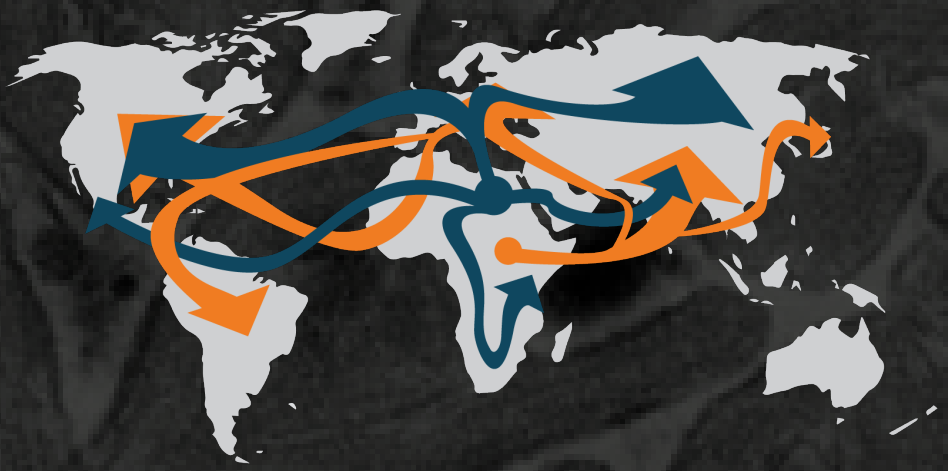
Introduction

Emerging Infectious Diseases (EIDs) have threatened society throughout our history. Despite the sophistication of modern medicine, EIDs continue to endanger human populations and their frequency and severity could be on the rise. Modern transportation allows more of us to travel farther and faster than ever before and the spread of EIDs is an unwelcome by-product. Infected travelers can carry diseases to new continents before any symptoms appear and before quarantine or other precautionary actions can be taken.



This map, adapted from Haisam Hussein's "Contagion" illustration (Lapham's Quarterly 2009), shows the global spread of leprosy, in orange, and smallpox, in blue.

Two other features of modern society have also contributed to a new generation of EIDs. Society is changing land-use patterns in many ways; wilderness is being converted into farmland, farmland into suburbs, and suburbs into megacities. Global climate change is driving shifts in the geographic distribution of habitat types and their biological communities. These two forces – changing land-use and global climate change – are creating new zones of contact between wild species, domesticated species, and human populations. Many infectious diseases have complex life cycles that can pass through different non-human host species that act as hidden reservoirs and transmission vectors that eventually lead to humans. Each new encounter between species is an opportunity for pathogens and parasites to jump to new host species, including humans. Studies have suggested 60% or more of the EIDs that affect humans have jumped from wild or domesticated species.

How will society meet the threat to global public health that EIDs represent? Two challenges are readily apparent. First, the medical research and public health agencies in different countries must work more closely together to identify and respond to outbreaks more rapidly. Governments around the world are attempting to meet this first challenge by launching international collaborations and communications networks. These collaborations include the Global Health Initiative, launched in 2009, and more recently, the Global Health Security Agenda, dedicated to improving screening, accelerating the speed with which outbreaks are reported internationally, and coordinating rapid responses.

Second, the research communities devoted to biomedicine, wildlife biology, veterinary science, microbiology, and other fields must see themselves as a single, global, collaborative research community when it comes to infectious diseases. Understanding and stopping the transmission of diseases among humans, wild, and domesticated species will require new traditions of collaboration that will replace long-entrenched disciplinary boundaries. This second challenge is the greater of the two. It calls on government agencies, research institutions, professional associations, and individual researchers to undergo a cultural change that values integrative approaches as well as research excellence within narrower, traditionally defined missions.

1400+ species of microbes and internal parasites are pathogenic (that is, they cause human disease).

61% of these are zoonotic (that is, they're passed between animals and humans).

175 of the pathogenic species cause significant human disease outbreaks.

75% of these are zoonotic.

From Taylor, Latham and Woolhouse, 2001

Definitions of **terms shown in bold:**

Emerging Infectious Diseases (EIDs): A disease that appears suddenly from an unknown source, spreads rapidly, and results in significant illness and numbers of deaths. Associated with:

- Re-emerging infectious diseases: EIDs that disappeared, were forgotten, and reappeared at a later time and possibly a different place; and
- Zoonotic infectious diseases: EIDs that spread from wild or domesticated animal species to humans.

Object-based Scientific Collections (or simply **Scientific Collections**): Objects that are gathered for scientific study as part of a specific research project or periodic surveillance/monitoring effort. In this context "collections" can include:

- Biodiversity collections in natural history museums, herbaria, zoos, aquariums, botanical gardens, and culture collections including frozen tissue and DNA samples;
- Ecological samples (water, soil, airborne particulate matter);
- Human patient samples (e.g., surgical tissue, blood, serum);
- Parasites and pathogens; and
- Veterinary samples of wild and domesticated animal species.

Interagency Working Group on Scientific Collections (IWGSC) is an activity of the federal National Science and Technology Council of the White House. IWGSC's mission is to coordinate policies across U.S. government agencies that own and operate scientific collections.

Workshop "Engaging Scientific Collections in Emerging Infectious Disease Research" was held on 23-24 October 2014 at the Smithsonian Institution's National Museum of Natural History in Washington, DC.

The **Disease Outbreak Cycle** describes the typical progression of an EID through four phases following the outbreak event (see next page). The topics and the types of scientific collections discussed during the workshop are listed for each phase of the cycle.

The Workshop

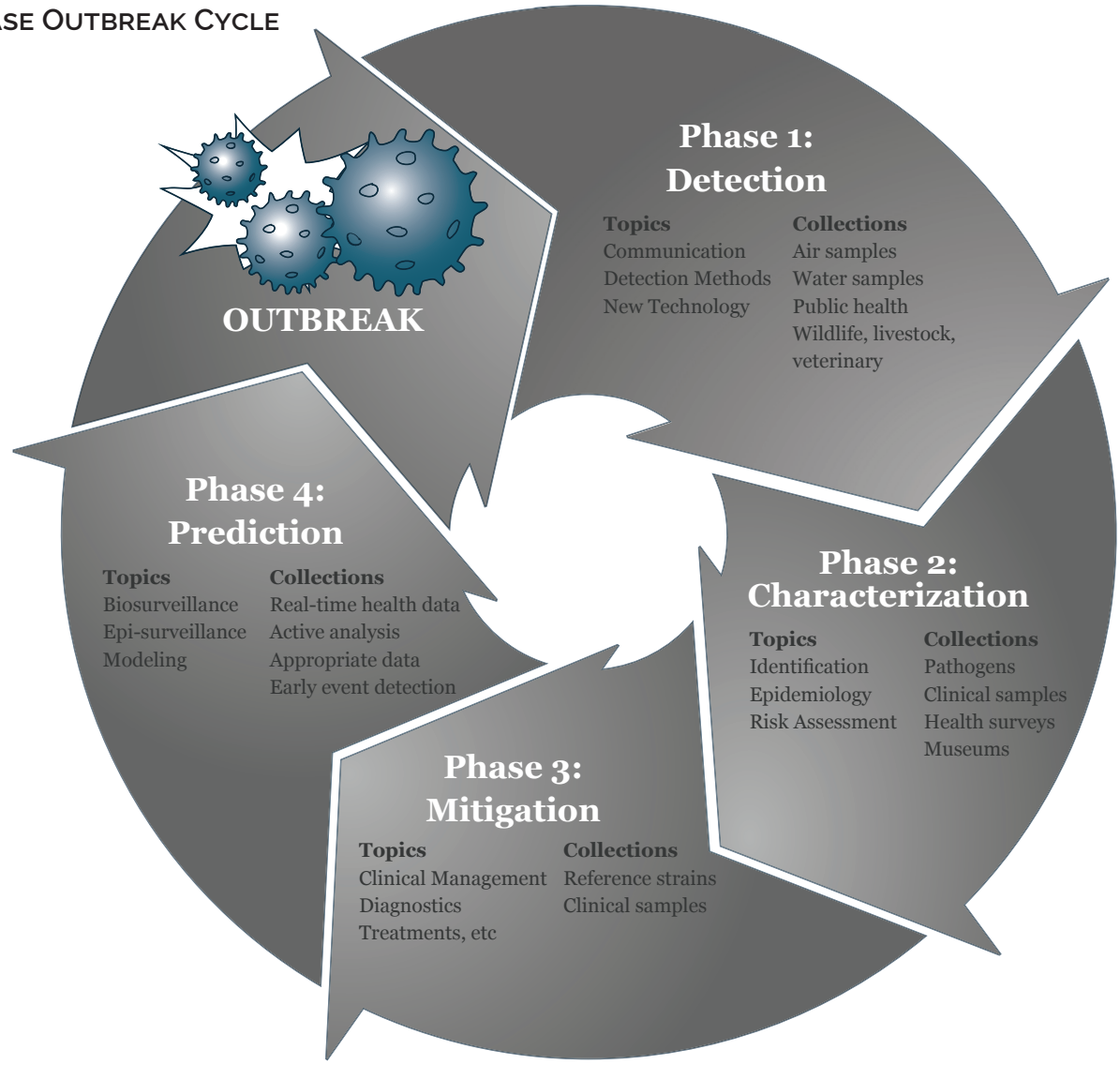
Scientific Collections International (SciColl), in collaboration with the U.S. Department of Health and Human Services' (HHS) Office of the Assistant Secretary for Preparedness and Response (ASPR) and the Smithsonian Institution, brought more than forty participants from different disciplines and countries together for a two-day workshop on **Emerging Infectious Diseases (EIDs)**. More specifically, this international, interdisciplinary workshop was devoted to exploring the potential impact that **Object-based Scientific Collections** in different disciplines can have on the study, prevention, early identification, and control of EIDs. The range of impacts that scientific collections can have across disciplines, including public health, has been previously highlighted by the U.S. **Interagency Working Group on Scientific Collections** (IWGSC 2009). Several IWGSC members participated in this workshop (see Appendix).

The agenda for the **workshop** was structured around the four phases of the **Disease Outbreak Cycle**, each of which was explored using a specific case study (Febrile Diseases, Arenavirus, Neglected Tropical Diseases, and Hantavirus). Common themes across the case studies were numerous and workshop participants identified four main findings on how the scientific collections in their respective research fields were, or could have been, used.

This report lays out four main findings, each of which includes an articulation of specific unmet needs, and a list of proposed action items. The major actionable concepts identified during the workshop include:

- Increase engagement between the EID research community and scientific collections in several disciplines;
- Changes in institutional, national, and international policies and procedures that could improve access to and sharing of samples from scientific collections;
- Data gaps and/or disconnects between scientific collections and their stakeholders; and
- Promising novel approaches to research, communication, and cross-disciplinary integration of data provided by scientific collections.

Disease Outbreak Cycle



Outbreak

A disease outbreak is the sudden occurrence of a disease in excess of what would normally be expected in a defined population, geographical area, or season. A single case of a communicable disease long absent from a population, or caused by an agent not previously recognized in that community or area, or the emergence of a previously unknown disease, may also constitute an outbreak.

1. Emergence and Detection

includes identifying unanticipated signs of an outbreak, such as school and work absenteeism, increased doctor visits, over the counter pharmaceutical sales, and analyzing populations with corresponding behaviors and symptoms as part of syndrome surveillance.

2. Characterization

includes efforts to isolate, study, and identify the causal agent, its sources, reservoirs, vector species and transmission pathways.

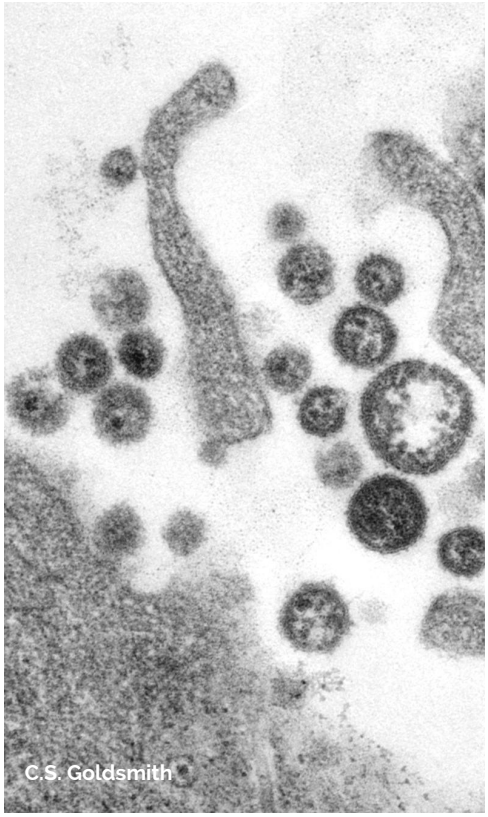
3. Mitigation and Intervention

includes efforts at containment and the development and deployment of tests, treatments and vaccines for the disease.

4. Prediction and Monitoring

is devoted to gathering data on the presence of the causal agent in all relevant populations (sources, reservoirs, vectors and humans) and using these data to forecast possible future outbreaks and target surveillance efforts.

Finding I: New collections, collecting methods and collection management practices are needed. Scientific collections are normally constructed for the needs of a particular discipline, but they could be serving the needs of many other user communities.



Lassa fever is often misdiagnosed based on symptoms similar to those of other diseases. Therefore antibody tests or DNA sequencing are often needed to positively identify it.

Scientific collections are constructed in two ways. Some collections are amassed for research projects that address specific questions. The sampling schemes and the selection of data recorded with each sample are designed to answer that question. Other collections are created and managed with the more general mission to serve the needs of future researchers. In both cases, researchers and collection managers operate within the paradigm of their particular research discipline.

Workshop participants discussed how different disciplines approach collecting objects and their associated data that might be effective in studying and combating EIDs. Discussions were structured around four case studies, each of which focused on a different phase of the Disease Outbreak Cycle. Common struggles and areas for improvement emerged from these multi-disciplinary discussions. The Unmet Needs of this broad user community are presented here.

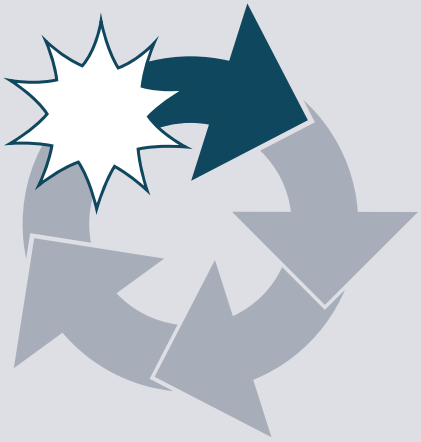
Disease Detection: Undiagnosed Febrile Diseases

Lassa Fever and several related febrile diseases are common in the west African countries of Sierra Leone, Liberia, and Guinea, which led practitioners to assume that most febrile diseases encountered are already known. However, a high percentage of the suspected Lassa patients test negative for the disease and further testing could identify the infection in only 25% of the Lassa-negative cases.

Unmet Needs for Detecting EIDs:

1. More systemic programs to collect and preserve samples of potential reservoir and vector species associated with newly discovered and/or undiagnosed infectious disease agents.

Case Study: Detection



Undiagnosed Febrile Diseases, Sierra Leone, 2008

Emergence/Detection: Sierra Leone, Liberia and Guinea constitute a hyperendemic region for Lassa Fever but 60-70% of patients with febrile diseases are negative for Lassa based on immunoassays. Lassa-negative patients have been misdiagnosed with Dengue, West Nile, yellow fever, Rift Valley fever, Marburg, Ebola, and others.
Characterization: Antibody tests and DNA sequencing can identify some but not all undiagnosed fevers; data on true geographic ranges of many diseases are incomplete underestimates.
Mitigation: Limited by high proportion of undiagnosed diseases.
Prediction: Non-existent because relationships between the many Lassa-like diseases and their vectors and reservoirs are unknown.

For more information see Schoepp et al. (2014).

Characterizing Disease Agents: Arenavirus

A previously unknown arenavirus emerged in Zambia and was stopped in a South African care facility after only five deaths. The new virus was characterized with pyrosequencing of samples sent to Columbia University in New York thanks to a collaborative relationship between two individuals. Such lucky coincidences are rare and do not provide a scalable approach to the characterization of EIDs.

Unmet Needs for Characterizing EIDs:

2. Expanded programs for **Geographic** and **Longitudinal Sampling** and preservation of pathogens to characterize patterns and trends in their distribution;
3. Standardized analyses of newly-discovered pathogens and online access to analytical results linked to collection data;
4. Greater access to databases of pathogen collections and assays developed from those collections reported in similar geographic areas for the rapid detection of EIDs; and
5. In cases when a facility does not have adequate equipment or tools, the transfer of samples to testing locations in other countries and regions of the world. This will require rapid, simplified procedures for international transfer of samples as called for in Article 8 of the **Nagoya Protocol**.

Many infectious diseases can pass through different non-human host species that act as hidden reservoirs and transmission vectors that eventually lead to humans. Each new encounter between species is an opportunity for pathogens and parasites to jump to new host species.

Geographic or **Horizontal sampling**: collecting objects from similar systems across a wide geographic range to characterize the breadth of variation in a system.

Longitudinal or **Historic sampling:** collecting objects in similar systems at different times in history to characterize temporal changes in a system.

The **Nagoya Protocol** for Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization entered into force on 12 October 2014 as an extension of the Convention on Biological Diversity. Article 8 calls on Parties to the Protocol to "Pay due regard to cases of present or imminent emergencies that threaten or damage human, animal or plant health, as determined nationally or internationally."

Lujo Hemorrhagic fever, Zambia, 2008

Emergence/Detection: A patient shows hemorrhagic fever symptoms outside the known area of Lassa Fever and related arenaviruses and is quickly transferred to regional facility in Johannesburg, South Africa. Several attending health care workers also become ill and are admitted to the facility.
Characterization: RT-PCR results were inconclusive. Through personal contacts with Columbia University and CDC, an official at the care facility obtains viral pyrosequencing results that indicated the presence of a previously unknown arenavirus that is not closely related to known species.
Mitigation: All patients were isolated to stop further transmission. Four patients expired; fifth and final patient to show symptoms received ribavirin treatment following characterization and recovered.
Prediction: Although pyrosequencing provided data that could lead to the development of reagents for further study, no efforts have been made to identify reservoirs, vectors and transmission mechanisms.

For further information see Paweska et al. (2009).

Case study: Characterization

1986 **3.2 million**

1996 **152,814**

2006 **25,217**

2014 **126**

One of the 17 NTDs, Guinea worm disease has no known medicine or vaccine.

Yet eradication is seemingly just around the corner for what was once a disease with over 3 million cases in 20 countries. Through community-based intervention and education it has been eradicated in several regions (throughout Asia and the middle East) and is nearing eradication in Africa- and with it, the world.

Source: The Carter Center and WHO

Neglected Tropical Diseases (NTDs) are a diverse group of diseases that are common in low-income populations in tropical and sub-tropical regions around the world. Established as a group in the early 2000s to raise awareness and funding, most are treatable and several global initiatives have recently declared efforts to eradicate or eliminate many of them by 2020. Combined they afflict upwards of 1 billion people and kill over 500,000 each year.

Ecosystem Sampling (also known as Life cycle sampling): Collecting and preserving an organism and all the other organisms associated with its passage through a generation (e.g., hosts, parasites, pathogens, reservoirs, food sources, predators, prey). Ecosystem sampling of a disease life cycle can involve several habitat systems (e.g., rivers, lakes, grasslands and forests) and multiple historical time horizons.

Disease Mitigation: Neglected Tropical Diseases

Seventeen **Neglected Tropical Diseases (NTDs)** are caused by pathogens and parasites that pass through multiple host and vector species during their complex life cycles. Though this poses a challenge to eradication, each host and stage offers a different opportunity to interrupt the life cycles and stop the disease. For example, Colwell et al. (2003) showed that filtering drinking water through locally woven fabric can reduce cholera by removing the copepod plankton that carry *Vibrio cholerae*. This same technique has proven effective in eradicating other diseases, including dracunculiasis carried by guinea worms in Africa.

Unmet Needs for EID Mitigation:

6. Increased programs of **Ecosystem Sampling** and the establishment of reference collections to identify and characterize all the stages, reservoirs, and vectors of a disease agent, with the goal of designing mechanisms to interrupt the disease cycle and to monitor changes over time. Reference collections would be valuable for detecting changes in pathogens over time exposed to different selection pressures, such as increasing drug treatments.

Case Study: Mitigation

Neglected Tropical Diseases

Emergence/Detection: 17 or more debilitating diseases caused by viruses, bacteria, protozoa, helminthes; detection can be by presence of parasite eggs in feces, immunological testing and molecular identification of infection.
Characterization: Involves not just the disease agent but reservoirs, vectors, transmission mechanisms, and their habitat preferences.
Mitigation: Different strategies are possible (e.g., behavioral changes to avoid vectors, improved sanitation, purifying drinking water) but all require knowledge of disease pathways.
Prediction: Most NTDs involve aquatic reservoir and/or vector species (snails, mosquitoes) so environmental modification (including dams and irrigation) and climate change can lead to increased infections.

For more information see Molyneux (2004).

Disease Prediction: Hantavirus

When an outbreak of a previously unknown Hantavirus was characterized in the Four Corners region of the U.S., rodent collections were examined. These collections went back decades, enabling researchers to find the emergence of the virus in rodent populations even before it had emerged in humans. The museum collections also covered a wide geographic region, allowing health officials to predict outbreak areas based on occurrences of infections. These new capabilities relied on **Holistic Sampling** and preservation of the rodents in a way that preserved the host, its parasites, and tissue samples.

Museum collections cover many geographic regions, allowing health officials to predict outbreak areas based on previous occurrences of infections.

Unmet Needs for EID Prediction:

7. Expanded **Surveillance or Monitoring** programs and construction of reference collections of wildlife, domesticated species, and microbes for modeling and prediction of EIDs;
8. Retrospective sampling of existing collections of suspected wildlife reservoir and vector species, determining geographic patterns and vertical/historic trends in the distributions of disease agents; and
9. Stronger linkages between public health agencies and databases of disease agents in wildlife and domesticated species.

Holistic Sampling: Collecting and preserving multiple objects and/or component parts associated with a specific time, place and/or organism (e.g., hosts, ectoparasites, endoparasites, gut contents, feces, frozen tissue, blood, pathogens, reservoirs, food sources, predators, prey).

Surveillance (or Monitoring): A general term for the gathering of samples or information for the early detection of an emerging phenomenon. In this context, surveillance or monitoring can take the following forms:

- 'Just in Case' monitoring: Gathering and preserving samples or data with no specific target in mind to document conditions across many possibilities, primarily for retrospective analysis of pre-existing conditions (e.g., periodic surveys, public health sampling);
- 'Just in Time' surveillance: Rapid collection of samples and data soon after a phenomenon occurs to characterize an event and its causes; and
- Archives from unexplained events: Gathering and preserving samples from autopsies/necropsies related to unexplained deaths, unidentified diseases, for comparison with emerging diseases.

Sin Nombre Hantavirus, New Mexico, 1993

Emergence/Detection: Respiratory failure due to fluid build-up, rapid onset, high mortality in healthy patients. After the 1993 outbreak of the Sin Nombre Virus (SNV), outbreaks of other Hantaviruses occurred in Latin America, each with a different rodent reservoir species.
Characterization: The SNV was identified by CDC as a Hantavirus using antibodies from local patients and serum from other global cases. Rodent tissue in museums showed polyclonal antibodies and RNA sequences for SNV as early as 1979.
Mitigation: Earlier patient stabilization and improved care through crisis period; rodent control programs and public health warnings when rodent numbers are high (after El Niño events).
Prediction: Hantaviruses have strong associations with reservoir species. Museum samples have helped document the presence of rodent hosts with viral loads during periods of wet weather, and the relationship between increased rodent populations and outbreaks in humans. Recent screening of other museum tissues detected new Hantaviruses (of unknown human pathogenicity) in worldwide populations of shrews, moles, and now bats.

For more information see Yates et al. (2002).

Case Study: Prediction

Finding II: The long-term use and impact of collections for EID research will require new policies for collection growth and management.

Scientific collections face twin challenges: (1) selecting objects for long-term preservation based on their potential for future use and impact, and (2) increasing the likelihood of future use and impact through good management. These opportunities for increased use and impact come at a time when many collections face reduced support. If properly managed, collections can attract new users and sources of support for expansion and new applications (IWGSC 2009).

Unmet Needs:

10. Collaboration between collections professionals and potential user communities (e.g., public health, biomedical research) to develop programs for managing objects and their related data for an expanded user community;

11. Effective policies for the evaluation and selection of samples and specimens collected by research projects (sometimes termed **Project Collections**) for transfer to **Institutional Collections** for long-term preservation; and

12. Knowledgeable management staff to assist non-traditional users of their collections. Collections managers have a deep understanding of collections, databases, annotations, and metadata that new users value. Career positions and programs for training, development, and recruitment will be essential.

One unmet need the workshop committee found was a common and standardized language for sampling, specimens, collections, data, and metadata that overcome language barriers and promote database interoperability across disciplines and countries.

Finding III: Increasing awareness and access across disciplinary boundaries to scientific collections and their associated databases will have long-term impact.

Even leading researchers have limited knowledge of the breadth and depth of scientific collections in other disciplines. The databases associated with these collections are often offline or are known only to practitioners in that field. Research on and response to EIDs will benefit from increased awareness of and improved access to collections and their associated databases.

Unmet Needs:

13. A more seamless, transparent network of scientific collections and associated databases. Working groups that cross disciplinary (like the IWGSC of the U.S. government) and national (like the World Federation of Culture Collections) boundaries; and

14. A comprehensive online clearinghouse that would provide information on scientific collections in all disciplines. SciColl and IWGSC are in the process of developing the **GRSciColl** for this purpose.

Project Collections and **Institutional Collections** are two types of **Object-based Scientific Collections.** Most objects that are collected for research spend a period of time as part of **Project Collections** which are used and managed by researchers. Objects can be transferred from a Project Collection to an **Institutional Collection** (also termed 'reference' or 'archival' collection) through a formal accessioning process. The objects in Institutional Collections are overseen by professional collection managers for long-term preservation and use by the research community.

GRSciColl: The Global Registry of Scientific Collections is an expansion of the Global Registry of Biodiversity Repositories (GRBio). It will provide online access to information about collections in archaeology, anthropology, biodiversity, biomedicine, earth and space sciences, applied fields (e.g., agriculture, technology, veterinary sciences) and other disciplines.

Finding IV: The detection, characterization, mitigation, and prediction of EIDs are a Big Data challenge and need appropriate responses on both the demand and supply sides.

Public health officials and disease researchers face a variety of obstacles at each stage of the disease outbreak cycle. Some challenges call for 'horizontal' data on the geographic distribution of an infectious agent, or its occurrence across host and vector species. Other challenges demand 'vertical' data on the history of an infectious agent through time. Sampling across days to weeks is needed during the early stages of an outbreak. Samples that take researchers back years, decades, or even centuries can reveal the origins of an outbreak and can help predict new EIDs. Scientific collections can meet these demands but only through a global information system that operates in the mode of **Big Data**, comparable to those used in commerce, banking, and data-intensive research fields, such as astrophysics and genomic science.

since 2007 the Global Disease Detection Operations Center of the U.S. CDC monitored and reported

1300 unique outbreaks of more than

140 diseases to have occurred in over

150 different countries.

Unmet Needs:

15. A common and standardized language for sampling, specimens, collections, data, and metadata that overcomes language barriers and promotes database interoperability across disciplines and countries. For example, georeferencing is essential for the integration of diverse datasets, such as virus mapping;

16. More effective standards for **Metadata and Annotations** used by scientific collections that will make them more easily discoverable by potential users;

17. Adoption of national and international policies requiring public release of data and metadata associated with scientific collections, including publications based on their utilization; and

18. Fewer, more comprehensive and more interconnected portals into data on disease outbreaks, relevant collections and their databases.

Big Data: The most commonly encountered information in a system (in contrast with long-tail data that represent relatively rare information). In this context, Big Data may be generated by:

- Large-scale efforts to collect survey data (e.g., the U.S. census, public health surveys such as NHANES);
- New technologies that generate very large volumes of data per unit of time (e.g., next-generation DNA sequencers); and
- Highly inter-connected systems with many distributed sensors or other input devices (e.g., medical record systems, internet searches).

Metadata and Annotations: Information items attached to a sample or observation of interest that make discovery and re-use of the primary data more probable and useful (e.g., geolocation, date/time, environmental conditions, associated samples or observations).

Guinea Worm larvae, cause of a Neglected Tropical Disease (see case study on page 6).

Proposed Action Items

Participants identified three broad Action Items that complement the more specific unmet needs presented above. The following longer-term Action Items were considered the highest priorities.

Action Item A. Introduce the potential impact of scientific collections into the discussions of ONE HEALTH and other international initiatives

The workshop concluded that collections can make important contributions to EID research and management, but awareness of collections may be limited among participants in global health initiatives. The unmet needs described under Finding I suggest some tangible goals to pursue, such as new approaches to field sampling and improved access to online data on collections, samples, and their characteristics.

The following stakeholders can play a leadership role:

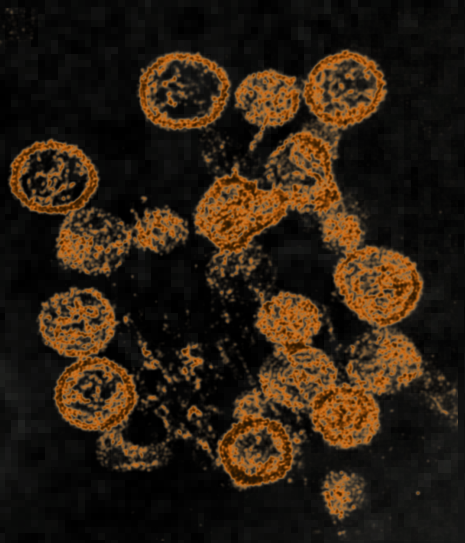
- Workshop participants who are active in these and other initiatives are in a good position to introduce the topic and disseminate this report;
- HHS can raise awareness of collections through its involvement in the implementation of the Global Health Security Agenda;
- Several U.S. government agencies, international partners and diverse stakeholders are involved in the Agenda's implementation and their activities provide opportunities to introduce the workshops and recommendations; and
- SciColl should also play a proactive role in disseminating the report and its recommendations through conferences and through the media.

Action Item B. Promote collaborations to create a new interdisciplinary culture of Collecting and Collections

The workshop's discussion of EIDs provided one example of many potential areas in which scientific collections can find new users, stakeholders and impact. The unmet needs presented under Findings II and III describe objectives that would generate benefits to the scientific collections, the EID researchers who want to use them, and the general public. Realizing these benefits will require regular interactions between collections and a much wider range of stakeholders in the biomedical and global health communities.

To accomplish this:

- The people who build, manage, and oversee scientific collections need to look beyond their traditional community of practice for new users and applications;
- Institutions that are open to expanding and managing their collections in new ways will increase the use and impact of their collections and will find new users and sources of financial, administrative, and political support;
- Networking among diverse collections needs to occur to gain a greater awareness of what types of collections exist across disciplines; and
- Raising awareness within each discipline of the potential impact scientific collections can have on EIDs will be the first step. **Professional associations** and networks of collections are in the best position to raise awareness and promote discussion within disciplines. Similarly, interdisciplinary bodies like IWGSC (and its counterparts in other countries) and SciColl can cross the disciplinary boundaries.



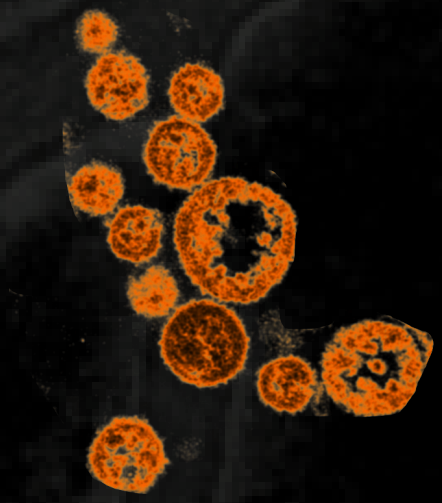
Sin Nombre Hantavirus (see case study on page 7)

Action Item C. Create an information system to increase awareness, access and use of collections across disciplines

An important component of the cultural change recommended above is increasing the visibility and accessibility of collections across disciplinary boundaries. The unmet needs presented under Finding IV are important obstacles to be overcome and the joint development of GRSciColl by SciColl and IWGSC is an important first step.

A broadly inclusive online information system should be built that:

- Helps researchers find the collections and associated data they need from disciplines unfamiliar to them;
- Empowers and relies on research communities in different disciplines to enter and update information about their collections;
- Facilitates the adoption of important 'orphaned' collections before they are lost or destroyed;
- Links data records (e.g., public health data, test results, gene sequences) to source specimen and culture collection data; and
- Re-links dissociated specimens and data, such as parasites and their hosts, which may be stored in different collections and/or institutions.



Lassa Fever virus (see case study on page 4).

Professional associations and networks of collections
Examples are the Society for the Preservation of Natural History Collections (SPNHC), International Society of Biological and Environmental Repositories (ISBER), SYNTHESYS (an EU network of systematic biology facilities), the World Federation of Culture Collections (WFCC), and the Consortium of European Taxonomic Facilities (CETAF),

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U.S. Army Maj. Eric Wagar and Simba Mobagi, a laboratory technologist with Kenya's Rachuonyo district hospital, diagnose malaria in blood samples.

Appendix: Workshop Participants and Report Contributors

(* denotes members and staff of the U.S. IWGSC)

Last Name	First Name	Affiliation
Alves	Tony	U.S. Army
Baker	Thomas	Joint Pathology Center
Ciammachilli	Franco	Assistant Secretary for Preparedness and Response, HHS
Conn	David Bruce	Berry College and Museum of Comparative Zoology, Harvard University
Cook	Joseph	Museum of Southwestern Biology, University of New Mexico
*Crane	Adele	SciColl
Damann	Franklin	National Museum of Health and Medicine
da Silva	Manuela	Fundação Oswaldo Cruz
*DiEuliis	Diane	Assistant Secretary for Preparedness and Response, HHS
Fleischer	Robert	Smithsonian Conservation Biology Institute
Fulks	Tricia	SciColl
Glaeser	Jessie	U.S. Culture Collection Network and Forest Service, USDA
*Graham	Eileen	SciColl
Grefenstette	John	Public Health Dynamics Laboratory, University of Pittsburgh
Harris	Beth	Animal and Plant Health Inspection Service-Veterinary Services, USDA
Helgen	Kristofer	NMNH, Smithsonian Institution
Hewitt	Judith	National Institute of Allergy and Infectious Diseases, NIH
Hoberg	Eric	Agricultural Research Service, USDA
Hoffman	Maria	Food and Drug Administration
Huffman	Robert	Biosurveillance Management Office
Jaffe	Richard	Assistant Secretary for Preparedness and Response, HHS
Lane	Richard	Independent Consultant
McElroy	Kristina	U.S. Army
*McQuillan	Geraldine	National Center for Health Statistics, CDC
Morgan	Jeff	U.S. Department of Defense
Morse	Stephen	Mailman School of Public Health, Columbia University
Mullins	Piper	Pan-Smithsonian Cryo-Initiative
Murray	Suzan	National Zoological Park, Smithsonian Institution
Nelson	Ann Marie	Joint Pathology Center
Nelson	Martha	Fogarty International Center, NIH
Olinger	Gene	National Institute of Allergy and Infectious Diseases, NIH
Pugh	Rebecca	National Institute of Standards and Technology
Resque	Hugo	Evandro Chagas Institute, Virology Section
Rollinson	David	Natural History Museum London
Sanders	John	U.S. Department of Homeland Security
*Schindel	David	SciColl
Simione	Frank	ATCC
Viboud	Cecile	Fogarty International Center, NIH
White	LeAnn	National Wildlife Health Center, USGS

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